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**Department of Defense
Fiscal Year (FY) 2021 Budget Estimates**

February 2020



Navy

Justification Book Volume 1 of 5

Research, Development, Test & Evaluation, Navy

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The estimated cost of this report for the Department of the Navy (DON) is \$11,862.

The estimated total cost for supporting the DON budget justification material is approximately \$2,970,459 for the 2020 fiscal year. This includes \$82,977 in supplies and \$2,887,482 in labor.

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Navy • Budget Estimates FY 2021 • RDT&E Program

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Navy • Budget Estimates FY 2021 • RDT&E Program

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Department of Defense Appropriations Act, 2021

Research, Development, Test and Evaluation, Navy

For expenses necessary for basic and applied scientific research, development, test and evaluation, including maintenance, rehabilitation, lease, and operation of facilities and equipment, \$21,486,610 to remain available for obligation until September 30, 2022.

FY 2021 Overseas Contingency Operations funding can be separated into the following categories:

OCO for Direct War Costs (\$42,500): OCO for Direct War costs are those combat or direct combat support costs that will not continue to be expended once combat operations end at major contingency locations.

OCO for Enduring Requirements (\$17,062): OCO for Enduring Requirements are enduring in-theater and in-CONUS costs that will likely remain after combat operations cease, and have previously been funded in OCO.

OCO for Base Requirements (\$0): OCO for Base Requirements is OCO funding for base budget requirements in support of the National Defense Strategy. The Budget requests these funds in OCO to comply with the base budget defense caps included in the Budget Control Act of 2011.

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Department of Defense
 FY 2021 President's Budget
 Exhibit R-1 FY 2021 President's Budget
 Total Obligational Authority
 (Dollars in Thousands)

Appropriation	FY 2019 (Base + OCO)	FY 2020 Base Enacted	FY 2020 Emergency	FY 2020 OCO Enacted	FY 2020 Total Enacted (Base+Emerg+ OCO)
	-----	-----	-----	-----	-----
Research, Development, Test & Eval, Navy	18,738,363	20,155,115	130,444	164,410	20,449,969
Total Research, Development, Test & Evaluation	18,738,363	20,155,115	130,444	164,410	20,449,969

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Department of Defense
 FY 2021 President's Budget
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 Total Obligational Authority
 (Dollars in Thousands)

Appropriation	FY 2021 Base	FY 2021 OCO for Base Requirements	Direct War and Enduring Costs	FY 2021 Total OCO	FY 2021 Total (Base + OCO)
	Research, Development, Test & Eval, Navy	21,427,048		59,562	59,562
Total Research, Development, Test & Evaluation	21,427,048		59,562	59,562	21,486,610

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Department of Defense
FY 2021 President's Budget
Exhibit R-1 FY 2021 President's Budget
Total Obligational Authority
(Dollars in Thousands)

Summary Recap of Budget Activities	FY 2019 (Base + OCO)	FY 2020 Base Enacted	FY 2020 Emergency	FY 2020 OCO Enacted	FY 2020 Total Enacted (Base+Emerg+ OCO)
	-----				-----
Basic Research	662,024	650,800			650,800
Applied Research	1,002,162	1,159,739			1,159,739
Advanced Technology Development	831,351	807,280			807,280
Advanced Component Development & Prototypes	4,033,262	5,329,143		40,006	5,369,149
System Development & Demonstration	5,840,606	6,112,602		1,122	6,113,724
Management Support	1,437,664	999,165	130,444		1,129,609
Operational Systems Development	4,931,294	5,096,386		123,282	5,219,668
Software and Digital Technology Pilot Programs					
Total Research, Development, Test & Evaluation	18,738,363	20,155,115	130,444	164,410	20,449,969
Summary Recap of FYDP Programs	-----				
Strategic Forces	234,760	204,609			204,609
General Purpose Forces	1,866,214	1,770,467		15,000	1,785,467
Intelligence and Communications	707,765	692,955			692,955
Research and Development	14,039,673	15,652,568	130,444	41,128	15,824,140
Central Supply and Maintenance	63,255	74,961			74,961
Administration and Associated Activities	2,376	1,460			1,460
Space	40,735	15,868			15,868
Classified Programs	1,783,585	1,742,227		108,282	1,850,509
Total Research, Development, Test & Evaluation	18,738,363	20,155,115	130,444	164,410	20,449,969

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Department of Defense
 FY 2021 President's Budget
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 (Dollars in Thousands)

Summary Recap of Budget Activities	FY 2021 Base	FY 2021 OCO for Base Requirements	FY 2021 OCO for Direct War and Enduring Costs	FY 2021 Total OCO	FY 2021 Total (Base + OCO)
Basic Research	603,087				603,087
Applied Research	953,175				953,175
Advanced Technology Development	760,396				760,396
Advanced Component Development & Prototypes	6,503,074		55,418	55,418	6,558,492
System Development & Demonstration	6,263,883		1,144	1,144	6,265,027
Management Support	991,222				991,222
Operational Systems Development	5,327,043		3,000	3,000	5,330,043
Software and Digital Technology Pilot Programs	25,168				25,168
Total Research, Development, Test & Evaluation	21,427,048		59,562	59,562	21,486,610
Summary Recap of FYDP Programs					
Strategic Forces	330,493				330,493
General Purpose Forces	1,792,408		3,000	3,000	1,795,408
Intelligence and Communications	730,315				730,315
Research and Development	16,655,343		56,562	56,562	16,711,905
Central Supply and Maintenance	51,865				51,865
Administration and Associated Activities	1,536				1,536
Space	70,056				70,056
Classified Programs	1,795,032				1,795,032
Total Research, Development, Test & Evaluation	21,427,048		59,562	59,562	21,486,610

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Department of the Navy
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Basic Research	662,024	650,800			650,800
Applied Research	1,002,162	1,159,739			1,159,739
Advanced Technology Development	831,351	807,280			807,280
Advanced Component Development & Prototypes	4,033,262	5,329,143		40,006	5,369,149
System Development & Demonstration	5,840,606	6,112,602		1,122	6,113,724
Management Support	1,437,664	999,165	130,444		1,129,609
Operational Systems Development	4,931,294	5,096,386		123,282	5,219,668
Software and Digital Technology Pilot Programs					
Total Research, Development, Test & Evaluation	18,738,363	20,155,115	130,444	164,410	20,449,969
Summary Recap of FYDP Programs					
Strategic Forces	234,760	204,609			204,609
General Purpose Forces	1,866,214	1,770,467		15,000	1,785,467
Intelligence and Communications	707,765	692,955			692,955
Research and Development	14,039,673	15,652,568	130,444	41,128	15,824,140
Central Supply and Maintenance	63,255	74,961			74,961
Administration and Associated Activities	2,376	1,460			1,460
Space	40,735	15,868			15,868
Classified Programs	1,783,585	1,742,227		108,282	1,850,509
Total Research, Development, Test & Evaluation	18,738,363	20,155,115	130,444	164,410	20,449,969

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Summary Recap of Budget Activities	FY 2021 Base	FY 2021 OCO for Base Requirements	FY 2021 OCO for Direct War and Enduring Costs	FY 2021 Total OCO	FY 2021 Total (Base + OCO)
Basic Research	603,087				603,087
Applied Research	953,175				953,175
Advanced Technology Development	760,396				760,396
Advanced Component Development & Prototypes	6,503,074		55,418	55,418	6,558,492
System Development & Demonstration	6,263,883		1,144	1,144	6,265,027
Management Support	991,222				991,222
Operational Systems Development	5,327,043		3,000	3,000	5,330,043
Software and Digital Technology Pilot Programs	25,168				25,168
Total Research, Development, Test & Evaluation	21,427,048		59,562	59,562	21,486,610
Summary Recap of FYDP Programs					
Strategic Forces	330,493				330,493
General Purpose Forces	1,792,408		3,000	3,000	1,795,408
Intelligence and Communications	730,315				730,315
Research and Development	16,655,343		56,562	56,562	16,711,905
Central Supply and Maintenance	51,865				51,865
Administration and Associated Activities	1,536				1,536
Space	70,056				70,056
Classified Programs	1,795,032				1,795,032
Total Research, Development, Test & Evaluation	21,427,048		59,562	59,562	21,486,610

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Appropriation: 1319N Research, Development, Test & Eval, Navy

Program Line Element No	Item	Act	FY 2019	FY 2020	FY 2020	FY 2020	FY 2020	Total Enacted S
			(Base + OCO)	Base Enacted	Emergency	OCO Enacted	(Base+Emerg+ e OCO)	c
1 0601103N	University Research Initiatives	01	155,539	167,850			167,850	U
2 0601152N	In-House Laboratory Independent Research	01	19,123	19,121			19,121	U
3 0601153N	Defense Research Sciences	01	487,362	463,829			463,829	U
	Basic Research		662,024	650,800			650,800	
4 0602114N	Power Projection Applied Research	02	26,903	28,546			28,546	U
5 0602123N	Force Protection Applied Research	02	175,857	215,517			215,517	U
6 0602131M	Marine Corps Landing Force Technology	02	61,593	69,104			69,104	U
7 0602235N	Common Picture Applied Research	02	40,559	42,846			42,846	U
8 0602236N	Warfighter Sustainment Applied Research	02	64,010	95,825			95,825	U
9 0602271N	Electromagnetic Systems Applied Research	02	74,934	88,497			88,497	U
10 0602435N	Ocean Warfighting Environment Applied Research	02	87,715	82,582			82,582	U
11 0602651M	Joint Non-Lethal Weapons Applied Research	02	6,137	6,346			6,346	U
12 0602747N	Undersea Warfare Applied Research	02	75,998	98,075			98,075	U
13 0602750N	Future Naval Capabilities Applied Research	02	135,523	152,012			152,012	U
14 0602782N	Mine and Expeditionary Warfare Applied Research	02	37,399	54,074			54,074	U
15 0602792N	Innovative Naval Prototypes (INP) Applied Research	02	151,176	152,354			152,354	U

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Appropriation: 1319N Research, Development, Test & Eval, Navy

Program Line Element No	Item	Act	FY 2021 Base	FY 2021 OCO for Base Requirements	FY 2021 Direct War and Enduring Costs	FY 2021 Total OCO	FY 2021 Total (Base + OCO)	S e c
1 0601103N	University Research Initiatives	01	116,816				116,816	U
2 0601152N	In-House Laboratory Independent Research	01	19,113				19,113	U
3 0601153N	Defense Research Sciences	01	467,158				467,158	U
	Basic Research		603,087				603,087	
4 0602114N	Power Projection Applied Research	02	17,792				17,792	U
5 0602123N	Force Protection Applied Research	02	122,281				122,281	U
6 0602131M	Marine Corps Landing Force Technology	02	50,623				50,623	U
7 0602235N	Common Picture Applied Research	02	48,001				48,001	U
8 0602236N	Warfighter Sustainment Applied Research	02	67,765				67,765	U
9 0602271N	Electromagnetic Systems Applied Research	02	84,994				84,994	U
10 0602435N	Ocean Warfighting Environment Applied Research	02	63,392				63,392	U
11 0602651M	Joint Non-Lethal Weapons Applied Research	02	6,343				6,343	U
12 0602747N	Undersea Warfare Applied Research	02	56,397				56,397	U
13 0602750N	Future Naval Capabilities Applied Research	02	167,590				167,590	U
14 0602782N	Mine and Expeditionary Warfare Applied Research	02	30,715				30,715	U
15 0602792N	Innovative Naval Prototypes (INP) Applied Research	02	160,537				160,537	U

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Program Line Element No Number	Item	Act	FY 2019	FY 2020	FY 2020	FY 2020	FY 2020	Total Enacted S
			(Base + OCO)	Base Enacted	Emergency	OCO Enacted	(Base+Emerg+ OCO)	c
16 0602861N	Science and Technology Management - ONR Field Activities	02	64,358	73,961			73,961	U
	Applied Research		-----	-----	-----	-----	-----	-----
			1,002,162	1,159,739			1,159,739	
17 0603123N	Force Protection Advanced Technology	03	32,140	40,286			40,286	U
18 0603271N	Electromagnetic Systems Advanced Technology	03	8,639	9,499			9,499	U
19 0603640M	USMC Advanced Technology Demonstration (ATD)	03	170,659	212,347			212,347	U
20 0603651M	Joint Non-Lethal Weapons Technology Development	03	12,956	13,307			13,307	U
21 0603673N	Future Naval Capabilities Advanced Technology Development	03	210,631	222,477			222,477	U
22 0603680N	Manufacturing Technology Program	03	57,322	65,138			65,138	U
23 0603729N	Warfighter Protection Advanced Technology	03	39,949	34,149			34,149	U
24 0603758N	Navy Warfighting Experiments and Demonstrations	03	64,422	67,739			67,739	U
25 0603782N	Mine and Expeditionary Warfare Advanced Technology	03	38,541	13,335			13,335	U
26 0603801N	Innovative Naval Prototypes (INP) Advanced Technology Development	03	196,092	129,003			129,003	U
	Advanced Technology Development		-----	-----	-----	-----	-----	-----
			831,351	807,280			807,280	
27 0603178N	Medium and Large Unmanned Surface Vehicles (USVs)	04						U
28 0603207N	Air/Ocean Tactical Applications	04	29,136	40,643		2,400	43,043	U

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Appropriation: 1319N Research, Development, Test & Eval, Navy

Program Line Element No	Item	Act	FY 2021 Base	FY 2021 OCO for Base Requirements	FY 2021 OCO for Direct War and Enduring Costs	FY 2021 Total OCO	FY 2021 Total (Base + OCO)	S e c
16 0602861N	Science and Technology Management - ONR Field Activities	02	76,745				76,745	U
	Applied Research			953,175			953,175	
17 0603123N	Force Protection Advanced Technology	03	24,410				24,410	U
18 0603271N	Electromagnetic Systems Advanced Technology	03	8,008				8,008	U
19 0603640M	USMC Advanced Technology Demonstration (ATD)	03	219,045				219,045	U
20 0603651M	Joint Non-Lethal Weapons Technology Development	03	13,301				13,301	U
21 0603673N	Future Naval Capabilities Advanced Technology Development	03	246,054				246,054	U
22 0603680N	Manufacturing Technology Program	03	60,122				60,122	U
23 0603729N	Warfighter Protection Advanced Technology	03	4,851				4,851	U
24 0603758N	Navy Warfighting Experiments and Demonstrations	03	40,709				40,709	U
25 0603782N	Mine and Expeditionary Warfare Advanced Technology	03	1,948				1,948	U
26 0603801N	Innovative Naval Prototypes (INP) Advanced Technology Development	03	141,948				141,948	U
	Advanced Technology Development			760,396			760,396	
27 0603178N	Medium and Large Unmanned Surface Vehicles (USVs)	04	464,042				464,042	U
28 0603207N	Air/Ocean Tactical Applications	04	35,386				35,386	U

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Appropriation: 1319N Research, Development, Test & Eval, Navy

Program Line Element No Number	Item	Act	FY 2019	FY 2020	FY 2020	FY 2020	FY 2020
			(Base + OCO)	Base Enacted	Emergency	OCO Enacted	Total Enacted S (Base+Emerg+ OCO)
29 0603216N	Aviation Survivability	04	7,618	11,919			11,919 U
30 0603239N	ISO Naval Construction Forces	04					U
31 0603251N	Aircraft Systems	04	790	1,473			1,473 U
32 0603254N	ASW Systems Development	04	6,877	7,172			7,172 U
33 0603261N	Tactical Airborne Reconnaissance	04	3,537	3,419			3,419 U
34 0603382N	Advanced Combat Systems Technology	04	38,674	57,947			57,947 U
35 0603502N	Surface and Shallow Water Mine Countermeasures	04	116,113	407,800			407,800 U
36 0603506N	Surface Ship Torpedo Defense	04	6,822	7,242			7,242 U
37 0603512N	Carrier Systems Development	04	5,388	4,997			4,997 U
38 0603525N	PILOT FISH	04	140,354	196,648			196,648 U
39 0603527N	RETRACT LARCH	04	28,653	11,980		22,000	33,980 U
40 0603536N	RETRACT JUNIPER	04	109,958	129,163			129,163 U
41 0603542N	Radiological Control	04	735	689			689 U
42 0603553N	Surface ASW	04	1,078	1,137			1,137 U
43 0603561N	Advanced Submarine System Development	04	103,267	115,717			115,717 U
44 0603562N	Submarine Tactical Warfare Systems	04	12,180	11,192			11,192 U
45 0603563N	Ship Concept Advanced Design	04	73,750	96,846			96,846 U
46 0603564N	Ship Preliminary Design & Feasibility Studies	04	12,839	22,534			22,534 U
47 0603570N	Advanced Nuclear Power Systems	04	256,137	181,652			181,652 U

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Appropriation: 1319N Research, Development, Test & Eval, Navy

Program Line Element No Number	Item	Act	FY 2021	FY 2021	FY 2021	FY 2021	FY 2021	S
			Base	OCO for Base Requirements	Direct War and Enduring Costs	Total OCO	(Base + OCO)	e
29 0603216N	Aviation Survivability	04	13,428				13,428	U
30 0603239N	ISO Naval Construction Forces	04	2,350				2,350	U
31 0603251N	Aircraft Systems	04	418				418	U
32 0603254N	ASW Systems Development	04	15,719				15,719	U
33 0603261N	Tactical Airborne Reconnaissance	04	3,411				3,411	U
34 0603382N	Advanced Combat Systems Technology	04	70,218				70,218	U
35 0603502N	Surface and Shallow Water Mine Countermeasures	04	52,358				52,358	U
36 0603506N	Surface Ship Torpedo Defense	04	12,816				12,816	U
37 0603512N	Carrier Systems Development	04	7,559				7,559	U
38 0603525N	PILOT FISH	04	358,757				358,757	U
39 0603527N	RETRACT LARCH	04	12,562		36,500	36,500	49,062	U
40 0603536N	RETRACT JUNIPER	04	148,000				148,000	U
41 0603542N	Radiological Control	04	778				778	U
42 0603553N	Surface ASW	04	1,161				1,161	U
43 0603561N	Advanced Submarine System Development	04	185,356				185,356	U
44 0603562N	Submarine Tactical Warfare Systems	04	10,528				10,528	U
45 0603563N	Ship Concept Advanced Design	04	126,396				126,396	U
46 0603564N	Ship Preliminary Design & Feasibility Studies	04	70,270				70,270	U
47 0603570N	Advanced Nuclear Power Systems	04	149,188				149,188	U

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Appropriation: 1319N Research, Development, Test & Eval, Navy

Program Line Element No Number	Item	Act	FY 2019	FY 2020	FY 2020	FY 2020	FY 2020
			(Base + OCO)	Base Enacted	Emergency	OCO Enacted	Total Enacted S (Base+Emerg+ e OCO)
48 0603573N	Advanced Surface Machinery Systems	04	26,272	87,408			87,408 U
49 0603576N	CHALK EAGLE	04	33,943	54,877			54,877 U
50 0603581N	Littoral Combat Ship (LCS)	04	36,864	16,934			16,934 U
51 0603582N	Combat System Integration	04	15,710	17,251			17,251 U
52 0603595N	Ohio Replacement	04	528,146	427,051			427,051 U
53 0603596N	LCS Mission Modules	04	99,728	108,505			108,505 U
54 0603597N	Automated Test and Analysis	04	36,563	42,653			42,653 U
55 0603599N	Frigate Development	04	119,821	59,007			59,007 U
56 0603609N	Conventional Munitions	04	8,942	9,988			9,988 U
57 0603635M	Marine Corps Ground Combat/Support System	04		51,997			51,997 U
58 0603654N	Joint Service Explosive Ordnance Development	04	60,316	33,478		14,178	47,656 U
59 0603713N	Ocean Engineering Technology Development	04	5,697	5,619			5,619 U
60 0603721N	Environmental Protection	04	19,629	20,564			20,564 U
61 0603724N	Navy Energy Program	04	31,726	58,014			58,014 U
62 0603725N	Facilities Improvement	04	5,177	3,440			3,440 U
63 0603734N	CHALK CORAL	04	254,023	307,392			307,392 U
64 0603739N	Navy Logistic Productivity	04	2,803	3,857			3,857 U
65 0603746N	RETRACT MAPLE	04	307,563	242,144			242,144 U
66 0603748N	LINK PLUMERIA	04	347,395	396,509			396,509 U

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Appropriation: 1319N Research, Development, Test & Eval, Navy

Program Line Element No	Item	Act	FY 2021 Base	FY 2021 OCO for Base Requirements	FY 2021 OCO for Direct War and Enduring Costs	FY 2021 Total OCO	FY 2021 Total (Base + OCO)	S e c
48 0603573N	Advanced Surface Machinery Systems	04	38,449				38,449	U
49 0603576N	CHALK EAGLE	04	71,181				71,181	U
50 0603581N	Littoral Combat Ship (LCS)	04	32,178				32,178	U
51 0603582N	Combat System Integration	04	17,843				17,843	U
52 0603595N	Ohio Replacement	04	317,196				317,196	U
53 0603596N	LCS Mission Modules	04	67,875				67,875	U
54 0603597N	Automated Test and Analysis	04	4,797				4,797	U
55 0603599N	Frigate Development	04	82,309				82,309	U
56 0603609N	Conventional Munitions	04	9,922				9,922	U
57 0603635M	Marine Corps Ground Combat/Support System	04	189,603				189,603	U
58 0603654N	Joint Service Explosive Ordnance Development	04	43,084		14,461	14,461	57,545	U
59 0603713N	Ocean Engineering Technology Development	04	6,346				6,346	U
60 0603721N	Environmental Protection	04	20,601				20,601	U
61 0603724N	Navy Energy Program	04	23,422				23,422	U
62 0603725N	Facilities Improvement	04	4,664				4,664	U
63 0603734N	CHALK CORAL	04	545,763		3,000	3,000	548,763	U
64 0603739N	Navy Logistic Productivity	04	3,884				3,884	U
65 0603746N	RETRACT MAPLE	04	353,226				353,226	U
66 0603748N	LINK PLUMERIA	04	544,388				544,388	U

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			(Base + OCO)	Base Enacted	Emergency	OCO Enacted	Total Enacted S (Base+Emerg+ e OCO)
67 0603751N	RETRACT ELM	04	49,869	63,434			63,434 U
68 0603764M	LINK EVERGREEN	04		30,000			30,000 U
69 0603764N	LINK EVERGREEN	04		167,735			167,735 U
70 0603790N	NATO Research and Development	04	9,280	7,697			7,697 U
71 0603795N	Land Attack Technology	04	6,924	5,900		1,428	7,328 U
72 0603851M	Joint Non-Lethal Weapons Testing	04	26,695	28,466			28,466 U
73 0603860N	Joint Precision Approach and Landing Systems - Dem/Val	04	99,123	51,341			51,341 U
74 0603925N	Directed Energy and Electric Weapon Systems	04	138,988	135,919			135,919 U
75 0604014N	F/A -18 Infrared Search and Track (IRST)	04	104,505	112,416			112,416 U
76 0604027N	Digital Warfare Office	04	19,217	37,000			37,000 U
77 0604028N	Small and Medium Unmanned Undersea Vehicles	04	16,062	47,261			47,261 U
78 0604029N	Unmanned Undersea Vehicle Core Technologies	04	26,406	41,910			41,910 U
79 0604030N	Rapid Prototyping, Experimentation and Demonstration.	04	27,495	31,000			31,000 U
80 0604031N	Large Unmanned Undersea Vehicles	04	57,942	68,310			68,310 U
81 0604112N	Gerald R. Ford Class Nuclear Aircraft Carrier (CVN 78 - 80)	04	81,021	105,756			105,756 U
82 0604126N	Littoral Airborne MCM	04	14,052	20,248			20,248 U
83 0604127N	Surface Mine Countermeasures	04	14,764	18,735			18,735 U

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67 0603751N	RETRACT ELM	04	86,730				86,730	U
68 0603764M	LINK EVERGREEN	04	236,234				236,234	U
69 0603764N	LINK EVERGREEN	04						U
70 0603790N	NATO Research and Development	04	6,880				6,880	U
71 0603795N	Land Attack Technology	04	10,578		1,457	1,457	12,035	U
72 0603851M	Joint Non-Lethal Weapons Testing	04	28,435				28,435	U
73 0603860N	Joint Precision Approach and Landing Systems - Dem/Val	04	33,612				33,612	U
74 0603925N	Directed Energy and Electric Weapon Systems	04	128,845				128,845	U
75 0604014N	F/A -18 Infrared Search and Track (IRST)	04	84,190				84,190	U
76 0604027N	Digital Warfare Office	04	54,699				54,699	U
77 0604028N	Small and Medium Unmanned Undersea Vehicles	04	53,942				53,942	U
78 0604029N	Unmanned Undersea Vehicle Core Technologies	04	40,060				40,060	U
79 0604030N	Rapid Prototyping, Experimentation and Demonstration.	04	12,100				12,100	U
80 0604031N	Large Unmanned Undersea Vehicles	04	78,122				78,122	U
81 0604112N	Gerald R. Ford Class Nuclear Aircraft Carrier (CVN 78 - 80)	04	107,895				107,895	U
82 0604126N	Littoral Airborne MCM	04	17,366				17,366	U
83 0604127N	Surface Mine Countermeasures	04	18,754				18,754	U

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			(Base + OCO)	Base Enacted	Emergency	OCO Enacted	Total Enacted S (Base+Emerg+ e OCO)
84 0604272N	Tactical Air Directional Infrared Countermeasures (TADIRCM)	04	45,853	58,449			58,449 U
85 0604289M	Next Generation Logistics	04	5,890	19,420			19,420 U
86 0604292N	Future Vertical Lift (Maritime Strike)	04					U
87 0604320M	Rapid Technology Capability Prototype	04	6,986	4,558			4,558 U
88 0604454N	LX (R)	04	5,463	12,500			12,500 U
89 0604536N	Advanced Undersea Prototyping	04	108,482	187,187			187,187 U
90 0604636N	Counter Unmanned Aircraft Systems (C-UAS)	04		3,100			3,100 U
91 0604659N	Precision Strike Weapons Development Program	04	89,477	637,254			637,254 U
92 0604707N	Space and Electronic Warfare (SEW) Architecture/Engineering Support	04	6,952	5,263			5,263 U
93 0604786N	Offensive Anti-Surface Warfare Weapon Development	04	141,383	115,419			115,419 U
94 0303354N	ASW Systems Development - MIP	04	8,889	9,991			9,991 U
95 0304240M	Advanced Tactical Unmanned Aircraft System	04	17,554	45,407			45,407 U
96 0304240N	Advanced Tactical Unmanned Aircraft System	04	9,300				U
97 0304270N	Electronic Warfare Development - MIP	04	466	609			609 U
	Advanced Component Development & Prototypes		4,033,262	5,329,143		40,006	5,369,149
98 0603208N	Training System Aircraft	05	14,345	15,514			15,514 U

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84 0604272N	Tactical Air Directional Infrared Countermeasures (TADIRCM)	04	59,776				59,776	U
85 0604289M	Next Generation Logistics	04						U
86 0604292N	Future Vertical Lift (Maritime Strike)	04	5,097				5,097	U
87 0604320M	Rapid Technology Capability Prototype	04	3,664				3,664	U
88 0604454N	LX (R)	04	10,203				10,203	U
89 0604536N	Advanced Undersea Prototyping	04	115,858				115,858	U
90 0604636N	Counter Unmanned Aircraft Systems (C-UAS)	04	14,259				14,259	U
91 0604659N	Precision Strike Weapons Development Program	04	1,102,387				1,102,387	U
92 0604707N	Space and Electronic Warfare (SEW) Architecture/Engineering Support	04	7,657				7,657	U
93 0604786N	Offensive Anti-Surface Warfare Weapon Development	04	35,750				35,750	U
94 0303354N	ASW Systems Development - MIP	04	9,151				9,151	U
95 0304240M	Advanced Tactical Unmanned Aircraft System	04	22,589				22,589	U
96 0304240N	Advanced Tactical Unmanned Aircraft System	04						U
97 0304270N	Electronic Warfare Development - MIP	04	809				809	U
	Advanced Component Development & Prototypes		6,503,074		55,418	55,418	6,558,492	
98 0603208N	Training System Aircraft	05	4,332				4,332	U

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			(Base + OCO)	Base Enacted	Emergency	OCO Enacted	Total (Base+Emergency OCO)
99 0604212N	Other Helo Development	05	23,307	38,835			38,835 U
100 0604214M	AV-8B Aircraft - Eng Dev	05	45,639	27,441			27,441 U
101 0604215N	Standards Development	05	3,624	3,642			3,642 U
102 0604216N	Multi-Mission Helicopter Upgrade Development	05	16,178	19,196			19,196 U
103 0604218N	Air/Ocean Equipment Engineering	05	15,212				U
104 0604221N	P-3 Modernization Program	05	2,074				U
105 0604230N	Warfare Support System	05	9,401	8,601			8,601 U
106 0604231N	Tactical Command System	05	53,110	73,920			73,920 U
107 0604234N	Advanced Hawkeye	05	205,612	226,596			226,596 U
108 0604245M	H-1 Upgrades	05	53,083	60,991			60,991 U
109 0604261N	Acoustic Search Sensors	05	41,395	47,013			47,013 U
110 0604262N	V-22A	05	131,363	191,235			191,235 U
111 0604264N	Air Crew Systems Development	05	30,005	19,172			19,172 U
112 0604269N	EA-18	05	235,963	123,637			123,637 U
113 0604270N	Electronic Warfare Development	05	86,719	114,349			114,349 U
114 0604273M	Executive Helo Development	05	237,300	176,211			176,211 U
115 0604274N	Next Generation Jammer (NGJ)	05	426,729	491,884			491,884 U
116 0604280N	Joint Tactical Radio System - Navy (JTRS-Navy)	05	3,178	190,689			190,689 U
117 0604282N	Next Generation Jammer (NGJ) Increment II	05	91,216	90,922			90,922 U

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99 0604212N	Other Helo Development	05	18,133				18,133	U
100 0604214M	AV-8B Aircraft - Eng Dev	05	20,054				20,054	U
101 0604215N	Standards Development	05	4,237				4,237	U
102 0604216N	Multi-Mission Helicopter Upgrade Development	05	27,340				27,340	U
103 0604218N	Air/Ocean Equipment Engineering	05						U
104 0604221N	P-3 Modernization Program	05	606				606	U
105 0604230N	Warfare Support System	05	9,065				9,065	U
106 0604231N	Tactical Command System	05	97,968				97,968	U
107 0604234N	Advanced Hawkeye	05	309,373				309,373	U
108 0604245M	H-1 Upgrades	05	62,310				62,310	U
109 0604261N	Acoustic Search Sensors	05	47,182				47,182	U
110 0604262N	V-22A	05	132,624				132,624	U
111 0604264N	Air Crew Systems Development	05	21,445				21,445	U
112 0604269N	EA-18	05	106,134				106,134	U
113 0604270N	Electronic Warfare Development	05	134,194				134,194	U
114 0604273M	Executive Helo Development	05	99,321				99,321	U
115 0604274N	Next Generation Jammer (NGJ)	05	477,680				477,680	U
116 0604280N	Joint Tactical Radio System - Navy (JTRS-Navy)	05	232,818				232,818	U
117 0604282N	Next Generation Jammer (NGJ) Increment II	05	170,039				170,039	U

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			(Base + OCO)	Base Enacted	Emergency	OCO Enacted	Total Enacted S (Base+Emerg+ e OCO)
118 0604307N	Surface Combatant Combat System Engineering	05	367,189	375,681			375,681 U
119 0604311N	LPD-17 Class Systems Integration	05	902	640			640 U
120 0604329N	Small Diameter Bomb (SDB)	05	84,029	50,096			50,096 U
121 0604366N	Standard Missile Improvements	05	199,499	195,296			195,296 U
122 0604373N	Airborne MCM	05	8,024	10,916			10,916 U
123 0604378N	Naval Integrated Fire Control - Counter Air Systems Engineering	05	32,512	30,084			30,084 U
124 0604419N	Advanced Sensors Application Program (ASAP)	05					U
125 0604501N	Advanced Above Water Sensors	05	30,551	30,179			30,179 U
126 0604503N	SSN-688 and Trident Modernization	05	119,911	78,625			78,625 U
127 0604504N	Air Control	05	60,323	44,923			44,923 U
128 0604512N	Shipboard Aviation Systems	05	13,530	14,632			14,632 U
129 0604518N	Combat Information Center Conversion	05	18,626	16,094			16,094 U
130 0604522N	Air and Missile Defense Radar (AMDR) System	05	26,079	38,349			38,349 U
131 0604530N	Advanced Arresting Gear (AAG)	05	168,427	122,495			122,495 U
132 0604558N	New Design SSN	05	174,351	321,010			321,010 U
133 0604562N	Submarine Tactical Warfare System	05	77,529	62,426			62,426 U
134 0604567N	Ship Contract Design/ Live Fire T&E	05	69,337	46,809			46,809 U
135 0604574N	Navy Tactical Computer Resources	05	4,460	3,692			3,692 U

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118 0604307N	Surface Combatant Combat System Engineering	05	403,712				403,712	U
119 0604311N	LPD-17 Class Systems Integration	05	945				945	U
120 0604329N	Small Diameter Bomb (SDB)	05	62,488				62,488	U
121 0604366N	Standard Missile Improvements	05	386,225				386,225	U
122 0604373N	Airborne MCM	05	10,909				10,909	U
123 0604378N	Naval Integrated Fire Control - Counter Air Systems Engineering	05	44,548				44,548	U
124 0604419N	Advanced Sensors Application Program (ASAP)	05	13,673				13,673	U
125 0604501N	Advanced Above Water Sensors	05	87,809				87,809	U
126 0604503N	SSN-688 and Trident Modernization	05	93,097				93,097	U
127 0604504N	Air Control	05	38,863				38,863	U
128 0604512N	Shipboard Aviation Systems	05	9,593				9,593	U
129 0604518N	Combat Information Center Conversion	05	12,718				12,718	U
130 0604522N	Air and Missile Defense Radar (AMDR) System	05	78,319				78,319	U
131 0604530N	Advanced Arresting Gear (AAG)	05	65,834				65,834	U
132 0604558N	New Design SSN	05	259,443				259,443	U
133 0604562N	Submarine Tactical Warfare System	05	63,878				63,878	U
134 0604567N	Ship Contract Design/ Live Fire T&E	05	51,853				51,853	U
135 0604574N	Navy Tactical Computer Resources	05	3,853				3,853	U

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136 0604601N	Mine Development	05	22,105	56,464			56,464 U
137 0604610N	Lightweight Torpedo Development	05	62,448	109,349			109,349 U
138 0604654N	Joint Service Explosive Ordnance Development	05	6,829	8,237			8,237 U
139 0604657M	USMC Ground Combat/Supporting Arms Systems - Eng Dev	05		20,085			20,085 U
140 0604703N	Personnel, Training, Simulation, and Human Factors	05	6,287	5,500			5,500 U
141 0604727N	Joint Standoff Weapon Systems	05	424	16,225			16,225 U
142 0604755N	Ship Self Defense (Detect & Control)	05	175,129	178,603		1,122	179,725 U
143 0604756N	Ship Self Defense (Engage: Hard Kill)	05	185,971	115,130			115,130 U
144 0604757N	Ship Self Defense (Engage: Soft Kill/EW)	05	124,769	95,282			95,282 U
145 0604761N	Intelligence Engineering	05	25,965	45,610			45,610 U
146 0604771N	Medical Development	05	36,761	33,181			33,181 U
147 0604777N	Navigation/ID System	05	99,650	45,755			45,755 U
148 0604800M	Joint Strike Fighter (JSF) - EMD	05	64,692	1,710			1,710 U
149 0604800N	Joint Strike Fighter (JSF) - EMD	05	63,535	1,490			1,490 U
150 0604850N	SSN(X)	05					U
151 0605013M	Information Technology Development	05	12,545	1,494			1,494 U
152 0605013N	Information Technology Development	05	233,521	268,547			268,547 U
153 0605024N	Anti-Tamper Technology Support	05	6,049	4,882			4,882 U

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			Base	OCO for Base Requirements	Direct War and Enduring Costs	Total OCO	(Base + OCO)	c
136 0604601N	Mine Development	05	92,607				92,607	U
137 0604610N	Lightweight Torpedo Development	05	146,012				146,012	U
138 0604654N	Joint Service Explosive Ordnance Development	05	8,383				8,383	U
139 0604657M	USMC Ground Combat/Supporting Arms Systems - Eng Dev	05	33,784				33,784	U
140 0604703N	Personnel, Training, Simulation, and Human Factors	05	8,599				8,599	U
141 0604727N	Joint Standoff Weapon Systems	05	73,744				73,744	U
142 0604755N	Ship Self Defense (Detect & Control)	05	157,490		1,144	1,144	158,634	U
143 0604756N	Ship Self Defense (Engage: Hard Kill)	05	121,761				121,761	U
144 0604757N	Ship Self Defense (Engage: Soft Kill/EW)	05	89,373				89,373	U
145 0604761N	Intelligence Engineering	05	15,716				15,716	U
146 0604771N	Medical Development	05	2,120				2,120	U
147 0604777N	Navigation/ID System	05	50,180				50,180	U
148 0604800M	Joint Strike Fighter (JSF) - EMD	05	561				561	U
149 0604800N	Joint Strike Fighter (JSF) - EMD	05	250				250	U
150 0604850N	SSN(X)	05	1,000				1,000	U
151 0605013M	Information Technology Development	05	974				974	U
152 0605013N	Information Technology Development	05	356,173				356,173	U
153 0605024N	Anti-Tamper Technology Support	05	7,810				7,810	U

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154 0605212M	CH-53K RDTE	05	383,558	506,955			506,955 U
155 0605215N	Mission Planning	05	32,032	72,566			72,566 U
156 0605217N	Common Avionics	05	49,316	37,055			37,055 U
157 0605220N	Ship to Shore Connector (SSC)	05	1,425	19,909			19,909 U
158 0605327N	T-AO 205 Class	05	1,253	1,682			1,682 U
159 0605414N	Unmanned Carrier Aviation (UCA)	05	503,989	649,055			649,055 U
160 0605450M	Joint Air-to-Ground Missile (JAGM)	05	16,031	18,393			18,393 U
161 0605500N	Multi-mission Maritime Aircraft (MMA)	05	32,998	21,472			21,472 U
162 0605504N	Multi-Mission Maritime (MMA) Increment III	05	159,572	141,534			141,534 U
163 0605611M	Marine Corps Assault Vehicles System Development & Demonstration	05	64,311	50,137			50,137 U
164 0605813M	Joint Light Tactical Vehicle (JLTV) System Development & Demonstration	05		2,105			2,105 U
165 0204202N	DDG-1000	05	137,004	111,435			111,435 U
166 0303267N	Auctioned Spectrum Relocation Fund*	05	102,762				U
167 0303467N	SENSR Spectrum Pipeline SRF**	05	1,012				U
168 0303567N	Non-SENSR Spectrum Pipeline SRF***	05	2,000				U
169 0304785N	Tactical Cryptologic Systems	05	39,385	91,091			91,091 U
170 0306250M	Cyber Operations Technology Development	05	6,546	19,874			19,874 U
System Development & Demonstration			5,840,606	6,112,602		1,122	6,113,724

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			Base	OCO for Base Requirements	OCO for Direct War and Enduring Costs	Total OCO	(Base + OCO)	e
154 0605212M	CH-53K RDTE	05	406,406				406,406	U
155 0605215N	Mission Planning	05	86,134				86,134	U
156 0605217N	Common Avionics	05	54,540				54,540	U
157 0605220N	Ship to Shore Connector (SSC)	05	5,155				5,155	U
158 0605327N	T-AO 205 Class	05	5,148				5,148	U
159 0605414N	Unmanned Carrier Aviation (UCA)	05	266,970				266,970	U
160 0605450M	Joint Air-to-Ground Missile (JAGM)	05	12,713				12,713	U
161 0605500N	Multi-mission Maritime Aircraft (MMA)	05	24,424				24,424	U
162 0605504N	Multi-Mission Maritime (MMA) Increment III	05	182,870				182,870	U
163 0605611M	Marine Corps Assault Vehicles System Development & Demonstration	05	41,775				41,775	U
164 0605813M	Joint Light Tactical Vehicle (JLTV) System Development & Demonstration	05	2,541				2,541	U
165 0204202N	DDG-1000	05	208,448				208,448	U
166 0303267N	Auctioned Spectrum Relocation Fund	05						U
167 0303467N	SENSR Spectrum Pipeline SRF	05						U
168 0303567N	Non-SENSR Spectrum Pipeline SRF	05						U
169 0304785N	Tactical Cryptologic Systems	05	111,434				111,434	U
170 0306250M	Cyber Operations Technology Development	05	26,173				26,173	U
System Development & Demonstration			6,263,883		1,144	1,144	6,265,027	

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Program Line Element No Number	Item	Act	FY 2019	FY 2020	FY 2020	FY 2020	FY 2020
			(Base + OCO)	Base Enacted	Emergency	OCO Enacted	Total Enacted S (Base+Emerg+ OCO)
171 0604256N	Threat Simulator Development	06	91,921	62,678			62,678 U
172 0604258N	Target Systems Development	06	10,686	12,027			12,027 U
173 0604759N	Major T&E Investment	06	86,967	107,348			107,348 U
174 0605126N	Joint Theater Air and Missile Defense Organization	06	46				U
175 0605152N	Studies and Analysis Support - Navy	06	3,870	3,908			3,908 U
176 0605154N	Center for Naval Analyses	06	42,361	47,669			47,669 U
177 0605285N	Next Generation Fighter	06	4,981	7,100			7,100 U
178 0605502N	Small Business Innovative Research	06	433,656				U
179 0605804N	Technical Information Services	06	1,465	988			988 U
180 0605853N	Management, Technical & International Support	06	84,378	113,844			113,844 U
181 0605856N	Strategic Technical Support	06	4,068	3,742			3,742 U
182 0605861N	RDT&E Science and Technology Management	06	1,041				U
183 0605863N	RDT&E Ship and Aircraft Support	06	100,950	93,872			93,872 U
184 0605864N	Test and Evaluation Support	06	370,229	392,528	130,444		522,972 U
185 0605865N	Operational Test and Evaluation Capability	06	21,218	25,145			25,145 U
186 0605866N	Navy Space and Electronic Warfare (SEW) Support	06	16,032	12,652			12,652 U
187 0605867N	SEW Surveillance/Reconnaissance Support	06		8,402			8,402 U

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171 0604256N	Threat Simulator Development	06	22,075				22,075	U
172 0604258N	Target Systems Development	06	10,224				10,224	U
173 0604759N	Major T&E Investment	06	85,195				85,195	U
174 0605126N	Joint Theater Air and Missile Defense Organization	06						U
175 0605152N	Studies and Analysis Support - Navy	06	3,089				3,089	U
176 0605154N	Center for Naval Analyses	06	43,517				43,517	U
177 0605285N	Next Generation Fighter	06						U
178 0605502N	Small Business Innovative Research	06						U
179 0605804N	Technical Information Services	06	932				932	U
180 0605853N	Management, Technical & International Support	06	94,297				94,297	U
181 0605856N	Strategic Technical Support	06	3,813				3,813	U
182 0605861N	RDT&E Science and Technology Management	06						U
183 0605863N	RDT&E Ship and Aircraft Support	06	104,822				104,822	U
184 0605864N	Test and Evaluation Support	06	446,960				446,960	U
185 0605865N	Operational Test and Evaluation Capability	06	27,241				27,241	U
186 0605866N	Navy Space and Electronic Warfare (SEW) Support	06	15,787				15,787	U
187 0605867N	SEW Surveillance/Reconnaissance Support	06	8,559				8,559	U

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			(Base + OCO)	Base Enacted	Emergency	OCO Enacted	(Base+Emerg+ e OCO)	c
188 0605873M	Marine Corps Program Wide Support	06	21,158	34,734			34,734	U
189 0605898N	Management HQ - R&D	06	40,165	39,673			39,673	U
190 0606355N	Warfare Innovation Management	06	40,722	28,750			28,750	U
191 0606942M	Assessments and Evaluations Cyber Vulnerabilities	06	6,731					U
192 0606942N	Assessments and Evaluations Cyber Vulnerabilities	06	42,285					U
193 0305327N	Insider Threat	06	1,682	2,645			2,645	U
194 0902498N	Management Headquarters (Departmental Support Activities)	06	1,568	1,460			1,460	U
195 0909980N	Judgment Fund Reimbursement	06	49					U
196 0909999N	Financing for Cancelled Account Adjustments	06	759					U
197 1206867N	SEW Surveillance/Reconnaissance Support	06	8,676					U
Management Support			-----	-----	-----	-----	-----	-----
			1,437,664	999,165	130,444		1,129,609	
199 0604227N	HARPOON Modifications	07	5,016	2,302			2,302	U
200 0604840M	F-35 C2D2	07	222,644	391,165			391,165	U
201 0604840N	F-35 C2D2	07	215,366	354,960			354,960	U
202 0607658N	Cooperative Engagement Capability (CEC)	07	124,413	127,924			127,924	U
203 0607700N	Deployable Joint Command and Control	07	2,817					U
204 0101221N	Strategic Sub & Weapons System Support	07	145,670	125,766			125,766	U

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188 0605873M	Marine Corps Program Wide Support	06	42,749				42,749	U
189 0605898N	Management HQ - R&D	06	41,094				41,094	U
190 0606355N	Warfare Innovation Management	06	37,022				37,022	U
191 0606942M	Assessments and Evaluations Cyber Vulnerabilities	06						U
192 0606942N	Assessments and Evaluations Cyber Vulnerabilities	06						U
193 0305327N	Insider Threat	06	2,310				2,310	U
194 0902498N	Management Headquarters (Departmental Support Activities)	06	1,536				1,536	U
195 0909980N	Judgment Fund Reimbursement	06						U
196 0909999N	Financing for Cancelled Account Adjustments	06						U
197 1206867N	SEW Surveillance/Reconnaissance Support	06						U
Management Support			-----	-----	-----	-----	991,222	
199 0604227N	HARPOON Modifications	07	697				697	U
200 0604840M	F-35 C2D2	07	379,549				379,549	U
201 0604840N	F-35 C2D2	07	413,875				413,875	U
202 0607658N	Cooperative Engagement Capability (CEC)	07	143,667				143,667	U
203 0607700N	Deployable Joint Command and Control	07						U
204 0101221N	Strategic Sub & Weapons System Support	07	173,056				173,056	U

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			(Base + OCO)	Base Enacted	Emergency	OCO Enacted	Total Enacted S (Base+Emerg+ OCO)
205 0101224N	SSBN Security Technology Program	07	40,804	43,354			43,354 U
206 0101226N	Submarine Acoustic Warfare Development	07	11,102	6,815			6,815 U
207 0101402N	Navy Strategic Communications	07	37,184	28,674			28,674 U
208 0204136N	F/A-18 Squadrons	07	199,881	187,911			187,911 U
209 0204163N	Fleet Telecommunications (Tactical)	07	1,613				U
210 0204228N	Surface Support	07	9,328	34,602			34,602 U
211 0204229N	Tomahawk and Tomahawk Mission Planning Center (TMPC)	07	233,913	273,036			273,036 U
212 0204311N	Integrated Surveillance System	07	68,326	103,382			103,382 U
213 0204313N	Ship-Towed Array Surveillance Systems	07	15,250	14,449			14,449 U
214 0204413N	Amphibious Tactical Support Units (Displacement Craft)	07	4,840	6,931			6,931 U
215 0204460M	Ground/Air Task Oriented Radar (G/ATOR)	07	43,184	28,891			28,891 U
216 0204571N	Consolidated Training Systems Development	07	101,451	128,673			128,673 U
217 0204574N	Cryptologic Direct Support	07	4,244				U
218 0204575N	Electronic Warfare (EW) Readiness Support	07	64,264	71,143			71,143 U
219 0205601N	HARM Improvement	07	116,881	132,371			132,371 U
220 0205604N	Tactical Data Links	07	96,542				U

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205 0101224N	SSBN Security Technology Program	07	45,970				45,970	U
206 0101226N	Submarine Acoustic Warfare Development	07	69,190				69,190	U
207 0101402N	Navy Strategic Communications	07	42,277				42,277	U
208 0204136N	F/A-18 Squadrons	07	171,030				171,030	U
209 0204163N	Fleet Telecommunications (Tactical)	07						U
210 0204228N	Surface Support	07	33,482				33,482	U
211 0204229N	Tomahawk and Tomahawk Mission Planning Center (TMPC)	07	200,308				200,308	U
212 0204311N	Integrated Surveillance System	07	102,975				102,975	U
213 0204313N	Ship-Towed Array Surveillance Systems	07	10,873				10,873	U
214 0204413N	Amphibious Tactical Support Units (Displacement Craft)	07	1,713				1,713	U
215 0204460M	Ground/Air Task Oriented Radar (G/ATOR)	07	22,205				22,205	U
216 0204571N	Consolidated Training Systems Development	07	83,956				83,956	U
217 0204574N	Cryptologic Direct Support	07						U
218 0204575N	Electronic Warfare (EW) Readiness Support	07	56,791				56,791	U
219 0205601N	HARM Improvement	07	146,166				146,166	U
220 0205604N	Tactical Data Links	07						U

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			(Base + OCO)	Base Enacted	Emergency	OCO Enacted	Total Enacted S (Base+Emerg+ e OCO)
221 0205620N	Surface ASW Combat System Integration	07	25,478	29,572			29,572 U
222 0205632N	MK-48 ADCAP	07	66,934	72,265			72,265 U
223 0205633N	Aviation Improvements	07	130,986	125,461			125,461 U
224 0205675N	Operational Nuclear Power Systems	07	117,028	106,192			106,192 U
225 0206313M	Marine Corps Communications Systems	07	180,758	156,307		15,000	171,307 U
226 0206335M	Common Aviation Command and Control System (CAC2S)	07	4,628	4,489			4,489 U
227 0206623M	Marine Corps Ground Combat/ Supporting Arms Systems	07	95,319	51,788			51,788 U
228 0206624M	Marine Corps Combat Services Support	07	27,642	44,528			44,528 U
229 0206625M	USMC Intelligence/Electronic Warfare Systems (MIP)	07	37,821	27,886			27,886 U
230 0206629M	Amphibious Assault Vehicle	07	18,757	5,476			5,476 U
231 0207161N	Tactical AIM Missiles	07	36,444	19,488			19,488 U
232 0207163N	Advanced Medium Range Air-to-Air Missile (AMRAAM)	07	27,698	34,191			34,191 U
236 0303109N	Satellite Communications (SPACE)	07		34,344			34,344 U
237 0303138N	Consolidated Afloat Network Enterprise Services (CANES)	07	23,322	22,873			22,873 U
238 0303140N	Information Systems Security Program	07	43,348	44,853			44,853 U
239 0305192N	Military Intelligence Program (MIP) Activities	07	6,081	8,913			8,913 U
240 0305204N	Tactical Unmanned Aerial Vehicles	07	8,529	9,451			9,451 U

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221 0205620N	Surface ASW Combat System Integration	07	29,348				29,348	U
222 0205632N	MK-48 ADCAP	07	110,349				110,349	U
223 0205633N	Aviation Improvements	07	133,953				133,953	U
224 0205675N	Operational Nuclear Power Systems	07	110,313				110,313	U
225 0206313M	Marine Corps Communications Systems	07	207,662				207,662	U
226 0206335M	Common Aviation Command and Control System (CAC2S)	07	4,406				4,406	U
227 0206623M	Marine Corps Ground Combat/ Supporting Arms Systems	07	61,381				61,381	U
228 0206624M	Marine Corps Combat Services Support	07	10,421				10,421	U
229 0206625M	USMC Intelligence/Electronic Warfare Systems (MIP)	07	29,977		3,000	3,000	32,977	U
230 0206629M	Amphibious Assault Vehicle	07	6,469				6,469	U
231 0207161N	Tactical AIM Missiles	07	5,859				5,859	U
232 0207163N	Advanced Medium Range Air-to-Air Missile (AMRAAM)	07	44,323				44,323	U
236 0303109N	Satellite Communications (SPACE)	07	41,978				41,978	U
237 0303138N	Consolidated Afloat Network Enterprise Services (CANES)	07	29,684				29,684	U
238 0303140N	Information Systems Security Program	07	39,094				39,094	U
239 0305192N	Military Intelligence Program (MIP) Activities	07	6,154				6,154	U
240 0305204N	Tactical Unmanned Aerial Vehicles	07	7,108				7,108	U

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			(Base + OCO)	Base Enacted	Emergency	OCO Enacted	(Base+Emerg+ e OCO)	c
241 0305205N	UAS Integration and Interoperability	07	24,235	40,446			40,446	U
242 0305208M	Distributed Common Ground/Surface Systems	07	7,610	22,042			22,042	U
243 0305208N	Distributed Common Ground/Surface Systems	07	45,338					U
244 0305220N	MQ-4C Triton	07	13,395	11,784			11,784	U
245 0305231N	MQ-8 UAV	07	23,144	29,618			29,618	U
246 0305232M	RQ-11 UAV	07	524	509			509	U
247 0305234N	Small (Level 0) Tactical UAS (STUASL0)	07	5,265	9,410			9,410	U
248 0305239M	RQ-21A	07	6,000	10,914			10,914	U
249 0305241N	Multi-Intelligence Sensor Development	07	80,232	70,612			70,612	U
250 0305242M	Unmanned Aerial Systems (UAS) Payloads (MIP)	07	5,956	10,004			10,004	U
251 0305251N	Cyberspace Operations Forces and Force Support	07						U
252 0305421N	RQ-4 Modernization	07	218,366	185,446			185,446	U
253 0307577N	Intelligence Mission Data (IMD)	07						U
254 0308601N	Modeling and Simulation Support	07	6,824	12,119			12,119	U
255 0702207N	Depot Maintenance (Non-IF)	07	36,961	48,182			48,182	U
256 0708730N	Maritime Technology (MARITECH)	07	26,294	26,779			26,779	U

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241 0305205N	UAS Integration and Interoperability	07	62,098				62,098	U
242 0305208M	Distributed Common Ground/Surface Systems	07	21,500				21,500	U
243 0305208N	Distributed Common Ground/Surface Systems	07						U
244 0305220N	MQ-4C Triton	07	11,120				11,120	U
245 0305231N	MQ-8 UAV	07	28,968				28,968	U
246 0305232M	RQ-11 UAV	07	537				537	U
247 0305234N	Small (Level 0) Tactical UAS (STUASL0)	07	8,773				8,773	U
248 0305239M	RQ-21A	07	10,853				10,853	U
249 0305241N	Multi-Intelligence Sensor Development	07	60,413				60,413	U
250 0305242M	Unmanned Aerial Systems (UAS) Payloads (MIP)	07	5,000				5,000	U
251 0305251N	Cyberspace Operations Forces and Force Support	07	34,967				34,967	U
252 0305421N	RQ-4 Modernization	07	178,799				178,799	U
253 0307577N	Intelligence Mission Data (IMD)	07	2,120				2,120	U
254 0308601N	Modeling and Simulation Support	07	8,683				8,683	U
255 0702207N	Depot Maintenance (Non-IF)	07	45,168				45,168	U
256 0708730N	Maritime Technology (MARITECH)	07	6,697				6,697	U

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			(Base + OCO)	Base Enacted	Emergency	OCO Enacted	(Base+Emerg+ e OCO)	c
257 1203109N	Satellite Communications (SPACE)	07	32,059	15,868				15,868 U
9999 999999999	Classified Programs		1,783,585	1,742,227		108,282	1,850,509	U
	Operational Systems Development		4,931,294	5,096,386		123,282	5,219,668	
258 0608013N	Risk management Information - Software Pilot Program	08						U
259 0608231N	Maritime Tactical Command and Control (MTC2) - Software Pilot Program	08						U
	Software and Digital Technology Pilot Program							
Total Research, Development, Test & Eval, Navy			18,738,363	20,155,115	130,444	164,410	20,449,969	

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257 1203109N	Satellite Communications (SPACE)	07	70,056				70,056	U
9999 999999999	Classified Programs		1,795,032				1,795,032	U
	Operational Systems Development		5,327,043		3,000	3,000	5,330,043	
258 0608013N	Risk management Information - Software Pilot Program	08	14,300				14,300	U
259 0608231N	Maritime Tactical Command and Control (MTC2) - Software Pilot Program	08	10,868				10,868	U
	Software and Digital Technology Pilot Program		25,168				25,168	
Total Research, Development, Test & Eval, Navy			21,427,048		59,562	59,562	21,486,610	

*Funding in this Program Element was transferred during the year of execution from the Spectrum Relocation Fund (SRF) in support of the Advanced Wireless Services 3 (AWS-3) auction and is associated with the reallocation or sharing of the 1755-1780 MHz and 1695-1710 MHz bands. The SRF is administered by the Office of Management and Budget (OMB), which approves SRF transfers to federal agencies on an annual basis in consultation with the National Telecommunications and Information Administration (NTIA).

**Funding in this Program Element was transferred during the year of execution from the Spectrum Relocation Fund (SRF) in support of the Joint Spectrum Efficient National Surveillance Radar (SENSR) Pipeline Plan to determine the feasibility and impacts of the proposed spectrum reallocation of the 1300-1350 MHz band. The SRF is administered by the Office of Management and Budget (OMB), which approves SRF transfers to federal agencies on an annual basis in consultation with the National Telecommunications and Information Administration (NTIA).

***Funding in this Program Element was transferred during the year of execution from the Spectrum Relocation Fund (SRF) in support of the proposed reallocation of the 1300-1350 MHz band and adjacent bands. Funds in this Program Element are to be used for activities and costs associated with the study of systems or operations not included in the Joint Spectrum Efficient National Surveillance Radar (SENSR) Pipeline Plan. The SRF is administered by the Office of Management and Budget (OMB), which approves SRF transfers to federal agencies on an annual basis in consultation with the National Telecommunications and Information Administration (NTIA).

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy											Date: February 2020	
Appropriation/Budget Activity					R-1 Program Element (Number/Name)							
1319: Research, Development, Test & Evaluation, Navy / BA 1: Basic Research					PE 0601103N / University Research Initiatives							
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	0.000	155.539	167.850	116.816	-	116.816	119.141	121.595	124.040	126.521	Continuing	Continuing
0000: University Research Initiatives	0.000	114.993	116.850	116.816	-	116.816	119.141	121.595	124.040	126.521	Continuing	Continuing
9999: Congressional Adds	0.000	40.546	51.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	91.546

A. Mission Description and Budget Item Justification

The Office of Naval Research's (ONR) mission is to ensure the technological advantage of U.S. Naval forces. ONR fosters scientific research necessary for the discovery, development and delivery of new technologies. Often this research is done in partnership with academia. Multidisciplinary University Research Initiative (MURI) efforts involve teams of researchers investigating high priority topics and opportunities that intersect more than one traditional technical discipline. This program includes support for multidisciplinary basic research in a wide range of naval relevant scientific and engineering disciplines that enables the U.S. Navy to maintain technological superiority and for the university research infrastructure to acquire the research instrumentation needed to maintain and improve the quality of university research important to the Navy. For many military problems this multidisciplinary approach serves to stimulate innovation, accelerate research progress and expedite transition of results into Naval applications. The Defense University Research Instrumentation Program (DURIP) supports university research infrastructure essential to high quality, Navy-relevant research. The instrumentation program complements other Navy research programs by supporting the purchase of high cost research instrumentation that is necessary to carry out cutting-edge research. The program supports Presidential Early Career Awards for Scientists and Engineers (PECASE), single investigator research efforts performed by outstanding academic scientists and engineers early in their research careers. This program provides the knowledge base, scientific concepts, and technological advances for the maintenance of Naval power and national security. The Minerva Research Initiative is funded in partnership with the Office of the Secretary of Defense to support basic social science and multi-disciplinary research aimed at improving national security and international stability. The goals of this program are to enhance connections between DoD and academia and build cultural and foreign area knowledge on topics ranging from the mechanisms of radicalization to geopolitical power projection strategies in a multi-polar world.

Today's Sailors and Marines are enabled by naval Science and Technology (S&T). Since 1946, the Office of Naval Research (ONR) has fostered scientific research related to the maintenance of maritime superiority and national defense. ONR manages the Department of the Navy's (DON) portfolio of naval Basic and Applied research, and Advanced Technology Development investments to ensure naval forces can effectively deter conflict, but when called upon, fight, win and come home safe. Current investments hedge against uncertainty, providing solutions to commanders today, and options for the future. The Naval S&T budget supports higher guidance defined by the National Defense Strategy, and responds to requirements identified by the Secretary of the Navy through research priorities set by the Chief of Naval Research, coordinated across the Naval Research Enterprise (NRE), and outlined in the Naval R&D Framework.

This Program Element (PE) funds Basic Research and systematic study directed toward greater knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications towards processes or products in mind. The work in this PE can be classified between Technology Readiness Level (TRL) 1 (basic principles observed and reported) and TRL 2 (technology concept and/or application formulation).

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy				Date: February 2020
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1319: Research, Development, Test & Evaluation, Navy / BA 1: Basic Research		PE 0601103N / University Research Initiatives		
Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.				
B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO
Previous President's Budget	161.433	116.850	116.816	-
Current President's Budget	155.539	167.850	116.816	-
Total Adjustments	-5.894	51.000	0.000	-
• Congressional General Reductions	-	-		
• Congressional Directed Reductions	-	-		
• Congressional Rescissions	-	-		
• Congressional Adds	-	51.000		
• Congressional Directed Transfers	-	-		
• Reprogrammings	-	-		
• SBIR/STTR Transfer	-5.894	0.000		
• Rate/Misc Adjustments	0.000	0.000	0.000	-
				0.000
Congressional Add Details (\$ in Millions, and Includes General Reductions)	FY 2019	FY 2020		
Project: 9999: Congressional Adds				
Congressional Add: Defense University Research Instrumentation Program	9.654	10.000		
Congressional Add: Radar Technology	5.792	0.000		
Congressional Add: Biocoherent Energy	5.792	0.000		
Congressional Add: Basic Research	9.654	0.000		
Congressional Add: Aircraft Fleet Readiness and Sustainment	9.654	8.000		
Congressional Add: University research initiatives	0.000	20.000		
Congressional Add: Advanced digital radars	0.000	8.000		
Congressional Add: Multi-disciplinary university research	0.000	5.000		
	40.546	51.000		
	40.546	51.000		
Congressional Add Subtotals for Project: 9999				
Congressional Add Totals for all Projects				
	40.546	51.000		
Change Summary Explanation				
Funding: No significant change.				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020				
Appropriation/Budget Activity 1319 / 1					R-1 Program Element (Number/Name) PE 0601103N / University Research Initiatives				Project (Number/Name) 0000 / University Research Initiatives						
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost			
0000: University Research Initiatives	0.000	114.993	116.850	116.816	-	116.816	119.141	121.595	124.040	126.521	Continuing	Continuing			
A. Mission Description and Budget Item Justification															
<p>The Office of Naval Research's (ONR) mission is to ensure the technological advantage of U.S. Naval forces. ONR fosters scientific research necessary for the discovery, development and delivery of new technologies. Often this research is done in partnership with academia. Multidisciplinary University Research Initiative (MURI) efforts involve teams of researchers investigating high priority topics and opportunities that intersect more than one traditional technical discipline. This program includes support for multidisciplinary basic research in a wide range of naval relevant scientific and engineering disciplines that enables the U.S. Navy to maintain technological superiority and for the university research infrastructure to acquire the research instrumentation needed to maintain and improve the quality of university research important to the Navy. For many military problems, this multidisciplinary approach serves to stimulate innovation, accelerate research progress, and expedite transition of results into Naval applications. The DURIP project supports university research infrastructure essential to high quality, Navy-relevant research. The instrumentation project complements other Navy research programs by supporting the purchase of high cost research instrumentation that is necessary to carry out cutting-edge research. The PECASE project supports single-investigator research efforts performed by outstanding academic scientists and engineers early in their research careers. This project provides the knowledge base, scientific concepts, and technological advances for the maintenance of Naval power and national security.</p>															
B. Accomplishments/Planned Programs (\$ in Millions)											FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<p>Title: Defense University Research Instrumentation Program (DURIP)</p> <p>Description: DURIP funds are awarded to universities to purchase relatively high cost research instrumentation that is normally not included in single-investigator research grants. Individual grants range from \$50K to \$1.5M. Funding for DURIP efforts is awarded after the Office of the Secretary of Defense (OSD) selects and announces the awardees, which typically takes place towards the second half of the fiscal year. In turn, universities need to purchase the instrumentation and take delivery before any billing occurs. It frequently takes several months for delivery and billing to be completed. DURIP is a one-year program.</p> <p>FY 2020 Plans:</p> <p>Provide funding for instrumentation to enhance basic research, such as: human-machine interfaces, basic research on communications and networks, basic research on power generation and storage, basic research on high-performance materials, and basic research in the ocean sciences and underwater acoustics. Implement the instrumentation investments made for research efforts, such as: transmission electron microscopy, infrared optoelectronic measurements, an underwater acoustic communication system, basic thermal property</p>											23.374	23.266	23.272	0.000	23.272

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 1	R-1 Program Element (Number/Name) PE 0601103N / University Research Initiatives	Project (Number/Name) 0000 / University Research Initiatives				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
measurements, cardiorespiratory physiology phenotyping, and high-speed stereographic imaging for multiphase flows.						
FY 2021 Base Plans: - Research Instrumentation: Funding for instrumentation to enhance basic research through numerous focus areas including photonic diagnostics for the development of advanced materials, high fidelity laser profiling of biologically active sediments for seabed models, instrumentation for studies of high Reynolds Number non-equilibrium flows, a dynamic material testing system for characterizing, investigating and designing artificial muscle, and instrumentation for the development and characterization of solid propulsion, among many others.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant change from FY 2020 to FY 2021						
Title: Multidisciplinary University Research Initiative (MURI) Description: Research efforts include high priority topics that intersect more than one traditional discipline. MURI topics are selected to address Naval Science and Technology (S&T) Framework Priorities as described in the Naval Research and Development Framework. Funding for MURI efforts is awarded after Office of the Secretary of Defense (OSD) announces the awardees, which typically takes place towards the second half of the fiscal year. Since the MURI program funds academic researchers, execution of the efforts typically ramp up during the summer months. MURI projects make significant contributions to Navy and Department of Defense (DoD) objectives by speeding up scientific programs, by cross-fertilization of ideas, by hastening the transition of basic research to practical applications, and by training students in cross-disciplinary approaches to science and engineering research of importance to DoD. MURI projects are five-year programs.		83.363	84.823	81.827	0.000	81.827
FY 2020 Plans: The MURI program will support multidisciplinary basic research topics, such as: the role of epigenetics in human performance, research on understanding scenes and events through joint parsing, cognitive reasoning and lifelong learning, research on bio-inspired adaptive sonar for classification and guidance in complex environments, research on neural circuits underlying symbolic processing in primate cortex and basal ganglia, and research on chemistry and physics at extreme temperature and pressure: molecules, crystals and microstructures. These investigations support high						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 1	R-1 Program Element (Number/Name) PE 0601103N / University Research Initiatives	Project (Number/Name) 0000 / University Research Initiatives				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
priority topics and scientific opportunities to address strategically important Department of Defense (DoD) research areas that intersect more than one traditional technical discipline.						
FY 2021 Base Plans: - Multidisciplinary Research: Initiate multidisciplinary basic research efforts on the fundamental limits on information latency, advanced analytical and computational modeling of arctic sea ice, molecularly programmable graphene, identifying invariances for improved modeling and prediction of oceanographic phenomena, high performance organic electronics, bio-inspired models of distributed information processing, active perception and knowledge exploitation in navigation and spatial awareness, the advanced dynamics of coupled human/machine systems. - Fund previous years basic research efforts in other high priority topics for the Navy and DoD.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The funding decrease from FY 2020 to FY 2021 is due to funds being realigned from this R2 Activity to the new Minerva Research Initiative R2 Activity. Minerva Research Initiative efforts have been funded since 2010 and were previously included in the MURI R2 Activity of this PE. In an effort to increase visibility and improve tracking, funds have been realigned into the new R2 Activity.						
Title: Presidential Early Career Awards (PECASE) Description: PECASE awards are made to academic scientists early in their research careers for extremely prestigious, single-investigator research in areas of vital importance to the Navy. Awards provide national recognition and research grants of up to \$200K per year for five years. OSD, with policy and oversight responsibility for the PECASE program, awards a minimum of four new awards per year. PECASE is a five year program.		8.256	8.761	8.764	0.000	8.764
FY 2020 Plans: The program will support early career investigators in research areas within the Navy Research and Development (R&D) framework priority objectives, such as: the design of an end-to-end protocol for dynamic spectrum access networks; the determination of multiscale interactions in tropical cyclone structure and intensity changes; the engineering of nonreciprocal acoustic materials and microwave systems through phonon-assisted						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 1	R-1 Program Element (Number/Name) PE 0601103N / University Research Initiatives	Project (Number/Name) 0000 / University Research Initiatives				
<u>B. Accomplishments/Planned Programs (\$ in Millions)</u>		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
directional coupling; and the development of therapeutic hydrogel sensors for the monitoring and treatment of wounds, among others.						
FY 2021 Base Plans: - Fund new basic research projects in Naval priority areas including efficient information processing, layered chalcogenide heterointerfaces, information retrieval by exploiting the unique geometry of sparse arrays, and the prediction, design and control the assembly of hierarchically mesostructured materials. - Support previous year ongoing basic research projects performed by early career investigators.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant change from FY 2020 to FY 2021						
Title: Minerva Research Initiative (MRI) (Social Science Networking) Description: The Minerva Research Initiative is funded in partnership with the Office of the Secretary of Defense to support basic social science and multi-disciplinary research aimed at improving national security and international stability. The goals of this program are to enhance connections between DoD and academia and build cultural and foreign area knowledge on topics ranging from the mechanisms of radicalization to geopolitical power projection strategies in a multi-polar world.		0.000	0.000	2.953	0.000	2.953
FY 2020 Plans: N/A						
FY 2021 Base Plans: - Create and implement a theoretical framework to automate cyber vulnerability assessment and remediation for information operations in social contexts, for example, the injection of disinformation into social networks to influence the political attitudes or those exposed to it. Investigate models and methods for understanding online influence.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement:						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020
Appropriation/Budget Activity 1319 / 1	R-1 Program Element (Number/Name) PE 0601103N / University Research Initiatives		Project (Number/Name) 0000 / University Research Initiatives	
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base
The funding increase from FY 2020 to FY 2021 is due to funds being moved from the MURI R2 Activity to this new Minerva Research Initiative (MRI) R2 Activity. MRI efforts have been funded in the MURI R2 Activity of this PE since 2010. In an effort to increase visibility and improve tracking, funds have been realigned from the MURI R2 Activity into this new R2 Activity.				FY 2021 OCO
Accomplishments/Planned Programs Subtotals		114.993	116.850	116.816
C. Other Program Funding Summary (\$ in Millions)		0.000	116.816	
N/A				
Remarks				
D. Acquisition Strategy				
N/A				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity 1319 / 1					R-1 Program Element (Number/Name) PE 0601103N / University Research Initiatives					Project (Number/Name) 9999 / Congressional Adds			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
9999: Congressional Adds	0.000	40.546	51.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	91.546	
A. Mission Description and Budget Item Justification Congressional Interest Items not included in other Projects.													
B. Accomplishments/Planned Programs (\$ in Millions)											FY 2019	FY 2020	
Congressional Add: Defense University Research Instrumentation Program											9.654	10.000	
FY 2019 Accomplishments: This increase will provide additional Defense University Research Instrumentation Program (DURIP) awards to enable performers to take advantage of the evolving technological advances in scientific instrumentation to study the physical, chemical, biological, geological and geophysical processes of the oceans. The global ocean environment is the primary Navy-relevant operational environment and ocean research requires specialized sea-going marine equipment.													
FY 2020 Plans: Provide additional Defense University Research Instrumentation Program (DURIP) awards to enable performers to take advantage of the evolving technological advances in scientific instrumentation to study the physical, chemical, biological, geological and geophysical processes of the oceans.													
Congressional Add: Radar Technology											5.792	0.000	
FY 2019 Accomplishments: Conduct efforts for the design, construction and testing of a mobile, ground-based, active aperture array (active electronically scanned antenna - AESA) utilizing cutting-edge science and technology for critical aperture components (receiver and transmitter).													
FY 2020 Plans: N/A													
Congressional Add: Biocoherent Energy											5.792	0.000	
FY 2019 Accomplishments: Basic science research to identify mechanisms to enhance coherent energy transfer between photoactive molecules attached to nucleic acid nanostructures for application to synthetic light harvesting systems, optoelectronic devices, information processing systems, and possibly quantum computing. - AIM 1: Conduct and develop computational and experimental approaches to identify the best structures of photoactive molecules and their nucleic acid nanostructures that can efficiently transfer energy coherently.													

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy			Date: February 2020
Appropriation/Budget Activity 1319 / 1	R-1 Program Element (Number/Name) PE 0601103N / University Research Initiatives	Project (Number/Name) 9999 / Congressional Adds	
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020
- AIM2: Assemble the superior photoactive molecules into structures using nucleic acid self-assembly and assess performance.			
FY 2020 Plans: N/A			
Congressional Add: Basic Research		9.654	0.000
FY 2019 Accomplishments: This increase furthers the U. S. Navy's efforts to support multidisciplinary basic research in a wide range of scientific and engineering disciplines that enable the U.S. Navy to maintain its technological superiority. This increase will fund additional Multidisciplinary University Research Initiative (MURI) awards and Presidential Early Career Awards for Scientists and Engineers (PECASE). Additional new MURI topics will address the most critical Naval R&D priorities to translate future force attributes into research objectives. Additional outstanding young scientists and engineers will be funded under PECASE to address the continued need for scientists and engineers to address future Naval problems. These research objectives include improving human-machine interfaces, increasing the flexibility and reach of the naval force through the incorporation of autonomous systems, enabling maneuverability, efficiency and resiliency for sustained operations, transforming vast data into timely knowledge; and enabling offensive and defensive actions that are multi-domain, integrated, and cost-effective.			
FY 2020 Plans: N/A			
Congressional Add: Aircraft Fleet Readiness and Sustainment		9.654	8.000
FY 2019 Accomplishments: Basic research focus on advanced laboratory equipment and capabilities in support of Aviation Structures.			
FY 2020 Plans: Continue basic research for focus on advanced laboratory equipment and capabilities in support of Aviation Structures.			
Congressional Add: University research initiatives		0.000	20.000
FY 2019 Accomplishments: N/A			
FY 2020 Plans: Conduct University basic research initiatives			
Congressional Add: Advanced digital radars		0.000	8.000
FY 2019 Accomplishments: N/A			
FY 2020 Plans: Conduct basic research supporting Advanced digital radars.			
Congressional Add: Multi-disciplinary university research		0.000	5.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy			Date: February 2020
Appropriation/Budget Activity 1319 / 1	R-1 Program Element (Number/Name) PE 0601103N / University Research Initiatives	Project (Number/Name) 9999 / Congressional Adds	
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020
<i>FY 2019 Accomplishments:</i> N/A <i>FY 2020 Plans:</i> Conduct Multi-disciplinary university research.			
Congressional Adds Subtotals		40.546	51.000
C. Other Program Funding Summary (\$ in Millions)			
N/A			
Remarks			
D. Acquisition Strategy			
N/A			

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity					R-1 Program Element (Number/Name)								
1319: Research, Development, Test & Evaluation, Navy / BA 1: Basic Research					PE 0601152N / In-House Lab Independent Res								
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
Total Program Element	0.000	19.123	19.121	19.113	-	19.113	19.492	19.895	20.295	20.701	Continuing	Continuing	
0000: In-House Lab Independent Res	0.000	19.123	19.121	19.113	-	19.113	19.492	19.895	20.295	20.701	Continuing	Continuing	

A. Mission Description and Budget Item Justification

The Office of Naval Research's (ONR) mission is to ensure the technological advantage of U.S. Naval forces. ONR fosters scientific research necessary for the discovery, development and delivery of new technologies. Naval laboratories funded by ONR provide cutting-edge solutions and to Navy and national challenges. The In-house Laboratory Independent Research (ILIR) program provides opportunities to strengthen the Naval Science and Engineering (S&E) workforce capabilities through basic research conducted at the Naval Warfare Centers and Laboratories. These research efforts address high risk/high payoff warfighter science and technological needs, as well as attract the next generation of researchers to consider employment within the Department of the Navy. ILIR also provides opportunities for advanced degrees, technical publications, presentations, and patents. The Science and Engineering Apprenticeship Program (SEAP) and the Naval Research Enterprise Intern Program (NREIP) summer programs encourage students to pursue science and engineering careers, further their education via mentoring by laboratory personnel, and participate in research, which can lead to employment within the Department of the Navy.

Today's Sailors and Marines are enabled by naval Science and Technology (S&T). Since 1946, the Office of Naval Research (ONR) has fostered scientific research related to the maintenance of maritime superiority and national defense. ONR manages the Department of the Navy's (DON) portfolio of naval Basic and Applied research, and Advanced Technology Development investments to ensure naval forces can effectively deter conflict, but when called upon, fight, win and come home safe. Current investments hedge against uncertainty, providing solutions to commanders today, and options for the future. The Naval S&T budget supports higher guidance defined by the National Defense Strategy, and responds to requirements identified by the Secretary of the Navy through research priorities set by the Chief of Naval Research, coordinated across the Naval Research Enterprise (NRE), and outlined in the Naval R&D Framework.

This Program Element (PE) funds Basic Research and systematic study directed toward greater knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications towards processes or products in mind. The work in this PE can be classified between Technology Readiness Level (TRL) 1 (basic principles observed and reported) and TRL 2 (technology concept and/or application formulation).

Due to the number of efforts in PE 0601152N, the programs described herein are representative of the work included in this PE.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy					Date: February 2020
Appropriation/Budget Activity	R-1 Program Element (Number/Name)				
1319: <i>Research, Development, Test & Evaluation, Navy / BA 1: Basic Research</i>	PE 0601152N / <i>In-House Lab Independent Res</i>				
B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	19.237	19.121	19.113	-	19.113
Current President's Budget	19.123	19.121	19.113	-	19.113
Total Adjustments	-0.114	0.000	0.000	-	0.000
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.114	0.000			
• Rate/Misc Adjustments	0.000	0.000	0.000	-	0.000
Change Summary Explanation					
Funding: No significant change.					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020	
Appropriation/Budget Activity					R-1 Program Element (Number/Name)				Project (Number/Name)			
1319 / 1					PE 0601152N / In-House Lab Independent Res				0000 / In-House Lab Independent Res			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
0000: In-House Lab Independent Res	0.000	19.123	19.121	19.113	-	19.113	19.492	19.895	20.295	20.701	Continuing	Continuing

A. Mission Description and Budget Item Justification

The Office of Naval Research's (ONR) mission is to ensure the technological advantage of U.S. Naval forces. ONR fosters scientific research necessary for the discovery, development and delivery of new technologies. Naval laboratories funded by ONR provide cutting-edge solutions and to Navy and national challenges. The In-house Laboratory Independent Research program provides opportunities to strengthen the Naval Science and Engineering workforce capabilities through basic research conducted at the Naval Warfare Centers and Laboratories. These research efforts address high risk/high payoff warfighter science and technological needs, as well as attract the next generation of researchers to consider employment within the Department of the Navy. ILIR also provides opportunities for advanced degrees, technical publications, presentations, and patents. The Science and Engineering Apprenticeship Program (SEAP) and the Naval Research Enterprise Intern Program (NREIP) summer programs encourage students to pursue science and engineering careers, further their education via mentoring by laboratory personnel, and participate in research, which can lead to employment within the Department of the Navy.

This project sustains U.S. Naval S&T superiority, provides new technological concepts for the maintenance of naval power and national security, and mitigates scientific surprises, while exploiting scientific breakthroughs and providing options for new Future Naval Capabilities. It addresses the S&T research areas of the Naval Research and Development Framework for long term Navy and Marine Corps improvements. It is in consonance with future warfighting concepts and doctrine developed at the Naval Warfare Development Command and the Marine Corps Combat Development Command and enables technologies that significantly improve the Joint Chiefs of Staff's Future Joint Warfighting Capabilities.

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: In-House Laboratory Independent Research (ILIR) Description: The In-house Laboratory Independent Research program provides opportunities to strengthen the Naval Science and Engineering workforce capabilities through basic research conducted at the Naval Warfare Centers and Laboratories. These research efforts address high risk/high payoff warfighter science and technological needs, as well as attract the next generation of researchers to consider employment within the Department of the Navy. ILIR also provides opportunities for advanced degrees, technical publications, presentations, and patents.	16.590	16.588	16.580	0.000	16.580
FY 2020 Plans: Provide funding for ILIR program which enables laboratories to sponsor focused, high-risk/potential high reward basic research to the Navy and Marine Corps on a discretionary basis. Each project is funded for at most three years with the goal being to transition successful technologies to either a higher level of research or to a program					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 1	R-1 Program Element (Number/Name) PE 0601152N / In-House Lab Independent Res	Project (Number/Name) 0000 / In-House Lab Independent Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
of record. Approximately 120 projects will be funded all aligned with the Research and Development (R&D) framework focus areas.						
FY 2021 Base Plans: Further develop and maintain the Science and Engineering workforce by providing funding to Naval Warfare Centers and Laboratories to foster high risk/ high reward basic research initiatives of Naval interest. Each of the Naval sites will evaluate existing research projects and propose new topics. All efforts will be selected based on warfighter needs, researcher capabilities, and science and technology alignment.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant change between FY 2020 and FY 2021.						
Title: Science Technology Engineering and Math (STEM) Efforts at Navy Labs Description: This effort will support both the Science and Engineering Apprenticeship Program (SEAP) and the Naval Research Enterprise Intern Program (NREIP) summer programs to encourage participating students to pursue science and engineering careers, to further their education via mentoring by laboratory personnel and their participation in research, and to make them aware of Department of the Navy (DON) research and technology efforts, which can lead to employment within the DON. Participating students will spend eight to ten weeks during the summer doing research at approximately 19 to 20 DON laboratories.		2.533	2.533	2.533	0.000	2.533
FY 2020 Plans: Provide opportunities for approximately 300 high school students and 600 college students, both undergraduate and graduates, to participate in research at multiple Department of Navy Laboratories during the summer via the NREIP for undergraduate and graduate students and the SEAP for high school students. These paid internships last between 8-10 weeks.						
FY 2021 Base Plans: Provide opportunities for high school (SEAP) and college/ graduate students (NREIP) to participate in Navy and Marine Corps-relevant research at Naval Warfare Centers and Laboratories. Increase the number of participating sites, mentors, and interns from previous fiscal years. Distribute summary charts of each intern's						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020
Appropriation/Budget Activity 1319 / 1	R-1 Program Element (Number/Name) PE 0601152N / <i>In-House Lab Independent Res</i>	Project (Number/Name) 0000 / <i>In-House Lab Independent Res</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base
work and accomplishments to Naval sites and conduct return-on-investment analysis to improve participant impact and future retention.				
FY 2021 OCO Plans: N/A				
FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant change between FY 2020 and FY 2021.				
Accomplishments/Planned Programs Subtotals		19.123	19.121	19.113
		0.000	19.113	
C. Other Program Funding Summary (\$ in Millions)				
N/A				
Remarks				
D. Acquisition Strategy Not applicable.				

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy											Date: February 2020	
Appropriation/Budget Activity					R-1 Program Element (Number/Name)							
1319: Research, Development, Test & Evaluation, Navy / BA 1: Basic Research					PE 0601153N / Defense Research Sciences							
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	0.000	487.362	463.829	467.158	-	467.158	478.089	487.336	496.945	506.884	Continuing	Continuing
0000: Defense Research Sciences	0.000	448.266	458.329	467.158	-	467.158	478.089	487.336	496.945	506.884	Continuing	Continuing
9999: Congressional Adds	0.000	39.096	5.500	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	44.596

A. Mission Description and Budget Item Justification

The Office of Naval Research (ONR) was established by Congress in 1946 to plan, foster and encourage scientific research in recognition of its paramount importance to maintaining American naval power. This Program Element (PE) addresses DON's basic research needs to target and solve some of the Navy's and national most vexing challenges. Basic research is the seed corn for new ideas and lays the foundation for new innovative technologies and future naval capabilities. This PE's basic research efforts include scientific study and experimentation directed toward increasing knowledge and understanding of national security in the maritime domain and related aspects of physical, chemical, engineering, environmental and life sciences. Ultimately, basic research efforts lead to and support more advanced aspects of applied research in capability-related 'thrusts', which advance Navy and Marine Corps objectives in: Autonomous Systems; Artificial Intelligence and Machine Learning; Command, Control, Communications and Computers (C4); Information Analysis and Decision Support; Intelligence, Surveillance and Reconnaissance; Logistics; Materials; Operational Environments; Platforms; Power and Energy Technology; Sensors and Electronics; Warfighter Performance and Protection; Weapons; and Science, Technology, Education and Mathematics (STEM) education and outreach.

Decisive naval capability begins with Science and Technology (S&T) research. This PE ensures a robust portfolio of naval relevant S&T and enables new technological concepts to maintain maritime superiority. These investments are selected to meet research priorities set by the Chief of Naval Research and defined in the Naval Research and Development Framework, which support Navy and Marine Corps near to long-term requirements. Scientific breakthrough from this research become solutions to technical challenges via the Future Naval Capabilities (FNCs) pipeline, and new capability options for the future in the Innovative Naval Prototypes (INPs) portfolio.

Today's Sailors and Marines are enabled by naval Science and Technology (S&T). Since its inception, the Office of Naval Research (ONR) has fostered scientific research related to the maintenance of maritime superiority and national defense. ONR manages the Department of the Navy's (DON) portfolio of naval Basic and Applied research, and Advanced Technology Development investments to ensure naval forces can effectively deter conflict, but when called upon, fight, win and come home safe. Current investments hedge against uncertainty, providing solutions to commanders today, and options for the future. The Naval S&T budget supports higher guidance defined by the National Defense Strategy, and responds to requirements identified by the Secretary of the Navy through research priorities set by the Chief of Naval Research, coordinated across the Naval Research Enterprise (NRE), and outlined in the Naval R&D Framework. In addition, ONR's S&T investment portfolio supports National Naval Responsibilities (NNR) critical to the naval services where the Navy has historically taken the lead (ocean acoustics, undersea weapons, naval engineering, undersea medicine and sea-based aviation) to ensure decisive naval capability in the maritime domain.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy		Date: February 2020			
Appropriation/Budget Activity 1319: <i>Research, Development, Test & Evaluation, Navy / BA 1: Basic Research</i>	R-1 Program Element (Number/Name) PE 0601153N / <i>Defense Research Sciences</i>				
This Program Element (PE) funds Basic Research and systematic study directed toward greater knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications towards processes or products in mind. The work in this PE can be classified between Technology Readiness Level (TRL) 1 (basic principles observed and reported) and TRL 2 (technology concept and/or application formulation).					
Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.					
B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	499.102	470.007	472.158	-	472.158
Current President's Budget	487.362	463.829	467.158	-	467.158
Total Adjustments	-11.740	-6.178	-5.000	-	-5.000
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-11.678			
• Congressional Rescissions	-	-			
• Congressional Adds	-	5.500			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-11.740	0.000			
• Program Adjustments	0.000	0.000	-5.000	-	-5.000
• Rate/Misc Adjustments	0.000	0.000	0.000	-	0.000
Congressional Add Details (\$ in Millions, and Includes General Reductions)					
Project: 9999: Congressional Adds	FY 2019	FY 2020			
Congressional Add: <i>Basic Research</i>	33.787	0.000			
Congressional Add: <i>Navy ROTC Cybersecurity Training Program</i>	5.309	5.500			
Congressional Add Subtotals for Project: 9999					
Congressional Add Totals for all Projects					
	39.096	5.500			
	39.096	5.500			

Change Summary Explanation

Funding: The reduction in FY 2021 is due to completion of the Basic Research Challenge efforts and Young Investigator Program efforts, and due to the realignment of resources for basic research administered through ONR Global to higher priority Navy requirements.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity 1319 / 1					R-1 Program Element (Number/Name) PE 0601153N / Defense Research Sciences				Project (Number/Name) 0000 / Defense Research Sciences				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
0000: Defense Research Sciences	0.000	448.266	458.329	467.158	-	467.158	478.089	487.336	496.945	506.884	Continuing	Continuing	

A. Mission Description and Budget Item Justification

The Office of Naval Research (ONR) was established by Congress in 1946 to plan, foster and encourage scientific research in recognition of its paramount importance to maintaining American naval power. This Project addresses DON's basic research needs to target and solve some of the Navy's and national most vexing challenges. Basic research is the seed corn for new ideas and lays the foundation for new innovative technologies and future naval capabilities. This Project's basic research efforts include scientific study and experimentation directed toward increasing knowledge and understanding of national security in the maritime domain and related aspects of physical, chemical, engineering, environmental and life sciences.

Ultimately, basic research efforts lead to and support more advanced aspects of applied research in capability-related 'thrusts', which advance Navy and Marine Corps objectives in: Autonomous Systems; Artificial Intelligence and Machine Learning; Command, Control, Communications and Computers (C4); Information Analysis and Decision Support; Intelligence, Surveillance and Reconnaissance; Logistics; Materials; Operational Environments; Platforms; Power and Energy Technology; Sensors and Electronics; Warfighter Performance and Protection; Weapons; and Science, Technology, Education and Mathematics (STEM) education and outreach.

This Project sustains U.S. Naval Science and Technology (S&T) superiority, provides new technological concepts for the maintenance of naval power and national security, and helps avoid scientific surprise. These investments are based-on satisfying research priorities defined in the Naval Research and Development Framework. Scientific breakthroughs from this basic research provide solutions to technical challenges via the Future Naval Capabilities (FNCs) pipeline, and new capability options for the future force in the form of Innovative Naval Prototypes (INPs).

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<p>Title: Air, Ground and Sea Vehicles</p> <p>Description: Sailors and Marines operate air, ground and sea vehicles in some of the most extreme environments on the planet. Basic research advances the capacity of naval platforms operating under, on and above the seas, and to project power ashore. Ongoing research in the Air, Ground and Sea Vehicles activity will increase platform performance, reliability, improve human-machine teaming, reduce the cost of at-sea operations and enhance the effectiveness of distributed maritime operations.</p> <p>The efforts research focus include: surface and subsurface signatures; free-surface, subsurface, and propulsor hydromechanics; hull life assurance; advanced ship concepts; distributed intelligence for automated survivability; advanced electrical power systems; air vehicles; air platforms propulsion and power; air platforms survivability</p>	56.453	56.469	56.362	0.000	56.362

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 1	R-1 Program Element (Number/Name) PE 0601153N / Defense Research Sciences	Project (Number/Name) 0000 / Defense Research Sciences				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
and signature control; special aviation projects; environmental quality; logistics; power generation, energy conversion, and storage; and advancements in naval technology innovations.						
FY 2020 Plans: Air Vehicles Basic research investments include fixed-wing, rotary wing, and vertical/short takeoff and landing (V/STOL) aircraft, ship/aircraft dynamic interface, air vehicle management, and control, aerodynamics, and aeromechanics. Additional research investments include airframe structures and materials science address durability, service life, readiness, affordability, and future capabilities development. Most airframe challenges are not platform or design specific; they are fully represented in both current new-build and planned next-generation platform designs. Additional areas of research include metallic structures and materials, composite structures and materials, and advanced concepts related to: design, failure analysis, materials selection, fabrication, and sustainment of air-vehicle structures. Conducting university research supports rotorcraft technology areas such as tilt rotor aeromechanics, rotor flow field/ship air wake coupling during shipboard operations, flight simulation of advanced ducted fan air vehicles, active rotor control for enhanced shipboard operations, autonomous rotorcraft operations in shipboard environment, and innovative rotor design concepts for naval applications. Continuing Sea-Based Aviation National Naval Responsibility (NNR) research in Virtual Dynamic Interface (VDI), advanced manned/unmanned handling qualities and control for Naval operations, improved fixed wing launch and recovery high lift aerodynamics and performance, Enhanced fixed wing V/STOL operations, and autonomous deck operations. Continuing SBA Structures and Materials NNR research for advanced airframes in metallic structures, combined loading mechanics, lightweight advanced polymer and ceramic composites, inspection and repair of composite structures, material coatings and sealants, and advanced concepts in manufacturing and multifunctional structures. Science of Autonomy and Control of Unmanned Systems Conduct basic research related to critical multidisciplinary autonomy and unmanned systems challenges that cut across areas/domains, including air, sea, undersea and ground. This includes multi-disciplinary research into the science of autonomy and unmanned control and focuses on four interrelated areas: scalable and robust distributed collaboration among autonomous or unmanned systems; human/unmanned system collaboration; autonomous perception and intelligent decision-making; and intelligent architectures for autonomous systems. Science of Advanced Naval Power and Energy Systems Conduct basic research related to critical S&T to investigate efforts related to thermal science and engineering; power electronics/electro-magnetics; distribution and control of power; power management; and energy						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 1	R-1 Program Element (Number/Name) PE 0601153N / Defense Research Sciences	Project (Number/Name) 0000 / Defense Research Sciences				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
conversion, storage and generation. Pursue research in computer-aided material design; scarce materials mitigation strategies; electrochemical materials; and functional polymeric materials, leading to technological underpinnings for advanced energy capture and power storage and distribution.	Science of Advanced Naval Platform Performance Conduct basic research related to critical S&T to investigate efforts related to propulsor, surface, and subsurface hydrodynamics; platform dynamics and performance; alternative hull materials; structural acoustics; and submarine security. Expand research related to naval engineering, platform design, and multiple platform control, including COLUMBIA CLASS Program, SSN(X), unmanned surface vessels, and swarm boats efforts, and support to the centers for innovative naval technology.					
Sea Platform Survivability Science Conduct basic research related to critical S&T to investigate efforts related to platform structural reliability; acoustic and non-acoustic (electromagnetic) signatures; computational mechanics and signatures; metamaterials; and digital ship design and optimization, and improving the understanding of the generation, radiation, propagation, scatter, and detection of a variety of signal types (acoustic, chemical, optical, electromagnetic, hydrodynamic and radiological) associated with a submarine's operation.	Materials & Coatings Science Pursue research in identifying new nanostructured materials and coatings processing, ultimately for naval applications.					
Corrosion Control Science Conduct basic research related to critical S&T to investigate corrosion control technologies.	Ship and Air Platform Machinery and Systems Conduct basic research to advance the technical superiority of Sea-Based Aviation Science and Technology NNR in propulsion, power and thermal management related technologies with emphasis on propulsion cycles, subsystems, and integration, turbo machinery and drive systems, jet noise reduction, hot section materials and coatings, and small UAV propulsion. Conduct research to improve the power density, fuel efficiency, range and operating reliability of future large, medium and small engines. Continue studies to obtain a better fundamental understanding of the technologies involved with Rotating Detonation Engines and integration into platforms and weapon systems using thermodynamic models, Computational Fluid Dynamics and sub-scale experiments. Pursue research for better fundamental understanding of the underlying physics of jet noise production from					

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Appropriation/Budget Activity 1319 / 1	R-1 Program Element (Number/Name) PE 0601153N / Defense Research Sciences	Project (Number/Name) 0000 / Defense Research Sciences				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
	multi-stream, hot, supersonic jets, and control schemes through fundamental modeling of unsteady and turbulent flow fields and development of more accurate and efficient computational tools. Continue basic research to improve jet engine material durability and temperature and temperature rate capabilities in both benign and corrosive environments. Increase the technical maturity of lightweight ceramic heat exchangers for small engines with no new efforts identified.					
FY 2021 Base Plans: Sea-Based Aviation National Naval Responsibility (Formerly Air Vehicles) - Conduct research for Air Vehicle Science & Technology in aerodynamic interface, advanced manned/unmanned handling qualities and control for Naval operations, control law synthesis methods to improve aircraft launch and recovery, high lift aerodynamics and performance, advanced methods to achieve fixed wing efficiency with Vertical/Short Take-off and Landing (V/STOL) launch & recovery, and autonomous deck operations. - Conduct ongoing research in Aircraft Science & Technology efforts include: advanced analytical methods for achieving guaranteed performance in multibody control systems, advanced modeling and analysis methods for ship/aircraft aerodynamic interface, air vehicle flying qualities and control, and mechanical/environmental failure prediction research. Flight Dynamics & Control (Formerly Air Vehicles) Research will develop theory and analysis methods to better understand the phenomena and natural dynamics of air vehicles operating in the marine environment. Collaborative research will improve our knowledge of control system interactions between piloted aircraft and human performance. The Focus areas are: - Multibody control systems and the ability to demonstrate guaranteed performance relative to a desired end state; - Robust and precise control in the presence of highly turbulent flow fields; - Algorithms to enable precise ship-relative navigation in GPS-denied environments. Aerodynamics (Formerly Air Vehicles) Research will develop advanced computational methods addressing the Navy-unique challenges: - Fully coupled aerodynamic interface between ships and aircraft; - Advanced methods for reduced-order modeling of complex flow fields; - Advanced methods for manipulating more precisely the flow fields around air vehicles operating in the maritime environment.						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 1	R-1 Program Element (Number/Name) PE 0601153N / Defense Research Sciences	Project (Number/Name) 0000 / Defense Research Sciences				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Science of Autonomy and Control of Unmanned Systems Research related to critical multidisciplinary autonomy challenges that cut across areas/domains, including air, sea, undersea and ground. This includes multi-disciplinary research into the science of autonomy focuses on four interrelated areas: <ul style="list-style-type: none"> - Scalable and robust distributed collaboration among autonomous systems; - Human/unmanned system collaboration; - Perception-based adaptation across uncertain naval environments; - Embodied and situated intelligence and architectures. - Expand research on agile, theory-based tools and methods for safe, assured, robust, verifiable, and trustable autonomy. 	Air Platform Machinery and Systems(Formerly Ship and Air Platform Machinery Systems) <ul style="list-style-type: none"> - Conduct basic research to advance the technical superiority of Sea-Based Aviation Science and Technology in Propulsion, Power and Thermal management related technologies with emphasis on propulsion cycles, subsystems, and integration, turbo machinery and drive systems, and hot section materials and coatings. - Conduct basic research to improve the power density, fuel efficiency, speed, range and operating reliability of future large, medium and small engines. - To obtain a better fundamental understanding of the technologies involved with Rotating Detonation Engines and integration into platforms and weapon systems using thermodynamic models, Computational Fluid Dynamics and sub-scale experiments will continue studies in FY21. - Conduct basic research for high stage-loading and efficient turbomachinery including distortion tolerant fans, casing treatments and advanced methods in blade-disk aerodynamics; advanced cooling and thermal management for engines and auxiliary systems including new concepts of heat collection, distribution and rejection; advanced turbine engine materials and coatings; highly integrated propulsion inlets and exhausts and dust ingestion research: including modeling, separating, deposition, coatings and sensing. - To improve jet engine material durability and temperature rate capabilities in both benign and corrosive environments will continue its basic research in FY21. 					
Platform Design and Engineering (covers efforts previously called Science of Advanced Naval Platform Performance and Sea Platform Survivability Science) <ul style="list-style-type: none"> - Conduct basic research related to critical S&T to investigate efforts related to platform performance, platform autonomy and control, platform survivability and tactical submarine evolution plan (TSEP) S&T. 						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 1	R-1 Program Element (Number/Name) PE 0601153N / Defense Research Sciences	Project (Number/Name) 0000 / Defense Research Sciences				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
- Efforts for platform performance, autonomy and control include, but are not limited to, the following: understanding, predicting and controlling turbulent free-surface and stratified wakes leading to mitigation, tools to accurately predict platform maneuvering performance supporting future designs, current platform operational tactics, platform control and "digital twins" and developing reliability-based knowledge and tools to improve performance and affordability of ship hull structural systems from cradle to grave.						
- Efforts for platform survivability and TSEP S&T include, but are not limited to, the following: structural acoustic and propulsor source characterization, developing signature mitigation technologies, providing state of the art signature and detection range prediction tools that accurately model platforms to emerging threats and developing wideband, light-weight, affordable low observable materials.						
Power, Energy & Propulsion (covers efforts previously called Science of Advanced Naval Power and Energy)						
- Conduct basic research related to critical S&T to investigate efforts related to heat transfer and thermal management; power generation; energy storage; distribution and control; and motors and actuators.						
- Efforts include, but are not limited to, the following: wide band gap (WBG) materials growth for next generation power electronic devices, improving power density, efficiency and control authority of WBG SiC Power Electronic Building Blocks by increasing switching frequencies, developing multidisciplinary collaborative ship design tools and nanostructured heat transfer surfaces and materials for enhanced thermal transport.						
Sustainment and Logistics (covers efforts previously called Corrosion Control Science)						
- Conduct basic research related to critical S&T to investigate maintenance technology, manufacturing and repair, sustainment technologies and advanced logistics.						
- Efforts include, but are not limited to, the following: corrosion control, condition-based maintenance and prognostics, repair and component replacement technologies, replenishment at sea and decision support.						
Materials (covers efforts previously called Materials & Coatings Science and Science of Advanced Naval Power and Energy)						
- Pursue research in computer-aided material design; scarce materials mitigation strategies; electrochemical materials and functional polymeric materials, leading to technological underpinnings for advanced energy capture and power storage and distribution; structural materials for performance improvement and resiliency; identifying new nanoengineered materials and processing for naval applications.						
FY 2021 OCO Plans:						
N/A						
FY 2020 to FY 2021 Increase/Decrease Statement:						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 1	R-1 Program Element (Number/Name) PE 0601153N / Defense Research Sciences	Project (Number/Name) 0000 / Defense Research Sciences				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
There is no significant change from FY 2020 to FY 2021.						
Title: Atmosphere and Space Sciences		25.196	25.899	27.060	0.000	27.060
Description: Effective Naval operations depend upon accurately understanding the maritime operating environment and predicting its characteristics at high spatial and temporal resolution in areas that may be inaccessible. Understanding atmospheric phenomena and their impact on the electromagnetic spectrum from the sea surface to space provides a significant warfighting advantage. Efforts include: Marine Meteorology and Prediction and Space Sciences. These efforts support basic research on process studies, fundamental observations, data discovery, and modeling in the atmosphere and space with the goal of improving the ability to predict the battlespace environment anywhere on the globe. Emphasis is placed on the marine atmosphere, the tropics, polar regions, the ionosphere and other areas where new understanding is needed in order to overcome predictability barriers that limit the accuracy of current forecast models. Efforts are underway to understand the interactions of physics between the atmosphere, space, land, ocean and ice, represent these coupled processes in models, and extend them across scales from local to planetary, with the goal of extending the skill of predictions to seasonal and interannual timescales. Recent efforts have also focused on the processes that control tropical cyclone formation, structure and intensity changes and phenomena that affect electromagnetic and electro-optic propagation in the marine atmosphere. Research results provide the foundation for improved global and regional forecasts of the operational environment and for development of next-generation coupled prediction systems. Research areas evolve in response to priorities of the Oceanographer of the Navy.						
FY 2020 Plans: The overall objective of this research is to improve the quality of the atmospheric and space environmental products that are provided to the warfighter and to allow accurate assessment of the impact of space and atmospheric phenomena on the performance of weapon systems. These objectives require advancing our basic understanding of atmospheric and space processes ranging from the surface to space, including interactions of the atmosphere with the land, sea, waves, and ice.						
Battlespace Environments Navy operations in the littoral zone are affected by complex topography and air-sea-land contrasts and phenomena occurring on very short time and space scales. Research is supported to investigate key physical processes, clouds and moisture phenomena in order to improve their representation in models. Efforts are focused on those phenomena that affect the predictability of parameters of most relevance to Naval operations (e.g. coastal						

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Appropriation/Budget Activity 1319 / 1	R-1 Program Element (Number/Name) PE 0601153N / Defense Research Sciences	Project (Number/Name) 0000 / Defense Research Sciences				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
	meteology, surface winds, visibility, refractivity, etc.). New and non-conventional observational data sources are explored through efforts that develop novel data assimilation methodologies in order to realize the full potential of such observations. Systems are being employed which operate in or through the earth's upper troposphere, middle and upper atmosphere and the near space environment where environmental supports are crude or non-existent, thus, efforts are supported that seek to extend the range of prediction systems to much higher altitudes. Research is supported to improve understanding of the physics of the upper atmosphere and ionosphere, and to improve the representation of the interface between the troposphere and stratosphere because of its effects upon medium term weather prediction.					
Marine Meteorology and Prediction						
Research initiatives to improve the sub-grid scale parameterization of clouds, radiation and mixing in the marine boundary layer that developed several innovative new "scale-aware" parameterizations; transition these to applied research and directly into a new version of the Navy's global numerical weather prediction system (NAVGEN). This activity is scheduled to be completed in FY 2020. High-altitude airborne field experiments over major hurricanes during which an unprecedented set of high-resolution soundings covering the full depth of the storms were obtained allowed detailed physical processes to be observed for the first time. This activity is scheduled to be completed in FY 2020.						
Results from airborne observations over tropical cyclones will be analyzed and applied to new and existing models to make a substantial improvement in the skill for predicting intensity and structure change in tropical cyclones.						
Atmospheric process research will seek to advance our understanding of atmospheric and space processes ranging from the surface to space. This includes marine boundary layer physics, air-sea-wave-ice coupling, processes affecting electro-optic and electromagnetic propagation, and better representation of clouds and moisture in numerical weather prediction models. A new research initiative will be initiated to focus on the origin, evolution and effects of Arctic cyclones that are poorly predicted but are believed to have a strong influence on Arctic ice. Airborne observations over the Arctic from high-altitude research aircraft will be used to investigate processes from the stratosphere to the surface in order to improve their representation in numerical weather prediction models that can be coupled to the physics of the ocean and ice.						
Space Research						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 1	R-1 Program Element (Number/Name) PE 0601153N / Defense Research Sciences	Project (Number/Name) 0000 / Defense Research Sciences				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
	Perform best-in-class, experimentally-led sensing research and development (R&D) that is integrated across three environmental areas -- geospace, heliospace, and high-energy space -- which underpin, connect, and inform successful operations, with metrics to increase technology readiness towards rapidly prototyping solutions for accelerated delivery. Geospace research will attempt to overcome key scientific and computational impediments to a future physics-based Navy ionospheric prediction capability recently identified as a critical capability gap for high frequency (HF) radio-wave technologies for electromagnetic maneuver warfare, by means of focused scientific research on key drivers from the lower atmosphere and thermosphere that are necessary to achieve short term forecasts of HF propagation globally. Heliospace efforts may advance our understanding of solar magnetic fields and how they influence the near-earth environment. High-energy space development will assist in understanding particle acceleration mechanisms in high energy solar flares by studying gamma-ray and neutron emissions that are measured in space.					
Space Sciences						
	On-going investigation to assimilate observations into space weather models, with an eventual goal of a prediction system that could provide detection and warnings of tsunamis as a variety of observational systems will be utilized to increase the understanding of the physics of ionospheric irregularities and other space weather phenomena. Recent observations have shown that a number of phenomena, including tsunamis, can generate acoustic gravity waves that have an airglow signature in the thermosphere/ionosphere.					
FY 2021 Base Plans:						
Battlespace Environments						
- Develop the quality of the environmental products that are provided in support of war fighters and to more accurately assess the impact of the atmosphere on the performance of weapon systems, we must advance our basic understanding of atmospheric processes ranging from thousands of kilometers down to meters, including interactions of the atmosphere with the land, sea, wave, and ice.						
- Improve our ability to exploit environmental observations to help us characterize those processes more accurately. Navy operations are increasingly taking place in the littoral zone, where complex topography and air-sea-land contrasts affect the environment on very short time and space scales, as well as in the tropics and sub-tropics, where longer time scale oscillations and seasonal signals also affect short-term weather events. While today's numerical analysis and prediction systems are more capable of resolving and predicting highly variable phenomena than were the systems of 10-20 years ago, there are still processes that are not well understood, including, atmospheric clouds and moisture, that require further study to improve their representation in models.						

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Appropriation/Budget Activity 1319 / 1	R-1 Program Element (Number/Name) PE 0601153N / Defense Research Sciences	Project (Number/Name) 0000 / Defense Research Sciences				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
- Comprehend the distribution of aerosols in the atmosphere play an important role moisture formation as well as atmospheric visibility. A growing number of non-conventional observational data sources require new and novel data assimilation methodologies to be developed before their potential is fully realized. Systems are being employed which operate in or through the earth's upper troposphere, middle and upper atmosphere and the near space environment where environmental supports are crude or non-existent.	- Understand the measurements and predictive models are needed to mitigate these shortfalls.					
- Recognize the interface between the troposphere and stratosphere is gaining increased attention because of its possible effect upon medium term weather prediction. This is most convincingly seen in the influence of the jet stream on the trajectory of storm systems and air masses in the troposphere. Current analysis indicates that incorporation of correct physics at this boundary and assimilation of stratospheric data into numerical weather prediction models may be almost as important as the physical interaction with the ocean surface.						
Marine Meteorology and Prediction						
- Launch the Land-Air-Sea Interaction Closures research initiative to improve coupled nearshore atmospheric and oceanographic phenomena						
- Investigate key physical processes, clouds and moisture phenomena in order to improve their representation in models. Efforts will be focused on those phenomena that affect the predictability of parameters of highest relevance to Naval operations. New and non-conventional observational data sources will be explored and novel data assimilation methodologies will be developed and tested that will continue research in FY21.						
- Conduct deployment of observing systems in the upper troposphere, middle and upper atmosphere and the near-space environment to extend the range of prediction systems to much higher altitude.						
- Carry forward the research to improve medium range weather prediction through enhanced understanding of the physics of the upper atmosphere and ionosphere, and to improve the representation of the interface between the troposphere and stratosphere.						
- Move forward the research initiative to improve the understanding of processes that contribute to the poorly predicted rapid intensification of tropical cyclones (TCs) through major observing experiments.						
- Extend the analysis of high-altitude airborne field observations over major hurricanes (during which an unprecedented set of high-resolution soundings covering the full depth of the storms were obtained) allowed detailed physical processes to be observed for the first time.						
- The field and modeling initiatives that focus on the origin, evolution and effects of Arctic cyclones believed to have a strong influence on Arctic ice will continue in FY21.						
- Finished the predictability of Intra-Seasonal Tropical Oscillations (PISTON) research initiative and field studies of monsoonal phenomena in the northern Indian Ocean.						

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Appropriation/Budget Activity 1319 / 1	R-1 Program Element (Number/Name) PE 0601153N / Defense Research Sciences	Project (Number/Name) 0000 / Defense Research Sciences				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Space Research This program perform best-in-class, experimentally-led sensing research and development (R&D) that is integrated across three environmental areas -- geospace, heliospace, and high-energy space -- which underpin, connect, and inform successful operations, with metrics to increase technology readiness towards rapidly prototyping solutions for accelerated delivery. The following programs include: Geospace - To take away key scientific and computational impediments to a future physics-based Navy ionospheric prediction capability recently identified as a critical capability gap for high frequency (HF) radio-wave technologies for electromagnetic maneuver warfare, by means of focused scientific research on identification of which key drivers from the lower atmosphere and thermosphere are necessary to achieve short term forecasts of HF propagation globally. Heliospace - Launch efforts to advance the understanding for the solar magnetic fields and how it influence the near-earth environment. High-Energy Space - Launch efforts to understand particle acceleration mechanisms in high energy solar flares by studying gamma-ray and neutron emissions that are measured in space.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The increase from FY 2020 to FY 2021 is due to increase emphasis and investment in Heliospace and High-Energy Space focused basic research.						
Title: Science Addressing Hybrid Threats Description: Naval expeditionary forces increasingly face the specter of hybrid adversaries using conventional weapons combined with terror, crime, cyber, information operations, etc. A hybrid adversary is flexible and adapts quickly to synchronize advanced state weapons systems, disruptive commercial technologies, cheap expedient homemade weapons, and a variety of novel tactics. The Sciences Addressing Hybrid Threats (SAHT) (formerly Counter Improvised Explosive Device (IED)) activity seeks to establish and nurture science to counter these growing challenges, while collaborating with and leveraging results from more traditional naval research portfolios.	23.194	25.823	24.290	0.000	24.290	

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Appropriation/Budget Activity 1319 / 1	R-1 Program Element (Number/Name) PE 0601153N / Defense Research Sciences	Project (Number/Name) 0000 / Defense Research Sciences				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
The SAHT Sciences program provides research for Naval Forces to fight hybrid threats, and adversaries in expeditionary operations. Naval Expeditionary Forces need science advances to address a range of Basic Research challenges that result from physical and operational environmental limitations so harsh that solutions push basic discovery and invention. Naval Forces able to operate amphibiously and in the littoral will have all of their capabilities exposed to degrading sea and land physical effects. Expeditionary forces operating austere must be agile and lethal but will be constrained by size, weight, and power requirements and must be sustained across distributed forces covering large areas.	Complicating the problem context further is the nature of hybrid threats, and adversaries. A hybrid adversary can be state or non-state using a combination of conventional and irregular methods and weapons. For example a hybrid threat could use criminal acts in concert with conventional artillery and IEDs and in turn social media for combined effects greater and broader than the sum of the parts. These coordinated multivariate threats occur across the spectrum of conflict with a dynamic but unified strategy. A hybrid adversary is flexible and adapts quickly, synchronizing advanced state weapons systems, disruptive commercial technologies, cheap expedient homemade weapons, and a variety of tactics. The Sciences Addressing Hybrid Threats program seeks to establish and nurture science to address these threats not covered in more conventional warfare science efforts and in environments not researched elsewhere.					
The efforts research focus include: physics addressing the electromagnetic spectrum for use in Command and Control and high energy physics addressing Directed Energy Weapons; machine perception, reasoning and collaborative behaviors of autonomy enabling numerous potential expeditionary autonomous systems; artificial intelligence enabling future Intelligence systems; optics, electronics, and photonics research to enable revolutionary spectral awareness in small low power sensors; computer and network science to enable expeditionary computing coupled with Data Science research to conduct data analysis; fundamental chemistry and materials science research to advance technologies to support sustainment; basic materials research to explore and improve armor and structural materials; electrochemical energy conversion and storage research to sustain the force; chemistry and physics to provide disruptive energetics for expeditionary Fires; and biology, physiology, and cognitive sciences addressing the Naval Expeditionary warfighters human abilities.	FY 2020 Plans: Conduct work in hazard defeat to understand new concepts, techniques and methods, for the design, growth, and characterization of electronic, electro-optic, and bio sensors to counter hybrid explosive hazards threats, immersive sciences for automated methods for generating content and/or behaviors for use augmented and mixed reality technologies, and neuromorphic computing and novel opto-electronic technologies. End perovskite					

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
chemistry based solar cell efforts. Initiate efforts in understanding multifunction machine learning and artificial intelligence systems operating in realistic electromagnetic threat environments.						
Evaluate and quantify the changes in electrical signaling, resulting from strain on the neuronal cells subjected to shock and blast waves. The study is critical to define and understand blast and impact injuries at the cellular level resulting in mild or severe traumatic brain injury. Studies on hearing loss from repeated exposure to high levels of acoustic waves created by high performance jet engines operating on ocean platforms. Understanding of fundamental changes on IR optical standoff and point detection of improvised explosives, chemical warfare agents and toxic industrial chemicals. Develop and demonstrate a predictive framework of IR spectral signatures based on the fundamental optical properties of materials. Earlier studies on related topics have provided design and fabrication of protection garments from IED explosives and advanced design concepts for helmets to significantly reduce neuronal damage caused by shock and blast waves. Novel biomaterials that enable epidermal electronics for warfighter protection to light weight distributed chemical sensors.						
FY 2021 Base Plans: <ul style="list-style-type: none">- Conduct high specificity standoff detection efforts to provide high probability detection and classification of explosive components in support of hazard defeat to counter continuously evolving explosive threats.- Extend exploring concepts, techniques and methods, for the design, growth, and characterization of electronic and electro-optic sensors to counter improvised explosive devices (IEDs).- Carry-Forward the artificial intelligence / machine learning investigation of multifactorial information environment parameters in order to automate the process of detecting, identifying and distinguishing intent. Conduct discovery research on multi-class, multi-objective deep reinforced learning algorithms with automated training.- Carry-on the investigation of ultra-wideband compact hybrid analog and digital computational devices and algorithms that can adapt to dynamic information and electromagnetic threat environments. Utilizing existing knowledge of emergent behavior in distributed robotic systems as a foundation, conduct discovery research and develop theories for creating swarming behavior in heterogeneous multi-domain autonomous systems.- Launch the research and develop theories to predict adversarial behavior in autonomy-enabled battle spaces.- Conduct researching novel energetic materials that provide order of magnitude increases over current conventional energetics in reactive, explosive, and propulsive phenomena including high-energy ingredient synthesis, modeling, characterization, and the fundamentals of initiation mechanisms for these materials.- The research in materials, chemistry and physics, emphasizing phenomena that demonstrate non-linear behavior for naval applications will continue to expand in FY21.						

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B. Accomplishments/Planned Programs (\$ in Millions)					
FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	
- Conduct research to explore new, rugged, low cost, and high specific power sources, including solar cell technologies, including investigation into the stability of the solar cells.					
FY 2021 OCO Plans: N/A					
FY 2020 to FY 2021 Increase/Decrease Statement: The decrease from FY 2020 to FY 2021 is due to reduced basic research investment in materials and designs for blast resistant garments and helmet design.					
Title: Human Systems Description: Naval forces operate under, on and above the seas. Coordinating multi-domain operations are inherently complex. Improving human-machine effectiveness, teaming and rapid decision-making in a distributed maritime environment is essential to respond within the time constraints of an AI-dominant future. Human Systems research contributes to solutions and technologies that resolve complexity and respond rapidly to new threats beyond human speed. The efforts research focus include: Research on attention and decision making in human and human-machine teaming tasks related to Naval missions, including command decision making, cognitive systems for human-machine teaming, computational neuroscience, human interactions with autonomous systems, attention and sensory processing, social cultural and behavioral modeling, and social network and computational social sciences.	16.114	18.563	18.863	0.000	18.863
FY 2020 Plans: Command Decision Making Develop approaches for proactive decision support for Naval command and control tasks, with an emphasis on supervised machine learning of expert planning and dynamic re-planning.					
Human-Machine Teaming Develop empirical and computational models of cognition and create algorithms and architectures that aspire to human-level intelligence or ability. The algorithms and cognitive models serve to: (i) Advance the understanding of human cognition; (ii) Enable systems to recognize, understand, predict, perform, assist, and evaluate human					

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
behavior; and (iii) Improve the effectiveness of intelligent systems, human users/operators, and hybrid human-machine teams in Naval operations.						
Neurosciences and Human Interaction With Autonomous Systems						
Develop neuroscience principles to identify neural circuits, architectures, and algorithms that can be emulated to develop novel sensing, control, pattern recognition, neuromorphic processors, and intelligent systems. Conduct research on neural mechanisms of memory consolidation, working memory, and retrieval to enable intelligent systems with human-like associative memory skills.						
Attention In Sensory Processing						
Develop mechanisms of attention, including its role in skilled perceptual and cognitive performance. Understand attention to task-relevance as a factor in personnel selection and training. Incorporate mechanisms of attention into machine learning.						
Social, Cultural, and Behavioral Modeling						
Develop computationally-efficient methods to model human behavior and social network analytics. Efforts include modeling information and cyber warfare, as well future sensor and weapon developments and their impact on Warfighter performance. Use machine learning to create synthetic decision makers.						
Social Networks and Computational Social Science						
Develop methods and tools pertaining to social media network analysis, including problems of monitoring social media, social hysteria propagation, and group polarization to support methods for information environment assessment, humanitarian assistance, and disaster response.						
FY 2021 Base Plans:						
Command Decision Making						
- Conduct research to explore Command and Control (C2) human-machine collaboration and management of algorithms that adapt using machine learning (ML).						
- Utilize machine learning algorithms for analysis and forecasting of "what if" scenarios across the human capital enterprise.						

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Cognitive Science for Human-Machine Teaming						
- Explore previously developed computational models that act as surrogates, teammates, trainers, and assistants to human warfighters.						
- Conduct research on empirical and computational models of cognition and create algorithms and architectures that can be embedded into autonomous systems to provide higher-level intelligence and ability.						
- Explore natural communication between humans and machines in Naval domains, including natural language dialogue for intuitive interfaces that lower cognitive load.						
Computational Neuroscience						
(This thrust was previously part of the Neurosciences and Human Interaction With Autonomous Systems FY20 Plan)						
- Conduct research to identify neural circuits, architectures, and algorithms that can be emulated to develop novel sensing, control, pattern recognition, neuromorphic processors, and intelligent systems.						
- Explore neural network dynamics and build large-scale models of cerebral cortex.						
- Conduct discovery research on neural mechanisms of memory processes.						
- Explore neural models of sensorimotor control and spatial navigation.						
Human Interaction with Autonomous Systems						
(This thrust was previously part of the Neurosciences and Human Interaction with Autonomous Systems FY20 Plan)						
- Explore warfighter collaboration with autonomous and mission-capable robotic systems.						
- Explore approaches for training robots to perform complex manipulation skills using machine learning and human demonstration.						
- Conduct research to begin developing models of effective collaboration between humans and intelligent machines on complex tasks.						
Attention in Sensory Processing						
- Conduct research to create and validate measures of the role of attention in the performance of complex military tasks.						
- Investigate novel, brain-based, approaches to computer vision that incorporate top-down attentional processing to facilitate input interpretation.						
- Develop novel, neurally inspired, techniques exploiting attentional mechanisms to facilitate recognition of sound sources in highly-cluttered acoustic environments.						

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Social, Cultural, and Behavioral Modeling - Conduct research to improve computational efficiency and effectiveness in modeling human behavior, information and cyber warfare. - Discover improved information warfare models, sensors and associated metrics of conflict and competition for estimating warfighter performance. - Develop models of decision-making and strategy needed to develop synthetic decision makers. - Investigate machine learning and artificial intelligence techniques for effective information environment exploitation.						
Social Networks and Computational Social Science - Conduct research to develop algorithms, methods and tools for analysis of social hysteria propagation and group polarization; improve methods of information environment assessment and strategic communication. - Refine detection of adversarial information maneuvers across social media platforms. - Conduct research to develop information environment assessment capabilities for humanitarian assistance and disaster response.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant change from FY 2020 to FY 2021.						
Title: Mathematics, Computer, and Information Sciences Description: Basic research efforts directed toward increasing knowledge and understanding in mathematical foundation and computational theory and tools for design, communication, and control, with emphasis on intelligent autonomous system. The purpose is to sustain U.S. Naval Science and Technology (S&T) superiority, provide new technological concepts for the maintenance of naval power and national security, and help avoid scientific surprise. Advancements in computing capacity/speed, algorithms and data science is foundational to a more interoperable, synchronized and distributed naval force. The pace and complexity of modern naval operations requires rapid access to secure, accurate information. Efforts include: Mathematical foundation and computational theory and tools for design, communication, and control of intelligent autonomous systems; theory, algorithms and tools for decision support; decision theory, algorithms, and tools; heterogeneous information integration, management, and presentation; information	44.836	50.354	60.046	0.000	60.046	

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	<p>assurance, computation and information foundation for cyber defense, secure and reliable information infrastructure for command and control; mathematical optimization for optimal resource allocation and usage; modeling and computation of complex physical phenomena; modeling and computation for electromagnetic and acoustic wave propagation and scattering; seamless, robust connectivity and networking; foundations for novel computing hardware, including nanoscale materials, emerging devices and circuits, emerging computational architecture and nanofabrication.</p> <p>The Science of Artificial Intelligence Program focuses on discovery research to extend state-of-the-science in artificial intelligence for the unique challenges of the Naval domain. These challenges include operations in spatially and temporally variable and uncertain environments with limited communications.</p> <p>FY 2020 Plans: Communications and Networking</p> <p>Conduct basic research in antenna technology to include electrically small antennas, wideband multifunction antennas, compatibility of phased array antennas with naval platforms and marine environments, directional beam forming/steering techniques, and special-purpose submarine communication antenna systems; radio communications to include anti-jam and low-probability-of-intercept techniques, satellite communications (SATCOM) performance enhancements, interference mitigation, adaptive equalization, bandwidth efficient modulation, cognitive radio for dynamic spectrum management, and high data rate tactical communications techniques including communications at speed and depth (for submarines); and wireless networks to include mobile ad-hoc wireless networking algorithms/protocols, end-to-end Quality-of-Service, joint/coalition interoperability, service oriented tactical networking, mission-based policy and network controls and management.</p> <p>Quantum Information Sciences</p> <p>Conduct basic research of quantum key distribution (QKD) protocols and implementations for the purpose of understanding the security implications for QKD in the maritime environment, the development of protocols that simultaneously minimize leakage of information to the environment and the creation of secure networks, as well as schemes to maximize the information carried by a continuous or discrete variable; and research of algorithms for naval functions such as routing, weapon-target pairing, etc., a key application such as radar cross section calculation.</p>					

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Nanoscale Computing Devices and Systems						
Develop novel techniques for synthesis, assembly and characterization of molecular scale (sub-10 nanometers) nanographene structures for their electronic, optical, magnetic and quantum functionalities. Research, assess, test and develop alternative computing architectures (beyond von-Neumann), including but not limited to, various implementations of neuromorphic architectures and quantum information systems.						
Mathematical Data Science						
Conduct basic research in mathematics, probability, statistics, signal processing, machine learning, data engineering, and information theory. The program aims to develop rigorous mathematical and algorithmic answers to questions that are currently addressed using heuristics or non-principled approaches. Focus is on problems in learning and inference from both big and small data, representation of data, modeling dynamical properties of and determining causal effects in complex networks, multi-modal, multi-scale information integration, and decision making under uncertainty.						
Machine Learning, Reasoning and Intelligence						
Conduct basic research in the area of building intelligent agents that can function in the environments in which warfighters operate, that is, environments that are unstructured, open, complex and dynamically changing. Agents (cyber or physical) do not yet have the level of intelligence needed to operate in such open, uncertain and unpredictable environments either independently or alongside warfighters. In the area of Intelligence for Autonomous Agents, basic research includes the development of principles for machine intelligence, efficient computational methods, algorithms and tools for building versatile smart agents that can perform missions autonomously with minimal human supervision and collaborate seamlessly with teams of warfighters and other agents. In the area of Image Understanding, basic research includes the development of theory and algorithms for understanding surveillance imagery, for semantic search of visual datasets, and for autonomous agent perception. The main focus is on reconstructing 3D scenes, recognizing object classes and specific objects, recognizing activities and events, inferring intentions, as well as succinct natural language descriptions of images and video.						
Applied and Computational Analysis Program						

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Conduct basic research in modern and classical mathematical analysis with emphasis on mathematical and computational models of physical phenomena. Naval interest in waves, flows, materials, structures, and information processing motivates research in the areas of multi-phase, multi-physics, including analytically rigorous and computationally robust and efficient modeling of fatigue, fracture, dislocation, nucleation, shocks and contact lines; dynamical systems, and oceanic and atmospheric modeling, including fluid transport, mixing, and predictability of models for nonlinear dynamics; and inverse problems arising from acoustic and electromagnetic wave propagation and scattering.	Cyber Security and Complex Software Systems					
Conduct basic research in computing systems and complex software systems that meet required assurances for security, safety, reliability and performance to measurably improve the information-processing challenges of future naval systems. Cyber Security sub-program investigates and develops wide-ranging principles and techniques for continuously maintaining confidentiality, integrity, and availability of information and information infrastructures, focusing on the software, the hardware and the network. The program seeks to establish an autonomic, secure and dependable informational infrastructure toward achieving Information Dominance. Complex Software sub-program investigates principles, algorithms and methods, and develops software engineering tools for achieving efficient, timely, robust and secure software executables, focusing on science for software construction, correctness and efficiency by revisiting software development and deployment methodology. Efficient, timely, robust and secure software is a requirement for secure information infrastructure toward achieving Information Dominance.	Networked Sensing					
Conduct basic research in optical components and infrared technologies including lasers and focal plane arrays using narrow bandgap semiconductors for the purpose of imaging through clouds, fog, haze and dust; persistent surveillance for severely size constrained airborne applications; detecting anomalies and targets; and autonomous sensing for Unmanned Autonomous Vehicle (UAV) platforms and networked sensing over multiple sensors and/or sensor platforms.	Mathematical Optimization and Operations Research					
The primary focus of the Mathematical Optimization program is the development of new, cutting-edge theory and algorithms for most efficiently solving problems in linear, nonlinear, integer, and combinatorial						

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
optimization. Theoretical development, algorithmic design and analysis, computational methods, and software prototypes for large-scale problems are of interest. This directive includes, but is not limited to, cutting plane and polyhedral techniques for mixed-integer programming, decomposition approaches for large (non)convex problems, and interior-point and first-order algorithms for conic/convex optimization. Advances that produce provably optimal or near-optimal solutions, as well as those applicable to large problem domains are favored. Innovative strategies for dealing with uncertainty from stochastic optimization, robust optimization, and simulation-based optimization are of growing interest. Research supported by this program is expected to make fundamental contributions to the areas of mathematical optimization and operations research.						
Information Technology: To address the continued need for improving the operational capability of Naval information and communication systems in the areas of: high assurance software; secure tactical connectivity; AI and autonomy; and the processing, integration, and presentation of information. The expected payoff is: the development of improved methods for producing, analyzing, and securing Naval software systems; new design concepts for future Naval tactical communication systems and networks; intelligent autonomy and improved interaction with autonomous systems; and improved methods for information analysis, fusion, and presentation. New research projects will deliver technology for improved AI inference and human/AI interaction, predictive models for human cognitive performance, models for predicting and controlling complex networks in uncertain and hostile environments, and technology for improved presentation of complex, information-rich datasets.						
Integration of domain knowledge and machine learning to enable fast and robust learning of diverse, complex concepts and tasks. Development of artificial intelligence in support of: (i) Informing and assisting different stages of the decision making process, and (ii) Developing interfaces and dialogue systems for human-machine teaming. Efforts in distributed artificial intelligence will identify principles and tractable computational methods for flexible and resilient approaches to learning, sharing, reasoning, and decentralized planning for situation awareness. Efforts will develop brain-inspired artificial intelligence algorithms and architectures and neuromorphic hardware to accelerate deep learning.						
FY 2021 Base Plans: Communications and Networking: Develop the scientific foundation and understanding of wireless communications and networking technologies that enable the Naval warfighter to maintain access to mission critical information in contested environments. Research thrust areas include: Tactical Communications:						

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
- Complete cross-layer cooperation and relay forwarding with improved throughput						
- Complete multicast network coding						
- Continue interference alignment studies with improved source and channel coding for better interference management. Transitioned to a 6.2 Applied Research program for prototyping with digital chaos.						
- Continue developing new techniques for wireless distributed computing and device-to-device communication						
- Initiate development of new algorithmic framework for signal retrieval using non-uniform sparse array geometries						
- Initiate novel wireless communications methods across air-water boundary						
Tactical Networks:						
- Complete developing principles of a Wireless Network Operating System. Transitioned to a 6.2 Applied Research program for software implementation.						
- Complete unified approach to fast-converging multipath congestion control, scheduling and routing						
- Continue developing a feedback control model to determine the limit of fast adaptive traffic engineering.						
- Continue investigations in to new algorithms, protocols and middleware for dynamic and scalable multi-hop ad hoc wireless networking in contested environments						
- Initiate Artificial Intelligence/Machine Learning (AI/ML) techniques for multi-dimensional Quality-of-Service optimization						
- Initiate development of cognitive methods and algorithms to maintain network resiliency under link disruptions without adding excess overhead						
Quantum Information Sciences						
- Continue research on novel techniques for controlling quantum states to improve performance of surveillance and navigation sensors and clocks						
- Continue research on integrated chips for quantum information processing enabled by quantum optics for potential improvements in surveillance and communications						
- Initiate research on demonstrations of systems having a quantum advantage in the solution of optimization problems and quantum simulation of complex physical systems						
Nanoscale Computing Devices and Systems						
- Complete research on neuromorphic chip design and testing. Next phase will be systems level prototyping, carried out under the Technology Candidate program						
- Continue research on ultra-low power nanoelectronic devices, circuits and systems						

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
- Continue research on atomic precision control of graphene nanostructures using chemical synthesis techniques - Continue research on spin based electronics, focusing on single atom and single molecule level control - Initiate research on carbon based quantum systems that are compatible with bottom-up chemical synthesis paradigm						
Mathematical Data Science - Complete research in decision-making under uncertainty using game-theoretic approaches. - Continue basic research in mathematics, probability, statistics, signal processing, machine learning, data engineering, and information theory. - Initiate research on privacy in complex networks.						
Machine Learning, Reasoning and Intelligence - Continue developing the science base and computational methods for building versatile intelligent agents which can function autonomously in uncertain, unstructured, uncontrolled, open-world environments, and can collaborate seamlessly with humans and other agents. - Initiate program in developing new mathematical methods for principled design of deep learning architectures and analysis of their behavior. Deep learning is a powerful technique for knowledge acquisition and model-building, however mathematical tools for predicting their performance in cases for which they are not trained does not yet exist. Thus far, deploying learning-based intelligent systems require exhaustive and expensive empirical verification. This program is expected to develop techniques for predicting performance learning-based systems, to improve their generalization abilities, and to reduce the need for empirical verification.						
Applied and Computational Analysis Program - Continue to develop robust, reliable and near-real-time computational models for predicting environmental behavior , i.e. atmospheric, oceanic, and material sciences. Research areas include: -Multi-Scale/Multi-Physics Modeling: Hydrodynamics, salinity and thermodynamics -Dynamical Systems and Oceanic and Atmospheric Modeling: Develop mathematical tools to understand the complex structure of the oceans and atmosphere -Inverse Methods: Develop mathematical tools for acoustics, electromagnetism and optics.						
Cyber Security and Complex Software Systems - Complete research on ONR invented BFT++ classes of CPS resiliency, as it has transitioned to FNCs						

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- Complete research and development of de-bloating and de-layering of COTS for attach surface reduction, as the projects have transitioned to INP.						
- Continue ONR signature research on automated exploration of cryptographic algorithms						
- Continue further development of heterogeneous processing operating systems & compiler (Popcorn Linux) for supporting hypervisors and virtualization, building an alternative cloud infrastructure that is more efficient, powerful and secure.						
- Continue to explore novel application of ONR's concept of hybrid, formal-statistical machine learning (Learn2Reason) in cyber security and software systems environment						
- Continue to explore variations of physics-based cyber physical system security approaches beyond ONR's BFT ++						
- Continue to improve scalability and capability of bottom-up (binary) formal methods						
- Continue further development of capability for automatic generation of material decoys (Noise Factory)						
- Initiate Investigation on security aspect of non-volatile main memory usage for future computing systems						
- Initiate research on applications & efficacy of autonomic computing for cyber physical systems						
 Networked Sensing The primary focus of the Networked Sensing program is to conduct basic research in optical components and infrared technologies to enable significant leap-ahead capabilities for the survivability and lethality of Naval forces in complex environments.						
- Complete efforts that explored computational imaging techniques for next-generation waveform design for active three-dimensional imaging and measuring and inverting the effects of light scattering on imaging (e.g., seeing through fog).						
- Continue efforts exploring advanced photonics techniques to maximize information extraction from individual photons and through tailored optical beams with the goal of being able to image at long-ranges and in degraded conditions.						
- Continue efforts on fundamental implications of classical entanglement on imaging and metrology.						
- Initiate efforts to discover highly-sensitive, multi-spectral detector materials and active sensing modalities for imaging through clouds, fog, haze and dust.						
 Mathematical Optimization and Operations Research						
- Complete advances to special continuous nonconvex programs wherein both the objective to be optimized and the restrictions that enforce the system characteristics are expressed in terms of decision variables that are allowed to realize a continuum of values.						

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<p>- Complete advances to stochastic optimization that include a framework for distributed decomposition of different classes of large-scale problems, and the solving of real-size instances of nonlinear chance-constrained stochastic programs.</p> <p>- Complete the development of new families of cutting planes that effectively remove infeasible or non-optimal solutions from consideration.</p> <p>- Complete a major update of the Pajarito mixed-integer nonlinear programming solver; this code is the fastest open-source mixed-integer second order conic program software.</p> <p>- Continue investigations on discrete and nonlinear-continuous programs for which input parameters are known with certainty, but for which the acquisition of optimal decision strategies can be computationally intensive.</p> <p>- Continue research on optimizing stochastic programs that, due to incomplete or partial information, have input parameters that are not known with certainty.</p> <p>- Continue to Identify exploitable mathematical structures within specific decision problems for the purpose of devising superior solution algorithms.</p> <p>- Initiate new methods for strategically formulating and solving optimization problems that arise in resource allocation, logistics, and system planning.</p> <p>Science of Artificial Intelligence (AI)</p> <p>- Explore principled computational frameworks for integrating domain knowledge and machine learning for fast robust learning of diverse, complex concepts and tasks with light supervision. Domain knowledge includes physical models as well as rules, relations and semantic descriptions. A complementary objective is to gain insights into how humans incorporate prior knowledge and learning from scant data to improve their skills and learn new concepts and tasks, and use these insights to inform the computational framework.</p> <p>- Explore artificial intelligence in support of collaborative, complex command decision making. The objectives are to advance the scientific understanding of collaborative complex-decision making that is typical of Naval command decision making, and to develop AI technologies that actively inform and assist either in individual tasks or in the overall decision-making process. Key features of the desired technologies are that they possess the ability to assess the relative meaning and the context-sensitive importance of new or changing information, and convey or explain the basis of their recommendations in human-understandable terms.</p> <p>- Decentralized perception and planning in dynamics environments. The objective is to develop a unified framework for perception and planning for resources distributed across multiple platforms (agents, platforms, autonomous systems or vehicle swarms) to exploit the massive, diverse data obtained, while subject to communication limitations. Efforts in distributed artificial intelligence will identify principles and tractable computational methods for flexible and resilient approaches to learning, sharing, reasoning, and decentralized situation awareness and action planning. 4. Efforts will develop new brain-inspired artificial intelligence</p>					

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algorithms and architectures that provide richer computational capabilities than current deep learning networks and to model compact neuromorphic hardware suitable for edge computing and signal processing in small Naval platforms.						
Information Technology - Address the continued need for improving the operational capability of Naval information and communication systems in the areas of: high assurance software; secure tactical connectivity; AI and autonomy; and the processing, integration, and presentation of information. The expected payoff is: the development of improved methods for producing, analyzing, and securing Naval software systems; new design concepts for future Naval tactical communication systems and networks; intelligent autonomy and improved interaction with autonomous systems; and improved methods for information analysis, fusion, and presentation. New research projects will deliver technology for improved AI inference and human/AI interaction, predictive models for human cognitive performance, models for predicting and controlling complex networks in uncertain and hostile environments, and technology for improved presentation of complex, information-rich datasets.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: This funding increase from FY 2020 to FY 2021 is in response to the CNO Design for Maritime Supremacy 2.0, instructing ONR to advance and guide AI fundamental research enabling: AI verification methods; long-duration missions for Naval unmanned surface ships; AI processing at the tactical edge; intelligent agents that rapidly learn, generate high-volume course of action excursions and assist humans in making collaborative, complex decisions, and achieve the goal of enabling our sailors and marines to make better decisions faster than our adversaries in dynamic environments.						
Title: Materials/Processes Description: Lighter, faster, stronger is a winning combination. Naval materials research produces quieter submarines, fuel-efficient ships/vehicles and systems capable of operating under extreme temperature and chemical environments. New materials will result in warfighting advantages, as well as, systems that ensure environmental compliance, improved system reliability/resilience, stealthier materials, reduced manufacturing/maintenance and lower total ownership costs. The efforts research focus include: structural materials; functional materials; maintenance reduction; undersea warfare, physics and chemistry of materials, and manufacturing science.		56.957	58.636	56.784	0.000	56.784

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Accomplishments and plans described below are examples for each effort category. This activity also includes peer-review basic research to develop innovative solutions and enhance the science and engineering base.						
Beginning in FY 2020, The Environmental Science thrust has been re-aligned under Functional Materials to address the evolution of work within this program area.						
FY 2020 Plans: Structural Materials	Conduct basic research related to critical science and technology (S&T) for structural materials, including, but not limited to, the following: structural metals, polymer composite materials, solid mechanics, propulsion materials, sensors & non-destructive evaluation (NDE) prognostics and structural cellular materials.					
Functional Materials (Formerly Environmental Science)	Conduct basic research related to critical S&T for functional materials, including, but not limited to, the following: transduction materials, acoustic transduction science, nanoparticles, oxide materials, and anti-fouling and fouling release coatings including investigation of effect of new polymers, materials, processes, and novel testing methodologies for coating efficacy for environmental quality control.					
Maintenance Reduction	Conduct basic research related to critical S&T for maintenance reduction, including, but not limited to, the following: corrosion models, stainless steel carburization, corrosion, and coatings.					
Manufacturing Science	Additive Manufacturing (AM) using structural metals is of particular interest to the Navy for a wide variety of applications. However, the composition and properties of the AM alloy can change significantly during deposition, requiring new alloy development efforts to determine the initial composition that will produce the intended composition and properties in the AM-fabricated component. This effort will begin to address the need					

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by designing, developing and optimizing new metallic alloy compositions for AM that are resistant to the effects of the Naval/maritime environment.						
Materials and Chemistry						
Designing advanced materials depends on novel synthesis, processing, characterization, and performance. This effort addresses all materials including metals, alloys, ceramics, composites, semiconducting and superconducting material and bimolecular materials. Some examples of ongoing studies are (1) uncovering the physical, chemical, optical and biological phenomena in the nanometer scale, (2) understanding the effect of coatings on the conductions of ions and electrons, (3) developing better understanding on the performance of spin-polarized electrons for advanced electronic switches and memories, (4) developing fundamental understanding of electron transfer and carbon fixation pathways in microbial consortia and relate them to energy harvesting, material synthesis and sensing, (5) understanding the mechanism of bioactuation for novel wound healing applications, biocatalysis for mitigation and sensing, biocorrosion/fouling for improving operational efficiency and reducing operational maintenance cost, (6) computational capabilities to understand the microstructures/defects in metals and alloys of Naval interest, computational fluid dynamics simulations for jet engine noise reduction, flapping wing design to hypersonics. Several accomplishments have been demonstrated for materials using 3D printing, mobility of electrons of one spin, design of microbial cells to extract power from the coastal ocean sediments.						
Undersea Warfare						
Laboratory and theoretical/numerical studies focused on creating new techniques for understanding, predicting, and controlling the interactions between acoustic and elastic waves such as: underwater coupling architectures that achieve a broad range of acoustic impedances; and the creation of high efficiency silicon based thin film thermoelectric modules for undersea warfare applications by exploiting nanocrystallization, multilayering to control thermal conductivity.						
FY 2021 Base Plans:						
Structural Materials						
- Conduct basic research related to critical science and technology (S&T) of the composition-processing-structure-property relationships that define structural materials capabilities using and enabling an Integrated Computational Materials Engineering (ICME) approach to build, capture and exploit understanding of key						

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materials systems including, but not limited to, the following: structural metals, polymer composite materials, solid mechanics, propulsion materials, and additive manufacturing.						
Functional Materials - Conduct basic research related to critical S&T for functional materials, including, but not limited to, the following: transduction materials, acoustic transduction science, and anti-fouling and fouling release coatings including investigation of effect of new polymers, materials, processes, and novel testing methodologies for coating efficacy for environmental quality control.						
Manufacturing - Conduct basic research related to critical S&T for manufacturing science to develop a fundamental understanding of the processes and materials to enable advances in manufacturing technology for naval systems. - Efforts include, but are not limited to, the following: multidisciplinary research task into furthering the sciences associated with advances in manufacturing processes, using Integrated Computational Materials Engineering (ICME) approach to develop new naval advanced manufactured (AM) alloys, determining the effects of alloy chemistry, AM parameters and post processing on mechanical and corrosion properties and developing new alloys for expeditionary AM use without post processing.						
Materials and Chemistry - Conduct efforts on: atomistic simulations of complex materials chemistry and solid state physics including characterization and control of dopants and defects at the single-atom-scale, 2D materials, heterostructure processing and properties; nanoscale design, synthesis, processing and characterization of functionalized particles, surfaces and solids; magentoekectronics, spintronics, topological phases and two dimensional materials for low power, high speed microelectronics; surface chemistry for advanced catalytic functions supporting advanced synthesis and processing, nanoscale driven reaction and transport mechanisms for power and energy, corrosion science and electrochemical current control; and direct control of a material's magnetic order through metamagnetic phase transitions to enable tunable, ultra-low power and high speed components for electronic and energy harvesting.						
Undersea Materials - Laboratory and theoretical/numerical studies focus on creating new techniques for understanding, predicting, and controlling the interactions between acoustic and elastic waves such as: underwater coupling architectures that achieve a broad range of acoustic impedances; the creation of high efficiency silicon based thin film						

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thermoelectric modules for undersea warfare applications by exploiting nanocrystallization, multilayering to control thermal conductivity; and the creation of high performance transducer materials, such as textured ferroelectric ceramics, to achieve high power performance at reduced cost and complexity.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The decrease from FY 2020 to FY 2021 is due to decreased investment in basic research associated with Undersea Materials and research associated with the interactions between acoustic and elastic waves.						
Title: Medical and Biological Sciences Description: The health and performance of Sailors and Marines is a top priority. Extensive research in the medical and biological sciences discover and leverage breakthroughs to improve naval warfighter performance, so they can fight, win and come home safe. Sailors and Marines operate in the harshest working environments at sea and around the world. Conducting research, developing new equipment and gaining a better understanding of challenges in their operating environments will ensure optimal performance, prevent harm and equip the DON to provide the best care for its warfighters. Discover and leverage emerging multi-disciplinary basic research to improve warfighter health within areas including bio-inspired autonomous systems; bioengineering; biophysics; synthetic biology; microbial electrochemical systems and microbiome research; bio-inspired multi-spectral camouflage; sensory neuroscience and physiology; Naval force health protection; undersea medicine; health monitoring and modeling research; and health and welfare of the Navy's marine mammals.		19.159	19.707	19.648	0.000	19.648
FY 2020 Plans: Bio-Inspired Autonomous Systems Develop bio-inspired propulsion and control systems that enable high-lift, stealthy propulsion without propellers and achieve high maneuverability for underwater vehicles. Efforts include: (i) Bio-sensing for sensorimotor control; (ii) Bio-inspired design principles for distributed sensing, actuation and control in soft biological structures; and (iii) Principles of locomotion of amphibious animals to enable bio-inspired amphibious and cross-domain vehicles.						
Bioengineering and Life Sciences						

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Develop DNA-based nanostructures for fundamental circuits and biosensing; biomimetic and bio-inspired underwater adhesives; biopolymer energy sources; and explore approaches to generate nanomaterials by design. Pursue research in biological and bio-inspired, water-responsive materials for energy conversion and actuators. Maintain the health and fitness of the U.S. Navy's marine mammals for duty and readiness.	Naval Biosciences and Synthetic Biology for Naval Applications					
Develop research on synthetic biology for bioelectronics devices, materials, and information processing. Efforts include: (i) Elucidating microbe-materials interactions and extracellular electron transfer mechanisms for detection of materials defects/failures, identifying novel biogenic structures, and improving microbial electrochemical functions; (ii) Exploring the role of the human microbiome in host response to behavioral and physical stressors; (iii) Developing synthetic biology approaches to enable manipulation of microbiome organisms for Warfighter resilience or status monitoring; (iv) Executing research on synthetic biology approaches to enable novel bioelectronics and information processing strategies.	Warfighter Augmentation					
Develop cognitive and physiological systems that enable human performance to exceed current limitations, including novel adaptations to inhospitable environments. Efforts include: Alternative oxygen sources, epigenetic modifications of globin protein expression for variable regulation of oxygen tissue supplies, bionics, texture-shifting of biological organisms, and multi-functional textiles.	Sensory Neuroscience and Physiology					
Investigate neurological pathways of sensory systems including: (i) Examining mechanisms of nerve cell and axonal fiber deterioration in high noise environments; (ii) Accelerating understanding of nerve cell and axonal regeneration; and (iii) Exploring novel treatment strategies for hearing restoration.	Physiological Monitoring and Modeling					
Develop fundamental mechanisms that enable prediction and identification of cognitive and physical performance levels in extreme expeditionary environments. Design novel low-powered sensing capabilities.						

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Naval Force Health Protection						
Discover technologies including: (i) Novel modeling and simulation approaches to improve Warfighter protection; (ii) Maritime casualty care; and (iii) Medical logistics through optimized design, development, and operational planning.						
Undersea Medicine and Performance						
Develop cognitive and physiological responses in undersea environments to expand the operational envelope (e.g. depth and time) for divers and combat swimmers. Explore enhancement of human physiology with pharmacological agents and other therapies to protect humans from undersea environmental challenges.						
Stress Responses						
Develop impact of military operational environments on biomarkers predictive of individual Warfighter's reactivity to stress. Explore effects of chronic stress in conjunction with circadian cycle changes on these biomarkers.						
FY 2021 Base Plans:						
Bio-Inspired Autonomous Systems						
- Conduct discovery research on bio-inspired propulsion that enables stealthy propulsion and amphibious ability. Explore bio-inspired closed loop control with biosensor for obstacle avoidance, and high maneuverability. Explore schooling and swarming based on previously identified principles of bio sensing.						
Bioengineering and Life Sciences						
- Conduct development of nanometer-sized, 1-, 2-, and 3-dimensional DNA nanostructures with no undesired side products; a semiconductor chip-based device for massively parallel electronic detection of DNA sequences using reconfigurable DNA nanostructures as detectors; and DNA-based approaches for creating chemically-addressable systems with nm-scale precision over mm-scale ranges.						
- Extend exploring the influence of charge on the bonding of adhesive polymers, the delivery of adhesives underwater using a combination of oppositely charged polymers, and the generation of adhesives from biological polymers.						
- Carry on with discovery research on the mechanisms underlying the water-responsive behaviors of bacterial spores. Further explore silk-based biomaterials for energy harvesting and energy storage.						

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- Move-Forward to combine machine learning with multiscale computational modeling to design biological composite materials with any optimized material functions.						
<p>Naval Biosciences and Synthetic Biology for Naval Applications</p> <p>- Research directed toward engineering biological systems for microbial-based sensing, bio-electronics/electronic materials, and microbiome strategies for warfighter augmentation. Efforts include: synthetic biology studies of electroactive microbial chassis to enable opto-electronic sensing, signaling and electronic materials; elucidating natural/engineered microbial mechanisms of biogenic mineral synthesis and sequestration (including rare-earth minerals); investing synthetic biology approaches for designing microbes/microbial communities to enhance warfighter resilience and sensory capabilities.</p>						
<p>Warfighter Augmentation</p> <p>- Conduct discovery research on bio-inspired mechanisms to develop multi-spectral camouflage technologies. Efforts include texture and shape modulation, color adaptation, near to far infrared concealment, and mechanisms for tunable regulation of multi-functional textiles.</p>						
<p>Sensory Neuroscience and Physiology</p> <p>- Investigate means for enhancing warfighter sensory perception, including exploration of neurological pathways of the auditory system. Advance strategies to improve sound localization, augment auditory function, and discover novel treatments for auditory injury mitigation and therapy.</p>						
<p>Physiological Monitoring and Modeling</p> <p>- Conduct discovery research on novel sensing capabilities and biomarkers for understanding individual biological functions. Further improve physiologic signal monitoring capabilities that exceed current capabilities. Explore innovative technologies for real-time sensing and observation of individual responses to environmental and operational stressors.</p>						
<p>Naval Force Health Protection</p> <p>- Conduct exploration of computational models and soft material properties to predict warfighter injuries. Results will guide future development of protective gear and casualty prevention strategies. Conduct discovery research on novel nanoscale therapeutics for treating expeditionary traumas. Explore autonomy as a means to prolonged casualty care and evacuation.</p>						

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Undersea Medicine - Further our understanding of human physiology in the extreme conditions experienced in the undersea environment and compare this to marine mammals, which have adapted to these conditions. Explore oxygen availability in the ocean for novel approaches to undersea life support. Transitioned pharmacological candidates to applied research efforts to validate efficacy and refine treatment protocol.						
Stress Response - Conduct discovery research on human performance in stressful or austere environments and on indicators (e.g. biomarkers) of human vulnerability and human resilience. Explore the effects of circadian rhythm disruption combined with chronic variable stress on the neuroimmunoendocrine stress axis.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant change from FY 2020 to FY 2021.						
Title: Ocean Sciences Description: Understanding and predicting oceanographic phenomena provides significant warfighting advantages to naval forces. Ocean Sciences research addresses the full spectrum of physical oceanography to enable observation, modeling, and prediction of the maritime environment. Efforts include: studying common operating areas for naval forces in the open oceans, the Arctic and littorals; elucidating the coupling between oceanographic and acoustical phenomena relevant to such mission areas such as Anti-Submarine Warfare and Mine Warfare; development of global, regional and local predictive models that fully couple the ocean-atmosphere-wave-ice domains; development and use of autonomous systems for the collection of environmental observations and continuing support to research vessels of the U.S. Academic Research Fleet to enable at-sea oceanographic science. Research within the Ocean Sciences subactivity responds to the mission needs of the Oceanographer of the Navy's mission. At-sea research involves ancillary studies to ensure full compliance with environmental requirements.	74.420	81.641	82.968	0.000	82.968	
FY 2020 Plans: Physical Oceanography and Prediction						

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	Complete studies of the flow encountering abrupt topography in the Western Pacific on the mean and transient circulation structures. Continue the study of multi-scale embedded modeling and prediction. Conduct the studies of the prediction of and observations of 3-D Lagrangian studies and abilities to predict the vertical pathways in the ocean. Conduct the evaluation of novel employment of instrumentation including drifters and unmanned undersea vehicles to study these 3-D Lagrangian structures. Conduct the studies of the input and fate of near-initial shear and energy in the ocean via observational and predictive studies in the Greenland, Ireland, United Kingdom (GIUK) regions. Conduct the evaluation and testing and "hardening" of ocean instrumentation in high wave states and austere conditions. Conduct the study of the improvement of prediction systems by identifying, targeting, and obtaining key observations in critical targeted areas. Continue the evaluation of novel delivery systems of expeditionary ocean instrumentation to support targeted observing.					
Littoral Geosciences and Optics	Develop methodologies and/or observing technologies, for air, sea surface or subsurface, manned or unmanned, which are: a) nimble, cost-effective, rapidly re-locatable, or will offer bold insight into littoral dynamics, (e.g., tagging of marine seabirds in the Distributed, Autonomous, Scalable Hydrographic Charting and Meteorology and Oceanography (METOC) Sampling (DASHCAMS) Department Research Initiative (DRI)), or b) utilize sensors on operational platforms in ways which increase battlespace awareness or can be used to map the maritime domain while idle. Conduct studies and modeling of shelf, near-shore, delta, estuarine, and riverine dynamics, including surface and internal waves, currents, stratification, sediment transport and the seabed response (Inner Shelf DRI) and coastal winds driving shallow water response (Coastal Land-Air-Sea DRI). Conduct studies to understand shallow water features which will affect acoustic propagation or acoustic system performance (Undersea Remote Sensing DRI) and/or events which cause swimmer or navigational hazards (bathymetry-wave-current-wind interactions). Conduct studies using remote sensing of the coastal and riverine environment, above and below the sea surface and canopy, using electro-optic (EO), infrared (IR), radar, synthetic aperture radar (SAR), interferometric SAR (inSAR) and acoustic, from land or ship-based, unmanned vehicles, airplanes or satellites (Undersea Remote Sensing DRI). Develop new remote sensing tools and algorithms that can be used to initialize forecast models in distant, remote and/or denied areas. Conduct modeling and field studies of storm processes affecting the littoral environment, including the atmosphere, sea surface, water column, sea bed and suspended or dissolved materials. Predicting the initiation, transport and/or erosion of materials in response to storm events that create navigationally significant bathymetry or traffic-ability changes and/or changes in optical clarity.					
Marine Mammals and Biology						

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Areas of research include monitoring and detection, integrated ecosystem, and effects of sound on marine mammals. Conduct basic research to develop and test new and existing technology to detect, classify, localize and potentially track marine mammals in the marine environment, which are used to develop density and abundance estimates of marine mammals as a required input for all Navy sound effects modeling done under mandate of the federal Marine Mammal Protection Act and National Environmental Policy Act. Conduct multidisciplinary studies including tagging, visual surveys, and passive acoustics to collect baseline measures of marine mammal behaviors and distributions relative to environmental features and marine mammal prey fields. These baseline measures provide a context for interpreting responses to naval acoustic sources. Also, continue research on the effects of sound include behavioral, physiological (hearing and stress response), and population-level consequences of sound exposure on marine life. Conduct research to characterize the gas management and kinetics (stores and use) in marine mammals. Conduct research using increase in funds to characterize and quantify the cumulative effects of multiple stressors on marine mammal populations. Conduct research to advance our understanding of sound reception mechanisms in mysticetes (large whales).						
Effects of Sound						
Research on behavioral, physiological (hearing and stress response), and potentially population-level consequences of sound exposure on marine life. Research to characterize the causal chain of events leading from sound exposure to biologically significant behavioral reactions that might increase risks of population-level effects and/or the potential for stranding. An additional focus is to characterize the gas management and kinetics (stores and use) in marine mammals. Research the mechanisms that enable marine mammals to dive to deep depths for long durations while mitigating, if not avoiding, health threats. Initiate research to advance our understanding of sound reception mechanisms in mysticetes (large whales) will require a thorough exploration of the anatomy surrounding the ear and the whole head combined with modeling sound propagation through various tissues of whale heads and/or bodies. Another research focus is to better understand the stress response in marine mammals to sound exposure. Research on understanding of the natural variation of stress markers, better understand and characterize the relationships among hormones or other biomarkers in different matrices, define and compare the quantitative and temporal relationships of hormones across the different matrices, and evaluate and characterize the relationship between the physiological stress response in marine mammals and acoustic exposure and biologically significant disturbance. Research to develop statistical models of the population consequences of acoustic disturbance to be fitted to data from marine mammal populations and lead collaborative development of transferable models of the effects of disturbance on marine mammals.						

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Monitoring and Detection						
Research to develop and test new and existing technology to detect and classify marine mammals in the marine environment and during periods of low light such as passive acoustics, and infrared (IR). Research and development of passive acoustic signal processing algorithms for detection, classification, and localization of marine mammals. Continue the development and testing of autonomous hardware platforms using passive acoustics and/or IR to detect and classify marine mammals using a variety of fixed, towed, floating, and profiling platforms.						
Arctic sciences						
Research to improve the understanding of physical processes in the Arctic environment that impact current and projected Naval operations. Efforts include research to characterize the behavior of sea ice, including melt and reformation, ice rheology and motion, and interactions with ocean stratification, surface waves, and the atmosphere. The research program includes development of Arctic System models and data assimilation techniques for improved prediction, exploration and development of new sensors and unmanned platforms to collect observations of the Arctic environment, and the research into new algorithms to characterize sea ice from space-based remote sensing. An effort to better understand processes controlling the stratification of the Arctic Ocean will conclude this year.						
Ocean Acoustics						
Expand research to understand propagation and scattering of acoustic energy in a wide range of ocean environments. New emphasis will be placed on the information content contained in underwater acoustic signals for use in machine learning/big-data analytics. Areas of research include shallow-water scattering mechanisms related to reverberation and clutter; seabed acoustic measurements supporting geo-acoustic inversion; acoustic propagation through internal waves and coastal ocean processes and the development of unified ocean/seabed/acoustic models, including scattering from rough surfaces, biologics and bubbles; and penetration/propagation within the porous seafloor. In deep water research will include the effects of environmental variability induced by ocean internal waves, internal tides and mesoscale processes, and by bathymetric features including seamounts and ridges, on the stability, statistics, spatial distribution, and predictability of broadband acoustic signals. Also of interest is the coherence and depth dependence of deep-water ambient noise. An increasing emphasis will be placed on understanding the effects of Arctic conditions on acoustic propagation and ambient noise, particularly in under-ice environments, as facilitated by a basin wide data collection effort scheduled to begin in FY 2020.						

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Battlespace Environments						
The overall objective of this research is to improve basic understanding of physical, seafloor and biological oceanographic processes on space and time scales of naval interest. The work includes studies of aspects of ocean circulation (fronts, eddies and turbulence), thermodynamics (mixing and acoustic impacts), waves (including their impact on sea ice and rogue waves), sea ice (including land fast ice) as well as ocean boundary layer processes. Emphasis is on improved measurements, laboratory and model based experiments to quantify and understand important oceanographic processes that lead to the development of ocean dynamic/thermodynamic models from global to submesoscale scales, and to couple these oceanographic models with atmospheric, ice, biological, sediment response, and optical models. Surveillance of coastal land areas and waters is important to support Navy operations, so the research foci include an improved use of overhead (airborne and satellite) active and passive microwave sensors, overhead optical sensors, surface-based (ships and ground-based) grazing angle microwave sensors. To predict bottom boundary physical, geological, geochemical, geoacoustic and geotechnical properties in shallow-water operating areas requires: a) an improved understanding of processes that generate and modify the shape, structure and physical properties of the seafloor, subsea floor, ocean water column and ice-cover and topography/morphology; b) use of rapid, airborne characterization of littoral environments including time-varying coastal topography, littoral bathymetry, sea-level height, land and seafloor sedimentary structures to explain/predict the observed changes; c) remote sensing of bulk properties of Arctic sea-ice over broad two-dimensional areas that previously could be sampled only at spot locations by in-situ sampling; and d) quantification of the influence of turbulence generated at the seafloor boundary layer on vertical mixing and stratification in shallow water outside the surf zone.						
FY 2021 Base Plans: Physical Oceanography and Prediction Areas of research include ocean circulation, thermodynamics and mixing, and the dynamics of surface gravity waves, nonlinear internal waves and the interaction of waves with sea ice in order to inform a basic understanding of sub-mesoscale physical oceanography parameters from the tropics to the poles. Sub-						

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mesoscale understanding of the ocean is necessary to support the required fidelity and accuracy of ocean feature inputs to navy warfighting applications. - The studies of monsoon intraseasonal variability and air-sea interaction in the Bay of Bengal in the Indian Ocean will complete in FY21. - The three-dimensional Lagrangian ocean circulation and the prediction of vertical pathways in the ocean will continue its studies. - The input and fate of near-initial shear and energy in the ocean via observational and predictive studies in the Greenland, Iceland, United Kingdom (GIUK) regions will continue its studies. - The novel delivery systems of expeditionary ocean instrumentation to support targeted observing will continue its evaluation. - The ocean fronts, eddies and turbulence; ocean thermodynamics including mixing and acoustic impacts; ocean boundary layer processes and surface gravity waves in sea ice and rogue waves will continue its studies. - The study on the rapid evolution of the upper ocean in the high North Atlantic between Iceland and the European continent to better understand the physical processes that control vertical and horizontal density structures in the upper ocean will initiate in FY21. - The seasonal variability of processes that control sea surface temperature in the Arabian Sea to understand the relevant space and time scales that will enable improved prediction of extended range ocean and weather forecasts through the reduction of ocean temperature biases in coupled models will initiate a study to explore in FY21. Littoral Geosciences and Optics Areas of research include understanding processes and predicting the evolution of the highly nonlinear, coupled nearshore region in which mutual interactions of the atmosphere, sea surface, water column and seabed are all important. - The modeling and field studies of high spatial and temporal resolution coastal land-air-sea interactions and their role in creating atmospheric electromagnetic ducting will initiate its fundamental theoretical in FY21. The objective is to resolve wind forcing in coastal areas in order to more accurately force coastal wave and current models and understand when ducting may occur in such land-air-sea configurations as nearshore mountains, estuaries and urban coastal environments. - The rocky coasts which line a significant portion of the world's coastline but have been poorly studied will initiate the systematic studies in FY21. - The autonomous, scalable, hydrographic charting and parameter sampling littoral studies using autonomous systems paired with remote sensing will initiate and distributed in FY21.						

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- The ocean phenomenologies that can be sensed via airborne and satellite active and passive microwave sensors, overhead optical sensors, and ship or shore-based grazing angle microwave sensors to enable surveillance of the entire battlespace environment will continue research in FY21.						
- The sonar undersea remote sensing using autonomous underwater vehicles in conjunction with land, air and satellite remote sensing will continue its efforts in FY21. The objective is to both provide subsea interpretation of undersea dynamics from sonar remote sensing, and to provide the subsea structure of surface dynamics/manifestations viewed from space.						
- The predict physical, geological, geochemical, geoacoustic and geotechnical properties of the seafloor in shallow-water operating environments will continue its research in FY21.						
- The field and modeling efforts to elucidate inner shelf dynamics will conclude in FY21.						
Marine Mammals and Biology Areas of research include monitoring and detection, integrated ecosystem, and effects of sound on marine mammals.						
- Carry out multidisciplinary studies including tagging, visual surveys, and passive acoustics to study baseline measures of marine mammal behaviors and distributions relative to environmental features and marine mammal prey fields. Research on behavioral, physiological and population-level consequences of sound exposure on marine life.						
- Conduct physiological studies of diving in marine mammals. The objective is to understand the mechanisms that enable marine mammals to dive to deep depths for long durations while mitigating or avoiding health threats.						
- Extend to study the sound reception mechanisms in large whales through the exploration of the anatomy and sound propagation through various tissues. The objective is to estimate the hearing range of large whales with a particularly emphasis to identify the regions of greatest sensitivity.						
- Move forward to characterize the stress response in marine mammals to sound exposure and how it may affect animal health, fitness, and survival. Research objectives are to study the natural variation of stress markers, better understand and characterize the relationships among hormones or other biomarkers, and define and compare the quantitative and temporal relationships of hormones. Increased emphasis will be on studies to evaluate and characterize the relationship between the physiological stress response via hormones and biomarkers in marine mammal immune status, and animal health and biologically significant effects on individual fitness and survival.						
- Extend studies to develop statistical models of the population consequences of acoustic disturbance. The objective is to characterize the causal chain of events leading from sound exposure to biologically significant behavioral and physiological.						

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B. Accomplishments/Planned Programs (\$ in Millions)				
FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<ul style="list-style-type: none"> - Conduct research to develop technologies to detect and classify marine mammals in the marine environment to provide marine mammal density and abundance estimates required for Navy sound effects modeling done under mandate of the federal Marine Mammal Protection Act (MMPA) and National Environmental Policy Act (ESA). <p>Arctic Sciences Areas of research include the complex processes governing the interaction of the arctic atmosphere, ocean, and sea ice, including formation, deformation, and melting. Physical processes in the arctic environs are inherently different from those in non-polar regions.</p> <ul style="list-style-type: none"> - Finished stratified ocean dynamics in the Arctic (SODA) research initiative to better understand the evolving oceanic structures and interaction of fresh and salt water in the high latitudes. - Ended the sea ice dynamics experiments (SIDEx) research initiative to better understand the impact of increasing open water on the formation, evolution and disintegration of the Arctic ice pack. - Extend Arctic fieldwork to characterize the behavior of sea ice, including melt and reformation, ice rheology and motion, and interactions with ocean stratification, surface waves, and the atmosphere. - Move forward the development of Arctic System models and data assimilation techniques for improved prediction and development of new sensors and unmanned platforms to collect observations of the Arctic environment, including development new algorithms to characterize sea ice from space-based remote sensing. - Conduct the remote sensing of bulk properties of Arctic sea-ice over broad two-dimensional areas that previously could be sampled only by localized in-situ methods. <p>Ocean Acoustics Areas of research contribute to improved basic understanding of the physical, seafloor and biological parameters that affect acoustic propagation in the ocean. Accurate acoustic predictions are required to keep our undersea assets undetected as well as to enable the detection and tracking of adversary assets.</p> <ul style="list-style-type: none"> - Conduct research to understand propagation and scattering of acoustic energy in shallow-water ocean environments. Areas of research include shallow-water scattering mechanisms related to reverberation and clutter; seabed acoustic measurements supporting geoacoustic inversion; acoustic propagation through internal waves and coastal ocean processes and the development of unified ocean/seabed/acoustic models, including scattering from rough surfaces, biologics and bubbles; and penetration/propagation within the porous seafloor. - Extend the investigation in optimal representations information contained in acoustic data. Specific efforts will include the investigation summary statistics and sparse encoding of underwater acoustic data. The objective is to enable efficient analysis and compact representations of acoustic scenes. - Launch efforts in auralization applicable to the ocean battlespace. Specific efforts will include investigations into source separation, characterization, and recombination along with physical, biological, and anthropogenic sound 				

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generating mechanisms. An objective is to model and simulate acoustic phenomena in undersea environments to be rendered as virtual soundfields.	- Conduct research into the effects of environmental variability induced by ocean internal waves, internal tides and mesoscale processes, and by bathymetric features including seamounts and ridges, on the stability, statistics, spatial distribution, and predictability of broadband acoustic signals. Also of interest is the coherence and depth dependence of deep-water ambient noise.					
	- Carry out investigations into the effects of Arctic conditions on acoustic propagation and ambient noise, particularly in under-ice environments, as facilitated by an FY20 trans-arctic basin collection effort. Initiate analysis of data from the trans-arctic basin collection effort.					
	- Launch the joint physical oceanography and acoustic field studies to investigate propagation and scattering in regions characterized by complex bathymetry and/or meteorological and oceanographic forcing. Specific efforts will include processes studies with the objective of linking observed ocean and acoustic phenomena. An objective is to characterize oceanographic phenomena and the effects on acoustic propagation and scattering at different frequencies.					
	- Begin the efforts in characterizing and forecasting sediment acoustic properties. Specific efforts will include investigations aimed at linking local physical and biological processes to acoustic observables. Continue analysis efforts related to acoustic seabed characterization experiment. Specific efforts will include development and verification of geoacoustic models and inference techniques for soft sediments based on experimental evidence.					
Battlespace Environments						
- This research is to improve basic understanding of physical, seafloor and biological oceanographic processes on space and time scales of naval interest. Emphasis is on improved measurements, laboratory and model based experiments to quantify and understand important oceanographic processes that lead to the development of ocean dynamic/thermodynamic models from global to sub-mesoscale scales, and to couple these oceanographic models with atmospheric, ice, biological, sediment response, and optical models. While today's numerical analysis and prediction systems are more capable of resolving and predicting highly variable phenomena than were the systems of 10-20 years ago, there are still oceanographic processes that are not well understood and must be studied including aspects of ocean circulation (fronts, eddies and turbulence), thermodynamics (mixing and acoustic impacts), waves (including their impact on sea ice and rogue waves), sea ice (including landfast ice) as well as ocean boundary layer processes. Navy and Marine Corps requirements also include: a) an improved use of overhead (airborne and satellite) active and passive microwave sensors, overhead optical sensors, surface-based (ships and ground-based) grazing angle microwave sensor, b) use of remote sensing of bulk properties of Arctic sea-ice over broad two-dimensional areas that previously could						

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be sampled only at spot locations by in-situ sampling, and c) use of newly available higher resolution (sub-mesoscale) oceanographic data.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The funding increase from FY 2020 to FY 2021 is due to support of enhanced at-sea field experimentation in support of Task Force Ocean activities.						
Title: Science and Engineering Education, Career Development and Outreach		43.232	49.014	42.734	0.000	42.734
Description: Maintaining maritime superiority requires a highly technical naval workforce. Science and Engineering Education, Career Development and Outreach activity addresses the critical need to attract the brightest and cultivate the best. These experiences prepare participants for rewarding Naval civilian careers and build the extra-mural performer base community.						
The efforts research focus include: participation in science fairs, summer research interns/fellows at Naval laboratories, graduate fellowships for individuals expected to become members of the engineering faculty at Historically Black Colleges and Universities and Minority Institutions (HBCU/MIs), and curricular enrichment programs. Grants awarded center on Naval research efforts supporting Science, Technology, Engineering and Math (STEM). Outreach includes the encouragement, promotion, planning, coordination and administration of Naval S&T efforts to promote the development of a highly skilled Naval technical workforce.						
The Department of the Navy's (DON) Historically Black Colleges and Universities/Minority Institutions (HBCU/MI) program oversees the Navy's efforts to engage and support our nation's HBCU/MIs and is responsible for developing and managing efforts that strengthen and support the capabilities of HBCU/MIs to participate in basic, applied, and advanced research programs within the Naval Research Enterprise (NRE).						
SCHOOLHOUSE TRAINING: Discovery research on instructional strategies and techniques for schoolhouse training including virtual, augmented, and mixed reality environments. Correlate effective schoolhouse training and measures of downstream performance, including development of theories into skill acquisition and decay.						
The ONR Young Investigator Program (YIP) was established in 1985 to attract outstanding faculty members to the Department of Navy's basic research program by identifying individuals that show exceptional promise for doing creative research and encourage their teaching and research careers through long term support. Young						

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Investigator awards are for a period of three years. Annual request for proposals are solicited via a funding opportunity announcement and is open to tenure-track faculty in science, engineering, and mathematics. Topics are competitively selected based on faculty achievements, technical proposal, benefit to the Navy and Marine Corps, and institution support.	Naval Research Institution: Through a Memorandum of Understanding between the United States Naval Academy (USNA) and the Office of Naval Research, this program contributes to the technical education of midshipmen by providing an opportunity to enhance their experience in research and knowledge of the positive impact that understanding of Science, Technology, Engineering, and Mathematics (STEM) has on fleet and forces capabilities.					
Funding also supports the Office of Naval Research (ONR) Global mission to serve as the enduring Navy and Marine Corps global presence in technical and operational communities, investing in trusted partnerships to discover and connect science and technology leaders for sustained maritime security. This is accomplished by establishing quality, relevant connections between the international research and development community, Naval fleet/forces, Department of Defense (DOD), other US Government agencies and international partners. The direct impact of this investment is to leverage international basic research during increasingly dynamic global interdependence and improve the ability to solve DON Science & Technology challenges through shared knowledge with partners.	FY 2020 Plans: Support Science, Technology, Education and Mathematics (STEM) initiatives and multi-year efforts that are intended to be approximately three years in length and in topics supporting STEM education relevant to naval science and technology workforce development. Start development of pilot efforts to improve STEM through the development of new curricula and experiential learning activities that respond to new naval Science and Technology personnel and knowledge needs. Expand existing successes to scale working projects and achieve greater impact and implementation of funded efforts. Support new activities to targeting regional efforts to drive greater impact on educational systems and increase workforce opportunity for the naval Science and Technology community. Continue coordination of Department of the Navy (DON) STEM efforts. This effort will continue to support programs that provide hands-on research experiences in STEM fields for United States Naval Academy (USNA) midshipmen and faculty members to enhance the midshipmen's educational environment at the USNA.					

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Enhance and maximize HBCU/MI's faculty and student awareness of STEM and other defense-related educational research opportunities to make significant contributions to the NRE by increasing the number of students and faculty participating in DoN HBCU/MI fellowships and internships and increasing the number of Research and Development grants awarded by the DoN HBCU/MI Program to HBCU/MIs. Support efforts to provide student internships and faculty fellowships that will increase the capability of Science and Technology efforts into a new age of discovery. Ongoing efforts include attracting student veterans to research and career opportunities in STEM related fields.						
25 to 35 Young Investigators are selected for award annually from the many proposals received. Ongoing efforts cover a wide range of topics of naval S&T interest. Recent topics include innovative technical approaches to: vortex flow in hypersonic aerodynamics; real-time accurate positioning in robotics, acoustic meta-materials for marine surfaces, cyclone intensity forecasting, advanced mathematical optimization for statistical applications, cephalopod inspired camouflage, digitization of human performance, soil characterization capability from remote sensing, thermal transport at solid-solid interfaces, and high-temperature multi-principal alloys. These and other research topics will benefit today's and the next generation warfighter by improving lethality, survivability, communications, and training. Additionally, many of these investigators will provide long-term support and knowledge in solving naval related S&T challenges.						
ONR Global will foster collaboration with international organizations and researchers by awarding grants in innovative basic research to discover, access and assess revolutionary, high-payoff technologies for future Naval missions and capabilities.						
SCHOOLHOUSE TRAINING: Discovery research efforts include: (i) Developing optimized training and retention models; (ii) Designing better training schedules; and (iii) Developing skill tutors for maintenance tasks.						
FY 2021 Base Plans: Support Science, Technology, Education and Mathematics (STEM) initiatives and multi-year efforts that are intended to be approximately three years in length and in topics supporting STEM education relevant to naval science and technology workforce development. Start development of pilot efforts to improve STEM through the development of new curricula and experiential learning activities that respond to new naval Science and Technology personnel and knowledge needs. Expand existing successes to scale working projects and achieve greater impact and implementation of funded efforts. Support new activities to targeting regional efforts to drive greater impact on educational systems and increase workforce opportunity for the naval Science and Technology community. Continue coordination of Department of the Navy (DON) STEM efforts.						

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This effort will continue to support programs that provide hands-on research experiences in STEM fields for United States Naval Academy (USNA) midshipmen and faculty members to enhance the midshipmen's educational environment at the USNA.						
<p>Young Investigator Program (YIP) Each year, 25 to 35 individuals that show exceptional promise for performing creative research receive YIP awards. Topics are competitively selected based on faculty achievements, technical proposal, benefit to the Navy and Marine Corps, and institution support. Ongoing efforts cover a wide range of topics of naval S&T interest. Recent topics include innovative technical approaches to: vortex flow in hypersonic aerodynamics; real-time accurate positioning in robotics, acoustic meta-materials for marine surfaces, cyclone intensity forecasting, advanced mathematical optimization for statistical applications, cephalopod inspired camouflage, digitization of human performance, soil characterization capability from remote sensing, thermal transport at solid-solid interfaces, and high-temperature multi-principal alloys. These and other research topics will benefit today's and the next generation warfighter by improving lethality, survivability, communications, and training. Additionally, many of these investigators will provide long-term support and knowledge in solving naval related S&T challenges. Complete Young Investigator Program projects initiated in fiscal year 2019.</p> <p>ONR Global will continue to foster collaboration with international organizations and researchers by awarding grants in innovative basic research to discover, access and assess revolutionary, high-payoff technologies for future Naval missions and capabilities.</p> <p>SCHOOLHOUSE TRAINING: Research efforts include: (i) Developing optimized training and retention models; (ii) Designing better training schedules; and (iii) Developing skill tutors for maintenance tasks.</p> <p>The Naval Enterprise Partnership Teaming will continue with the Universities for National Entrepreneurship (NEPTUNE) program to promote and sponsor Naval Postgraduate School personnel to conduct research in the areas of Navy Energy Education & Training and course curriculum development for NPS energy-related courses for energy security and energy resiliency. Additionally, the US Naval Academy (USNA) will perform research on the combustion chemistry of Navy engines and other energy-related areas. Conduct discovery research to develop simulators for teaching dynamic tasks using new cognitive models. Develop artificial intelligence-based tutors to teach transfer across military career ratings.</p> <p>Historically Black Colleges and Universities / Minority Institutions (HBCU/MI)</p>						

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Expand the opportunities for HBCU/MI's faculty and student to participate in fellowships and internships at warfare centers and labs thereby increasing the number of STEM and Defense-related research. Develop new outreach plans to increase the number of HBCU/MI white paper and grant proposal submissions. Establish a HBCU/MI Post-doctoral program that supports the efforts of increasing the number of HBCU/MI students working within the Navy STEM related fields. Increase the number of science fairs at HBCU/MI that have partnerships with local schools.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The reduction from FY 2020 to FY 2021 is due to completion of the Basic Research Challenge efforts and Young Investigator Program efforts, and due to the realignment of resources for basic research administered through ONR Global to higher priority Navy requirements.						
Title: Sensors, Electronics and Electronic Warfare (EW) Description: Basic research efforts directed toward increasing knowledge, developing components and algorithmic advances for electronics, sensing and electronic warfare to ensure the Navy has the appropriate technologies in order to counter current and future threats. These efforts are broadly applicable to sensing and electronic warfare on individual Naval platforms, as well as, efforts that seek to integrate capabilities across multiple platforms. The efforts research focus include: sensing, diagnostics, and detectors; navigation and timekeeping; nanoelectronics; wide band gap power devices; real-time targeting; Electro-Optical/Infra-Red (EO/IR) electronics; EO/IR electronic warfare; EO/IR sensors for surface/aerospace surveillance; Radio Frequency (RF) sensors for surface/aerospace surveillance; solid state electronics; vacuum electronics; and RF electronic warfare.	47.295	48.804	52.862	0.000	52.862	
FY 2020 Plans: Sensors, Electronics and Electronic Warfare (SEEW) Conduct basic research in the areas of solid state transistors and devices for high frequency analog and digital operation; high efficiency, highly linear amplifiers for microwave, millimeter-wave, low-noise, and power applications; superconducting and other technologies which are designed to deliver software defined, wide band, simultaneous signal functionality for conventional system contexts, including, but not limited to,						

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satellite communications (SATCOM), Surveillance, Electronic Warfare (EW), signal intelligence (SIGINT), and communications; electronics and photonics technology that provides for the control, reception, transmission and processing of signals; and continue research to advance navigation, timekeeping and sensing technology, including cooling and trapping of atoms and ions; Bose-Einstein condensation and coherent matter-wave physics; optically-based frequency standards; improved time and frequency metrology using quantum entanglement and quantum logic processing; quantum optomechanics; and coherence and control of quantum systems.						
Electronics						
Create new knowledge and understanding and explore new concepts, components, techniques and methods, for the design, growth, and characterization of electronic, electromagnetic, quantum phenomenology, and electro-optical materials, fabrication processes, electronic and electro-optic components, including novel electromagnetic concepts and techniques, and plasma phenomena and theory. Create new knowledge and understanding for quantum computing algorithms and their use to create new understanding of materials by design, process optimization, and quantum simulation.						
Electromagnetic Warfare						
Fundamental research is being conducted looking at a very novel concept of using radars for long range speech reception and playback is ongoing. Radar Cross Section (RCS) prediction capabilities for naval vessels is being researched to cover ultra-wide bandwidths, significantly expanding our predictive narrow band capabilities. When coupled with another developmental effort on multistatic radar theory will provide a broad perspective of target signatures essential to defining radar and EW performance requirements. Research in the Electro-Optical/Infra-Red (EO/IR) domain will demonstrate new filtering technique enabling 30x gain in sensitivity and 3x gain in resolution for multi-color image sensors.						
Materials and Chemistry						
Design novel experiments and theoretical models to create advanced or improved materials using new concepts and techniques for applications and sensors and advanced electronics. Improve target identification algorithms utilizing nonlinear dynamics. Understand and demonstrate the principles and mechanisms of DNA-based molecular-scale machines to amplify detection of biochemical agents. Fabricate single atomic layer of materials to create 2-dimensional ferromagnets and semiconductors. The material of choice will be single						

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layer Molybdenum disulfide (MoS ₂) for utilization as indirect gap semiconductors. The Navy unique single stage accelerator mass spectrometer to evaluate the fine scale detection limits of fusion products and isotopes. Understand protein-surface interactions leading highly sensitive biosensors. First principle theoretical models are developed to understand the principles governing the interactions between surfaces and small molecules. Previous studies in these areas have demonstrated success in designing biological and chemical sensors with parts per trillion sensitivity as well as understanding of electronic mobility of graphene due to the effects of edge and defects.	Undersea Warfare					
Laboratory, field, and theoretical/numerical studies to investigate physical phenomenon related to acoustic propagation and scattering in oceanic environments such as: prediction of the scattering signature of a structure using noise sources of opportunity; fundamental physical phenomena of wave propagation in ocean environments; approaches to separate of an acoustical field from turbulent flow on an acoustic array; and new structural acoustics theory.	FY 2021 Base Plans: Sensors, Electronics and Electronic Warfare (SEEW) - Conduct basic research in the areas of solid state transistors and devices for high frequency analog and digital operation; high efficiency, highly linear amplifiers for microwave, millimeter-wave, low-noise, and power applications; superconducting and other technologies which are designed to deliver software defined, wide band, simultaneous signal functionality for conventional system contexts, including, but not limited to, satellite communications (SATCOM), Surveillance, Electronic Warfare (EW), signal intelligence (SIGINT), and communications; electronics and photonics technology that provides for the control, reception, transmission and processing of signals. - The single photon emission in solid state materials and approaches to manipulate emitter properties through structured materials will initiate studies in FY21. - The novel techniques for the cooling and trapping of atoms and molecules. Continue the development of protocols for sensing and timekeeping devices based on quantum systems, including clocks with improved short and long term performance and electromagnetic field sensors will continue basic research in FY21. - The development of inertial and gravity sensors based on light-atom interferometry will continue in FY21.					
Electronics						

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
- Create new theories and explore new concepts, components, techniques and methods, for the design, growth, and characterization of electronic, electromagnetic, quantum phenomenology, and electro-optical materials, fabrication processes, electronic and electro-optic components, including novel electromagnetic concepts and techniques, and plasma phenomena and theory.						
- Develop a understanding for quantum computing algorithms and their use to create new understanding of materials by design, process optimization, and quantum simulation.						
Electromagnetic Warfare The projects in this area conduct basic research efforts with the overarching objective to establish the mathematical constructs, techniques, computational procedures, and scientific foundations the for analysis/design of signal, image, control, and data generating systems for use in Navy, other DOD, dual-use, or commercial development programs. Each project has defined objectives within the contexts of the Naval Research Enterprise Research and Development Strategic Framework and Marine Corps S&T Strategic Plan. These efforts include: - Develop ultrafast, efficient, and accurate time domain (TD) algorithms to predict the ultra-wideband radar cross-section (RCS) of complex naval platforms by solving the long-standing late-time instability problem; - Investigating mathematical, statistical and algorithmic issues associated with performing robust and adaptive detection and discrimination of targets when sensed by multiple, resource-constrained, unmanned vehicle sensors operating in a decentralized fashion and in highly cluttered environments. - Conducting research to establish basic feasibility of novel emerging non-linearized imaging and feature extraction techniques with respect to existing and/or realistic multi-static sensing geometries, research to utilize and enhance the understanding and applicability of topological techniques to enable improved capabilities for target detection, object identification, and data fusion. - Carrying out research to enable the imaging of self-illuminating thermal objects occluded by walls by sensing non-specular reflections from rough surfaces such as open doors and around corners to allow for asymmetric warfare through image recovery in previously denied conditions. - Engage in research to develop advanced multi-dimensional Convolutional Neural Network approaches and algorithms to investigate and demonstrate improved means of analyzing high-dimensional data resulting in improved results for classification, segmentation, anomaly/ target detection.						
Materials and Chemistry - Design novel experiments and theoretical models to create advanced or improved materials using new concepts and techniques for applications and sensors and advanced electronics.						

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<ul style="list-style-type: none"> - Improve target identification algorithms utilizing nonlinear dynamics. Understand and demonstrate the principles and mechanisms of DNA-based molecular-scale machines to amplify detection of biochemical agents. - Fabricate single atomic layer of materials to create 2-dimensional ferromagnets and semiconductors. The material of choice will be single layer MoS2 for utilization as indirect gap semiconductors. - Conduct unique single stage accelerator mass spectrometer to evaluate the fine scale detection limits of fusion products and isotopes. - Recognize the protein-surface interactions leading highly sensitive biosensors. - Develop principle theoretical models to understand the principles governing the interactions between surfaces and small molecules. Prior studies in these areas have demonstrated success in designing biological and chemical sensors with parts per trillion sensitivity as well as understanding of electronic mobility of graphene due to the effects of edge and defects. <p>Undersea Warfare Efforts include research in Laboratory, field, and theoretical/numerical studies to investigate physical phenomenon related to acoustic propagation and scattering in oceanic environments such as:</p> <ul style="list-style-type: none"> - Prediction of the scattering signature of a structure using noise sources of opportunity. - Fundamental physical phenomena of wave propagation in ocean environments. - Develop approaches to separate an acoustical field from turbulent flow on an acoustic array. - Create new structural acoustics theory for scattering from large, complex undersea objects. - Develop new approaches to monitoring the acoustic signature and structural state of undersea vessels. <p>FY 2021 OCO Plans: N/A</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: The funding increase from FY 2020 to FY2021 is due to increased investment in the defects in Bio-Sensors that detect the interaction between surface and small molecules.</p>						
Title: Weapons	Description: Naval S&T discovers, develops and delivers decisive naval capabilities. Superior defense deters aggression, but when called upon, enables naval forces to fight, win and come home safe. This Program focuses on a number of fundamental scientific areas aimed at expanding the underlying understanding of disciplines that are broadly useful for a wide range of naval weapon applications. Research into emerging technologies like directed energy explore the scientific limitations of laser technology for utilization in maritime environments.	19.848	23.419	25.541	0.000	25.541

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Continued research in hypersonics will address unique challenges like extreme temperatures and air flow. Ultimately, naval S&T strives to ensure that no Sailor or Marine will ever be in a fair fight.	The efforts research focus includes: undersea weaponry; air weaponry; energetic materials and solid rocket propulsion; expeditionary operations, including communications, materials, landmine detection, human sensory enhancements, lightweight power sources and information efficiency; directed energy and counter directed energy, hypersonic aerodynamics and materials, and applied electromagnetics. This activity includes peer-review basic research to develop fundamental knowledge and enhance the science and engineering workforce and technology base.					
FY 2020 Plans: Research will focus on undersea weaponry; energetic materials and rocket propulsion; directed energy, counter directed energy, applied electromagnetics, and hypersonics.	Undersea Weaponry Pursue advanced concepts for sea warfare and weapons to include conducting basic science and research to explore new ideas and technologies to enhance the performance of existing power & energy sources, undersea weapons, unmanned vehicles, aircraft, ships and submarines for the Navy. Sunset efforts on supercavitation and expand autonomous control technology for surface and subsurface vehicles and weapons.					
Air Weaponry Research will focus on the areas of solid and hybrid rocket propulsion, advanced structural and aperture materials, navigation, aerodynamics, single and multi-missile control, and power management. This effort will enable missiles with greatly increased speed, range and lethality to meet future naval warfare needs.	Directed Energy Research will focus on the scientific limitations of laser technology for utilization at tactically significant ranges. The goals of the program include research of laser sources, adaptive optics compensation techniques, understanding of long range atmospheric propagation physics, and characterization of laser-matter interactions. This program will lead to understanding which directed energy (DE) is best for Naval defense applications.					
Counter Directed Energy						

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Research will investigate ability to counter directed energy weapons in high energy lasers or high power radiofrequency devices. Analytical models, modeling and simulation, and laboratory experiments on laser and High Power Microwave protection methods for future naval aviation, missiles, and surface ship systems and platforms.						
Energetic Materials and Rocket Propulsion Research will investigate new energetic chemical compounds with superior specific energy and energy density, brisance, insensitivity, etc. for useful warhead fills and solid rocket propellants. Methods for improved understanding of formulations and advanced modeling and simulations on composite energetic materials will be investigated along with new methods and instruments for characterization.						
Hypersonics Research will address the fundamental understanding of the underlying phenomena unique to hypersonic flight where extreme temperatures and other unique flow and material conditions arise. Areas of research include boundary layer physics in shockwave dominated flows around highly-swept or slender bodies, Aero-thermo-elastic and/or aero-servo-elastic effects arising from control surface actuation at high speeds, descriptions of high-speed boundary layer transition that unify theories across disparate external conditions, novel strategies for extending regions of laminar flow and advanced hypersonic aerodynamic design tools that incorporate modern predictions of transition pathways, freestream noise contributions, time/heating dependent surface finish effects, and unsteady aerodynamics. Ultra-high temperature materials, coatings, and thermal protection systems will also be investigated.						
FY 2021 Base Plans: Undersea Weapons Conduct basic research related to critical S&T to develop technologies for legacy and next-generation offensive and defensive undersea weapons (USWs) and payloads capable of engaging threat submarines, surface ships and torpedoes. Efforts include, but are not limited to, the following: - Undersea and Surface Vehicle Autonomy - Advanced concepts for Sea Warfare - USW Hydro and Propulsion, - USW Warheads - Naval Undersea Research Program						
Air Weaponry						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 1	R-1 Program Element (Number/Name) PE 0601153N / Defense Research Sciences	Project (Number/Name) 0000 / Defense Research Sciences				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Research will focus on the areas of solid and hybrid rocket propulsion, advanced structural and aperture materials, navigation, aerodynamics, single and multi-missile control, and power management. This effort will enable missiles with greatly increased speed, range and lethality to meet future naval warfare needs.	Directed Energy and Counter Directed Energy Research will focus on the fundamental scientific processes of laser and microwave technologies leading towards Naval utilization at tactically significant ranges in offensive and defensive applications. Program goals included the research: <ul style="list-style-type: none">- Laser/Microwave Sources- Adaptive Optics- Antennas- Power/Energy Conversion and Modulation- Understanding of Propagation/Interaction Physics- Characterization of laser-matter interactions for ultra-intense laser beams- Electromagnetic-Electronic Coupling- Identifying new nanostructured materials and coatings processing for naval applications.- Investigate unique interactions of photons with materials and coatings, including nonlinear optical materials and unique photochromic materials that react by creating direct mechanical strain from photons.					
Energetic Materials and Rocket Propulsion Research will investigate advanced energetic materials which provide reactive, explosive, and propulsive phenomena including high energy ingredient synthesis, modeling, characterization, and the fundamentals of initiation, decomposition and combustion/shock. Research will include: <ul style="list-style-type: none">- Synthetic methodology for new energetic materials and material concepts with superior specific energy and energy density, brisance, insensitivity, etc. for useful warhead fills and solid rocket propellants.- Novel Diagnostic methods for improved understanding of formulations and dynamic combustion/shock and related energetic materials dynamic phenomena.- Advanced modeling and simulations on energetic materials, along with new methods and instrumentation for characterization.	Hypersonics Basic research will address long-range weapon components able to survive high temperature exposure for several minutes and thwart anti-access/ area denial countermeasures. Additional areas of research include: <ul style="list-style-type: none">- Hypersonic boundary-layers and shock-wave / boundary-layer interactions					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020
Appropriation/Budget Activity 1319 / 1	R-1 Program Element (Number/Name) PE 0601153N / Defense Research Sciences		Project (Number/Name) 0000 / Defense Research Sciences	
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base
<ul style="list-style-type: none"> - Prediction of hypersonic weapon flight performance and control including the influence of non-continuum, non-equilibrium and aero-thermo-servo-elastic effects - Environment-material interactions - Test facilities, instrumentation and diagnostics - Ultra-High temperature materials - High-Speed Propulsion 				FY 2021 OCO
FY 2021 OCO Plans: N/A				FY 2021 Total
FY 2020 to FY 2021 Increase/Decrease Statement: The funding increase from FY 2020 to FY 2021 is a result of increased investments in Energetic Materials, Hypersonics and Counter Directed Energy Weapons technologies research.				
Title: Basic Research Challenge Description: The ONR Basic Research Challenge (BRC) program was established in 2008 to competitively select and fund promising research programs in new areas not addressed by the current basic research program. The program stimulates new, high-risk basic research projects in multidisciplinary and departmental collaborative efforts, and funds topics that foster leading edge science and attract new principal investigators and organizations. Basic Research Challenge awards are for a period of four years. Topics are submitted by Office of Naval Research (ONR) program officers and are selected for BRC awards. Basic Research Challenge award topics are then issued as a broad agency announcement. Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.		21.562	0.000	0.000
FY 2020 Plans: Beginning in FY 2020, the Basic Research Challenge program resources have been realigned into associated research efforts across the basic research portfolio to better align these resources with Navy Basic Research opportunities and priorities.				
FY 2021 Base Plans: N/A				
FY 2021 OCO Plans:				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020			
Appropriation/Budget Activity 1319 / 1		R-1 Program Element (Number/Name) PE 0601153N / Defense Research Sciences	Project (Number/Name) 0000 / Defense Research Sciences				
B. Accomplishments/Planned Programs (\$ in Millions)			FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
N/A							
Accomplishments/Planned Programs Subtotals			448.266	458.329	467.158	0.000	467.158
C. Other Program Funding Summary (\$ in Millions)							
N/A							
Remarks							
D. Acquisition Strategy							
Not applicable.							

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity 1319 / 1					R-1 Program Element (Number/Name) PE 0601153N / Defense Research Sciences				Project (Number/Name) 9999 / Congressional Adds				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
9999: Congressional Adds	0.000	39.096	5.500	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	44.596	
A. Mission Description and Budget Item Justification Congressional Interest Items not included in other Projects.													
B. Accomplishments/Planned Programs (\$ in Millions)											FY 2019	FY 2020	
Congressional Add: Basic Research											33.787	0.000	
FY 2019 Accomplishments: Conduct basic research efforts including scientific study and experimentation directed toward increasing knowledge and understanding in national security related aspects of physical, engineering, environmental and life sciences. Basic research effort subject areas include: Autonomous Systems; Artificial Intelligence/Machine Learning; Command, Control, Communications and Computers (C4); Marine as a System; Information Analysis and Decision Support; Intelligence, Surveillance and Reconnaissance; Logistics; Materials; Operational Environments; Platforms; Power and Energy Technology; Sensors and Electronics; Warrior Performance and Protection; Weapons and Support (Education and Outreach).													
FY 2020 Plans: N/A													
Congressional Add: Navy ROTC Cybersecurity Training Program											5.309	5.500	
FY 2019 Accomplishments: Explore and implement a collegiate program to train Navy ROTC and civilian students to be able to provide and enhance Naval cybersecurity as military or civilian experts. Funding will also support professorial mentoring and continued education outreach.													
FY 2020 Plans: Explore and implement a collegiate program to train Navy ROTC and civilian students to be able to provide and enhance Naval cybersecurity as military or civilian experts. Funding will also support professorial mentoring and continued education outreach.													
Congressional Adds Subtotals											39.096	5.500	
C. Other Program Funding Summary (\$ in Millions)													
N/A													
Remarks													

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy		Date: February 2020
Appropriation/Budget Activity 1319 / 1	R-1 Program Element (Number/Name) PE 0601153N / Defense Research Sciences	Project (Number/Name) 9999 / Congressional Adds
D. Acquisition Strategy N/A		

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy											Date: February 2020	
Appropriation/Budget Activity					R-1 Program Element (Number/Name)							
1319: Research, Development, Test & Evaluation, Navy / BA 2: Applied Research					PE 0602114N / Power Proj Applied Research							
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	0.000	26.903	28.546	17.792	-	17.792	21.918	23.184	27.440	27.989	Continuing	Continuing
0000: Power Proj Applied Research	0.000	14.354	18.546	17.792	-	17.792	21.918	23.184	27.440	27.989	Continuing	Continuing
9999: Congressional Adds	0.000	12.549	10.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	22.549

A. Mission Description and Budget Item Justification

In an Artificial Intelligence (AI)enabled maritime battlespace, the ability to fight at the speed of light will determine the outcome. The effective defense against threats increasingly beyond human speed, will enable U.S. naval forces to outthink, outmaneuver and outfight adversaries. This Program Element (PE) supports both advanced technology research and near to mid-term transition opportunities. The advanced research focus is primarily on directed energy, high speed weapon propulsion, Electro-Optic/Infrared (EO/IR) sensor technologies, and Naval Precision Strike Operations. The goal of this research is to develop technologies and capabilities that enable Directed Energy (DE) weapons as well as defense against adversary DE systems; the development of vehicle and propulsion technology for high-speed weapons operating from Mach 3 to Mach 8 and beyond; investment in the areas of Electro Optic/Infrared devices and advanced sensors; and technologies that provide the navy of the future the ability to quickly locate, target, and strike critical targets ashore.

Today's Sailors and Marines are enabled by naval Science and Technology (S&T). Since 1946, the Office of Naval Research (ONR) has fostered scientific research related to the maintenance of maritime superiority and national defense. ONR manages the Department of the Navy's (DON) portfolio of naval Basic and Applied research, and Advanced Technology Development investments to ensure naval forces can effectively deter conflict, but when called upon, fight, win and come home safe. Current investments hedge against uncertainty, providing solutions to commanders today, and options for the future. The Naval S&T budget supports higher guidance defined by the National Defense Strategy, and responds to requirements identified by the Secretary of the Navy through research priorities set by the Chief of Naval Research, coordinated across the Naval Research Enterprise (NRE), and outlined in the Naval R&D Framework.

This Program Element (PE) funds Applied Research, which is the systematic study to understand the means to meet a recognized and specific need. Most of the work in this PE can be classified between Technology Readiness Level (TRL) 2 (technology concept and/or application formulation) and TRL 4 (component and/or breadboard validation in laboratory environments).

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy					Date: February 2020
Appropriation/Budget Activity	R-1 Program Element (Number/Name)				
1319: <i>Research, Development, Test & Evaluation, Navy / BA 2: Applied Research</i>	PE 0602114N / <i>Power Proj Applied Research</i>				
B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	27.643	18.546	19.583	-	19.583
Current President's Budget	26.903	28.546	17.792	-	17.792
Total Adjustments	-0.740	10.000	-1.791	-	-1.791
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	10.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.740	0.000			
• Program Adjustments	0.000	0.000	-1.791	-	-1.791
• Rate/Misc Adjustments	0.000	0.000	0.000	-	0.000
Congressional Add Details (\$ in Millions, and Includes General Reductions)	FY 2019	FY 2020			
Project: 9999: <i>Congressional Adds</i>					
Congressional Add: <i>High Performance Microwave for Counter-IED Research</i>	8.688	0.000			
Congressional Add: <i>Directed Energy</i>	3.861	0.000			
Congressional Add: <i>Microwave systems for counter-UAS defense</i>	0.000	10.000			
	Congressional Add Subtotals for Project: 9999				
	Congressional Add Totals for all Projects				
Change Summary Explanation					
Funding: The Program decrease in FY 21 reflects reduced investment in Information Security and Mathematics, Electronics, and Quantum Fundamental research as part of the annual Science and Technology portfolio assessment and realignment.					
Technical: no significant change					
Schedule: no significant change					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020				
Appropriation/Budget Activity 1319 / 2					R-1 Program Element (Number/Name) PE 0602114N / Power Proj Applied Research					Project (Number/Name) 0000 / Power Proj Applied Research					
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost			
0000: Power Proj Applied Research	0.000	14.354	18.546	17.792	-	17.792	21.918	23.184	27.440	27.989	Continuing	Continuing			
A. Mission Description and Budget Item Justification															
In an Artificial Intelligence (AI)enabled maritime battlespace, the ability to fight at the speed of light will determine the outcome. The effective defense against threats increasingly beyond human speed, will enable U.S. naval forces to outthink, outmaneuver and outfight adversaries. This Project supports both advanced technology research and near to mid-term transition opportunities. The advanced research focus is primarily on directed energy, high speed weapon propulsion, electro-optic/infrared (EO/IR) sensor technologies, and Naval Precision Strike Operations. The goal of this research is to develop technologies and capabilities that enable Directed Energy (DE) weapons as well as defense against adversary DE systems; the development of vehicle and propulsion technology for high-speed weapons operating from Mach 3 to Mach 8 and beyond; investment in the areas of Electro Optic/Infrared devices and advanced sensors; and technologies that provide the navy of the future the ability to quickly locate, target, and strike critical targets ashore.															
B. Accomplishments/Planned Programs (\$ in Millions)											FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Directed Energy											6.284	6.427	7.044	0.000	7.044
Description: The goal of this activity is to develop technologies and capabilities that enable Directed Energy (DE) weapons for naval applications as well as defense against adversary Directed Energy systems.															
FY 2020 Plans:															
Component Technologies															
- Conduct research efforts and thrusts in component technologies and basic understanding of laser/material interactions to enable higher power, more lethal High Energy Laser (HEL), high power Microwave/Radio Frequency, and Ultra Short Pulse Laser (USPL) weapons capabilities. Some examples of research include the development of novel laser and beam directory architectures, improved sensor and illuminator technologies including materials and coating, improved HEL electrical to optical efficiency, improved laser sources with enhanced spectrum control, reduced system jitter and improved precision aim point maintenance. Other research areas that will be explored are the syntheses of target recognition, pose/trajectory estimation, autonomous aim point selection and maintenance including tracking through intermittent viewing conditions such as waves and clouds, understanding atmospheric characterization and modeling tools, blooming, laser/material/target interactions, novel laser sources in Medium Wavelength Infrared (MWIR) and the Long Wavelength Infrared, USPL propagations and effects. Research will continue in Counter Directed Energy Weapons (CDEW), in response to the development of HEL and high-power microwave (HPM) and high-power radio frequency															

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602114N / Power Proj Applied Research	Project (Number/Name) 0000 / Power Proj Applied Research				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
threats. Complete effort to develop a fiber based high power laser operating in the eye safe regime beyond 2 microns.						
Electronics - Conduct applied research efforts to apply innovative Science and Technology (S&T) in plasmas, pulsed power, electromagnetic acceleration, particle beams, high-energy & Ultra Short Pulse Lasers, and non-linear optics to support current and future Navy and DoD needs.						
FY 2021 Base Plans: Component Technologies Conduct exploratory research and develop component technologies that enables higher power, more lethal High Energy Laser (HEL), High Power Microwave (HPM) and Ultra Short Pulse Laser (USPL) weapons. Research efforts include: - Development of novel laser and beam-director architectures - Improved sensor and illuminator technologies - Improved HEL electrical-to-optical efficiency - Improved laser sources with enhanced spectrum control - Reduced system jitter and improved precision aim-point maintenance - Improved characterization of atmosphere and associated modeling tools - Improved understanding of blooming and laser/material/target interactions - Development of novel laser sources in MWIR and LWIR - Improved understanding of USPL propagation mechanisms and effects Counter Directed Energy Weapons (CDEW) Conduct exploratory research in response to development of HEL and HPM threats. Research efforts include: - Development of understanding of HPM use in EM Maneuver Warfare and Integrated Defense of US naval forces - Improved understanding of HPM effects and lethality - Improved predictive tools and testing instrumentation						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602114N / Power Proj Applied Research	Project (Number/Name) 0000 / Power Proj Applied Research				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Electronics: To develop and apply innovative S&T in plasmas, pulsed power, electromagnetic acceleration, particle beams, high-energy & ultra-short-pulse lasers (USPL), and non-linear optics to support current and future Navy and DoD needs. - Research efforts include: Adaptive Optics for Nonlinear Atmospheric Propagation of High-Power Laser Pulses and on Multiband Tunable High Power Fiber Laser.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant change between FY 2020 and FY 2021.						
Title: High Speed Propulsion and Advanced Weapon Technologies Description: This activity is focused on applied research to support the development of vehicle and propulsion technology for high-speed weapons operating from Mach 3 to Mach 8 and beyond. The goal is to develop computational, experimental and flight testing capabilities along with the workforce needed to support the development of hypersonic weapons. Research includes: Objectives: - Prediction and control of hypersonic boundary-layers and shock-wave boundary-layer interactions - Development of hypersonic ground test facilities, instrumentation and nonintrusive diagnostics - Prediction of interactions between materials and the high-speed flight environment such as flight through weather and oxidation of thermal protection systems - Development of improved modeling tools to predict the aerothermal and aerodynamic performance of hypersonic weapons over a wide range of velocities and altitudes - Development of ultra-high temperature materials, cooling strategies and thermal protection systems that can survive the launch and flight environment - Development high-speed propulsion technologies such as solid fuel ramjets FY 2020 Plans: Investments to include topics relevant for development of high speed propulsion for solid rocket motors and hybrid type propulsion technologies such as solid-fuel ramjets for greatly enhanced projectile range and missiles. High-speed and hypersonic external aerodynamic technologies will be investigated to support future development efforts to enable hypersonic boost-glide missiles and hypersonic ship-launched projectiles.	3.823	7.774	8.767	0.000	8.767	

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602114N / Power Proj Applied Research	Project (Number/Name) 0000 / Power Proj Applied Research				
<u>B. Accomplishments/Planned Programs (\$ in Millions)</u>		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
	<p>Specific research and development plans include continued development of very long range hypersonic boost-glide missiles and hypersonic ship-launched projectiles; advanced computational and experimental techniques for hypersonic boundary layer transition; high temperature thermal management research; ultra-high temperature materials research for hypersonic leading edges and nose tips; technology maturation of advanced airframes and controls; high G-force components and miniaturization of electronics; advanced guidance and control technologies for high speed weapons; insulator and ablative technology investigations; high speed propulsion and integrated airframe technology development to enhance system range, responsiveness, and reliability; and advanced material solutions to high speed airframes and air systems operating in maritime environments.</p> <p>FY 2021 Base Plans: High Speed Propulsion Technologies Current investments relevant to the development of high-speed propulsion technologies such as solid-fuel ramjets to extend the range of projectiles and missiles will continue. High-speed and hypersonic external aerodynamic technologies such as laminar flow control will be investigated to support future developments to enable hypersonic missiles and hypersonic ship-launched projectiles.</p> <p>New research plans include:</p> <ul style="list-style-type: none"> - Ground experiments and sounding-rocket flight experiments to demonstrate: under relevant conditions, new aeroshell material technology to extend laminar flow - High-fidelity computations, ground test techniques and flow diagnostics to characterize neutral and ionized gas species over the nose-tip region, frustum and wake of ablating hypersonic vehicles - Experimental and computational studies to extend the flight envelope of solid fuel ramjets to higher speeds and altitudes and to improve throttle-ability. <p>FY 2021 OCO Plans: N/A</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: The funding increase from FY 2020 to FY 2021 is associated with an increased concentration on the applied research in the areas of rocket and combined propulsion, warheads and energetic materials and advanced aerodynamics and control concepts.</p>					
Title: Navigation, Electro Optic/Infrared (EO/IR), and Sensor Technologies		2.515	2.596	0.587	0.000	0.587

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602114N / Power Proj Applied Research	Project (Number/Name) 0000 / Power Proj Applied Research				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Description: This activity describes Navy Science and Technology investments in the areas of Electro Optic/ Infrared (EO/IR) devices and advanced sensors and includes investment/performance in the technology areas of EO/IR, Electronic Warfare (EW), Electromagnetic Warfare, and Communications.						
FY 2020 Plans: Electronics: Create and explore new concepts, components, techniques, and subsystems for the detection of Ultra-violet (UV), visible, and infrared radiation to support current and future Navy and DoD needs with attention given to quantum enabled precise time, and magnetic and gravimetric sensing. Electromagnetic Warfare: Multiple efforts will be executed to address the necessary technologies to engage Electro Optic/Infrared threats through both active and passive countermeasures technologies and assuring deployment capabilities are available to achieve the proper disposition of materials for extended durations. Recent results in the application of new material concepts applied to IR concepts have received interest for potential follow on consideration pending successful demonstrations.						
FY 2021 Base Plans: Electronics To develop and explore new concepts, components, techniques, and subsystems for the detection of UV, visible, and infrared radiation to support current and future Navy and DoD needs with attention given to quantum-enabled precise time, and magnetic and gravimetric sensing. Current plans are to focus efforts on: - Solution-Processed Ultra-Sensitive, Room-Temperature Short Wave Infrared/ Mid-Wave Infrared (SWIR/ MWIR) Photodetectors. Electromagnetic Warfare Efforts completing in FY 2021: - Micro-Gas Chromatography with Stationary-Phase Infrared Spectroscopy; Optimize in column planar IR sensor and GC column configuration; Test with range of representative analytes including complex mixture challenges; Include existing IMS or mass spectrometer technology for direct comparison testing; and Demonstrate in						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602114N / Power Proj Applied Research	Project (Number/Name) 0000 / Power Proj Applied Research				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
column planar IR sensor GC sensor to Government program managers and industry for transitions and commercialization.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The decrease in funding from FY 2020 to FY 2021 is due to completion of Micro-Gas Chromatography research and reduced investment in Electromagnetic Warfare related EO/IR technologies.						
Title: Strike and Littoral Combat Technologies Description: The focus of this activity is on those technologies that will support Naval Precision Strike Operations and provide the Navy of the future the ability to quickly locate, target, and strike critical targets ashore.		1.732	1.749	1.394	0.000	1.394
FY 2020 Plans: Electromagnetic Warfare: Technology development is ongoing to address capabilities to understand the defeat mechanism for operations of Intelligence Surveillance and Reconnaissance (ISR) platforms using non-traditional frequencies as well as protecting current capabilities against electronic attack through enhanced concepts. The non-traditional integration of ISR capabilities is being implemented into a major Commercialization Pilot Programs (CPP) funded effort at NRL to validate expectations at minimal cost to this program and expand the capability of a significant testing resource.						
FY 2021 Base Plans: Electromagnetic Warfare The projects in this area are developing technology and techniques to provide the Navy of the future the ability to quickly locate, target, and strike critical targets ashore.						
Current research efforts include: - New high-resolution sensing techniques for emerging USN needs in Maritime ISR to allow 3D imaging through cloud cover - Machine-learning-based resource management for distributed radar system operation to support search and track requirements while minimizing emissions to degrade, defeat, and delay counter targeting.						
Ended in FY20:						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602114N / Power Proj Applied Research	Project (Number/Name) 0000 / Power Proj Applied Research				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
- Developed electronic protection (EP) techniques and algorithms to enable surveillance, imaging, and targeting in EW denied areas.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The decrease in funding from FY 2020 to FY 2021 is due to the Electronic Protection technologies effort completing in FY20.						
Accomplishments/Planned Programs Subtotals		14.354	18.546	17.792	0.000	17.792
C. Other Program Funding Summary (\$ in Millions)						
N/A						
Remarks						
D. Acquisition Strategy						
N/A						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity 1319 / 2					R-1 Program Element (Number/Name) PE 0602114N / Power Proj Applied Research				Project (Number/Name) 9999 / Congressional Adds				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
9999: Congressional Adds	0.000	12.549	10.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	22.549	
A. Mission Description and Budget Item Justification													
Congressional Interest Items not included in other Projects.													
B. Accomplishments/Planned Programs (\$ in Millions)											FY 2019	FY 2020	
<i>Congressional Add:</i> High Performance Microwave for Counter-IED Research											8.688	0.000	
<i>FY 2019 Accomplishments:</i> Funds will be used towards the isolating/determining High Power Microwave (HPM) waveform spaces that enable control over desired levels-of-lethality on small Unmanned Aerial Vehicle (sUAV) and similar targets, with the least power density, to drive development of transitional HPM sources and electronically steerable radiators.													
<i>FY 2020 Plans:</i> N/A													
<i>Congressional Add:</i> Directed Energy											3.861	0.000	
<i>FY 2019 Accomplishments:</i> Develop advanced components for use in Directed Energy applications.													
<i>FY 2020 Plans:</i> N/A													
<i>Congressional Add:</i> Microwave systems for counter-UAS defense											0.000	10.000	
<i>FY 2019 Accomplishments:</i> N/A													
<i>FY 2020 Plans:</i> Conduct applied research for Microwave systems for counter-UAS defense													
Congressional Adds Subtotals											12.549	10.000	
C. Other Program Funding Summary (\$ in Millions)													
N/A													
Remarks													
D. Acquisition Strategy													
N/A													

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy											Date: February 2020	
Appropriation/Budget Activity					R-1 Program Element (Number/Name)							
1319: Research, Development, Test & Evaluation, Navy / BA 2: Applied Research					PE 0602123N / Force Protection Applied Res							
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	0.000	175.857	215.517	122.281	-	122.281	124.750	127.298	129.854	132.450	Continuing	Continuing
0000: Force Protection Applied Res	0.000	121.314	119.517	122.281	-	122.281	124.750	127.298	129.854	132.450	Continuing	Continuing
9999: Congressional Adds	0.000	54.543	96.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	150.543

A. Mission Description and Budget Item Justification

America is a maritime nation with global responsibilities that require U.S. naval forces be respected around the world and decisive when it matters. The Office of Naval Research (ONR) was established to guide ongoing research to ensure the technical superiority of the U.S. Navy and Marine Corps. This Program Element (PE) addresses applied research associated with providing the capability of Platform and Force Protection for the U.S. Navy. This program supports the development of technologies associated with all naval platforms (surface, subsurface, terrestrial, and air) and the protection of those platforms. The goal is to provide the ability to deter, or avoid engagements, and if necessary, fight and win against adversary naval platforms or weapons. In the event of conflict, naval platforms must be able to resist and control damage while preserving operational capability. Research is focused on providing technologically superior defense of naval assets and delivering warfighting capabilities at reduced total ownership costs for surface and subsurface platforms through investments in applied research in: a) Power, Energy & Propulsion and b) Platform Design and Engineering. This program develops technologies for reduced observables technology and enhanced capability of naval aviation aircraft platforms in terms of mission effectiveness, platform range, responsiveness, survivability, observability, readiness, safety and life cycle cost. The program addresses technology development to provide substantial improvements in energetic material systems and subsystems, primarily in terms of performance, but also addressing safety, reliability, and affordability concerns. The program supports mission-driven problem solving within the Naval Research and Development Establishment (NR&DE) through agile and rapid prototyping processes, while also promoting implementation of a common, effective innovation process and language.

Today's Sailors and Marines are enabled by naval Science and Technology (S&T). Since 1946, the Office of Naval Research (ONR) has fostered scientific research related to the maintenance of maritime superiority and national defense. ONR manages the Department of the Navy's (DON) portfolio of naval Basic and Applied research, and Advanced Technology Development investments to ensure naval forces can effectively deter conflict, but when called upon, fight, win and come home safe. Current investments hedge against uncertainty, providing solutions to commanders today, and options for the future. The Naval S&T budget supports higher guidance defined by the National Defense Strategy, and responds to requirements identified by the Secretary of the Navy through research priorities set by the Chief of Naval Research, coordinated across the Naval Research Enterprise (NRE), and outlined in the Naval R&D Framework.

This Program Element (PE) funds Applied Research, which is the systematic study to understand the means to meet a recognized and specific need. Most of the work in this PE can be classified between Technology Readiness Level (TRL) 2 (technology concept and/or application formulation) and TRL 4 (component and/or breadboard validation in laboratory environments).

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy					Date: February 2020
Appropriation/Budget Activity	R-1 Program Element (Number/Name)				
1319: Research, Development, Test & Evaluation, Navy / BA 2: Applied Research	PE 0602123N / Force Protection Applied Res				
B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	180.549	119.517	119.535	-	119.535
Current President's Budget	175.857	215.517	122.281	-	122.281
Total Adjustments	-4.692	96.000	2.746	-	2.746
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	96.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-4.692	0.000			
• Program Adjustments	0.000	0.000	2.746	-	2.746
• Rate/Misc Adjustments	0.000	0.000	0.000	-	0.000
Congressional Add Details (\$ in Millions, and Includes General Reductions)	FY 2019	FY 2020			
Project: 9999: Congressional Adds					
Congressional Add: Alternative Energy Research	27.030	0.000			
Congressional Add: Power Generation and Storage Research	4.827	5.000			
Congressional Add: Hybrid Composite Structures Research for Enhanced Mobility	4.827	5.000			
Congressional Add: Standoff Detection of Buried Hazards	2.896	0.000			
Congressional Add: Advanced Energetics Research	7.240	10.000			
Congressional Add: Advanced Hull Form Development and Demonstration	7.723	0.000			
Congressional Add: Electric propulsion for military craft and advanced planing hulls	0.000	5.000			
Congressional Add: Test bed for autonomous ship systems	0.000	4.000			
Congressional Add: Talent and technology for Navy power and energy systems	0.000	9.500			
Congressional Add: Compact high flow fan	0.000	4.000			
Congressional Add: Network cyber security and resiliency	0.000	4.000			
Congressional Add: Navy alternative energy research, development, testing and deployment	0.000	20.000			
Congressional Add: Data-model fusion for naval platforms and systems	0.000	5.000			
Congressional Add: Blue carbon capture/direct air capture	0.000	8.000			
Congressional Add: Energy resilience efforts	0.000	8.000			

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy		Date: February 2020
Appropriation/Budget Activity 1319: <i>Research, Development, Test & Evaluation, Navy / BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602123N / <i>Force Protection Applied Res</i>	
Congressional Add Details (\$ in Millions, and Includes General Reductions)		FY 2019 FY 2020
Congressional Add: <i>Coastal environmental research</i>		0.000 5.000
Congressional Add: <i>Platform reliability and advanced technical research</i>		0.000 3.500
	Congressional Add Subtotals for Project: 9999	54.543 96.000
	Congressional Add Totals for all Projects	54.543 96.000
Change Summary Explanation		
Funding: The program increase is due to increased programmed investment in 3D airborne imaging and unmanned undersea technologies.		
Technical: no significant change		
Schedule: no significant change		

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020	
Appropriation/Budget Activity					R-1 Program Element (Number/Name)				Project (Number/Name)			
1319 / 2					PE 0602123N / Force Protection Applied Res				0000 / Force Protection Applied Res			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
0000: Force Protection Applied Res	0.000	121.314	119.517	122.281	-	122.281	124.750	127.298	129.854	132.450	Continuing	Continuing
A. Mission Description and Budget Item Justification												
America is a maritime nation with global responsibilities that require U.S. naval forces be respected around the world and decisive when it matters. The Office of Naval Research (ONR) was established to guide ongoing research to ensure the technical superiority of the U.S. Navy and Marine Corps. This project addresses applied research associated with providing the capability of Platform and Force Protection for the U.S. Navy. It supports the development of technologies associated with all naval platforms (surface, subsurface, terrestrial, and air) and the protection of those platforms. The goal is to provide the ability to deter, or avoid engagements, and if necessary, fight and win against adversary naval platforms or weapons. In the event of conflict, naval platforms must be able to resist and control damage while preserving operational capability. Research is focused on providing technologically superior defense of naval assets and delivering warfighting capabilities at reduced total ownership costs for surface and subsurface platforms through investments in applied research in: a) Power, Energy & Propulsion and b) Platform Design and Engineering. This program develops technologies for reduced observables technology and enhanced capability of naval aviation aircraft platforms in terms of mission effectiveness, platform range, responsiveness, survivability, observability, readiness, safety and life cycle cost. The program addresses technology development to provide substantial improvements in energetic material systems and subsystems, primarily in terms of performance, but also addressing safety, reliability, and affordability concerns.												
B. Accomplishments/Planned Programs (\$ in Millions)												
						FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total		
Title: Aircraft Technology						35.419	35.882	35.889	0.000	35.889		
Description: The Aircraft Technology activity develops technologies for reduced observables technology and enhanced capability of naval aviation aircraft platforms in terms of mission effectiveness, platform range, responsiveness, survivability, observability, readiness, safety and life cycle cost. It also develops new Naval air vehicle concepts and high impact, saleable naval air vehicle technologies, such as - autonomous air vehicle command and control, helicopter and tilt rotor systems, aerodynamics, propulsion systems, materials, structures and flight controls for future and legacy air vehicles.												
Variable Cycle Advanced Technology (VCAT) Program will identify and mature critical, relevant propulsion system technologies that enable the Next Generation Air Dominance (NGAD) carrier-based aircraft. The Sea-Based Aviation National Naval Responsibility (SBA NNR) Structures and Materials program will develop the next generation structural capability and material response science for aircraft technology in fixed and rotary wing, manned and unmanned airframe technology to achieve reduced weight, increased durability, strength, streamlined manufacturability, reduced life-cycle cost and maintenance/readiness gaps improvements.												

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602123N / Force Protection Applied Res	Project (Number/Name) 0000 / Force Protection Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Program payoffs include increased availability/readiness, reduced sustainment requirements, fatigue/loads life enhancement, reduced weight and improved range, and advanced prognostics design tools.						
These efforts address unique attributes to propulsion and power technologies for Naval Aviation, as well as those having higher importance to Naval Aviation and some that are more pervasive to all of military aviation. Related basic research efforts are addressed under 0601153N Defense Research Sciences.						
FY 2020 Plans: Conduct ongoing research related to Sea Based Aviation National Naval Responsibility (SBA NNR) priorities in Aviation, Propulsion, and Structures and Materials. Ongoing research in Aircraft Technology, examples of research/efforts include Virtual Ship/Aircraft Dynamic Interface, Manned/Unmanned Handling Qualities and Control, Automated Deck Operations, High Lift Aerodynamics and Vertical/Short Take-off and Landing (V/STOL) Operations, the development of rotorcraft/Vertical Take-Off and Landing (VTOL) systems automated launch and recovery technology and mechanical/ environmental failure prediction research. Examples of ongoing research in Propulsion include the Variable Cycle Advanced Technology (VCAT) Program. Major engine manufacturers and system contractors will develop/mature the highest priority, long-lead propulsion system technologies, including variable/adaptive cycle engine components, for next generation carrier-based Tactical Aircraft (TACAIR) systems. Ongoing research in Structures and Materials include: advanced composite durability technology; new materials development; process-property relationship analysis; improved material selection tools; structural life prediction; multi-functional surfaces; and structural optimization for reducing structural weight. Methods to expanding material degradation risk prediction and operational environment-driven materials selection methods will be created. Examples of ongoing research related to Autonomy include: high confidence/Safe Autonomous Control in naval environments and on supervisory control of decentralized heterogeneous Unmanned Aircraft Systems (UAS). Expand efforts on safe-perception based autonomous control in complex naval environments and on autonomy to support combined unmanned and manned air systems/units. Specific efforts in FY 2020 include:						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602123N / Force Protection Applied Res	Project (Number/Name) 0000 / Force Protection Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Efforts to mature Integrated Propulsion, Power and Thermal Management System technologies to an appropriate level to meet the next generation TACAIR Technology Maturation Readiness Review notional plan and schedule. Investigate technologies that could increase engine efficiency, power and aircraft range including engine inlet distortion control, turbomachinery and drive systems optimization, high temperature engine materials and coatings, engine compressor casing treatments and advanced thermal management and transport systems.	Flight Dynamics & Control analysis and scaled experiments to demonstrate knowledge fundamental aspects of phenomena associated with multibody control systems with a focus on the ability to demonstrate guaranteed performance relative to a desired end state. Demonstrate algorithms and technology to enable precise ship-relative navigation in GPS-denied environments.					
Aerodynamics research to demonstrate a new method for in situ measurement if ship airwake dynamics. Demonstrate a leap forward in the capability to run real-time simulations of the coupled aerodynamics involved in ship-based recovery of rotary wing aircraft in order to advance the capability of piloted simulations and increase their effectiveness as training tools.	High Fidelity Composite Characterization for Rapid Certification of Advanced Structures - application of previously developed advanced characterization methods for current and emerging next generation Composites. This data will feed rapid certification through advanced damage modeling and failure predictions. Advanced Galvanic Compatibly Theory for Operationally Optimized Material Selection - validation and transition of novel compatibility theory to improve material selection and design in vehicle sustainment and life extension.					
FY 2021 Base Plans: Research related to Sea Based Aviation National Naval Responsibility (SBA NNR) priorities in Aviation, Propulsion, and Structures and Materials. Research in Aircraft Science & Technology include: - Advanced analytical methods for achieving guaranteed performance in multibody control systems. - Control law synthesis methods to expand the recovery envelope and reduce touchdown loads. - Advanced modeling and analysis methods for ship/aircraft aerodynamic interface.						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602123N / Force Protection Applied Res	Project (Number/Name) 0000 / Force Protection Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
- Air vehicle flying qualities and control.						
- High lift aerodynamics and control.						
- Vertical/Short Take-off and Landing (V/STOL) science & technology.						
- Automated launch and recovery technology.						
- Mechanical/environmental failure prediction research.						
Basic and applied research in Flight Dynamics & Control will develop theory, analysis and experimental data to better understand and exploit the natural dynamics of air vehicles operating in the marine environment.						
Focus areas in Flight Dynamics & Control include:						
- Multibody control systems and the ability to demonstrate guaranteed performance relative to a desired end state.						
- Robust and precise control in the presence of highly turbulent flow fields to increase operational capability and reduce structural requirements for ship-based operations;						
- Algorithms and sensors to enable precise ship-relative navigation in GPS-denied environments;						
- Control effectors and vehicle configurations to enable platforms with VTOL utility and fixed-wing efficiency.						
- Additionally, collaborative research will improve our knowledge of control system interactions between piloted aircraft and human performance.						
Basic and applied Aerodynamics research will include:						
-New methods for in situ measurement of ship airwake dynamics;						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602123N / Force Protection Applied Res	Project (Number/Name) 0000 / Force Protection Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
-Advanced computational methods addressing the Navy-unique challenge of a fully coupled aerodynamic interface between ships and aircraft; -Advanced methods for reduced-order modeling of complex flow fields to enable real-time, high-fidelity simulations of ship-based aircraft operations; -Advanced methods for manipulating and more precisely controlling the flow fields around air vehicles operating in the maritime environment. Applied research in aircraft Propulsion and Power concepts for high speed, long endurance and responsiveness include: -High stage-loading and efficient Turbomachinery; -Cooling and thermal management for engines and auxiliary systems; -Advanced materials and coatings; -Diagnostics and control for Integrated Power, Propulsion and Thermal Management; -Highly integrated Propulsion inlets, exhausts, and Dust Ingestion research: including modeling, separating, deposition, coatings and sensing. -Next Generation Air Dominance Enabler applied research in aircraft engine advanced casing treatments, advanced compression system technologies and engine robustness in austere sand and salt environments. Research related to Autonomy include: -High confidence/Safe Autonomous Control in naval environments and on supervisory control of decentralized heterogeneous Unmanned Aircraft Systems (UAS).						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602123N / Force Protection Applied Res	Project (Number/Name) 0000 / Force Protection Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<p>-Expand efforts on new theory-based methods and processes for rapid and safe adoption of new autonomy capabilities including Verification and Validation, safety, and robustness within complex naval, adversarial environments.</p> <p>-Expand efforts on safe-perception based autonomous control in complex naval environments and on autonomy to support combined unmanned and manned air systems/units.</p> <p>Structures and Materials Research:</p> <p>-High Fidelity Composite Characterization for Rapid Certification of Advanced Structures: application of previously developed advanced characterization methods for current and emerging next generation Composites. This data will feed rapid certification through advanced damage modeling and failure predictions.</p> <p>-Advanced Galvanic Compatibly Theory for Operationally Optimized Material Selection: validation and transition of novel compatibility theory to improve material selection and design in vehicle sustainment and life extension.</p> <p>-Structural Remediation: materials and processes for extending and restoring structural material operational life via advanced repair and remanufacturing process research and development.</p>						
<p>FY 2021 OCO Plans: N/A</p>						
<p>FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant funding change from FY 2020 to FY 2021.</p>						
<p>Title: Fleet Force Potection and Defense Against Undersea Threats</p> <p>Description: Fleet Force Protection and Defense against Undersea Threats efforts include applied research for complementary sensor and processing technologies for platform protection. Current small platforms (both surface and airborne) have little to no situational awareness (SA) or self-protection against air, surface, and asymmetric threats. A goal of this activity is to provide these platforms with effective self-protection. The technology areas specific to platform protection will develop individual, multispectral electro-optical (EO), infrared (IR), radio frequency (RF), electro-magnetic (EM), visual and acoustic or chemical sensors/ biosensors and associated processing. To defend platforms from current and advanced threats in at-sea littoral</p>		5.775	5.834	9.010	0.000	9.010

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602123N / Force Protection Applied Res	Project (Number/Name) 0000 / Force Protection Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
	environments and in port, these technologies must improve multispectral detection and distribution of specific threat information.					
FY 2020 Plans: Sensors and Associated Processing: Develop a new 3D ISAR capability for moving targets in air, space, ground, and sea to allow better target recognition. Materials and Chemistry: Design and develop, utilizing room temperature ionic liquids, to demonstrate and fabricate inexpensive, miniaturized, low power electrochemical sensors for use in autonomous as well as distributed sensor networks. Develop real time, standoff, moving target, laser based detection for explosives and hazardous chemicals with the intent of shifting the paradigm of trace chemical detection through surface contact swabbing to a faster, more flexible wide area, standoff method for significant enhancement of force protection. Develop and design a new class of safe high performance rechargeable zinc air batteries to supplant state of lithium-ion batteries. Development of chemical vapor sensing strategy for application in marine environment, significantly different than terrestrial environment. Significant accomplishments include performance demonstration of highly sensitive electrochemical detection elements incorporated into electronic integrated circuits. Demonstration of high efficiency of zinc sponge anode in an electrochemical cell. Undersea Warfare: Conceptualize and perform laboratory and field studies to: develop acoustics technology and associated signal processing for the detection of small Unmanned Aerial Vehicles (UAVs); and the development of a pressure tolerant, inexpensive hydrogen storage based on hydrogenated graphene to increase undersea storage capacity.						
FY 2021 Base Plans: Electromagnetic Warfare (formerly Sensors and Associated Processing): - Research conducted by one project in this area provides an increase in the performance of airborne imaging radars by developing a 3D imaging capability for maritime applications. The objective is to develop a new 3D ISAR capability for moving targets to allow better target recognition with reduced time-on-target for reduced platform vulnerability and improved speed and accuracy to discriminate threat from non-threat targets. Materials and Chemistry:						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602123N / Force Protection Applied Res	Project (Number/Name) 0000 / Force Protection Applied Res				
<u>B. Accomplishments/Planned Programs (\$ in Millions)</u>		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
- Design and develop inexpensive, miniaturized, low power electrochemical sensors for use in autonomous and distributed sensor networks. Develop real time, standoff, moving target, laser based detection for explosives and hazardous chemicals. Development of chemical vapor sensing strategy for application in marine environment. Development of ultra-high strength sintered ceramics for significant improvements in personnel protection and platform survivability.						
- Current plans focus efforts on use of metal oxide nanoparticle functionalization of graphene conductometric devices to detect sulfur compounds in vapor and liquid phase aviation; establishing a new paradigm for tunable substrates for efficient sample preconcentration (sensitivity enhancement) and partial separations (selectivity enhancement); and fabrication and optimization of chemical vapor sensor devices made from large-area chemical vapor deposition grown transition metal dichalcogenide films and demonstrate that they can be used to create a chemical sensor array that can identify particular chemical analytes of importance to nerve gas/explosive detection by creating particular opto-electronic fingerprint for each analyte.						
Undersea Warfare:						
- Developing acoustics technology and associated signal processing to detect and track small-unmanned aerial vehicles for force and infrastructure protection. Development of a pressure tolerant, inexpensive hydrogen storage based on hydrogenated graphene to increase undersea storage capacity. Development of technologies for active control of acoustic scattering to increase stealth and survivability of unmanned undersea vehicles.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The increase from FY 2020 to FY 2021 is due to increased investment in 3D airborne imaging and unmanned undersea technologies.						
Title: Advanced Energetics		5.497	5.380	5.382	0.000	5.382
Description: Advanced Energetics efforts address technology development to provide substantial improvements in energetic material systems and subsystems, primarily in terms of performance, but also addressing safety, reliability, and affordability concerns. Goals include: advanced energetic materials for warheads, propellants, and reactive material based subsystems for both defensive and offensive applications. Efforts include:						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602123N / Force Protection Applied Res	Project (Number/Name) 0000 / Force Protection Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
	development of new fuels, oxidizers, explosive ingredients and formulations; and reliable simulation tools and diagnostics to develop and design superior-performance, and/or reduced-vulnerability systems tailored to specific warfighter missions.					
FY 2020 Plans: Conduct research related to Advanced Energetics including development and evaluation of advanced explosive/propellant/reactive ingredients and formulations for the next generation higher performing systems. Conduct research in proof of concept efforts to develop insensitive explosives, propellants, and munitions without compromising performance. This work involves development of high quality, small particle energetic ingredients, novel processing techniques, and advanced energy conversion concepts; and involves both theoretical and experimental efforts. Conduct research focused on chemical processing technologies. Incorporate molecular design and crystal morphology technology into scale-up and process development. New compliant commodity energetic ingredients will be transitioned to the industrial base as appropriate. Conduct research in development and diagnostics of novel energy conversion concepts to enhance performance, more efficiently exploit available energy, and more effectively couple energy to target for air, surface, and underwater warhead application.						
FY 2021 Base Plans: - Conduct applied research related to Advanced Energetic materials with a focus on higher tactical weapon performance including speed, range, and overall lethality in addition to proof of concept efforts to develop insensitive explosives, propellants, and munitions without compromising performance.						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy			Date: February 2020			
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602123N / Force Protection Applied Res	Project (Number/Name) 0000 / Force Protection Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<ul style="list-style-type: none"> - Research areas include development and evaluation of advanced explosive/propellant/reactive composite ingredients and formulations for the next generation higher performing systems in addition to novel manufacturing/chemical processing/scale-up technologies and process development efforts. This work involves development of high quality, small particle energetic and other formulation-enabling ingredients, novel processing techniques, and advanced energy conversion concepts, and involves both multi-scale theoretical and various dynamic diagnostic experimental efforts. - Conduct research focused on ingredient chemistry and chemical processing technologies, and incorporate molecular design and crystal morphology technology into scale-up and process development. New compliant commodity energetic ingredients will be transitioned to the industrial base as appropriate. - Conduct research in development and application of experimental diagnostics of novel energy conversion concepts to enhance performance, more efficiently exploit available energy, and more effectively couple energy to target for air, surface, and underwater warhead and propulsion applications. - Conduct research in development and application of modeling and simulation to predict dynamic response and effects of energetic processes such as ignition, combustion/deflagration, shock, fragmentation, and detonation in order to predict weapon performance, lethality, and lifecycle for air, surface, and underwater weapon applications. 						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant funding change from FY 2020 to FY 2021.						
Title: Surface Ship and Submarine Hull Mechanical and Electrical (HM&E) Description: Technology programs focused on providing technologically superior warfighting capabilities at reduced total ownership costs for surface and subsurface platforms through investments in applied research and advanced technology development of programs in: a) Power, Energy & Propulsion and b) Platform Design and Engineering. This element also includes the National Naval Responsibility in Naval Engineering (NNR-NE). Specific research themes are: Power, Energy and Propulsion Technology:		70.037	67.859	67.438	0.000	67.438

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602123N / Force Protection Applied Res	Project (Number/Name) 0000 / Force Protection Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Efforts address electrical and auxiliary system and component technology to dramatically improve energy and power density, operating efficiency, and recoverability from casualties. A major investment focus is providing the power and energy required for directed energy weapons on current and future surface combatants.	Platform Design and Engineering Technology: This project includes the following efforts: <ul style="list-style-type: none">- Hydrodynamics: Critical platform design for surface ships hydrodynamics that is focused on the theory, computation, and lab and at-sea experimentation to develop understanding and prediction capabilities for all hydrodynamic phenomena associated with surface ships and small craft, their effects on vessel performance, and concepts for modification.- Platform Structures: Focused on time-varying, structural reliability analysis and prediction for a ship structural system with uncertainty quantification and propagation.- Unmanned Surface Vehicles (USV): Autonomy for USVs and related mission functions aligned with Naval S&T strategic focus on autonomy and unmanned vehicles.- Sea Platform Survivability Technology: Aligned with survivability S&T strategic focus area, research investigates electromagnetic (EM) sources (including major ferro and non-ferromagnetic sources, eddy currents, and Corrosion Related Magnetic Fields (CRM)) that are associated with naval platforms.					
FY 2020 Plans: Advanced Naval Power and Energy Systems Research and Technology: Advanced energy systems research includes a significant research program with the Hawaii Natural Energy Institute (HNEI) at the University of Hawaii that is focused on the analysis and optimization of resilient electrical grids and microgrids in the Pacific region. Prior and on-going research has demonstrated the ability of advanced batteries and other power management technologies to greatly enhance the stability and reliability of electrical grids possessing high penetrations of variable renewable energy resources. Results from these demonstrations will be used to evaluate and increase the energy resiliency of critically infrastructures on DOD installations in the Pacific. The HNEI program has also initiated a new collaboration with the Alaska Center for Energy and Power (ACEP) at the University of Alaska Fairbanks to explore the use of energy storage technologies and distributed energy resources to enhance the energy resiliency of microgrids at remote locations and at DOD facilities in cold weather environments.						

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Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602123N / Force Protection Applied Res	Project (Number/Name) 0000 / Force Protection Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
To support both new and existing surface ship and submarine programs, specific new and ongoing efforts are aimed at supporting electrical system reliability, as well as advanced power distribution and control and will utilize the Electric Ship Research and Development Consortium (ESRDC) to develop modeling and simulation tools, system analysis tools and models to provide critical design and operational capabilities for the all-electric ship program, accelerate development and demonstration of technologies, and to reduce risk of technology insertion. These efforts also address the national shortage of naval electrical power engineers.						
Ongoing research related to the Next Generation Integrated Power System (NGIPS) and Distribution/Control of Power Advanced Power Systems with a focus on power and energy requirements for directed energy weapons and advance sensor systems on current and future surface combatants, as well as for unmanned naval platforms.						
Advanced Sea Platform Technology:						
New and ongoing applied research related to critical S&T that supports platform design and advanced capability efforts related to propulsor, surface, and subsurface hydrodynamics; platform performance, and platform structural reliability. Specifically, efforts to utilize advanced analytics (machine learning and artificial intelligence), incorporate environmental effects on platform performance, research related to advancing unmanned sea surface vessel technologies and capabilities. Specific naval engineering and platform design efforts to support set-based design for the Next Generation Attack Submarine SSN(X), and efforts to mitigate technology and susceptibility risk for the COLUMBIA class submarine program and the Future Surface Combatant Force.						
Sea Platform Survivability Technology:						
New and ongoing applied research related to critical S&T to investigate efforts related to signature reduction; structural and machinery acoustics; machinery autonomy; and platform survivability (detectability and susceptibility); and acoustic and non-acoustic signatures. Specifically, efforts utilizing advanced analytics (machine learning and artificial intelligence) and the integration of environmental effects on platform performance and detectability, Specific naval engineering and platform design efforts to support the Next Generation Attack Submarine SSN(X), and efforts to mitigate technology and susceptibility risk for the COLUMBIA class submarine program and the Future Surface Combatant Force. Ongoing base program efforts, initiated in FY 2018 and FY 2019, include ocean surface scatter in RF propagation, wake measurement technologies, thermal management						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
1319 / 2	PE 0602123N / Force Protection Applied Res					
systems, high power control modules for ship application, decision support/uncertainty analysis in operational environments, and reactive composite materials.						
Submarine Security S&T New and ongoing research efforts focused on the science and physics based signal detection technologies that, individually or as a system, can impact the security of the SSBN and submarines in general. Efforts looking at both passive and active detection technologies with near term (0-5 years), mid-term (5-10 years) and far term (10-20 years) implications, as well as improving the understanding of the generation, radiation, propagation, scatter, and detection of a variety of signal types (acoustic, chemical, optical, electromagnetic, hydrodynamic and radiological) associated with a submarine's operation.						
Autonomy Technology: Ongoing research related to critical multidisciplinary autonomy challenges that cut across areas/domains, including air, sea, undersea and ground. This includes multi-disciplinary research into the science of autonomy focuses on four interrelated areas: scalable and robust distributed collaboration among autonomous systems; human/unmanned system collaboration; autonomous perception and intelligent decision-making; and intelligent architectures for autonomous systems. Continue research to develop and test autonomy for Medium Displacement Unmanned Surface Vehicle (MDUSV) missions including perception and classification. Ongoing efforts, initiated in FY 2018 and FY 2019, include network information sciences, long-range high-resolution imaging, and decision support/uncertainty analysis for operational environments. In particular, continue research to develop and test autonomy for Unmanned Undersea Vehicle (UUV) missions including understanding of counter-UUV autonomy options; implementations and testing. Autonomy development involving a shared world model and sensor feedback will continue. Extensive in-water testing will continue.						
FY 2021 Base Plans: Power, Energy and Propulsion Technology (covers efforts previously called Advanced Naval Power and Energy Systems Research and Technology): - Advanced energy systems research focused on the analysis and optimization of resilient electrical grids and microgrids in the Pacific and across DON critical mission areas. Prior and on-going research has demonstrated the ability of advanced batteries and other power management technologies to greatly enhance the stability and reliability of electrical grids. Results from these demonstrations will be used to evaluate and increase the energy						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602123N / Force Protection Applied Res	Project (Number/Name) 0000 / Force Protection Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
resiliency of critically infrastructures on DON installations. Efforts include enhancing collaborations across academia, industry and DON beneficiaries.	- To support both new and existing surface ship and submarine programs, specific new and ongoing efforts are aimed at supporting electrical system reliability, as well as advanced power distribution and control and will utilize the Electric Ship Research and Development Consortium (ESRDC) to develop modeling and simulation tools, system analysis tools and models to provide critical design and operational capabilities for the all-electric ship program, accelerate development and demonstration of technologies, and to reduce risk of technology insertion. These efforts also address the national shortage of naval electrical power engineers. - Next Generation Integrated Power System (NGIPS) and Distribution/Control of Power Advanced Power Systems: focus on power and energy requirements for directed energy weapons and advance sensor systems on current and future surface combatants, as well as for unmanned naval platforms. Platform Design and Engineering Technology (covers efforts previously called Advanced Sea Platform Technology, Sea Platform Survivability Technology, Submarine Security S&T and Autonomy Technology): - Conduct applied research related to critical S&T that supports platform design and advanced capability efforts related to propulsor, surface, and subsurface hydrodynamics; platform performance, and platform structural reliability. Specifically, efforts to utilize advanced analytics (machine learning and artificial intelligence), incorporate environmental effects on platform performance, research related to advancing unmanned sea surface vessel technologies and capabilities. Specific naval engineering and platform design efforts to support set-based design for the Next Generation Attack Submarine SSN(X), and efforts to mitigate technology and susceptibility risk for the COLUMBIA class submarine program and the Future Surface Combatant Force. - Conduct applied research related to critical S&T to investigate efforts related to signature reduction; structural and machinery acoustics; machinery autonomy; and platform survivability (detectability and susceptibility); and acoustic and non-acoustic signatures. Specifically, efforts utilizing advanced analytics (machine learning and artificial intelligence) and the integration of environmental effects on platform performance and detectability, Specific naval engineering and platform design efforts to support the Next Generation Attack Submarine SSN(X), and efforts to mitigate technology and susceptibility risk for the COLUMBIA class submarine program and the Future Surface Combatant Force. Ongoing base program efforts, initiated in FY 2018 and FY 2019, include ocean surface scatter in RF propagation, wake measurement technologies, thermal management systems, high					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602123N / Force Protection Applied Res	Project (Number/Name) 0000 / Force Protection Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
power control modules for ship application, decision support/uncertainty analysis in operational environments, and reactive composite materials.	- Conduct research efforts focused on the science and physics based signal detection technologies that, individually or as a system, can impact the security of the SSBN and submarines in general. Efforts looking at both passive and active detection technologies with near term (0-5 years), mid-term (5-10 years) and far term (10-20 years) implications, as well as improving the understanding of the generation, radiation, propagation, scatter, and detection of a variety of signal types (acoustic, chemical, optical, electromagnetic, hydrodynamic and radiological) associated with a submarine's operation. - Ongoing research related to critical multidisciplinary autonomy challenges that cut across areas/domains, including air, sea, undersea and ground. This includes multi-disciplinary research into the science of autonomy focuses on four interrelated areas: scalable and robust distributed collaboration among autonomous systems; human/unmanned system collaboration; autonomous perception and intelligent decision-making; and intelligent architectures for autonomous systems. Ongoing efforts, initiated in FY 2018 and FY 2019, include network information sciences, long-range high-resolution imaging, and decision support/uncertainty analysis for operational environments. In particular, continue research to develop and test autonomy for Unmanned Undersea Vehicle (UUV) missions including understanding of counter-UUV autonomy options; implementations and testing. Autonomy development involving a shared world model and sensor feedback will continue. Extensive in-water testing will continue. Spectrum Superiority: - Continuing research efforts for passive and active long-range high-resolution detection and imaging for increased survivability and situational awareness even in degraded/contested environments. - Demonstrate portable distributed multi-domain sensor and surveillance technologies in portable expeditionary warfare form factor to protect forces in denied and contested EM environments. Reduce size of electronic warfare devices into handheld form factor to counter advanced threats. Electronics:					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy			Date: February 2020		
Appropriation/Budget Activity 1319 / 2		R-1 Program Element (Number/Name) PE 0602123N / Force Protection Applied Res		Project (Number/Name) 0000 / Force Protection Applied Res	
B. Accomplishments/Planned Programs (\$ in Millions)					
FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	
- Develop and explore new high voltage, high efficiency wide bandgap and ultra-wide bandgap power switches for electric propulsion and electric weapons. Current plans are to focus efforts on: Pioneering Vertical GaN High Power Switches; and Ultra-Wide Bandgap Gallium Oxide Power Device Transformative Integrated GaN Power Technology Platform.					
Materials and Chemistry: - Design and demonstrate a rechargeable Zn-air battery with pulse-power capability that incorporates a Zn sponge anode and trifunctional air cathodes. The resulting rechargeable Zn-air battery prototype will validate a new class of safe, high-performance, rechargeable Zn-air batteries that will provide attractive options for future military and civilian applications.					
Undersea Warfare: - Conduct research to reduce the time and cost for Submarine hull inspections by creating technologies for non-destructive evaluation (NDE) of submerged elastic surfaces coated with highly absorptive layers.					
FY 2021 OCO Plans: N/A					
FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant funding change from FY 2020 to FY 2021.					
Title: Naval Research Enterprise Description: The Naval Research Enterprise (NRE) supports mission-driven problem solving within the Naval Research and Development Establishment (NR&DE) through agile, rapid prototyping processes, while also promoting implementation of a common, effective innovation process and language. Adopting a common innovation process stimulates effective NR&DE-wide collaborations and facilitates NR&DE-wide sharing and implementation of best practices to accelerate the delivery of innovative capabilities to the warfighter. Activities are based on three foundational principles: (1) utilize innovative technical and business pathways that accelerate technology acquisition and deployment to the warfighter; (2) leverage the commercial market and attract private investments to accelerate and reduce the cost for defense acquisition and deployment of technologies that provide capabilities to the warfighter; and (3) employ innovative best-practices in contracting that accelerate awards and provide flexibility and speed in technology maturation and acquisition.	4.586	4.562	4.562	0.000	4.562

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602123N / Force Protection Applied Res	Project (Number/Name) 0000 / Force Protection Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
	<p>Efforts also include some continuing projects originally supported under the Independent Applied Research (IAR) Program established in 2013 to focus on solving a wide range of Naval Science and Technology (S&T) fleet issues utilizing unique Naval Warfare Center (WC) laboratory capabilities. Starting in FY20, the NRE funds are shifting to support the agile, rapid prototyping processes that will continue to take advantage of the WC unique capabilities, while promoting mission-driven problem solving and collaborations.</p> <p>FY 2020 Plans:</p> <p>Independent Applied Research (IAR) shall align with Naval Research framework priorities (IAR projects which were three years in duration); Augmented Warfighter, Integrated & Distributed Forces; Operational Endurance, Sensing and Sense-Making, and Scalable Lethality. FY20 IAR projects will expand efforts in the areas of physics, chemistry, biotechnology, earth sciences, mathematics, and other hard and soft sciences. Representative projects include; Life Preserver Performance in Waves, Electronic Warfare Activity Recognition, Boron-Based Solid Fuel Development for Ramjet Application, Modularization Algorithm for Additive Manufactured Parts, Data Visualization Support for Creation of a Numerical Table: Effects on Training and Performance, Development of a Fully Integrated Ignition System for Multiple Pulse Hybrid Rocket Motor Firings, Active Sonar-based Cooperative Unmanned Underwater Vehicle Interception, and Ultra Short Pulse Laser Induced Plasma Filaments for Extended Covert Communications.</p> <p>Fund the development of innovative prototypes at Warfare Centers and Naval Laboratories solving key warfighter problems that are identified through the Hacking for Defense innovation process pipeline.</p> <p>FY 2021 Base Plans:</p> <ul style="list-style-type: none">- Fund the development of innovative prototypes at Warfare Centers, Naval Laboratories and related DON organizations solving key warfighter problems that are identified through the Hacking for Defense (H4D) innovation process pipeline.- Efforts will be carried out under a pilot designated Naval Innovations Process Adoption (NIPA) to emphasize the implementation of a common process and language to promote collaborations and facilitate the use of best practices to accelerate the delivery of capabilities to the warfighter.					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020
Appropriation/Budget Activity 1319 / 2		R-1 Program Element (Number/Name) PE 0602123N / Force Protection Applied Res	Project (Number/Name) 0000 / Force Protection Applied Res	
B. Accomplishments/Planned Programs (\$ in Millions)				
FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
- The NIPA pilot is based on the proven Lean Innovation startup process adapted for defense innovation as Hacking for Defense (H4D). The H4D process employs an innovation pipeline composed of four primary steps, with each step lasting approximately 3 months, so that a prototype is delivered and evaluated within one year.				
FY 2021 OCO Plans: N/A				
FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant funding change from FY 2020 to FY 2021.				
Accomplishments/Planned Programs Subtotals		121.314	119.517	122.281
C. Other Program Funding Summary (\$ in Millions)		0.000	122.281	
N/A				
Remarks				
D. Acquisition Strategy				
N/A				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity 1319 / 2					R-1 Program Element (Number/Name) PE 0602123N / Force Protection Applied Res				Project (Number/Name) 9999 / Congressional Adds				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
9999: Congressional Adds	0.000	54.543	96.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	150.543	
A. Mission Description and Budget Item Justification Congressional Interest Items not included in other Projects.													
B. Accomplishments/Planned Programs (\$ in Millions)													
Congressional Add: Alternative Energy Research											27.030	0.000	
FY 2019 Accomplishments: Funding used to carryout alternative energy research in several areas including modeling and simulation tools for energy efficient ship design, unmanned vehicle power systems, cyber-secure and resilient micro-grids, marine-derived renewable energy, and a variety of shore-based energy efforts addressing energy challenges in the Asia-Pacific regions, including Hawaii, Alaska, Guam, California, and Australia.													
FY 2020 Plans: N/A													
Congressional Add: Power Generation and Storage Research											4.827	5.000	
FY 2019 Accomplishments: Conduct and expand on-going competitively awarded efforts that improve Li-ion battery safety and increase micro-grid resiliency and efficiency													
FY 2020 Plans: Conducted and expanded on-going competitively awarded efforts that improved Li-ion battery safety and increased micro-grid resiliency and efficiency													
Congressional Add: Hybrid Composite Structures Research for Enhanced Mobility											4.827	5.000	
FY 2019 Accomplishments: This effort will develop advanced fiber reinforced plastics for maritime craft and vessel structural components having the strength and weight benefits of traditional composite materials but without the corresponding cost and producibility limitations. In addition, this effort will develop hybrid inflatable structures for high load applications culminating in building and testing a full-scale lightweight ramp structure capable of supporting a 75 ton M1A1 tank. This ramp concept combines a metallic or composite compression member, drop stitch panels, and tension cables to form a lightweight, foldable ramp compatible with smaller vessels such as the Expeditionary Fast Transport and amphibious craft concepts such as the Ultra-Heavy Amphibious Connector.													
FY 2020 Plans: Develop advanced fiber reinforced plastics for maritime craft and vessel structural components having the strength and weight benefits of traditional composite materials but without the corresponding cost and													

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy			Date: February 2020
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602123N / Force Protection Applied Res	Project (Number/Name) 9999 / Congressional Adds	
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020
producibility limitations. In addition, this effort will develop hybrid inflatable structures for high load applications culminating in building and testing a full-scale lightweight ramp structure capable of supporting a 75 ton M1A1 tank. This ramp concept combines a metallic or composite compression member, drop stitch panels, and tension cables to form a lightweight, foldable ramp compatible with smaller vessels such as the Expeditionary Fast Transport and amphibious craft concepts such as the Ultra-Heavy Amphibious Connector.			
Congressional Add: Standoff Detection of Buried Hazards FY 2019 Accomplishments: Detection of Buried Hazards : Develop the basic signal processing requirements for the Laser Multi-Beam Differential Interferometric Sensor system have been analyzed and transformed into system specifications. Draft the necessary test plan to investigate the effectiveness based both acoustic and seismic excitation for buried object detection in outdoor environment FY 2020 Plans: N/A		2.896	0.000
Congressional Add: Advanced Energetics Research FY 2019 Accomplishments: These funds will be used towards the advanced demonstration of energetic materials in a variety of weapon system applications to include: high performance solid rocket and air breathing propulsion, reactive materials demonstrations and effects in advanced lethality and effectiveness models, advanced warhead concepts to include novel reactive shaped charge configurations, hybrid reactive material warhead demonstrations, and the development and demonstration of any necessary modeling and simulation capabilities for quantification of damage effects on adversary weapon systems, and other potential energetic technologies. FY 2020 Plans: Funds will be used for continued research towards the advanced demonstration of energetic materials in a variety of weapon system applications to include: high performance solid rocket and air breathing propulsion, reactive materials demonstrations and effects in advanced lethality and effectiveness models, advanced warhead concepts to include novel reactive shaped charge configurations, hybrid reactive material warhead demonstrations, and the development and demonstration of any necessary modeling and simulation capabilities for quantification of damage effects on adversary weapon systems, and other potential energetic technologies.		7.240	10.000
Congressional Add: Advanced Hull Form Development and Demonstration		7.723	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy			Date: February 2020
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602123N / Force Protection Applied Res	Project (Number/Name) 9999 / Congressional Adds	
B. Accomplishments/Planned Programs (\$ in Millions)			
FY 2019 Accomplishments: Using computation fluid dynamic modeling, design innovative sea-keeping small-craft with improved performance characteristics utilizing advanced building techniques and materials.		FY 2019	FY 2020
FY 2020 Plans: N/A			
Congressional Add: Electric propulsion for military craft and advanced planing hulls		0.000	5.000
FY 2019 Accomplishments: N/A			
FY 2020 Plans: Conduct applied research in Electric propulsion for military craft and advanced planning hulls.			
Congressional Add: Test bed for autonomous ship systems		0.000	4.000
FY 2019 Accomplishments: N/A			
FY 2020 Plans: Conduct applied research in Test bed for autonomous ship systems.			
Congressional Add: Talent and technology for Navy power and energy systems		0.000	9.500
FY 2019 Accomplishments: N/A			
FY 2020 Plans: Conduct applied research in Talent and technology for Navy power and energy systems.			
Congressional Add: Compact high flow fan		0.000	4.000
FY 2019 Accomplishments: N/A			
FY 2020 Plans: Conduct applied research in Compact high flow fan.			
Congressional Add: Network cyber security and resiliency		0.000	4.000
FY 2019 Accomplishments: N/A			
FY 2020 Plans: Conduct applied research in Network cyber security and resiliency.			
Congressional Add: Navy alternative energy research, development, testing and deployment		0.000	20.000
FY 2019 Accomplishments: N/A			
FY 2020 Plans: Conduct applied research in Navy alternative energy research, development, testing and deployment.			
Congressional Add: Data-model fusion for naval platforms and systems		0.000	5.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy			Date: February 2020
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602123N / Force Protection Applied Res	Project (Number/Name) 9999 / Congressional Adds	
B. Accomplishments/Planned Programs (\$ in Millions)			
FY 2019 Accomplishments: N/A		FY 2019	FY 2020
FY 2020 Plans: Conduct applied research in Data-model fusion for naval platforms and systems.			
Congressional Add: Blue carbon capture/direct air capture		0.000	8.000
FY 2019 Accomplishments: N/A			
FY 2020 Plans: Conduct applied research in Blue carbon capture/direct air capture.			
Congressional Add: Energy resilience efforts		0.000	8.000
FY 2019 Accomplishments: N/A			
FY 2020 Plans: Conduct applied research in Energy resilience efforts.			
Congressional Add: Coastal environmental research		0.000	5.000
FY 2019 Accomplishments: N/A			
FY 2020 Plans: Conduct applied research in Coastal environmental research.			
Congressional Add: Platform reliability and advanced technical research		0.000	3.500
FY 2019 Accomplishments: N/A			
FY 2020 Plans: Conduct applied research in Platform reliability and advanced technical research.			
Congressional Adds Subtotals			54.543 96.000
C. Other Program Funding Summary (\$ in Millions)			
N/A			
Remarks			
D. Acquisition Strategy			
Not applicable.			

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy											Date: February 2020				
Appropriation/Budget Activity					R-1 Program Element (Number/Name)										
1319: Research, Development, Test & Evaluation, Navy / BA 2: Applied Research					PE 0602131M / Marine Corps Lndg Force Tech										
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost			
Total Program Element	0.000	61.593	69.104	50.623	-	50.623	51.624	52.674	53.728	54.803	Continuing	Continuing			
2958: Cyberspace Activities	0.000	0.000	6.273	5.200	-	5.200	5.100	5.100	5.100	5.202	Continuing	Continuing			
3001: Marine Corps Landing Force Tech	0.000	54.835	50.331	45.423	-	45.423	46.524	47.574	48.628	49.601	Continuing	Continuing			
9999: Congressional Adds	0.000	6.758	12.500	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	19.258			

A. Mission Description and Budget Item Justification

The U.S. Navy/Marine Corps team is the most potent naval fighting force in the world. Fundamental to their success are the technologies necessary for effective distributed maritime operations. The Office of Naval Research (ONR) combines knowledge of the naval mission with researchers to select and explore solutions critical to expeditionary warfighting needs.

This Program Element (PE) addresses requirements outlined in the Marine Corps Operating Concept, which calls for Expeditionary Forces to conduct maneuver warfare in challenging, contested maritime environments characterized by complex terrain, technology proliferation, information and electronic warfare. Additionally, an emergent operation stressor is the contested urban environment which exemplifies the characterizations listed above. The urban environment is one of the most complex terrains with physical compartmentalization and canalization, additional physical dimensions (subterranean and multi-story structures), crowded conditions and associated threat obscuration, communications challenges, informational and human aspects, and proliferation of observation and fires technologies. This environment requires capabilities addressing all the activities within this PE and while it provides many challenges, unique opportunities are also presented and can further shape technology approaches.

These future challenges and portents demand robust technologies for the Marine Corps, but the technology options are constrained. They must have a lightweight deployable character, and the ability to operate in austere conditions with little fixed infrastructure or support while retaining the agility and lethality of an integrated maneuver force. Technology must provide full spectrum capability against robust and complex peer and near-peer adversaries while meeting Size, Weight, Power, Post limitations, and information availability within Distributed, Intermittent and Limited environments.

The approach within this PE encompasses ideas that support both revolutionary and evolutionary capabilities, and in this way considers and balances both "push" and "pull" aspects of technology projects.

This Program Element (PE) funds Applied Research, which is the systematic study to understand the means to meet a recognized and specific need. Most of the work in this PE can be classified between Technology Readiness Level (TRL) 2 (technology concept and/or application formulation) and TRL 4 (component and/or breadboard validation in laboratory environments).

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319: Research, Development, Test & Evaluation, Navy / BA 2: Applied Research		R-1 Program Element (Number/Name) PE 0602131M / Marine Corps Lndg Force Tech				
B. Program Change Summary (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget		63.212	56.604	50.623	-	50.623
Current President's Budget		61.593	69.104	50.623	-	50.623
Total Adjustments		-1.619	12.500	0.000	-	0.000
• Congressional General Reductions		-	-			
• Congressional Directed Reductions		-	-			
• Congressional Rescissions		-	-			
• Congressional Adds		-	12.500			
• Congressional Directed Transfers		-	-			
• Reprogrammings		-	-			
• SBIR/STTR Transfer		-1.619	0.000			
• Rate/Misc Adjustments		0.000	0.000	0.000	-	0.000
Congressional Add Details (\$ in Millions, and Includes General Reductions)						
Project: 9999: Congressional Adds						
Congressional Add: Program Increase						
Congressional Add: Interdisciplinary Expeditionary Cybersecurity Research						
Congressional Add: Marine Corps Asset Life-Cycle Management						
		Congressional Add Subtotals for Project: 9999				
		Congressional Add Totals for all Projects				
		FY 2019	FY 2020			
		0.000	5.000			
		4.827	7.500			
		1.931	0.000			
		6.758	12.500			
		6.758	12.500			

Change Summary Explanation

Funding: No change from FY 2020 President's Budget request to FY 2021 President's Budget request

Technical: no significant change

Schedule: no significant change

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy										Date: February 2020							
Appropriation/Budget Activity					R-1 Program Element (Number/Name)				Project (Number/Name)								
1319 / 2					PE 0602131M / Marine Corps Lndg Force Tech				2958 / Cyberspace Activities								
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost					
2958: Cyberspace Activities	0.000	0.000	6.273	5.200	-	5.200	5.100	5.100	5.100	5.202	Continuing	Continuing					

A. Mission Description and Budget Item Justification

This Project activity provides freedom of maneuver and influence in the cyber-electronic warfare domain while simultaneously denying the same to the adversary and protecting critical command systems. Technologies are being developed using a multi-disciplinary approach that combines Radio Frequency electronics, digital signal processing, computer engineering, software engineering, machine learning and data science to support Naval Expeditionary warfighters operating with size, weight and power constrained equipment in Disrupted, Intermittent, Limited environments. Areas of applied research include distributed precision time, predictive software defined radio architectures, coordinated Cyber and Spectrum maneuver to mitigate detection and exploitation, tactical Cyber visualization, discovering and mapping networks in dense urban environments, contextual awareness and blind channel characterization.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
s	0.000	6.273	5.200	0.000	5.200

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020
Appropriation/Budget Activity 1319 / 2		R-1 Program Element (Number/Name) PE 0602131M / <i>Marine Corps Lndg Force Tech</i>		Project (Number/Name) 2958 / <i>Cyberspace Activities</i>
B. Accomplishments/Planned Programs (\$ in Millions)				
FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
- Cyber threat identification (cyber health assessments) to include vulnerability research for ubiquitous embedded systems will focus on devices commonly carried by Marines will continue. - Algorithm and tool development for Cyber-EW capabilities for tactical engagement will continue. - Sense-making algorithms through machine learning for the cyber physical layer and Algorithms to assist in supply chain validation that are designed for small form-factor tools will be initiated.				
FY 2021 OCO Plans: N/A				
FY 2020 to FY 2021 Increase/Decrease Statement: The funding decrease from FY 2020 to FY 2021 reflects a transition of enabling technologies for dynamic radio frequency agility efforts from this activity to the Future Naval Capabilities activity in 0603640M.				
Accomplishments/Planned Programs Subtotals		0.000	6.273	5.200
C. Other Program Funding Summary (\$ in Millions)		0.000	6.273	5.200
Remarks				
D. Acquisition Strategy				
N/A				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020				
Appropriation/Budget Activity					R-1 Program Element (Number/Name)				Project (Number/Name)						
1319 / 2					PE 0602131M / Marine Corps Lndg Force Tech				3001 / Marine Corps Landing Force Tech						
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost			
3001: Marine Corps Landing Force Tech	0.000	54.835	50.331	45.423	-	45.423	46.524	47.574	48.628	49.601	Continuing	Continuing			
A. Mission Description and Budget Item Justification															
This project funds applied research; technology assessment, road mapping, and concept development; and less technologically mature projects within the Future Naval Capability (FNC) process as means to inform, enhance, enable, and invent future concepts and capabilities with new Science and Technology (S&T). This project is organized into ten activities, the core of which is represented by the eight Expeditionary Warfighting Capability Areas.															
B. Accomplishments/Planned Programs (\$ in Millions)											FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Command, Control, Communications, and Computers (C4) Description: This activity investigates robust, resilient, and secure networked communications pathways and capability that support an expeditionary force's distributed and disaggregated operations. Research supports both networked and local computation for communications that exploits the expeditionary forces close physical proximity to threats while mitigating shortfalls commiserate within Distributed, Intermittent and Limited environments. Expeditionary forces must operate in the cyber domain and in addition to defending communications networks, vehicles, and weapons systems, are reliant on electronic controllers for basic operations and as such are susceptible to cyber attacks. Technologies addressed within this activity include secure, robust, self-forming, mobile communications networks; distributed computing to support information dissemination to all echelons; improved capabilities in over-the-horizon, beyond line-of-sight, and restricted environment communications and sensors; and software and data processing to support formation of an appropriate common picture. Other efforts include power management, low detectability, conforming to Size, Weight, Power, Cost constraints, and interoperability within the joint environment. FY 2020 Plans: The Command, Control, Communications and Computers (C4) research focuses on operations in the challenging warfighter electromagnetic spectrum environment by making investments in the multifunction electronic warfare domains. Mission requirements include lightweight, portable, deployable systems for expeditionary forces. Investigations include increasing bandwidth and dynamic range in portable systems. Also included are electromagnetic signature management, machine learning, countermeasures and interoperability technologies to manage control and exploitation of the electromagnetic spectrum. Focus also includes											4.430	4.750	5.300	0.000	5.300

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602131M / Marine Corps Lndg Force Tech	Project (Number/Name) 3001 / Marine Corps Landing Force Tech				
<u>B. Accomplishments/Planned Programs (\$ in Millions)</u>		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
developing underlying technologies to enable multifunction operations at multiple-domain cryptography and security levels. Research is closely coordinated with the Intelligence, Surveillance, and Reconnaissance and Expeditionary Cyber research to address the multifunction requirement of future systems.	FY 2021 Base Plans: - Research areas will expand to include novel portable materials for rapid deployment of back-up Command, Control, Communications and Computers (C4) assets, and distributed system technology enablers for operating in denied / contested electromagnetic (EM) environments. - Continued focus on operations in the challenging warfighter EM spectrum environment by making investments in the multifunction electronic warfare domains. Mission requirements include lightweight, portable, deployable systems for expeditionary forces. Investigations include increasing bandwidth and dynamic range in portable systems. - Electromagnetic signature management, machine learning, countermeasures and interoperability technologies will progress to manage control and exploitation of the electromagnetic spectrum. Focus includes developing underlying technologies to enable multifunction operations at multiple-domain cryptography and security levels. Research is closely coordinated with the Intelligence, Surveillance, and Reconnaissance and Expeditionary Cyber research to address the multifunction requirement of future systems.					
FY 2021 OCO Plans: N/A	FY 2020 to FY 2021 Increase/Decrease Statement: The increase from FY 2020 and FY 2021 is due to increased research investment in technologies for contested electromagnetic (EM) environments.					
Title: Firepower Description: The activity investigates a large variety of weapons to provide the warfighter with a decisive, yet surgical, tactical advantage to collectively address 21st-century combined-arms warfare against peer and near-peer states. Research efforts increase the reach, lethality and capacity, while retaining mobility and tempo beneficial to expeditionary maneuver warfare. Maintaining focus on size, weight, power, cost Size, Weight, Power, Cost and Distributed, Intermittent and Limited environments stresses the technical solutions available. Technologies being developed are intended for application on both current and future expeditionary weapons. They include, but are not limited to fuze, fire control, launch/propulsion, lethality, and accuracy.	7.843	7.595	3.000	0.000	3.000	

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602131M / Marine Corps Lndg Force Tech	Project (Number/Name) 3001 / Marine Corps Landing Force Tech				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<p>FY 2020 Plans: Resources in this activity will be used to conduct research in end-to-end navigation technologies suitable for shaping the trajectories of extended range, precision, gun-launched munitions in satellite- and network-denied environments. Conduct research into real-time, multi-spectral target detection and identification technologies for individual shooters will continue in order to improve anomaly and object detection and decision-aid algorithms. Conduct research to develop thin film coatings that will change how munitions interact with electromagnetic waves, and for novel materials and processes to improve energetic output of explosives.</p>						
<p>FY 2021 Base Plans: - Research will progress in end-to-end navigation technologies suitable for shaping trajectories of extended range, precision, gun-launched munitions in satellite- and network-denied environments. Complete application of these same technologies as they apply to extended range mortars. - Proceed with research into real-time, multi-spectral target detection and identification technologies for individual shooters. This continues to improve anomaly and object detection during degraded visibility and long-range day and night situations and to improve decision-aid algorithms. - Progress research to develop thin film coatings that will change how munitions interact with electromagnetic waves. - Development of novel materials and processes to improve energetic output of explosives will continue.</p>						
<p>FY 2021 OCO Plans: N/A</p>						
<p>FY 2020 to FY 2021 Increase/Decrease Statement: The funding decrease from FY 2020 to FY2021 reflects an alignment to Naval priorities and a targeted reduction in supporting technologies for extended-range mortars.</p>						
<p>Title: Force Protection</p> <p>Description: This activity investigates new ways and means to protect forces and materiel across all operational settings, from contested sea-land surface interfaces to complex urban environments. The portfolio protects against adversaries' challenges such as guided-rockets and missiles, mobile coastal artillery, threat Electronic Warfare, and counter Intelligence, Surveillance and Reconnaissance. Mines and obstacles both in the water and ashore also complicate amphibious landings. The activity invests in vehicle survivability aspects that are</p>		6.670	6.500	6.596	0.000	6.596

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
	exacerbated due to Size, Weight, Power, Cost constraints inherent to Marine Corps operation and the harsh nature of the amphibious environment.					
	Technologies addressed include lightweight armor for ballistic and underbody blast protection, advanced sensors for counter tactical surveillance, active protection, and signature management. This activity also considers technology for payloads, packages and sensors that are needed by amphibious vehicles (both manned and unmanned) including mine counter measures; explosive hazard defeat systems; and obstacle and threat detection systems as well as technologies for improved protection for individuals against blast, ballistic and blunt impact threats.					
FY 2020 Plans:	Research will continue to focus on detecting ambush threats and surveillance of vehicles and personnel prior to reaching threat engagement range. Sensing modalities and advanced algorithms leveraging computer vision and machine learning will continue to be developed to provide counter targeting and tactical surveillance. Improve signature management and control, to include material development, will be explored. Develop improved active protection system countermeasures to expand threat set and protected area and improve robustness to operational environments and enabling technologies for countering unmanned aerial vehicles through kinetic and directed energy means.					
FY 2021 Base Plans:	- Detection technologies related to threat ambush scenarios will be concluded. - Efforts for application of low-cost sensors and computer vision/machine learning approaches will expand and be extended to include amphibious assault environment and utilization of unmanned platforms for autonomous first-wave scenarios. This will encompass operations in mined littoral and beach environments and obstacled landing areas. - Research will continue in enabling technologies for countering unmanned aerial vehicles threats. This addresses both an increase in number and sophistication of threat systems to include kinetic and/or controlled interceptors as well as directed energy approaches.					
FY 2021 OCO Plans:	N/A					
FY 2020 to FY 2021 Increase/Decrease Statement:						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602131M / Marine Corps Lndg Force Tech	Project (Number/Name) 3001 / Marine Corps Landing Force Tech				
<u>B. Accomplishments/Planned Programs (\$ in Millions)</u>		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
There is no significant change between FY 2020 and FY 2021						
Title: Human Performance, Training and Education	Description: This activity investigates two technology investment areas: warrior resilience, and decision-making and expertise development. Warrior resilience is focused on advanced training technologies and methodologies that enhance neural, cognitive, and physical readiness. Decision making and expertise development accelerates and improves the advancement in retention of skills in decision making, situation awareness, including individual and team adaptability and coordination on decentralized, dynamic and dispersed battlefields.	3.687	3.700	3.700	0.000	3.700
FY 2020 Plans: Across the three technology investment areas of 'Warrior Resilience' (WR), 'Decision Making and Expertise Development' (DMED), and Operational Tools (OT) research will continue to focus on providing small unit leaders with effective training and tools to gain them the winning edge on the battlefield. These capabilities will provide information to the warfighter at the point of friction and with increased information flow ("the right information, presented the right way, at the right time") to aid cognitive reasoning about the effects of the battlefield - whether physical or physiological - and mitigation of negative aspects of combat. The WR portfolio will fund research into further understanding the necessity, and ability, to train front-line (infantry) troops for maximum performance. The DMED portfolio will research and implement state-of-the-art and science of learning-based training techniques to improve the development of small unit decision making expertise. The Operational Tools portfolio will increase the ability of the warfighter to process information and speed decision making by implementing novel data collection techniques (multi-spectral collection of signals across the electro-optical spectrum) and processing of these inputs for display - in real time, as the ultimate goal - directly to the individual who requires the information to make a timely, accurate decision.						
FY 2021 Base Plans: - Warrior Resilience: Research in training and decision tools will progress to provide information to the warfighter at the point of friction, increase information flow to aid situational awareness of the battlefield, and mitigate negative aspects of combat. Advance research into necessity and ability to provide continual training for front-line (infantry) troops while deployed for maximum performance. - Decision Making and Expertise Development: Research into implementation of state-of-the-art and science of learning-based training techniques to improve the development of small unit decision-making expertise will continue.						

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
- Operational Tools: Further research into the ability of the warfighter to process information and speed good decision making by implementing novel data collection and visualization techniques.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant change between FY 2020 and FY 2021						
Title: Intelligence, Surveillance, And Reconnaissance (ISR) Description: This activity investigates enhanced situational awareness, persistent surveillance, and tactical decision making through automated analysis of data and rapid integration of information and acquired knowledge. Specific technologies in this activity effectively present actionable information to decision-makers, especially those at the lower command levels. This includes biometric monitoring for expeditionary operations, operational Course Of Action (COA) development, and autonomous surveillance in support of distributed operations.		6.969	6.276	5.600	0.000	5.600
FY 2020 Plans: Conduct research in applying supervised learning and unsupervised learning algorithms to the Naval domain. Continue development of strong Artificial Intelligence as applied to both images and text. Accelerate development of algorithms that can infer patterns in common intelligence and tactical pictures useful to the development of decision support tools. Accelerate the development of planners that can learn from historical data. Develop a question answering capability that is relevant to the Naval domain. Exam network formation, growth and fracture.						
FY 2021 Base Plans: - Development of algorithms that can infer patterns in common intelligence and tactical pictures useful to the development of decision support tools will be continued. - Utilize mission planners that will learn from historical data to demonstrate more timely and complete common intelligence pictures. - Use Artificial Intelligence (AI) and machine learning to automate mission planning and mission re-planning. - Increase research in end-to-end deep reinforced learning, as well as demonstrate warfare at machine speed that can be applied to a very large force of manned and unmanned platforms. - Conduct applied research on strong artificial intelligence decision support systems that avoid bad decisions even when presented with very noisy data.						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy			Date: February 2020			
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B. Accomplishments/Planned Programs (\$ in Millions)						
		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<ul style="list-style-type: none"> - Research in smart graphs, network shaping metrics, actionable visualizations, and network fractures will continue. - Transition select AI efforts to Innovative Naval Prototypes(INP). 						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The funding decrease from FY 2020 to FY 2021 reflects transition of artificial intelligence developments with Naval application into the Innovative Naval Prototype program.						
Title: USMC FNC Technology Candidates Description: This R-2 Activity addresses the applied research associated with the Marine Corps' participation in the Department of the Navy's (DoN) Future Naval Capabilities (FNC) Program. The objective of the work in this Program Element (PE) is to develop and mature technologies needed by the Marine Corps to initiate FNCs in PE 0603640M Marine Corps Advanced Technology Development (ATD) that can be commenced at higher Technology Readiness Levels (TRLs). Investments in this activity are coordinated with similar and non-duplicative efforts in PE 0602750N Future Naval Capabilities Applied Research, where the Navy's participation in the FNC Program is funded. The FNC Program is structured to accelerate the transition of new technologies to the Fleet and Force. Each effort is assessed for its technology maturity and transition commitment. Funding for FNCs, which have Technology Readiness Levels (TRLs) of 4/5 to 6 and also have transition funding commitments from acquisition Programs of Record, are resourced in PE 0603640M Marine Corps Advanced Technology Development. Funding for technology candidates at lower TRLs (3 to 4) are resourced in this PE 0602131M, Marine Corps Landing Force Technology. ONR works closely with the Resource Sponsors and acquisition stakeholders to develop high priority technological capabilities needed by the operational forces. FNC Budget Activity (BA) 2 investments develop candidate FNC technologies in an agile fashion by exploiting technology advances that respond rapidly to naval needs. This approach facilitates an optimum response when developing and maturing the technology options that can be developed further in PE 0603640M Marine Corps Advanced Technology Development (ATD). The FNC Program favors a high level of collaboration. PE R-2 activities are mostly organized by the Office of Naval Research (ONR) Departments, which are tasked to collaborate with the acquisition stakeholders and their resource sponsors.		4.799	4.800	4.795	0.000	4.795

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<u>B. Accomplishments/Planned Programs (\$ in Millions)</u>		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
A complete accounting of the technology candidates being developed and a full disposition of each technology development effort funded in this PE is provided annually to the Congressional oversight committees.						
FY 2020 Plans: Future Naval Capability Technology Candidate development in FY20 will continue to focus on a broad range of technologies including, but are not limited to, investments that focus on developing and maturing new capabilities for asymmetric and irregular warfare, distributed operations, information dominance, maneuverability, survivability, self-defense and expeditionary warfare.						
FY 2021 Base Plans: This activity will continue to focus on developing promising technologies emerging from the FNC Applied Research program that have been matured to a Technology Readiness Level of 4 to 5. Development efforts include, but are not limited to, technologies that: - Enable greater signature management of the Marine Air-Ground Task Force (MAGTF) - Support a multi-domain sensing of the electronic spectrum, Command and Control integration and automated collaboration of warfighting functions - Enhance mobility, propulsion, autonomy, weapons, materials, logistics, vehicle architectures, and Electronic Warfare protection for a light armored vehicle fleet - Support improved warfighter feedback and enhanced learning in live, virtual and constructive environments - Optimize the balance between hardening and flexible software development for future dynamic engagements in contested environments with adversaries - Produce new repair techniques to include the use of solid-state technologies such as cold-spray and additive friction stir welding for structural repairs						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant change between FY 2020 and FY 2021.						
Title: Logistics		5.784	6.254	6.228	0.000	6.228
Description: This activity investigates the practical discipline and real world application of the deployment, sustainment, reconstitution, and re-deployment of forces engaged in expeditionary operations. Logistics replaces mass with assured knowledge and speed, is equally capable ashore or afloat in austere environments,						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020
Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)		
<u>B. Accomplishments/Planned Programs (\$ in Millions)</u>				
		FY 2019	FY 2020	FY 2021 Base
				FY 2021 OCO
				FY 2021 Total
1319 / 2	PE 0602131M / Marine Corps Lndg Force Tech			
and is fully scalable to meet uncertain requirements. This includes efficient and responsive force sustainment, planning and directing logistics operations, logistics demand reduction, fleet maintenance, and expeditionary energy. Expeditionary Energy enhances combat capability of expeditionary warfighters by increasing the efficiency and effectiveness of energy production, storage, distribution and use. Beyond traditional energy efforts, this portfolio also looks at other issues, including energy-efficient behaviors and hybridization of energy sources. These pillars are thoroughly integrated and perpetually related in execution.				
FY 2020 Plans: Logistics development in FY20 will focus on the broad range of technologies noted in the FY19 plans section above. Research into friction stir welding, additive friction stir welding, and cold spray for structural repair of Marine Corps equipment will complete. Research will be initiated in artificial intelligence tools to support logistics planning, execution, and combat support. Develop enhancing autonomous logistics aerial/ground asset teaming. Develop cyberphysical security of Digital Manufacturing methods, including Additive Manufacturing.				
FY 2021 Base Plans: - Continue research to predict vehicle health and prognostics of remaining useful life for military ground vehicles and equipment in support of logistics planning, execution and combat support. Continue to investigate use of aerial unmanned logistics to provide operational and tactical level supply. Advance enhancement of combat capability by increasing energy production, storage, and distribution including curbing energy consumption of the individual Marine and other tactical assets Activities continue to involve applied research into new, rugged, low cost, and high specific power solar cell technologies, including investigation into the stability of the solar cells. Investigate developing more energy efficient componentry as part of the Marine warfighter loadout				
FY 2021 OCO Plans: N/A				
FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant change between FY 2020 and FY 2021				
Title: Maneuver	9.486	9.022	8.770	0.000
Description: This activity investigates new ways and means to land forces and material through contested sea-land surface interfaces to then conduct maneuver warfare. In order to enable future Amphibious Operations, research efforts will support autonomous operations across the sea-surf-ground environment, improved fuel efficiency and speed of amphibious vehicles, amphibious vehicle technologies, water performance, and				8.770

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
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<u>B. Accomplishments/Planned Programs (\$ in Millions)</u>		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
amphibious payloads to change the dynamics of a surface amphibious assault. This includes the emergence manned-unmanned teaming and autonomous vehicle collaboration.	The technologies included in this work address areas of mobility, materials, propulsion, signature reduction, modularity, and unmanned systems.					
FY 2020 Plans: Research will focus on intelligent mobility technologies to enable greater capability in harsh off road and littoral environments. Efforts will include better understanding of the ground interface through terrain characterization and researching enhanced platform effectors that allow the system to adapt to varying terrain approaching real time thereby increasing operational tempo. Efforts also include the development of forward-operating autonomous unmanned systems, in communication limited and Global Positioning System denied environments, with a focus on sense-making from local-sensors at the edge. Research will continue to improve the impacts of the surf zone and other land-sea interfaces on vehicle dynamics.						
FY 2021 Base Plans: - Research will focus on intelligent mobility technologies to enable greater capability in harsh off road and littoral environments, with efforts including predictive and adaptive mobility testing and demonstration - Progress research to gain a better understanding of the ground interface through terrain characterization and researching enhanced platform effectors that allow the system to adapt to varying terrain approaching in real time, increasing operational tempo - Continue research for amphibious vehicle autonomy through development of components for low-cost robotic autonomy kits (e.g. Sensing & Perception, Planning & Control, Localization, World Modeling and Integration) - Develop sensors and autonomous behaviors to enable combat ground and amphibious vehicles to perform landing zone reconnaissance, create feint and decoys, deploy mine countermeasures, and provide direct/indirect fires for future deployment in contested landing environment through integration of payloads developed under other activities						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant change between FY 2020 and FY 2021						
Title: Expeditionary Cyber		3.574	0.000	0.000	0.000	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Description: This activity provides freedom of maneuver and influence in the cyber-electronic warfare domain while simultaneously denying the same to the adversary and protecting critical command systems. Technologies are being developed using a multi-disciplinary approach that combines Radio Frequency electronics, digital signal processing, computer engineering, software engineering, machine learning and data science to support Naval Expeditionary warfighters operating with size, weight and power constrained equipment in Disrupted, Intermittent, Limited environments. Areas of applied research include distributed precision time, predictive software defined radio architectures, coordinated Cyber and Spectrum maneuver to mitigate detection and exploitation, tactical Cyber visualization, discovering and mapping networks in dense urban environments, contextual awareness and blind channel characterization.						
FY 2020 Plans: N/A						
FY 2021 Base Plans: N/A						
FY 2021 OCO Plans: N/A						
Title: Future Concepts, Technology Assessment, And Roadmapping Description: This activity supports the planning and integration of technology development efforts across the entire Program Element (PE). In conjunction with the Concepts Based Capabilities System and the Marine Corps Warfighting Laboratory, unique and novel concepts for advanced warfighting are developed and validated. Effectiveness analyses are conducted to identify the synergistic effects that can be achieved through the integration of emerging technology with innovative tactics, doctrine, and techniques. Technology assessments are conducted to determine the supporting technologies that have the highest impact across the warfare areas, and warrant further investment within this PE. Technology Roadmapping is conducted to help identify opportunities to leverage technology development within the Department of the Navy and the Department of Defense, as well as with the commercial sector and university communities. The resultant technology investment strategy is developed and used to guide out-year technology development efforts.	1.593	1.434	1.434	0.000	1.434	
FY 2020 Plans: Assess systems of technologies that best address warfare environments and drivers described in the MOC and the Navy's A Design for Maintaining Maritime Superiority. Identify and integrate numerous technology options						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
within expeditionary design constraints to develop technology counterparts to Operational Concepts. Create technology roadmaps, concepts, and holistic systems of systems approaches that fulfil the needs identified in Operational Concepts such as the Marine Corps' Expeditionary Advanced Based Operations Concept and Littoral Operations in a Contested Environment Concept and enhance expeditionary capabilities against peer and near-peer adversaries.						
FY 2021 Base Plans: - Assess technologies and technology concepts that have potential alignment to the Marine Corps Operating Concept (MOC) as well as ability to support both Expeditionary Advanced Basing and Distributed Maritime Operation concepts - Extend development of technology roadmaps, concepts, and holistic systems of systems approaches that fulfill the needs identified in these concepts - Conduct warfighter workshops and wargaming to understand highest potential for these technologies in order to shape investment priorities						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant change between FY 2020 and FY 2021						
Accomplishments/Planned Programs Subtotals		54.835	50.331	45.423	0.000	45.423
C. Other Program Funding Summary (\$ in Millions)						
N/A						
Remarks						
D. Acquisition Strategy						
N/A						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity					R-1 Program Element (Number/Name)				Project (Number/Name)				
1319 / 2					PE 0602131M / Marine Corps Lndg Force Tech				9999 / Congressional Adds				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
9999: Congressional Adds	0.000	6.758	12.500	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	19.258	
A. Mission Description and Budget Item Justification													
Congressional Interest Items not included in other Projects.													
B. Accomplishments/Planned Programs (\$ in Millions)													
Congressional Add: Program Increase													
FY 2019 Accomplishments: N/A													
FY 2020 Plans: Conduct applied research supporting Marine Corp Landing Force Technologies													
Congressional Add: Interdisciplinary Expeditionary Cybersecurity Research													
FY 2019 Accomplishments: This program will fund the following research efforts in FY19:													
- Identification of system vulnerabilities within blue and gray cyberspace that affect Expeditionary Cyber operations													
- Develop proof of vulnerabilities, where applicable													
- Propose defensive technologies and methodologies for target platforms													
FY 2020 Plans: This program will fund the following research efforts in FY20:													
- Identification of system vulnerabilities within blue and gray cyberspace that affect Expeditionary Cyber operations													
- Develop proof of vulnerabilities, where applicable													
- Propose defensive technologies and methodologies for target													
Congressional Add: Marine Corps Asset Life-Cycle Management													
FY 2019 Accomplishments: Conduct research for new sensors and integrated vehicle health management systems for emerging vehicle programs and prototypes, such as the Armored Reconnaissance Vehicle, in order to enhance overall asset lifecycle management.													
FY 2020 Plans: N/A													
Congressional Adds Subtotals													
6.758													

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy	Date: February 2020	
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602131M / <i>Marine Corps Lndg Force Tech</i>	Project (Number/Name) 9999 / <i>Congressional Adds</i>
C. Other Program Funding Summary (\$ in Millions)		
N/A		
Remarks		
D. Acquisition Strategy		
N/A		

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity					R-1 Program Element (Number/Name)								
1319: Research, Development, Test & Evaluation, Navy / BA 2: Applied Research					PE 0602235N / Common Picture Applied Research								
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
Total Program Element	0.000	40.559	42.846	48.001	-	48.001	50.698	52.435	55.167	56.271	Continuing	Continuing	
0000: Common Picture Applied Research	0.000	40.559	42.846	48.001	-	48.001	50.698	52.435	55.167	56.271	Continuing	Continuing	

A. Mission Description and Budget Item Justification

Activities and efforts in this program examine concepts and technologies that enable the transformation to Distributed Maritime Operations (DMO). Network centric capabilities rely on information to connect assets and provide timely and accurate understanding of the environment. The mission area requirements for rapid, accurate decision-making; dynamic, efficient, mission- focused communications and networks; and pervasive and persistent sensing drive network centric S&T investments.

Today's Sailors and Marines are enabled by Naval Science and Technology (S&T). Since 1946, the Office of Naval Research (ONR) has fostered scientific research related to the maintenance of maritime superiority and national defense. ONR manages the Department of the Navy's (DON) portfolio of naval Basic and Applied research, and Advanced Technology Development investments to ensure naval forces can effectively deter conflict, but when called upon, fight, win and come home safe. Current investments hedge against uncertainty, providing solutions to commanders today, and options for the future. The Naval S&T budget supports higher guidance defined by the National Defense Strategy, and responds to requirements identified by the Secretary of the Navy through research priorities set by the Chief of Naval Research, coordinated across the Naval Research Enterprise (NRE), and outlined in the Naval R&D Framework.

This Program Element (PE) funds Applied Research, which is the systematic study to understand the means to meet a recognized and specific need. Most of the work in this PE can be classified between Technology Readiness Level (TRL) 2 (technology concept and/or application formulation) and TRL 4 (component and/or breadboard validation in laboratory environments).

Due to the number of efforts in this Program Element (PE), the programs described herein are representative of the work included in this PE.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy					Date: February 2020
Appropriation/Budget Activity	R-1 Program Element (Number/Name) PE 0602235N / Common Picture Applied Research				
B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	36.348	49.297	49.431	-	49.431
Current President's Budget	40.559	42.846	48.001	-	48.001
Total Adjustments	4.211	-6.451	-1.430	-	-1.430
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-6.451			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	4.808	0.000			
• SBIR/STTR Transfer	-0.597	0.000			
• Program Adjustments	0.000	0.000	-1.430	-	-1.430
• Rate/Misc Adjustments	0.000	0.000	0.000	-	0.000

Change Summary Explanation

Funding: The program decrease in FY21 of \$1.430 million is from reduced investment in the areas of Cyber Superiority and Information Superiority as part of the annual reassessment and adjustment of the ONR Science and Technology portfolio.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity					R-1 Program Element (Number/Name)				Project (Number/Name)				
1319 / 2					PE 0602235N / Common Picture Applied Research				0000 / Common Picture Applied Research				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
0000: Common Picture Applied Research	0.000	40.559	42.846	48.001	-	48.001	50.698	52.435	55.167	56.271	Continuing	Continuing	

A. Mission Description and Budget Item Justification

Activities and efforts in this program examine concepts and technologies that enable the transformation to network centric warfare. Network centric capabilities rely on information to connect assets and provide timely and accurate understanding of the environment. The mission area requirements for rapid, accurate decision-making; dynamic, efficient, mission-focused communications and networks; and pervasive and persistent sensing drive network centric Science and Technology S&T investments.

The activities described in this Program Element (PE) address future Navy and Marine Corps capabilities needed to maintain maritime superiority and ensure national security. They are based on input from Naval Research Enterprise (NRE) stakeholders (including the Naval enterprises, the combatant commands, OPNAV and Headquarters Marine Corps) and are designed to exploit breakthroughs in science and technology in order to deliver maximum warfighting benefit to our sailors and marines. These efforts are aligned with shared priorities throughout the whole of RDT&E in order to quickly advance new capabilities from discovery to deployment across the warfighting domains.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Communication and Networks Description: The overarching objective of this activity is to develop high throughput dynamic wireless communications and network technologies critical to the mission performance and robustness of naval communications for widely dispersed, mobile air, land, surface and submerged platforms. These platforms are often Size, Weight and Power (SWaP) limited, and will operate under constraints of cluttered Radio Frequency (RF) spectrum, harsh Electro-Magnetic Interference (EMI) and Beyond Line Of Sight (BLOS) conditions. The technical payoff is increased network data rates, interoperability across heterogeneous radios, dynamic bandwidth management, and greater mobile network connectivity. The operational payoff is that warfighters from the operational command to the tactical edge have near real-time access to information, knowledge and decision-making necessary to perform their tasks, including coalition and allied forces. Emphasis is on tactical edge communications and networks to fully realize net-centric warfare, bridging the Global Information Grid (GIG) and the 'disadvantaged user', e.g., small-deck combatants, submarines, unmanned vehicles, distributed sensors and ground units in urban and RF challenged environments. The current specific objectives are:	7.224	7.223	6.158	0.000	6.158

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602235N / Common Picture Applied Research	Project (Number/Name) 0000 / Common Picture Applied Research				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Radios and Apertures: - Develop technologies for high band radio, electrically-small and actively scanned antennas, addressing critical issue of radio spectrum bandwidth efficiency, spectrum contention and clutter, agile frequency communications with dynamic spectrum access, all-digital front-end with wide dynamic range, power amplifier efficiency, multipath effects, saltwater propagation and Beyond Line Of Sight (BLOS) communications. - Develop algorithms and signal processing for space-time-frequency diversity communications, including measures for electronic protection, such as low-intercept, antijam waveforms and modulation. - Develop affordable antenna technologies for small size and weight, high radiation efficiency, and wideband operation with rapid beam-steering. - Develop alternatives to Radio Frequency (RF) communications in airborne and terrestrial environments as well as high data rate underwater communications for undersea warfare (distributed sensor netting, unmanned underwater vehicle data exfiltration, submarine Communications at Speed and Depth) using Electro-Optic/Infra-Red (EO/IR) technologies. - Develop secure, high bandwidth communications systems and the exploitation of existing and emerging network protocols that will avail development of new, Low Earth Orbit (LEO) based data transport mechanisms.						
Tactical Networking and Network Control/Management: - Develop advanced networking techniques for robust, highly dynamic environments; interoperable networks for secure communications and protocols, bandwidth and network management techniques that manage and allocate bandwidth across tactical and theater levels in support of net-centric operations. - Develop rapidly auto-configuring and self-organizing networks with efficient and survivable routing, secure authentication, mobility management and Quality-of-Service guarantee, while optimizing network resources. - Address low bandwidth, synchronization and reliability for Service Oriented Architecture (SOA)/Middleware Architecture in both Mobile Ad-hoc Networks (MANET) and infrastructure-based Internet Protocol (IP) backbone networks. - Develop cognitive network planning and operations engines whose criteria are based directly on mission objectives, while self-adapting and managing the spectrum allocation and radio resources in such a way that network operations, SOA community of interest, and computer network defense are integrated to form a single common tactical network picture that requires a minimum of human intervention and skill.						
FY 2020 Plans: Communications and Networks: Continue ongoing research and related thrusts in antenna technology to include electrically small antennas, wideband multifunction antennas, compatibility of phased array antennas with						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602235N / Common Picture Applied Research	Project (Number/Name) 0000 / Common Picture Applied Research				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
naval platforms and marine environments, directional beam forming/steering techniques, and special-purpose submarine communication antenna systems; radio communications to include anti-jam and low-probability-of-intercept techniques, Satellite communications (SATCOM) performance enhancements, interference mitigation, adaptive equalization, bandwidth efficient modulation, cognitive radio for dynamic spectrum management, and high data rate tactical communications techniques including communications at speed and depth (for submarines); and wireless networks to include mobile ad-hoc wireless networking algorithms/protocols, end-to-end Quality-of-Service, joint/coalition interoperability, service oriented tactical networking, mission-based policy and network controls and management.	Initiate new efforts and research supporting the development of a transmission signal waveform that is less detectable, but operates with higher capacity for a given range, than existing waveforms.					
Information Technology: Continue work to provide secure, resilient, effective network-centric and information warfare capability for the Navy/Marine Corps by addressing deficiencies and science gaps in tactical networks. These capabilities address unique military environment and application challenges enabling new mission concepts requiring minimal human intervention. Current work and near-term plans focus on three specific objectives: dynamic network structural analytics and adaptation; robust network organization and transport, distributed group collaboration and discovery; and adaptive signaling and sensing to improve military wireless communications. Current research projects will deliver technology for high assurance Field-Programmable Gate Array (FPGA) application design, technology for increasing the performance of low powered networks by using compressed sensing technology, and technology to improve the design of distributed and cooperative Intelligence, Surveillance and Reconnaissance (ISR), Integrated Cyber and Electronic Warfare (ICE) operations in denied and contested Electromagnetic environments.	Develop a transmission signal waveform that is less detectable, but operates with higher capacity for a given range, than existing waveforms.					
FY 2021 Base Plans: Communication and Networks: -Complete research on communications payloads for small satellites. -Complete research on software-defined networking techniques for tactical operations. -Continue research on communications with low probability of detection. -Continue research on novel path computation algorithms and autonomous distributed network control. -Initiate research on efficient approaches for wideband, multi-beam, high-power communications.						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602235N / Common Picture Applied Research	Project (Number/Name) 0000 / Common Picture Applied Research				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
-Initiate research on optical beam distortion and phase front corrections with machine learning and neural networks. -Initiate research on quantum techniques for secure underwater magnetic and optical communications systems. -Initiate research on artificial intelligence approaches to establish network policies based on Commander Intent.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The decrease from FY 2020 to FY 2021 is due to completion of research on communications payloads for small satellites and software-defined networking techniques for tactical operations.						
Title: Applied Information Sciences for Decision Making Description: The goal of this activity is to develop enablers for decision making and mission execution in order to achieve battlespace superiority. It focuses on the development of algorithms and software technologies that identify and integrate informational content from multiple sources, leading to decision aids that support user-cognitive processes. Because persistent sensors are generating massive amounts of data, the focus is on technologies that not only integrate information from diverse sources, but also provide indications of information significance in ways that support the user's decision needs, regardless of location and operational situation. To achieve this, it must be possible to automate understanding of the battlespace by identifying objects, determining relationships among the objects, recognizing activities, assessing intent, and automatically generating courses of action with associated risks and uncertainty. Effort will also be devoted to developing technology for increasing assurance and security for Consultation, Command and Control (C3) information systems and technology for improving information discovery and information presentation in such systems. The Nano Electronics Technology activity is focused on developing ultra-low power, higher performance computing devices and components that are based on novel functionalities of nanometer scale materials and are enabled by improved understanding of nanomaterials, new devices and circuit design concepts, as well as new architectures uniquely suited for nanoscale systems. Applied research in artificial intelligence focuses on the unique challenges of the Naval domain by providing intelligent decision aids while operating in the complex spatio-temporal environments of distributed Naval forces.		26.663	28.885	34.384	0.000	34.384
FY 2020 Plans: Quantum Information Sciences: Conduct research of Quantum Key Distribution (QKD) protocols and implementations for the purpose of understanding the security implications for QKD in the maritime environment,						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602235N / Common Picture Applied Research	Project (Number/Name) 0000 / Common Picture Applied Research				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
	<p>the development of protocols that simultaneously minimize leakage of information to the environment and the creation of secure networks, as well as schemes to maximize the information carried by a continuous or discrete variable. Conduct research into interconversion of optical and mechanical quantum states for memory and potential processing tasks.</p> <p>Computational Methods for Decision Making: Conduct research of Information Integration, Automated Image Understanding, and Resource Optimization for the purpose of developing innovative methods for combining traditional and non-traditional data from sensors and disparate sources to provide the best estimate of objects, events, and conditions in the battlespace, in terms of their identity, associated error or uncertainty, context, impact, while inferring relationships and their intentions; developing automated, image and signal intelligence understanding tools based on rigorous mathematical and statistical methods that lead to improved change detection, improve object and activity detection and recognition capabilities, context and scene understanding, and inferring of the threat levels to support decision making and persistent and adaptive surveillance; and developing automated decision-support tools based on mathematically rigorous techniques (e.g., mathematical optimization) that support decision-making to ensure the best use of scarce and/or expensive resources, achieving optimal allocations for large complex scenarios, including ones that contain uncertainty, in drastically reduced amounts of time. Develop methods that support decision making in networked sensor management and allocation to ensure sensor assets are deployed in an optimal, or near optimal, manner. The amount of data that the decision makers are facing today is much larger than any time before in human history. In addition, the data is much more complex, heterogeneous and fast changing. Analysis of such large and complex datasets is beyond the cognitive abilities of any single decision maker. The aim of this thrust is to develop new methods for extraction and analysis of relevant information from large-scale datasets, and to develop new tools for distributed information sharing and decision-making. To achieve this aim, it is required to advance fundamental understanding of networks (such as social and organizational networks), and to integrate rigorous methods from mathematical and computational sciences with methods from social sciences. Imitate new research to study the interplay of three phenomena, heterogeneous and dynamically generated input data from various sources, online decisions, and online learning. Develop methods for integrating massive amounts of diverse data, and present useful information to a tactical commander for planning. Develop new ways to extract and understand human/content interactions to build an algorithm of personalized learning actions for learning and training purposes.</p> <p>Nanoscale Electronics Technology: Conduct research in novel nanometer scale (feature size near or below 10nm) logic/memory devices and related circuits and architectures to deliver ultra-low power, light weight</p>					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602235N / Common Picture Applied Research	Project (Number/Name) 0000 / Common Picture Applied Research				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
	<p>and high performance computational capability for autonomous vehicles and individual warfighters. Initiate exploration of ultra-low power computing applications utilizing mixed signal neuromorphic chips.</p> <p>Cyber Defense: Conduct research in cyber systems, leveraging results from basic research program, developing and evaluating technical approaches for future naval capabilities. The program investigates technologies for enhancing efficiency, robustness and cyber resiliency for all classes of computing systems in naval enterprise systems as well as Navy's real-time safety critical cyber physical systems. Continue efforts to mature technologies and continue work to introduce new capabilities into many cyber security areas, such as automated cryptographic design exploration, cyber decoys and disinformation, automated Commercial Off-The-Shelf (COTS) cyber attack surface reduction, intrinsic cyber attack resilient industrial control systems, and many more. Addressing the root cause of cyber vulnerability and reducing reliance to operator is one of the main theme of the program.</p> <p>Data Analytics: Conduct research in new approaches to support tactical decision making and assured networked command and control. This is performed by producing distributed situation assessment of a commander's environment through development of a common tactical picture; developing collaborative, distributed mission plans; monitoring and dynamically replanning mission execution as required; understanding their environment by being able to access distributed heterogeneous enterprise information stores intelligently through use of autonomic software; effectively using sensor information and making resource allocation decisions and information operations. Specific research involves real-time computing, decision aids and collaborative workspaces; secure distributed architectures; and information warfare methods to protect secure information. Initiate new research efforts supporting the development of a set of Assured Command and Control (AC2) applications that can operate in challenging communications environments.</p> <p>Electromagnetic Warfare: Continue efforts to research and develop technologies for advancing the state-of-the-art in being able to uniquely identify target of interest in very complex environments using passive technologies to assure high confidence to the decision maker when combined with other information sources. This is being accomplished by expanding specific emitter identification technologies into areas detecting previously unaddressed and unexplored to maintain battlespace superiority.</p> <p>Information Technology: Objective is to improve the operational capability and security of Naval decision support systems and decrease the cost of these systems through transformative advances in information management that enables agility and timely, accurate decision making. The military capability from this task area is technology</p>					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602235N / Common Picture Applied Research	Project (Number/Name) 0000 / Common Picture Applied Research				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
to support improved situational awareness and operational effectiveness, improved techniques for dealing with information-intensive applications, and information management processes that improve the speed and accuracy of decisions and actions.	New research projects will deliver technology for Deep Learning networks that can explain their decisions, improved hydraulic efficiency for meso-scale robotic systems, and adaptive memory for long duration autonomous systems. Applied research on artificial intelligence in support of: Collaborative complex decision-making; Developing artificial intelligence technologies that actively inform and assist different stages of the decision making process; Developing interfaces and dialogue systems for human-machine teaming; Developing agile intelligent cognitive electronic warfare algorithms and architectures; Integrating artificial intelligence with robotic systems for human-machine collaboration and robot training; and Predictive maintenance (digital twin) for Naval platforms.					
FY 2021 Base Plans: Quantum Information Sciences: - Complete research of Quantum Key Distribution (QKD) protocols and implementations for the purpose of understanding the security implications for QKD in the maritime environment, the development of protocols that simultaneously minimize leakage of information to the environment and the creation of secure networks, as well as schemes to maximize the information carried by a continuous or discrete variable. - Continue quantum communication research as it applies to practical approaches to secure key generation that include technologically limited eavesdropper assumptions. - Continue research into interconversion of optical and mechanical quantum states for memory and potential processing tasks. - Initiate research into the application of on-chip optical processing with quantum states of light for suppressing noise for measurement and communication devices. Computational Methods for Decision Making:						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602235N / Common Picture Applied Research	Project (Number/Name) 0000 / Common Picture Applied Research				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
- Complete methods for camera array-based imaging for recognition of objects occluders such as trees and shrubs. - Complete methods for learning patterns of activity in relatively limited spaces (e.g., street intersections, building entrances) from long-duration surveillance imagery. - Complete methods for agent-based models for identification of inefficiencies in decision-making in large organizational networks. - Complete agent-based modeling of collective humane performance. - Complete application of mathematical methods, development of mathematical tools, and construction of computer software for solving specific resource allocation problems. - Continue methods for robust recognition of activities in surveillance videos based on the integration of plan recognition and short-duration action recognition. - Continue methods for recognition of activities in urban and semi-urban areas from surveillance video based on weakly supervised deep learning techniques. - Continue methods based on probabilistic (and-or) graphs for modeling events and activities toward automated understanding of data acquired by Naval information systems. - Continue methods based on computer vision, deep learning, and reasoning for detection, tracking, and reacquisition of small vessels in (intermittent) aerial surveillance imagery for interdiction of sea-borne smuggling. - Continue development of methods for large-scale coordination and aggregation of individual preferences. - Continue development of methods for adaptive training on individual and group levels. - Continue development of methods for large-scale assessment and evaluation of distributed information. - Continue development of methods for continuous learning and expertise assessment. - Continue development of mathematical models, theory, and solution methods for most effectively allocating scarce resources (funds, information, personnel, equipment) within competitive environments. - Initiate development of methods for Unmanned Aerial Vehicle (UAV)-based video surveillance along roads and rivers that are partially occluded by tree canopies using a marsupial system consisting of a large UAV capable of long-duration flight and several small quadcopters. - Initiate analysis of information flow and dynamics of influence in large networks. - Initiate development of tools for structured and distributed deliberation and decision-making. - Initiate development of secure and privacy-preserving tools for information sharing. - Initiate development of visual sense making capabilities for distributed Navy teams to successfully run operations in increasingly contested, diverse, multi-expertise, and highly data driven decisional contexts. - Initiate a research emphasis on defender-attacker-defender problems that seek strategies for obtaining resilient operational systems under the threat of attack.						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602235N / Common Picture Applied Research	Project (Number/Name) 0000 / Common Picture Applied Research				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Nanoscale Electronics Technology: - Continue research on Two-Dimensional (2D) materials and related device and circuit functions. Specifically, the program will push the limit of 2D semiconductor transistors through van der Waals integration, explore surface and interface engineering of 2D heterostructures, devise and test devices and circuits with graded 2D materials, and also explore flexible wearable electronic system by exploiting large scale graphene and other 2D materials.						
Cyber Defense: - Complete initial research and development on security and resilience for cyber physical systems and automated Commercial Off-The- Shelf (COTS) cyber attack surface reduction. - Continue to conduct research in cyber systems, leveraging results from basic research program, developing and evaluating technical approaches for future naval capabilities. The program investigates technologies for enhancing efficiency, robustness and cyber resiliency for all classes of computing systems in naval enterprise systems. - Continue efforts to mature technologies and continue work to introduce new capabilities into many cyber security areas, such as automated cryptographic design exploration, cyber decoys and disinformation, and many more. - Addressing the root cause of cyber vulnerability and reducing reliance to operator is one of the main themes of the program.						
Data Analytics: - Finalize research into new approaches to support tactical decision making and assured networked command and control. - Finalize the development of resilient networking capabilities that are designed to operate in challenging communications environments during wartime employment applying Machine learning to automate routing decisions in low bandwidth environments. - Finalize refinement of Assured Command and Control (AC2) applications with the addition of artificial intelligence to operate in challenging wartime networked environments to enable production of distributed situation assessment of a commander's environment through development of a common tactical picture that: 1. develops collaborative, distributed mission plans; monitoring and dynamically re-planning mission execution as required; understanding their environment by being able to access distributed heterogeneous enterprise information stores intelligently.						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602235N / Common Picture Applied Research	Project (Number/Name) 0000 / Common Picture Applied Research				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
2. effectively uses sensor information and makes resource allocation decisions and information operations during wartime. - Finalize specific research involving real-time adaptable networking, computing, decision aids and collaborative workspaces; secure distributed architectures; and information warfare methods to protect secure information. - Conduct a proof of concept in a FY21: Fleet Exercise and Red-Cell event to enable smooth technology transition to Programs Of Record (POR) and rapid Fleet employment.	Science of Artificial Intelligence: - Further develop principled computational frameworks for integrating domain knowledge and machine learning for fast robust learning of diverse, complex concepts and tasks with light supervision. Domain knowledge includes physical models, as well as rules, relations and semantic descriptions. - Create a unified framework for perception and planning for resources distributed across multiple platforms (agents, platforms, autonomous systems or vehicle swarms) to exploit the massive, diverse data obtained, while subject to communication limitations. - Explore new brain-inspired artificial intelligence algorithms and architectures that provide richer computational capabilities than current deep learning networks and to model compact neuromorphic hardware suitable for edge computing and signal processing in Naval platforms.					
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The funding increases from FY 2020 to FY 2021 reflects the increased emphasis and investment in Artificial Intelligence related applied research associated with advancing naval capabilities for decision making tools, systems, and supporting technologies. This funding increase is also responsive to the CNO Design for Maritime Supremacy 2.0, instructing ONR to advance and guide AI fundamental research enabling: AI verification methods; long-duration missions for Naval unmanned surface ships; AI processing at the tactical edge; intelligent agents that rapidly learn, generate high-volume course of action excursions and assist humans in making collaborative, complex decisions, and achieve the goal of enabling our sailors and marines to make better decisions faster than our adversaries in dynamic environments.	1.535	1.550	1.723	0.000	1.723	
Title: Multi-Source Integration and Combat Identification						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020
Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)		
<u>B. Accomplishments/Planned Programs (\$ in Millions)</u>				
		FY 2019	FY 2020	FY 2021 Base
				FY 2021 OCO
				FY 2021 Total
Description: This activity addresses Theater Air And Missile defense (TAMD), and responds to warfighter needs for rapid, high confidence Combat Identification (CID) of air and missile threats at long range, using real time and non-real time threat attributes and intelligence information.				
FY 2020 Plans: Electromagnetic Warfare: Continue efforts to improve Radio Frequency (RF) detection of targets at High Frequency (HF) frequencies as precursors to adversary air attacks and improvements in HF surface wave radar array geometries. Continue work on concepts for rapidly assessing concurrent multiple missiles with multiple EW responses to provide for rapid high quality assessment in this complex environment. Expand ship signatures analysis for certain threat categories to determine how to mitigate vulnerabilities and develop methods for robust countermeasures employment.				
FY 2021 Base Plans: Electromagnetic Warfare: The research being conducted by three projects in this area address Theater Air and Missile Defense (TAMD), and responds to warfighter needs for rapid, high confidence identification of air and missile threats at long range, using real time and non-real time threat attributes and intelligence information. Current efforts include: - Extending a previously developed technology to discover features of ship signatures vulnerable to certain threat detections and determine how to mitigate these. - Using models to determine the enhanced radar cross section of Hyper Velocity Vehicles (HVV) and provide improved prediction and interpretation from HVV flights for early detection/identification and performance evaluation of these vehicles. - Efficient broadband two-dimensional high frequency transmit arrays for Over-The-Horizon (OTH) Radar to enable two dimensional transmit beam steering, adaptive transmit side lobe control and reduced prime power requirements for long range detection of objects in the environment.				
FY 2021 OCO Plans:				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: No significant changes from FY 2020 to FY 2021; no programmatic impact.						
Title: Tactical Space Exploitation		5.137	5.188	5.736	0.000	5.736
Description: The Tactical Space Exploitation initiative explores the application of new space craft technologies on small, light-weight and low-cost satellites, to enhance naval warfighting capabilities by taking advantage of the global access, revisit and connectivity provided by orbital platforms.						
Spacecraft Technology: Affordable, expendable payload and bus technologies will be developed, which will serve as building blocks for future responsive space systems: payloads, bus technologies and significant space robotic technologies that address on-orbit inspection, servicing, repair and assembly, and mission-life extension.						
FY 2020 Plans: Space Research and Spacecraft Technology: Continue efforts to advanced, high-payoff technologies that will preserve, protect, and enhance space capabilities in the performance of functions that are of critical importance to Navy-Marine Corps operations while also reducing the cost of DoD space activities.						
Next-Generation Sensing: Continue efforts to develop a single pixel camera architecture for passive microwave imaging, maintaining currently delivered spatial resolution and calibration performance while significantly reducing current aperture diameter.						
Spacecraft Technology: Continue work to develop a new capability for local Space Situational Awareness (SSA) with a novel system that detects and tracks objects in close proximity to a satellite that is equipped with this capability.						
FY 2021 Base Plans: Space Research and Spacecraft Technology:						
To perform early-applied discovery Research and Development (R&D) to ensure Navy-Marine Corps access to critical space-associated capabilities on the ground, at sea, and in a contested space environment. Research thrusts include spacecraft R&D in five strategic cross-cutting areas that lead to the fielding of systems which perform functions critically important to operations. These areas are: (1) Advanced Space Platform						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy			Date: February 2020			
Appropriation/Budget Activity 1319 / 2		R-1 Program Element (Number/Name) PE 0602235N / Common Picture Applied Research	Project (Number/Name) 0000 / Common Picture Applied Research			
B. Accomplishments/Planned Programs (\$ in Millions)						
		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Technologies, such as development of new and prototype space systems that are tailored to specific threats, including technologies which reduce cost, mass, power and/ or extend on-orbit lifetimes, and sub-systems that advance propulsion and control capabilities towards precision maneuvering while minimizing fuel; (2) Next-generation Payloads and Sensors, including space robotic capabilities to address on-orbit inspection, servicing, repair, assembly, and mission life extension; (3) Connectivity for disadvantaged users that is rugged, high-bandwidth and space based; (4) Space Weather, and (5) Space Situational Awareness.						
Current efforts include: <ul style="list-style-type: none"> - Developing and validating models of cathode breakdown and plasma formation to demonstrate reliable, repeatable cathode ignition using plasma heating, which will benefit the Navy by enabling instant ignition within seconds for responsive, low-power operation aboard highly mobile small satellites. - Developing a Global Positioning System (GPS)-denied satellite autonomous navigation system that can operate for years with no input from operators or external systems and still perform a useful mission; developing a simulation tool capable of predicting the change in the aerodynamic performance of hypersonic vehicles after impact with atmospheric cloud formations over a range of mission scenarios and weather conditions. - Demonstrating the successful completion of a robotic assembly task using a formally stable haptic feedback scheme in the presence of communication latency that allows an operator to feel how the robot is moving, rather than rely only on camera views or simulations. 						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: No significant changes from FY 2020 to FY 2021; no programmatic impact.						
Accomplishments/Planned Programs Subtotals		40.559	42.846	48.001	0.000	48.001
C. Other Program Funding Summary (\$ in Millions)						
N/A						
Remarks						
D. Acquisition Strategy						
N/A						

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy											Date: February 2020	
Appropriation/Budget Activity					R-1 Program Element (Number/Name)							
1319: Research, Development, Test & Evaluation, Navy / BA 2: Applied Research					PE 0602236N / Warfighter Sustainment Applied Res							
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	0.000	64.010	95.825	67.765	-	67.765	66.134	67.657	68.226	69.591	Continuing	Continuing
0000: Warfighter Sustainment Applied Res	0.000	57.349	63.825	67.765	-	67.765	66.134	67.657	68.226	69.591	Continuing	Continuing
9999: Congressional Adds	0.000	6.661	32.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	38.661

A. Mission Description and Budget Item Justification

U.S. Sailors and Marines underpin all missions. Advances in Artificial Intelligence (AI) enabled decision aides, autonomy, human-machine training, augmented performance, command and control and protective equipment will ensure their advantage in a complex, maritime environment. This Program Element (PE) conducts applied research to address Warfighter protection and performance concerns, including efforts that focus on advanced Naval materials, biocentric technologies, decision support, intelligent and autonomous systems, human performance optimization, training and education technologies, social and cultural, and biomedical technologies. This PE also supports the Office of Naval Research (ONR) Global mission to serve as the preeminent external facilitator for the Naval Research Enterprise. This is accomplished by establishing quality, relevant connections between the international research and development community, Naval fleet/forces, DOD, other US Government agencies and international partners.

Today's Sailors and Marines are enabled by naval Science and Technology (S&T). Since 1946, the Office of Naval Research (ONR) has fostered scientific research related to the maintenance of maritime superiority and national defense. ONR manages the Department of the Navy's (DON) portfolio of naval Basic and Applied research, and Advanced Technology Development investments to ensure naval forces can effectively deter conflict, but when called upon, fight, win and come home safe. Current investments hedge against uncertainty, providing solutions to commanders today, and options for the future. The Naval S&T budget supports higher guidance defined by the National Defense Strategy, and responds to requirements identified by the Secretary of the Navy through research priorities set by the Chief of Naval Research, coordinated across the Naval Research Enterprise (NRE), and outlined in the Naval R&D Framework.

This Program Element (PE) funds Applied Research, which is the systematic study to understand the means to meet a recognized and specific need. Most of the work in this PE can be classified between Technology Readiness Level (TRL) 2 (technology concept and/or application formulation) and TRL 4 (component and/or breadboard validation in laboratory environments).

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy					Date: February 2020
Appropriation/Budget Activity	R-1 Program Element (Number/Name)				
1319: Research, Development, Test & Evaluation, Navy / BA 2: Applied Research	PE 0602236N / Warfighter Sustainment Applied Res				
B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	65.782	63.825	64.558	-	64.558
Current President's Budget	64.010	95.825	67.765	-	67.765
Total Adjustments	-1.772	32.000	3.207	-	3.207
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	32.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-1.772	0.000			
• Program Adjustments	0.000	0.000	3.207	-	3.207
• Rate/Misc Adjustments	0.000	0.000	0.000	-	0.000
Congressional Add Details (\$ in Millions, and Includes General Reductions)	FY 2019	FY 2020			
Project: 9999: Congressional Adds					
Congressional Add: <i>Program Increase</i>	2.317	0.000			
Congressional Add: <i>Warfighter Safety and Performance</i>	4.344	0.000			
Congressional Add: <i>Laser peening technology</i>	0.000	4.000			
Congressional Add: <i>Lightweight anti-corrosion nanotechnology coating enhancement</i>	0.000	5.000			
Congressional Add: <i>Polymer coatings for reduced ice and fouling adhesion</i>	0.000	6.000			
Congressional Add: <i>Undersea domain human performance requirements</i>	0.000	3.000			
Congressional Add: <i>Engineered systems to prevent hearing loss</i>	0.000	5.000			
Congressional Add: <i>Extreme environment warfighter safety research</i>	0.000	4.000			
Congressional Add: <i>Female musculoskeletal research</i>	0.000	5.000			
	Congressional Add Subtotals for Project: 9999				
	Congressional Add Totals for all Projects				
	6.661	32.000			
	6.661	32.000			

Change Summary Explanation

The funding increase from FY 2020 to FY 2021 is due to \$3.3M of funds for the 1000 Molecules program that supports the sustainable transition of critical synthetic biology capabilities.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020				
Appropriation/Budget Activity 1319 / 2					R-1 Program Element (Number/Name) PE 0602236N / Warfighter Sustainment Applied Res				Project (Number/Name) 0000 / Warfighter Sustainment Applied Res						
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost			
0000: Warfighter Sustainment Applied Res	0.000	57.349	63.825	67.765	-	67.765	66.134	67.657	68.226	69.591	Continuing	Continuing			
A. Mission Description and Budget Item Justification															
U.S. Sailors and Marines underpin all missions. Advances in AI-enabled decision aides, autonomy, human-machine training, augmented performance, command and control and protective equipment will ensure their advantage in a complex, maritime environment. This Program conducts applied research to address Warfighter protection and performance concerns, including efforts that focus on advanced Naval materials, biocentric technologies, decision support, intelligent and autonomous systems, human performance optimization, training and education technologies, social and cultural, and biomedical technologies. This PE also supports the Office of Naval Research (ONR) Global mission to serve as the preeminent external facilitator for the Naval Research Enterprise. This is accomplished by establishing quality, relevant connections between the international research and development community, Naval fleet/forces, DOD, other US Government agencies and international partners.															
B. Accomplishments/Planned Programs (\$ in Millions)											FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Advanced Naval Materials Description: Advanced Naval Materials efforts support several Science and Technology (S&T) Focus Areas, in particular Platform Design & Survivability, and perform research across a broad spectrum of technical areas including: structural materials to increase platform performance and survivability at reduced weight and cost; advanced, high-performance materials for energy systems; corrosion mitigation strategies; high-temperature propulsion systems; and enhanced sonar transducers.											11.205	14.715	16.874	0.000	16.874
FY 2020 Plans: - Conduct research on Agile Manufacturing Integrated Computational Materials Engineering (ICME). This effort will establish a robust collection of predictive capabilities based on quantitative experimentation and characterization at all appropriate length scales to accelerate the development and optimization of new materials, and the design of advanced components while reducing the time required for qualification. Application of these tools will enable greater confidence and utilization of additive manufacturing and other advanced manufacturing technologies. - Conduct ongoing research on materials development and advanced processing technologies for acoustic transduction.															

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602236N / Warfighter Sustainment Applied Res	Project (Number/Name) 0000 / Warfighter Sustainment Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
- Conduct research on structural materials to include the following: nanostructured materials and coatings processing, composite development, cellular materials, high temperature materials, metals and alloys for structural applications, and alternative hull materials.						
- Conduct applied research related to critical S&T to investigate corrosion control modeling, high strength corrosion resistant coatings and compositionally complex alloys, and corrosion resistant additive manufactured alloys.						
- Conduct ongoing research that develops enabling manufacturing technology to scale up and improve affordability of science and technology products. Key tasks for this period include development of affordable fabrication technology for submarine coatings.						
Materials and Chemistry: Develop novel and scalable processing methods to produce mechanically robust high temperature superconductor tapes with minimal AC loss for various naval applications such as transformers, inductors, stators and for pulsed power delivery systems for all electric ships. Design new microfluidic system for direct write additive manufacturing to significantly improve the existing techniques. Design of multifunctional material systems for use in new helmet design to mitigate multiple threats. Compositional modifications and processing parameters to optimize material performance have been demonstrated leading to current plans for their utilization.						
FY 2021 Base Plans: Materials: Conduct research to build Agile Manufacturing - Integrated Computational Materials Engineering (ICME) toolkit infrastructure. Conduct ongoing research efforts to improve affordability and reliability of piezoelectric transduction materials. Conduct research to develop advanced structural alloys and composites, joining and repair technologies. Conduct research to pursue commercially viable processing for nano-engineered materials, including ceramics, metals, and materials systems. Continue development of new, advanced, environmentally benign Anti-Fouling (AF)/Anti-Corrosive (AC) coating systems for Navy platforms.						
Sustainment & Logistics: Conduct applied research to investigate corrosion control modeling, high performance longer-life corrosion resistant coatings, compositionally complex alloys, corrosion resistant additive manufactured components and atmospheric corrosion of aluminum 5000 components.						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602236N / Warfighter Sustainment Applied Res	Project (Number/Name) 0000 / Warfighter Sustainment Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Manufacturing: Develop manufacturing technology to help accelerate capability to the fleet in areas such as high-energy laser (HEL) weapons, advanced electronic warfare, and electronic controls for unmanned vehicles.						
Initiate efforts focused on demonstrating the deposition of quality carbon phosphonitride materials for liquid-based additive manufacturing techniques tailored for use in true 3-D direct write processes. Efforts will enable this technology to produce inexpensive, high quality parts; and demonstrating that next generation TBCs can be optimized to meet 20-year survivability requirements for use in a marine diesel environment to support an increase in operating temperatures from 500 to 800 degrees Celsius.						
Materials and Chemistry: Ongoing efforts include designing new microfluidic system for direct write additive manufacturing to significantly improve the existing techniques, and efforts to determine thermal barrier coating (TBC) degradation mechanisms and susceptibility and apply that understanding to optimize TBCs for marine use and enable long service-life applications in severe environments.						
Efforts completing with reduced investment in FY21 include work on computational models of thermal, ballistic impact, blunt impact and blast overpressure effects on helmet design and account for biomechanical response and fluid dynamics associated with helmet design and materials testing. Effort employs optimization software that utilizes model results to design helmet pad material and helmet suspension geometry against multiple performance requirements.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The funding increase from FY 2020 to FY 2021 is due to the environmental quality effort being realigned to this R-2 Activity from the Environmental Quality activity beginning in FY 2021. The Environmental Quality (EQ) efforts depend heavily on materials, polymer science and chemistry. To take greater advantages of these synergies, the EQ program is being realigned to the Advanced Naval Materials R2 Activity.						
Title: Biocentric Technologies		5.223	7.596	11.433	0.000	11.433

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602236N / Warfighter Sustainment Applied Res	Project (Number/Name) 0000 / Warfighter Sustainment Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Description: Applied research to develop knowledge and technologies for future Naval capabilities. Research area include: bioinspired and biomimetic materials; synthetic biology for maritime surveillance; bioenergy harvesting and electronics; warfighter augmentation; and marine mammal health. This research provides secure and agile options to enhance performance and reduce cost; increases novel power and energy solutions to safely extend operational duration; and improve stealth, maneuverability, and mission capability of platforms and autonomous systems.	FY 2020 Plans: Bio-Inspired Systems: Applied research in areas of: Control of bio-inspired autonomous vehicles in complex maneuvers; and Integration of biomimetic sonar with bio-inspired underwater vehicles for obstacle detection and avoidance. Human Interaction with Autonomous Systems: Applied research in areas of: Development of brain-based intelligent systems to support collaboration between humans and autonomous systems; and Research on human and robotic teammates. Biocentric Technology: Applied research of Naval biosensors, biomaterials, and bioprocess technologies: Accelerate engineering development and optimization of microbial undersea energy harvesting systems for sustainable and autonomous powering of Naval underwater sensor and communication nodes; Examine feasibility of microbial electrochemical systems for shipboard waste-to-energy conversion (including disabled submarine scenarios); Accelerate research in human microbiome for divers, combat swimmers, and submariners; Applied research of devices incorporating engineered sentinel organisms for environmental monitoring (including the human gut); and Integration of programmable cellular controllers with robotic devices. Bioengineering and Life Sciences: Applied research in the areas of: Sequencing technologies as diagnostic tools for viral pathogens in chemical and environmental samples; Various formulations of polymer mimics of mussel adhesion proteins for underwater applications; Highly-efficient proton exchange membrane fuel cells based on designer catalysts and novel catalyst supports for Naval applications; and Improving the health and welfare of the Navy's marine mammals including development of immunobioassays for stress and infection detection and acoustic analysis of dolphin sounds as an indicator of their well-being;					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020
Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)		
<u>B. Accomplishments/Planned Programs (\$ in Millions)</u>				
		FY 2019	FY 2020	FY 2021 Base
				FY 2021 OCO
				FY 2021 Total
1319 / 2	PE 0602236N / Warfighter Sustainment Applied Res			
Warfighting Augmentation: Applied research in multi-functional textiles that interact with autonomous life support, neuromuscular control and waste management, biosensors and bio-electronics, and adaptive and integrative protection.				
Materials and Chemistry: Develop novel approaches to rapidly identify antibiotic resistant genes in bacterial pathogens of importance for the entire US military force. Success of this effort will enable our transitional partners, the Naval Medical Research Center and the Naval Medical Research Laboratories, for rapid identification of highly resistant bacterial pathogens. A major success has been demonstrated by utilizing Naval Research Laboratory (NRL) developed microbial resistant determinant assay for its advances to system design.				
FY 2021 Base Plans: Bio-Inspired Autonomous Systems: Conduct applied research on bio-inspired underwater vehicle propulsion and control. Conduct applied research to develop precision navigation and advanced search behaviors. Integrate biosonar into a bio-inspired unmanned vehicle to evaluate obstacle detection and avoidance in congested spaces. Conduct applied research to develop and evaluate lateral line based intelligent sensing and control.				
Human Interaction with Autonomous Systems: Conduct applied research to develop agile humanoid robot teammates. This includes incorporating computer vision reasoning and human communication. Conduct applied research to train mission capable robots to perform complex manipulation skills. Conduct applied research to develop technology to enhance diver performance with small AUV assistants.				
Biocentric Technology: Conduct applied research on Naval biosensors, biomaterials, and bioprocess technologies. This includes conducting multi-month/year tests of microbial underwater energy harvesting systems (in various ports, rivers, test sites), expand to deep water marine environments and test ability to power new devices; decreasing efforts in study microbial electrochemical systems for ship/sub waste-to-energy conversion (including disabled submarine scenarios); conducting studies of prebiotic food additives/probiotics for effects on microbiome and performance in human subjects; developing strategies to incorporate programmable cellular controllers (sense-and-respond microbes) for environmental monitoring into relevant Naval platforms; and conducting research on the influence of sample source and rapid dilution of DNA sequencing for monitoring undersea environments.				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602236N / Warfighter Sustainment Applied Res	Project (Number/Name) 0000 / Warfighter Sustainment Applied Res				
<u>B. Accomplishments/Planned Programs (\$ in Millions)</u>		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Bioengineering and Life Sciences: Conduct applied research to assess new instrumentation for hastening the time of sequence analysis of viruses in clinical and environmental samples in the field; further develop bio-inspired and biomimetic adhesive materials for underwater applications; demonstrate more efficient proton exchange membrane fuel cells; determine whether an individual dolphin's vocalizations can be correlated with veterinary and trainer observations to develop a sound model for the animal that describes their welfare; and investigate serum and urine markers of kidney injury in bottlenose dolphins.						
Warfighter Augmentation: Applied research on the development of technologies to enhance undersea capabilities, including bio-inspired underwater geolocation.						
Materials and Chemistry: Develop a semi-automated assay system that will enable our transition partners, the Naval Medical Research Center and Naval Medical Research Unit laboratories, to rapidly identify antibiotic resistance genes in bacterial pathogens of importance to the U.S. military. The science, technology and resulting system will contribute directly to warfighter health, performance and survivability. Efforts completing with reduced investment in FY 2021 include demonstrations that the assay system provides better and greater identification of resistance determinants from clinical matrices than whole shotgun metagenomic sequencing.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The funding increase from FY 2020 to FY 2021 is due to \$3.3M of funds for the 1000 Molecules program that supports the sustainable transition of critical synthetic biology capabilities.						
Title: Environmental Quality Description: Environmental Quality technologies enable sustained world-wide Navy operations in compliance with all local, state, regional, national and international laws, regulations and agreements.		2.698	2.672	0.000	0.000	0.000
FY 2020 Plans:						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602236N / Warfighter Sustainment Applied Res	Project (Number/Name) 0000 / Warfighter Sustainment Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Ongoing development of new, advanced, environmentally benign Anti-Fouling (AF)/Anti-Corrosive (AC) coating systems for Navy platforms.						
Ongoing development of advanced environmentally sound technologies for shipboard waste treatment and pollution abatement systems.						
FY 2021 Base Plans: N/A						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The funding decrease from FY 2020 to FY 2021 is due to the Environmental Quality (EQ) effort being realigned to the Advanced Naval Materials R-2 Activity. The Environmental Quality efforts depend heavily on materials, polymer science and chemistry. To take greater advantages of these synergies, the EQ program is being realigned into the Advanced Naval Materials R2 Activity.						
Title: Human Factors and Organizational Design Description: New hybrid warfare operations threaten every Navy/Marine Corps mission abroad and Warfighters need new techniques, tactics, and procedures to anticipate, forecast, and adapt to unconventional influence tactics and strategies. These applied research efforts will improve system interface designs and human-level decision support in Naval contexts. Research areas include human-machine teaming, social networks and computational social science, and command decision making. FY 2020 Plans: Human-Machine Teaming: Applied research on system interface designs and human-machine interaction methodologies that enable or enhance Warfighter performance and human-machine teaming. Focus areas include: (i) Physiological monitoring and cognitive state estimation; (ii) Psychoacoustics and audio-visual scene interpretation; and (iii) Rapid interface design evaluation. Social Networks and Computational Social Science: Applied research in information environment assessment, civil-military communications (public affairs) information operation, and psychological operations. This research addresses problems of countering influence operations, dealing with polarized audiences, and mitigation of social hysteria propagation in online and real-world information campaigns. These efforts include gamification to	5.752	5.745	5.736	0.000	5.736	

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602236N / Warfighter Sustainment Applied Res	Project (Number/Name) 0000 / Warfighter Sustainment Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
provide principles and foundational frameworks for development of training and exercises, including operating in contested information environments.						
Command Decision Making: Applied research in decision aid algorithms and human interfaces for command and control processes, to include alerting command staff when mission re-planning is required. Research technologies to capture and share practical knowledge that is learned on the job and effectively share with peers as a supplement to formal training. Conduct applied research for the development of supervised learning algorithms that capture mission planning workflow for a range of missions.						
FY 2021 Base Plans: Cognitive Science for Human-Machine Teaming Conduct applied research on system interface designs and human-machine interaction methodologies that enable or enhance Naval Warfighter performance and human-machine teaming. Efforts investigating physiological monitoring and cognitive state estimation are complete and the focus will shift to: Psychoacoustics and audio-visual scene interpretation implemented in computational models that serve as the front end for cognitive architectures and new human interfaces; construction of computational models that integrate top-down expectation; and gaze control to enable multisensory perception within a cognitive architecture for autonomous systems. Social Networks and Computational Social Science Conduct applied research in information environment assessment, civil-military communications (public affairs), information operations and strategic communication. Develop improved course of action guidance and capabilities to detect and defuse: disinformation, social hysteria and group polarization campaigns. Develop information conflict war-game capabilities relevant to international exercises. Command Decision Making Develop information display concepts to include alerting and decision aid algorithms for complex, multi-dimensional data. These concepts are critical for avoiding collisions, accomplishing rendezvous, determining the value of information, and planning courses of action.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement:						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602236N / Warfighter Sustainment Applied Res	Project (Number/Name) 0000 / Warfighter Sustainment Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
There is no significant change between FY 2020 and FY 2021.						
Title: Human Research Protection Program (HRPP)	2.685	2.705	2.739	0.000	2.739	
Description: The Federal Policy for the Protection of Human Subjects is codified in the Department of Defense (DoD) as part 219 of title 32, Code of Federal Regulations (also known and hereinafter referred to as the "Common Rule"). DoD Instruction 3216.02 establishes policy and assigns responsibilities for the protection of human subjects in DoD-supported programs to implement the Common Rule and requires Heads of DoD Components to establish and oversee DoD Component policies and procedures that ensure compliance with federal and DoD requirements. The Secretary of the Navy Instruction (SECNAVINST) 3900.39E CH-1 identifies the Chief of Naval Research as providing support and expertise for human research protection in research conducted or supported by the Navy and Marine Corps Systems Commands and institutions, operational forces, training Commands, and Department of the Navy (DON)-supported research involving human subjects performed by non-DoD institutions. The Human Research Protection Program (HRPP) program protects the rights, safety, and welfare of human subjects in research conducted or sponsored by the Navy and Marine Corps by: 1) ensuring that research involving human subjects complies with federal regulations, DoD Directives, DON Instructions, and Marine Corps Orders governing research protection requirements; and 2) providing education and training programs in human research ethics to all levels of staff involved in the review, approval, conduct, management, or support of DON human subjects research (HSR).						
FY 2020 Plans: Execute DON HRPP Management Plan; provide day-to-day oversight of DON HRPP activities; conduct periodic site inspections and assist visits; conduct training for Exempt Determination Officials, conduct Component and Headquarters-level review of DON-supported human subjects research; provide subject matter expertise and guidance on all DON-supported research involving human subjects; implement revisions to Standard Operating Procedures in light of revisions to the Common Rule and SECNAVINST 3900.39E; and provide DON input to USD(R&E) and other DoD policy guidance impacting DON human research-related efforts.						
FY 2021 Base Plans: Build a Research Protection Community of Excellence; establish two new HRPPs; coordinate and finalize SECNAVINST 3900.39F; Program Management of the DON Research Protections Information Technology Management System for management and compliance oversight of ongoing human research protections activities; establish policy for single Institutional Review Board review; provide education and training programs in human research ethics to all levels of staff involved in the review, approval, conduct, support, or management						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602236N / Warfighter Sustainment Applied Res	Project (Number/Name) 0000 / Warfighter Sustainment Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
of DON HSR; provide subject matter expertise and guidance on all DON-supported research involving human subjects.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant change between FY 2020 and FY 2021.						
Title: Medical and Human Performance Technologies Description: Medical and human performance applied research technologies have historically been funded out of the 0602236N Medical Technologies R2 Activity. Starting in FY21, this R2 Activity will be described in two categories to better explain the program areas related to medical and human performance research in this exhibit. Efforts categorized as Medical Technologies focus on research after injury. Efforts categorized as Human Performance Technologies focus on research before injury. The medical portion of this applied research activity focuses on reducing operational health threats, development of point-of-injury medical equipment, and medical diagnostic capabilities and treatments. This research will improve the Fleet's ability to save lives, especially during prolonged field care. The human performance portion of this applied research activity focuses on improving undersea performance of divers and submarine crews; sensory perception and performance to improve warfighter capabilities during exposure to high levels of acoustic or electromagnetic energy; and physiological monitoring of Naval forces during training and operational environments. To avoid duplication of effort, research is coordinated with other Services through the Office of the Secretary of Defense Communities of Interest.		5.839	5.771	5.764	0.000	5.764
FY 2020 Plans: Undersea Medicine and Performance: Applied research efforts include: Integrated diving helmet audio-visual displays; and Pharmacological agents and technologies to mitigate decompression sickness and oxygen toxicity.						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Sensory Neuroscience and Whole-body Physiology: Applied research to improve personal protective equipment and monitoring systems in order to mitigate biomedical effects of exposure to high-levels of acoustic pressure or electromagnetic energy.						
FY 2021 Base Plans: Medical and human performance applied research technologies have historically been funded out of the 0602236N Medical Technologies R2 Activity. Starting in FY 2021, this R2 Activity will be described in two specific categories to better explain the program areas related to medical and human performance research in this exhibit. Efforts categorized as Medical Technologies focus on research after injury. Efforts categorized as Human Performance Technologies focus on research before injury.						
Medical Technologies Conduct applied research to treat impaired tactical auditory sense and sense-making. Identify near infrared medical treatment and mitigation of auditory temporary threshold shifts. Conduct applied research to enhance casualty identification, classification, and prioritization for manned and unmanned casualty care evacuation. Conduct research to provide therapeutic care using nanotechnology, pharmacological agents, and autonomy for casualties in disaggregated environments.						
Human Performance Technologies Conduct applied research efforts to develop technologies to monitor and protect divers from environmental stressors, such as temperature, pressure, and limited visibility. Develop manned-unmanned teaming platforms to aid a diver in enhanced situational awareness and expand diving windows of opportunity. Conduct applied research to understand impacts of loud noises within dive helmets and human exposure to electromagnetic energy; develop exposure monitoring and mitigation strategies; and improve personal protective equipment and communication technologies. Develop human physiologic and biologic sensors for real-time monitoring of performance status in training and operational environments. Continue applied research efforts to reduce high performance tactical aircraft jet noise including High Fidelity Modeling, Advanced Diagnostics, and Noise Reduction Concepts, for human protection.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement:						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020
Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)		
<u>B. Accomplishments/Planned Programs (\$ in Millions)</u>				
		FY 2019	FY 2020	FY 2021 Base
				FY 2021 OCO
				FY 2021 Total
1319 / 2	PE 0602236N / Warfighter Sustainment Applied Res			
There is no significant change between FY 2020 and FY 2021.				
Title: The Office of Naval Research Global		19.060	19.733	20.335
Description: Supports the Office of Naval Research (ONR) Global mission to serve as the preeminent external facilitator for the Naval Research Enterprise. This is accomplished by establishing quality, relevant connections between the international research and development community, Naval fleet/forces, DOD, other US Government agencies and international partners.				0.000
Science Advisors (SA) This effort ensures that the operational Naval fleet/force help shape the DON investment in science and technology (S&T), develops teaming relationships to rapidly prototype, experiment, demonstrate and transition technology, supports development of technology-based capability options for Naval forces, and enables warfighting innovations based on technical and conceptual possibilities. The SA Program also informs capability-based war games using current and future technology to identify future capability strengths and shortfalls that assist in shaping the DON investment strategy. The ONR Global SA Program enables continuous communication and collaboration between the warfighters, the Naval Research & Development Enterprise, and strategic development commands.				20.335
International science The ONR Global mission is also accomplished through PhD-level scientists located in Asia, Europe and South America, providing coverage in these regions as well as Africa, Australia/New Zealand and the Middle East. ONR Global scientists actively search the globe for emerging scientific research and promising technologies, collaborating with international organizations and researchers through liaison visits and grants in innovative applied research. The direct impact of this investment is to leverage international research during increasingly dynamic global interdependence and improve the ability to solve DON S&T challenges through shared knowledge and technologies with partners. In addition, this investment builds global S&T awareness to reduce the risk of potential technological surprise, and supports theater security cooperation goals to sustain cooperative relationships with an expanding set of international partners.				
International engagement				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602236N / Warfighter Sustainment Applied Res	Project (Number/Name) 0000 / Warfighter Sustainment Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
ONR Global also supports international engagement with partner nations through the development and maintenance of bilateral and multilateral relationships, international agreements, and other activities that promote RDT&E collaboration and interoperability.						
FY 2020 Plans: Support all Science Advisor program efforts across Fleet and Forces Commands; objectively assess placement of current Science Advisors and requests for additional support in terms of impact to the Fleet and S&T return on investment. Support PhD-level scientists, in seven overseas offices, continuing to engage with international scientists and engineers through liaison visits to research institutions and continue actively fostering international collaboration by awarding research grants. Support international engagement with ten partner nations, three multi-lateral groups, and support to the Northern Atlantic Treaty Organization (NATO), in order to increase collective Naval capability, capacity, and interoperability.						
FY 2021 Base Plans: Support all Science Advisor program efforts across Fleet and Forces Commands; objectively assess placement of current Science Advisors and requests for additional support in terms of impact to the Fleet and S&T return on investment. Support PhD-level scientists, in seven overseas offices, continuing to engage with international scientists and engineers through liaison visits to research institutions and continue actively fostering international collaboration by awarding research grants. Support international engagement with ten partner nations, three multi-lateral groups, and support to the Northern Atlantic Treaty Organization (NATO), in order to increase collective Naval capability, capacity, and interoperability.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement:						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602236N / Warfighter Sustainment Applied Res	Project (Number/Name) 0000 / Warfighter Sustainment Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
There is no significant change between FY 2020 and FY 2021.						
Title: Training Technologies Description: Applied research to enhance the ability to train and educate Naval forces from time of recruitment through separation from the military. This includes use of simulated environments in classroom and deployed environments. Improved efficiency and cost-effectiveness is achieved by applying operations research, modeling and simulation, and instructional, cognitive, and computer sciences to the development, delivery, evaluation, and execution of training and education. To avoid duplication of effort, research is coordinated with other Services via the Office of the Secretary of Defense Communities of Interest.		4.887	4.888	4.884	0.000	4.884
FY 2020 Plans: Technologies for Naval Training: Applied research to augment training, skill maintenance, and evaluation through gaming, and learning theory. Research includes developing effective instructional strategies in intelligent tutors and conducting evaluation of intelligent job aids. Develop computational models of skill decay for psychomotor, perceptual, and cognitive skills, and refresher training strategies. Advanced Integrated Maritime Mission Modeling: Applied research in the development of live, virtual, and constructive training and experimentation technologies. Efforts will include developing tools for training in denied and degraded electromagnetic environments and in extreme weather environments.						
FY 2021 Base Plans: Technologies for Naval Training Conduct applied research for measuring cognitive ability, interests, and aptitude on Naval forces throughout their military career. Develop tools to track training and education efficacy and develop instructional strategies as needed to improve performance. Advanced Integrated Maritime Mission Modeling Apply advanced modeling and simulation tools to develop live-virtual-constructive training at both pier side and at-sea of navigation teams on Naval surface platforms.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement:						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020
Appropriation/Budget Activity 1319 / 2		R-1 Program Element (Number/Name) PE 0602236N / Warfighter Sustainment Applied Res	Project (Number/Name) 0000 / Warfighter Sustainment Applied Res	
B. Accomplishments/Planned Programs (\$ in Millions)			FY 2019	FY 2020
There is no significant change between FY 2020 and FY 2021.			FY 2021 Base	FY 2021 OCO
		Accomplishments/Planned Programs Subtotals	57.349	63.825
			67.765	0.000
				67.765
C. Other Program Funding Summary (\$ in Millions)				
N/A				
Remarks				
D. Acquisition Strategy				
N/A				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity 1319 / 2					R-1 Program Element (Number/Name) PE 0602236N / Warfighter Sustainment Applied Res				Project (Number/Name) 9999 / Congressional Adds				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
9999: Congressional Adds	0.000	6.661	32.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	38.661	
A. Mission Description and Budget Item Justification Congressional Interest Items not included in other Projects.													
B. Accomplishments/Planned Programs (\$ in Millions)													
Congressional Add: Program Increase											2.317	0.000	
FY 2019 Accomplishments: Research into social networks and the impact of novel technologies on human behavior in crisis and collaborative contexts.													
FY 2020 Plans: N/A													
Congressional Add: Warfighter Safety and Performance											4.344	0.000	
FY 2019 Accomplishments: Conduct research to include: continued studies on decompression sickness, oxygen toxicity, optimization of diver performance, and assessment of the impact of thermal stress on operational performance.													
FY 2020 Plans: N/A													
Congressional Add: Laser peening technology											0.000	4.000	
FY 2019 Accomplishments: N/A													
FY 2020 Plans: Conduct applied technology development for Laser Peening Technology.													
Congressional Add: Lightweight anti-corrosion nanotechnology coating enhancement											0.000	5.000	
FY 2019 Accomplishments: N/A													
FY 2020 Plans: Conduct applied technology development for Lightweight anti-corrosion nanotechnology coating enhancement.													
Congressional Add: Polymer coatings for reduced ice and fouling adhesion											0.000	6.000	
FY 2019 Accomplishments: N/A													
FY 2020 Plans: Conduct applied technology development for Polymer coatings for reduced ice and fouling adhesion.													
Congressional Add: Undersea domain human performance requirements											0.000	3.000	

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy			Date: February 2020
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602236N / Warfighter Sustainment Applied Res	Project (Number/Name) 9999 / Congressional Adds	
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020
FY 2019 Accomplishments: N/A			
FY 2020 Plans: Conduct applied technology development for Undersea domain human performance requirements.			
Congressional Add: Engineered systems to prevent hearing loss		0.000	5.000
FY 2019 Accomplishments: N/A			
FY 2020 Plans: Conduct applied technology development for Engineered systems to prevent hearing loss.			
Congressional Add: Extreme environment warfighter safety research		0.000	4.000
FY 2019 Accomplishments: N/A			
FY 2020 Plans: Conduct applied technology development for Extreme environment warfighter safety research.			
Congressional Add: Female musculoskeletal research		0.000	5.000
FY 2019 Accomplishments: N/A			
FY 2020 Plans: Conduct applied technology development for Female Musculoskeletal research.			
Congressional Adds Subtotals		6.661	32.000
C. Other Program Funding Summary (\$ in Millions)			
N/A			
Remarks			
D. Acquisition Strategy			
N/A			

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity					R-1 Program Element (Number/Name)								
1319: Research, Development, Test & Evaluation, Navy / BA 2: Applied Research					PE 0602271N / Electromagnetic Systems Applied Research								
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
Total Program Element	0.000	74.934	88.497	84.994	-	84.994	88.642	93.377	95.111	97.013	Continuing	Continuing	
0000: Electromagnetic Systems Applied Research	0.000	74.934	83.497	84.994	-	84.994	88.642	93.377	95.111	97.013	Continuing	Continuing	
9999: Congressional Adds	0.000	0.000	5.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	5.000	

A. Mission Description and Budget Item Justification

Freedom of maneuver on a global scale for U.S. naval forces depends upon assured access to the electromagnetic spectrum and the ability to deny adversary exploitation. Electromagnetic technologies must fluidly deliver communication, surveillance electronic warfare and digital integration to understand, shape and defend the battlespace. The Electromagnetic Systems Applied Research Program addresses technology needs associated with Naval platforms for new capabilities in Electro-Optic and Infrared (EO/IR) Sensors, Surveillance, Electronic Warfare, Navigation, Solid State Electronics, Vacuum Electronics Power Amplifiers, and Nanoelectronics. The program supports development of technologies to enable capabilities in Missile Defense, Directed Energy, Platform Protection, Time Critical Strike, and Information Distribution. Activities and efforts within this Program have attributes that focus on enhancing the affordability of warfighting systems.

Today's Sailors and Marines are enabled by Naval Science and Technology (S&T). Since 1946, the Office of Naval Research (ONR) has fostered scientific research related to the maintenance of maritime superiority and national defense. ONR manages the Department of the Navy's (DON) portfolio of naval Basic and Applied research, and Advanced Technology Development investments to ensure naval forces can effectively deter conflict, but when called upon, fight, win and come home safe. Current investments hedge against uncertainty, providing solutions to commanders today, and options for the future. The Naval S&T budget supports higher guidance defined by the National Defense Strategy, and responds to requirements identified by the Secretary of the Navy through research priorities set by the Chief of Naval Research, coordinated across the Naval Research Enterprise (NRE), and outlined in the Naval R&D Framework.

This Program Element (PE) funds Applied Research, which is the systematic study to understand the means to meet a recognized and specific need. Most of the work in this PE can be classified between Technology Readiness Level (TRL) 2 (technology concept and/or application formulation) and TRL 4 (component and/or breadboard validation in laboratory environments).

Due to the number of efforts in this Program Element (PE), the programs described herein are representative of the work included in this PE.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy					Date: February 2020
Appropriation/Budget Activity	R-1 Program Element (Number/Name)				
1319: <i>Research, Development, Test & Evaluation, Navy / BA 2: Applied Research</i>	PE 0602271N / <i>Electromagnetic Systems Applied Research</i>				
B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	76.497	83.497	83.259	-	83.259
Current President's Budget	74.934	88.497	84.994	-	84.994
Total Adjustments	-1.563	5.000	1.735	-	1.735
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	5.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-1.563	0.000			
• Program Adjustments	0.000	0.000	1.735	-	1.735
• Rate/Misc Adjustments	0.000	0.000	0.000	-	0.000
Congressional Add Details (\$ in Millions, and Includes General Reductions)	FY 2019	FY 2020			
Project: 9999: <i>Congressional Adds</i>					
Congressional Add: <i>Electromagnetic systems applied research</i>					
	0.000	5.000			
	0.000	5.000			
	0.000	5.000			
Congressional Add Subtotals for Project: 9999					
Congressional Add Totals for all Projects					

Change Summary Explanation

The \$1.735 program increase in FY 2021 supports increased investment in specialized signal processing engines to leverage machine learning algorithms for improved Electronic Support (ES) and Electronic Attack (EA) capabilities.

Technical: Not applicable.

Schedule: Not applicable.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020				
Appropriation/Budget Activity					R-1 Program Element (Number/Name)				Project (Number/Name)						
1319 / 2					PE 0602271N / Electromagnetic Systems Applied Research				0000 / Electromagnetic Systems Applied Research						
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost			
0000: Electromagnetic Systems Applied Research	0.000	74.934	83.497	84.994	-	84.994	88.642	93.377	95.111	97.013	Continuing	Continuing			
A. Mission Description and Budget Item Justification <p>Freedom of maneuver on a global scale for U.S. naval forces depends upon assured access to the electromagnetic spectrum and the ability to deny adversary exploitation. Electromagnetic technologies must fluidly deliver communication, surveillance electronic warfare and digital integration to understand, shape and defend the battlespace. This project addresses technology opportunities associated with Naval platforms for new capabilities in Electro-Optic and Infrared (EO/IR) Sensors, Surveillance, Electronic Warfare, Navigation, Solid State Electronics, Vacuum Electronics Power Amplifiers, and Nanoelectronics. The project supports development of technologies to enable capabilities in Missile Defense, Directed Energy, Platform Protection, Time Critical Strike, and Information Distribution. This project directly supports the Department of Defense Joint Warfighter Plan and the Defense Technology Area Plans. Activities and efforts within this program have attributes that focus on enhancing the affordability of warfighting systems. The program also provides for technology efforts to maintain proactive connectivity and collaboration between Department Of the Navy (DON) Science and Technology (S&T) and Joint, Navy, and Marine Corps commands worldwide. Due to the number of efforts in this Program Element (PE), the programs described herein are representative of the work included in this PE.</p>															
B. Accomplishments/Planned Programs (\$ in Millions) <p>Title: Electronic Warfare Technology</p> <p>Description: The overarching objective of this activity is to develop technologies that enable the development of affordable, effective and robust Electronic Warfare (EW) systems across the entire Electromagnetic Spectrum (EMS) that will increase the operational effectiveness and survivability of U.S. Naval units. Technology development is focused on Distributed Electronic Warfare in support of Distributed Maritime Operations. Emphasis is placed on passive sensors and active and passive Countermeasure (CM) systems that exploit and counter a broad range of electromagnetic threats. The focus is on maintaining near perfect, real-time knowledge of the enemy; countering the threat of missiles against deployed Naval forces; precision identification and location of threat emitters; and development of technologies that have broad application across multiple disciplines within the EW mission area. This activity also includes developments to protect these technologies from external interference, and modeling and simulation required to support the development of these technologies.</p> <p>The current objectives are:</p> <ul style="list-style-type: none"> - Electronic Warfare (EW) Radio Frequency (RF) Technology: Develop and demonstrate technologies in the RF spectrum (covering frequencies from kilohertz to terahertz) that include developments in detection, signal 											FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
											37.706	43.534	42.634	0.000	42.634

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
1319 / 2	PE 0602271N / Electromagnetic Systems Applied Research					
processing and passive/active techniques for wideband Electronic Attack (EA), Electronic Protection (EP) and the Electronic Support (ES) mission areas. - EW Electro-Optic/Infrared (EO/IR) Technology: Develop and demonstrate counter EO/IR technologies extending from the ultraviolet to the far infrared spectral bands. This includes advances in multispectral sensors, multiband sources, beam forming/steering, and signal processing and transmission. - EW Integrated and Networked Technology: Develop and demonstrate technologies that will enable an increased situational awareness and response across the electromagnetic spectrum (EMS) with broad spatial coverage using all available EW assets to provide coordinated, adaptive and networked EW sensing, protection and attack. - Advanced EW Enabling Technologies: Develop classified advanced electronic warfare technology in support of current and predicted capability requirements emphasizing distributive effects.						
FY 2020 Plans: Reinvigorate investments in fundamental component technologies that drive performance of electronic warfare system across the range of functions from sensor, signal processing, decision and collaboration software and response. Develop advanced antenna solutions to enable Simultaneous Transmit And Receive (STAR) with high directivity. Innovate new Radio-Frequency (RF) amplifier technology to deliver high power, broadband devices that extend into the millimeter-Wave in small form factors. Leverage emerging compute architectures and advanced algorithms to provide signal processing solutions for operating coherent, distributed arrays in complex electromagnetic environments. Develop deep learning methods for improved electronic warfare functions in the signal processing chain. Apply machine learning techniques to surface self-defense systems. Develop counter-measure solutions to optical sensors including non-mechanical beam steering and laser technologies to increase the effectiveness of Electro-Optic/Infrared (EO/IR) countermeasures in addition to passive obscurant technology. Improve modeling of sensor systems to provide integrated capability across optical and RF domain. Develop test technology for affordable fielding of cognitive, collaborative Electronic Warfare (EW) effector systems. Electromagnetic Warfare: The RF domain research includes discovery of communications networks and mechanisms for their disruption and defeat. Selected examples of research include discovery of parameters to identify functional characteristics of emerging radar system, advanced algorithms to specifically identify modern radar sources, using micro-jammers in a phased array configuration, exploiting optical emission characteristics, and development of a						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602271N / Electromagnetic Systems Applied Research	Project (Number/Name) 0000 / Electromagnetic Systems Applied Research				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
novel deep reinforcement learning and Q-network software framework to develop and refine control policies for participating offensive and defensive agents.						
FY 2021 Base Plans: Electronic Warfare (EW): - Extend research for federated, coordinated, and integrated EW systems in the areas of Electronic Surveillance (ES); decoys and countermeasures against weapon tracking and guidance systems; electronic attack (EA) against adversary command, control, communications, computers, intelligence, surveillance, reconnaissance and targeting (C4ISR); electronic protection (EP) of our own weapons and C4ISR from intentional and unintentional interference; and force-level kinetic/non-kinetic coordination and resource optimization. - Complete component fabrication, assembly, testing & demonstration of compact broadband & high power RF transmitter arrays and compact IR-UV laser sources for size, weight, and power (SWaP) constrained unmanned systems that began in FY19. Additionally, these plans include completing fabrication, testing & demonstration of new compute processing architectures specifically designed to leverage algorithms & deep learning techniques for Electronic Surveillance (ES) applications. - RF domain research will initiate development and implementation of algorithms and techniques into the new processing architectures previously developed for EW applications. - Develop tactics against modern and emerging radar sources for improving Naval mission effectiveness. This research domain will initiate development and techniques coordination between RF and EO/IR transmitters and receivers for single and distributed platforms utilizing compact broadband & high power RF transmit arrays and compact IR-UV laser sources developed previously. Electromagnetic Warfare:						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy			Date: February 2020			
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602271N / Electromagnetic Systems Applied Research	Project (Number/Name) 0000 / Electromagnetic Systems Applied Research				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019 FY 2020 FY 2021 Base FY 2021 OCO FY 2021 Total				
<p>The research being conducted by 22 projects is very diverse and includes efforts across a broad spectrum of Radio Frequency (RF) and Electro-Optic/Infrared (EO/IR) technologies that cover the detection of energy in the environment to the formulation of active and passive engagement techniques. The primary objectives in FY 2021 include research focused on Detection, Detection and Engagement, and Engagement.</p> <p>Current plans are to focus efforts on:</p> <ul style="list-style-type: none"> - Electromagnetic Warfare Detection focus on: Near-real-time geolocation of stationary (or slowly moving) RF emitters, and in particular, emerging threat radars employing unusual waveforms resulting in accurate geolocation; novel real-time signal processing techniques to dramatically increase the useful information content reported in receiver measurements of radar-band signals providing the warfighter with a low-ambiguity warning of detected; improving the effectiveness of emitter classification of modern radars for several functions including AIS validation increasing Maritime Domain Awareness; and applying recently developed machine learning methods to the problem of functional classification of radar emissions and demonstrate the ability to perform the functional classification in real time to overcome the inadequacy conventional emitter classification methods. - Electromagnetic Warfare Detection and Engagement focuses on: discovering and defeating unknown and adaptive radios by developing algorithms to observe their behavior, analyze their networking protocols, and optimize engagement techniques to interfere with their objectives. - Electromagnetic Warfare Engagement include: developing and demonstrating high gain distributed aperture technologies compatible with micro-jammer glide vehicles to increase the effective radiated power of a ground-based micro-jammer constellation to provide sufficient power to radars. Developing and demonstrating an evolvable Electronic Warfare (EW) transceiver design that optimizes cueing receiver processing to increase situational awareness and enable adaptive electronic attack response in complex electromagnetic environments to provide effective processing of emergent complex radar modes. <p>FY 2021 OCO Plans: N/A</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: The decrease from FY 2020 to FY 2021 reflects the realignment of funds from the Electronic Warfare Technology R2 activity to the Navigation R2 activity for increased investment in Quantum S&T Precision, Navigation, and Timing (PNT) programs in order to meet higher Navy priorities.</p>						
Title: EO/IR Sensor Technologies		7.102	7.141	7.559	0.000	7.559

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602271N / Electromagnetic Systems Applied Research	Project (Number/Name) 0000 / Electromagnetic Systems Applied Research				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Description: The overarching objective is to develop technologies that enable affordable, wide area, persistent surveillance optical architectures. Included are modeling and simulation required to support the development of these technologies. Efforts will also include the development of optical Radio-Frequency (RF) components, infrared technologies including lasers and focal plane arrays using narrow bandgap semiconductors. The current specific objectives are: - Optically Based Terahertz (THz) and Millimeter Wave (MMW) Distributed Aperture Systems: Develop optically based terahertz (THz) and millimeter wave distributed aperture systems for imaging through clouds, fog, haze and dust on air platforms. - Wide Area Optical Architectures: Develop wide area optical architectures for persistent surveillance for severely size constrained airborne applications. - Hyperspectral sensors and processing: Develop visible, shortwave Infrared (IR), mid-wave IR, and long-wave IR hyperspectral sensors, along with processing algorithms to detect anomalies and targets. - Coherent Laser Radar (LADAR): Develop and improve components for LADAR applications including fiber lasers, coherent focal planes, and advanced processing. - Autonomous and Networked sensing: Develop algorithms and processing that supports autonomous sensing for Unmanned Autonomous Vehicles (UAV) platforms and that supports networked sensing over multiple sensors and/or sensor platforms.						
FY 2020 Plans: Conduct applied research in optical components, infrared technologies and signal processing for the purpose of affordable, wide area, persistent surveillance and targeting applications in all weather conditions. Specific areas of research include: novel optical architectures for affordable persistent surveillance to support search, detection, classification, identification and targeting functions; development of laser and passive mmW detectors for imaging through degraded visual environments (e.g., clouds, fog, haze and dust); low size, weight, and power hyper-spectral sensors for severely size and power constrained airborne applications; development of automatic algorithms for autonomously detecting and recognizing anomalies and targets using networked sensors and/or sensor platforms; novel techniques for Electro-Optic/Infrared (EO/IR) countermeasures to detect, track and/or jam sensors. Electronics:						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602271N / Electromagnetic Systems Applied Research	Project (Number/Name) 0000 / Electromagnetic Systems Applied Research				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Create and explore new concepts, components, techniques, and subsystems for the generation, and transmission of Ultra-Violet (UV), visible, and infrared radiation to support current and future Navy and DoD needs.						
<p>Electromagnetic Warfare: Work is ongoing to address the critical deficiency with respect to operations in brownout conditions. Infrared (IR) and terahertz technologies are being modified and integrated with the expectations that combining these two technologies an effective solution can be obtained. Bistatic radar and imaging technology is being developed to extend surveillance capabilities and passively engage targets. A unique approach permitting rapid active scanning of a battlefield in the IR domain using a non-mechanically scanned mechanism is under development. This technology if successful will eliminate the multiple laser ball systems currently required to accomplish this same requirement at lower Size, Weight and Power (SWAP). Active work is also being focused on developing capabilities for high resolution, wide field of view sensors on modest sized Unmanned Autonomous Systems (UAS) platforms.</p> <p>Materials and Chemistry: Advanced fabrication methods to develop micro-retro-reflectors operating in short wavelength Maritime Infrared (IR) systems. This study is directed to develop unique spectral bar codes. Major accomplishments include development of high refractive index glass composition.</p> <p>FY 2021 Base Plans:</p> <p>EO/IR Sensor Technologies:</p> <ul style="list-style-type: none">-Complete studies of novel optical architectures to support affordable persistent surveillance systems.-Complete development of sensitive passive mmW detectors for detection of targets in degraded visual environments (e.g., clouds, fog, haze and dust).-Continue work on active imaging laser systems to significantly extend operational range and imaging capabilities in degraded conditions (e.g., dense maritime fog).-Continue development of a room-temperature mid-wave infrared (MWIR) detector array that will significantly decrease Size, Weight, Power and Cost (SWaP-C) of MWIR imaging devices.						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020
Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)		
B. Accomplishments/Planned Programs (\$ in Millions)				
		FY 2019	FY 2020	FY 2021 Base
				FY 2021 OCO
				FY 2021 Total
<p>-Continue to develop novel techniques for Electro-Optic/Infrared (EO/IR) countermeasures to detect, track and/or jam sensors.</p> <p>-Initiate efforts to develop and test optical architectures to demonstrate simultaneous wide field of view and high resolution imaging for search, detection, classification, identification and targeting functions.</p> <p>-Initiate development of real-time combat ID algorithms for detecting and tracking simultaneous targets from networked, high-resolution, wide field of view, and persistent surveillance systems.</p> <p>Electronics: To develop and explore new concepts, components, techniques, and subsystems for the generation, and transmission of UV, visible, and infrared radiation to support current and future Navy and DoD needs.</p> <p>Current plans are to focus efforts on:</p> <ul style="list-style-type: none">- Advanced p-type Gallium-Free Superlattice Long Wave Infrared (LWIR) Sensors.- Night and Day Maritime Infrared (IR). <p>Electromagnetic Warfare: Research being conducted by six projects in this area are developing EO/IR technologies to improve imaging, target identification, threat detection, and engagement capabilities for the war fighter.</p> <p>Current examples of efforts include:</p> <ul style="list-style-type: none">- New system design and data processing algorithms for small, low-power, high resolution extremely wide FOV IR systems.- Ability to detect, track and defeat an imaging threat sensor over a wide field of view using optical phase conjugation to overcome the existing field of view limitations imposed by current spatial light modulator technology.- Improvement in resolution without changing the imaging optics by projecting patterns onto the scene then using knowledge of the patterns computationally recover a higher resolution image resulting in improved resolution enabling better intelligence, surveillance, reconnaissance, and targeting. <p>FY 2021 OCO Plans:</p>				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602271N / Electromagnetic Systems Applied Research	Project (Number/Name) 0000 / Electromagnetic Systems Applied Research				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant change between FY 2020 and FY 2021.						
Title: Navigation Technology		6.110	7.827	9.218	0.000	9.218
Description: The overarching objective of this activity is to develop technologies that enable the development of affordable, effective and robust Position, Navigation and Timing (PNT) capabilities using non-Global Positioning System (GPS) navigation devices, and atomic clocks. This project will increase the operational effectiveness of U.S. Naval units. Emphasis is placed on GPS Anti-Jam (AJ) Technology; Precision Time and Time Transfer Technology; and Non- GPS Navigation Technology (Inertial aviation system, bathymetry, gravity and magnetic navigation). The focus is on the mitigation of GPS electronic threats, the development of atomic clocks that possess unique long-term stability and precision, and the development of compact, low-cost Inertial Navigation Systems (INS).						
The following are non-inclusive examples of plans for projects funded in this activity.						
FY 2020 Plans: Conduct applied research in position, navigation and timing. This research aims to develop techniques and technology to provide assured, cost-effective, and mission relevant PNT to the warfighter. Areas of investment included robust GPS, non-GPS navigation aids, and assured timekeeping. Specifically, GPS Anti-Jam Antennas and Receivers for Navy platforms for the purpose of providing precision navigation capabilities in the presence of electronic threats and anti-spoofing/anti-jam processors for the purpose of providing precision navigation capabilities in the presence of emergent threats; Tactical grade atomic clocks that possess unique long-term stability and precision for the purpose of providing GPS-independent precision time and transferring Coordinated Universal Time (UTC) as maintained at the United States Naval Observatory (USNO) time via alternative electromagnetic links for the purpose of providing GPS-independent precision time; and Inertial navigation systems for the purpose of providing an alternative means of providing precision navigation, a correlation navigation technique using earth maps of high precision, for those Naval platforms which may not have GPS navigation capabilities and/or loss of GPS signals.						
FY 2021 Base Plans: Navigation Technology: -Complete research into radar based shoreline navigation						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy			Date: February 2020		
Appropriation/Budget Activity 1319 / 2		R-1 Program Element (Number/Name) PE 0602271N / Electromagnetic Systems Applied Research		Project (Number/Name) 0000 / Electromagnetic Systems Applied Research	
B. Accomplishments/Planned Programs (\$ in Millions)					
	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
-Complete research on ocean current compensation techniques for improved inertial navigation. -Continue research on automated celestial navigation for submarine platforms. -Continue research on thermal atomic beam inertial capability. -Initiate research on next generation atomic clocks. -Initiate development of earth magnetic anomaly maps for improved magnetic navigation.					
FY 2021 OCO Plans: N/A					
FY 2020 to FY 2021 Increase/Decrease Statement: The increase from FY 2020 to FY 2021 is due to the realignment of funds from the Electronic Warfare Technology R2 activity to the Navigation R2 activity for increased investment in Quantum S&T Precision, Navigation, and Timing (PNT) programs in order to meet higher Navy priorities.					
Title: Solid State Electronics Description: The overarching objective of this activity is to develop higher performance components and subsystems for all classes of military Radio-Frequency (RF) systems that are based on solid state physics phenomena and are enabled by improved understanding of these phenomena, new circuit design concepts and devices, and improvements in the properties of electronic materials. An important subclass are the Very High Frequency (VHF), Ultra-High Frequency (UHF), Microwave (MW), and Millimeter Wave (MMW) power amplifiers for Navy all-weather radar, surveillance, reconnaissance, electronic attack, communications, and smart weapon systems. Another subclass are the analog and high speed, mixed signal components that connect the electromagnetic signal environment into and out of digitally realized, specific function systems. These improved components are based on both Silicon (Si) and compound semiconductors (especially the wide bandgap materials and narrow bandgap materials), low and high temperature superconductors, novel nanometer scale structures and materials. Components addressed by this activity emphasize the MMW and Submillimeter Wave (SMMW) regions with an increasing emphasis on devices capable of operating in the range from 50 Gigahertz (GHz) to 10 Terahertz (THz). The functionality of the technology developed cannot be obtained through Commercial-Off- The-Shelf (COTS) as a result of the simultaneous requirements placed on power, frequency, linearity, operational and instantaneous bandwidth, weight, and size. Effort will involve understanding the properties of engineered semiconductors as they apply to quantum information science and technology.					12.620 13.520 9.841 0.000 9.841
FY 2020 Plans:					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602271N / Electromagnetic Systems Applied Research	Project (Number/Name) 0000 / Electromagnetic Systems Applied Research				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Electronics: Ongoing development of electronic materials, devices, components, and circuits in the frequency range of ~ 1 Megahertz to ~ 10 Terahertz that provide system performance edge compared to current state of the art solid state electronics to ensure supremacy of future radar, Electronic Warfare (EW), communications, sensor, and intelligence systems. Continue ongoing research efforts in the areas of solid state transistors and devices for high frequency analog and digital operation; high efficiency, highly linear amplifiers for microwave, millimeter-wave, low-noise, and power applications; superconducting and other technologies which are designed to deliver software defined, wide band, many simultaneous signal functionality over a wide range of frequencies, in increasingly field-ready packaging and demonstrate the ability of these components to deliver superior functionality in conventional system contexts, including, but not limited to, Satellite Communications (SATCOM), Surveillance EW, Signal Intelligence (SIGINT), and communications; electronics and photonics technology that provides for the control, reception, transmission and processing of signals. Explore and develop new materials, devices, components, and circuits that apply quantum phenomena of entanglement, superposition and/or wave function correlation for performance not achievable by classical methods.						
FY 2021 Base Plans: Solid State Electronics: - Continue ongoing development of electronic materials, devices, components, and circuits in the frequency range of ~ 1 Megahertz to ~ 10 Terahertz that provide system performance edge compared to current state of the art solid state electronics to ensure supremacy of future radar, Electronic Warfare (EW), communications, sensor, and intelligence systems. - Continue ongoing research efforts in the areas of solid state transistors and devices for high frequency analog and digital operation; high efficiency, highly linear amplifiers for microwave, millimeter-wave, low-noise, and power applications; superconducting and other technologies which are prototyped to demonstrate the ability of these components to deliver superior functionality in conventional system contexts, including, but not limited to, Satellite Communications (SATCOM),						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602271N / Electromagnetic Systems Applied Research	Project (Number/Name) 0000 / Electromagnetic Systems Applied Research				
<u>B. Accomplishments/Planned Programs (\$ in Millions)</u>		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Surveillance Electronic Warfare (EW), Signal Intelligence (SIGINT), and communications; electronics and photonics technology that provides for the control, reception, transmission and processing of signals. - Leading efforts will include the development and transition of nitrogen-polar based HEMT technology for advanced highly linear receivers and efficient transmitters. - Explore and develop new materials, devices, components, and circuits that apply quantum phenomena of entanglement, superposition and/or wave function correlation for performance not achievable by classical methods. - Investigate integrated circuit technologies in conventional superconductors and Gallium Nitride as platforms for quantum-based functional components.						
Electronics: Current plans are to focus efforts on: - AlN Tunneling Hot Electron Transfer Amplifier for MMW Power; Phase Change Material RF Components. - Autonomous-Reconfigurable RF and mm-Wave Components. - Memristive Neuromorphic Computing Elements. - Rapid RF IC Prototyping and Manufacture via Micro-assembly. - Neural Red-Out Integrated Circuits. - ScAlN Based High Power Density MM Wave Transistors.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The decrease from FY 2020 to FY 2021 is due to a realignment of funds from the Solid State Electronics R2 activity to the Surveillance Technology R2 activity for an increased investment in Electromagnetic Maneuver Warfare (EMW) and the balancing of Naval priorities.						
Title: Surveillance Technology Description: The overarching objective of this activity is to develop advanced sensor and sensor processing systems for continuous, high volume, theater-wide air and surface surveillance, battle group surveillance, real time reconnaissance and ship defense. Major technology goals include long-range target detection and discrimination, Target Identification (ID) and fire control quality target tracking in adverse weather, background	9.030	9.085	13.770	0.000	13.770	

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602271N / Electromagnetic Systems Applied Research	Project (Number/Name) 0000 / Electromagnetic Systems Applied Research				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
clutter and electronic countermeasure environments and includes modeling and simulation required to support the development of these technologies.	The current specific objectives are: <ul style="list-style-type: none">- Radar Architectures, Sensors, and Software which Address Ballistic Missile and Littoral Requirement Shortfalls: Develop radar architectures, sensors, and software which address Ballistic Missile and Littoral requirement shortfalls including: sensitivity; clutter rejection; and flexible energy management.- Algorithms, Sensor Hardware, and Signal Processing Techniques for Automated Radar Based Contact Mensuration and Feature Extraction: Develop algorithms, sensor hardware, and signal processing techniques for automated radar based contact mensuration and feature extraction in support of asymmetric threat classification and persistent surveillance and to address naval radar performance shortfalls caused by: man-made jamming and Electronic Counter Measures (ECM), unfavorable maritime conditions, and atmospheric and ionosphere propagation effects.- Software and Hardware for a Multi-Platform, Multi-Sensor Surveillance System: Develop software, and hardware for a multi-platform, multi-sensor surveillance system for extended situational awareness of the battlespace.- Small Unmanned Autonomous Vehicles (UAV) Collision Avoidance/Autonomy Technology: Develop small UAV collision avoidance/autonomy technology.					
FY 2020 Plans: Electromagnetic Warfare: Efforts in this area are expanding the surveillance of adversary platforms by developing advanced signal processing techniques to bistatically detect surface vessels by sensing reflected ubiquitous transmissions and for the detection and discrimination of small Unmanned Autonomous Systems (UAS) in a clutter filled environment. Additionally, technology development to enable full spectrum battlespace awareness through an ultra-wideband aperture for simultaneously 360 degree beamforming and low-profile ultra-low cross-polarization ultra-wide-band apertures to provide resilient electronic protection for Naval platforms. Conduct applied research in sensors, networking and communication connectivity for the purpose of developing an affordable and fully automated network of time-coordinated mono-static, bi-static and passive surveillance sensors providing real-time tracking, identification, and engagement information with persistent wide area awareness. Specifics Surveillance Technology research objectives include: Radar - research into antenna apertures, electronics, and signal processing continue to provide enhanced capability to detect, track, and automatically identify targets and threats; Signal Intelligence - the use of interferometric and sophisticated signal processing algorithms enable						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602271N / Electromagnetic Systems Applied Research	Project (Number/Name) 0000 / Electromagnetic Systems Applied Research				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
the detection, geolocation, tracking, and identification of targets; Network Sensing - research areas include sensor data fusion, multi-hypothesis decision making, multi-target tracking, and methods for handling and fusing disparate and intermittent data sources; and Electronic Protection - develop methods to mitigate Electronic Attack (EA) and Electromagnetic Interference (EMI) to RF sensors and networks.						
FY 2021 Base Plans: Surveillance Technology: - Continue technology development to enable full spectrum battlespace awareness through an ultra-wideband aperture for simultaneously 360-degree beamforming and low-profile ultra-low cross-polarization ultra-wide-band apertures to provide resilient electronic protection for Naval platforms. - Continue research in sensors, networking and communication connectivity for the purpose of developing an affordable and fully automated network of collaborative time-coordinated mono-static and Multi-Input Multi-Output (MIMO), surveillance sensors providing real-time tracking, identification, targeting and engagement information with persistent wide area awareness. - Continue efforts to develop affordable and scalable advanced antenna apertures - Continue efforts to develop electronics and signal processing to enable Radio Frequency (RF) agility and waveform diversity to provide enhanced capability to find, fix, track, target, and assess targets and threats as well as provide automatic target identification. - Continue research in the use of interferometric, polarimetric, RF agility, and sophisticated signal processing algorithms to enable the detection, geolocation, tracking, and identification of targets in harsh natural and man-made clutter and interference. - Continue research to enable sensor RF convergence, surveillance allocations, data fusion, multi-hypothesis decision making, multi-target tracking, and methods for handling and fusing disparate and intermittent data sources. Continue efforts to develop methods to mitigate Electronic Attack (EA) and Electromagnetic Interference (EMI) to RF sensors and networks. - Initiate experimentation with fixed and mobile digital array radars to test and validate MIMO capabilities to provide						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602271N / Electromagnetic Systems Applied Research	Project (Number/Name) 0000 / Electromagnetic Systems Applied Research				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
improved detection, tracking, targeting, electronic protection and survivability.						
<p>Electromagnetic Warfare: Eight projects are conducting research efforts in this area to expand the surveillance and detection of adversary and own force platforms in the environment by developing advanced sensor and sensor processing technologies to increase Maritime Domain Awareness.</p> <p>Current plans are to focus efforts on:</p> <ul style="list-style-type: none"> - Radar techniques for detection and identification of small Unmanned Autonomous Vehicles (UAV) and to develop classification and identification techniques for addressing evolving DHS/USMC requirements for assessing this type of threat in tactical environments. - Validate algorithms using innovative concepts from discrete mathematics to accurately predict ship radar cross section (RCS) so as better assess platform vulnerability. - Innovative target detection and clutter suppression algorithms for ultra-high frequency SAR that exploits fluctuation and motion within the scene to provide wide-area, automated detection of small targets at long ranges. <p>FY 2021 OCO Plans: N/A</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: The increase from FY 2020 to FY 2021 reflects an alignment of funds from the Solid State Electronics R2 activity to the Surveillance Technology R2 activity for an increased investment in Electromagnetic Maneuver Warfare (EMW) to meet Naval priorities.</p>						
<p>Title: Vacuum Electronics Power Amplifiers</p> <p>Description: The overarching objective of this activity is to develop Millimeter Wave (MMW) and sub-MMW power amplifiers for use in Naval all-weather radar, surveillance, reconnaissance, electronic attack, and communications systems. The technology developed cannot, for the most part, be obtained through Commercial Off The Shelf (COTS) as a result of the simultaneous requirements placed on power, frequency, bandwidth, weight, and size. Responding to strong interests from the various user communities, efforts are focused on the development of technologies for high-data-rate communications, electronic warfare and high-power radar applications at Millimeter Wave (MMW) and upper-MMW regime. The emphasis is placed on achieving high power at high frequency in a compact form factor. Technologies include utilization of spatially distributed electron</p>	2.366	2.390	1.972	0.000	1.972	

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602271N / Electromagnetic Systems Applied Research	Project (Number/Name) 0000 / Electromagnetic Systems Applied Research				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
beams in amplifiers, such as sheet electron beams and multiple-beams, and creation of simulation based design methodologies based on physics-based and geometry driven design codes.						
The current specific objectives are: - High Power Millimeter and Upper Millimeter Wave Amplifiers: Develop science and technology for high power millimeter and upper millimeter wave amplifiers including high current density diamond cathodes, sheet and multiple electron beam formation and mode suppression techniques in overmoded structures. - Lithographic Fabrication Techniques: Develop lithographic fabrication techniques for upper-millimeter wave amplifiers. - Accurate and Computationally Effective Device-Specific Multi-Dimensional Models for Electron Beams: Develop accurate and computationally effective device-specific multi-dimensional models for electron beam generation, large-signal and stability analysis to simulate device performance and improve the device characteristics.						
FY 2020 Plans: Electronics: Exploratory and develop electron beam physics, beam-wave interaction structures, microfabrication techniques, RF materials, and physics-based modeling to produce designs and prototypes of compact, efficient, broadband, linear, high power devices operating at mmW & sub-mmW frequencies.						
FY 2021 Base Plans: Electronics: The overarching objective of this activity is to develop Millimeter Wave (MMW) and sub-MMW power amplifiers for use in Naval all-weather radar, surveillance, reconnaissance, electronic attack, and communications systems. The technology developed cannot, for the most part, be obtained through Commercial Off The Shelf (COTS) as a result of the simultaneous requirements placed on power, frequency, bandwidth, weight, and size. Responding to strong interests from the various user communities, efforts are focused on the development of technologies for high-data-rate communications, electronic warfare and high-power radar applications at MMW and upper-MMW regime. Specifically, this area explores and develops electron beam physics, beam-wave interaction structures, microfabrication techniques, Radio Frequency (RF) materials, and physics-based modeling to produce designs and prototypes of compact, efficient, broadband, linear, high power devices operating at Millimeter Wave (MMW) & sub-MMW frequencies. The emphasis is placed on achieving high power at high frequency in a compact form factor. Technologies include utilization of spatially distributed electron						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020
Appropriation/Budget Activity 1319 / 2		R-1 Program Element (Number/Name) PE 0602271N / Electromagnetic Systems Applied Research		Project (Number/Name) 0000 / Electromagnetic Systems Applied Research
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base
beams in amplifiers, such as sheet electron beams and multiple-beams, and creation of simulation based design methodologies based on physics-based and geometry driven design codes. Current plans are to focus efforts on: - Monolithic, Microfabricated Traveling Wave Amplifier Arrays. - Electron Focusing Heterostructures for Compact High-Power MM Wave Amplifiers. - Multiple Electron Beam Architecture for Upper-MMW Power Amplifiers.				FY 2021 OCO
FY 2021 OCO Plans: N/A				FY 2021 Total
FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant change between FY 2020 and FY 2021.		Accomplishments/Planned Programs Subtotals	74.934	83.497
			84.994	0.000
C. Other Program Funding Summary (\$ in Millions)		84.994		
N/A				
Remarks				
D. Acquisition Strategy				
N/A				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity 1319 / 2					R-1 Program Element (Number/Name) PE 0602271N / Electromagnetic Systems Applied Research				Project (Number/Name) 9999 / Congressional Adds				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
9999: Congressional Adds	0.000	0.000	5.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	5.000	
A. Mission Description and Budget Item Justification Congressional Interest Items not included in other Projects.													
B. Accomplishments/Planned Programs (\$ in Millions)											FY 2019	FY 2020	
<i>Congressional Add:</i> Electromagnetic systems applied research											0.000	5.000	
<i>FY 2019 Accomplishments:</i> N/A													
<i>FY 2020 Plans:</i> Conduct Electromagnetic systems applied research											Congressional Adds Subtotals	0.000	5.000
C. Other Program Funding Summary (\$ in Millions)													
N/A													
Remarks													
D. Acquisition Strategy													
N/A													

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy											Date: February 2020	
Appropriation/Budget Activity					R-1 Program Element (Number/Name)							
1319: Research, Development, Test & Evaluation, Navy / BA 2: Applied Research					PE 0602435N / Ocean Wrfghtg Env Applied Res							
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	0.000	87.715	82.582	63.392	-	63.392	69.358	75.374	76.389	77.917	Continuing	Continuing
0000: Ocean Wrfghtg Env Applied Res	0.000	42.342	60.082	63.392	-	63.392	69.358	75.374	76.389	77.917	Continuing	Continuing
9999: Congressional Adds	0.000	45.373	22.500	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	67.873

A. Mission Description and Budget Item Justification

Assuring access to the global maritime domain is ensured by technologies that reliably and accurately sense and predict the ocean environment. Coordinated distributed maritime operations is only possible when timely, actionable information is delivered to commanders. This program element (PE) addresses applied research to develop and exploit tactical understanding of the ocean environment to maintain U.S. maritime superiority and ensure national security. Research performed in this PE transforms basic oceanographic, geologic, acoustic, optical and chemical research into predictive models and technologies that provide new or enhanced warfare capabilities for the Battlespace Environment (BSE). The objectives of this program are met through direct observation of the ocean environment by shipboard, unmanned vehicle, drifting, profiling and remote sensing modalities, among others; assimilation of these observations into predictive environmental models; and provision of critical environmental knowledge to tactical decision aids.

Today's Sailors and Marines are enabled by naval Science and Technology (S&T). Since 1946, the Office of Naval Research (ONR) has fostered scientific research related to the maintenance of maritime superiority and national defense. ONR manages the Department of the Navy's (DON) portfolio of naval Basic and Applied research, and Advanced Technology Development investments to ensure naval forces can effectively deter conflict, but when called upon, fight, win and come home safe. Current investments hedge against uncertainty, providing solutions to commanders today, and options for the future. The Naval S&T budget supports higher guidance defined by the National Defense Strategy, and responds to requirements identified by the Secretary of the Navy through research priorities set by the Chief of Naval Research, coordinated across the Naval Research Enterprise (NRE), and outlined in the Naval R&D Framework.

This Program Element (PE) funds Applied Research, which is the systematic study to understand the means to meet a recognized and specific need. Most of the work in this PE can be classified between Technology Readiness Level (TRL) 2 (technology concept and/or application formulation) and TRL 4 (component and/or breadboard validation in laboratory environments).

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy					Date: February 2020
Appropriation/Budget Activity	R-1 Program Element (Number/Name)				
1319: <i>Research, Development, Test & Evaluation, Navy / BA 2: Applied Research</i>	PE 0602435N / <i>Ocean Wrfghtg Env Applied Res</i>				
B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	89.998	63.894	64.143	-	64.143
Current President's Budget	87.715	82.582	63.392	-	63.392
Total Adjustments	-2.283	18.688	-0.751	-	-0.751
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-3.812			
• Congressional Rescissions	-	-			
• Congressional Adds	-	22.500			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-2.283	0.000			
• Program Adjustments	0.000	0.000	-0.751	-	-0.751
• Rate/Misc Adjustments	0.000	0.000	0.000	-	0.000
Congressional Add Details (\$ in Millions, and Includes General Reductions)	FY 2019	FY 2020			
Project: 9999: <i>Congressional Adds</i>					
Congressional Add: <i>Naval Special Warfare</i>	9.654	10.000			
Congressional Add: <i>Task Force Ocean</i>	9.654	10.000			
Congressional Add: <i>Acoustics Research</i>	1.931	0.000			
Congressional Add: <i>Multi-Modal Detection Research</i>	9.654	0.000			
Congressional Add: <i>Persistent Maritime Surveillance</i>	14.480	0.000			
Congressional Add: <i>Arctic geospatial information</i>	0.000	2.500			
	Congressional Add Subtotals for Project: 9999				
	Congressional Add Totals for all Projects				
	45.373	22.500			
	45.373	22.500			

Change Summary Explanation

Schedule: Not applicable.

Technical: Not applicable.

Funding: The reduction in FY21 is due to the realignment of resources to higher Navy priority requirements.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020				
Appropriation/Budget Activity					R-1 Program Element (Number/Name)				Project (Number/Name)						
1319 / 2					PE 0602435N / Ocean Wrfghtg Env Applied Res				0000 / Ocean Wrfghtg Env Applied Res						
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost			
0000: Ocean Wrfghtg Env Applied Res	0.000	42.342	60.082	63.392	-	63.392	69.358	75.374	76.389	77.917	Continuing	Continuing			
A. Mission Description and Budget Item Justification															
This project provides the foundational environmental knowledge for undersea, surface and air-based warfighting technologies and effective operations anywhere on the globe, as well as the operation of unattended sensors and unmanned air, surface and underwater vehicles. This project includes the National Oceanographic Partnership Program (NOPP) and efforts aimed at understanding and predicting the impacts of underwater sound on marine mammals. Major efforts of this project are devoted to: gaining real-time knowledge of the Battlespace Environment (BSE), understanding the variability between processes in the world's ocean, providing the on-scene commander with the capability to exploit the environment to tactical advantage. Research results are transitioned to the Fleet Numerical Meteorology and Oceanography Center and to the Naval Oceanographic Office where they are used to provide timely information about the natural environment for all fleet operations. Efforts include ocean and atmospheric analysis and prediction for real-time description of the operational environment from space to sub-seafloor, shallow water acoustics, sensors for undersea surveillance and weapon systems, and influences of the natural environment on Mine Countermeasures, Naval Mining, Anti-Submarine Warfare (ASW) and Naval Special Warfare systems.															
B. Accomplishments/Planned Programs (\$ in Millions)											FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Coastal Geosciences/Optics											7.862	11.552	10.030	0.000	10.030
Description: The Coastal Geosciences/Optics activity develops knowledge of the littoral, nearshore and riverine environments in which physical, acoustical and optical processes are dominated by the presence of the sea or river bed and air-water interface. Predictive environmental models, custom climatological databases, adaptive sampling schemes, technologies for nearshore observations and advanced remote sensing capabilities provide critical foundational information for Naval Special Warfare, Mine and Expeditionary Warfare and Amphibious operations. This Program emphasizes field research in navally relevant environments, including many that require research outside the U.S.															
FY 2020 Plans: Applied research investments in this activity support the development and testing of littoral models, sensors, platforms (air, surface, undersea or space) and remote sensing algorithm development to enable prediction of coastal battlespace environments anywhere on the globe. Efforts include development of new sensors and ocean remote sensing to quantify littoral geophysical variables, e.g., bathymetry, shallow-water bottom types, waves, currents, temperature, salinity, vector winds, optical properties.															

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020	
Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)			
B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Battlespace Environments: Conceptualize and perform laboratory, field, and numerical modeling studies to understand and exploit various geoscience and optical environmental phenomena in areas that are scientifically challenging, require innovation, and are of interest to the Navy/Marine Corps. Encompasses the design, performance, analysis and underlying theory of field and laboratory experiments designed to understand geological/geophysical, biological, and optical phenomena (including bioluminescence), in the oceans and littoral zones, and to validate that understanding. To develop models that can predict bottom boundary physical, geological, geochemical, geo-acoustic and geotechnical properties in shallow-water operating areas requires: a) an improved understanding of processes that generate and modify the shape, structure and physical properties of the seafloor and sub-seafloor, and its topography/morphology. Includes efforts to develop new or enhance existing shipboard, in-situ, airborne, and space-borne sensors and appropriate inversion and though-the-sensor techniques to obtain, store, utilize, merge and/or exploit data and create operationally and tactically useful environmental information of the littorals and bottom. This includes specification and development of sensors, signal processing, inversion, and other analysis tools when needed. Surveillance of coastal land areas and waters is important to support Navy operations. The Navy/Marine Corps needs include an improved use rapid, airborne characterization of littoral environments including time-varying coastal topography, littoral bathymetry, sea-level height, land and seafloor sedimentary structures as well as quantification of the influence of turbulence generated at the seafloor boundary layer on vertical mixing and stratification in shallow water outside the surf zone.					
Undersea Warfare: Conceptualize and perform laboratory and field studies to understand and exploit energy storage and retrieval from the benthic interface and the potential to balance small scale and large scale intermittent power generation with power demand for persistent operation of marine sensors presently powered by batteries.					
FY 2021 Base Plans:					
- Inner Shelf Modeling: Conclude modeling of the inner shelf field experiment region.					
- GuST turbulence probe: Maintain development of the GuST turbulence probe.					
- Satellite Based Sensing: Pursue improving the world's global bathymetry map from satellite data. Specific new efforts will utilize ICESAT for shoreline digital elevation models and connect with new investigations and methods extending altimetry-based seabed models up onto the continental shelves. Maintain efforts focused on determining bathymetry from satellite based-remote sensing for shallow muddy and turbid waters.					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602435N / Ocean Wrfghtg Env Applied Res	Project (Number/Name) 0000 / Ocean Wrfghtg Env Applied Res				
<u>B. Accomplishments/Planned Programs (\$ in Millions)</u>		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
- Inner Shelf Processes: Initiate studies of non-hydrostatic modeling of inner shelf processes, including internal waves and fronts. Initiate a systematic study of biases introduced into the inner shelf sea-surface-temperature field by the global ocean model.						
- Remote Sensors: Initiate optimization studies of adaptive sampling in the littorals using a small unmanned aerial vehicle that is also capable of maneuver underwater.						
- Sonar: Initiate technology development to observe and map bottom currents and bathymetry from drifting, bottom-following sensors.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The funding decrease from FY 2020 to FY 2021 is due to reduced investment in the level of support needed for optical phenomena in the ocean and littoral zones as the program shifts focus to more development of atmosphere and space environmental technologies that interest the Navy.						
Title: Marine Mammals and Biology Description: The goal of the Marine Mammals and Biology activity focus is to better understand and characterize the effects of underwater sounds produced by Navy acoustic sources on marine mammals. Studies address characterizing marine mammal and their ecosystems, quantifying effects of sound exposure on marine mammals, and improving the ability to monitoring and detect marine mammals in the open ocean. Research results supports Navy environmental compliance information needs and facilitates acquiring Letter of Authorizations from regulators that enable all Navy training and testing operations, and the development of appropriate state-of-the-art mitigation measures.		3.482	3.482	3.484	0.000	3.484
FY 2020 Plans: Extramural Marine Mammals and Biology - Areas of research include monitoring and detection, integrated ecosystem, and effects of sound on marine mammals.						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602435N / Ocean Wrfghtg Env Applied Res	Project (Number/Name) 0000 / Ocean Wrfghtg Env Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Integrated Ecosystem Research: Further research using animal tagging and passive acoustic monitoring to study behaviors, movement and distribution of marine mammals relative to key environmental properties (biotic and abiotic).						
Effects of Sound: Conduct research on behavioral effects to potentially population-level consequences of sound exposure on marine life. Initiate research to characterize the gas management and kinetics (stores and use) in marine mammals. Conduct research into the mechanisms that enable marine mammals to dive to deep depths for long durations while mitigating, if not avoiding, health threats. Conduct research to advance our understanding of sound reception mechanisms in mysticetes (large whales) will require a thorough exploration of the anatomy surrounding the ear and the whole head combined with modeling sound propagation through various tissues of whale heads and/or bodies. Conduct research to develop an understanding of the natural variation of stress markers, better understand and characterize acute and chronic effects of the stress response on individuals and populations of marine mammals. Conduct research on potential effects of Navy sources on marine mammal behavior, life functions (e.g. feeding, breeding, migrating), vital rates (e.g. adult survival, reproduction), and population level effects. Understanding the effects of naval activities on species or stocks of marine mammals, including effects on annual rates of recruitment and survival.						
Monitoring and Detection: Conduct research and development of technology for detection, classification, and localization of marine mammals.						
Models & Databases: Conduct research to provide tools to support environmental compliance efforts and decision making related to how marine mammals are affected by anthropogenic sounds. Initiate research using increase in funds to characterize and quantify the cumulative effects of multiple stressors on marine mammal populations.						
FY 2021 Base Plans: This focus area conducts applied research in areas including monitoring and detection, integrated ecosystem, and effects of sound on marine mammals. - Passive Acoustics: Further research efforts on passive acoustics and other technology, including the development and testing of new autonomous hardware platforms and signal processing algorithms for detection, classification, and localization of marine mammals. Maintain research using animal tagging and passive acoustic						

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<u>B. Accomplishments/Planned Programs (\$ in Millions)</u>		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
monitoring to quantify behaviors, movement and distribution of marine mammals relative to key biotic and abiotic environmental properties.	- Sound Effects Modeling: On going research to quantify the behavioral effects to potentially population-level consequences of sound exposure on marine life. - Marine Mammals: Conduct research to design equipment and capability to quantify the gas management and kinetics in marine mammals to elucidate the mechanisms that enable marine mammals to dive to deep depths. - Sound Reception Mechanisms in whales: Pursue research to advance our understanding of sound reception mechanisms in large whales including the anatomy surrounding the ear and the whole head. - Sonar Exposure: Maintain research into the stress response of marine mammals to sonar exposure with an emphasis on quantifying the effects of prolonged exposure effects on immune system suppression, reproductive failure, accelerated aging, and slowed growth. - Marine Mammal Behavior: Pursue research on potential effects of Navy sources on marine mammal behavior, life functions, vital rates and population level effects. - Environmental Compliance: On going research to provide tools to support environmental compliance efforts and decision making related to how marine mammals can be affected by anthropogenic sounds.					
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant change between FY 2020 and FY 2021						
Title: Marine Meteorology	9.417	9.908	11.545	0.000	11.545	
Description: The Marine Meteorology activity develops observing technologies, predictive models, Numerical Weather Prediction (NWP) systems and Tactical Decision Aids (TDA) that describe the atmospheric environment and its impacts on naval sensors and operations. This activity focuses on uniquely marine aspects of atmospheric science such as air-sea interaction, coupled ocean-atmosphere modeling, Electromagnetic (EM) and electro-optical (EO) propagation, coastal meteorology, tropical cyclone (TC) prediction, and the use of						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020
Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)		
1319 / 2	PE 0602435N / Ocean Wrfghtg Env Applied Res	0000 / Ocean Wrfghtg Env Applied Res		
B. Accomplishments/Planned Programs (\$ in Millions)				
		FY 2019	FY 2020	FY 2021 Base
remote sensing to obtain quantitative observations of atmospheric properties. Aspects of the atmospheric environment of particular interest include near-surface phenomena that affect refractivity, marine boundary layer dynamics that affect clouds, rain, visibility and fog, and processes that control TC structure, track, and intensity. Objectives of this activity are improved NWP systems and TDAs that provide nowcast and forecast skill at global, regional, and tactical scales for operational support, sensor and system development, and performance prediction.				
FY 2020 Plans: Perform field measurements; theoretical analyses; development of data assimilation and modeling technologies; increasing knowledge content of data from remote sensing and through-the-sensor systems; improve the representation of dynamical and physical processes, coupled atmosphere/ocean/wave/ice/land processes, atmospheric predictability, and methodologies for probabilistic forecasting and characterization of uncertainty. These studies include efforts to develop appropriate techniques to obtain atmospheric environmental data from airborne and spaceborne sensors.				
Additional effort is focused on parameters that affect Electric Optical (EO) and Electric Magnetic (EM) propagation in the marine environment. Develop and improve/optimize the Navy's regional Numerical Weather Prediction (NWP) prediction system (COAMPS) by increasing resolution and incorporating new physics and numerical methods to provide much more accurate forecasts, particularly for poorly predicted phenomena like Arctic storms, and coupling with ocean and ice forecast models. Develop and improve tropical cyclone forecast models through improved physics, coupling to the ocean and upper atmosphere, assimilation of new observations, data assimilation methods and novel ensemble methods that quantify forecast uncertainty.				
Conduct research on a next-generation global NWP model that incorporates efficient numerical methods, variable-resolution grids, improved representation of physics, and that can operate efficiently on future computation systems. The goal is to potentially replace the rectangular nested-grid systems currently in use, and combine global and regional modeling into a unified and more efficient system.				
Encompasses the design, performance, analysis and underlying theory of field and laboratory experiments and telescoping, global-to-tactical scale numerical simulations specifically designed to understand atmospheric environmental processes and phenomena. Includes efforts to develop appropriate inversion and other techniques to obtain atmospheric environmental data from airborne and space-borne sensors. Includes empirical and numerical model development techniques and associated efforts designed to improve atmospheric				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602435N / Ocean Wrfghtg Env Applied Res	Project (Number/Name) 0000 / Ocean Wrfghtg Env Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<p>prediction, diagnose problems and increase the efficiency and accuracy of those models and model systems in a variety of computational environments. Includes efforts to fuse, merge and exploit atmospheric data and create operationally useful information. The research is coordinated with operational customers to enable rapid transition of research into operations.</p> <p>FY 2021 Base Plans:</p> <ul style="list-style-type: none">- Data Assimilation and Modeling: Further collection of field observations; theoretical analyses; and development of data assimilation and modeling technologies- Through the Sensor systems: Maintain applied research and studies aimed at increasing knowledge content of data from remote sensing and through-the-sensor systems as well as improving the representation of dynamical and physical processes, coupled atmosphere/ocean/wave/ice/land processes, atmospheric predictability, and methodologies for probabilistic forecasting and characterization of uncertainty. These studies include efforts to develop appropriate techniques to obtain atmospheric environmental data from airborne and space-borne sensors.- Tactical Decision Aids: Conduct efforts focused on parameters that affect EO and EM propagation in the marine environment with the goal of representing the real current and forecast atmosphere in tactical decision aids.- Numerical Weather Prediction: Maintain applied research to improve and optimize COAMPS, the Navy's regional numerical weather prediction system by increasing resolution and incorporating new physics and numerical methods to provide much more accurate forecasts for poorly predicted Arctic storms. Conduct applied research on a next-generation global model that incorporates efficient numerical methods, variable resolution grids, improved representation of physics, and that can operate efficiently on future computation systems.- Tropical Forecast Prediction Models: Pursue to develop and improve tropical cyclone forecast models to more accurately predict the rapid intensification of strong tropical cyclones.- Atmospheric Prediction: Maintain efforts on the design, performance, analysis and underlying theory of global-to-tactical scale numerical simulations specifically designed to represent atmospheric environmental processes and phenomena. Includes efforts to develop appropriate inversion and other techniques to obtain atmospheric environmental data from airborne and space-borne sensors; empirical and numerical model development						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602435N / Ocean Wrfghtg Env Applied Res	Project (Number/Name) 0000 / Ocean Wrfghtg Env Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
techniques and associated efforts designed to increase the efficiency and accuracy of model systems in a variety of computational environments. Research is coordinated with operational customers to enable rapid transition of research into advanced development efforts and eventually operations.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The increase from FY 2020 to FY 2021 is due to the shift of advancement and ability to predict and validate model forecast in Ocean Battlespace Environment using a mix of science, modeling and engineering.						
Title: National Oceanographic Partnership Program (NOPP)		8.781	8.742	8.742	0.000	8.742
Description: This activity focuses on Navy investments in the National Oceanographic Partnership Program (NOPP). NOPP, established by the US Congress (Public Law 104-201) in FY97, is a unique collaboration among U.S. federal agencies involved in conducting, funding, or utilizing results of ocean research. NOPP's value to the Navy derives from the capacity of the partnership to enable and ensure multi-agency efforts where such collaboration enhances efficiency or effectiveness, reduces costs, or both. NOPP topics address scientific problems that cross agency missions, fall in gaps between agencies or are too large for any single agency to fund.						
FY 2020 Plans: The focus remains on topics that cross agency missions and/or are too large for one agency to address alone; this includes ocean/coastal dynamical process studies, observation and modeling systems, development of sensors, communications and data acquisition, storage and processing tools required to affect it, modernization of ocean research and observation infrastructure, and marine mammal-related research. Conduct of studies focused on model verification, constraint of boundary conditions and fluxes of mass, heat and momentum across them (air-sea, deep ocean-seabed, land-sea), and responses to storm and/or persistent forcing are anticipated. Expand the development and utilization of small space-based sensors for oceanographic and atmospheric dynamics research; and miniaturized, low-power, next generation sensors for ocean measurements.						
FY 2021 Base Plans: - National Oceanographic Partnership Program (NOPP): NOPP focus areas include topics of interest to multiple federal agencies that share ocean-related missions and are effectively investigated via partnerships. Topics include ocean, atmosphere, and coastal dynamical process studies; development of sensors, communications,						

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Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602435N / Ocean Wrfghtg Env Applied Res	Project (Number/Name) 0000 / Ocean Wrfghtg Env Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
and data acquisition approaches and methodologies for ocean research; modernization of ocean research and observation infrastructure; and studies of soundscapes in the ocean related to marine mammal research.						
- Oceanographic Observations and Modeling: Maintain oceanographic studies focused on model verification, constraint of boundary conditions and fluxes of mass, heat and momentum across them (air-sea, deep ocean-seabed, land-sea), and responses to storm and/or persistent forcing.						
- Space Based Sensors: Further the development and utilization of small space-based sensors for oceanographic and atmospheric dynamics research. - Next Generation Oceanographic sensors: Continue development of miniaturized, low-power, next generation sensors for ocean measurements including soft materials.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant change between FY 2020 and FY 2021.						
Title: Ocean Acoustics		2.074	15.240	18.545	0.000	18.545
Description: The Ocean Acoustics activity focuses on the impact of the natural ocean environment on acoustic wave phenomena in support of undersea warfare and underwater force protection operations. This activity studies underwater acoustic propagation, scattering from ocean boundaries, and ambient noise issues that impact the development and employment of acoustic systems. The littoral zone has been the ocean environment of greatest interest. Aspects of this environment, that greatly impact underwater acoustic systems, are the shallow water, the consequent closeness and physical significance of the ocean bottom, and the complexities inherent to rapid changes of the ocean structure. The objectives of this program are met through measuring, analyzing, modeling and simulating, and exploiting ocean acoustic factors to gain advantage over potential adversaries using undersea acoustic systems. Results of this activity support acoustic sensor and system development, performance prediction, and tactical decision aids. This activity will also focus on efforts addressing research needs identified by Task Force Ocean that will enable tactical maneuver for the future submarine force. The efforts funded by this Program Element (PE) fall generally into two topic areas: Analysis and understanding of the impact of environmental conditions on sonar data, and the development of reduced order ocean-acoustic models to enable environmental awareness and prediction on forward platforms.						

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Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)				
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B. Accomplishments/Planned Programs (\$ in Millions)						
FY 2020 Plans:		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<p>Conduct research efforts to enable environmental awareness and tactical exploitation of the environment by forward naval platforms. Activities will include the development of technologies and algorithms to incorporate in situ environmental sensing into an on-scene environmental characterization capability, inversion of sensor data to infer the local environment, and the development of capabilities to exploit the ocean environment for tactical advantage. Research efforts are informed by the outcome of the Tactical Oceanography Symposia series conducted by the Office of Naval Research, which involve academic researchers, industry partners, and the operational Navy.</p> <p>Conduct applied research to provide the Warfighter with improved Anti-Submarine Warfare (ASW) performance assessment models and tactical decision aids to plan ASW operations, evaluate effectiveness of ASW systems, and enable environmental adaptive system control. The capability to provide ASW sensor and system performance models, realistic simulations, and measures of effectiveness that incorporate and exploit critical environmental knowledge requires coupling ocean dynamics and acoustics, ambient noise characterization in the littorals, acoustic and optical scattering and propagation characterization, through-the-sensor measurement techniques for in situ environmental parameters, measurement and prediction of uncertainty, and development of tactical decision tools. Efforts include continuation of applied research to enhance passive sonar performance capability in the Arctic environment by developing a better passive sonar performance prediction model and new acoustic ice-characterization methods.</p>						
FY 2021 Base Plans:						
<ul style="list-style-type: none">- Anti-Submarine Warfare: Conduct applied research to develop improved Anti-Submarine Warfare (ASW) performance assessment models and tactical decision aids to plan ASW operations, evaluate effectiveness of ASW systems, and enable environmental adaptive system control.- Sensors: Maintain to provide Anti-Submarine Warfare (ASW) sensor and system performance models, realistic simulations, and measures of effectiveness. This includes incorporating and exploiting critical environmental knowledge and requires coupling ocean dynamics and acoustics, ambient noise characterization in the littorals. It also includes applied research in acoustic and optical scattering and propagation characterization, through-the-sensor measurement techniques for in situ environmental parameters, measurement and prediction of uncertainty, and development of tactical decision tools. Conduct research efforts to enable environmental						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602435N / Ocean Wrfghtg Env Applied Res	Project (Number/Name) 0000 / Ocean Wrfghtg Env Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
awareness and tactical exploitation of the environment by forward naval platforms. Activities will include the development of technologies and algorithms to incorporate in situ environmental sensing into an on-scene environmental characterization capability, inversion of sensor data to infer the local environment, and the development of capabilities to exploit the ocean environment for tactical advantage. Research efforts are informed by activities conducted by Task Force Ocean, which involve academic researchers, industry partners, and the operational Navy.	- Passive Sonar: Further applied research to enhance passive sonar performance capability in the Arctic environment by developing a better passive sonar performance prediction model and new acoustic ice-characterization methods. - Environmental Acoustics: Initiate development of ensemble prediction products that exploit improved computational speeds for both underwater and atmospheric acoustics. - Sensors: Initiate development of improved performance prediction products that exploit emerging space based sensing/characterization for rough bubbly surface boundaries.					
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The increase from FY 2020 to FY 2021 is due to the acceleration of the Task Force Ocean project to gain a better understanding on the oceans, especially in the Artic, with respect to global prediction based on the outcome of the Chief Naval Operations Task Force Ocean working groups and recommended courses of action.						
Title: Physical Oceanography	Description: The Physical Oceanography activity develops knowledge of the physics of the ocean to enable tactical naval use and exploitation of the battlespace. This is achieved through the development of predictive models of the water mass structure, waves, currents, and air-sea interactions and developing measurement/observation technology. Other applications utilize knowledge of the interaction of the water column hydrodynamics and the acoustics to predict the undersea transmission characteristics and sources of uncertainty in these statistics. Utilizing knowledge of the ocean surface physics, the physical oceanography program seeks to exploit the combination of remotely sensed data, in-situ data, and adaptively sampled data to optimize predictions of ocean currents and water column structure. These predictions, custom databases, adaptive sampling schemes and data programs serve Surface Warfare, Anti-Submarine Warfare, Naval Special	10.726	11.158	11.046	0.000	11.046

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1319 / 2	PE 0602435N / Ocean Wrfghtg Env Applied Res	0000 / Ocean Wrfghtg Env Applied Res		
B. Accomplishments/Planned Programs (\$ in Millions)				
Warfare, and Mine and Expeditionary Warfare operations. Oceanographic field research that uses active acoustic transmissions requires modeling of the acoustic effects of sound on marine life in order to meet Navy environmental requirements.		FY 2019	FY 2020	FY 2021 Base
<p>FY 2020 Plans:</p> <p>Conduct applied oceanographic research including field campaigns to study ocean processes and dynamics, ocean model development, and data assimilation from the open ocean to the nearshore environments. Data assimilation development extends use of coupled modeling approaches to include air-ice-wave-ocean-land models. Studies develop new or enhance existing shipboard, in-situ, airborne, and space borne sensors and appropriate inversion and "through the sensor" techniques to obtain physical oceanographic environmental data, and to fuse and exploit oceanographic data to create operationally useful information.</p> <p>The testing of the Remote Ocean Sampling System for air-sea surface flux sampling will be completed following the deployments in the North Atlantic. Efforts to develop advanced autonomy for the operations of gliders in extreme environments is also completed. Testing of gliders with turbulence sensors, Unmanned Underwater Vehicles (UUVs) with turbulence sensors will continue. Additional efforts develop ocean drifters with stable salinity sensors and high resolution turbulence sensors will continue.</p> <p>Continue the effort to develop a capability to estimate global ocean forecast uncertainty from ensembles which will enable risk assessment with skill out to 30 days, providing the real-time assessment of environmental uncertainty anywhere on demand and risk analysis products that can be used as inputs to existing decision support tools such as risk quantification and mission planning. Continue the effort to develop a new capability for accurate and rapid characterization of the local ocean battlespace utilizing the ability of gliders to work in coordinated teams and 4-dimensional variation assimilation to maximize impact of the glider data in a high-resolution local forecast model for more accurate ocean predictions.</p> <p>Testing of ocean instrumentation that features energy harvesting will be initiated. The TOPSIDE software of the data server module will be tested with ocean data sets that are publically available and cloud computing and serving will be evaluated and tested.</p> <p>Battlespace Environments: A program including field research on ocean processes and dynamics, ocean model development, and data assimilation from the open ocean to the nearshore and riverine environments is directed towards model system development and analysis. Model and data assimilation development is extending to</p>			FY 2021 OCO	FY 2021 Total

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<p>the field of coupled models including air-ice-wave-ocean-land models. Encompasses the design, analysis and underlying theory of field and laboratory experiments designed to understand ocean environmental processes and phenomena. It includes model development to improve ocean environmental predictive capabilities, through improved physical characterization, diagnosis, efficiency and accuracy of these models in a variety of computational environments. Also includes efforts to develop new or enhance existing shipboard, in-situ, airborne, and spaceborne sensors and appropriate inversion and "through the sensor" techniques to obtain physical oceanographic environmental data. Includes effort to fuse and exploit oceanographic data to create operationally useful information. The research is coordinated with operational customers to enable its rapid transition into operational systems.</p> <p>FY 2021 Base Plans:</p> <ul style="list-style-type: none">- Sensors: Conduct testing and integration of turbulence sensors and other ocean oceanographic sensors into unmanned platforms to expand ocean sampling capabilities. Maintain development of autonomous sensors and platforms for use in the Arctic ocean environment. Further field campaigns to study ocean processes and dynamics, ocean model development, and data assimilation from the open ocean to the nearshore environments. Conduct studies to develop new or enhance existing shipboard, in-situ, airborne, and space borne sensors and appropriate inversion and through the sensor techniques to obtain physical oceanographic environmental data.- Data Assimilation: On going data assimilation development to coupled modeling approaches including air-ice-wave-ocean-land models.- Earth System Prediction Models: Pursue to develop the capability to utilize Earth System Prediction Models to forecast the global ocean using ensemble prediction methods to enable risk assessment with skill to 30 days.- Ocean Battlespace: Maintain the effort to develop a new capability for accurate and rapid characterization of the local ocean battlespace utilizing the ability of gliders to work in coordinated teams and 4-dimensional variation assimilation to maximize impact of the glider data in a high-resolution local forecast model for more accurate ocean predictions.- Remote Sensing and Sampling: Accomplished testing of the Remote Ocean Sampling System for air-sea surface flux sampling in the North Atlantic.						

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
- Riverine input to the coastal ocean: Conclude research to couple an overland flow hydrology model to a coastal ocean model to capture rainfall-runoff events.						
- Task Force Ocean: Initiate research coordinated with Task Force Ocean including efforts to develop new and enhance existing shipboard, in-situ, airborne, and space-borne sensors, appropriate inversion methods, and through the sensor techniques to obtain physical oceanographic environmental data in conjunction with acoustical observations.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant change between FY 2020 and FY 2021						
Accomplishments/Planned Programs Subtotals		42.342	60.082	63.392	0.000	63.392
C. Other Program Funding Summary (\$ in Millions)						
N/A						
Remarks						
D. Acquisition Strategy						
N/A						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity 1319 / 2					R-1 Program Element (Number/Name) PE 0602435N / Ocean Wrfghtg Env Applied Res				Project (Number/Name) 9999 / Congressional Adds				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
9999: Congressional Adds	0.000	45.373	22.500	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	67.873	
A. Mission Description and Budget Item Justification Congressional Interest Items not included in other Projects.													
B. Accomplishments/Planned Programs (\$ in Millions)											FY 2019	FY 2020	
Congressional Add: Naval Special Warfare FY 2019 Accomplishments: Funds support applied oceanographic research to exploit ocean currents, water surface and seafloor roughness, and ocean opto-acoustical properties, among other phenomena, to enhance underwater vehicle and diver operations. FY 2020 Plans: Conduct applied oceanographic research to exploit ocean currents, water surface and seafloor roughness, and ocean opto-acoustical properties, among other phenomena, to enhance underwater vehicle and diver operations.											9.654	10.000	
Congressional Add: Task Force Ocean FY 2019 Accomplishments: Funds support development and use of artificial intelligence and machine learning techniques for large ocean and acoustic data sets; through-the-sensor environmental characterization, including assimilation into nested local environmental prediction models; exploration and development of advanced signal processing techniques that incorporate local ocean structure, including ambient noise characterization; and exploration of analytic techniques linking physical oceanographic variability with acoustic propagation, including field efforts to collect relevant data sets. FY 2020 Plans: Continued exploration of analytic techniques linking physical oceanographic variability with acoustic propagation, including field efforts to collect relevant data sets. The development and use of artificial intelligence and machine learning techniques for large ocean and acoustic data sets. Through-the-sensor environmental characterization, including assimilation into nested local environmental prediction models. Exploration and development of advanced signal processing techniques that incorporate local ocean structure, including ambient noise characterization											9.654	10.000	
Congressional Add: Acoustics Research FY 2019 Accomplishments: Funds support research in applied acoustics, advanced sensor capabilities and better undersea environment data to directly characterizing the physical environment and provide information											1.931	0.000	

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B. Accomplishments/Planned Programs (\$ in Millions) to monitor ecosystem health, impacts, and change. These investments will improve performance of U.S. Navy sonar systems for surveillance and reconnaissance. FY 2020 Plans: N/A		FY 2019	FY 2020
Congressional Add: Multi-Modal Detection Research FY 2019 Accomplishments: Funds support research in non-acoustic detection, tracking, localization, and identification of underwater threats.		9.654	0.000
FY 2020 Plans: N/A			
Congressional Add: Persistent Maritime Surveillance FY 2019 Accomplishments: Funds support research to enable long-duration observations of oceanographic, acoustic, and geophysical characteristics, among others, in the maritime environment.		14.480	0.000
FY 2020 Plans: N/A			
Congressional Add: Arctic geospatial information FY 2019 Accomplishments: N/A		0.000	2.500
FY 2020 Plans: Conduct applied research to Artic geospatial information.			
Congressional Adds Subtotals		45.373	22.500
C. Other Program Funding Summary (\$ in Millions)			
N/A			
Remarks			
D. Acquisition Strategy			
N/A			

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity					R-1 Program Element (Number/Name)								
1319: Research, Development, Test & Evaluation, Navy / BA 2: Applied Research					PE 0602651M / JT Non-Lethal Wpns Applied Res								
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
Total Program Element	0.000	6.137	6.346	6.343	-	6.343	6.468	6.600	6.732	6.866	Continuing	Continuing	
0000: JT Non-Lethal Wpns Applied Res	0.000	6.137	6.346	6.343	-	6.343	6.468	6.600	6.732	6.866	Continuing	Continuing	
A. Mission Description and Budget Item Justification													
The DoD Non-Lethal Weapons (NLW) Program was established by the FY96 National Defense Authorization Act. The Office of the Secretary of Defense designated the Commandant of the Marine Corps (CMC) as the DoD NLW Executive Agent (EA). The EA exercises centralized responsibility for joint research and development of non-lethal weapons and technology through the Joint Non-Lethal Weapons Program (JNLWP). The Office of the Under Secretary of Defense for Acquisition and Sustainment (A&S) serves as the OSD Principal Staff Assistant and oversees, in consultation with the Under Secretary of Defense for Policy, the DoD NLW Executive Agent.													
The efforts described in this Program Element (PE) reflect science and technology (S&T) investment decisions by the Joint Non-Lethal Weapons Integrated Product Team, a multi-service flag level corporate board that provides executive oversight and management for the JNLWP for the CMC. This direction is based on the requirements and capabilities sought by the Services and the Coast Guard, as identified in the DoD's Non-Lethal Weapons Joint Capabilities Based Assessment Document. This coordinated joint S&T development approach addresses mutual capability gaps and assures the most relevant non-lethal technologies, capabilities and equipment are provided to the operating forces while eliminating duplicative service S&T investment. These applied research initiatives feed non-lethal capabilities which directly support the National Defense Strategy (NDS) objective of strategic competition by providing options to the joint force in pursuit of national objectives in legal or policy constrained scenarios, as well as complementing the use of lethal effects in complex combat scenarios, for example, in urban environments with large civilian populations. Ongoing NLW studies, analyses and exercise efforts with NATO and Allies also support NDS objectives to strengthen alliances and partnerships. Resulting capabilities facilitate a fully integrated non-lethal competency as a complement to lethal firepower, providing force application options for below lethal threshold engagements.													
This program funds the applied research, study, assessment, and demonstration of technologies that could provide a non-lethal capability or target effect. Investment areas include applied research related to: non-lethal directed energy weapons (lasers, millimeter wave and high power microwave) for counter-personnel and counter-materiel missions; non-lethal acoustic and optical technologies; advanced non-lethal materials (including materials for vehicle/vessel stopping and counter-facility applications); associated human effects and effectiveness for new non-lethal stimuli; injury potential and effectiveness of directed energy, electric incapacitation, ocular, and acoustic based non-lethal technologies; and developing models of crowd behavior and dynamics.													
This PE funds Applied Research, which is the systematic study to understand the means to meet a recognized and specific need. Most of the work in this PE can be classified between Technology Readiness Level (TRL) 2 (technology concept and/or application formulation) and TRL 4 (component and/or breadboard validation in laboratory environments).													
Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.													

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy					Date: February 2020
Appropriation/Budget Activity	R-1 Program Element (Number/Name)				
1319: <i>Research, Development, Test & Evaluation, Navy / BA 2: Applied Research</i>	PE 0602651M / <i>JT Non-Lethal Wpns Applied Res</i>				
B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	6.299	6.346	6.343	-	6.343
Current President's Budget	6.137	6.346	6.343	-	6.343
Total Adjustments	-0.162	0.000	0.000	-	0.000
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.162	0.000			
• Rate/Misc Adjustments	0.000	0.000	0.000	-	0.000
Change Summary Explanation					
Funding: no significant change					
Technical: no significant change					
Schedule: no significant change					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020				
Appropriation/Budget Activity					R-1 Program Element (Number/Name)				Project (Number/Name)						
1319 / 2					PE 0602651M / JT Non-Lethal Wpns Applied Res				0000 / JT Non-Lethal Wpns Applied Res						
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost			
0000: JT Non-Lethal Wpns Applied Res	0.000	6.137	6.346	6.343	-	6.343	6.468	6.600	6.732	6.866	Continuing	Continuing			
A. Mission Description and Budget Item Justification															
This project funds the applied research, study, assessment, and demonstration of technologies that could provide a non-lethal capability or target effect. Investment areas include applied research related to: non-lethal directed energy weapons (lasers, millimeter wave and high power microwave) for counter-personnel and counter-materiel missions; non-lethal acoustic and optical technologies; advanced non-lethal materials (including materials for vehicle/vessel stopping and counter-facility applications); associated human effects and effectiveness for new non-lethal stimuli; injury potential and effectiveness of directed energy, electric stun, ocular, and acoustic based non-lethal technologies; and developing models of crowd behavior and dynamics.															
B. Accomplishments/Planned Programs (\$ in Millions)															
											FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: (U) Joint Non-Lethal Weapons											6.137	6.346	6.343	0.000	6.343
FY 2020 Plans:															
Conduct research and investigation of emergent technologies and effects with the potential to address non-lethal counter-personnel and counter-materiel capability gaps. Some examples of counter-personnel research include optimizing known NLW effectiveness and discovery of new human target behavioral effects which mitigate these Joint Requirements Oversight Counsel-approved joint non-lethal effects capability-gaps. Other examples are the assessment and study of new NLW technologies related to: (1) increasing the range of current NLWs; (2) increasing their duration of effect; and (3) increasing the volume of fire associated with NLWs. This includes developing longer range, more compact: (1) NL sound and light devices; (2) smaller, lighter, and more power efficient high power microwave systems; and (3) developing new non-lethal laser induced plasma weapons for long range counter-personnel and counter-materiel applications. The objective is to further reduce non-lethal directed energy weapon system size, weight, power consumption, thermal cooling requirements and overall system cost while increasing counter-personnel and counter-materiel capabilities. Continue applied research to characterize new non-lethal phenomena and assess new target human effects and weapon effectiveness, including development of dose response and injury correlates for new NLW technologies. Continue concept exploration of novel NLW capabilities for integration into future escalation of force platforms. Transition results to higher levels of technology development and demonstration as feasibility is determined.															
FY 2021 Base Plans:															
Continue research and investigation of intermediate force effects and emergent technologies with the potential to further address the Joint Requirements Oversight Council (JROC)-approved non lethal counter-personnel															

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602651M / JT Non-Lethal Wpns Applied Res	Project (Number/Name) 0000 / JT Non-Lethal Wpns Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
and counter-materiel capability gaps. Specifically, explore new non-lethal effects and evaluate alternative innovative applications of existing technologies to address future non-lethal capability needs as escalation of force platforms. Some examples of counter-personnel research include further optimization of non-lethal human effects, and enhanced understanding of human target behavioral effects.						
Conduct applied research to characterize non-lethal phenomena and to assess target human effects and weapon effectiveness, including the development of dose response and injury correlates for new Non-Lethal Weapons (NLW) technologies. Other research includes the assessment and study of new intermediate force technologies related to NLW effectiveness and behavioral response, such as advancing the understanding of Flash Bang effects on humans to support novel non-explosive alternatives to pyrotechnic non-lethal devices. Some examples of counter-materiel research include the investigation of novel intermediate force capabilities for increased delivery and employment options for applications such as vehicle and vessel stopping, and the further optimization of intermediate force materials for integration into future escalation of force platforms. Other research includes feasibility and design studies for high peak power radio frequency directed energy sources and other high power microwave directed energy technologies (e.g., lasers, millimeter-waves) with extended range applications and longer duration of effect. Other examples of counter-materiel research include the investigation and conceptual design of high power microwave technologies to enable improved reduce overall size, weight, power consumption, thermal cooling requirements, and overall system costs (SWaP-C) performance. Results will support the transition of viable technologies to higher levels of development and demonstration to further mitigate the JROC-approved joint non-lethal effects capability-gaps.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant change between FY 2020 and FY 2021						
Accomplishments/Planned Programs Subtotals		6.137	6.346	6.343	0.000	6.343
C. Other Program Funding Summary (\$ in Millions)						
N/A						
Remarks						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy	Date: February 2020	
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602651M / <i>JT Non-Lethal Wpns Applied Res</i>	Project (Number/Name) 0000 / <i>JT Non-Lethal Wpns Applied Res</i>
D. Acquisition Strategy N/A		

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy											Date: February 2020	
Appropriation/Budget Activity					R-1 Program Element (Number/Name)							
1319: Research, Development, Test & Evaluation, Navy / BA 2: Applied Research					PE 0602747N / Undersea Warfare Applied Res							
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	0.000	75.998	98.075	56.397	-	56.397	57.518	58.697	59.876	61.072	Continuing	Continuing
0000: Undersea Warfare Applied Res	0.000	56.691	57.075	56.397	-	56.397	57.518	58.697	59.876	61.072	Continuing	Continuing
9999: Congressional Adds	0.000	19.307	41.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	60.307

A. Mission Description and Budget Item Justification

The Undersea Warfare Applied Research Program Element (PE) funds applied research efforts in undersea target detection, classification, localization, tracking, and neutralization. Associated efforts focus on new Anti-Submarine Warfare (ASW) operational concepts that promise to improve wide-area surveillance, detection, localization, tracking, and attack capabilities against quiet adversary submarines operating in noisy and cluttered shallow water environments. Related efforts are aimed at leveraging technologies that will protect the country's current capital investment in surveillance, submarine, surface ship, and air ASW assets. Research focused on understanding the impacts on marine mammals of manmade underwater sound is also conducted in the PE.

The activities described in this PE address future Navy and Marine Corps capabilities needed to maintain maritime superiority and ensure national security. Targeted capabilities are based on input from Naval Research Enterprise stakeholders including combatant commands, Office of the Chief of Naval Operations (OPNAV) and Headquarters Marine Corps and are designed to exploit breakthroughs in science and technology in order to deliver maximum undersea warfighting benefit to our sailors and marines.

Today's Sailors and Marines are enabled by naval Science and Technology (S&T). Since 1946, the Office of Naval Research (ONR) has fostered scientific research related to the maintenance of maritime superiority and national defense. ONR manages the Department of the Navy's (DON) portfolio of naval Basic and Applied research, and Advanced Technology Development investments to ensure naval forces can effectively deter conflict, but when called upon, fight, win and come home safe. Current investments hedge against uncertainty, providing solutions to commanders today, and options for the future. The Naval S&T budget supports higher guidance defined by the National Defense Strategy, and responds to requirements identified by the Secretary of the Navy through research priorities set by the Chief of Naval Research, coordinated across the Naval Research Enterprise (NRE), and outlined in the Naval R&D Framework.

This Program Element (PE) funds Applied Research, which is the systematic study to understand the means to meet a recognized and specific need. Most of the work in this PE can be classified between Technology Readiness Level (TRL) 2 (technology concept and/or application formulation) and TRL 4 (component and/or breadboard validation in laboratory environments).

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy					Date: February 2020
Appropriation/Budget Activity	R-1 Program Element (Number/Name)				
1319: <i>Research, Development, Test & Evaluation, Navy / BA 2: Applied Research</i>	PE 0602747N / <i>Undersea Warfare Applied Res</i>				
B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	78.049	57.075	57.197	-	57.197
Current President's Budget	75.998	98.075	56.397	-	56.397
Total Adjustments	-2.051	41.000	-0.800	-	-0.800
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	41.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-2.051	0.000			
• Program Adjustments	0.000	0.000	-0.800	-	-0.800
• Rate/Misc Adjustments	0.000	0.000	0.000	-	0.000
Congressional Add Details (\$ in Millions, and Includes General Reductions)	FY 2019	FY 2020			
Project: 9999: <i>Congressional Adds</i>					
Congressional Add: <i>Program Increase</i>	19.307	0.000			
Congressional Add: <i>Navy and academia submarine partnerships</i>	0.000	10.000			
Congressional Add: <i>Machine discovery and invention</i>	0.000	4.000			
Congressional Add: <i>Instrumented tow cable</i>	0.000	5.000			
Congressional Add: <i>Navy undersea warfare science and technology strategy</i>	0.000	2.000			
Congressional Add: <i>Undersea sensing and communications</i>	0.000	5.000			
Congressional Add: <i>Energetics and warhead technology development</i>	0.000	8.000			
Congressional Add: <i>Autonomous undersea robotics systems</i>	0.000	7.000			
	Congressional Add Subtotals for Project: 9999				
	Congressional Add Totals for all Projects				
	19.307	41.000			
	19.307	41.000			

Change Summary Explanation

Schedule: Not applicable.

Technical: Not applicable.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy	Date: February 2020
Appropriation/Budget Activity 1319: <i>Research, Development, Test & Evaluation, Navy / BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602747N / <i>Undersea Warfare Applied Res</i>
Funding: No significant change.	

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020				
Appropriation/Budget Activity					R-1 Program Element (Number/Name)				Project (Number/Name)						
1319 / 2					PE 0602747N / Undersea Warfare Applied Res				0000 / Undersea Warfare Applied Res						
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost			
0000: Undersea Warfare Applied Res	0.000	56.691	57.075	56.397	-	56.397	57.518	58.697	59.876	61.072	Continuing	Continuing			
A. Mission Description and Budget Item Justification															
This PE funds applied research efforts in undersea target detection, classification, localization, tracking, and neutralization. Associated efforts focus on new ASW operational concepts that promise to improve wide-area surveillance, detection, localization, tracking, and attack capabilities against quiet adversary submarines operating in noisy and cluttered shallow water environments. Related efforts are aimed at leveraging technologies that will protect the country's current capital investment in surveillance, submarine, surface ship, and air ASW assets.															
B. Accomplishments/Planned Programs (\$ in Millions)											FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Anti-Submarine Warfare (ASW) Distributed Search											15.034	15.455	14.443	0.000	14.443
Description: ASW Distributed Search focuses on the development of technologies for the tactical search for undersea targets ranging from hours to weeks, using automated sensor systems deployed around operating areas, including along key transit routes to protect naval/maritime forces, around temporarily fixed sea base regions and naval force operating areas, or around fixed defensive regions and areas of interest, such as key US/Allied ports. "Search" is conducted in concentrated areas, typically exploiting cues received from surveillance systems. The objective is to develop rapidly deployable systems employing automated detection and classification capabilities for use in both shallow and deep water operating environments. Related efforts include the development of distributed systems; Unmanned Undersea Vehicle-based and affordable off-board deployable sensing systems employing persistent detection concepts and components; and active acoustic sensing and processing techniques, navy-unique transduction and underwater networking technologies. These efforts provide an extended reach of organic platform-based systems through the use of new sensor concepts, improved materials for advanced sensors, optimized deployment, employment, and automated operation of distributed sensor fields.															
FY 2020 Plans:															
Undersea Warfare Applied research is focused on technologies that enable both platform-based and off-board systems to detect and classify the ultra-quiet, low-Doppler submarine threat in complex operating environments. The capability to provide non-covert Anti-Submarine Warfare (ASW) tactical search for both shallow and deep water operational areas against all submarine threats requires improved sensor technology to extend the capabilities of platform-based systems; innovative sensor technology for off-board and rapidly deployable systems; characterization of and signal processing to control reverberation, clutter, and noise;															

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020
Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)		
<u>B. Accomplishments/Planned Programs (\$ in Millions)</u>				
		FY 2019	FY 2020	FY 2021 Base
				FY 2021 OCO
				FY 2021 Total
1319 / 2	PE 0602747N / Undersea Warfare Applied Res			
characterization of target radiation and scattering physics for all threat submarines; physics-based detection and classification algorithms with automation where possible; and knowledge and exploitation of the complex operational environment. Continue sensor development and signal processing-related research which focuses on multistatic active sonar concepts that operate in convergence zone environments, high duty cycle active sonar, and developing concepts for next-generation active sonar system automation. Initiate non-acoustic, orthogonal concepts that complement and augment active sonar concepts.				
Undersea Warfare Conceptualize and perform laboratory measurements, field measurements, and theoretical/numerical analysis focused on technologies that enable both platform-based and off-board systems to detect and classify the ultra-quiet, low-Doppler submarine threats in complex operating environments such as: advancing sensing, onboard processing/decision making, and information sharing capabilities to enable multi-static ASW using multiple autonomous, coordinated and cooperating autonomous underwater vehicles (AUVs); the development of a new types of underwater sound sources; and efforts that capitalize on structural acoustic features of unmanned underwater vehicles (UUVs) and advance sonar design, sensing, and processing/decision making to enable high performance detection and classification of adversarial UUVs.				
FY 2021 Base Plans: - Active Sonar: Conduct development of advanced signal and information processing for high duty cycle active sonar. Further development of concepts for next-generation active sonar system automation, leveraging the latest advances in machine learning and artificial intelligence. Initiate non-acoustic, orthogonal concepts that complement and augment active sonar concepts - Sensors: Maintain applied research in improved sensor technology to extend the capabilities of platform-based systems as well as innovative sensor technology for off-board and rapidly deployable systems - Signal Processing: Conduct research in characterization of and signal processing to control reverberation, clutter, and noise; characterization of target radiation and scattering physics for all threat submarines; physics-based detection and classification algorithms with automation where possible; and knowledge and exploitation of the complex operational environment.				
FY 2021 OCO Plans:				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020	
Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)			
B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
N/A					
FY 2020 to FY 2021 Increase/Decrease Statement: The funding decrease from FY 2020 to FY 2021 is due to reduced investment in the development of advanced sensing, onboard processing/decision making, and information sharing capabilities to enable multi static Anti Submarine Warfare (ASW) using multiple autonomous, coordinated and cooperating Autonomous Underwater Vehicles.					
Title: Anti-Submarine Warfare (ASW) Precision Localization Description: ASW Precision Localization focuses on the development and demonstration of technologies which use information from surveillance or search systems to determine an area of uncertainty (AOU) relative to target range, bearing, and depth adequate to handoff to an attack system. Precision Localization employs non-acoustic techniques such as magnetic and optical sensing to highly localize submerged threats. The objective is to increase magnetic sensor range and robustness, enable deployment on Unmanned Air Vehicles (UAVs), and increase optical sensing search rates. Efforts include the development of non-traditional tracking and advanced magnetic and electric field sensors and processing. These technologies will provide a decreased AOU size thus enabling the effective use of smaller, more versatile torpedoes as well as increased performance gain in detection, targeting, tracking/trailing, and homing via target acquisition and covert prosecution. FY 2020 Plans: Shift focus from classical magnetic and electric field sensing toward other modalities and sampling approaches. Investigate alternative methods for Precision Localization leveraging magnetic and electric field sensing technologies and incorporating alternative technologies and approaches. Execute research into novel methods to develop smaller and power efficient, high performance magnetic, electric field and novel sensors. Pursue research on advanced concepts for processing arrays of independent sensors to create adaptive information theoretic sensor systems. Continue research into remote methods of sensing target signatures. Expand Optical Sensing research related to critical Science and Technology (S&T) for Precision Localization. Execute research to better exploit the information capacity available in photonic systems toward development of higher performance optical sensors. Pursue information theoretic optical sampling and telemetry characteristics to better support sensor performance and data integrity. Extend the effectiveness that photonic sensors operate across the air-water interface. Extend the distance optical sensors can effectively operate within the water column. FY 2021 Base Plans:	3.469	3.468	3.469	0.000	3.469

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602747N / Undersea Warfare Applied Res	Project (Number/Name) 0000 / Undersea Warfare Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
- Precision Localization: Conduct research on advanced sensing modalities and sampling approaches. Investigate alternative methods for Precision Localization leveraging magnetic and electric field sensing technologies and incorporating alternative technologies and approaches.						
- Sensors: Further research into novel methods to develop smaller and power efficient, high performance magnetic, electric field and novel sensors. Conduct research on advanced concepts for processing arrays of independent sensors to create adaptive information theoretic sensor systems. Initiate applied research into information theoretic optical sampling and telemetry characteristics to better support sensor performance and data integrity; improve the effectiveness of photonic sensor operations across the air-water interface; and extend the distance optical sensors can effectively operate within the water column.						
- Remote and Optical Sensing: Maintain research into remote methods of sensing target signatures. Continue research on optical sensing for precision localization and to better exploit the information capacity available in photonic systems to increase sensor performance.						
- Magnetic and Electric sensing: Concluded applied research on classical magnetic and electric field sensing.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant change between FY 2020 and FY 2021						
Title: Anti-Submarine Warfare (ASW) Surveillance Description: ASW Surveillance focuses on improving detection, classification, and localization capabilities in large ocean areas relative to the capabilities of existing ASW surveillance systems. The related technologies support the conduct of covert, wide-area surveillance ranging from one day to six months. The objectives are to develop and demonstrate technologies that provide clandestine indications and warnings in far forward and contested operating areas, and in complex operational environments against all submarine threats, including new threats with unknown target signatures and tactics. Covertness implies use of non-observable platforms and/or deployed automated sensors employing passive sonar, or other non-detectable methods. The surveillance process includes initial detection and classification. Efforts include the development of Unmanned Undersea Vehicle-based and affordable, off-board deployable sensing systems employing a wide variety of surveillance concepts and components. These efforts focus on alternative detection phenomena, vector/tensor	22.316	22.288	22.617	0.000	22.617	

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602747N / Undersea Warfare Applied Res	Project (Number/Name) 0000 / Undersea Warfare Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
sensors, automated acoustic processing, more compact and longer lasting power sources, and high bandwidth, acoustic communications links.	<p>FY 2020 Plans: Complete Signal processing related research that focuses on combining information from multiple arrays in a distributed field that exploit new acoustic signatures, improve detection of weak acoustic sources obscured by clutter, and new sensor and signal processing concepts that exploit underwater acoustic propagation physics to improve the detection of weak acoustic sources in high clutter environments. Initiate signal processing related research to develop artificial intelligence technology providing optimized sonar system line-ups that adjust themselves in real time to the current undersea environment. Begin to investigate applicable non-acoustic methods of detection and classification of ultra-quiet, low-Doppler submarines in complex operating environments.</p> <p>Laboratory measurements, field measurements, and theoretical/numerical analysis leading to non-platform-based and clandestine systems to provide ASW clandestine indications and warnings in far-forward and contested areas such as: new sensor concepts to provide improved performance in smaller packages; automated passive acoustic and non-acoustic detection and classification algorithms; undersea communications; acoustically quiet UUV propulsion; and knowledge and exploitation of the complex operational environment.</p> <p>FY 2021 Base Plans:</p> <ul style="list-style-type: none">- Sonar: Conduct signal processing related research to develop artificial intelligence technology providing optimized sonar system line-ups that adjust themselves in real time to the current undersea environment.- Sensors: Conduct studies to improve performance of acoustic vector sensors, vector magnetometers, electrochemical sensors and three-axis magnetometers.- Underwater Vehicle Propulsion: Conduct development of approaches for fluid-loaded elastic structures and soft-bodied unmanned underwater vehicle propulsion.- Signal Processing: Further investigate applicable non-acoustic methods of detection and classification of ultra-quiet, low-Doppler submarines in complex operating environments. Initiate applied research to exploit					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602747N / Undersea Warfare Applied Res	Project (Number/Name) 0000 / Undersea Warfare Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
recent advances in basic / theoretical computer science to efficiently implement signal processing and artificial-intelligence algorithms using mathematical approaches including randomized methods.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant change between FY 2020 and FY 2021						
Title: Marine Mammals Description: The goal of the Marine Mammals and Biology activity focus is to better understand and characterize the effects of underwater sounds produced by Navy acoustic sources on marine mammals. Studies address characterizing marine mammal and their ecosystems, quantifying effects of sound exposure on marine mammals, and improving the ability to monitoring and detect marine mammals in the open ocean. Research results supports Navy environmental compliance information needs and facilitates acquiring Letter of Authorizations from NOAA regulators that enable all Navy training and testing operations, and the development of appropriate state-of-the-art mitigation measures. The marine mammals research conducted in this Program Element (PE) represents part of a total effort executed in coordination with complementary research performed in PE 0602435N Ocean Warfighting Environment Applied Research.		2.464	2.464	2.465	0.000	2.465
FY 2020 Plans: Extramural Marine Mammals and Biology - Areas of research include monitoring and detection, integrated ecosystem, and effects of sound on marine mammals. Integrated Ecosystem Research: Further research using animal tagging and passive acoustic monitoring to study behaviors, movement and distribution of marine mammals relative to key environmental properties (biotic and abiotic). Effects of Sound: Conduct research on behavioral effects to potentially population-level consequences of sound exposure on marine life. Initiate research to characterize the gas management and kinetics (stores and use) in marine mammals. Conduct research into the mechanisms that enable marine mammals to dive to deep depths for long durations while mitigating, if not avoiding, health threats. Conduct research to advance our						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602747N / Undersea Warfare Applied Res	Project (Number/Name) 0000 / Undersea Warfare Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
understanding of sound reception mechanisms in mysticetes (large whales) will require a thorough exploration of the anatomy surrounding the ear and the whole head combined with modeling sound propagation through various tissues of whale heads and/or bodies. Continue research to develop an understanding of the natural variation of stress markers, better understand and characterize acute and chronic effects of the stress response on individuals and populations of marine mammals. Conduct research on potential effects of Navy sources on marine mammal behavior, life functions (e.g. feeding, breeding, migrating), vital rates (e.g. adult survival, reproduction), and population level effects. Understanding the effects of naval activities on species or stocks of marine mammals, including effects on annual rates of recruitment and survival.	Monitoring and Detection: Continue research and development of technology for detection, classification, and localization of marine mammals.					
Models & Databases: Continue research to provide tools to support environmental compliance efforts and decision-making related to how marine mammals are affected by anthropogenic sounds. Initiate research using increase in funds to characterize and quantify the cumulative effects of multiple stressors on marine mammal populations.	FY 2021 Base Plans: FY 2021 efforts include applied research in areas including monitoring and detection, integrated ecosystem, and effects of Anti-Submarine Warfare (ASW) sonar on marine mammals. - Passive Acoustic Monitoring: Further research efforts on passive acoustics and other technology supporting wide area surveillance, including the development and testing of new autonomous hardware platforms and signal processing algorithms for detection, classification, and localization of marine mammals. Maintain research using animal tagging and passive acoustic monitoring to quantify behaviors, movement and distribution of marine mammals relative to key environmental properties and sonar exposure, both incidental and experimental. - Sonar Exposure: Conduct research to quantify the behavioral effects to potentially population-level consequences of sonar exposure on marine life to develop risk criteria for Navy's sound effects modeling, and develop quantitative inputs for modeling biologically significant effects on marine mammal populations. Navy sound effects modeling is used in Environmental Impact Statements, and subsequent Letters of Authorization issued by the NOAA regulator that enable all Navy ASW exercises and testing.					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602747N / Undersea Warfare Applied Res	Project (Number/Name) 0000 / Undersea Warfare Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
- Marine Mammals: Further research to design equipment and capability to quantify the gas management and kinetics in marine mammals to evaluate the mechanisms that enable marine mammals to dive to deep.						
- Sound Reception Mechanisms in Whales: Pursue research to advance our understanding of sound reception mechanisms in large whales including the anatomy surrounding the ear and the whole head to improve and validate finite element models of sound propagation through various tissues.						
- Marine Mammal Behavior: On going research into the stress response of marine mammals to ASW sonar exposure with an emphasis on quantifying the effects of prolonged exposure effects on immune system suppression, reproductive failure, accelerated aging, and slowed growth. Conduct research on potential effects of Navy Anti-Submarine Warfare (ASW) sonar sources on marine mammal behavior, life functions, vital rates, and population level effects. The goal is to understand and quantify the effects of naval activities on species or stocks of marine mammals, including effects on annual rates of recruitment and survival.						
- Environmental Compliance: Maintain research to provide tools to support environmental compliance efforts and decision making related to how marine mammals can be affected by anthropogenic sounds.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant change between FY 2020 and FY 2021						
Title: Undersea Weaponry Description: Undersea Weaponry focuses on the development of technologies for current and next-generation, offensive and defensive weapons capable of engaging submarines, surface ships and threat torpedoes. Specific efforts focus on increasing probability of kill and probability of counter-kill by improving sensor performance, engagement tactics, vehicle propulsion and warhead lethality. New weapon and delivery concepts are being assessed. Detailed information regarding Undersea Weaponry Applied Research program plans and objectives is at a higher classification.		13.408	13.400	13.403	0.000	13.403
FY 2020 Plans:						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602747N / Undersea Warfare Applied Res	Project (Number/Name) 0000 / Undersea Warfare Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Conduct applied research related to critical Science and Technology (S&T) for supercavitation, advanced warheads, new torpedo fuel formulations, small-scale weapon concepts, and propulsion systems for undersea vehicles and platforms.						
FY 2021 Base Plans: - Undersea Weaponry: Conduct applied research related to critical Science and Technology (S&T) for advanced warhead and fuzing concepts, characterization of torpedo fuel and new fuel formulations, small-scale weapon concepts, dynamic testing of vehicles to assess kinematics, and propulsion systems for undersea vehicles and platforms.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant change between FY 2020 and FY 2021						
Accomplishments/Planned Programs Subtotals		56.691	57.075	56.397	0.000	56.397
C. Other Program Funding Summary (\$ in Millions)						
N/A						
Remarks						
D. Acquisition Strategy						
N/A						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity					R-1 Program Element (Number/Name)				Project (Number/Name)				
1319 / 2					PE 0602747N / Undersea Warfare Applied Res				9999 / Congressional Adds				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
9999: Congressional Adds	0.000	19.307	41.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	60.307	
A. Mission Description and Budget Item Justification													
Efforts for Undersea Warfare Applied Research													
B. Accomplishments/Planned Programs (\$ in Millions)											FY 2019	FY 2020	
<i>Congressional Add:</i> Program Increase											19.307	0.000	
<i>FY 2019 Accomplishments:</i> Efforts for Undersea Warfare Applied Research													
<i>FY 2020 Plans:</i> N/A													
<i>Congressional Add:</i> Navy and academia submarine partnerships											0.000	10.000	
<i>FY 2019 Accomplishments:</i> N/A													
<i>FY 2020 Plans:</i> Conduct applied research in Navy and academia submarine partnerships.													
<i>Congressional Add:</i> Machine discovery and invention											0.000	4.000	
<i>FY 2019 Accomplishments:</i> N/A													
<i>FY 2020 Plans:</i> Conduct applied research in Machine discovery and invention.													
<i>Congressional Add:</i> Instrumented tow cable											0.000	5.000	
<i>FY 2019 Accomplishments:</i> N/A													
<i>FY 2020 Plans:</i> Conduct applied research for Instrumented tow cable.													
<i>Congressional Add:</i> Navy undersea warfare science and technology strategy											0.000	2.000	
<i>FY 2019 Accomplishments:</i> N/A													
<i>FY 2020 Plans:</i> Conduct applied research in Navy undersea warfare science and technology strategy.													
<i>Congressional Add:</i> Undersea sensing and communications											0.000	5.000	
<i>FY 2019 Accomplishments:</i> N/A													
<i>FY 2020 Plans:</i> Conduct applied research in Undersea sensing and communications.													
<i>Congressional Add:</i> Energetics and warhead technology development											0.000	8.000	

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy			Date: February 2020
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602747N / Undersea Warfare Applied Res	Project (Number/Name) 9999 / Congressional Adds	
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020
FY 2019 Accomplishments: N/A			
FY 2020 Plans: Conduct applied research in Energetics and warhead technology development.			
Congressional Add: Autonomous undersea robotics systems		0.000	7.000
FY 2019 Accomplishments: N/A			
FY 2020 Plans: Conduct applied research in Autonomous undersea robotics systems.			
Congressional Adds Subtotals		19.307	41.000
C. Other Program Funding Summary (\$ in Millions)			
N/A			
Remarks			
D. Acquisition Strategy			
N/A			

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity					R-1 Program Element (Number/Name)								
1319: Research, Development, Test & Evaluation, Navy / BA 2: Applied Research					PE 0602750N / Future Naval Capabilities Applied Research								
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
Total Program Element	0.000	135.523	152.012	167.590	-	167.590	180.900	184.622	188.333	192.100	Continuing	Continuing	
0000: Future Naval Capabilities Applied Research	0.000	135.523	148.012	167.590	-	167.590	180.900	184.622	188.333	192.100	Continuing	Continuing	
9999: Congressional Adds	0.000	0.000	4.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	4.000	

A. Mission Description and Budget Item Justification

The Office of Naval Research (ONR) works closely across the Department of the Navy (DON) and Naval Research Enterprise (NRE) to develop high priority technological capabilities needed by the operational forces. From their beginnings, the U.S. Navy and Marine Corps have leveraged technology innovation to gain decisive advantage. However, breakthroughs don't happen overnight. Critical to sustaining the pipeline of new capabilities, is maintaining a priority-driven portfolio of naval science and technology (S&T) to deliver solutions to known requirements, and experiment with potential game-changing ideas. The Naval S&T budget supports higher guidance defined by the National Defense Strategy, and responds to requirements identified by the Secretary of the Navy. Specifically, this PE develops component technologies in the Future Naval Capabilities (FNC) Program primarily to address cost, schedule and performance challenges in acquisition programs, accelerating delivery. The term Technology Candidate refers to component applied research efforts, which contingent on success, will continue development as FNCs in PE 0603673N Advanced Technology Development. Efforts in this PE are coordinated with related work in the USMC Technology Candidates Activity of PE 0602131M Marine Corp Landing Force Technology.

This Program Element (PE) funds Applied Research, which is the systematic study to understand the means to meet a recognized and specific need. Most of the work in this PE can be classified between Technology Readiness Level (TRL) 2 (technology concept and/or application formulation) and TRL 4 (component and/or breadboard validation in laboratory environments).

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy					Date: February 2020
Appropriation/Budget Activity		R-1 Program Element (Number/Name)			
1319: Research, Development, Test & Evaluation, Navy / BA 2: Applied Research		PE 0602750N / Future Naval Capabilities Applied Research			
B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	137.701	154.755	167.590	-	167.590
Current President's Budget	135.523	152.012	167.590	-	167.590
Total Adjustments	-2.178	-2.743	0.000	-	0.000
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-6.743			
• Congressional Rescissions	-	-			
• Congressional Adds	-	4.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-2.178	0.000			
• Rate/Misc Adjustments	0.000	0.000	0.000	-	0.000
Congressional Add Details (\$ in Millions, and Includes General Reductions)	FY 2019	FY 2020			
Project: 9999: Congressional Adds					
Congressional Add: C4ISR and special projects	0.000	4.000			
			Congressional Add Subtotals for Project: 9999		
			0.000	4.000	
			Congressional Add Totals for all Projects		
			0.000	4.000	
Change Summary Explanation					
Funding:	No significant change.				
Technical:	Not applicable.				
Schedule:	Not applicable.				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity					R-1 Program Element (Number/Name)				Project (Number/Name)				
1319 / 2					PE 0602750N / Future Naval Capabilities Applied Research				0000 / Future Naval Capabilities Applied Research				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
0000: Future Naval Capabilities Applied Research	0.000	135.523	148.012	167.590	-	167.590	180.900	184.622	188.333	192.100	Continuing	Continuing	

A. Mission Description and Budget Item Justification

Future Naval Capabilities (FNC) budget activity (BA) 2 investments develop candidate FNC technologies in an agile fashion by exploiting technology advances that respond rapidly to Naval needs. This approach facilitates an optimum response when developing and maturing the technology options that can be developed further in Program Element (PE) 0603673N, Future Naval Capabilities Advanced Technology Development.

The FNC Program favors a high level of collaboration. PE R-2 activities are mostly organized by the Office of Naval Research (ONR) Science and Technology Departments, which are tasked to collaborate with the acquisition stakeholders and their resource sponsors. A complete accounting of the technology candidates being developed and a full disposition of each technology development effort funded in this PE is provided annually to the Congressional oversight committees.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Expeditionary Maneuver Warfare (EMW) and Combating Terrorism Description: The objective of this activity is to develop and mature technologies in asymmetric and irregular warfare, distributed operations, information warfare, survivability and self-defense to a point where they can be proposed and continued as FNCs in PE 0603673N, Future Naval Capabilities Advanced Technology Development.	6.639	11.723	14.613	0.000	14.613
FY 2020 Plans: Future Naval Capabilities (FNC) Technology Candidate development in FY 2020 will continue to focus on the technologies noted in the FY 2019 plans. Investments include technologies that: improve warfighter effectiveness in command, control, computers and communication for small unit naval expeditionary warfighters; enhance fires capabilities so warfighters employed in small, distributed units will have the tools they need to locate and decisively destroy larger enemy forces; improve force protection for small units and individual warfighters against a myriad of enemy attack modes; improve human performance by developing new training technologies, knowledge products, architectures, and systems that can accelerate mental, emotional and cognitive decision-making skill; mature emerging technologies for future intelligence, surveillance and reconnaissance systems; develop and mature new maintenance technologies for expeditionary combat systems; develop new expeditionary energy technologies that support distributed operations from the individual Marine to small units; develop novel technologies and innovative concepts that will improve the maneuverability of the Marine Corps Air Ground Task Force by enhancing the movement of troops and equipment from shipboard to					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602750N / Future Naval Capabilities Applied Research	Project (Number/Name) 0000 / Future Naval Capabilities Applied Research				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
inland objectives; and mature new technologies that will improve the standoff detection and neutralization of improvised explosive devices.						
<p>FY 2021 Base Plans:</p> <ul style="list-style-type: none"> - Extend focus on the technologies that will enhance long-range fires capabilities so warfighters employed in small distributed units will have the tools they need to locate and decisively destroy larger enemy forces - Progress and expand in the area of providing new training technologies, knowledge products, architectures, and systems that can accelerate mental, emotional and cognitive decision-making skill, to include human-machine teaming and greater naval capability to detect, localize and neutralize mines and improvised explosive devices that challenge the naval forces ability to operate in contested maritime environments - Establish novel technologies and innovative concepts that will improve the maneuverability of the Marine Corps Air Ground Task Force by enhancing the movement of troops and equipment from shipboard to inland objective <p>Emerging technologies for future intelligence, surveillance and reconnaissance systems will transition to the Future Naval Capabilities program.</p> <p>Efforts to enhance expeditionary forces use of artificial intelligence, autonomy, and material development in areas of naval logistics will be initiated. This includes developing technologies to improve warfighter effectiveness in command, control, computers and communication for small unit naval expeditionary warfighters</p>						
<p>FY 2021 OCO Plans:</p> <p>N/A</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement:</p> <p>The FY 2020 to FY 2021 increase is due to increased investment in the areas of expeditionary logistics, training to improve human performance and decision making, and mine countermeasures.</p>						
<p>Title: C4ISR and Special Projects</p> <p>Description: The objective of this activity is to develop and mature technologies in data science, mathematical optimization, computational and information sciences, quantum information sciences, electronics, command and control, combat systems, communications, cyber security, cyber operations, electronic warfare, sensing and surveillance, and precision timing and navigation, as well as technologies for surface and airborne vehicles, and cruise missile defense weapons to a point where they can be proposed and continued as Future Naval</p>		64.908	55.720	56.429	0.000	56.429

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020
Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)		
<u>B. Accomplishments/Planned Programs (\$ in Millions)</u>				
		FY 2019	FY 2020	FY 2021 Base
				FY 2021 OCO
				FY 2021 Total
1319 / 2	PE 0602750N / Future Naval Capabilities Applied Research			
Capabilities (FNC) in program element (PE) 0603673N, Future Naval Capabilities Advanced Technology Development.				
FY 2020 Plans: Future Naval Capabilities (FNC) Technology Candidate development in FY 2020 will continue to focus on technologies noted in the FY 2019 plans. Investments include technologies that: advance techniques and algorithms for information processing and integration, information operations, information assurance, cyber protection, communications and networking, computational decision-making, accurate decision making, and command and control technologies with a specific focus on enabling rapid; exploit advancements in electronics, sensors and network technologies enabling new and innovative uses of the electromagnetic spectrum in areas of surface and aerospace surveillance, communications, electronic combat, and precision time and navigation; improve adaptive persistent surveillance capabilities; develop new digital radio frequency technologies supporting active aperture, phased arrays capable of performing multiple functions simultaneously; improve soft-kill performance and real-time assessment, as well as provide multiple means to detect and measure incoming threats. FY20 investments focuses on the following areas: communications and networking; decision tools; cyber; sensor deception and defeat; advanced sensing, counter ISR and processing; cross platform technologies; and advanced systems and components. The objectives of communications and networking include maturing promising communications and networking technologies and enable rapid transition to the fleet. The objectives of sensor deception and defeat include maturing the underlying technologies, techniques and algorithms that degrade, neutralize, or destroy an adversary's combat capability. The objectives of decision tools include dedicating applied research to develop decision tools to allow Commanders to rapidly and confidently move from data-to-options-to-informed decisions. The objectives of cyber include maturing innovative cyber approaches to enhance resilience, safety, reliability, and efficiency of cyber systems in warfighting platforms. The objectives of advanced sensing and processing thrust is to maturing sensing system and processing technologies to deliver enhanced operational capabilities for Intelligence, Surveillance, Reconnaissance and Targeting applications. The objectives of cross platform technologies include maturing electro-magnetic enabling technologies that rely on geographic separation of platform sensors to deliver enhanced operational capabilities. The objectives of				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602750N / Future Naval Capabilities Applied Research	Project (Number/Name) 0000 / Future Naval Capabilities Applied Research				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
advanced systems and components include maturing the underlying components and systems for improved electro optical (EO), radio frequency (RF) and Precision, Navigation, and Timing (PNT) systems.						
FY 2021 Base Plans: Future Naval Capabilities (FNC) Technology Candidate development in FY 2021 will continue to focus on the following thrust areas: Communications and Networking; Decision Tools; Cyber; Sensor Deception and Defeat; Advanced Sensing and Processing; Cross Platform Technologies, and Advanced Systems and Components. The objectives of Communications and Networking include maturing promising communications and networking technologies to enable distributed maritime operations. The objectives of Sensor Deception and Defeat include maturing the underlying technologies, techniques and algorithms that degrade, neutralize, or destroy an adversary's C4ISR capability. The objectives of Decision Tools include dedicating applied research to develop decision tools to allow Commanders to rapidly and confidently move from data-to-options-to-informed decisions. The objectives of Cyber include maturing innovative cyber approaches to enhance the resilience, safety, reliability, and efficiency of cyber systems in warfighting platforms. The objectives of Advanced Sensing and Processing include maturing sensing system and processing technologies to deliver enhanced operational capabilities for Intelligence, Surveillance, Reconnaissance and Targeting applications. The objectives of Cross Platform Technologies include maturing electro-magnetic enabling technologies that rely on geographic separation of platform sensors to deliver enhanced operational capabilities. The objectives of Advanced Systems and Components include maturing the underlying components and systems for improved Electro Optical (EO), Radio Frequency (RF) and Precision, Navigation, and Timing (PNT) systems. Extend efforts in developing: - Government Off the Shelf (GOTS) software router and apps to meet Fleet resilient networking objectives in contested warfighting scenarios. - A low-cost, high-fidelity network deception framework (CyberMoat) that lies to attackers on-demand and automated tools to coerce malware agents to deceive adversary Command and Control. - An operating system that enables automatic and efficient use of heterogeneous computing architectures for cyber resilience without requiring change to legacy source code. - Key technologies for off-board RF illumination sources to enable Multi-Input Multi-Output and receive-only sensing in a distributed environment. - Ultra-efficient neural network hardware.						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602750N / Future Naval Capabilities Applied Research	Project (Number/Name) 0000 / Future Naval Capabilities Applied Research				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Initiate the development of new Technology Candidates selected to start in FY 2021 in the areas of Communications and Networking, Sensor Deception and Defeat, Decision Tools, Cyber, Advanced Sensing and Processing, Cross Platform Technologies, and Advanced Systems and Components.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The FY20 to FY21 increase is due to initiation of new Technology Candidates selected to start in FY 2021 in the areas of Communications and Networking, Sensor Deception and Defeat, Decision Tools, Cyber, Advanced Sensing and Processing, Cross Platform Technologies, and Advanced Systems and Components.						
Title: Ocean Battlespace Sensing Description: The objective of this activity is to enable maritime domain access and distributed operations for Naval forces in contested ocean environments through superior maritime battlespace awareness and undersea threat detection, identification and neutralization. Specifically, activities will develop and mature technologies that ultimately support undersea warfare, subsurface/seabed warfare, antisubmarine warfare, and mine warfare including mine countermeasures and naval mining. Activities will also develop and mature methods and technological approaches for environmental sensing and prediction for the maritime battlespace. The desired outcome for efforts in this activity is to mature the applied research results to a point where they can be focused on particular enabling capabilities and proposed to be continued as Future Naval Capabilities (FNC) in program element (PE) 0603673N, Future Naval Capabilities Advanced Technology Development. Additionally, a subset of technologies explored herein are intended to support expeditionary access and will be further matured, focused, and ultimately demonstrated under the USMC's Advanced Technology Demonstration effort in PE 0603640M MC Advanced Technology Demo.		20.399	24.476	24.299	0.000	24.299
FY 2020 Plans: Future Naval Capabilities (FNC) Technology Candidate development in FY 2020 will continue technologies noted previously in the FY 2019 plans with a primary focus on improving the ability to exploit environmental sensing, modeling and prediction to enable more effective anti-submarine warfare (ASW) and mine warfare (MIW) applications.						
FY 2021 Base Plans:						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602750N / Future Naval Capabilities Applied Research	Project (Number/Name) 0000 / Future Naval Capabilities Applied Research				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
- Continue efforts in technologies for precise localization and neutralization of fully buried mines; understanding how to achieve noise reduction for expeditionary Surveillance Towed Array Sensor System (SURTASS) including sensing approaches and noise rejection algorithm development.						
- Conclude efforts in understanding how to potentially miniaturize and marinize existing fuel cells for use in a large-diameter unmanned underwater vehicle; algorithm development for theater-level Anti-Submarine Warfare (ASW) battle management; integrated minefield planning where specific efforts include evaluation of prototype algorithms for staff-level planning of mixed minefields, multiple minefields, and alternative delivery techniques; and studying air-sea process impacts for in-air Electromagnetic (EM) propagation.						
- Initiate efforts in high temperature superconducting approaches to minesweeping; innovative naval mine delivery methods; advanced acoustic sources for floating and mobile ASW sensing systems as well as expeditionary SURTASS; and storm surge and inundation forecasting models.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant change between FY 2020 and FY 2021.						
Title: Sea Warfare and Weapons Description: The objective of this activity is to develop and mature technologies that enable superior warfighting capabilities for surface and sub-surface naval platforms and undersea weaponry to a point where they can be proposed and continued as Future Naval Capabilities in program element (PE) 0603673N, Future Naval Capabilities Advanced Technology Development.		16.738	20.921	27.565	0.000	27.565
FY 2020 Plans: The focus in FY 2020 will be on maturing technologies for future FNCs (Future Naval Capabilities) involving off-board refueling and data transfer, autonomous situational awareness, hazard avoidance, and high temperature superconducting magnetic influence sweep payloads for unmanned surface vehicles; advanced batteries to increase torpedo range and endurance; robust power control for integrated surface ship power and combat systems; precision lift in austere at-sea environments for surface ship replenishment and weapons reload; digital tools to automate operation and control of unmanned platforms integrated with manned platforms in mission environments; and in situ repair of shipboard copper-nickel heat exchanger tubing. Additionally, applied						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
1319 / 2	PE 0602750N / Future Naval Capabilities Applied Research					
research will begin on emerging technologies in the areas of autonomy, digital analytics for platforms and logistics, platform maintenance and sustainability, undersea weapons, advanced manufacturing, and energy systems.						
FY 2021 Base Plans: Initiate efforts in: - Addressing platform endurance and resiliency; naval force sustainment; and logistics. These efforts include signature management, undersea weapons improvements, digital twin development and ship hull-based coatings.						
Continue efforts in: - Undersea platform signature management and control to support the tactical submarine evolution science and technology plan. - Technologies to improve the long-range operational capabilities of undersea weapons. - "Digital twin" development with the expansion to integrate condition-based maintenance; and power and energy to improve overall platform resiliency. - Methods to produce rapidly low cost, high performance autonomous unmanned platforms. - Improved environmentally benign platform coatings to reduce maintenance costs and improve platform hydrodynamic efficiency.						
Conclude efforts in: - Precision lift in austere at-sea environments. These efforts were transitioned to an OSD funded effort for at-sea test and evaluation. - The unmanned vehicle commercial battery effort anticipating transition into ongoing development programs. - Offboard Refueling and Data Transfer for Unmanned Surface Vehicles and Robust Combat Power Control as the efforts will be proposed as candidates for Future Naval Capabilities. - Tech Candidate Innovation and Prototype Activities. Specific efforts are being covered under another program element to more closely align work with the Navy's innovation initiative.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement:						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602750N / Future Naval Capabilities Applied Research	Project (Number/Name) 0000 / Future Naval Capabilities Applied Research				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
The FY 2020 to FY 2021 increase is due to initiation of efforts in addressing platform endurance and resiliency; naval force sustainment; and logistics. These efforts include signature management, undersea weapons improvements, digital twin development and ship hull-based coatings.						
Title: Warfighter Performance		8.115	10.150	14.590	0.000	14.590
Description: The objective of this activity is to develop and mature technologies that enhance Naval warfighting effectiveness and efficiency within the broad array of Warfighter Performance science and technology domains (Undersea Medicine, Biological Sciences, Bio-robotics, Capable Manpower, Command Decision Making, Force Health Protection, Human/Robot Interaction, Noise-Induced Hearing Loss, and Training and Simulation) to a point where they can be proposed and continued as Future Naval Capabilities (FNC) in program element (PE) 0603673N, Future Naval Capabilities Advanced Technology Development.						
FY 2020 Plans: Technologies developed under this activity enhance Naval operators use of: Autonomy, Artificial Intelligence, and Robotics (AAR), including cross-domain facilitated communication between operators and unmanned vehicles; Communications and Networking/Cyber (CN/C) technologies such as expeditionary command, control, communications, intelligence, surveillance, and reconnaissance (C4ISR); Advanced Analytics and Decision Making (AADM) capabilities including Naval training tools and decision-assist technologies for denied and degraded environments; Manpower, Performance, Protection, and Medical support (MPPM) capabilities such as directed energy bioeffects, monitoring performance in austere environments, and predictors of blast injury.						
FY 2021 Base Plans: Initiate efforts in: - Applied Human-level artificial intelligence and autonomy that enables the ability for each operator to control multiple autonomous platforms and payloads - Social media incorporation for command, control, communications, intelligence, surveillance, and reconnaissance (C4ISR) - Multi-media, forecasting, and Live, Virtual, and Constructive capabilities to improve manpower selection, training, education, and job performance - Human protection, performance, and biomedical capabilities to increase warfighter lethality and survivability and biotechnologies to provide alternatives to conventional material resources. Continue efforts on:						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602750N / Future Naval Capabilities Applied Research	Project (Number/Name) 0000 / Future Naval Capabilities Applied Research				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
- Modeling and simulation of warfighting environments and systems for training and rehearsal, including cyber and information warfare operations and use of new autonomous systems, technologies for monitoring and forecasting human performance during training and operations, and technologies for a non-rigid 1 atmosphere dive suit. Conclude efforts on: - Energy harvesting using microbial fuel cells, data analytics for workplace behavior capture and trend analysis, and detailed physiological human modeling for injury prediction.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The FY 2020 to FY 2021 increase is due to increased investment in autonomous vehicle control improvement, innovative social media applications and biotechnology development for alternative material resources.						
Title: Naval Air Warfare and Weapons Description: The objective of this activity is to develop and mature technologies in directed energy, energetic materials, autonomy, electromagnetic launch, and high speed conventional air and surface weapons to a point where they can be proposed and continued as Future Naval Capabilities in PE 0603673N, Future Naval Capabilities Advanced Technology Development.		18.724	25.022	30.094	0.000	30.094
FY 2020 Plans: The focus of FY2020 will be on maturing technologies for future FNCs that will improve kinetic and non-kinetic capabilities of existing and future naval weapon systems, as well as introduce technological advancements into core Naval operations. Technology investments will be made to introduce artificial intelligence and machine learning into mission planning, make generational enhancements to rocket motor propulsion, investigate sub-system advancement for hypersonic weapons, mature directed energy applications for defense, expand aircraft and ship self-defense capabilities, create alternate aircraft repair methodologies, and improve aircraft-ship interoperability.						
FY 2021 Base Plans: Initiate efforts on: - Investigate solid fuel ramjet technology applications to missiles and projectiles for increased range, speed and maneuverability						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020			
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602750N / Future Naval Capabilities Applied Research	Project (Number/Name) 0000 / Future Naval Capabilities Applied Research					
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	
- Leverage ongoing collaborative weapons technologies for application to additional munitions and weapons - Leverage ongoing reactive materials initiatives for application to additional munitions and weapons.	Continues efforts on: - Developing, designing and testing solid state, High-Power Microwave (HPM) systems for enhanced lethality - Development of advanced technologies leading to kinetic-kill defenses against adversary hypersonic weapons - Development of a pulsed laser to defeat advanced threats. Complete efforts on: - The investigation of advanced air-to-surface/ground seeker technologies; - Advanced technologies for the development of Naval hypersonic weapons and improved high value, low density aircraft self-defense against next generation air-to-air threats.						
FY 2021 OCO Plans: N/A	FY 2020 to FY 2021 Increase/Decrease Statement: The FY 2020 to FY 2021 increase is due to increased investments for investigations in semi-autonomous collaborative weapons technologies, greatly expanded reactive materials application to warheads, and non-traditional rocket motor technologies.	Accomplishments/Planned Programs Subtotals	135.523	148.012	167.590	0.000	167.590
C. Other Program Funding Summary (\$ in Millions)							
N/A							
Remarks							
D. Acquisition Strategy							
N/A							

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity 1319 / 2					R-1 Program Element (Number/Name) PE 0602750N / Future Naval Capabilities Applied Research				Project (Number/Name) 9999 / Congressional Adds				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
9999: Congressional Adds	0.000	0.000	4.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	4.000	
A. Mission Description and Budget Item Justification Congressional Interest Items not included in other Projects.													
B. Accomplishments/Planned Programs (\$ in Millions)													
<i>Congressional Add:</i> C4ISR and special projects											0.000	4.000	
<i>FY 2019 Accomplishments:</i> N/A													
<i>FY 2020 Plans:</i> Conduct applied research in C4ISR and special projects											Congressional Adds Subtotals	0.000	4.000
C. Other Program Funding Summary (\$ in Millions)													
N/A													
Remarks													
D. Acquisition Strategy													
N/A													

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy											Date: February 2020	
Appropriation/Budget Activity					R-1 Program Element (Number/Name)							
1319: Research, Development, Test & Evaluation, Navy / BA 2: Applied Research					PE 0602782N / Mine and Expeditionary Warfare Applied Research							
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	0.000	37.399	54.074	30.715	-	30.715	31.326	31.968	32.611	33.264	Continuing	Continuing
0000: Mine and Expeditionary Warfare Applied Research	0.000	35.468	36.074	30.715	-	30.715	31.326	31.968	32.611	33.264	Continuing	Continuing
9999: Congressional Adds	0.000	1.931	18.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	19.931

A. Mission Description and Budget Item Justification

Sea mines remain a significant threat to ships. In fact, fifteen U.S. Navy ships have been sunk or damaged by mines since World War II, almost four times more than any other weapon. The Mine and Expeditionary Warfare Applied Research Program Element (PE) provides technologies for Naval Mine Countermeasures (MCM), Expeditionary Warfare, U.S. Naval sea mining, Naval Special Warfare (NSW), and Joint Tri-Service Explosive Ordnance Disposal (EOD) as well as continuing support to research vessels of the U.S. Academic Research Fleet for operations and maintenance that enable applied research at sea. This program strongly aligns with the Joint Chiefs of Staff Joint Warfighting Capability Objectives through the development of technologies to achieve military objectives with minimal casualties and collateral damage. This investment will enable Ship-to-Objective Maneuver (STOM) and focus on technologies that will provide the Naval Force with the capability to dominate the battlespace, project power from the sea, and support forces ashore with particular emphasis on rapid MCM operations. These efforts concentrate on the development and transition of technologies for the MCM-related and Urban Asymmetric/Expeditionary Warfare Operations (UAEO)-related Future Naval Capabilities (FNC) Enabling Capabilities (ECs).

The Mine and Obstacle Detection and Neutralization efforts include technologies for clandestine and overt minefield reconnaissance, organic ship self-protection, organic mine hunting and neutralization/breaching. The Urban Asymmetric Operation effort includes critical warfighting functions such as Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR), fires, maneuver, sustainment, etc. The Naval Special Warfare and Explosive Ordnance Disposal technology efforts concentrate on the development of technologies for safe near-shore mine detection, diver mobility and survivability, and ordnance disposal operations. The activities described in this PE address future Navy and Marine Corps capabilities needed to maintain maritime superiority and ensure national security. They are based on input from Naval Research Enterprise stakeholders including the Naval enterprises, the combatant commands, Office of the Chief of Naval Operations (OPNAV) and Headquarters Marine Corps and are designed to exploit breakthroughs in science and technology in order to deliver maximum warfighting benefit to our sailors and Marines. These efforts align with shared priorities throughout the whole of RDT&E in order to quickly advance new capabilities from discovery to deployment across the warfighting domains.

Today's Sailors and Marines are enabled by naval Science and Technology (S&T). Since 1946, the Office of Naval Research (ONR) has fostered scientific research related to the maintenance of maritime superiority and national defense. ONR manages the Department of the Navy's (DON) portfolio of naval Basic and Applied research, and Advanced Technology Development investments to ensure naval forces can effectively deter conflict, but when called upon, fight, win and come home safe. Current investments hedge against uncertainty, providing solutions to commanders today, and options for the future. The Naval S&T budget supports higher guidance defined by the National Defense Strategy, and responds to requirements identified by the Secretary of the Navy through research priorities set by the Chief of Naval Research, coordinated across the Naval Research Enterprise (NRE), and outlined in the Naval R&D Framework.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy	Date: February 2020																																																																														
Appropriation/Budget Activity 1319: <i>Research, Development, Test & Evaluation, Navy / BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602782N / <i>Mine and Expeditionary Warfare Applied Research</i>																																																																														
This Program Element (PE) funds Applied Research, which is the systematic study to understand the means to meet a recognized and specific need. Most of the work in this PE can be classified between Technology Readiness Level (TRL) 2 (technology concept and/or application formulation) and TRL 4 (component and/or breadboard validation in laboratory environments).																																																																															
Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.																																																																															
B. Program Change Summary (\$ in Millions)	<table> <thead> <tr> <th></th><th>FY 2019</th><th>FY 2020</th><th>FY 2021 Base</th><th>FY 2021 OCO</th><th>FY 2021 Total</th></tr> </thead> <tbody> <tr> <td>Previous President's Budget</td><td>38.214</td><td>36.074</td><td>30.298</td><td>-</td><td>30.298</td></tr> <tr> <td>Current President's Budget</td><td>37.399</td><td>54.074</td><td>30.715</td><td>-</td><td>30.715</td></tr> <tr> <td>Total Adjustments</td><td>-0.815</td><td>18.000</td><td>0.417</td><td>-</td><td>0.417</td></tr> <tr> <td> • Congressional General Reductions</td><td>-</td><td>-</td><td></td><td></td><td></td></tr> <tr> <td> • Congressional Directed Reductions</td><td>-</td><td>-</td><td></td><td></td><td></td></tr> <tr> <td> • Congressional Rescissions</td><td>-</td><td>-</td><td></td><td></td><td></td></tr> <tr> <td> • Congressional Adds</td><td>-</td><td>18.000</td><td></td><td></td><td></td></tr> <tr> <td> • Congressional Directed Transfers</td><td>-</td><td>-</td><td></td><td></td><td></td></tr> <tr> <td> • Reprogrammings</td><td>-</td><td>-</td><td></td><td></td><td></td></tr> <tr> <td> • SBIR/STTR Transfer</td><td>-0.815</td><td>0.000</td><td></td><td></td><td></td></tr> <tr> <td> • Program Adjustments</td><td>0.000</td><td>0.000</td><td>0.417</td><td>-</td><td>0.417</td></tr> <tr> <td> • Rate/Misc Adjustments</td><td>0.000</td><td>0.000</td><td>0.000</td><td>-</td><td>0.000</td></tr> </tbody> </table>		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	Previous President's Budget	38.214	36.074	30.298	-	30.298	Current President's Budget	37.399	54.074	30.715	-	30.715	Total Adjustments	-0.815	18.000	0.417	-	0.417	• Congressional General Reductions	-	-				• Congressional Directed Reductions	-	-				• Congressional Rescissions	-	-				• Congressional Adds	-	18.000				• Congressional Directed Transfers	-	-				• Reprogrammings	-	-				• SBIR/STTR Transfer	-0.815	0.000				• Program Adjustments	0.000	0.000	0.417	-	0.417	• Rate/Misc Adjustments	0.000	0.000	0.000	-	0.000
	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total																																																																										
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Congressional Add: <i>Clandestine mine neutralization</i>																																																																															
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Technical: Not applicable.																																																																															
Schedule: Not applicable.																																																																															

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy	Date: February 2020
Appropriation/Budget Activity 1319: <i>Research, Development, Test & Evaluation, Navy / BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602782N / <i>Mine and Expeditionary Warfare Applied Research</i>
Funding: FY21 Program increase supports increased investment in Mine/Obstacle Detection.	

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020				
Appropriation/Budget Activity					R-1 Program Element (Number/Name)				Project (Number/Name)						
1319 / 2					PE 0602782N / Mine and Expeditionary Warfare Applied Research				0000 / Mine and Expeditionary Warfare Applied Research						
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost			
0000: Mine and Expeditionary Warfare Applied Research	0.000	35.468	36.074	30.715	-	30.715	31.326	31.968	32.611	33.264	Continuing	Continuing			
A. Mission Description and Budget Item Justification															
This Project focuses on reducing the time involved in conducting Mine Countermeasure (MCM) operations and increasing safe standoff from minefields. It develops and transitions technologies for MCM-related and UAEO-related Future Naval Capabilities (FNC). The MCM effort includes technologies for clandestine and overt minefield reconnaissance, organic ship self-protection, organic mine-hunting, neutralization/breaching and clearance. The Littoral Warfare effort includes critical warfighting functions such as C4ISR, fires, maneuver, sustainment. The sea mining effort emphasizes technologies for future sea mines. The Naval Special Warfare and Explosive Ordnance technology efforts concentrate on the development of technologies to enhance diver capabilities including: safe near-shore mine sensing, mobility and survivability, and ordnance disposal operations.															
B. Accomplishments/Planned Programs (\$ in Millions)											FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Mine Technology											6.962	7.635	2.116	0.000	2.116
Description: This activity primary focuses on developing and demonstrating technologies to support on-demand battlespace shaping through advanced undersea weapons and next generation mining concepts. Efforts include Command & Control to support remote control, advanced sensing technologies, compatibility with options for unmanned delivery, detection & classification, and targeting solutions. Modular Undersea Effectors (MUSE) research supports Fleet demand for capability and prototype development for next generation naval mining concepts. MUSE also develops and investigates flexible, scalable, and asymmetric technologies to deliver next generation naval mining effects for legacy programs of record. This program provides critical Science and Technology (S&T) for development and capability in new acquisition programs of record.															
FY 2020 Plans: Conduct advanced technology development in advanced mining technologies for clandestine, flexible, and scalable minefield deployment, longevity, and endurance, to include remote control, advanced sensing for detection and classification, command & control (C2), and more discriminative targeting solutions. Efforts in this thrust include prototyping and demonstration of advanced sensors and sensor configuration technologies for improved discrimination as well as communications, command, and control technologies. Continue prototyping and demonstration for next-generation target detection devices and mine effects.															
Joint Service Explosive Ordnance Disposal (EOD):															

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602782N / Mine and Expeditionary Warfare Applied Research	Project (Number/Name) 0000 / Mine and Expeditionary Warfare Applied Research				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Conduct applied technology development and demonstration in electro-optic & acoustic technologies for buried mine detection, robotic manipulation for ordnance exploitation & neutralization, standoff detection and classification for ordnance, and identification of explosives. Efforts in this thrust include prototype and demonstration of laser interferometric sensor/systems for detection of buried objects, highly dexterous dual manipulator systems (manipulators, controllers) for EOD robots for precision render safe and neutralization missions, technologies for low-observable underwater ordnance neutralization and technologies for the inspection of underwater explosive threats.						
FY 2021 Base Plans: - Target Detection Devices (Mine & Expeditionary Warfare): Further efforts in developments in advanced sensors and algorithmic capabilities that are applicable toward existing target detection devices (TDDs), development of concepts for remote controlled mines, and assessment of sea mine technologies in order to maintain a level of expertise in naval mines. Specific effort will include advanced sensing modalities for improved discrimination. The objective is to achieve a miniaturized, highly capable TDD to advance legacy mine capacity. - Minefield Concepts (Mine & Expeditionary Warfare): Conclude applied research, algorithm development, early prototypes, and experimentation on intermediate and deep-water minefield concepts. - Naval Mine Subcomponents (Mine & Expeditionary Warfare): Initiate efforts in alternative packaging and miniaturization of naval mine subcomponents. Specific effort will include advanced sensing, remote control and communications, and advanced energetics. The objective is to achieve alternative capability to incrementally advance legacy mine capacity, and find new capability within legacy delivery mechanisms.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The funding decrease from FY 2020 to FY 2021 is due to the reduced investment and conclusion of applied research in intermediate and deep-water minefield concepts.						
Title: Mine/Obstacle Detection		17.233	17.329	17.834	0.000	17.834
Description: This activity focuses on applied research to enable longer detection ranges and precise detection and mine location with fewer false alarms in a variety of challenging environments. It supports Mine Countermeasures (MCM) related Future Naval Capabilities (FNCs). Efforts include novel sonar technologies for						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602782N / Mine and Expeditionary Warfare Applied Research	Project (Number/Name) 0000 / Mine and Expeditionary Warfare Applied Research				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
	longer range detection and classification of mine-like targets, magnetic gradiometer sensing, electro-optic (EO) technology for buried mine identification, and sensor integration onto Unmanned Underwater Vehicles (UUVs). EO sensor research develops algorithms to enable image processing for rapid overt reconnaissance from an Unmanned Aerial Systems (UAS). Efforts include the development of processing, classification and data fusion techniques to reduce operator workload, and an expert system used to predict mine burial. Efforts also support development of MCM Mission Modules for Littoral Combat Ships.					
	The program is strongly aligned with the Oceanographer of the Navy (N2/N6E) and the research topics addressed by this activity reflect the priorities for improved forecasts of the operational environment and the development and use of autonomous systems for the collection of environmental observations and continuing support to research vessels of the U.S. Academic Research Fleet for operations and maintenance that enable science at sea. Field research within this activity that uses active acoustic transmissions requires modeling of the acoustic effects of sound on marine life in order to meet Navy environmental requirements.					
FY 2020 Plans: Conduct applied research in novel mine hunting technologies to enable unmanned systems to operate flexibly across a wide range of dynamic and unstructured environments and operations. Research thrusts include the development of new algorithms, innovative processing schemes, prototype hardware, studies of acoustic communications between unmanned Mine Countermeasure (MCM) systems in dynamic environments; new transducer designs and sensors for miniaturizing MCM capabilities onto smaller unmanned systems and operating with increased autonomy; novel algorithmic approaches and hardware designs that consolidate and optimize sensing, navigation, and communications for smaller autonomous mine hunting and neutralization systems. Conduct investigations of joint sensing and communication approaches for multi-vehicle mine hunting; and, performance estimation for automatic target recognition on non-imaging systems. Laboratory, field, and theoretical/numerical studies will provide new solutions to enable more rapid and effective mine detection and classification. Emphasis will be placed on reducing timelines, or even eliminating post-mission analysis through enhanced scene understanding derived from acoustic and/or other sensing modalities. Specific research activities include; the development of Unmanned Underwater Vehicle (UUV's) autonomy to exploit the ambient environmental conditions to optimize performance; extend the reach of MCM UUVs						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602782N / Mine and Expeditionary Warfare Applied Research	Project (Number/Name) 0000 / Mine and Expeditionary Warfare Applied Research				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
	<p>to operate at deeper depths; characterization of the flow generated by various propulsion approaches; measurements and modeling of the physics associated with the acoustic interactions with targets and the environment, which can be exploited for detection and classification; investigations that lead to new parameterizations of the ocean seabed applicable to modern mine hunting systems; investigations that link observable impacts on acoustic scattering and/or propagation with the underlying phenomenology that affects the environment, including oceanographic and biologic processes; investigations aimed at linking target scattering physics modalities to specific properties in the feature space domain used for Automatic Target Recognition.</p> <p>FY 2021 Base Plans:</p> <ul style="list-style-type: none">- Autonomous Vehicles (Mine & Expeditionary Warfare): Conduct efforts to develop approaches for coupling between autonomous vehicles and their sensor payloads. Continue efforts to characterize flow generated by biomimetic propulsion approaches.- Mine & Expeditionary Warfare (Target Recognition and Signal Processing): Conclude efforts in non-environmentally adaptive automatic target recognition and associated signal processing approaches. <p>-Mine Countermeasures (MCM) Data (Mine & Expeditionary Warfare): Initiate efforts to aggregate, curate and interrogate real and simulated data sets for in-situ algorithm adaptation, optimization, and performance assessment. The objective is to enable unmanned systems to operate flexibly across a wide range of dynamic and unstructured environments.</p> <p>- MCM Sensor (Mine & Expeditionary Warfare): Initiate development of next-generation small, highly capable MCM sensors. Specific efforts include sensors, electronics, and computing technology. The objective is to increase deployment options for unmanned systems.</p> <p>- Threat Detection/Robotic Techniques (Mine & Expeditionary Warfare): Initiate development of robotic technologies to respond to detected threats. Specific effort will include dexterity, haptics and algorithms to achieve human-like behaviors. The objective is to sense and interact with the environment and threats.</p> <p>FY 2021 OCO Plans:</p> <p>N/A</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement:</p>					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602782N / Mine and Expeditionary Warfare Applied Research	Project (Number/Name) 0000 / Mine and Expeditionary Warfare Applied Research				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
The funding increase from FY 2020 to FY 2021 is due to initiation and further development of Mine Countermeasures(MCM) sensors, threat detection/robotic techniques and to develop approaches for coupling between autonomous vehicles and their sensor payloads.						
Title: Mine/Obstacle Neutralization Description: This activity includes applied research to support selected Mine Countermeasures-related Future Naval Capabilities (FNC) for the rapid neutralization of mines and obstacles, and sea mine jamming techniques to increase surface ship safe standoff from threat mines. It includes computational tools and models to assess mine and obstacle vulnerability and lethality of novel approaches for neutralization to support various far-term Surf Zone and Beach Zone mine and obstacle breaching system concepts. FY 2020 Plans: Conduct applied research to support rapid mine and obstacle neutralization and mine sweeping techniques to enable maneuver of joint forces and increase the safe standoff of various tactical platforms and surface ships from the threat of mines. Research thrusts include development of lethality, vulnerability models, technology concept assessments, and algorithmic approaches to support neutralization of mines and obstacles in all water depths and on the beach, which includes Surf Zone and Beach Zone mine and obstacle breaching concepts; novel approaches for neutralization of buried mines; advanced techniques for emulation sweep; and methods to enable precision neutralization of buried mines. Conclude assessment of preliminary methods for emulation sweep. Conclude investigation of coupling of reacquire and identify capabilities with precision neutralization of buried mines. FY 2021 Base Plans: - Rapid Neutralization of Mines and Obstacles: Maintain effort in rapid neutralization of mines and obstacles including development of lethality and vulnerability models, technology concept assessments, and approaches for neutralization of mines and obstacles in all water depths, the surf zone, beach and inland. The objective is to enable maneuver of joint forces from ship to inland objective. - Advanced Minesweeping: Conduct effort in advanced minesweeping including development of compact, efficient approaches for sweeping advanced influence mines. The objective is to increase the safe standoff of various tactical platforms and surface ships. - Mine-setting Mode Techniques: Conclude applied research on mine-setting-mode techniques for emulation minesweeping	0.435	0.435	0.435	0.000	0.435	

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602782N / Mine and Expeditionary Warfare Applied Research	Project (Number/Name) 0000 / Mine and Expeditionary Warfare Applied Research				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
- Robotics: Initiate development of robotic technologies to respond to detected targets including work on dexterity, haptics and algorithms to achieve human-like behaviors. The objective is to interact with the mine and/or obstacle to achieve neutralization, clearance, render-safe or removal for exploitation.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant change between FY 2020 and FY 2021.						
Title: Special Warfare/EOD Description: The goal of this effort is to develop technologies to extend stand-off of special operations and Explosive Ordnance Disposal (EOD) forces in clandestine hydrography, mine clearance and port security missions while increasing the range and effectiveness of divers. Advanced technologies are needed to gain access to areas contaminated by area-denial sensors and/or booby traps. Developed technologies will transition to the Joint Service EOD Program, the Naval EOD Program, or the DOD Technical Response Group. This activity includes applied research in sensor technology for Naval Special Warfare (NSW) and EOD autonomous and handheld sonar systems to increase detection range and accuracy in harsh environments. Other efforts include such mission support technology improvements as communications, navigation and life support for UUVs and human divers.		10.838	10.675	10.330	0.000	10.330
FY 2020 Plans: Conduct applied research in sensor, render-safe and neutralization technologies for NSW and EOD autonomous and handheld systems, mission support technology enhancements for manned and unmanned platforms (air, surface or undersea) and new concepts to increase the efficiency and mobility of unmanned platforms and divers (e.g., communications, propulsion, navigation, and life support), and threat identification, exploitation, and remediation technologies. Efforts include development of technologies which will: excavate buried Improvised Explosive Device; use advanced robotic manipulators for complex underwater EOD missions; support Joint Service Explosive Ordnance Disposal (JSEOD) applied research; detect trace and bulk explosive materials at extended standoff distances; detect buried improvised explosive devices, explosive threats and mines using handheld or unmanned platforms; inspect explosive threats from safe standoff, enhance diver situational awareness and autonomous inspection of structures; conduct vessel interdiction; allow tagging, tracking and						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602782N / Mine and Expeditionary Warfare Applied Research	Project (Number/Name) 0000 / Mine and Expeditionary Warfare Applied Research				
<u>B. Accomplishments/Planned Programs (\$ in Millions)</u>		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
locating of targets; conduct characterization, inspection, surveillance and reconnaissance of denied and under canopy areas. Conclude assessment of excavation techniques.						
<p>FY 2021 Base Plans:</p> <ul style="list-style-type: none"> - Advanced Robotic Techniques: Maintain efforts in advanced robotic technologies including development of human-like manipulators and haptics. - Platforms: Further development of air, surface and subsurface platforms to conduct operations in the littorals to improve diver mobility and safety, address drag reduction, diver propulsion, communications, navigation, thermal envelope, life support and contamination protection. - Ordnance Detection: Conclude efforts for sensors to detect buried improvised explosive devices. Specific effort includes technologies for compact, held-hand radar concepts. The objective is to improve the performance of hand-held radar technology to achieve a low false alarm rate. - Sensor Techniques: Initiate effort to develop compact sensor technologies to diagnose explosive threats and unexploded ordnance including the development of hand-held or robot deployable sensor technologies. The objective is to determine the status of explosive threats and unexploded ordnance. - Neutralization Explosive Threats: Initiate effort to develop technologies to enable render-safe or neutralization of explosive threats and unexploded ordnance. - Unmanned Systems Situational Awareness: Initiate onboard processing in unmanned systems to enable environmental situational awareness (SA) in the littorals. <p>FY 2021 OCO Plans:</p> <p>N/A</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement:</p> <p>There is no significant change between FY 2020 and FY 2021</p>						
Accomplishments/Planned Programs Subtotals		35.468	36.074	30.715	0.000	30.715
C. Other Program Funding Summary (\$ in Millions)						
N/A						
Remarks						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy	Date: February 2020	
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602782N / <i>Mine and Expeditionary Warfare Applied Research</i>	Project (Number/Name) 0000 / <i>Mine and Expeditionary Warfare Applied Research</i>
D. Acquisition Strategy N/A		

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity 1319 / 2					R-1 Program Element (Number/Name) PE 0602782N / Mine and Expeditionary Warfare Applied Research				Project (Number/Name) 9999 / Congressional Adds				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
9999: Congressional Adds	0.000	1.931	18.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	19.931	
A. Mission Description and Budget Item Justification													
Congressional Interest Items not included in other Projects.													
B. Accomplishments/Planned Programs (\$ in Millions)											FY 2019	FY 2020	
<i>Congressional Add:</i> Unmanned Aerial and Deep Submersible Platforms											1.931	0.000	
<i>FY 2019 Accomplishments:</i> Funds will be used to further development of autonomous aerial and submersible platforms in cluttered environments.													
<i>FY 2020 Plans:</i> N/A													
<i>Congressional Add:</i> Underwater mine defeat capabilities urgent operational need											0.000	10.000	
<i>FY 2019 Accomplishments:</i> N/A													
<i>FY 2020 Plans:</i> Conduct applied research in Underwater mine defeat capabilities urgent operational need.													
<i>Congressional Add:</i> Clandestine mine neutralization											0.000	8.000	
<i>FY 2019 Accomplishments:</i> N/A													
<i>FY 2020 Plans:</i> Conduct applied research in Clandestine mine neutralization.													
Congressional Adds Subtotals											1.931	18.000	
C. Other Program Funding Summary (\$ in Millions)													
N/A													
Remarks													
D. Acquisition Strategy													
N/A													

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy											Date: February 2020	
Appropriation/Budget Activity					R-1 Program Element (Number/Name)							
1319: Research, Development, Test & Evaluation, Navy / BA 2: Applied Research					PE 0602792N / Innovative Naval Prototypes (INP) Applied Res							
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	0.000	151.176	152.354	160.537	-	160.537	163.711	166.933	170.290	173.696	Continuing	Continuing
0000: Innovative Naval Prototypes (INP) Applied Res	0.000	151.176	111.453	2.485	-	2.485	54.292	143.529	170.290	173.696	Continuing	Continuing
2481: EMRG	0.000	0.000	7.632	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	7.632
2958: Cyberspace Activities	0.000	0.000	27.269	28.511	-	28.511	26.061	0.000	0.000	0.000	0.000	81.841
3416: HIJENKS	0.000	0.000	0.000	22.320	-	22.320	9.943	0.000	0.000	0.000	0.000	32.263
3423: LOCUST	0.000	0.000	0.000	22.046	-	22.046	5.553	0.000	0.000	0.000	0.000	27.599
3450: AMOS	0.000	0.000	0.000	8.401	-	8.401	6.463	8.404	0.000	0.000	0.000	23.268
3451: CLAWS	0.000	0.000	0.000	26.456	-	26.456	23.445	0.000	0.000	0.000	0.000	49.901
3452: ELEKTRA	0.000	0.000	0.000	6.032	-	6.032	3.977	0.000	0.000	0.000	0.000	10.009
3453: Hypersonic Booster	0.000	0.000	0.000	10.000	-	10.000	30.000	15.000	0.000	0.000	0.000	55.000
3454: MDUSV	0.000	0.000	0.000	4.850	-	4.850	0.000	0.000	0.000	0.000	0.000	4.850
3455: MINERVA	0.000	0.000	0.000	5.965	-	5.965	3.977	0.000	0.000	0.000	0.000	9.942
3456: Full Spectrum Undersea Warfare	0.000	0.000	0.000	23.471	-	23.471	0.000	0.000	0.000	0.000	0.000	23.471
9999: Congressional Adds	0.000	0.000	6.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	6.000

Note

In FY 2020, the Applied Research Electro-Magnetic Railgun (EMRG) high-power, kinetic energy weapon prototype development effort was realigned from Project Unit 0000 to Project Unit 2481 within this Program Element (PE).

The FY 2017 National Defense Authorization Act directed the services to realign Cyberspace Activity (CA) resources into individual cost codes, projects or program elements (PEs) in order to provide additional clarity and enhanced oversight of cyberspace pure resources. Within this PE, cyber funding was moved from Proj 0000 Innovative Naval Prototypes (INP) Applied Research to Proj 2958 Cyberspace Activities beginning in FY20, which was established to isolate and identify cyberspace activities.

The FY 2020 Appropriation Act directed ONR to establish appropriate projects for prototyping efforts to provide additional acquisition oversight, fiscal clarity and adherence to financial management practices. Within this PE, INP funding has been realigned from Proj 0000 Innovative Naval Prototypes (INP) Applied Research to new stand-alone projects as indicated below starting in FY 2021.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy	Date: February 2020
Appropriation/Budget Activity 1319: <i>Research, Development, Test & Evaluation, Navy / BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602792N / <i>Innovative Naval Prototypes (INP) Applied Res</i>
<ul style="list-style-type: none">- Proj 3416: HIJENKS- Proj 3423: LOCUST- Proj 3450: AMOS- Proj 3451: CLAWS- Proj 3452: ELEKTRA- Proj 3453: Hypersonic Booster- Proj 3454: MDUSV- Proj 3455: MINERVA- Proj 3456: Full Spectrum Undersea Warfare	
<p>A. Mission Description and Budget Item Justification</p> <p>The Office of Naval Research (ONR) portfolio includes efforts that solve problems and respond to mission requirements, as well as exploratory research for new ideas and breakthrough capabilities. Larger in scope, scale and risk Innovative Naval Prototypes (INP) are selected for their high-payoff and potential to revolutionize operational concepts. The efforts described in this Program Element (PE) address the Applied Research associated with the INP Program. These investments define the future of U.S. naval forces. Due to high technical risk, INPs typically have long duration but have no more than three years between decision points. They mature technologies from a Technology Readiness Level (TRL) of 2 or 3 to a TRL of 6. As such, INPs require both Budget Activity (BA) 2 and BA3 funding. The BA3 INP funds are specified in a separate PE, 0603801N Innovative Naval Prototypes Advanced Technology Development. INPs do not develop hardware for service use; rather they provide feeder technology that can be demonstrated in prototypes in the 6.3 portion of the INP program. Developing INPs requires a systematic expansion and application of knowledge to develop useful materials, devices, and systems oriented toward the design and development of prototypes applicable to specific mission area requirements. The efforts funded within this PE translate promising basic research into solutions for broadly defined military needs. These efforts include developing breadboard hardware and algorithms that establish the initial feasibility and practicality of proposed solutions to technological challenges, such as concept exploration efforts, studies, investigations, and non-system specific technology efforts. The Department of the Navy would have to make significant acquisition decisions to integrate the new technological capabilities into naval warfighting systems. INPs are selected by a process that involves senior leadership in the Department of the Navy.</p> <p>Information security concerns preclude fully detailed descriptions of project efforts, research activities, and technology development plans. Specific information on each project and activity will be provided separately to the Congressional oversight committees.</p> <p>This Program Element (PE) funds Applied Research, which is the systematic study to understand the means to meet a recognized and specific need. Most of the work in this PE can be classified between Technology Readiness Level (TRL) 2 (technology concept and/or application formulation) and TRL 4 (component and/or breadboard validation in laboratory environments).</p>	

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy					Date: February 2020
Appropriation/Budget Activity 1319: Research, Development, Test & Evaluation, Navy / BA 2: Applied Research		R-1 Program Element (Number/Name) PE 0602792N / Innovative Naval Prototypes (INP) Applied Res			
B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	154.085	153.062	160.537	-	160.537
Current President's Budget	151.176	152.354	160.537	-	160.537
Total Adjustments	-2.909	-0.708	0.000	-	0.000
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-6.708			
• Congressional Rescissions	-	-			
• Congressional Adds	-	6.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-2.909	0.000			
• Rate/Misc Adjustments	0.000	0.000	0.000	-	0.000
Congressional Add Details (\$ in Millions, and Includes General Reductions)	FY 2019	FY 2020			
Project: 9999: Congressional Adds					
Congressional Add: Thermoplastic carbon-fiber composite materials research	0.000	4.000			
Congressional Add: Thermoplastic tailorable universal feedstock composites	0.000	2.000			
	Congressional Add Subtotals for Project: 9999				
	Congressional Add Totals for all Projects				
	0.000	6.000			
	0.000	6.000			

Change Summary Explanation

Funding: No significant change.

Technical: Not applicable.

Schedule: Not applicable.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020	
Appropriation/Budget Activity					R-1 Program Element (Number/Name)				Project (Number/Name)			
1319 / 2					PE 0602792N / Innovative Naval Prototypes (INP) Applied Res				0000 / Innovative Naval Prototypes (INP) Applied Res			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
0000: Innovative Naval Prototypes (INP) Applied Res	0.000	151.176	111.453	2.485	-	2.485	54.292	143.529	170.290	173.696	Continuing	Continuing

Note

The FY 2020 Appropriation Act directed ONR to establish appropriate projects for prototyping efforts to provide additional acquisition oversight, fiscal clarity and adherence to financial management practices. Within this PE, INP funding has been realigned from Proj 0000 Innovative Naval Prototypes (INP) Applied Research to new stand-alone projects as indicated below starting in FY 2021.

- Proj 3416: HIJENKS
- Proj 3423: LOCUST
- Proj 3450: AMOS
- Proj 3451: CLAWS
- Proj 3452: ELEKTRA
- Proj 3453: Hypersonic Booster
- Proj 3454: MDUSV
- Proj 3455: MINERVA
- Proj 3456: Full Spectrum Undersea Warfare

A. Mission Description and Budget Item Justification

The efforts described in this Project address the Applied Research associated with the INP Program. These investments define the future of U.S. naval forces. Due to high technical risk, INPs typically have long duration but have no more than three years between decision points. They mature technologies from a Technology Readiness Level (TRL) of 2 or 3 to a TRL of 6. As such, INPs require both Budget Activity (BA) 2 and BA3 funding. The BA3 INP funds are specified in a separate PE, 0603801N Innovative Naval Prototypes Advanced Technology Development. INPs do not develop hardware for service use; rather they provide feeder technology that can be demonstrated in prototypes in the 6.3 portion of the INP program. Developing INPs requires a systematic expansion and application of knowledge to develop useful materials, devices, and systems oriented toward the design and development of prototypes applicable to specific mission area requirements. The efforts funded within this Project translate promising basic research into solutions for broadly defined military needs. These efforts include developing breadboard hardware and algorithms that establish the initial feasibility and practicality of proposed solutions to technological challenges, such as concept exploration efforts, studies, investigations, and non-system specific technology efforts. The Department of the Navy would have to make significant acquisition decisions to integrate the new technological capabilities into naval warfighting systems. INPs are selected by a process that involves senior leadership in the Department of the Navy.

Information security concerns preclude fully detailed descriptions of project efforts, research activities, and technology development plans. Specific information on each project and activity will be provided separately to the Congressional oversight committees.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602792N / Innovative Naval Prototypes (INP) Applied Res	Project (Number/Name) 0000 / Innovative Naval Prototypes (INP) Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Cyber		23.135	0.000	0.000	0.000	0.000
FY 2020 Plans: N/A						
FY 2021 Base Plans: N/A						
FY 2021 OCO Plans: N/A						
Title: Directed Energy / Electric Weapons		44.779	29.531	2.485	0.000	2.485
Description: The FY 2020 Appropriation Act encouraged the Navy to realign Innovative Naval Prototypes (INP) Program research and development efforts into individual projects in order to provide additional clarity and enhanced oversight of INP resources. From this Activity in Project Unit 0000, Program Element (PE) 0602792N Innovative Naval Prototypes (INP) Applied Res, INP funding was moved to new stand-alone projects as indicated below starting in FY 2021.						
- Proj 3416: HIJENKS						
- Proj 3453: Hypersonic Booster						
FY 2020 Plans: Conduct development efforts for a radio frequency effects payload (a joint USAF/USN project) with scalable electromagnetic effects. Conduct the Applied Research supporting initial lab and integration testing.						
Conduct research to develop a hypersonic cruise missile that is affordable and effective to mature critical technologies.						
FY 2021 Base Plans: Continue operational analysis and support to inform INP investment decisions in this activity by identifying technologies that will provide scalable lethality through enabling multi-domain, integrated, scalable kinetic and non-kinetic systems for offensive or defensive purposes.						
FY 2021 OCO Plans:						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602792N / Innovative Naval Prototypes (INP) Applied Res	Project (Number/Name) 0000 / Innovative Naval Prototypes (INP) Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
N/A						
FY 2020 to FY 2021 Increase/Decrease Statement:						
The decrease in FY 2021 is due to the realignment of the Hypersonic Booster and HIJENKS INP efforts from this Activity in Project Unit 0000, Program Element (PE) 0602792N Innovative Naval Prototypes (INP) Applied Res, to new stand-alone Project Units as follows:						
<ul style="list-style-type: none"> - Proj 3416: HIJENKS - Proj 3453: Hypersonic Booster 						
Title: Electromagnetic Maneuver Warfare		10.872	7.056	0.000	0.000	0.000
<p>Description: This R-2 Activity contains all Applied Research Innovative Naval Prototype (INP) investments that are developing new technologies for Electromagnetic Maneuver Warfare (EMW). The electromagnetic spectrum is a key operational maneuver space enabled by continuous, real-time awareness of all spectrum activity. This R-2 Activity supports spectrum dominance, which included efforts that focus on communications, surveillance, EMW and electronics to understand and shape the battle space. The ability to assure access to the full spectrum is essential for battle space awareness and threat surveillance/weapon sensor engagement. Technologies within this activity will provide for integrated and distributed forces capable of dynamic synchronized actions through interoperable forces by incorporation of autonomous/ disaggregated systems to increase flexibility and reach within the electromagnetic spectrum.</p>						
FY 2020 Plans:						
Develop efforts to enable a strike group to work cooperatively in the electromagnetic spectrum by optimizing electronic warfare, information operations, communications and radar performance. Conduct the Applied Research associated with the final design for a Low-band Radio Frequency Intelligent Distribution Resource (LowRIDR) for the EMC2 prototype.						
FY 2021 Base Plans:						
N/A						
FY 2021 OCO Plans:						
N/A						
FY 2020 to FY 2021 Increase/Decrease Statement:						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602792N / Innovative Naval Prototypes (INP) Applied Res	Project (Number/Name) 0000 / Innovative Naval Prototypes (INP) Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Applied Research Innovative Naval Prototype (INP) technologies being developed under this R-2 Activity completed in FY 2020 and will be leveraged starting in FY 2021 under the Advanced Long Range Targeting (ALRT) Activity within this Program Element (PE) 0602792N Innovative Naval Prototypes (INP) Applied Res.						
<p>Title: Undersea Warfare</p> <p>Description: The FY 2020 Appropriation Act encouraged the Navy to realign Innovative Naval Prototypes (INP) Program research and development efforts into individual projects in order to provide additional clarity and enhanced oversight of INP resources. From this Activity in Project Unit 0000, Program Element (PE) 0602792N Innovative Naval Prototypes (INP) Applied Res, INP funding was moved to new stand-alone projects as indicated below starting in FY 2021.</p> <ul style="list-style-type: none"> - Proj 3450: AMOS - Proj 3456: Full Spectrum Undersea Warfare <p>FY 2020 Plans: Conduct applied research associated with the development of an Arctic Mobile Observing System (AMOS), a prototype mobile sensing system incorporating Arctic-capable unmanned underwater vehicles that can be deployed anywhere in the Arctic using a central, ice-based buoy node to provide the critical infrastructure (power, communication, navigation, and environmental intelligence). AMOS will provide the Navy with a persistent Arctic presence and environmental Arctic domain awareness at a lower cost and less risk than manned platforms. The combination of Unmanned Underwater Vehicle (UUV) assets included in an AMOS node will determine the range, sensing capability and persistence of each node, and can be chosen based on need and Arctic location. Work under this effort will involve understanding the trade-offs and capabilities for the prototype system.</p> <p>Affordable Mobile ASW Surveillance System (AMASS): Complete Applied Research efforts to verify performance of components to enable next generation Anti-Submarine Warfare (ASW) capability.</p> <p>FY 2021 Base Plans: N/A</p> <p>FY 2021 OCO Plans:</p>		13.602	14.046	0.000	0.000	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020
Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)			
	PE 0602792N / Innovative Naval Prototypes (INP) Applied Res	0000 / Innovative Naval Prototypes (INP) Applied Res			
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO
N/A					
FY 2020 to FY 2021 Increase/Decrease Statement: The decrease in FY 2021 is due to the realignment of the AMOS and Full Spectrum Undersea Warfare INP efforts from this Activity in Project Unit 0000, Program Element (PE) 0602792N Innovative Naval Prototypes (INP) Applied Res, to new stand-alone Project Units as follows: - Proj 3450: AMOS - Proj 3456: Full Spectrum Undersea Warfare					
Title: Unmanned and Autonomous Systems Description: The FY 2020 Appropriation Act encouraged the Navy to realign Innovative Naval Prototypes (INP) Program research and development efforts into individual projects in order to provide additional clarity and enhanced oversight of INP resources. From this Activity in Project Unit 0000, Program Element (PE) 0602792N Innovative Naval Prototypes (INP) Applied Res, INP funding was moved to new stand-alone projects as indicated below starting in FY 2021. - Proj 3451: CLAWS - Proj 3423: LOCUST - Proj 3454: MDUSV					58.788 48.925 0.000 0.000 0.000
FY 2020 Plans: Conduct development of autonomous payloads for extra-large unmanned undersea vehicles. Conduct development of technologies that continue to support development of a scalable system of inexpensive Unmanned Aerial Vehicles (UAVs) in order to provide a disruptive capability in contested urban environments and against anti-access area denial defenses. Conduct development of technologies that will enable a self-deploying, highly autonomous, multi-mission/multi-payload Unmanned Surface Vehicle (USV) capable of operating with carrier strike groups and surface action groups at a very low operating cost.					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602792N / Innovative Naval Prototypes (INP) Applied Res	Project (Number/Name) 0000 / Innovative Naval Prototypes (INP) Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Conduct development of an autonomous control system for multiple Unmanned Surface Vehicle (USVs) consisting of cooperative task allocation, cooperative route planning/behaviors, and shared situational awareness.						
FY 2021 Base Plans: N/A						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The decrease in FY 2021 is due to the realignment of the CLAWS, LOCUST and MDUSV INP efforts from this Activity in Project Unit 0000, Program Element (PE) 0602792N Innovative Naval Prototypes (INP) Applied Res, to new stand-alone Project Units as follows: - Proj 3451: CLAWS - Proj 3423: LOCUST - Proj 3454: MDUSV						
Title: Artificial Intelligence Description: The FY 2020 Appropriation Act encouraged the Navy to realign Innovative Naval Prototypes (INP) Program research and development efforts into individual projects in order to provide additional clarity and enhanced oversight of INP resources. From this Activity in Project Unit 0000, Program Element (PE) 0602792N Innovative Naval Prototypes (INP) Applied Res, INP funding was moved to new stand-alone projects as indicated below starting in FY 2021. - Proj 3452: ELEKTRA - Proj 3455: MINERVA		0.000	11.895	0.000	0.000	0.000
FY 2020 Plans: Align Applied Research associated with the development of a prototype multi-domain integrated fires control capability enabled by Artificial Intelligence (AI) allowing for real-time, force-wide electromagnetic maneuver and soft-kill and hard-kill battle management. Thrust areas being explored include distributed combat data systems, AI battle management tools, and embedded machine learning.						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602792N / Innovative Naval Prototypes (INP) Applied Res	Project (Number/Name) 0000 / Innovative Naval Prototypes (INP) Applied Res				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Align Applied Research supporting the goal of demonstrating machine speed battle management tools to support continuous analysis and planning at the operational and tactical levels and dynamically synchronizing forces across intelligence, surveillance and reconnaissance, Command and Control and combat systems. Thrust areas being explored include distributed combat data systems, adaptive data analytics and a course of action and intentions assessment AI application.						
FY 2021 Base Plans: N/A						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The decrease in FY 2021 is due to the realignment of the ELEKTRA and MINERVA INP efforts from this Activity in Project Unit 0000, Program Element (PE) 0602792N Innovative Naval Prototypes (INP) Applied Res, to new stand-alone Project Units as follows: - Proj 3452: ELEKTRA - Proj 3455: MINERVA						
Accomplishments/Planned Programs Subtotals		151.176	111.453	2.485	0.000	2.485
C. Other Program Funding Summary (\$ in Millions)						
N/A						
Remarks						
D. Acquisition Strategy						
N/A						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020	
Appropriation/Budget Activity					R-1 Program Element (Number/Name)				Project (Number/Name)			
1319 / 2					PE 0602792N / Innovative Naval Prototypes (INP) Applied Res				2481 / EMRG			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
2481: EMRG	0.000	0.000	7.632	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	7.632

Note

Beginning in FY 2020, the Applied Research Electro-Magnetic Railgun (EMRG) high-power, kinetic energy weapon prototype development effort was realigned from Project Unit 0000 to Project Unit 2481 within Program Element (PE) 0602792N Innovative Naval Prototypes (INP) Applied Res.

A. Mission Description and Budget Item Justification

Electro-Magnetic Railgun (EMRG) is a high-power, kinetic energy weapon capable of launching precision guided projectiles using electricity instead of chemical propellants. When released into the railgun, an electric pulse launches the projectile at speeds up to Mach 6. EMRG will bring new capabilities, increased capacity and improved operational economy to fleet operations at sea. With its increased velocity and extended range, the EM Railgun provides multi-mission potential for hypersonic missile defense, anti-air & surface warfare, and naval surface fire support. EMRG is a multi-year effort in various stages of research and development within the Navy's Innovative Naval Prototypes (INP) family of RDT&E programs. The Activity identified in Project Unit 2481 specifically addresses Applied Research in support of the Electro-Magnetic Railgun (EMRG) high-power, kinetic energy weapon prototype development INP effort.

The efforts described in this Project address the Applied Research associated with the Innovative Naval Prototypes (INP) Program. These investments represent game changing technologies with the potential to revolutionize operational concepts. They are disruptive in nature, as they would dramatically change the way naval forces fight. Due to high technical risk, INPs typically have long duration but have no more than three years between decision points. They mature technologies from a Technology Readiness Level (TRL) of 2 or 3 to a TRL of 6. As such, INPs require both Budget Activity (BA) 2 and BA3 funding. The BA3 INP funds are specified in a separate Program Element (PE), 0603801N Innovative Naval Prototypes (INP) Adv Tec Dev. INPs do not develop hardware for service use; rather they provide feeder technology that can be demonstrated in prototypes in the 6.3 portion of the INP program. Developing INPs requires a systematic expansion and application of knowledge to develop useful materials, devices, and systems oriented toward the design and development of prototypes applicable to specific mission area requirements. The efforts funded within this PE translate promising basic research into solutions for broadly defined military needs. These efforts include developing breadboard hardware and algorithms that establish the initial feasibility and practicality of proposed solutions to technological challenges, such as concept exploration efforts, studies, investigations, and non-system specific technology efforts. The Department of the Navy would have to make significant acquisition decisions to integrate the new technological capabilities into naval warfighting systems. INPs are selected by a process that involves senior leadership in the Department of the Navy.

Information security concerns preclude fully detailed descriptions of project efforts, research activities, and technology development plans. Specific information on each project and activity will be provided separately to the Congressional oversight committees.

B. Accomplishments/Planned Programs (\$ in Millions)

Title: Electro-Magnetic Railgun (EMRG)

FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
0.000	7.632	0.000	0.000	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Description: Electro-Magnetic Railgun (EMRG) is a high-power, kinetic energy weapon capable of launching precision guided projectiles using electricity instead of chemical propellants. When released into the railgun, an electric pulse launches the projectile at speeds up to Mach 6. EMRG will bring new capabilities, increased capacity and improved operational economy to fleet operations at sea. With its increased velocity and extended range, the EM Railgun provides multi-mission potential for hypersonic missile defense, anti-air & surface warfare, and naval surface fire support.						
FY 2020 Plans: Conduct applied research addressing the unique technical challenges inherent in the construction, assembly and operation of an Electro-Magnetic (EM) Railgun prototype capable of launching long range projectiles at a tactically relevant muzzle energy and repetition rate. Special materials and compact sub-system components will be developed that are capable of operating in harsh thermal and electromagnetic environments. Advanced modeling tools will be utilized to assess design options, analyze system concepts, and inform experimental hardware design and testing. Develop and test next generation pulsed power components to assess performance and applicability towards future shipboard designs. Develop and refine algorithms for controlling the precision timed electromagnetic pulse used to fire the railgun in the rep-rate mode. Conduct material, physics and thermal property research for long life, rep-rate electromagnetic launch systems and actively monitor performance to understand the high currents, elevated operating temperatures, and cooling of components, so as to improve designs and increase their reliability. Utilize modeling and simulation tools that support simulated operational scenarios to quantify the value of HVP fired from a Railgun.						
FY 2021 Base Plans: N/A						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The funding decrease from FY 2020 to FY 2021 is due to the completion of Applied Research development efforts under this Activity.						
Accomplishments/Planned Programs Subtotals		0.000	7.632	0.000	0.000	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020
Appropriation/Budget Activity 1319 / 2				R-1 Program Element (Number/Name) PE 0602792N / Innovative Naval Prototypes (INP) Applied Res				Project (Number/Name) 2481 / EMRG			
C. Other Program Funding Summary (\$ in Millions)											
<u>Line Item</u>	<u>FY 2019</u>	<u>FY 2020</u>	<u>FY 2021</u>	<u>FY 2021</u>	<u>FY 2021</u>	<u>FY 2022</u>	<u>FY 2023</u>	<u>FY 2024</u>	<u>FY 2025</u>	<u>Cost To Complete</u>	<u>Total Cost</u>
• RDTEN/0603801N/2481: <i>EMRG</i>	0.000	7.368	9.500	-	9.500	0.000	0.000	0.000	0.000	0.000	16.868
• RDTEN/0603801N/3400: <i>Innovative Naval Prototypes (INP) Adv Tech Dev</i>	156.512	91.137	0.000	-	0.000	8.501	10.482	49.760	50.756	Continuing	Continuing

Remarks**D. Acquisition Strategy**

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020	
Appropriation/Budget Activity 1319 / 2					R-1 Program Element (Number/Name) PE 0602792N / Innovative Naval Prototypes (INP) Applied Res				Project (Number/Name) 2958 / Cyberspace Activities			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
2958: Cyberspace Activities	0.000	0.000	27.269	28.511	-	28.511	26.061	0.000	0.000	0.000	0.000	81.841

Note

The FY 2017 Appropriation Act directed the services to realign Cyberspace Activity (CA) resources into individual cost codes, projects or Program Elements (PEs) in order to provide additional clarity and enhanced oversight of cyberspace pure resources. Within this PE, cyber funding was moved from Proj 0000 Innovative Naval Prototypes (INP) Applied Research to Proj 2958 Cyberspace Activities, which was established to isolate and identify cyberspace activities.

A. Mission Description and Budget Item Justification

This Project contains all Applied Research Innovative Naval Prototype (INP) investments that are developing new technologies for cyber warfare. Potential adversaries are investing in advanced technologies that will challenge our advantages in the critical information domain. Nation states and non-state actors seek to degrade our command and control capabilities, networks and computer systems. Cyber threats continue to grow and rapidly proliferate. Technologies developed in this R-2 Activity will enable the warfighter to take immediate, appropriate action at any time, against any desired adversary, target or network by assuring that autonomous, continuous analyses of intelligence, persistent surveillance and open information sources have, at all times, optimized the possible courses of action based on commander's guidance. Technologies within this activity will foster operational endurance and enable sustained operations and resiliency for warfighters and platforms through enhanced cyber security/protection.

The efforts described in this Project address the Applied Research associated with the Innovative Naval Prototypes (INP) Program. These investments represent game changing technologies with the potential to revolutionize operational concepts. They are disruptive in nature, as they would dramatically change the way naval forces fight. Due to high technical risk, INPs typically have long duration but have no more than three years between decision points. They mature technologies from a Technology Readiness Level (TRL) of 2 or 3 to a TRL of 6. As such, INPs require both Budget Activity (BA) 2 and BA3 funding. The BA3 INP funds are specified in a separate Program Element (PE), 0603801N Innovative Naval Prototypes (INP) Adv Tec Dev. INPs do not develop hardware for service use; rather they provide feeder technology that can be demonstrated in prototypes in the 6.3 portion of the INP program. Developing INPs requires a systematic expansion and application of knowledge to develop useful materials, devices, and systems oriented toward the design and development of prototypes applicable to specific mission area requirements. The efforts funded within this PE translate promising basic research into solutions for broadly defined military needs. These efforts include developing breadboard hardware and algorithms that establish the initial feasibility and practicality of proposed solutions to technological challenges, such as concept exploration efforts, studies, investigations, and non-system specific technology efforts. The Department of the Navy would have to make significant acquisition decisions to integrate the new technological capabilities into naval warfighting systems. INPs are selected by a process that involves senior leadership in the Department of the Navy.

Information security concerns preclude fully detailed descriptions of project efforts, research activities, and technology development plans. Specific information on each project and activity will be provided separately to the Congressional oversight committees.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602792N / Innovative Naval Prototypes (INP) Applied Res	Project (Number/Name) 2958 / Cyberspace Activities				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Cyber		0.000	27.269	28.511	0.000	28.511
FY 2020 Plans: Conduct Applied Research addressing the unique technical challenges required to achieve a systematic reduction of any computing system's attack surface across all its layers of computing. Continue development of tools and techniques enabling powerful tailoring of an end-system computing environment to match the needs of deployed applications and users, removing software bloat and unused features, resulting in significantly reduced attack surface for both known and unknown vulnerabilities. Specific information on each project will be provided separately to the Congressional oversight committees.						
FY 2021 Base Plans: Continue Applied Research addressing the unique technical challenges required to achieve a systematic reduction of any computing system's attack surface across all its layers of computing. Continue development of tools and techniques enabling powerful tailoring of an end-system computing environment to match the needs of deployed applications and users, removing software bloat and unused features. Develop novel technology for automatically specializing communication protocol features to better match the needs of Naval applications. Deployment of this technology results in a minimal and reshaped cyber attack surface.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The funding increase from FY 2020 to FY 2021 is due to the ramp-up of Applied Research development efforts in the Total Platform Cyber Protection (TPCP) INP effort under this Activity.						
Accomplishments/Planned Programs Subtotals		0.000	27.269	28.511	0.000	28.511
C. Other Program Funding Summary (\$ in Millions)						
N/A						
Remarks						
D. Acquisition Strategy						
N/A						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020	
Appropriation/Budget Activity 1319 / 2					R-1 Program Element (Number/Name) PE 0602792N / Innovative Naval Prototypes (INP) Applied Res				Project (Number/Name) 3416 / HIJENKS			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
3416: HIJENKS	0.000	0.000	0.000	22.320	-	22.320	9.943	0.000	0.000	0.000	0.000	32.263

Note

High-power Joint Electromagnetic Non-Kinetic Strike (HIJENKS) plans and associated resources are realigned from Project Unit 0000 in Program Element (PE) 0602792N Innovative Naval Prototypes (INP) Applied Res into this new Project Unit 3416 effective FY 2021. This is not a new start.

A. Mission Description and Budget Item Justification

HIJENKS is a non-kinetic High Power Microwave (HPM) payload integrated on an airborne platform will enable the prosecution of multiple targets with area coverage across each target and open targets previously restricted due to collateral damage. HIJENKS increases operational access by disrupting land-based infrastructure facilities tied to adversary systems, decreases cost exchange ratios through non-kinetic engagement, and addresses targets previously restricted due to collateral damage concerns/moral hardening. It expands the competitive space in the electromagnetic spectrum to disrupt, degrade, and destroy critical electronic targets. The Activity identified in Project Unit 3416 specifically addresses Applied Research in support of the HIJENKS INP effort.

The efforts described in this Project address the Applied Research associated with the Innovative Naval Prototypes (INP) Program. These investments represent game changing technologies with the potential to revolutionize operational concepts. They are disruptive in nature, as they would dramatically change the way naval forces fight. Due to high technical risk, INPs typically have long duration but have no more than three years between decision points. They mature technologies from a Technology Readiness Level (TRL) of 2 or 3 to a TRL of 6. As such, INPs require both Budget Activity (BA) 2 and BA3 funding. The BA3 INP funds are specified in a separate Program Element (PE), 0603801N Innovative Naval Prototypes (INP) Adv Tec Dev. INPs do not develop hardware for service use; rather they provide feeder technology that can be demonstrated in prototypes in the 6.3 portion of the INP program. Developing INPs requires a systematic expansion and application of knowledge to develop useful materials, devices, and systems oriented toward the design and development of prototypes applicable to specific mission area requirements. The efforts funded within this PE translate promising basic research into solutions for broadly defined military needs. These efforts include developing breadboard hardware and algorithms that establish the initial feasibility and practicality of proposed solutions to technological challenges, such as concept exploration efforts, studies, investigations, and non-system specific technology efforts. The Department of the Navy would have to make significant acquisition decisions to integrate the new technological capabilities into naval warfighting systems. INPs are selected by a process that involves senior leadership in the Department of the Navy.

Information security concerns preclude fully detailed descriptions of project efforts, research activities, and technology development plans. Specific information on each project and activity will be provided separately to the Congressional oversight committees.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: HIJENKS	0.000	0.000	22.320	0.000	22.320

Description: HIJENKS is a non-kinetic High Power Microwave (HPM) payload integrated on an airborne platform will enable the prosecution of multiple targets with area coverage across each target and open targets

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy										Date: February 2020		
Appropriation/Budget Activity 1319 / 2			R-1 Program Element (Number/Name) PE 0602792N / Innovative Naval Prototypes (INP) Applied Res					Project (Number/Name) 3416 / HIJENKS				
B. Accomplishments/Planned Programs (\$ in Millions)												
FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total								
previously restricted due to collateral damage. HIJENKS increases operational access by disrupting land-based infrastructure facilities tied to adversary systems, decreases cost exchange ratios through non-kinetic engagement, and addresses targets previously restricted due to collateral damage concerns/moral hardening. It expands the competitive space in the electromagnetic spectrum to disrupt, degrade, and destroy critical electronic targets.												
FY 2020 Plans: N/A												
FY 2021 Base Plans: Continue applied research to enable Joint USAF/USN project development of a compact, multi-pulse High Powered Microwave (HPM) payload through focused Science and Technology (S&T) advancements in prime power, power conditioning, Radio Frequency (RF) sources and antennas, as well as lethality for targets of interest with improved Bomb Damage Assessment (BDA) and weaponeering capabilities. Focus on lethality testing and characterization as well as payload development and build activities.												
FY 2021 OCO Plans: N/A												
FY 2020 to FY 2021 Increase/Decrease Statement: The increase in FY 2021 is due to the realignment of the High-power Joint Electromagnetic Non-Kinetic Strike (HIJENKS) effort from Project Unit 0000 in this Program Element (PE) 0602792N Innovative Naval Prototypes (INP) Applied Res into this new Project Unit 3416.												
Accomplishments/Planned Programs Subtotals								0.000	0.000	22.320	0.000	22.320
C. Other Program Funding Summary (\$ in Millions)												
Line Item	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
• RDTEN/0603382N/3416: HIJENKS	0.000	0.000	14.981	-	14.981	16.945	24.690	0.000	0.000	0.000	56.616	
• RDTEN/0603801N/3416: HIJENKS	0.000	0.000	14.465	-	14.465	7.656	0.000	0.000	0.000	0.000	22.121	
Remarks												

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy	Date: February 2020	
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602792N / <i>Innovative Naval Prototypes (INP) Applied Res</i>	Project (Number/Name) 3416 / HIJENKS
D. Acquisition Strategy N/A		

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020	
Appropriation/Budget Activity					R-1 Program Element (Number/Name)				Project (Number/Name)			
1319 / 2					PE 0602792N / Innovative Naval Prototypes (INP) Applied Res				3423 / LOCUST			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
3423: LOCUST	0.000	0.000	0.000	22.046	-	22.046	5.553	0.000	0.000	0.000	0.000	27.599

Note

Low-Cost UAV Swarming Technology (LOCUST) plans and associated resources are realigned from Project Unit 0000 in this Program Element (PE) 0602792N Innovative Naval Prototypes (INP) Applied Res into this new Project Unit 3423 effective FY 2021. This is not a new start.

A. Mission Description and Budget Item Justification

Adversary military modernization and increasing contested domains require a shift in approach "...to strike diverse targets inside adversary air and missile defense networks to destroy mobile power-projection platforms. This will include capabilities to enhance close combat lethality in complex terrain." The Low-Cost UAV Swarming Technology (LOCUST) effort will develop and deliver autonomy, C2 architecture, and a series of modular payloads on a robust, scalable, flexible, multifunctional UAV system; employable from surface, sub-surface, airborne, and ground manned and un-manned systems to provide a dispersed, resilient, and adaptive capability to gain a competitive military advantage. LOCUST will provide ISR and precision loitering munitions capable of being launched from air, surface, ground, and sub-surface platforms to conduct both singular and swarm operations across battlespace in conjunction with Joint and manned operations. It will demonstrate multi-domain launch and strike operations, heterogeneous air platform payloads, unmanned from unmanned operations, distributed control of the strike mission, and refined cost elements for critical technologies that have supply chain assurance addressed. The Activity identified in Project Unit 3423 specifically addresses Applied Research in support of the LOCUST INP effort.

The efforts described in this Project address the Applied Research associated with the Innovative Naval Prototypes (INP) Program. These investments represent game changing technologies with the potential to revolutionize operational concepts. They are disruptive in nature, as they would dramatically change the way naval forces fight. Due to high technical risk, INPs typically have long duration but have no more than three years between decision points. They mature technologies from a Technology Readiness Level (TRL) of 2 or 3 to a TRL of 6. As such, INPs require both Budget Activity (BA) 2 and BA3 funding. The BA3 INP funds are specified in a separate Program Element (PE), 0603801N Innovative Naval Prototypes (INP) Adv Tec Dev. INPs do not develop hardware for service use; rather they provide feeder technology that can be demonstrated in prototypes in the 6.3 portion of the INP program. Developing INPs requires a systematic expansion and application of knowledge to develop useful materials, devices, and systems oriented toward the design and development of prototypes applicable to specific mission area requirements. The efforts funded within this PE translate promising basic research into solutions for broadly defined military needs. These efforts include developing breadboard hardware and algorithms that establish the initial feasibility and practicality of proposed solutions to technological challenges, such as concept exploration efforts, studies, investigations, and non-system specific technology efforts. The Department of the Navy would have to make significant acquisition decisions to integrate the new technological capabilities into naval warfighting systems. INPs are selected by a process that involves senior leadership in the Department of the Navy.

Information security concerns preclude fully detailed descriptions of project efforts, research activities, and technology development plans. Specific information on each project and activity will be provided separately to the Congressional oversight committees.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)				
1319 / 2	PE 0602792N / Innovative Naval Prototypes (INP) Applied Res	3423 / LOCUST				
<u>B. Accomplishments/Planned Programs (\$ in Millions)</u>						
Title:	LOCUST	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Description:	Adversary military modernization and increasing contested domains require a shift in approach "...to strike diverse targets inside adversary air and missile defense networks to destroy mobile power-projection platforms. This will include capabilities to enhance close combat lethality in complex terrain." The Low-Cost UAV Swarming Technology (LOCUST) effort will develop and deliver autonomy, C2 architecture, and a series of modular payloads on a robust, scalable, flexible, multifunctional UAV system; employable from surface, sub-surface, airborne, and ground manned and un-manned systems to provide a dispersed, resilient, and adaptive capability to gain a competitive military advantage. LOCUST will provide ISR and precision loitering munitions capable of being launched from air, surface, ground, and sub-surface platforms to conduct both singular and swarm operations across battlespace in conjunction with Joint and manned operations. It will demonstrate multi-domain launch and strike operations, heterogeneous air platform payloads, unmanned from unmanned operations, distributed control of the strike mission, and refined cost elements for critical technologies that have supply chain assurance addressed.	0.000	0.000	22.046	0.000	22.046
FY 2020 Plans:	N/A					
FY 2021 Base Plans:	Conduct applied research of technologies that support Collaborative, Coordinated, & Cognitive Autonomy (C3A) and large-scale Command and Control (C2) of unmanned swarm air vehicle systems engaging in complex behaviors in degraded environments. In order to further the goals of the C3A research area, the LOCUST program will continue development of autonomy algorithms (such as multi-agent multi-objective optimization, auction processes, and consensus-based particle filters) that optimize the dynamic resources allocation and navigation and implies the determination of how to pose UAVs, task them with missions of fine granularity, and plan their future poses. In the area of C2, LOCUST will continue development of the nominal architecture needed for swarm control (a flying ad-hoc network or FANET) that is subject to dynamic channel adjustment as well as quickly-changing scattering, fading, and multipath effect.					
FY 2021 OCO Plans:	N/A					
FY 2020 to FY 2021 Increase/Decrease Statement:						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy										Date: February 2020					
Appropriation/Budget Activity 1319 / 2			R-1 Program Element (Number/Name) PE 0602792N / Innovative Naval Prototypes (INP) Applied Res					Project (Number/Name) 3423 / LOCUST							
B. Accomplishments/Planned Programs (\$ in Millions)										FY 2019 FY 2020 FY 2021 Base FY 2021 OCO FY 2021 Total					
The increase in FY 2021 is due to the realignment of the Low-Cost UAV Swarming Technology (LOCUST) effort from Project Unit 0000 in this Program Element (PE) 0602792N Innovative Naval Prototypes (INP) Applied Res into this new Project Unit 3423.															
Accomplishments/Planned Programs Subtotals										0.000 0.000 22.046 0.000 22.046					
C. Other Program Funding Summary (\$ in Millions)															
Line Item	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost				
• RDTEN/0603801N/3423: LOCUST	0.000	0.000	12.750	-	12.750	3.396	0.000	0.000	0.000	0.000	16.146				
• RDTEN/0603382N/3423: LOCUST	1.879	2.960	3.561	-	3.561	6.425	5.949	0.000	0.000	0.000	20.787				
Remarks															
D. Acquisition Strategy															
N/A															

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity					R-1 Program Element (Number/Name)				Project (Number/Name)				
1319 / 2					PE 0602792N / Innovative Naval Prototypes (INP) Applied Res				3450 / AMOS				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
3450: AMOS	0.000	0.000	0.000	8.401	-	8.401	6.463	8.404	0.000	0.000	0.000	23.268	

Note

Arctic Mobile Observing System (AMOS) plans and associated resources are realigned from Project Unit 0000 in Program Element (PE) 0602792N Innovative Naval Prototypes (INP) Applied Res into this new Project Unit 3450 effective FY 2021. This is not a new start.

A. Mission Description and Budget Item Justification

The Arctic Mobile Observing System (AMOS) effort will develop a prototype mobile sensing system that can be deployed anywhere in the Arctic via the development of a sea ice-based buoy node that will enable the critical infrastructure (power, communication, environmental intelligence) to provide the Navy with a persistent Arctic presence at lower cost than manned platforms. AMOS is a mobile observing system of systems node that enables 2-way communications, under-ice vehicle navigation, and extended-duration autonomy in the complex Arctic environment. AMOS will provide a persistent, mobile, autonomous capability to monitor the operational environment and maritime operations of potential adversaries in the Arctic Ocean. The Activity identified in Project Unit 3450 specifically addresses Applied Research in support of the AMOS INP effort.

The efforts described in this Project address the Applied Research associated with the Innovative Naval Prototypes (INP) Program. These investments represent game changing technologies with the potential to revolutionize operational concepts. They are disruptive in nature, as they would dramatically change the way naval forces fight. Due to high technical risk, INPs typically have long duration but have no more than three years between decision points. They mature technologies from a Technology Readiness Level (TRL) of 2 or 3 to a TRL of 6. As such, INPs require both Budget Activity (BA) 2 and BA3 funding. The BA3 INP funds are specified in a separate Program Element (PE), 0603801N Innovative Naval Prototypes (INP) Adv Tec Dev. INPs do not develop hardware for service use; rather they provide feeder technology that can be demonstrated in prototypes in the 6.3 portion of the INP program. Developing INPs requires a systematic expansion and application of knowledge to develop useful materials, devices, and systems oriented toward the design and development of prototypes applicable to specific mission area requirements. The efforts funded within this PE translate promising basic research into solutions for broadly defined military needs. These efforts include developing breadboard hardware and algorithms that establish the initial feasibility and practicality of proposed solutions to technological challenges, such as concept exploration efforts, studies, investigations, and non-system specific technology efforts. The Department of the Navy would have to make significant acquisition decisions to integrate the new technological capabilities into naval warfighting systems. INPs are selected by a process that involves senior leadership in the Department of the Navy.

Information security concerns preclude fully detailed descriptions of project efforts, research activities, and technology development plans. Specific information on each project and activity will be provided separately to the Congressional oversight committees.

B. Accomplishments/Planned Programs (\$ in Millions)

Title: AMOS

FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
0.000	0.000	8.401	0.000	8.401

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602792N / Innovative Naval Prototypes (INP) Applied Res	Project (Number/Name) 3450 / AMOS				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Description: The Arctic Mobile Observing System (AMOS) effort will develop a prototype mobile sensing system that can be deployed anywhere in the Arctic via the development of a sea ice-based buoy node that will enable the critical infrastructure (power, communication, environmental intelligence) to provide the Navy with a persistent Arctic presence at lower cost than manned platforms. AMOS is a mobile observing system of systems node that enables 2-way communications, under-ice vehicle navigation, and extended-duration autonomy in the complex Arctic environment. AMOS will provide a persistent, mobile, autonomous capability to monitor the operational environment and maritime operations of potential adversaries in the Arctic Ocean.						
FY 2020 Plans: N/A						
FY 2021 Base Plans: Continue applied research in support of the development of the Arctic Mobile Observing System (AMOS). Specific efforts include the following: - Conducting at-sea experimentation to understand limits of two-way communications between AMOS platforms under sea ice in the Arctic maritime environment. - Evaluating the feasibility of Unmanned Underwater Vehicle (UUV) docking and recharge capabilities in the Arctic domain. - Improving the reliability of candidate AMOS nodes, platforms, and sensors for extended duration deployment in Arctic conditions. - Assessing designs of under-ice acoustic navigation systems using results from prior at-sea experiments. These technologies are a critical component of achieving persistence, and thus feasibility, by unmanned systems operating in harsh environments like the Arctic.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The increase in FY 2021 is due to the realignment of the Arctic Mobile Observing System (AMOS) effort from Project Unit 0000 in this Program Element (PE) 0602792N Innovative Naval Prototypes (INP) Applied Res into this new Project Unit 3450.						
Accomplishments/Planned Programs Subtotals		0.000	0.000	8.401	0.000	8.401

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy										Date: February 2020		
Appropriation/Budget Activity			R-1 Program Element (Number/Name)				Project (Number/Name)					
1319 / 2			PE 0602792N / Innovative Naval Prototypes (INP) Applied Res				3450 / AMOS					
C. Other Program Funding Summary (\$ in Millions)												
Line Item	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
• RDTEN/0603801N/3450: AMOS	0.000	0.000	4.524	-	4.524	3.480	4.525	0.000	0.000	0.000	12.529	
Remarks												
D. Acquisition Strategy												
N/A												

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity					R-1 Program Element (Number/Name)				Project (Number/Name)				
1319 / 2					PE 0602792N / Innovative Naval Prototypes (INP) Applied Res				3451 / CLAWS				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
3451: CLAWS	0.000	0.000	0.000	26.456	-	26.456	23.445	0.000	0.000	0.000	0.000	49.901	

Note

CLAWS plans and associated resources are realigned from Project Unit 0000 in Program Element (PE) 0602792N Innovative Naval Prototypes (INP) Applied Res into this new Project Unit 3451 effective FY 2021. This is not a new start.

A. Mission Description and Budget Item Justification

The CLAWS INP effort will develop an autonomous unmanned undersea weapon system capable of providing offensive effects to the Combatant Commanders beyond Phase 0 inside the first island chain. It will clandestinely extend the reach of large UUVs and increase the mission areas into kinetic effects. CLAWS will deliver algorithms to enable all families of UUVs to operate in complex, dynamic and degraded environments. CLAWS will demonstrate autonomous missions in denied waters, develop and demonstrate autonomous technologies for survivability of large UUVs, and develop autonomy and launch capabilities for special mission payloads. CLAWS will be able to complete missions 1&2 against near peer adversary defenses, maintain critical communication with Navy C2/Fires and provide critical ISR information. The Activity identified in Project Unit 3451 specifically addresses Applied Research in support of the CLAWS INP effort.

The efforts described in this Project address the Applied Research associated with the Innovative Naval Prototypes (INP) Program. These investments represent game changing technologies with the potential to revolutionize operational concepts. They are disruptive in nature, as they would dramatically change the way naval forces fight. Due to high technical risk, INPs typically have long duration but have no more than three years between decision points. They mature technologies from a Technology Readiness Level (TRL) of 2 or 3 to a TRL of 6. As such, INPs require both Budget Activity (BA) 2 and BA3 funding. The BA3 INP funds are specified in a separate Program Element (PE), 0603801N Innovative Naval Prototypes (INP) Adv Tec Dev. INPs do not develop hardware for service use; rather they provide feeder technology that can be demonstrated in prototypes in the 6.3 portion of the INP program. Developing INPs requires a systematic expansion and application of knowledge to develop useful materials, devices, and systems oriented toward the design and development of prototypes applicable to specific mission area requirements. The efforts funded within this PE translate promising basic research into solutions for broadly defined military needs. These efforts include developing breadboard hardware and algorithms that establish the initial feasibility and practicality of proposed solutions to technological challenges, such as concept exploration efforts, studies, investigations, and non-system specific technology efforts. The Department of the Navy would have to make significant acquisition decisions to integrate the new technological capabilities into naval warfighting systems. INPs are selected by a process that involves senior leadership in the Department of the Navy.

Information security concerns preclude fully detailed descriptions of project efforts, research activities, and technology development plans. Specific information on each project and activity will be provided separately to the Congressional oversight committees.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: CLAWS	0.000	0.000	26.456	0.000	26.456

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy								Date: February 2020							
Appropriation/Budget Activity 1319 / 2		R-1 Program Element (Number/Name) PE 0602792N / Innovative Naval Prototypes (INP) Applied Res			Project (Number/Name) 3451 / CLAWS										
B. Accomplishments/Planned Programs (\$ in Millions)								FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total			
Description: The CLAWS INP effort will develop an autonomous unmanned undersea weapon system capable of providing offensive effects to the Combatant Commanders beyond Phase 0 inside the first island chain. It will clandestinely extend the reach of large UUVs and increase the mission areas into kinetic effects. CLAWS will deliver algorithms to enable all families of UUVs to operate in complex, dynamic and degraded environments. CLAWS will demonstrate autonomous missions in denied waters, develop and demonstrate autonomous technologies for survivability of large UUVs, and develop autonomy and launch capabilities for special mission payloads. CLAWS will be able to complete missions 1&2 against near peer adversary defenses, maintain critical communication with Navy C2/Fires and provide critical ISR information.															
FY 2020 Plans: N/A															
FY 2021 Base Plans: Continue Applied Research on the development of autonomous payloads for extra-large unmanned undersea vehicles operating in denied and contested areas. Payloads will be both kinetic and non-kinetic. Additional effort will include development of autonomy to increase the operator trust for kinetic payloads in contested areas and the development of autonomy and command & control required for swarm payload from extra-large unmanned undersea vehicle.															
FY 2021 OCO Plans: N/A															
FY 2020 to FY 2021 Increase/Decrease Statement: The increase in FY 2021 is due to the realignment of the CLAWS effort from Project Unit 0000 in this Program Element (PE) 0602792N Innovative Naval Prototypes (INP) Applied Res into this new Project Unit 3451.															
Accomplishments/Planned Programs Subtotals								0.000	0.000	26.456	0.000	26.456			
C. Other Program Funding Summary (\$ in Millions)															
Line Item	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost				
• RDTE/N/0603801N/3451: CLAWS	0.000	0.000	15.300	-	15.300	14.339	0.000	0.000	0.000	0.000	29.639				
Remarks															

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy	Date: February 2020	
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602792N / <i>Innovative Naval Prototypes (INP) Applied Res</i>	Project (Number/Name) 3451 / CLAWS
D. Acquisition Strategy N/A		

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020	
Appropriation/Budget Activity 1319 / 2					R-1 Program Element (Number/Name) PE 0602792N / Innovative Naval Prototypes (INP) Applied Res				Project (Number/Name) 3452 / ELEKTRA			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
3452: ELEKTRA	0.000	0.000	0.000	6.032	-	6.032	3.977	0.000	0.000	0.000	0.000	10.009

Note

ELEKTRA Non-Kinetic and EMW Capability plans and associated resources are realigned from Project Unit 0000 in Program Element (PE) 0602792N Innovative Naval Prototypes (INP) Applied Res into this new Project Unit 3452 effective FY 2021. This is not a new start.

A. Mission Description and Budget Item Justification

Complex multi-domain threats can overwhelm the operator and individual platforms ability to defend the force. The ELEKTRA INP effort is developing "Human on the Loop" Artificial Intelligence (AI) enabled algorithms to perform force level kinetic/non-kinetic kill chain optimization and coordination across multiple domains at machine to machine speeds to increase the lethality and survivability of the Force. ELEKTRA will demonstrate AI/ML ability to coordinate kinetic/non kinetic effects autonomously with heterogeneous platforms, the ability to operate in degraded environments for hours and the ability to coordinate and execute domain kill chains simultaneously. It will deploy artificial intelligent (AI) and machine learning (ML) architecture, neural networked computing and large data handling to enable real time, force level effects assignment, coordination and resource management. The Activity identified in Project Unit 3452 specifically addresses Applied Research in support of the ELEKTRA INP effort.

The efforts described in this Project address the Applied Research associated with the Innovative Naval Prototypes (INP) Program. These investments represent game changing technologies with the potential to revolutionize operational concepts. They are disruptive in nature, as they would dramatically change the way naval forces fight. Due to high technical risk, INPs typically have long duration but have no more than three years between decision points. They mature technologies from a Technology Readiness Level (TRL) of 2 or 3 to a TRL of 6. As such, INPs require both Budget Activity (BA) 2 and BA3 funding. The BA3 INP funds are specified in a separate Program Element (PE), 0603801N Innovative Naval Prototypes (INP) Adv Tec Dev. INPs do not develop hardware for service use; rather they provide feeder technology that can be demonstrated in prototypes in the 6.3 portion of the INP program. Developing INPs requires a systematic expansion and application of knowledge to develop useful materials, devices, and systems oriented toward the design and development of prototypes applicable to specific mission area requirements. The efforts funded within this PE translate promising basic research into solutions for broadly defined military needs. These efforts include developing breadboard hardware and algorithms that establish the initial feasibility and practicality of proposed solutions to technological challenges, such as concept exploration efforts, studies, investigations, and non-system specific technology efforts. The Department of the Navy would have to make significant acquisition decisions to integrate the new technological capabilities into naval warfighting systems. INPs are selected by a process that involves senior leadership in the Department of the Navy.

Information security concerns preclude fully detailed descriptions of project efforts, research activities, and technology development plans. Specific information on each project and activity will be provided separately to the Congressional oversight committees.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: ELEKTRA	0.000	0.000	6.032	0.000	6.032

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602792N / Innovative Naval Prototypes (INP) Applied Res	Project (Number/Name) 3452 / ELEKTRA				
<u>B. Accomplishments/Planned Programs (\$ in Millions)</u>		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Description: Complex multi-domain threats can overwhelm the operator and individual platforms ability to defend the force. The ELEKTRA INP effort is developing "Human on the Loop" Artificial Intelligence (AI) enabled algorithms to perform force level kinetic/non-kinetic kill chain optimization and coordination across multiple domains at machine to machine speeds to increase the lethality and survivability of the Force. ELEKTRA will demonstrate AI/ML ability to coordinate kinetic/non kinetic effects autonomously with heterogeneous platforms, the ability to operate in degraded environments for hours and the ability to coordinate and execute domain kill chains simultaneously. It will deploy artificial intelligent (AI) and machine learning (ML) architecture, neural networked computing and large data handling to enable real time, force level effects assignment, coordination and resource management.						
FY 2020 Plans: N/A						
FY 2021 Base Plans: Continued applied research associated with the development and expansion of prototype multi-domain integrated fires control capabilities developed in FY2020. Additional research will include more advanced analytics for more complex kinetic/non-kinetic kill chains and battle management. FY2021 Thrust areas include researching additional electromagnetic maneuver warfare concepts, effects coordination techniques, required data analytics, and Human-Machine teaming concepts for AI applications to enable synchronizing forces across Intelligence, Surveillance and Reconnaissance (ISR), C2 and combat systems at the operational and tactical levels.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The increase in FY 2021 is due to the realignment of the ELEKTRA Non-Kinetic and EMW Capability effort from Project Unit 0000 in this Program Element (PE) 0602792N Innovative Naval Prototypes (INP) Applied Res into this new Project Unit 3452.						
Accomplishments/Planned Programs Subtotals		0.000	0.000	6.032	0.000	6.032

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy										Date: February 2020			
Appropriation/Budget Activity			R-1 Program Element (Number/Name)				Project (Number/Name)						
1319 / 2			PE 0602792N / Innovative Naval Prototypes (INP) Applied Res				3452 / ELEKTRA						
C. Other Program Funding Summary (\$ in Millions)													
Line Item	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost		
• RDTEN/0603801N/3452: ELEKTRA	0.000	0.000	10.869	-	10.869	12.926	9.946	4.973	5.072	Continuing	Continuing		

Remarks**D. Acquisition Strategy**

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020	
Appropriation/Budget Activity 1319 / 2					R-1 Program Element (Number/Name) PE 0602792N / Innovative Naval Prototypes (INP) Applied Res				Project (Number/Name) 3453 / Hypersonic Booster			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
3453: Hypersonic Booster	0.000	0.000	0.000	10.000	-	10.000	30.000	15.000	0.000	0.000	0.000	55.000

Note

Hypersonic Booster plans and associated resources are realigned from Project Unit 0000 in Program Element (PE) 0602792N Innovative Naval Prototypes (INP) Applied Res into this new Project Unit 3453 effective FY 2021. This is not a new start.

A. Mission Description and Budget Item Justification

The Navy currently lacks the ability to demonstrate a ship-launched, DARPA-developed Hypersonic Air-breathing Weapon Concept (HAWC) Cruiser as the original USAF-RAAF air-launch effort did not address naval capabilities. Hypersonic Booster will develop a CVN-capable HAWC All-Up-Round (AUR) for air-launched flight demonstration that will require a 25% reduction in overall length to fit in a CVN weapons elevator. The goal from the outset will be to leverage DARPA-developed HAWC program for naval applications. It will flight test a CVN compliant, HAWC AUR to demonstrate airframe and booster propulsion technologies. The Activity identified in Project Unit 3453 specifically addresses Applied Research in support of the Hypersonic Booster INP effort.

The efforts described in this Project address the Applied Research associated with the Innovative Naval Prototypes (INP) Program. These investments represent game changing technologies with the potential to revolutionize operational concepts. They are disruptive in nature, as they would dramatically change the way naval forces fight. Due to high technical risk, INPs typically have long duration but have no more than three years between decision points. They mature technologies from a Technology Readiness Level (TRL) of 2 or 3 to a TRL of 6. As such, INPs require both Budget Activity (BA) 2 and BA3 funding. The BA3 INP funds are specified in a separate Program Element (PE), 0603801N Innovative Naval Prototypes (INP) Adv Tec Dev. INPs do not develop hardware for service use; rather they provide feeder technology that can be demonstrated in prototypes in the 6.3 portion of the INP program. Developing INPs requires a systematic expansion and application of knowledge to develop useful materials, devices, and systems oriented toward the design and development of prototypes applicable to specific mission area requirements. The efforts funded within this PE translate promising basic research into solutions for broadly defined military needs. These efforts include developing breadboard hardware and algorithms that establish the initial feasibility and practicality of proposed solutions to technological challenges, such as concept exploration efforts, studies, investigations, and non-system specific technology efforts. The Department of the Navy would have to make significant acquisition decisions to integrate the new technological capabilities into naval warfighting systems. INPs are selected by a process that involves senior leadership in the Department of the Navy.

Information security concerns preclude fully detailed descriptions of project efforts, research activities, and technology development plans. Specific information on each project and activity will be provided separately to the Congressional oversight committees.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Hypersonic Booster	0.000	0.000	10.000	0.000	10.000

Description: The Navy currently lacks the ability to demonstrate a ship-launched, DARPA-developed Hypersonic Air-breathing Weapon Concept (HAWC) Cruiser as the original USAF-RAAF air-launch effort did not

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy								Date: February 2020							
Appropriation/Budget Activity 1319 / 2		R-1 Program Element (Number/Name) PE 0602792N / Innovative Naval Prototypes (INP) Applied Res			Project (Number/Name) 3453 / Hypersonic Booster										
B. Accomplishments/Planned Programs (\$ in Millions)								FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total			
address naval capabilities. Hypersonic Booster will develop a CVN-capable HAWC All-Up-Round (AUR) for air-launched flight demonstration that will require a 25% reduction in overall length to fit in a CVN weapons elevator. The goal from the outset will be to leverage DARPA-developed HAWC program for naval applications. It will flight test a CVN compliant, HAWC AUR to demonstrate airframe and booster propulsion technologies.															
FY 2020 Plans: N/A															
FY 2021 Base Plans: Continue Applied Research efforts on vehicle architectural studies in the area of cruiser aerodynamic design to include scramjet engine performance, including alternate forebody shapes, cowl notch configurations, bleed-hole patterns, and diverter leading edge and solid propellant rocket motor booster motor assembly with integral launch attachment and separation assembly concepts.															
FY 2021 OCO Plans: N/A															
FY 2020 to FY 2021 Increase/Decrease Statement: The increase in FY 2021 is due to the realignment of the Hypersonic Booster effort from Project Unit 0000 in this Program Element (PE) 0602792N Innovative Naval Prototypes (INP) Applied Res into this new Project Unit 3453.															
Accomplishments/Planned Programs Subtotals								0.000	0.000	10.000	0.000	10.000			
C. Other Program Funding Summary (\$ in Millions)															
Line Item	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost				
• RDTEN/0603801N/3453: <i>Hypersonic Booster</i>	0.000	0.000	0.000	-	0.000	0.000	20.000	30.000	30.600	Continuing	Continuing				
Remarks															
D. Acquisition Strategy															
N/A															

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020	
Appropriation/Budget Activity 1319 / 2					R-1 Program Element (Number/Name) PE 0602792N / Innovative Naval Prototypes (INP) Applied Res				Project (Number/Name) 3454 / MDUSV			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
3454: MDUSV	0.000	0.000	0.000	4.850	-	4.850	0.000	0.000	0.000	0.000	0.000	4.850

Note

Medium Displacement Unmanned Surface Vehicle (MDUSV) plans and associated resources are realigned from Project Unit 0000 in Program Element (PE) 0602792N Innovative Naval Prototypes (INP) Applied Res into this new Project Unit 3454 effective FY 2021. This is not a new start.

A. Mission Description and Budget Item Justification

The Medium Displacement Unmanned Surface Vehicle (MDUSV) project will develop and test a 132 ft. unmanned surface vehicle with ocean-spanning range, months of endurance, good seakeeping, and substantial payload. The vessel will have a high level of autonomy for independent operations under sparse supervisory control and have utility for a variety of Navy missions. MDUSVs capable of deployed blue-water operations with operator trust in safe, reliable operation, long-range and endurance autonomous operations. This will create a new paradigm for Navy surface force, a hybrid manned/unmanned force, and enable new tactics in performing naval missions. The Activity identified in Project Unit 3454 specifically addresses Applied Research in support of the MDUSV INP effort.

The efforts described in this Project address the Applied Research associated with the Innovative Naval Prototypes (INP) Program. These investments represent game changing technologies with the potential to revolutionize operational concepts. They are disruptive in nature, as they would dramatically change the way naval forces fight. Due to high technical risk, INPs typically have long duration but have no more than three years between decision points. They mature technologies from a Technology Readiness Level (TRL) of 2 or 3 to a TRL of 6. As such, INPs require both Budget Activity (BA) 2 and BA3 funding. The BA3 INP funds are specified in a separate Program Element (PE), 0603801N Innovative Naval Prototypes (INP) Adv Tec Dev. INPs do not develop hardware for service use; rather they provide feeder technology that can be demonstrated in prototypes in the 6.3 portion of the INP program. Developing INPs requires a systematic expansion and application of knowledge to develop useful materials, devices, and systems oriented toward the design and development of prototypes applicable to specific mission area requirements. The efforts funded within this PE translate promising basic research into solutions for broadly defined military needs. These efforts include developing breadboard hardware and algorithms that establish the initial feasibility and practicality of proposed solutions to technological challenges, such as concept exploration efforts, studies, investigations, and non-system specific technology efforts. The Department of the Navy would have to make significant acquisition decisions to integrate the new technological capabilities into naval warfighting systems. INPs are selected by a process that involves senior leadership in the Department of the Navy.

Information security concerns preclude fully detailed descriptions of project efforts, research activities, and technology development plans. Specific information on each project and activity will be provided separately to the Congressional oversight committees.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: MDUSV	0.000	0.000	4.850	0.000	4.850

Description: The Medium Displacement Unmanned Surface Vehicle (MDUSV) project will develop and test a 132 ft. unmanned surface vehicle with ocean-spanning range, months of endurance, good seakeeping, and

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy							Date: February 2020								
Appropriation/Budget Activity 1319 / 2			R-1 Program Element (Number/Name) PE 0602792N / Innovative Naval Prototypes (INP) Applied Res				Project (Number/Name) 3454 / MDUSV								
B. Accomplishments/Planned Programs (\$ in Millions)							FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total				
substantial payload. The vessel will have a high level of autonomy for independent operations under sparse supervisory control and have utility for a variety of Navy missions. MDUSVs capable of deployed blue-water operations with operator trust in safe, reliable operation, long-range and endurance autonomous operations. This will create a new paradigm for Navy surface force, a hybrid manned/unmanned force, and enable new tactics in performing naval missions.															
FY 2020 Plans: N/A															
FY 2021 Base Plans: Continue applied research of autonomous control for medium displacement unmanned surface systems, focusing on research into common behaviors across multiple missions, additional perception capability and modalities, and methodologies for developing trust in the performance of autonomous systems.															
FY 2021 OCO Plans: N/A															
FY 2020 to FY 2021 Increase/Decrease Statement:															
The increase in FY 2021 is due to the realignment of the Medium Displacement Unmanned Surface Vehicle (MDUSV) effort from Project Unit 0000 in this Program Element (PE) 0602792N Innovative Naval Prototypes (INP) Applied Res into this new Project Unit 3454.															
Accomplishments/Planned Programs Subtotals							0.000	0.000	4.850	0.000	4.850				
C. Other Program Funding Summary (\$ in Millions)															
Line Item	FY 2019	FY 2020	FY 2021	FY 2021	FY 2021					Cost To Complete	Total Cost				
• RDTEN/0603801N/3454: MDUSV	0.000	0.000	1.115	-	1.115					0.000	1.115				
Remarks															
D. Acquisition Strategy															
N/A															

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020	
Appropriation/Budget Activity 1319 / 2					R-1 Program Element (Number/Name) PE 0602792N / Innovative Naval Prototypes (INP) Applied Res				Project (Number/Name) 3455 / MINERVA			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
3455: MINERVA	0.000	0.000	0.000	5.965	-	5.965	3.977	0.000	0.000	0.000	0.000	9.942

Note

MINERVA - Artificial Intelligence (AI) Enhanced Warfighter Decision Superiority Capability plans and associated resources are realigned from Project Unit 0000 in Program Element (PE) 0602792N Innovative Naval Prototypes (INP) Applied Res into this new Project Unit 3455 effective FY 2021. This is not a new start.

A. Mission Description and Budget Item Justification

The need to operate in a multiple domain environment against highly capable peers requires improved decision quality and reduced decision timelines. MINERVA will develop AI and Machine-Learning (ML) capabilities to improve mission planning, intelligence gathering, execution and assessment. Minerva will deliver next-generation decision aids by combining operations research with emerging AI capabilities to create learning, self-adaptive automation that supports Composite Warfare Commander's (CWC) and their staffs at the Fleet, Force and Group echelons. It will establish a DevOps environment that includes warfighter staffs in the development and integration of new capabilities. The Activity identified in Project Unit 3455 specifically addresses Applied Research in support of the MINERVA INP effort.

The efforts described in this Project address the Applied Research associated with the Innovative Naval Prototypes (INP) Program. These investments represent game changing technologies with the potential to revolutionize operational concepts. They are disruptive in nature, as they would dramatically change the way naval forces fight. Due to high technical risk, INPs typically have long duration but have no more than three years between decision points. They mature technologies from a Technology Readiness Level (TRL) of 2 or 3 to a TRL of 6. As such, INPs require both Budget Activity (BA) 2 and BA3 funding. The BA3 INP funds are specified in a separate Program Element (PE), 0603801N Innovative Naval Prototypes (INP) Adv Tec Dev. INPs do not develop hardware for service use; rather they provide feeder technology that can be demonstrated in prototypes in the 6.3 portion of the INP program. Developing INPs requires a systematic expansion and application of knowledge to develop useful materials, devices, and systems oriented toward the design and development of prototypes applicable to specific mission area requirements. The efforts funded within this PE translate promising basic research into solutions for broadly defined military needs. These efforts include developing breadboard hardware and algorithms that establish the initial feasibility and practicality of proposed solutions to technological challenges, such as concept exploration efforts, studies, investigations, and non-system specific technology efforts. The Department of the Navy would have to make significant acquisition decisions to integrate the new technological capabilities into naval warfighting systems. INPs are selected by a process that involves senior leadership in the Department of the Navy.

Information security concerns preclude fully detailed descriptions of project efforts, research activities, and technology development plans. Specific information on each project and activity will be provided separately to the Congressional oversight committees.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: MINERVA	0.000	0.000	5.965	0.000	5.965

Description: The need to operate in a multiple domain environment against highly capable peers requires improved decision quality and reduced decision timelines. MINERVA will develop AI and Machine-Learning

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy										Date: February 2020				
Appropriation/Budget Activity 1319 / 2		R-1 Program Element (Number/Name) PE 0602792N / Innovative Naval Prototypes (INP) Applied Res				Project (Number/Name) 3455 / MINERVA								
B. Accomplishments/Planned Programs (\$ in Millions)										FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
(ML) capabilities to improve mission planning, intelligence gathering, execution and assessment. Minerva will deliver next-generation decision aids by combining operations research with emerging AI capabilities to create learning, self-adaptive automation that supports Composite Warfare Commander's (CWC) and their staffs at the Fleet, Force and Group echelons. It will establish a DevOps environment that includes warfighter staffs in the development and integration of new capabilities.														
FY 2020 Plans: N/A														
FY 2021 Base Plans: Conduct applied research on emerging artificial intelligence and machine learning methods to: enable a more complete and accurate common intelligence picture; automate the analysis of specific course of action/enemy course of action pairings; and enable blue force assets to collaborate across all warfighting domains. In addition, develop methods that continuously predict the outcome of a large scale war game, recommend a set of future decisions based on desired measures of effectiveness, and monitor mission execution and provide actionable alerts.														
FY 2021 OCO Plans: N/A														
FY 2020 to FY 2021 Increase/Decrease Statement: The increase in FY 2021 is due to the realignment of the MINERVA - ai Enhanced Warfighter Decision Superiority Capability effort from Project Unit 0000 in this Program Element (PE) 0602792N Innovative Naval Prototypes (INP) Applied Res into this new Project Unit 3455.														
Accomplishments/Planned Programs Subtotals										0.000	0.000	5.965	0.000	5.965
C. Other Program Funding Summary (\$ in Millions)												Cost To Complete		
Line Item	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	FY 2025 Complete	Total Cost	Continuing	Continuing	
• RDTEN/0603801N/3455: <i>MINERVA</i>	0.000	0.000	10.936	-	10.936	12.926	11.935	6.963	7.102	Continuing				
Remarks														

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy	Date: February 2020	
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602792N / <i>Innovative Naval Prototypes (INP) Applied Res</i>	Project (Number/Name) 3455 / MINERVA
D. Acquisition Strategy N/A		

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020	
Appropriation/Budget Activity					R-1 Program Element (Number/Name)				Project (Number/Name)			
1319 / 2					PE 0602792N / Innovative Naval Prototypes (INP) Applied Res				3456 / Full Spectrum Undersea Warfare			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
3456: Full Spectrum Undersea Warfare	0.000	0.000	0.000	23.471	-	23.471	0.000	0.000	0.000	0.000	0.000	23.471

Note

Full Spectrum Undersea Warfare plans and associated resources are realigned from Project Unit 0000 in Program Element (PE) 0602792N Innovative Naval Prototypes (INP) Applied Res into this new Project Unit 3456 effective FY 2021. This is not a new start.

A. Mission Description and Budget Item Justification

The FSUSW Project will develop new technology for offensive and defensive warfare conducted on the seabed, in the sea (i.e. subsea), and from the sea. FSUSW will address three thrusts identified in the Undersea Warfare Development Command's document, "Full Spectrum Undersea Warfare Concept of Operations (CONOPS)". These thrusts are: advanced offensive missions for submarines, subsea and seabed warfare, and distributed undersea warfare. Distributed undersea warfare technology will enable full participation of all undersea warfare assets in the Navy's Distributed Maritime Operations concept. FSUSW missions this Project addresses include Anti-Submarine Warfare (ASW), Anti Surface Warfare, Strike, Intelligence, Surveillance, and Reconnaissance, Mine Warfare, and Subsea and Seabed Warfare (SSW). The FSUSW Project includes the Affordable Mobile ASW Surveillance System (AMASS) research and will leverage technology developed in the separate PE 06022792N, Project Unit 3450, AMOS. The Activity identified in Project Unit 3456 specifically addresses Applied Research in support of the FSUW INP effort.

The efforts described in this Project address the Applied Research associated with the Innovative Naval Prototypes (INP) Program. These investments represent game changing technologies with the potential to revolutionize operational concepts. They are disruptive in nature, as they would dramatically change the way naval forces fight. Due to high technical risk, INPs typically have long duration but have no more than three years between decision points. They mature technologies from a Technology Readiness Level (TRL) of 2 or 3 to a TRL of 6. As such, INPs require both Budget Activity (BA) 2 and BA3 funding. The BA3 INP funds are specified in a separate Program Element (PE), 0603801N Innovative Naval Prototypes (INP) Adv Tec Dev. INPs do not develop hardware for service use; rather they provide feeder technology that can be demonstrated in prototypes in the 6.3 portion of the INP program. Developing INPs requires a systematic expansion and application of knowledge to develop useful materials, devices, and systems oriented toward the design and development of prototypes applicable to specific mission area requirements. The efforts funded within this PE translate promising basic research into solutions for broadly defined military needs. These efforts include developing breadboard hardware and algorithms that establish the initial feasibility and practicality of proposed solutions to technological challenges, such as concept exploration efforts, studies, investigations, and non-system specific technology efforts. The Department of the Navy would have to make significant acquisition decisions to integrate the new technological capabilities into naval warfighting systems. INPs are selected by a process that involves senior leadership in the Department of the Navy.

Information security concerns preclude fully detailed descriptions of project efforts, research activities, and technology development plans. Specific information on each project and activity will be provided separately to the Congressional oversight committees.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)				
1319 / 2	PE 0602792N / Innovative Naval Prototypes (INP) Applied Res	3456 / Full Spectrum Undersea Warfare				
B. Accomplishments/Planned Programs (\$ in Millions)						
		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Undersea Warfare Efforts		0.000	0.000	23.471	0.000	23.471
Description:	The FSUSW Project will develop new technology for offensive and defensive warfare conducted on the seabed, in the sea (i.e. subsea), and from the sea. FSUSW will address three thrusts identified in the Undersea Warfare Development Command's document, "Full Spectrum Undersea Warfare Concept of Operations (CONOPS)". These thrusts are: advanced offensive missions for submarines, subsea and seabed warfare, and distributed undersea warfare. Distributed undersea warfare technology will enable full participation of all undersea warfare assets in the Navy's Distributed Maritime Operations concept. FSUSW missions this Project addresses include Anti-Submarine Warfare (ASW), Anti Surface Warfare, Strike, Intelligence, Surveillance, and Reconnaissance, Mine Warfare, and Subsea and Seabed Warfare (SSW). The FSUSW Project includes the Affordable Mobile ASW Surveillance System (AMASS) research and will leverage technology developed in the separate PE 06022792N, Project Unit 3450, AMOS.					
FY 2020 Plans:	N/A					
FY 2021 Base Plans:	Initiate high performance component development for active ASW surveillance concepts. These components will be distributed, deployable, and affordable with long endurance station keeping. Initiate follow on research using results from the successful completion of the Affordable Mobile ASW Surveillance System (AMASS) phenomenology demonstration. Initiate research in other FSUSW mission areas.					
FY 2021 OCO Plans:	N/A					
FY 2020 to FY 2021 Increase/Decrease Statement:	The increase in FY 2021 is due to the realignment of the Full Spectrum Undersea Warfare, Undersea Warfare efforts from Project Unit 0000 in this Program Element (PE) 0602792N Innovative Naval Prototypes (INP) Applied Res into this new Project Unit 3456.					
Accomplishments/Planned Programs Subtotals		0.000	0.000	23.471	0.000	23.471
C. Other Program Funding Summary (\$ in Millions)						
N/A						
Remarks						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy		Date: February 2020
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602792N / <i>Innovative Naval Prototypes (INP) Applied Res</i>	Project (Number/Name) 3456 / <i>Full Spectrum Undersea Warfare</i>
D. Acquisition Strategy N/A		

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity 1319 / 2					R-1 Program Element (Number/Name) PE 0602792N / Innovative Naval Prototypes (INP) Applied Res				Project (Number/Name) 9999 / Congressional Adds				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
9999: Congressional Adds	0.000	0.000	6.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	6.000	
A. Mission Description and Budget Item Justification Congressional Interest Items not included in other Projects.													
B. Accomplishments/Planned Programs (\$ in Millions)													
<i>Congressional Add:</i> Thermoplastic carbon-fiber composite materials research										0.000	4.000		
<i>FY 2019 Accomplishments:</i> N/A													
<i>FY 2020 Plans:</i> Conduct Applied Research in Thermoplastic carbon-fiber composite materials research.													
<i>Congressional Add:</i> Thermoplastic tailorable universal feedstock composites										0.000	2.000		
<i>FY 2019 Accomplishments:</i> N/A													
<i>FY 2020 Plans:</i> Conduct Applied Research in Thermoplastic tailorable universal feedstock composites.													
Congressional Adds Subtotals										0.000	6.000		
C. Other Program Funding Summary (\$ in Millions)													
N/A													
Remarks													
D. Acquisition Strategy													
N/A													

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy											Date: February 2020	
Appropriation/Budget Activity					R-1 Program Element (Number/Name)							
1319: Research, Development, Test & Evaluation, Navy / BA 2: Applied Research					PE 0602861N / Science & Tech Management - ONR Field Acts							
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	0.000	64.358	73.961	76.745	-	76.745	78.401	79.582	81.106	82.556	Continuing	Continuing
0000: Science & Tech Management - ONR Field Acts	0.000	64.358	73.961	73.044	-	73.044	74.845	76.307	75.525	76.876	Continuing	Continuing
0824: Science & Technology Management	0.000	0.000	0.000	3.701	-	3.701	3.556	3.275	5.581	5.680	Continuing	Continuing

A. Mission Description and Budget Item Justification

This Program Element (PE) is for the Office of Naval Research (ONR) to cover corporate expenses including salaries, Information Technology (IT), Financial Improvement Plan (FIP) efforts, Defense Finance and Accounting Service (DFAS) Billings, and some of the day-to-day logistical costs. The vast majority of these items represent fixed costs associated with Scientists and Engineers supporting the Navy's Science and Technology (S&T) Programs.

This Program Element (PE) funds Applied Research, which is the systematic study to understand the means to meet a recognized and specific need. Most of the work in this PE can be classified between Technology Readiness Level (TRL) 2 (technology concept and/or application formulation) and TRL 4 (component and/or breadboard validation in laboratory environments).

B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	64.418	73.961	74.791	-	74.791
Current President's Budget	64.358	73.961	76.745	-	76.745
Total Adjustments	-0.060	0.000	1.954	-	1.954
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.060	0.000			
• Program Adjustments	0.000	0.000	1.954	-	1.954
• Rate/Misc Adjustments	0.000	0.000	0.000	-	0.000

Change Summary Explanation

The program increase supports the workforce requirements necessary to support, manage, and rapidly field technology to the fleet. The increase ensures funding is available to meet the salary needs of the current Scientific Program Officers workforce, the associated staff required to support the execution of the research, and an additional 20 FTE as determined by the recent ONR workforce shaping. FY21 increase supports CIVPER 1.9% pay raise.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy	Date: February 2020
Appropriation/Budget Activity 1319: <i>Research, Development, Test & Evaluation, Navy / BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602861N / <i>Science & Tech Management - ONR Field Acts</i>
Technical: Not applicable.	

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020	
Appropriation/Budget Activity					R-1 Program Element (Number/Name)				Project (Number/Name)			
1319 / 2					PE 0602861N / Science & Tech Management - ONR Field Acts				0000 / Science & Tech Management - ONR Field Acts			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
0000: Science & Tech Management - ONR Field Acts	0.000	64.358	73.961	73.044	-	73.044	74.845	76.307	75.525	76.876	Continuing	Continuing
Note												
N/A												
A. Mission Description and Budget Item Justification												
This project supports ONR leadership, management and direction for the Naval S&T program. This project funds ONR HQ Non-Management Headquarters Activities (Non-MHA) salaries, communications, and other fixed costs. ONR sponsors scientific advances, which lead to Future Naval Capabilities (FNCs), supporting the Fleet's ability to operate from a position of technological superiority. Functions performed include (1) scientific and technical direction of the nationwide 6.1 basic research program with colleges, universities, non-profit organizations and Naval Laboratories and Warfare Centers; (2) scientific and technical direction of the 6.2 applied research program through the Naval R&D laboratories and Warfare Centers and industry; (3) scientific and technical direction of the Naval 6.3 advanced technology development program through the Navy's R&D laboratories, Warfare Centers and industry; (4) management, resource formulation, program assessment, and contract negotiation/administration of the Navy basic research, applied research and advanced technology development program; and (5) coordination of the Navy's Technology Base program within the context of total DoD/Government (e.g., National Science Foundation, National Academy of Sciences) R&D initiatives in order to maximize scientific advances. This project also supports ONR Non-MHA management and direction for the following Navy-wide programs: Small Business Innovation Research, Naval Research Advisory Committee, Navy Patent Program, Historically Black Colleges and Universities/Minority Institutions Program, Navy Manufacturing Technology Program and the Ballistic Missile Submarine Nuclear (SSBN) Security Technology Program.												
Additionally, this project funds ONR field salaries, communications, and other fixed costs.												
B. Accomplishments/Planned Programs (\$ in Millions)												
Title: (U) Science & Tech Management - ONR Field Acts												
Description: This Project provides funds for Non-MHA Labor costs associated with executing ONR's mission to discover, develop, and transition innovative science and technology (S&T) to meet current and future needs of naval forces. The funds in this project pay the salaries of Scientific and Engineering and corporate business personnel who direct the execution of the Navy's basic research, applied research, and advanced technology development programs at the nation's universities/colleges, Navy laboratories, Warfare Centers, and private industry.												
FY 2020 Plans:												
						FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total		
						64.358	73.961	73.044	0.000	73.044		

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602861N / Science & Tech Management - ONR Field Acts	Project (Number/Name) 0000 / Science & Tech Management - ONR Field Acts				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
This project provides for all labor costs of ONR Headquarters in support of the entire Navy S&T program. The funds in this project pay the salaries of Scientific and Engineering and corporate business personnel who direct the execution of the Navy's basic research, applied research, and advanced technology development programs at the nation's universities/colleges, Navy laboratories, Warfare Centers, and private industry. This project provides for all basic labor costs of ONR activities in support of the entire Navy S&T program.						
FY 2021 Base Plans: This project provides for all labor costs of ONR Headquarters in support of the entire Navy S&T program. The funds in this project pay the salaries of Scientific and Engineering and corporate business personnel who direct the execution of the Navy's basic research, applied research, and advanced technology development programs at the nation's universities/colleges, Navy laboratories, Warfare Centers, and private industry. This project provides for all basic labor costs of ONR activities in support of the entire Navy S&T program.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The decrease to this project reflects the breakout of non-labor costs into a standalone project within this Program Element						
Accomplishments/Planned Programs Subtotals		64.358	73.961	73.044	0.000	73.044
C. Other Program Funding Summary (\$ in Millions)						
N/A						
Remarks						
D. Acquisition Strategy						
N/A						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity 1319 / 2					R-1 Program Element (Number/Name) PE 0602861N / Science & Tech Management - ONR Field Acts				Project (Number/Name) 0824 / Science & Technology Management				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
0824: Science & Technology Management	0.000	0.000	0.000	3.701	-	3.701	3.556	3.275	5.581	5.680	Continuing	Continuing	
Note Realignment of funds internally in the PE to create PRJ 0824 for fiscal clarity of non-labor support functions. This is not a new start.													
A. Mission Description and Budget Item Justification This Project provides funds for Non-Labor costs associated with executing ONR's mission to discover, develop, and transition innovative science and technology (S&T) to meet current and future needs of naval forces. Most all the funds in this project are fixed costs, such as communications, training, and other support functions.													
B. Accomplishments/Planned Programs (\$ in Millions)							FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total		
Title: Science and Technology Management Description: This Project provides funds for Non-Labor costs associated with executing ONR's mission to discover, develop, and transition innovative science and technology (S&T) to meet current and future needs of naval forces. Most all the funds in this project are fixed costs, such as communications, training, and other support functions.							0.000	0.000	3.701	0.000	3.701		
FY 2020 Plans: This project provides for non-labor costs of ONR Headquarters in support of the entire Navy S&T program. Most of the funds in this project are fixed costs, such as communications, training, and other support functions.													
FY 2021 Base Plans: N/A													
FY 2021 OCO Plans: N/A													
FY 2020 to FY 2021 Increase/Decrease Statement: The increase to this project reflects the breakout of non-labor costs into a standalone project within this Program Element.													
Accomplishments/Planned Programs Subtotals							0.000	0.000	3.701	0.000	3.701		

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy	Date: February 2020	
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602861N / <i>Science & Tech Management - ONR Field Acts</i>	Project (Number/Name) 0824 / <i>Science & Technology Management</i>
C. Other Program Funding Summary (\$ in Millions)		
N/A		
Remarks		
D. Acquisition Strategy		
N/A		

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity					R-1 Program Element (Number/Name)								
1319: Research, Development, Test & Evaluation, Navy / BA 3: Advanced Technology Development (ATD)					PE 0603123N / Force Protection Advanced Technology								
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
Total Program Element	0.000	32.140	40.286	24.410	-	24.410	21.723	17.080	17.423	17.773	Continuing	Continuing	
2912: Force Protection Advanced Technology	0.000	29.787	32.839	21.907	-	21.907	19.205	14.519	14.810	15.107	Continuing	Continuing	
3049: Force Protection	0.000	2.353	2.447	2.503	-	2.503	2.518	2.561	2.613	2.666	Continuing	Continuing	
9999: Congressional Adds	0.000	0.000	5.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	5.000	

A. Mission Description and Budget Item Justification

This PE addresses advanced technology development associated with providing the capability of Platform and Force Protection for the U.S. Navy. This program supports the development of technologies associated with mission capable, persistent and survivable Naval platforms (surface, subsurface, terrestrial and air) in the areas of Platform Design & Engineering, Power, Energy & Propulsion, and Materials. The program develops technologies for enhanced capability of Naval aviation aircraft platforms in terms of mission effectiveness, platform range, responsiveness, survivability, observability, readiness, safety and life cycle cost. It also develops new Naval air vehicle concepts and high impact, scalable Naval air vehicle technologies. The program also develops advanced technologies, critical to protecting naval installations, to provide seamless full spectrum protection against asymmetric attack by improving the ability to: detect and identify developing and immediate threats; shape our responses through improved situational awareness and decision making; shield personnel, mission critical facilities, infrastructure, and operating fleet assets; maintain essential functions; and sustain and restore critical services in the aftermath of an incident.

Today's Sailors and Marines are enabled by naval Science and Technology (S&T). Since 1946, the Office of Naval Research (ONR) has fostered scientific research related to the maintenance of maritime superiority and national defense. ONR manages the Department of the Navy's (DON) portfolio of naval Basic and Applied research, and Advanced Technology Development investments to ensure naval forces can effectively deter conflict, but when called upon, fight, win and come home safe. Current investments hedge against uncertainty, providing solutions to commanders today, and options for the future. The Naval S&T budget supports higher guidance defined by the National Defense Strategy, and responds to requirements identified by the Secretary of the Navy through research priorities set by the Chief of Naval Research, coordinated across the Naval Research Enterprise (NRE), and outlined in the Naval R&D Framework.

This Program Element (PE) funds Advanced Technology Development (ATD) that includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment. Efforts in this PE generally have Technology Readiness Levels TRL) of 4 (component and/or breadboard validation in laboratory environment.), 5 (component and/or breadboard validation in relevant environment.), or 6 (system/subsystem model or prototype demonstration in a relevant environment).

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy					Date: February 2020
Appropriation/Budget Activity		R-1 Program Element (Number/Name)			
1319: Research, Development, Test & Evaluation, Navy / BA 3: Advanced Technology Development (ATD)		PE 0603123N / Force Protection Advanced Technology			
B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	32.615	35.286	24.410	-	24.410
Current President's Budget	32.140	40.286	24.410	-	24.410
Total Adjustments	-0.475	5.000	0.000	-	0.000
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	5.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.475	0.000			
• Rate/Misc Adjustments	0.000	0.000	0.000	-	0.000
Congressional Add Details (\$ in Millions, and Includes General Reductions)	FY 2019	FY 2020			
Project: 9999: Congressional Adds					
Congressional Add: Additive manufacturing for functional delays	0.000	5.000			
Congressional Add Subtotals for Project: 9999	0.000	5.000			
Congressional Add Totals for all Projects	0.000	5.000			
Change Summary Explanation					
funding: No significant change.					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity					R-1 Program Element (Number/Name)				Project (Number/Name)				
1319 / 3					PE 0603123N / Force Protection Advanced Technology				2912 / Force Protection Advanced Technology				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
2912: Force Protection Advanced Technology	0.000	29.787	32.839	21.907	-	21.907	19.205	14.519	14.810	15.107	Continuing	Continuing	
A. Mission Description and Budget Item Justification													
This project addresses advanced technology development associated with providing the capability of Platform and Force Protection for the U.S. Navy. This project supports the development of technologies associated with mission capable, persistent and survivable Naval platforms (surface, subsurface, terrestrial, and air) in the areas of Platform Design & Engineering, Power, Energy & Propulsion, and Materials. This project develops technologies for enhanced capability of Naval aviation aircraft platforms in terms of mission effectiveness, platform range, responsiveness, survivability, observability, readiness, safety and life cycle cost. It also develops new Naval air vehicle concepts and high impact, scalable Naval air vehicle technologies.													
B. Accomplishments/Planned Programs (\$ in Millions)													
Title: Surface Ship and Submarine Hull Mechanical and Electrical (HM&E) Description: This project addresses advanced technology development associated with providing the capability of Platform and Force Protection for the U.S. Navy. This project supports the development of technologies associated with mission capable, persistent and survivable naval platforms (surface, subsurface and terrestrial) in the areas of Platform Design & Engineering, Power, Energy & Propulsion and Materials. The primary research efforts within this activity are focused on advanced technology development for Unmanned Sea Surface Vehicles in support of Naval S&T Focus Area on Autonomy and Unmanned Vehicles, At-Sea Vertical Launch System rearming and Advanced Materials Development. Unmanned Sea Surface Vehicle (USSV) technology development includes autonomous navigation for USSVs. Also funded in this activity is the Energy System Technology Evaluation Program (ESTEP), which promotes innovation and entrepreneurial opportunities for naval personnel and student veterans through advanced technology development and demonstration projects at naval facilities and laboratories. FY 2020 Plans: - Conduct advanced research related to critical S&T for development of autonomous navigation for Unmanned Sea Surface Vehicles from host ship. - Continue ESTEP project efforts, including assessment of advanced energy technologies; development of cyber-physical security for energy networks; and utilization of autonomous systems, artificial intelligence and advanced manufacturing to address operational challenges in logistics and readiness.													
FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total									
23.536	26.703	15.770	0.000	15.770									

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603123N / Force Protection Advanced Technology	Project (Number/Name) 2912 / Force Protection Advanced Technology				
<u>B. Accomplishments/Planned Programs (\$ in Millions)</u>		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
- Continue efforts for prototype and operational FY22 demonstration of At-Sea Rearm of Vertical Launch System (ASRV) capability in a relevant environment including crane, mooring system, strike-up/strike-down system fabrication and testing.						
FY 2021 Base Plans:						
- Autonomous Unmanned Surface Vessel (USV): advance research related to the development of planing hull platforms. The technologies resulting from these efforts are being moved forward for use on unmanned surface vessels.						
- Energy Systems Technology Evaluation Program (E-STEP): project efforts focus on assessing advanced energy technologies, developing cyber-physical security for energy networks, and utilizing autonomous systems, artificial intelligence and advanced manufacturing to address operational challenges in logistics and readiness. Program goals include: advance dual-use and naval-unique technologies that increase operational capabilities and efficiencies; leverage commercial technologies and private investments to provide warfighter capability at reduced cost; and evaluate innovative technologies from naval laboratories and startup companies.						
- At-Sea Rearm of Vertical Launch System (ASRV): efforts will focus on further adapting and integrating seabasing technologies into a single system to demonstrate the ASRV capability in Sea State 4 in FY2022. This will include increasing the number of potential rearming sites and reduce off station time associated with rearming at known geographic locations.						
- Quality Metal Additive Manufacturing (Quality MADE): conduct research to do a final parts demonstration for accelerated qualification of materials and manufacturing processes for structural components. This effort is expected to complete in FY2022.						
FY 2021 OCO Plans:						
N/A						
FY 2020 to FY 2021 Increase/Decrease Statement:						
The funding decrease from FY 2020 to FY 2021 is due to the (ASRV) moving beyond subsystem hardware purchases (completed in FY19 and FY20) to testing and integration in support of the demonstration in FY 2022.						
Title: Aircraft Technology		6.251	6.136	6.137	0.000	6.137
Description: The Aircraft Technology activity develops technologies for enhanced capability of Naval aviation aircraft platforms in terms of mission effectiveness, platform range, responsiveness, survivability, observability,						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603123N / Force Protection Advanced Technology	Project (Number/Name) 2912 / Force Protection Advanced Technology				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
readiness, safety and life cycle cost. It also develops new Naval air vehicle concepts and high impact, scalable Naval air vehicle technologies, such as helicopter and tiltrotor rotor drive systems, aerodynamics, propulsion systems, materials and structures for future and legacy air vehicles. This activity directly supports the Naval Research and Development Framework Priorities of Operational Endurance and Scalable Lethality.						
FY 2020 Plans: Conduct advanced technology development efforts and demonstrations of the Variable Cycle Advanced Technology (VCAT) Program which will enable the Navy's Next Generation Air Dominance (NGAD) carrier aircraft. Critical technology development efforts continue with major engine manufacturers and to develop/mature the highest priority, long lead propulsion system technologies, including variable/adaptive cycle engine controls, variable area turbines, Ceramic Matrix Composites (CMC), Polymer Matrix Composites (PMC), and Integrated Propulsion, Power and Thermal Management Systems (IPPTMS) architectures and technologies. These efforts will support the Navy's planned NGAD Technology Maturation and Risk Reduction program for the engine design and development, and Integrated Propulsion, Power and Thermal Management System.						
FY 2021 Base Plans: - Further development of advanced technology for the Navy's (NGAD) carrier aircraft enabling technologies. NGAD, previously known as VCAT, Critical Technology development efforts will continue with major engine manufacturers to develop/mature the highest priority, long lead propulsion system turbine engine technologies, including: - variable/adaptive cycle engine controls and variable area turbines, - Ceramic Matrix Composites (CMC) and Polymer Matrix Composites (PMCs), - Integrated Propulsion, Power and Thermal Management Systems (IPPTMS) architectures, - advanced casing treatments, splitted rotors and slatted rotors, - advanced compression system technologies and compact combustors, - improved robustness in austere environment (sand, dust and salt ingestion). - These Critical Technology Elements will feed into the NGAD Tech Maturity and Risk Reduction (TMRR) Program and increase the aircraft's range, speed and endurance.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement:						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020
Appropriation/Budget Activity 1319 / 3		R-1 Program Element (Number/Name) PE 0603123N / Force Protection Advanced Technology		Project (Number/Name) 2912 / Force Protection Advanced Technology
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base
There are no significant changes from FY 2020 to FY 2021.				FY 2021 OCO
		Accomplishments/Planned Programs Subtotals	29.787	32.839
			21.907	0.000
				21.907
C. Other Program Funding Summary (\$ in Millions)				
N/A				
Remarks				
D. Acquisition Strategy				
N/A				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020				
Appropriation/Budget Activity 1319 / 3					R-1 Program Element (Number/Name) PE 0603123N / Force Protection Advanced Technology				Project (Number/Name) 3049 / Force Protection						
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost			
3049: Force Protection	0.000	2.353	2.447	2.503	-	2.503	2.518	2.561	2.613	2.666	Continuing	Continuing			
A. Mission Description and Budget Item Justification															
Develop advanced technologies, critical to protecting naval installations, to provide seamless full spectrum protection against asymmetric attack by improving the ability to: detect and identify developing and immediate threats; shape our responses through improved situational awareness and decision making; shield personnel, mission critical facilities, infrastructure, and operating fleet assets; maintain essential functions; and sustain and restore critical services in the aftermath of an incident. Technologies developed will also seek to reduce the required manpower and skill levels devoted to the force protection mission, improving performance and reducing costs for the Navy.															
B. Accomplishments/Planned Programs (\$ in Millions)											FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Emerging Threats											2.353	2.447	2.503	0.000	2.503
Description: Naval Installations are a critical component in support of Navy global force projection. These installations, and the Navy ships, submarines, and aircraft located on them, are under increasing risk from asymmetric attack, including from new threat vectors such as unmanned air, surface, and subsurface vehicles. This project is focused on the development advanced technologies necessary for the protection of Naval Installations. Technical efforts address the detect -to-engage-to-assess requirements for Naval Installations by improving the ability to: sense and identify threats; support improved situational awareness and decision making; and develop effective countermeasures. Technologies developed will also seek to reduce the required manpower and skill levels devoted to the force protection mission.															
FY 2020 Plans: - Continue development, and conduct interim demonstration, of the Autonomous Maritime Asset Protection System (AMAPS) capability including integration of unmanned response technologies. Develop capability to detect and Counter small Unmanned Underwater Vehicles (C-UUV) in the harbor environment and integrate into AMAPS. Develop technologies to detect and counter small unmanned air threats within the constraints and parameters associated with Commander Naval Installations (CNIC) and NAVFAC requirements.															
FY 2021 Base Plans: - (AMAPS): conduct a final demonstration, which will include unmanned response capabilities and a fully integrated Rocket Propelled Grenade (RPG) of the Sea (RPG-S) (C-UUV) capability.															

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603123N / Force Protection Advanced Technology	Project (Number/Name) 3049 / Force Protection				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
- Day/night all weather sensors: conduct an interim demonstration, which will include multi-static radar, Passive Millimeter Wave (PMMW) and Dual Band Infrared electro-optic sensors, to detect small unmanned air threats and surface threats in Degraded Visual environments (DVE). Demonstrate the capability for these DVE sensors to accurately cue counter measures systems and assess their effect in real time.						
- Automated Target Recognition algorithms: conduct an interim demonstration to assist operations center personnel in detecting and identifying threats.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: There are no significant changes from FY 2020 to FY 2021.	Accomplishments/Planned Programs Subtotals	2.353	2.447	2.503	0.000	2.503
C. Other Program Funding Summary (\$ in Millions)						
N/A						
Remarks						
D. Acquisition Strategy		N/A				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity 1319 / 3					R-1 Program Element (Number/Name) PE 0603123N / Force Protection Advanced Technology				Project (Number/Name) 9999 / Congressional Adds				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
9999: Congressional Adds	0.000	0.000	5.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	5.000	
A. Mission Description and Budget Item Justification Congressional Interest Items not included in other Projects.													
B. Accomplishments/Planned Programs (\$ in Millions)													
<i>Congressional Add:</i> Additive manufacturing for functional delays										FY 2019	FY 2020		
<i>FY 2019 Accomplishments:</i> N/A										0.000	5.000		
<i>FY 2020 Plans:</i> Conduct technology development in Additive manufacturing for functional delays.										Congressional Adds Subtotals	0.000	5.000	
C. Other Program Funding Summary (\$ in Millions)													
N/A													
Remarks													
D. Acquisition Strategy													
N/A													

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity					R-1 Program Element (Number/Name)								
1319: Research, Development, Test & Evaluation, Navy / BA 3: Advanced Technology Development (ATD)					PE 0603271N / Electromagnetic Systems Advanced Technology								
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
Total Program Element	0.000	8.639	9.499	8.008	-	8.008	8.169	8.336	8.503	8.673	Continuing	Continuing	
2913: Electromagnetic Systems Advanced Technology	0.000	8.639	9.499	8.008	-	8.008	8.169	8.336	8.503	8.673	Continuing	Continuing	

A. Mission Description and Budget Item Justification

The Navy and Marine Corps' sophisticated electronics systems place heavy demands on the electromagnetic spectrum to accommodate information flow, defensive and offensive detection, tracking, and weapon system engagement. In distributed maritime operations, each of these platforms provides a set of capabilities that can be further combined for progressively larger and more complex operations. The Electromagnetic Systems Advanced Technology program addresses Radio Frequency (RF) technology for Surface and Aerospace Surveillance sensors and systems, Electronic Warfare (EW) sensors and systems, RF Communication Systems, Multi-Function sensor systems, and Position, Navigation and Timing (PNT) capabilities. Activities and efforts in this Program Element (PE) address technologies critical to enabling the transformation of discrete functions to network centric warfare capabilities, which simultaneously perform Radar, EW, and Communications and Network functions across platforms through multiple, simultaneous and continuous communications/data links.

Today's Sailors and Marines are enabled by Naval Science and Technology (S&T). Since 1946, the Office of Naval Research (ONR) has fostered scientific research related to the maintenance of maritime superiority and national defense. ONR manages the Department of the Navy's (DON) portfolio of naval Basic and Applied research, and Advanced Technology Development investments to ensure naval forces can effectively deter conflict, but when called upon, fight, win and come home safe. Current investments hedge against uncertainty, providing solutions to commanders today, and options for the future. The Naval S&T budget supports higher guidance defined by the National Defense Strategy, and responds to requirements identified by the Secretary of the Navy through research priorities set by the Chief of Naval Research, coordinated across the Naval Research Enterprise (NRE), and outlined in the Naval R&D Framework.

This Program Element (PE) funds Advanced Technology Development (ATD) that includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment. Efforts in this PE generally have Technology Readiness Levels TRL) of 4 (component and/or breadboard validation in laboratory environment.), 5 (component and/or breadboard validation in relevant environment.), or 6 (system/subsystem model or prototype demonstration in a relevant environment).

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy					Date: February 2020
Appropriation/Budget Activity	R-1 Program Element (Number/Name) PE 0603271N / Electromagnetic Systems Advanced Technology				
B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	8.804	9.499	8.008	-	8.008
Current President's Budget	8.639	9.499	8.008	-	8.008
Total Adjustments	-0.165	0.000	0.000	-	0.000
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.165	0.000			
• Rate/Misc Adjustments	0.000	0.000	0.000	-	0.000
Change Summary Explanation					
funding: No significant change.					
Technical: no significant change					
Schedule: no significant change					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020				
Appropriation/Budget Activity					R-1 Program Element (Number/Name)				Project (Number/Name)						
1319 / 3					PE 0603271N / Electromagnetic Systems Advanced Technology				2913 / Electromagnetic Systems Advanced Technology						
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost			
2913: Electromagnetic Systems Advanced Technology	0.000	8.639	9.499	8.008	-	8.008	8.169	8.336	8.503	8.673	Continuing	Continuing			
A. Mission Description and Budget Item Justification Work in this project addresses cost-effective Radio Frequency (RF) technology for Surface and Aerospace Surveillance sensors and systems, Electronic Warfare (EW) sensors and systems, RF Communication Systems, Multi-Function sensor systems, and Position, Navigation and Timing (PNT) capabilities.															
B. Accomplishments/Planned Programs (\$ in Millions)											FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Electronic and Electromagnetic Systems Description: The overarching objective of the Electronic and Electromagnetic Systems Activity is to develop, test, and demonstrate Communications, Electronic Attack (EA), Electronic Surveillance (ES), EW, and Radar functions. A portion of this Program Element (PE) is devoted to mid-term technology development in close concert with acquisition programs of record. The products of these efforts are planned for transition at the end of their schedule into the associated acquisition program of record. Technology development is focused on Distributed Electronic Warfare in support of Distributed Maritime Operations. Major thrust within the Electronics and Electromagnetic Systems program are: a) Advanced EW Enabling Technologies - Develop classified advanced electronic warfare technology in support of current and predicted capability requirements.											4.180	4.180	4.180	0.000	4.180
FY 2020 Plans: Conduct research in the areas of improved threat warning systems; electronic warfare support; decoys and countermeasures against weapon tracking and guidance systems; electronic attack against adversary Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR); and Electronic Protection (EP) of our own weapons and C4ISR from intentional and unintentional interference to control the Electromagnetic Spectrum (EMS) by exploiting, deceiving, or denying enemy use of the spectrum while ensuring its use by friendly forces. Refine design of and implement next-generation electronic warfare development and evaluation capability for the Navy (classified details available). Employ the updated capability for real-world assessments of existing electronic warfare and sensor system performance. Conduct analysis of results of FY 2019 test and evaluation activities. Refine and modify designs based on results, and initiate															

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603271N / Electromagnetic Systems Advanced Technology	Project (Number/Name) 2913 / Electromagnetic Systems Advanced Technology				
<u>B. Accomplishments/Planned Programs (\$ in Millions)</u>		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
implementation of modified and additional capabilities. Continue close coordination with associated Science and Technology (S&T) and acquisition programs.						
<p>FY 2021 Base Plans: Advanced Electronic Warfare Enabling Technologies: - Perform focused developments in the areas of Electronic Support (ES); decoys and countermeasures against weapon tracking and guidance systems; Electronic Attack (EA) against adversary Command, Control, Communications, Computers, Intelligence, Surveillance, Reconnaissance and Targeting (C4ISRT). - Develop Electronic Protection (EP) for our own weapons and Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) from intentional and unintentional interference. - Conduct Live, Virtual, and Constructive (LVC) test events of force-level kinetic/non-kinetic coordination and resource optimization. - Conduct analysis and report the results of FY 2020 test & evaluation activities.</p> <p>FY 2021 OCO Plans: N/A</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant change from FY 2020 to FY 2021.</p>						
<p>Title: Global Positioning System (GPS) and Navigation Technology</p> <p>Description: The overarching objective of this activity is to develop technologies that enable the development of affordable, effective and robust Position, Navigation and Timing (PNT) capabilities using non-Global Positioning System (GPS) navigation devices, or atomic clocks. This activity will increase the operational effectiveness of U.S. Naval units. The focus is on the mitigation of GPS electronic threats, the development of atomic clocks that possess unique long-term stability and precision, and the development of compact, low-cost, Inertial Navigation Systems (INS).</p> <p>FY 2020 Plans: Conduct advanced research and development in position, navigation and timing. This research aims to develop techniques and technology to provide assured, cost-effective, and mission relevant PNT to the warfighter. Areas of investment included robust GPS, non-GPS navigation aids, and assured timekeeping. Specifically, GPS Anti-Jam Antennas and Receivers for Navy platforms for the purpose of providing precision navigation capabilities in the presence of electronic threats and anti-spoofing/anti-jam processors for the purpose of providing precision</p>	4.459	5.319	3.828	0.000	3.828	

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603271N / Electromagnetic Systems Advanced Technology	Project (Number/Name) 2913 / Electromagnetic Systems Advanced Technology				
<u>B. Accomplishments/Planned Programs (\$ in Millions)</u>		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
navigation capabilities in the presence of emergent threats; Tactical grade atomic clocks that possess unique long-term stability and precision for the purpose of providing GPS-independent precision time and transferring UTC (USNO) time via alternative electromagnetic links for the purpose of providing GPS-independent precision time; and Inertial navigation systems for the purpose of providing an alternative means of providing precision navigation, a correlation navigation technique using earth maps of high precision, for those Naval platforms which may not have Global Positioning System (GPS) navigation capabilities and/or loss of GPS signals.						
FY 2021 Base Plans: Position, Navigation and Timing (PNT): - Complete research on automated celestial day night navigation for surface ships, transitioning to the Cooperative Engagement Capability program office. - Complete research on protected tactical waveforms for time transfer, transitioning to PMW 170's Wideband Anti-Jam Modem (WAM) system. - Continue research on miniature fiber optic inertial capability. - Continue research on wave forms for precision two way time transfer techniques and modem development. - Initiate research into mounted navigation for United States Marine Corps (USMC) specific platforms. - Initiate research into Low Earth Orbit constellation receivers for naval platforms.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The funding decrease from FY 2020 to FY 2021 is due to the decreased investment in Assured Time Dissemination research in the GPS and Navigation Technology thrust. This decrease is a result of the comprehensive DOD wide assessment of current Science and Technology (S&T) investments in the area of Position, Navigation and Timing ending in FY21.						
Accomplishments/Planned Programs Subtotals		8.639	9.499	8.008	0.000	8.008
<u>C. Other Program Funding Summary (\$ in Millions)</u>						
N/A						
<u>Remarks</u>						
<u>D. Acquisition Strategy</u>						
N/A						

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity					R-1 Program Element (Number/Name)								
1319: Research, Development, Test & Evaluation, Navy / BA 3: Advanced Technology Development (ATD)					PE 0603640M / MC Advanced Technology Demo								
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
Total Program Element	0.000	170.659	212.347	219.045	-	219.045	221.406	215.419	194.026	186.702	Continuing	Continuing	
2223: Marine Corps ATD	0.000	98.695	95.327	114.439	-	114.439	116.490	116.592	114.030	107.111	Continuing	Continuing	
2297: Futures Directorate	0.000	45.900	73.046	99.806	-	99.806	100.116	94.027	74.996	74.492	Continuing	Continuing	
2958: Cyberspace Activities	0.000	0.000	4.474	4.800	-	4.800	4.800	4.800	5.000	5.099	Continuing	Continuing	
9999: Congressional Adds	0.000	26.064	39.500	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	65.564	

A. Mission Description and Budget Item Justification

The U.S. Navy/Marine Corps team is the most potent naval fighting force in the world. Fundamental to their success are the technologies necessary for effective distributed maritime operations. The Office of Naval Research (ONR) combines knowledge of the naval mission with researchers to select and explore solutions critical to expeditionary warfighting needs. This Program Element (PE) addresses requirements outlined. Additionally, an emergent operation stressor is the contested urban environment which exemplifies the characterizations listed above. The urban environment is one of the most complex terrains with physical compartmentalization and canalization, additional physical dimensions (subterranean and multi-story structures), crowded conditions and associated threat obscuration, communications challenges, informational and human aspects, and proliferation of observation and fires technologies. This environment requires capabilities addressing all the activities within this PE and while it provides many challenges, unique opportunities are also presented and can further shape technology approaches.

These future challenges and portents demand robust technologies for the Marine Corps, but the technology options are constrained. They must have a lightweight deployable character, and the ability to operate in austere conditions with little fixed infrastructure or support while retaining the agility and lethality of an integrated maneuver force. Technology must provide full spectrum capability against robust and complex peer and near-peer adversaries while meeting Size, Weight, Power, Cost limitations, and information availability within Distributed, Intermittent and Limited environments.

The approach within this PE encompasses ideas that support both revolutionary and evolutionary capabilities, and in this way considers and balances both "push" and "pull" aspects of technology projects. This PE matures technologies emerging from PE 0602131M-Marine Corps Landing Force Technology to develop concept prototypes and initial experimentation to confirm feasibility in an environment relevant to operations.

This Program Element (PE) funds Advanced Technology Development (ATD) that includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment. Efforts in this PE generally have Technology Readiness Levels TRL) of 4 (component and/or breadboard validation in laboratory environment.), 5 (component and/or breadboard validation in relevant environment.), or 6 (system/subsystem model or prototype demonstration in a relevant environment).

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy					Date: February 2020
Appropriation/Budget Activity	R-1 Program Element (Number/Name)				
1319: Research, Development, Test & Evaluation, Navy / BA 3: Advanced Technology Development (ATD)	PE 0603640M / MC Advanced Technology Demo				
B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	174.809	172.847	168.520	-	168.520
Current President's Budget	170.659	212.347	219.045	-	219.045
Total Adjustments	-4.150	39.500	50.525	-	50.525
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	39.500			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-4.150	0.000			
• Program Adjustments	0.000	0.000	50.525	-	50.525
• Rate/Misc Adjustments	0.000	0.000	0.000	-	0.000
Congressional Add Details (\$ in Millions, and Includes General Reductions)	FY 2019	FY 2020			
Project: 9999: Congressional Adds					
Congressional Add: Common Unmanned Aerial Vehicle Simulation System	9.654	0.000			
Congressional Add: Flight Motion Simulator and Testing of UAVs	5.792	0.000			
Congressional Add: Modular Advanced Armed Robotic System 2.0	3.861	0.000			
Congressional Add: UAS Air-Delivered Extended Range Munitions Demo	6.757	0.000			
Congressional Add: Robotic protection system	0.000	5.000			
Congressional Add: Expeditionary mission planning enabled by high fidelity simulation	0.000	10.000			
Congressional Add: Extended range 155mm projectile	0.000	2.500			
Congressional Add: Adaptive threat force	0.000	7.000			
Congressional Add: Air drop extended range munitions	0.000	15.000			
	Congressional Add Subtotals for Project: 9999				
	Congressional Add Totals for all Projects				
	26.064	39.500			
	26.064	39.500			

Change Summary Explanation

The program increase in FY 2021 reflects an alignment to Naval priorities and a targeted investment in signature management and multi-domain sensors necessary to support warfighter requirements as well as increased investment in logistic material transport surface and aerial platforms.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy	Date: February 2020
Appropriation/Budget Activity 1319: <i>Research, Development, Test & Evaluation, Navy / BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603640M / MC Advanced Technology Demo
Marine Corps Warfighting Laboratory / Futures Directorate (MCWL/FD): Major program adjustments, beginning in FY20 and sustained across the FYDP, support Marine Corps specific Science and Technology initiatives, and are in accordance with Office of the Secretary of Defense (OSD) steady-state guidance. Efforts are justified in Project 2297.	

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity 1319 / 3					R-1 Program Element (Number/Name) PE 0603640M / MC Advanced Technology Demo				Project (Number/Name) 2223 / Marine Corps ATD				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
2223: Marine Corps ATD	0.000	98.695	95.327	114.439	-	114.439	116.490	116.592	114.030	107.111	Continuing	Continuing	

A. Mission Description and Budget Item Justification

This project funds technology demonstration, experimentation, and prototyping; and more technologically mature projects within the Future Naval Capability (FNC) process as means to inform, enhance, enable, and invent future concepts and capabilities with new Science and Technology (S&T). This project is organized into ten activities, the core of which is represented by the eight Expeditionary Warfighting Capability Areas.

Emphasized within this project are increased efforts to actively demonstrate advanced technologies and system concepts. These demonstrations and experiments focus on the specific technologies, not necessarily their operational application, and vary based on the technical maturity of the project. This early technology exposure gives Marines a view into the future and enables them to use their imagination and innovation to envision novel employment of the technology and inform the acquisition process.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Command, Control, Communications, Computers (C4)	6.480	10.000	28.598	0.000	28.598
Description: This activity investigates robust, resilient, and secure networked communications pathways and capability that support an expeditionary force's distributed and disaggregated operations. Research supports both networked and local computation for communications that exploits the expeditionary forces close physical proximity to threats while mitigating shortfalls commensurate within Distributed, Intermittent, and Limited environments. Expeditionary forces must operate in the cyber domain and in addition to defending communications networks, vehicles, and weapons systems, are reliant on electronic controllers for basic operations and as such are susceptible to cyberattacks.					
Technologies addressed within this activity include secure, robust, self-forming, mobile communications networks; distributed computing to support information dissemination to all echelons; improved capabilities in over-the-horizon, beyond line-of-sight, and restricted environment communications and sensors; and software and data processing to support formation of an appropriate common picture. Other efforts include power management, low detectability, conforming to Size, Weight, Power, Cost constraints, and interoperability within the joint environment.					
Further, this activity integrates and demonstrates enhanced communications and situational awareness capabilities in experimental and warfighting environments reflecting USMC operations. Advanced technology resources will be developed and applied to complement commercial, other service, and defense agency					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603640M / MC Advanced Technology Demo	Project (Number/Name) 2223 / Marine Corps ATD				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
investments to produce a technology base addressing identified Marine Corps technology gaps. Focus will be on developing component level prototypes and experimentation in relevant environments.						
FY 2020 Plans: The C4 and Electronic Warfare research effort focuses heavily on the continued development and integration of multiple underlying technologies into subsystems and system with the purpose of demonstrating the tactical exploitation of information and the electromagnetic spectrum. To address resiliency requirements of C4 this effort is closely coordinated with the Intelligence, Surveillance, and Reconnaissance and Expeditionary Cyber research portfolio also described herein so as to most efficiently exploit multifunction capabilities in portable reduced Size, Weight, Power, Cost systems. This integrated rapid co-design, prototyping, and experimentation approach will reduce time needed to provide new capabilities to the US Marine Corps. Developed and demonstrated technologies will include advanced signature management, interoperability, machine learning, spectrum maneuver, damage assessment monitoring, and information dominance for tactical edge systems. Additional emphasis of operating in the challenging warfighter electromagnetic spectrum environment is addressed in the multifunction electronic warfare domains.						
FY 2021 Base Plans: - Continue to emphasize operating in contested and denied electromagnetic spectrum (EMS) environments. The goal of operating ubiquitously in multifunction electronic warfare domains will be achieved by reducing size to handheld form factor focused heavily on the continued development and integration of multiple underlying technologies into systems and subsystems with the purpose of demonstrating the tactical exploitation of information and the EMS. To address resiliency requirements of Command, Control, Communications, Computers (C4) this effort is closely coordinated with the Intelligence, Surveillance, and Reconnaissance and Expeditionary Cyber research portfolio also described herein so as to most efficiently exploit multifunction capabilities in portable reduced Size, Weight, Power, and Cost systems. This integrated rapid co-design, prototyping, and experimentation approach will reduce time needed to provide new capabilities to the US Marine Corps. The following efforts are in collaboration with the CRIT and MuDRaCE FNC activities in this PE/project and leverage experimental discoveries under the MAGTF C4 project to accelerate development of high priority capabilities.						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603640M / MC Advanced Technology Demo	Project (Number/Name) 2223 / Marine Corps ATD				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
- Initiate the development to demonstrate technologies that include advanced signature management, machine learning, interoperability, spectrum maneuver, damage assessment monitoring, and information dominance for tactical edge systems. - Initiate the development to demonstrate portable distributed multi-domain sensor and surveillance technologies in portable expeditionary warfare form factor to protect forces in denied and contested EM environments.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The funding increase from FY2020 to FY2021 reflects an alignment to Naval priorities and a targeted investment in signature management and multi-domain sensors necessary to accelerate their development, help close high priority capability gaps, and meet the demands of the National Defense Strategy "forward force maneuver and posture resilience."						
Title: Firepower Description: The activity investigates a large variety of weapons to provide the warfighter with a decisive, yet surgical, tactical advantage to collectively address 21st-century combined-arms warfare against peer and near-peer states. Research efforts increase the reach, lethality, and capacity while retaining mobility and tempo beneficial to expeditionary maneuver warfare. Maintaining focus on Size, Weight, Power, Cost and Distributed, Intermittent and Limited environments stresses the technical solutions available. This activity furthers the maturity of researched technology solutions by also developing the integration required to effectively demonstrate and test emergent capabilities. Achieving a true combined arms state involves a full systems approach for both kinetic and non-kinetic capabilities all driven by a holistic targeting capability. This activity develops technology for application on current and future expeditionary weapons. It includes, but is not limited to, the following technologies: fuze, fire control, targeting, launch/propulsion, lethality, and accuracy.	15.985	9.000	8.160	0.000	8.160	
FY 2020 Plans: Finalize development of caseless small caliber ammunition: development of fuzing and sensor technologies for cannon-delivered area effects munitions, and development of supervised-autonomous weapon system control technologies for weaponized unmanned ground vehicles. Munitions developments will focus on low cost, extended range, precision munitions with improved lethality warhead payloads for use against stationary and moving targets on land and water, in satellite and network denied environments.						
FY 2021 Base Plans:						

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Appropriation/Budget Activity 1319 / 3		R-1 Program Element (Number/Name) PE 0603640M / MC Advanced Technology Demo		Project (Number/Name) 2223 / Marine Corps ATD					
B. Accomplishments/Planned Programs (\$ in Millions)									
	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total				
<ul style="list-style-type: none"> - Progress development of automated fire control technologies enabling automated target classification and prioritization for weaponized unmanned ground vehicles - Munition development will continue to focus on low-cost, extended range, precision guided munitions, having improved lethality warheads for use against various types of stationary and moving targets on land and water, and in satellite and network denied environments 									
FY 2021 OCO Plans: N/A									
FY 2020 to FY 2021 Increase/Decrease Statement: The funding decrease from FY20 to FY21 reflects a completion of caseless ammunition work in FY20.									
Title: Force Protection Description: This activity investigates new ways and means to protect forces and materiel across all operational settings from contested sea-land surface interfaces to complex urban environments. The portfolio protects against adversaries' challenges such as guided-rockets and missiles, mobile coastal artillery, threat Electronic Warfare and Counter Intelligence, and Surveillance and Reconnaissance. Mines and obstacles both in the water and ashore also complicate amphibious landings. The activity invests in vehicle survivability aspects that are exacerbated due to Size, Weight, and Power Cost constraints inherent to Marine Corps operation and the harsh nature of the amphibious environment. Technologies addressed include lightweight armor for ballistic and underbody blast protection, advanced sensors for counter tactical surveillance, active protection, and signature management. This activity also considers technology for payloads, packages and sensors that are needed by amphibious vehicles (both manned and unmanned) including mine counter measures; explosive hazard defeat systems; and obstacle and threat detection systems as well as technologies for improved protection for individuals against blast, ballistic and blunt impact threats. Technologies in this activity enable Marine Corps forces to maintain operational tempo through a range of environments by avoiding or detecting surveillance and targeting capabilities before engagement; counter detection and targeting (e.g. long range sniper, urban shooter, rocket propelled grenades) and delay vehicle detection and identification through signature management/control.					10.794	13.415	14.167	0.000	14.167
FY 2020 Plans:									

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603640M / MC Advanced Technology <i>Demo</i>	Project (Number/Name) 2223 / Marine Corps ATD				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
	FY 2020 Plans emphasize development of miniaturized hardware systems for the detection of threats across a variety of sensing modalities to take advantage of unique susceptibilities of threat systems at significant ranges. Leveraging these sensor systems, there will be development of computer vision and machine learning approaches for automated target recognition within these innovative sensing modalities. There will be development of feature extraction of threats leveraging Radio Frequency based 3-Dimensional buried object detection. Signature reduction materials and sensor hardware for pre-shot detection of ambush threats and surveillance will be demonstrated on platforms to evaluate enhanced survivability. Efforts will also include tactical decision aids that provide vehicle susceptibility assessment and route planning recommendations. Additionally, technologies and systems supporting the neutralization of threat systems via kinetic and non-kinetic means, to include unmanned aerial vehicles, will be developed.					
FY 2021 Base Plans:						
- Efforts that emphasize the further development of sensors and systems to enable autonomous amphibious assault under mined and obstacle environments will continue. This continues the work on buried object detection, and combines it with other sensor modalities such as magnetometers and electro-optical and integrate on a range of unmanned platforms. These platforms are capable of operating in and from the very shallow water/surf-zone under contested conditions as well as in-land cluttered environments.						
- Technologies and systems supporting the neutralization of threat systems via kinetic and non-kinetic/directed energy means will continue. These threats include unmanned aerial vehicles as well as defenses against direct-fire precision weapon systems.						
- Miniaturized hardware sensing systems will be developed for the detection of threats across a variety of sensing modalities to take advantage of unique susceptibilities of threat systems at significant ranges.						
- Develop advanced technologies that enable detection of hazards and surveillance/targeting systems in complex operational environments such as jungles and littorals. Demonstrate use of autonomous vehicles in the detection, neutralization, marking, and reporting of hazards.						
FY 2021 OCO Plans:						
N/A						
FY 2020 to FY 2021 Increase/Decrease Statement:						
The increase from FY 2020 to FY 2021 is due to an increase in applied technology developments to counter small Unmanned Aerial Vehicle Swarms.						
Title: Human Performance, Training and Education		5.863	5.300	5.650	0.000	5.650

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Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603640M / MC Advanced Technology Demo	Project (Number/Name) 2223 / Marine Corps ATD				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<p>Description: This activity investigates several technology investment areas; warrior resilience, and decision-making and expertise development. Warrior resilience is focused on advanced training technologies and methodologies that enhance neural, cognitive, and physical readiness. Decision making and expertise development accelerates development and improves the retention of skills in decision making, situation awareness, and individual and team adaptability and coordination on decentralized, dynamic and dispersed battlefields. Focus will be on developing component level prototypes for Marine for evaluation and experimentation.</p> <p>FY 2020 Plans: Conduct research in wearable physiological monitoring, predictive algorithms, health tracking capability, and related technologies will provide the opportunity to integrate with Marine Corps' 'Force Fitness Division' programs in support of close combat formations and populations, in order to increase physical readiness and reduce potential injuries. The use of these 'Warrior Resilience' programs may be demonstrated as integral elements of larger, multipurpose exercises focused on all aspects of military tasks, or as stand-alone events where the primary purpose is to illustrate the capability to achieve improved awareness of the physical and physiological readiness of the individual. The advance of augmented reality devices and the content available for collection and display, and each of their contribution to simulation-based training (and the increased decision-making ability that this training can afford) will provide the opportunity to demonstrate 3-Dimensional (3D) terrain visualization, battlefield control measures and effects, and target identification and classification. This robust and ever increasing capability will be incorporated into demonstration opportunities at ever-increasing levels of complexity and scale to demonstrate the increased decision making efficiency - in both speed and accuracy of information processing across the plan, execute, and debrief spectrum of operations. Demonstrations will include advances in hardware, software, collection and display capabilities that will support increased decision making and expertise development and warrior resilience.</p> <p>FY 2021 Base Plans: Demonstrate capability to increase physical readiness and reduce potential injuries by using wearable physiological monitoring devices, predictive algorithms, health tracking capability, and related technologies that support Marine Corps' 'Force Fitness Division' programs. The use of these Warrior Resilience programs may be demonstrated as integral elements of larger, multipurpose exercises focused on all aspects of military tasks, or as stand-alone events where the primary purpose is to illustrate the capability to achieve improved awareness of the physical and physiological readiness of the individual.</p>						

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Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603640M / MC Advanced Technology Demo	Project (Number/Name) 2223 / Marine Corps ATD				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Continue efforts demonstrating 3D terrain visualization, battlefield control measures and effects, and target identification and classification will continue. This robust and ever increasing capability will increase decision making efficiency - in both speed and accuracy of information processing. Develop assessment tools and experiential training solutions to place, retain, and educate the right Marine for the right military occupation.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant change between FY 2020 and FY 2021						
Title: Intelligence, Surveillance, and Reconnaissance (ISR) Description: This activity investigates enhanced situational awareness, persistent surveillance, and tactical decision making through automated analysis of data and rapid integration of information and acquired knowledge. Specific technologies in this activity effectively present actionable information to decision-makers, especially those at the lower command levels. This includes biometric monitoring for expeditionary operations, operational Course of Action development, and autonomous surveillance in support of distributed operations. Conduct advanced development research on the impact of machine learning on mission outcomes. Will investigate the operational relevance of enhanced situational understanding and machine-aided tactical decision-making. This includes presenting actionable information (e.g. support to planning, mission monitoring, and re-planning to decision makers). Further, this activity supports the demonstration of technologies to enhance situational awareness and tactical decision making through automated analysis, fusion of data, rapid integration of information, and acquired knowledge resulting in actionable intelligence at the lower command levels. The activity includes the demonstration of ISR efforts involving enhanced reconnaissance and persistent surveillance, and sensors for unmanned ground and aerial vehicles. Advanced technology demonstrations also include the collection of information [monitoring, sensing, and locating] in the 3-Dimensional urban battlespace as well as exploiting information [identifying and classifying data] as part of the intelligence preparation of the battlespace in order to facilitate operational maneuver and distributed operations.		8.460	8.400	9.136	0.000	9.136
FY 2020 Plans:						

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Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603640M / MC Advanced Technology Demo	Project (Number/Name) 2223 / Marine Corps ATD				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
	Conduct assessment of the operational utility of natural language processing and computer vision. Show operational relevance of computer vision as an autonomy enabler. Increase emphasis on the production of synthetic data useful to train decision aids. Accelerate deep learning enabled data fusion. Mature algorithms capable of analyzing signatures and signature changes from graph data. Initiate development of deep learning architecture enablers including dynamic graph stores and workflow managers for models.					
FY 2021 Base Plans: Conduct advanced development research on the operational utility of artificial intelligence/machine learning algorithms and develop applications to specifically apply these techniques to Marine Corps intelligence and operations activities. Increase emphasis on the use of model-based simulators to generate data useful for machine learning while learning how to combine real data with operational data. Conduct experimentation with operational forces to understand the utility and impact of these tools on improving and accelerating understanding and information-based decision-making as well as reductions in operator workload						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: Increase from FY20 to FY21 is to enable tactical AI/ML development, work has accelerated to utilize reinforcement to teach agents to complete Marine to FY21sential Task under diverse conditions within standards. These agents then act within physics based simulations to provide training data needed to produce exercise decision aids. Work has also accelerated to give these agents known human decision preferences/biases in order to pass a "Turing" test for agent enabled simulations.						
Title: USMC Future Naval Capabilities		26.585	26.849	26.783	0.000	26.783
Description: This R-2 Activity addresses the advanced technology development associated with the Marine Corps' participation in the Department of the Navy's (DoN) Future Naval Capabilities (FNC) Program. The objective of the work in this Program Element (PE) is to develop promising technologies emerging from the FNC technology candidates funded in PE 0602131M that have been matured to higher Technology Readiness Levels (TRLs). Investments in this activity are coordinated with similar and non-duplicative efforts in PE 0603673N. The FNC Program is structured to accelerate the transition of new technologies to the Fleet and Force. Each effort is assessed for its technology maturity and transition commitment. Funding for FNCs, which have Technology Readiness Levels (TRLs) of 4/5 to 6 and also have transition funding commitments from acquisition Programs of Record, are resourced in this PE 0603640M MC Advanced Technology Demo. Funding for FNC technology						

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Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603640M / MC Advanced Technology Demo	Project (Number/Name) 2223 / Marine Corps ATD				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
candidates at lower TRLs (3 to 4) is resourced in PE 0602131M Marine Corps Landing Force Tech. ONR is working closely with the Resource Sponsors and acquisition stakeholders to develop high priority technological capabilities needed by the operational forces.						
FNC budget activity (BA) 2 investments develop candidate FNC technologies in an agile fashion by exploiting technology advances that respond rapidly to naval needs. This approach facilitates an optimum response when developing and maturing the technology options that can be developed further in this PE 0603640M MC Advanced Technology Demo.						
The FNC Program favors a high level of collaboration. Collaboration with the acquisition stakeholders and their resource sponsors is required. A complete accounting of the technology candidates being developed and a full disposition of each technology development effort funded in this PE is provided annually to the Congressional oversight committees.						
FY 2020 Plans: The advanced technologies being developed under this R-2 Activity focus on developing promising technologies emerging from the FNC Applied Research program that have been matured to a Technology Readiness Level of 4 to 5. Technologies being developed include, but are not limited to, those that increase target prosecution speed and accuracy against enemy firing positions by compressing the kill chain timeline through sensor fusion, Command and Control integration, and automated collaboration of warfighting functions, those that will enhance mobility, propulsion, autonomy, weapons, materials, logistics, vehicle architectures, and Electronic Warfare protection for a light armored vehicle fleet, technologies associated with the development of an affordable, longer range mortar projectile, with precision delivery against stationary and moving targets during periods of full Global Positioning Satellite denial, technologies that optimize the balance between hardening and flexible software development for future dynamic engagements in contested environments with adversaries, and new repair techniques to include the use of solid-state technologies such as cold-spray and additive friction stir welding for structural repairs.						
FY 2021 Base Plans: This activity will continue to focus on developing promising technologies emerging from the FNC Applied Research program that have been matured to a Technology Readiness Level of 4 to 5. Technologies being developed include, but are not limited to:						

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Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)		
<u>B. Accomplishments/Planned Programs (\$ in Millions)</u>				
		FY 2019	FY 2020	FY 2021 Base
				FY 2021 OCO
				FY 2021 Total
CRIT				
- In collaboration with Command, Control, Communications, Computers (C4) activity in this PE/project, initiate the accelerated development of capabilities to demonstrate small form factor technologies that provide improved signature management of the Marine Air-Ground Task Force (MAGTF) in electromagnetic and information environments. This effort addresses a high priority Marine Corps capability gap and directly supports the National Defense Strategy by providing an 'advanced autonomous system' for 'forward force maneuver and posture resilience'.				
Enabling Dynamic Operational RF (ENDOR)				
- Continue work on ENDOR by initiating development of a more secure tactical computing infrastructure, reducing its attack surface for modern C-UAS and C-IED applications that use standardized interfaces for rapid hardware and software integration.				
Armored Reconnaissance Vehicle (ARV)				
- Complete the integration of technologies into transformational advanced reconnaissance vehicle technology demonstrators and test and evaluate the land and water propulsion system, sensors, weapons, survivability, and unmanned systems in a relevant environment to assess enhanced capabilities.				
Enhanced Lethality for Maritime Operations (ELMO)				
- In collaboration with a complementary effort funded in PE 0603673N - FNC Advanced Technology Demonstration, initiate development of new Multi-Function Sensor (MFAS) modes for the MQ-4C Triton Unmanned Aircraft System (UAS), enhancing Distributed Maritime Operations (DMO) with the Next Generation Network (NGN).				
Streamlined Marine After-Action Review Tool- Visualization (SMART-Viz)				
- In collaboration with a complementary effort funded in PE 0603673N - FNC Advanced Technology Demonstration, initiate technologies that provide timely and improved feedback to warfighters to enhance learning in live and simulated environments.				
Multi Domain Radar for the Contested Environment (MuDRaCE)				
- In collaboration with the C4 activity in this PE/project, initiate the accelerated development of capabilities for a highly mobile multi-domain radar system with improved effectiveness and survivability to support MAGTF units in contested environments. This effort leverages MAGTF C4 networking and sensor development for system				

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
of systems capability to ensure key National Defense Strategy requirement for expeditionary 'forward force maneuver and posture resilience' and addresses a high priority Marine Corps capability gap.						
<p>All Signal Tactical Real-Time Analyzer (ASTRAL)</p> <p>- Initiate the development of sensors able to detect, identify, and characterize complex signals in contested and congested electromagnetic environments. This program will explore novel topologies that help to address these applications using photonics. Particular emphasis will be given to the use of integrated photonics as a path to reduce overall system cost, size, weight and power (C-SWAP).</p>						
<p>FY 2021 OCO Plans: N/A</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant change between FY 2020 and FY 2021.</p>						
<p>Title: Logistics</p> <p>Description: This activity investigates the practical discipline and real world application of the deployment, sustainment, reconstitution, and re-deployment of forces engaged in expeditionary operations. Logistics replaces mass with assured knowledge and speed, is equally capable ashore or afloat in austere environments, and is fully scalable to meet uncertain requirements. This includes efficient and responsive force sustainment, planning and directing logistics operations, logistics demand reduction, fleet maintenance, and expeditionary energy. Expeditionary Energy enhances combat capability of expeditionary warfighters by increasing the efficiency and effectiveness of energy production, storage, distribution and use. Beyond traditional energy efforts, this portfolio also looks at other issues, including energy-efficient behaviors and hybridization of energy sources. These pillars are thoroughly integrated and perpetually related in execution.</p>		9.053	7.837	9.495	0.000	9.495
<p>FY 2020 Plans: Logistics development will focus on the broad range of technologies to demonstrate the military utility of enhancing combat capability by increasing energy production, storage, distribution, and curbing energy consumption of the individual Marine and other tactical assets. This includes advanced system research into the scaled use of high specific power solar cell for Marine Corps applications ranging from the individual warfighter to augmenting the power and combat endurance unmanned robotic vehicles. Additionally investigate, system level research and demonstration of enhanced power and energy technologies to support the Marine warfighter as a system, to include enhanced power and energy storage technology, more energy efficient equipment,</p>						

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Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603640M / MC Advanced Technology Demo	Project (Number/Name) 2223 / Marine Corps ATD				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
	and enhanced power networks that enhance mission duration, decrease combat load, and enhance combat performance. Research into friction stir welding and additive friction stir welding, and cold spray for structural repair of Marine Corps equipment will be completed.					
FY 2021 Base Plans: Advance the broad range of technologies to demonstrate the military utility of enhancing combat capability by increasing energy production, storage, distribution, and curbing energy consumption of the individual Marine and other tactical assets. Conduct advanced system research into the scaled use of high specific power solar cell for Marine Corps applications ranging from the individual warfighter to augmenting the power and combat endurance unmanned robotic vehicles. Progress efforts to investigate energy-efficient planning for unmanned aircraft, enabling modular and reconfigurable tactical microgrids and wave energy technologies.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The funding increase from FY 2020 to FY 2021 reflects an alignment to Naval priorities and increased investment in logistic material transport surface and aerial platforms.						
Title: Maneuver Description: This activity investigates new ways and means to land forces and material through contested sea-land surface interfaces and then conduct maneuver warfare. In order to enable future Amphibious Operations, research efforts will support autonomous operations across the sea-surf-ground environment, improved fuel efficiency and speed of amphibious vehicles, amphibious vehicle technologies, water performance, and amphibious payloads to change the dynamics of a surface amphibious assault. This includes the emergence manned-unmanned teaming and autonomous vehicle collaboration. The technologies included in this work address areas of mobility, materials, propulsion, signature reduction, modularity, and unmanned systems. This also encompasses navigating the surf zone by a small autonomous vehicle, navigating negative obstacles on land at speed, overcoming adversarial intent, and developing low-cost robotic autonomy kits to support expeditionary amphibious operations (e.g., ISR, mine-counter-measures, breaching, fire support, and logistics).	13.070	14.526	12.450	0.000	12.450	
FY 2020 Plans:						

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Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603640M / MC Advanced Technology Demo	Project (Number/Name) 2223 / Marine Corps ATD				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
FY 2020 Plans include research and evaluation of advanced technologies for full combat systems. Demonstrator platforms will be developed that integrate novel propulsion, mobility, and autonomous technologies to enable enhanced land operations and seamless transition between land and water environments. The automation and autonomy systems developed will concentrate on the surf-zone and beach operations and include work to include development of unmanned swarming amphibious assault craft.	FY 2021 Base Plans: Progress the development and evaluation of mobility technologies and future concepts for the ground and amphibious fleet to improve maneuverability across a range of challenging terrain environments. Demonstration platforms will continue to be used for further development of technologies to enable enhanced land operations and seamless transition between land and water environments. Expand efforts on the automation and autonomy systems to include development of low-cost, unmanned swarming amphibious assault capable platforms with a focus on performance in the surf zone and beach environments. Conduct experimentation in increasingly challenging environments to evaluate system performance. Transition enabling technologies for the Armored Reconnaissance Vehicle from this activity to the Future Naval Capabilities activity					
FY 2021 OCO Plans: N/A	FY 2020 to FY 2021 Increase/Decrease Statement: The funding decrease from FY20 to FY21 reflects a transition of enabling technologies for the Armored Reconnaissance Vehicle from this activity to the Future Naval Capabilities activity.					
Title: Expeditionary Cyber Description: This activity provides freedom of maneuver and influence in the cyber-electronic warfare domain while simultaneously denying the same to the adversary and protecting critical command systems. Technologies are being developed using a multi-disciplinary approach that combines Radio Frequency electronics, digital signal processing, computer engineering, software engineering, machine learning and data science to support Naval Expeditionary warfighters operating with size, weight and power constrained equipment in Disrupted, Intermittent, Limited environments. Areas of applied research include distributed precision time, predictive software defined radio architectures, coordinated Cyber and Spectrum maneuver to mitigate detection and exploitation, tactical Cyber visualization, discovering and mapping networks in dense urban environments, contextual awareness and blind channel characterization.	2.405	0.000	0.000	0.000	0.000	
FY 2020 Plans:						

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
N/A						
FY 2021 Base Plans: N/A						
FY 2021 OCO Plans: N/A						
Accomplishments/Planned Programs Subtotals		98.695	95.327	114.439	0.000	114.439
C. Other Program Funding Summary (\$ in Millions)						
N/A						
Remarks						
D. Acquisition Strategy						
N/A						

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Appropriation/Budget Activity 1319 / 3					R-1 Program Element (Number/Name) PE 0603640M / MC Advanced Technology Demo				Project (Number/Name) 2297 / Futures Directorate				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
2297: <i>Futures Directorate</i>	0.000	45.900	73.046	99.806	-	99.806	100.116	94.027	74.996	74.492	Continuing	Continuing	

A. Mission Description and Budget Item Justification

The mission of the Marine Corps Warfighting Laboratory / Futures Directorate (MCWL/FD) is to identify future challenges and opportunities, develop warfighting concepts, and comprehensively explore options in order to inform the combat development process to meet the challenges of the future operating environment. The Deputy Commandant, Combat Development and Integration (DC, CD&I) is the United States Marine Corps (USMC) advocate for Science and Technology (S&T). MCWL's Commanding General (CG) is the proponent of USMC S&T and serves as the USMC Executive Agent for Marine Corps S&T. The MCWL/FD also serves as the Marine Corps' liaison to the Joint Staff for Joint Concept Development and Experimentation; thereby facilitating service-specific experiments as well as participation in joint service experimentation.

As reflected in strategic guidance, expeditionary forces will provide an ever-ready quick strike force to protect United States (US) interests. MCWL/FD pursues concepts, capabilities, and solutions to ensure that Marine of the future force will be effectively organized, trained, and equipped to win across the range of military operations in an uncertain and complex environment. Prioritized investments in S&T are necessary to enable the future Marine Corps and maintain a technological advantage over our adversaries.

This project is organized into 6 activities, the core of which are represented by the Warfighting Capability Areas of the Marine Air-Ground Task Force (MAGTF). The project emphasizes development and demonstration of advanced technology capability concepts, and the examination of their operational application and military utility in the context of formal wargames and live-force field experimentation with Marines. This operational experimentation directly supports Marine Corps combat development to inform future capability requirements and optimize the acquisition process.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Combat Service Support (CSS) and Force Protection Description: This activity includes Marine Corps Warfighting Laboratory / Futures Directorate (MCWL/FD) Combat Service Support and Force Protection experimentation efforts including assessment of equipment, new Tactics, Techniques, and Procedures (TTPs), training opportunities, and proposed organizational changes associated with enhanced capabilities. This activity develops technology in support of a more distributed technologically advanced force, increasing range, effectiveness, and survivability of the Marine Corps Air-Ground Task Force (MAGTF). Most programs listed below are considered major (valued at \$500K or more) or have near real-time operational impact. Investments in this activity are conducted under the Thrust Areas of Expeditionary Logistics, Expeditionary Medicine, Force Protection, or Autonomy and Robotics.	8.002	9.447	23.555	0.000	23.555

FY 2020 Plans:

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Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
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	Develop prototypes and experiment with logistics enablers and air defense enhancements in support of (EABO) and Littoral Operations in a Contested Environment (LOCE) as prescribed by the Commandant's Planning Guidance (CPG). This includes development and experimentation with autonomous sea-based surface connectors for over-the-horizon missions during ship-to-shore maneuvers. Experiment with efficient and redundant hybrid energy platforms providing reliable electrical power using multiple fuel input sources. Develop a highly mobile and efficient hybrid power generation and storage capability that provides the flexibility to operate with a variety of energy sources in support of EABO. Effort includes developing a modular design combining JP-8 fuel cell, solar, battery and energy scavenging technologies. Integrate hybrid/electric capabilities within the MAGTF to experiment with alternative vehicle power, extended mobility, and logistics demand reduction functions; building Concepts of Operations (CONOPS) and TTPs for tactical mobility utilizing electric/hybrid power as a fuel source. Improve ground maneuver force and critical installation defense against small unmanned aerial systems (UASs). Effort includes development of new counter UAS architectures, integration of new sensors for detection and tracking, and development of new counter-UAS defeat mechanisms. Develop, test, and evaluate autonomous/automated aerial platforms for logistics resupply. Develop and experiment with highly autonomous and synchronous logistics capabilities in support of expeditionary MAGTF operations, offering increased flexibility and speed to Marines by means of seamless, end to-end logistics chain management and execution. Effort includes air, sea, and ground based systems, providing tactical commanders with an organic, responsive, and flexible option(s) to support disbursed and semi-independent maneuver operations. Develop an autonomous explosive detection and defeat capability. Continue to develop and experiment with medical technologies that enhance survivability; includes power management and energy scavenging capabilities which will enable more effective casualty warming and blood storage/distribution. Integrate and experiment with systems to provide battlefield medical command and control and information management.					
FY 2021 Base Plans:	- Unmanned Logistics and Defense - Continue prototype development and experimentation of logistics enablers and air defense enhancements in support of a more distributed technologically advanced force, in support of (EABO). This effort develops platforms that assess and analyze execution of high-tempo unmanned support to dispersed and disaggregated forces during joint air-ground operations. Continue development and experimentation with autonomous sea-based surface connectors for over-the-horizon missions during ship-to-shore maneuvers. This effort addresses maneuvering from seabases and littorals and includes autonomous breaching, well deck operations, payload integration, and bulk transport of personnel and equipment.					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603640M / MC Advanced Technology Demo	Project (Number/Name) 2297 / Futures Directorate				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
- Sustainment - Sustain multiple technologies either developed or leveraged from existing capabilities that can be integrated within the MAGTF to experiment with alternate vehicle power, extended mobility, hybrid energy, expeditionary fuel distribution, and small unit water purification to enable logistics demand reduction and provide alternate sustainment to the MAGTF at all levels. This includes continuing experimentation with efficient and redundant hybrid energy platforms providing reliable electrical power using multiple fuel input sources. - Counter UAS - Continue development of counter UAS architectures, integration of sensors for detection, tracking, and defeat of unmanned aerial threats. Evaluate a host of technologies for frangible rounds and added equipment attachments to counter small UAS rounds. - Explosive Detection/Defeat - Continue to develop an autonomous explosive detection and defeat capability; integrating specialized sensors for enhanced neutralization. - Medical - Complete development of power management and energy scavenging capability to enable a more effective casualty warming and blood storage/distribution. Continue to experiment with systems to provide battlefield medical command and control and information management. Initiate the design and integration of an Automated Artificial Intelligence Medical Information System (AAIMIS), facilitating a medical logistics push from the Capabilities Based Medical Treatment Facility (CBMTF) by providing the situational awareness via Medical Common Operating Picture (MedCOP) for medical supply utilization at forward deployed medical units. - Warfighter Performance - Provide increased lethality and mobility to the warfighter through the integration of technology directly attributable to individual combat equipment. Emphasis placed on voice reaction / voice enhanced technologies, as well as multi-mode unmanned systems command and control with augmented reality technologies. Littoral Connectors - Pursue development and enhancement of capabilities for end-to-end distribution, storage, and supply of fuel to air, ground, and sea platforms.						

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Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603640M / MC Advanced Technology Demo	Project (Number/Name) 2297 / Futures Directorate				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
- Unmanned Logistics and Defense - Expand and accelerate autonomous air, ground, and surface platform development/integration to support dispersed and segregated forces during joint operations.						
- Warfighter Performance - Initiate prototype development and integration of critical warfighter capabilities. Integrated into individual combat equipment, systems are designed to increase warfighter lethality and mobility.						
- Littoral Connectors - Initiate experimentation of a modernized landing craft to sustain movement ashore, provide intra-theatre lift, and increase Expeditionary Advanced Based (EAB) survivability.						
Title: Fires, Targeting, and Maneuver		6.029	7.174	4.824	0.000	4.824
Description: This activity includes Marine Corps Warfighting Laboratory / Futures Directorate (MCWL/FD) experimentation efforts in the areas of fires, targeting, and maneuver including assessment of equipment, new Tactics, Techniques, and Procedures (TTPs), training programs, and proposed organizational changes associated with enhanced capabilities. This area increases fires, targeting, and maneuver related troop environmental awareness, lethality, and mobility using fused sensors as well as unmanned weaponized and reconnaissance air and ground vehicle platforms to support experimentation. Most programs listed below are considered major (valued at \$500K or more) or have near real-time operational impact. Investments in this activity are conducted under the Thrust Areas of Marine Air-Ground Task Force (MAGTF) Fires, Maneuver, and Autonomy and Robotics.						
FY 2020 Plans: Continue to provide a multi-purposed Unmanned Ground Vehicle (UGV) which hosts a government-owned modular payload architecture and provides the ability to rapidly modify payloads for a variety of missions across the MAGTF. In concert, evaluate various payloads that enhance dismounted unit abilities across the warfighting functions. Continue to pursue company level precision guided munitions to increase responsiveness, survivability, and lethality to the ground combat element. Specifics include development of: a multi-tubed launcher integrated with a UGV and the ability to remotely launch Unmanned Aerial Systems (UASs) from distributed positions. Experiment with a multi-purpose, electro-optical missile system with a real-time wireless data link for ranges up to 25km; operated in either direct attack or mid-course navigation based on target coordinates. The system has the ability to carry a heat, fragmentation, or anti-armor payload and can be integrated with a variety of sea, air, and land platforms. Initiate pursuit into a recoverable, long-range reconnaissance and precision strike asset with lethal capability against armored targets. Facilitate the integration of a small UAS with the identification, engagement, assessment, and adjustment of indirect fires for an individual						

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Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603640M / MC Advanced Technology Demo	Project (Number/Name) 2297 / Futures Directorate				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<p>Marine operating with an indirect fire weapon. Increase lethality of ground forces through rapid design iteration and testing of small UASs (sUASs), including advanced sensors and warheads. Experimentation efforts will include integration of critical payloads for immediate use and will enable earlier force training. Assess potential solutions to identified marksmanship capability gaps. Ensure the availability of Utility Task Vehicles (UTVs) for integration, testing, assessment throughout the experimentation cycle. Pursue technologies to dramatically increase the range and lethality of the MAGTF using a Low-Cost Unmanned Aerial Vehicle (UAV) with integrated swarming technology to create a Lethal Miniature Aerial Munition (LMAM). Experiment with loitering munitions launched from a variety of platforms (air, ground, and sea). Conduct swarming follow-on efforts to develop distributed, cognitive, collaborative, and cooperative swarming behaviors for maximum effect and complexity on target. Investigate Naval Surface Missile (NSM) simulators for experimentation of weapons system and integration with naval system queuing. NSM simulator systems will be used to exercise the NSM coastal defense system in coordination with Naval target sensing and tasking, allowing Naval vessels to queue and task NSM launch.</p> <p>FY 2021 Base Plans:</p> <ul style="list-style-type: none">- Unmanned Ground Vehicle (UGV) - Continue to provide a multi-purposed UGV, with modular payload architecture, with specific focus on counter battery. Continue to integrate payloads for the UGV platform that enhance dismounted units across the warfighting functions.- Aerial Munitions - Continue to pursue company level precision guided munitions to increase responsiveness, survivability, and lethality to the ground combat element. Continue experimentation with loitering munitions launched from a variety of platforms (air, ground, and sea) to develop distributed, cognitive, collaborative, and cooperative swarming behaviors for maximum effect and complexity on target. Continue experimentation of long range Low-Cost UAV swarming technology. Objectives include integration of command and control, multi-tubed launchers, and autonomous ground platforms to test capability of remotely launching UASs from distributed positions.- Multi-Domain Fires - Continue the examination and testing of precision guided munitions, to include the development of an integrated communications architecture. Effort will inform anti-ship missile concept development. Initiate experimentation of an end-to-end kill chain in multiple environments, neutralizing targets in an effective and cost efficient manner.- Marksmanship - Complete assessment of potential solutions to identified marksmanship capability gaps.						

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
- Naval Surface Missile - Complete assessment of Naval Surface Missile simulators for experimentation of weapons system and integration with naval system queuing.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The funding decrease from FY20 to FY21 is directly attributable to the completion of marksmanship technology demonstrations and the assessment of a Naval Surface Missile solution.						
Title: Marine Air-Ground Task Force (MAGTF) Command, Control, Communications, and Computers (C4) Description: This activity encompasses all Marine Corps Warfighting Laboratory/Futures Directorate (MCWL/FD) Command, Control, Communications, and Computers (C4) experimentation efforts including assessment of equipment, new Tactics, Techniques, and Procedures (TTPs), training programs, and proposed organizational changes associated with enhanced C4 capabilities. The area provides cutting edge/enhanced Over-The-Horizon (OTH), Beyond Line of Sight (BLOS), satellite and non-satellite based C4 capabilities to support experimentation. Programs listed below are considered major (valued at \$500K or more) or have near real-time operational impact. Investments in this activity are conducted under the Thrust Areas of Command, Control, Communications, and Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) and Cyber/Electronic Warfare (Cyber/EW).	8.124	9.269	6.900	0.000	6.900	
FY 2020 Plans: Conduct research to identify and assess a collaborative solution that provides tailorable Over-the-Horizon (OTH), On-the-Move (OTM), and Beyond Line of Sight (BLOS) communications, situational awareness, and fires for units across a wide spectrum of air, ground, and sea operations. Experiment with an organic and persistent capability to wirelessly receive, process, and disseminate digital information from organic sensors (to dismounted users), with relevant and/or immediately actionable information. This is done while simultaneously enabling BLOS digital connectivity to both higher and adjacent units (supporting dismounted operations). Effort will enable BLOS digital connectivity to higher and adjacent units. Initiate efforts to automate the identification of targets and expedite the sharing of information between sensors, shooters, and approval authority. Integrate electronic warfare technologies (ground and airborne sensors) and cyber space warfare technologies into demonstrations and live-force experiments to inform requirements and develop Tactics, Techniques, and Procedures (TTPs) for use by operational forces. Experiment with a cyber mission execution framework enabling						

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Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603640M / MC Advanced Technology Demo	Project (Number/Name) 2297 / Futures Directorate				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
	<p>military commanders, planners, and operators to collaborate, understand, plan, and manage cyber operations in real-time against large-scale and dynamic network environments. Initiate cyber and communications infrastructure common operational picture tactics and procedures for situational awareness and coordination of battlefield effects. Experiment with worldwide social media mapping. This technology will enable real-time situational awareness of the information environment (IO), including content and location of social media users. Open IO technology will provide Marines at the tactical edge with alerts using civilian and adversary open source communications. Provide units at the tactical edge IO situational awareness, planning, and command and control tools to include measures of effectiveness.</p> <p>FY 2021 Base Plans:</p> <ul style="list-style-type: none">- Asymmetric Command and Control (C2) - Continue research to identify and assess a collaborative solution, providing tailorable OTH, OTM, and BLOS communications, situational awareness, and fires for units across a wide spectrum of air, ground, and sea operations. Efforts include upgrading radios with service specific cryptology.- Integrated C2 - Continue experimentation with an organic and persistent capability to wirelessly receive, process, and disseminate digital information from organic sensors (to dismounted users), with relevant and/or immediately actionable information. Efforts include maintenance of experimentation assets as well as development to enable receipt of ground entry point information from an aerial fused integrated network asset. In addition, continue to pursue automatic target recognition, identification, and prosecution.- Electronic Warfare / Cyberspace - Continue experimentation with a cyber mission execution framework enabling military commanders, planners, and operators to collaborate, understand, plan, and manage cyber operations in real-time against large-scale and dynamic network environments. Pursuits include evaluating cyber anomaly detection hardware devices that possess artificial intelligence (AI), identifying abnormal behaviors and notifying the user of deviations. Continue experimentation of cyber and communication infrastructure common operational picture TTPs, increasing situational awareness and battlefield effects. Investigate defensive, offensive, and cyberspace warfare protection and monitoring capabilities through all echelons of the Marine Expeditionary Forces (MEF).- Information Operations - Complete experimentation with worldwide social media mapping.					

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Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603640M / MC Advanced Technology <i>Demo</i>	Project (Number/Name) 2297 / Futures Directorate				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<p>- Air Command - Develop, integrate, and experiment with a Tactical Air Control Element (TACE); improving mobility and digital interoperability internal to the Marine Air Command and Control System. Efforts will provide an ability to control and de-conflict airspace.</p> <p>FY 2021 OCO Plans: N/A</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: The funding decrease from FY20 to FY21 is directly attributable to the completion of experimentation and assessment of worldwide social media mapping.</p>						
<p>Title: Marine Air-Ground Task Force (MAGTF) Intelligence, Surveillance, and Reconnaissance (ISR)</p> <p>Description: This activity includes Marine Corps Warfighting Laboratory / Futures Directorate (MCWL/FD) Intelligence, Surveillance and Reconnaissance (ISR) related experimentation efforts including assessment of equipment, new Tactics, Techniques, and Procedures (TTPs), training programs, and proposed organizational changes associated with enhanced ISR capabilities. Using a variety of fused sensors to mesh data, video, and images and incorporating a common tactical controller to operate multiple air and ground ISR platforms, this area enhances small unit situational awareness as well as exploitation and forward engagement ability via experimentation. Programs listed below are considered major (valued at \$500K or more) or have near real-time operational impact. Investments in this activity are conducted under the Thrust Areas of Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) and Autonomy and Robotics.</p> <p>FY 2020 Plans: Expand development of government-owned Unmanned Aerial Systems (UAS) architecture to allow for rapid design iterations in support of experimentation. Effort will continue to provide situational awareness of the battlespace, incorporating payloads that improve navigation and allow for multi-mode sensors. Experiment with enabling technologies to combine sensor and telemetry data from multiple unmanned platforms (ground, surface (water), and air); minimizing operator intervention over current systems, with the ability to react in a wide range of operational tasks, environmental conditions, and landscapes. Continue to develop a capability to display and control a myriad of unmanned platforms and sensor inputs in a fused network on a common controller for Intelligence, Surveillance and Reconnaissance (ISR) as well as target identification and prosecution. Initiate</p>		4.376	20.869	22.875	0.000	22.875

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Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)		
1319 / 3	PE 0603640M / MC Advanced Technology Demo	2297 / Futures Directorate		
B. Accomplishments/Planned Programs (\$ in Millions)				
		FY 2019	FY 2020	FY 2021 Base
experimentation with an autonomous reconnaissance system, improving threat situational awareness and reducing tactical surprise to assault forces on long range missions. Initiate an effort to receive, transmit, and fuse joint asset specialized sensor information to communications nodes afloat and ashore via an aerial gateway. Expand investigations to add a Mission-Configurable Software Defined Radio with an Electronically Steerable Array (ESA) to the currently developed communication pod. Missions will include, but not be limited to, Early Warning radar, Cueing radar and/or Electro-magnetic Spectrum Operations. Effort will utilize Artificial Intelligence (AI) software to fuse sensor information in order to generate track information on-board the pod and then push it to both terrestrial communications nodes and directly to aircraft. Seek to provide a multi-role, long reach, expeditionary, next generation network of ISR capabilities. This includes the enhancement of capabilities for multi-sensor collection, fusion and real-time transmission; multi-electro-magnetic spectrum operations; C4 network bridge and relay; escort and protection for assault forces; persistent and precision fires and targeting; integration of an early warning air defense network; and informing assault support.				FY 2021 OCO
FY 2021 Base Plans:				FY 2021 Total
<ul style="list-style-type: none">- Small UASs - Continue to expand experimentation and development of government-owned UAS architectures to allow for rapid design iterations. Continue experimentation with an autonomous reconnaissance system, improving threat situational awareness and reducing tactical surprise to assault forces on long range missions. Objectives include rapid design, build, test, and experimentation of technologies to increase ground maneuver force capabilities.- Robotic Autonomous Command and Control (C2) - Continue to investigate/experiment with enabling technologies; combining sensor and telemetry data from multiple unmanned platforms (ground, surface (water), and air). Efforts will include conducting multi-manned and unmanned system missions focusing on intuitive control and robust localization.- Universal Controller - Complete development of a common controller for ISR as well as target identification and prosecution. Program aspects successfully transitioned into programs of record.- Mapping - Continuing investigations into providing a small, lightweight, semi-autonomous system that can self-navigate structure interiors and subterranean environments while simultaneously creating real-time three-dimensional (3D) maps.				

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
- Fused Integrated Networking - Continue experimentation and development to receive, transmit, and fuse joint asset specialized sensor information to communication nodes afloat and ashore via an aerial gateway. Efforts include sharing of aerial obtained fused sensor data information and/or organically produced sensor information with other air, ground, space, surface, and sub-surface platforms.						
- Air-Launched Reconnaissance - Continue to provide a multi-role, long reach, expeditionary, next generation network of ISR capabilities. Efforts include providing a deployable UAS capable of dashing ahead of MV-22 aircraft to conduct final reconnaissance of the landing zone to update threat situation in route to the objective.						
- Information Operations - Develop and enhance capabilities to increase situational awareness and influence decision making. Specifically, efforts support the operational utility of artificial intelligence/machine learning.						
- Space - Initiate development of disruptive space-based capabilities to Marine Air-Ground Task Force (MAGTF) planners at the tactical edge, increasing cognitive awareness to the adversary space threat, and developing unique space-based tools for wargaming and concept development.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The FY20 to FY21 increase is directly attributable to the following areas: - Small Unmanned Aerial Systems (UASs) - Continue to explore and expand mission sets and exploit the tactical potential of small UASs across multiple Marine Corps domains; focusing on autonomy, innovative applications, and the most advanced small UAS technology. - Space - Initiate efforts to provide space-based capabilities to the Marine Air-Ground Task Force (MAGTF) planners at the tactical edge. Information Support - Develop and enhance capabilities to increase situational awareness and influence decision making. Specifically, efforts support the operational utility of artificial intelligence/machine learning.						
Title: Marine Corps Warfighting Laboratory / Futures Directorate (MCWL/FD) Operations (SUPPORT)	12.120	13.087	20.035	0.000	20.035	

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Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)		
1319 / 3	PE 0603640M / MC Advanced Technology Demo	2297 / Futures Directorate		
B. Accomplishments/Planned Programs (\$ in Millions)				
		FY 2019	FY 2020	FY 2021 Base
Description: Marine Corps Warfighting Laboratory / Futures Directorate (MCWL/FD) Operations (Support) efforts include overarching experimentation doctrine, planning, management, technical/engineering support, analysis, data collection and reporting, as well as technology transition tracking efforts. Programs listed below are considered major (valued at \$500K or more) or have near real-time operational impact.				FY 2021 OCO
FY 2020 Plans: MCWL/FD will elicit a broad range of unique analytical expertise to evaluate experiments in various warfighting areas. Design experimentation plans, collect data during experiments, perform reconstruction and analysis of experiments, and prepare experiment analysis reports. Identify global commercial technology trends/innovations and disruptive technologies which may impact future Marine Corps capabilities. Expand upon generalized as well as specific program level engineering, technical, and management support. In addition, technical program area management capability increased. Initiate investigations into development of a narrow Artificial Intelligence (AI) capability which is capable of automating data collection to assist in tracking and decision making regarding technology based programs of interest.				FY 2021 Total
FY 2021 Base Plans: <ul style="list-style-type: none">- Experimentation Analysis - Building upon lessons learned in previous experimentation, continue to design, collect data, and provide independent analytical evaluations of experiments. Analysts take active roles in supporting experimentation concept refinement, capability development, and identification of tactics, techniques and procedures; organizational changes; technologies; and training that the experiments are designed to test.- Commercial Forecasting - Explore new mechanisms to identify long-range commercially available technologies/innovations that may influence future Marine Corps investments.- Management Support - Continue to provide program level engineering, technical, and managerial support. Efforts include detailed program planning and tracking and encompass technology development and experimentation insertion; troop development and concepts of operation; and portfolio development and execution.- War Room - Continue to investigate Artificial Intelligence (AI) capabilities to streamline data collection and program presentation, facilitating informed rapid decision-making. Promote transparent communication, problem-solving, risk mitigation, and status reporting by visually communicating project activities, milestones, and transition opportunities.				

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
- Collaboration - Provide a laboratory facility to co-locate experimentation designers/implementers with project teams and technologists to enhance effectiveness of experimentation design, development, implementation, reporting, prototyping, and outreach of results.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The FY20 to FY21 increase is directly attributable to the following areas: - Management Support - Increase technical, engineering, and managerial staff support to provide necessary strategic planning and program management support across the enlarged spectrum of experiment-based initiatives. - Collaboration - Establish an environment to support continuous interactions of program technicians and experimentation designers. Structured with collaborative design and tool sets; this co-location will greatly aid in technology development, demonstration, as well as experiment implementation.						
Title: Warfighting Excellence Description: This activity includes Marine Corps Warfighting Laboratory / Futures Directorate (MCWL/FD) efforts in the development and assessment of joint and service warfighting concepts, joint and service missions, analysis of emerging threats and opportunities, and joint capability experimentation. It also includes MCWL/FD service experimentation in areas that impact multiple warfighting functions. Programs listed below are considered major (valued at \$500K or more) or have near- real-time operational impact.	7.249	13.200	21.617	0.000	21.617	
FY 2020 Plans: Aid the combat development process by conducting 11 core wargames. Focus areas include the CPG supported Expeditionary Advanced Base Operations (EABO) and Littoral Operations in a Contested Environment (LOCE). Create an effective collaborative wargaming environment that will increase the use of automated and analytical tools, and will provide the necessary quantitative and qualitative output for Marine Corps capability/concept development. Coordinate with the Marine Corps Systems Command's (MCSC's) Wargaming Center of Excellence to provide an encompassing wargaming ability throughout the Marine Corps. Focusing 15 to 30 years in the future, continue to offer top level identification and analysis of emerging asymmetric						

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
threats and opportunities. This is accomplished by capitalizing on a myriad of foresight assessments of future operating environments. Maintain insight and continue making contributions to support approved Joint Concept Technology Demonstrations (JCTDs) and Emerging Capability Technology Demonstrations (ECTDs) efforts and warfighting concepts; intended to provide rapidly fieldable capabilities by using emergent mature technologies matched with innovative operational concepts. This includes furthering demonstrations with a high-altitude balloon-borne communications platform and continuing development efforts of distributed mobile amphibious (and ground) assault fuel logistics capabilities. The communications platform effort involves demonstrating and experimenting with the military utility of a resilient, low cost, effective, high-altitude balloon-borne communications platform that can be rapidly deployed to enhance warfighter communications capabilities. The fuel logistics efforts include demonstration and experimentation to build the concept of employment as well as tactics, techniques, and procedures (TTPs) for inflatable, scalable, double-walled fuel storage, transport, and transfer systems for bulk fuel logistics. Continue in the conduct of a multi-year effort to enhance situational awareness; Command and Control (C2); and fires and maneuver in the dense urban environment. Conduct experimentation events to identify changes in training, organizing, and equipping future forces and provide venues for live-force evaluation and assessment. Bring concept developers, operational Subject Matter Experts (SMEs), and technologists together in order to discover, purchase, and assess new and advanced technologies that can aid in the implementation and refinement of the Expeditionary Advanced Base (EAB) concept. Additionally, by exposing technology and acquisition professionals to the concept, future development can be guided. Explore the use of modeling and simulation tools and techniques to gather, process, analysis, and utilize operational data in support of experiment development, execution, and assessment. Capitalizing on an OSD 2 year investment, provide organic, experimental opposition force capability (Red Team, Red Cell and Live Adversary Force). This will assist in providing a more realistic, adaptive, and cohesive enemy force/civil infrastructure for wargames, command post exercises, simulations, and experimentation events in order to support free-play, friendly force adaptation and decision-making skills.						
FY 2021 Base Plans: - Wargaming - Continue to plan and execute executive agent responsibilities for the Marine Corps Title Ten Wargame, Expeditionary Warrior, as well as other wargames to examine Marine Corps capstone, operating, and functional concepts and explore assigned topics. A minimum of 11 wargames will be conducted (4 large, 5 medium, and 2 small); all examining concept and combat development issues, experimentation, and other assigned topics. Establish a stand-alone Wargame Network (develop, test, train, and operate) that provides visualization support (tools, methods, and procedures) as well as modeling and simulation (M&S) capabilities during wargames.						

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
- Emerging Threats and Opportunities - Continue to assess and analyze the future security environment; identify and analyze emerging threats; develop and appraise promising concepts, opportunities and technologies; and serve as a catalyst to stimulate thought and debate on issues of importance to the Marine Corps. - JCTD - Continue to monitor and contribute to approved efforts that address joint and combatant command warfighting needs through the execution and demonstration of prototypes within two to four years. The program delivers developmental and operational prototypes to affordably operationalize technologies that enable warfighters to explore novel concepts and to facilitate informed transition to formal acquisition programs. Complete high-altitude balloon-borne communications and bulk-fuel logistics efforts. Develop technology to enable barges/vessels to serve as distributed resupply nodes in support of littoral operations. - Exercise Support - Continue multi-year effort to enhance the ability of the Marine Air-Ground Task Force (MAGTF) to conduct operations in the dense urban environment. Develop and refine objectives and capability areas to address challenges in the future operating environment. - Innovation - Conduct warfighter driven challenges to develop prototypes and foster innovation with the Marine Corps. Reaching out to fleet organizations, engage entities and develop required capabilities for further testing and evaluation. - Modeling, Simulation, and Analysis - Expand the use of M&S tools and techniques to provide analysis to support capability development activities. Model and assess naval operations with a focus on current pacing threat and theater. Provide analytical support to the Marine Corps Capability Based Assessment and Integration Process (MC CIP) and other complementary efforts. - Experimentation Opposition Force - Continue to demonstrate the abilities of a live adversary force. Force provides a realistic, adaptive, and cohesive adversary as well as civilian environmental characteristics. This concept strongly enhances experimentation and strengthens experiment hypotheses and objectives. - Autonomous First Wave - Initiate a multi-year campaign to assess an ecosystem of technologies to better understand and advance capabilities to ultimately increase the lethality and effectiveness of the warfighter on tomorrow's battlefield. Efforts include, manned and unmanned teams capable of conducting military operations in complex urban terrains and multi-domain environments.						

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
- Joint Assessment Strategies - Initiate investigations to pursue a lethal, resilient, and rapidly adaptive Joint Force capable of defeating and deterring potential adversaries. Experimentation efforts will seek to inform future warfighting architectures, address/solve identified challenges, and analyze the hardest military challenges facing the United States (US) and our allies.						
- Artificial Intelligence (AI) - Initiate operational integration of AI into concept based experimentation. Deliver AI enabled capabilities that address key missions, including improvement of situational awareness and decision-making, implementation of predictive maintenance and supply, and streamlining business processes.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The FY20 to FY21 increase is directly attributable to the following areas:						
- Wargaming - Establishment of a technical staff for wargame planning, development, and execution. These technical enablers are subject matter experts (SMEs) in modeling and simulation (M&S), visualization, and network development, programming, setup, and management. The increase in personnel, specialized equipment, and software will improve player interface, allow for increased interactive visualization, provide for more rapid and systematic wargame adjudication, improve qualitative analytic outputs, and identify topics for subsequent deeper computational analysis.						
- Modeling, Simulation, and Analysis - Data driven assessment of Marine Corps programs through the lens of the CPG and force design.						
- Experimentation Opposition Force - Capitalize on ideas and strategies suggested by SMEs and provide opposing forces with combative equipment and gear to reinforce live-force experimentation. Also provide equipment/gear/assets to aid with civilian interaction perceptions/realism.						
- Autonomous First Wave - Initiate a multi-year effort to provide guidance, vision, and unity of effort. Program objectives will feed and support live force experimentation as well as map directly to the National Defense Strategy (NDS) and CPG. Each Limited Objective Assessment (LOA) will portray a multi-disciplinary/cross-						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603640M / MC Advanced Technology Demo	Project (Number/Name) 2297 / Futures Directorate				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
functional approach towards larger foci; assessing technologies at different phases of ship-to-shore maneuver and combat operations in an urban environment.	- Joint Assessment Strategies - Research and address an increasingly contested environment with rapidly evolving security challenges; highlighted by the emergence of major peer competitors. - Artificial Intelligence (AI) - Investigate concepts, methods, toolkits, software applications, and ideologies to provide/promote AI support/use for MCWL concept based experimentation.					
	Accomplishments/Planned Programs Subtotals	45.900	73.046	99.806	0.000	99.806
C. Other Program Funding Summary (\$ in Millions)		N/A				
Remarks						
D. Acquisition Strategy		N/A				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020						
Appropriation/Budget Activity 1319 / 3					R-1 Program Element (Number/Name) PE 0603640M / MC Advanced Technology Demo				Project (Number/Name) 2958 / Cyberspace Activities								
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost					
2958: Cyberspace Activities	0.000	0.000	4.474	4.800	-	4.800	4.800	4.800	5.000	5.099	Continuing	Continuing					
A. Mission Description and Budget Item Justification																	
This Project activity provides freedom of maneuver and influence in the cyber-electronic warfare domain while simultaneously denying the same to the adversary and protecting critical command systems. Technologies are being developed using a multi-disciplinary approach that combines Radio Frequency electronics, digital signal processing, computer engineering, software engineering, machine learning and data science to support Naval Expeditionary warfighters operating with size, weight and power constrained equipment in Disrupted, Intermittent, Limited environments. Areas of applied research include distributed precision time, predictive software defined radio architectures, coordinated Cyber and Spectrum maneuver to mitigate detection and exploitation, tactical Cyber visualization, discovering and mapping networks in dense urban environments, contextual awareness and blind channel characterization.																	
B. Accomplishments/Planned Programs (\$ in Millions)																	
													FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Expeditionary Cyber													0.000	4.474	4.800	0.000	4.800
FY 2020 Plans: Cyber related demonstrations and experimentations will be conducted to verify the secure transfer of information across mobile tactical user platforms. Controlled demonstrations will be conducted to assess battle damage on a class of systems from the use of cyber effects. Demonstrations of cyber hardened operational systems will be conducted to showcase improved resiliency. Software redesign of modular Cyber/Electronic Warfare systems will be demonstrated as a proof of concept prototype. Initiate research to develop a rapid testing tool of major C2 and weapon systems to provide acquisition sponsors and operational planners a method to identify and project vulnerabilities and impacts within computing systems and networks as well as an operational assessment measures to determine how to proactively address these issues and maximize projection power.																	
FY 2021 Base Plans: - Cyber related research will initiate the advanced technology development of mitigation techniques related to USMC systems - Cyber related activities will continue to improve the overall cyber protection strategy for deployed systems at the battalion level and below that feed into the Marine Air-Ground Task Force (MAGTF) Information Group Integrated Command Center - Further research to better identify key cyber terrain at the physical, logical, and cyber persona layers that can be visualized at small unit level																	

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603640M / MC Advanced Technology Demo	Project (Number/Name) 2958 / Cyberspace Activities		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base
- Completion of integrating a framework to quickly reconfigure hardware accelerator devices to understand unknown signals of interest in the wild				
FY 2021 OCO Plans: N/A				
FY 2020 to FY 2021 Increase/Decrease Statement: Funding increase reflects a transition of enabling technologies for dynamic radio frequency agility efforts from 0602131M to this activity integrated into the Future Naval Capabilities activity being executed.				
Accomplishments/Planned Programs Subtotals				0.000 4.474 4.800 0.000 4.800
C. Other Program Funding Summary (\$ in Millions)				
N/A				
Remarks				
D. Acquisition Strategy				
N/A				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity					R-1 Program Element (Number/Name)				Project (Number/Name)				
1319 / 3					PE 0603640M / MC Advanced Technology Demo				9999 / Congressional Adds				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
9999: Congressional Adds	0.000	26.064	39.500	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	65.564	
A. Mission Description and Budget Item Justification													
Congressional Interest Items not included in other Projects.													
B. Accomplishments/Planned Programs (\$ in Millions)											FY 2019	FY 2020	
Congressional Add: Common Unmanned Aerial Vehicle Simulation System											9.654	0.000	
FY 2019 Accomplishments: Develop technology for mission simulation to help reduce the development cycle time of UAVs.													
FY 2020 Plans: N/A													
Congressional Add: Flight Motion Simulator and Testing of UAVs											5.792	0.000	
FY 2019 Accomplishments: Conduct research using computer simulation sensor modeling and actuator modeling in real-time with UAV hardware and software.													
FY 2020 Plans: N/A													
Congressional Add: Modular Advanced Armed Robotic System 2.0											3.861	0.000	
FY 2019 Accomplishments: MCWL/FD continued experiments to assess the military utility of small tactical autonomous unmanned ground vehicle systems. Multiple systems were purchased, integrated with a common ground remote control system and applicable communications assets, and performance tested using a variety of control parameters. Once demonstrated, results analysis is conducted and reported to aid in requirements identification.													
FY 2020 Plans: N/A													
Congressional Add: UAS Air-Delivered Extended Range Munitions Demo											6.757	0.000	
FY 2019 Accomplishments: Conduct research for technology maturation and testing of a full cartridge level solution prototype extended range guided projectile for an airborne platform. This proposed effort will develop and integrate enabling technologies with 81mm and 120mm extended mortar cartridges for launch from an airborne platform rather than ground launch from a mortar tube.													
FY 2020 Plans: N/A													
Congressional Add: Robotic protection system											0.000	5.000	

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy			Date: February 2020
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603640M / MC Advanced Technology Demo	Project (Number/Name) 9999 / Congressional Adds	
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020
FY 2019 Accomplishments: N/A			
FY 2020 Plans: Perform Marine Corp Advance Technology research in Robotic protection systems.			
Congressional Add: Expeditionary mission planning enabled by high fidelity simulation		0.000	10.000
FY 2019 Accomplishments: N/A			
FY 2020 Plans: Perform research in Expeditionary mission planning enabling advance high fidelity simulations.			
Congressional Add: Extended range 155mm projectile		0.000	2.500
FY 2019 Accomplishments: N/A			
FY 2020 Plans: Perform Advanced Technology research in Extended range 155mm projectiles.			
Congressional Add: Adaptive threat force		0.000	7.000
FY 2019 Accomplishments: N/A			
FY 2020 Plans: Perform Advance research in Adaptive threat force Technology.			
Congressional Add: Air drop extended range munitions		0.000	15.000
FY 2019 Accomplishments: N/A			
FY 2020 Plans: Perform Advanced Technology research in Air drop extended range munitions.			
Congressional Adds Subtotals		26.064	39.500
C. Other Program Funding Summary (\$ in Millions)			
N/A			
Remarks			
D. Acquisition Strategy			
N/A			

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy											Date: February 2020					
Appropriation/Budget Activity					R-1 Program Element (Number/Name)											
1319: Research, Development, Test & Evaluation, Navy / BA 3: Advanced Technology Development (ATD)					PE 0603651M / JT Non-Lethal Wpns Tech Dev											
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost				
Total Program Element	0.000	12.956	13.307	13.301	-	13.301	13.564	13.840	14.116	14.399	Continuing	Continuing				
3022: Joint Non Lethal Weapons	0.000	12.956	13.307	13.301	-	13.301	13.564	13.840	14.116	14.399	Continuing	Continuing				

A. Mission Description and Budget Item Justification

The DoD Non-Lethal Weapons Program was established by the FY96 National Defense Authorization Act. The Office of the Secretary of Defense designated the Commandant of the Marine Corps (CMC) as the DoD NLW Executive Agent (EA). The EA exercises centralized responsibility for joint research and development of non-lethal weapons and technology through the Joint Non-Lethal Weapons Program (JNLWP). The Office of the Under Secretary of Defense for Acquisition and Sustainment (A&S) serves as the OSD Principal Staff Assistant and oversees, in consultation with the Under Secretary of Defense for Policy, the DoD NLW Executive Agent.

The efforts described in this Program Element (PE) reflect science and technology (S&T) investment decisions by the Joint Non-Lethal Weapons (NLW) Integrated Product Team, a multi-service flag level corporate board that provides executive oversight and management for the JNLWP for the CMC. This direction is based on the requirements and capabilities sought by the Services and the Coast Guard, as identified in the DoD's Non-Lethal Weapons Joint Capabilities Based Assessment Document. This coordinated joint S&T development approach addresses mutual capability gaps and assures the most relevant non-lethal technologies, capabilities and equipment are provided to the operating forces while eliminating duplicative service S&T investment. These advanced technology development initiatives feed non-lethal capabilities which directly support the National Defense Strategy (NDS) objective of strategic competition by providing options to the joint force in pursuit of national objectives in legal or policy constrained scenarios, as well as complementing the use of lethal effects in complex combat scenarios, for example, in urban environments with large civilian populations. Ongoing NLW studies, analyses and exercise efforts with North Atlantic Treaty Organization (NATO) and Allies also support NDS objectives to strengthen alliances and partnerships. Resulting capabilities will facilitate a fully integrated non-lethal competency as a complement to lethal firepower, providing force application options for below lethal threshold engagements.

This program funds Advanced Technology Development of next-generation non-lethal capabilities and includes performing analysis, technology development efforts, and modeling and simulation necessary to ensure optimum weaponization and use of these capabilities. Investment areas include research and development of next-generation NLWs such as: non-lethal directed energy weapons (lasers, millimeter wave and high power microwave) for counter-personnel and counter-materiel missions; non-lethal counter-personnel technologies (acoustic, optical, and human electro-muscular disruption technologies), and advanced non-lethal materials (including materials for vehicle/vessel stopping and counter-facility applications). Next generation non-lethal systems focus on long-range localized non-lethal effects to identified threat individuals (or groups of individuals) and/or their threat weapons systems operating in complicated environments such as urban areas, crowds, buildings, vehicles, vessels, and also in close proximity to high-value civilian facilities.

This Program Element (PE) funds Advanced Technology Development (ATD) that includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment. Efforts in this PE generally have Technology Readiness Levels TRL of 4 (component and/or breadboard validation in laboratory environment.), 5 (component and/or breadboard validation in relevant environment.), or 6 (system/subsystem model or prototype demonstration in a relevant environment).

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy				Date: February 2020
Appropriation/Budget Activity	R-1 Program Element (Number/Name)			
1319: Research, Development, Test & Evaluation, Navy / BA 3: Advanced Technology Development (ATD)	PE 0603651M / JT Non-Lethal Wpns Tech Dev			
Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.				
B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO
Previous President's Budget	13.313	13.307	13.301	-
Current President's Budget	12.956	13.307	13.301	-
Total Adjustments	-0.357	0.000	0.000	-
• Congressional General Reductions	-	-		
• Congressional Directed Reductions	-	-		
• Congressional Rescissions	-	-		
• Congressional Adds	-	-		
• Congressional Directed Transfers	-	-		
• Reprogrammings	-	-		
• SBIR/STTR Transfer	-0.357	0.000		
• Rate/Misc Adjustments	0.000	0.000	0.000	-
				0.000
Change Summary Explanation				
Funding: No significant change				
Technical: no significant change				
Schedule: no significant change				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity					R-1 Program Element (Number/Name)				Project (Number/Name)				
1319 / 3					PE 0603651M / JT Non-Lethal Wpns Tech Dev				3022 / Joint Non Lethal Weapons				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
3022: Joint Non Lethal Weapons	0.000	12.956	13.307	13.301	-	13.301	13.564	13.840	14.116	14.399	Continuing	Continuing	
A. Mission Description and Budget Item Justification													
This project funds the research and development of next-generation Non-Lethal Weapons and includes performing analysis, technical development efforts, and modeling and simulation necessary to ensure optimum weaponization and use of these NLWs. Investment areas include research and development of next-generation Non-Lethal Weapons (NLW) such as: non-lethal directed energy weapons (lasers, millimeter wave and high power microwave) for counter-personnel and counter-materiel missions; non-lethal counter-personnel technologies (acoustic, optical, and human electro-muscular disruption technologies), and advanced non-lethal materiels (including materiels for vehicle/vessel stopping and counter-facility applications). Next-generation Non-Lethal Weapon systems focus on long-range localized Non-Lethal effects to identified threat individuals (or groups of individuals) and/or their threat weapons systems operating in complicated environments such as urban areas, crowds, buildings, vehicles, vessels, and also in close proximity to high-value civilian facilities.													
B. Accomplishments/Planned Programs (\$ in Millions)													
Title: Joint Non-Lethal Weapons													
FY 2020 Plans:													
Advance the development, integration, and demonstration of advanced technologies and payloads capable of addressing non-lethal counter-personnel and counter-materiel capability gaps while minimizing risk to the operator. Development efforts include the prototyping of: (1) a next-generation long range - long duration wireless Human Electro-Muscular Incapacitation munition; (2) short pulse source and other high power microwave waveforms that are effective against threat vehicle, vessel, and other target with embedded electronic systems; (3) longer range but more compact millimeter wave technologies capable of being integrated and tested on future escalation of force platforms; and (4) improved sound and light and non-lethal laser technologies. This includes the development and integration of advanced solid-state and vacuum-tube based millimeter wave technologies for counter-personnel directed energy effects. Continue human effects modeling and analysis efforts to incorporate risk of significant injury knowledge of specific next-generation NLWs currently under development and utilizing new non-lethal stimuli and phenomenologies. Transition prototype technologies offering operational utility to higher levels of technology development and acquisition.													
FY 2021 Base Plans:													
Conduct research and investigation of intermediate force effects and emergent technologies with the potential to further address the Joint Requirements Oversight Council (JROC) approved non lethal counter-personnel and counter-materiel capability gaps. Specifically, explore new non-lethal effects and evaluate alternative innovative applications of existing technologies to address future non-lethal capability needs as escalation													

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020	
Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)			
B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
of force platforms. Some examples of counter-personnel research include further optimization of non-lethal human effects, and enhanced understanding of human target behavioral effects. Conduct applied research to characterize non-lethal phenomena and to assess target human effects and weapon effectiveness, including the development of dose response and injury correlates for new Non-Lethal Weapons (NLW) technologies. Other research includes the assessment and study of new intermediate force technologies related to NLW effectiveness and behavioral response, such as advancing the understanding of Flash Bang effects on humans to support novel non-explosive alternatives to pyrotechnic non-lethal devices. Some examples of counter-materiel research include the investigation of novel intermediate force capabilities for increased delivery and employment options for applications such as vehicle and vessel stopping, and the further optimization of intermediate force materials for integration into future escalation of force platforms. Other research includes feasibility and design studies for high peak power radio frequency directed energy sources and other high power microwave directed energy technologies (e.g., lasers, millimeter-waves) with extended range applications and longer duration of effect. Other examples of counter-materiel research include the investigation and conceptual design of high power microwave technologies to enable improved reduce overall size, weight, power consumption, thermal cooling requirements, and overall system costs (SWaP-C) performance. Results will support the transition of viable technologies to higher levels of development and demonstration to further mitigate the JROC-approved joint non-lethal effects capability-gaps.					
FY 2021 OCO Plans: N/A					
FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant change between FY2020 and FY2021					
Accomplishments/Planned Programs Subtotals		12.956	13.307	13.301	0.000
C. Other Program Funding Summary (\$ in Millions)					
N/A					
Remarks					
D. Acquisition Strategy					
N/A					

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity					R-1 Program Element (Number/Name)								
1319: Research, Development, Test & Evaluation, Navy / BA 3: Advanced Technology Development (ATD)					PE 0603673N / Future Naval Capabilities Advanced Tech Dev								
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
Total Program Element	0.000	210.631	222.477	246.054	-	246.054	268.542	261.771	275.795	284.452	Continuing	Continuing	
3346: Future Naval Capabilities Adv Tech Dev	0.000	203.391	221.277	246.054	-	246.054	268.542	261.771	275.795	284.452	Continuing	Continuing	
9999: Congressional Adds	0.000	7.240	1.200	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	8.440	

A. Mission Description and Budget Item Justification

The Office of Naval Research (ONR) was established to ensure the technological advantage of U.S. Naval forces. Pursuing this mission, ONR manages the Department of the Navy's science and technology (S&T) research portfolio (Basic, Applied and Advanced Technology Development investments). This work includes the Future Naval Capabilities program, which provides technology solutions to known requirements, and often responds to cost, schedule and performance challenges in acquisition to accelerate capability delivery.

The efforts described in this Program Element (PE) 0603673N for FNC Advanced Technology Development have emerged from earlier research conducted in PE 0602750N for FNC Applied Research, and have transition funding commitments from the receiving acquisition Program of Record. Each effort in this PE is assessed and selected for its payoff to the naval warfighter, technological maturity and stakeholder commitment to deploy it to the Fleet/Force.

This Program Element (PE) funds Advanced Technology Development (ATD) that includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment. Efforts in this PE generally have Technology Readiness Levels TRL) of 4 (component and/or breadboard validation in laboratory environment.), 5 (component and/or breadboard validation in relevant environment.), or 6 (system/subsystem model or prototype demonstration in a relevant environment).

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy					Date: February 2020
Appropriation/Budget Activity		R-1 Program Element (Number/Name)			
1319: Research, Development, Test & Evaluation, Navy / BA 3: Advanced Technology Development (ATD)		PE 0603673N / Future Naval Capabilities Advanced Tech Dev			
B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	214.184	231.907	281.953	-	281.953
Current President's Budget	210.631	222.477	246.054	-	246.054
Total Adjustments	-3.553	-9.430	-35.899	-	-35.899
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-10.630			
• Congressional Rescissions	-	-			
• Congressional Adds	-	1.200			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-3.553	0.000			
• Program Adjustments	0.000	0.000	-35.899	-	-35.899
• Rate/Misc Adjustments	0.000	0.000	0.000	-	0.000
Congressional Add Details (\$ in Millions, and Includes General Reductions)	FY 2019	FY 2020			
Project: 9999: Congressional Adds					
Congressional Add: Advanced Development of High Yield Conventional Energetics				7.240	0.000
Congressional Add: Automated critical care system				0.000	1.200
			Congressional Add Subtotals for Project: 9999	7.240	1.200
			Congressional Add Totals for all Projects	7.240	1.200
Change Summary Explanation					
Funding:	The programmatic decrease of \$35.899M in FY 2021 and are in accordance with Office of the Secretary of Defense (OSD) steady-state guidance for S&T. Efforts are justified in Project 3346.				
Technical:	Not applicable.				
Schedule:	Not applicable.				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity					R-1 Program Element (Number/Name)				Project (Number/Name)				
1319 / 3					PE 0603673N / Future Naval Capabilities Advanced Tech Dev				3346 / Future Naval Capabilities Adv Tech Dev				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
3346: Future Naval Capabilities Adv Tech Dev	0.000	203.391	221.277	246.054	-	246.054	268.542	261.771	275.795	284.452	Continuing	Continuing	

A. Mission Description and Budget Item Justification

The Future Naval Capabilities (FNC) Program exploits technology advances and responds quickly to Naval needs. As a result, future Budget Activity (BA) 3 investments supporting the FNC Program are made less than one year before commencing execution. Because FNCs start at higher Technology Readiness Levels (TRL), the typical duration of an FNC is 3-years. The FNC Program favors a high level of collaboration. Program Element R-2 Activities align to warfare areas where the FNC technologies will be integrated into acquisition programs of record.

A complete accounting of FNC technologies and a full disposition of each technology development effort is provided annually to the Congressional oversight committees.

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<p>Title: Capable Manpower (CMP)</p> <p>Description: The Capable Manpower R-2 Activity focuses on the advanced technology development of new capabilities that leverage the underlying applied research investments in Program Element (PE) 0602750N Future Naval Capabilities (FNC) Applied Research. These advanced technology investments align to acquisition programs of record. Efforts focus on all aspects of training, including accelerated learning, training environments, ready relevant training, and Live-Virtual-Constructive (LVC) training.</p> <p>FY 2020 Plans: The advanced technologies being developed under this R-2 Activity in FY20 include technologies supporting the future integrated training environment and ready relevant learning. Training simulator software and hardware to support the rapid integration and interoperability of air and ground legacy and future simulation-based training is being developed to address the shortfall in sorties needed to maintain readiness for integrated air and ground operations of the marine air-ground task force. This technology will allow pilots and aircrews to train effectively in a common, simulated operating environment. Flexible and interoperable learning continuum and performance aids will be developed, providing individual career management, skill classification, selection, automatic training content re-engineering, supervisor evaluations, and Fleet readiness tracking. New machine learning algorithms will input training data from the lifelong learning record, and output a training model that is usable for adaptive</p>	7.514	10.640	6.400	0.000	6.400

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020	
Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)			
B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
1319 / 3	PE 0603673N / Future Naval Capabilities Advanced Tech Dev				
<p>FY 2021 Base Plans: Learning Continuum and Performance Aid (LCaPA): - Further develop machine learning algorithms to process and analyze training data from multiple legacy databases in order to modularize content delivery systems for manpower management.</p> <p>Streamlined Marine After-Action Review Tool - Visualization (SMART-Viz) - In collaboration with a complementary effort funded in PE 0603640M - Marine Corps Advanced Technology Demonstration, initiate technologies that provide timely and improved feedback to warfighters to enhance learning in live and simulated environments.</p> <p>FY 2021 OCO Plans: N/A</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: The decrease from FY20 to FY21 is primarily due to the completion in FY20 of the Navy's investment in the Future Integrated Training Environment (FITE) FNC.</p> <p>Title: Expeditionary Maneuver Warfare (EMW)</p> <p>Description: The Expeditionary Maneuver Warfare R-2 Activity focuses on the advanced technology development of new capabilities that leverage the underlying applied research investments in PE 0602750N, Future Naval Capabilities (FNC) Applied Research. These advanced technology investments align to acquisition programs of record.</p> <p>FY 2020 Plans: The advanced technologies being developed under this R-2 Activity in FY20 include those efforts that focus on Mine Countermeasures (MCM) task force planning, multi-mission airborne mine detection, and mine neutralization without collateral damage. Mission management tools will be developed for the Mine Countermeasures Commander to assist in the planning and re-planning, scheduling, and allocation of MCM task force assets using an extremely modular, open systems approach. This will provide MCM Commanders with the ability to rapidly re-plan and schedule emerging LCS/MCM Mission Package assets and maintain situational awareness of heterogeneous groups of systems. The investment in single-system, day/night, multi-mission airborne mine detection technologies usable at all water depths will be increased in order to reduce</p>	5.840	14.119	37.233	0.000	37.233

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)				
1319 / 3	PE 0603673N / Future Naval Capabilities Advanced Tech Dev	3346 / Future Naval Capabilities Adv Tech Dev				
B. Accomplishments/Planned Programs (\$ in Millions)						
the MCM timeline and facilitate our capability to counter surface/near surface mines in the Surf Zone or Beach Zone (BZ) at night. The viability of the preliminary design and schedule to support Fire Scout integration will be thoroughly explored. New mine neutralization technologies will enhance the effectiveness and efficiency of Navy expeditionary force capabilities in their assigned response mission to counter naval mine and maritime improvised explosive device threats. This technology will enhance the capability of the Maritime Expeditionary Standoff Response (MESR) System of Systems.		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
FY 2021 Base Plans: Low Observable No Collateral Damage-Neutralization (LONCD-N) System: - Continue activity on technologies for low observable mine neutralization without collateral damage. Specific effort includes subcomponent prototype construction, in-water experimentation, and initial data collection. These alternative mine neutralization technologies will enhance the capability of the Maritime Expeditionary Standoff Response (MESR) System of Systems and enable more clandestine MCM operations in support of JFEO. Single-system Multi-mission Airborne Mine Detection (SMAMD): - Complete activity on multi-mission airborne mine detection. Effort will include integrating the prototype airborne mine detection capability on an unmanned platform (currently targeting the MQ-8C Fire Scout); conducting a final demonstration; and collecting final performance data for transition. The desired outcome of this effort is a single-system, airborne mine detection technology to reduce the MCM timeline and facilitate our capability to counter surface and near-surface moored/drifting mines from deep water thru the Surf Zone (SZ), and proud mines on the Beach Zone (BZ), day or night. Compact Encapsulated Mine (C-ENCAP) - Initiate development of an alternative clandestine mine with flexible depth capability, improved lethality, payload-agnostic and Weapon System Explosives Safety Review Board (WSESRB)-compliant encapsulation, and multimodal sensing with multi-field planning software.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement:						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603673N / Future Naval Capabilities Advanced Tech Dev	Project (Number/Name) 3346 / Future Naval Capabilities Adv Tech Dev				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
The increase from FY20 to FY21 is primarily due to an FY21 ramp-up of the Navy's investment in a Low Observable No Collateral Damage - Neutralization (LONCD-N) System and a new investment starting in FY21 for a Compact Encapsulated Mine (C-ENCAP).						
Title: Force Health Protection (FHP)		0.802	0.000	0.000	0.000	0.000
Description: The Force Health Protection R-2 Activity focuses on the advanced technology development of new capabilities that leverage the underlying applied research investments in Program Element (PE) 0602750N, Future Naval Capabilities (FNC) Applied Research. These advanced technology investments align to acquisition programs or record.						
FY 2020 Plans: N/A						
FY 2021 Base Plans: N/A						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: N/A						
Title: Air Warfare (AW)		34.614	38.871	55.947	0.000	55.947
Description: The Air Warfare R-2 Activity focuses on the advanced technology development of new capabilities that leverage the underlying applied research investments in Program Element (PE) 0602750N, Future Naval Capabilities (FNC) Applied Research. These advanced technology investments align to acquisition programs of record. Efforts include human-machine interfaces for unmanned platforms and payloads that will assist with delegation of resources from one operator to another, airframe corrosion protection, and a Carrier Air Wing performance assessment tool that uses live, virtual, and constructive data to improve pilot and aircrew performance in near real-time.						
FY 2020 Plans: The advanced technologies being developed under this R-2 Activity in FY20 include those efforts that focus on enhanced corrosion protection for aircraft surfaces and galvanic interfaces in order to improve durability and reduce toxicity/exposures, advanced radio enhancements for long range anti-ship missiles and other weapons,						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603673N / Future Naval Capabilities Advanced Tech Dev	Project (Number/Name) 3346 / Future Naval Capabilities Adv Tech Dev				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
human machine interface and vehicle controller command and control technologies that implement full and partial UxV transfer of control and discovery, software performance assessment tools to automatically collect, fuse, display, analyze, and archive live virtual constructive training data from disparate systems, and multi-platform technologies for collaborative airborne manned and unmanned tactical electronic warfare operations at all jamming ranges.						
FY 2021 Base Plans: Cross-Domain Unmanned Systems (C-D UxS): - Further develop software and strategy to permit messaging between unmanned platforms and payloads in order to operate across the critical safety boundaries for unmanned systems groups. Fleet Adaptive Multilevel Measurement for Operations & Unit Systems (FAM2OUS): - Develop software toolkit to insert Advanced Tactics models into the Next Generation Threat System (NGTS). - Implement objective human performance measurement algorithms in the NGTS Analysis and Reporting Tool. Rapid Adaptive Planning for Time Sensitive Offensive Responsive Strike (RAPTORS): - Commence development of a many-on-many mission planning tool for salvos of weapons engaging adversary surface action groups. -Dynamic INtegrated Operations (DINO): - Continue the development of a Warfare Commanders Portal that provides an interface for the digital sharing of information from diverse ISR and mission planning/execution data sources across the entire kill chain. Artificial Intelligence is generating and ranking tactical strike mission courses of action based on this data, which will be provided to the Mission Commander. Electromagnetic Maneuver Warfare Resource Allocation Management (EMW RAM): - Continue development and demonstration of prototype algorithms and integrated software technologies for own-platform and multi-platform resource and task management of EW systems that enable autonomous distributed airborne EW operations at naval tactical ranges and timelines. The primary objective is to develop multi-platform airborne technologies for collaborative many-on-many manned & unmanned EW operations across all jamming ranges. Prototype software development and documentation includes an EW Battle Management (EWBM) framework, an advanced EW Adaptive System Management for lower-level resource						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603673N / Future Naval Capabilities Advanced Tech Dev	Project (Number/Name) 3346 / Future Naval Capabilities Adv Tech Dev				
<u>B. Accomplishments/Planned Programs (\$ in Millions)</u>		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
allocation management, and own-platform hybrid teaming between naval aircrews and machines for improving tactical mission effectiveness while reducing human workloads.						
<p>Advanced Capability Expansion (ACE):</p> <ul style="list-style-type: none"> - Continue the development of hardware and software that focus on extended range targeting and radar electronic attack protection for the E2-D Advanced Hawkeye APY-9 Radar Sub-System. - Solid State Structural Repair (S3R) - This effort will continue with a focus on beginning development of a Design of Experiments (DoE) to identify the Cold Spray process parameters for producing the optimal combination of adhesion, tensile, fatigue and ductility needed to perform structural repairs on Al-7050. The process parameters include gas type, gas pressure, gas temperature, nozzle raster or traverse speed, raster pattern, nozzle standoff distance, surface preparation and nozzle design. <p>Enhanced Lethality for Maritime Operations (ELMO)</p> <ul style="list-style-type: none"> - In collaboration with a complementary effort funded in PE 0603640M - Marine Corps Advanced Technology Demonstration, initiate development of new Multi-Function Sensor (MFAS) modes for the MQ-4C Triton Unmanned Aircraft System (UAS), enhancing Distributed Maritime Operations (DMO) with the Next Generation Network (NGN). <p>Landing Autonomous Navigation Technology for Enhanced Recovery to Navy Ships (LANTERNS)</p> <ul style="list-style-type: none"> - Initiate development of enhanced, Precise Ship-Relative Navigation (PS-RN) for reliable autonomous ship recovery of Unmanned Aerial Systems (UAS) in all weather, high deck motion environments. 						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The increase from FY20 to FY21 is primarily due to new investments starting in FY21 involving Solid State Structural Repair (S3R), Triton Enhanced Lethality for Naval Operations (ELMO) and Landing Autonomous Navigation Technology for Enhanced Recovery to Navy Ships (LANTERNS).						
Title: Information Warfare (IW)		73.074	61.814	50.169	0.000	50.169

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603673N / Future Naval Capabilities Advanced Tech Dev	Project (Number/Name) 3346 / Future Naval Capabilities Adv Tech Dev				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Description: The Information Warfare R-2 Activity focuses on the advanced technology development of new capabilities that leverage the underlying applied research investments in Program Element (PE) 0602750N, Future Naval Capabilities (FNC) Applied Research. These advanced technology investments align to acquisition programs of record.	FY 2020 Plans: The advanced technologies being developed under this R-2 Activity in FY20 cover rapidly evolving technological areas and include those that: a)enable distributed and networked sensor and weapon control by providing a communications interface for combat systems applications, b) deliver data and information via any combination of available tactical data links, c) enhance security, d) provide an improved capability to detect and track the newest generation of ultra-quiet submarines in the deep ocean, e) provide the surface fleet with a position fixing capability in a Global Positioning System (GPS) denied environment, f) correlate multi-sensor, multi-platform, radio-frequency, geo-location data to create a passive common operating picture and enable coordinated engagements of multi-mode, multi-aspect, threat sensors using networked tactical electronic warfare and information operations systems, g) build on networked electronic warfare infrastructures to provide new user interfaces for multi-platform, coordinated electronic support and electronic attack techniques, h) sense and assess real-time environmental conditions to improve sensor performance forecasting and automate the detection of very quiet targets within undersea surveillance barriers, and i) develop technologies that can be demonstrated in an 'A'-size sonobuoy capable of delivering the array gain required to localize and collect passive acoustic intelligence of ultra-quiet submarines at tactically relevant ranges through exploitation of a unique feature of the sound channel. FY 2021 Base Plans: Extended Range-Directional Frequency Analysis and Recording (ER-DIFAR) Sonobuoy: - Specific effort will include building and demonstrating an A-size (i.e., fits existing standard sonobuoy deployment chute) passive sonobuoy system capable of delivering the required array gain for target detection, localization, and measurement at the required range. It will also involve development of the Build 2 software using the prototype array and Build 1 software prototypes with lake test data. It will also involve conducting an at-sea checkout and integration into the into Build 1 processor hardware in the laboratory configuration. The desired outcome for ER-DIFAR is to provide acoustic intelligence to the Type Commander to aid in decisions for achieving readiness in warfighting enterprises in accordance with CNO's "Design for Maintaining Maritime Superiority version 2.0, Line of Effort Blue: Strengthen Navy Power at and from the Sea"					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020
Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)		
1319 / 3	PE 0603673N / Future Naval Capabilities Advanced Tech Dev	3346 / Future Naval Capabilities Adv Tech Dev		
B. Accomplishments/Planned Programs (\$ in Millions)				
SCAMM	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO
- Complete development of SCAMM for the Ship's Signal Exploitation Equipment (SSEE) program.				
Propagation Channel Assessment and Prediction (PCAP): - Specific effort will involve completing the development and testing of software and algorithms for ship RF systems that incorporate observed and predicted atmospheric conditions to provide ranges against signals of interest. It will also involve integration of PCAP into SLQ-32(V)6 Program of Record for final demonstration and testing.				
ACES: - Complete development of advanced adversary platform identification from non-traditional methods. Demonstrate this capability in an autonomous vehicle. Complete current and emerging protocol analyses.				
Advanced Naval Super Wideband Energy Receiver (ANSWER): - Continue development of a next generation recorder capable of processing a minimum of 20GHZ of simultaneous dynamic bandwidth. Demonstrate the recorder in the field to collect metrics and performance for rapid technology insertion into Naval systems.				
Acoustic Automation Processing for Undersea Surveillance Barriers: - Conclude activity in Acoustic Automated Processing (AAP) for Fixed Surveillance Systems. Specific effort will include delivering software and algorithms that automate the processes of cross-sensor correlation and signature recognition. Conduct testing to ensure these algorithms achieve suitable probability of detection vs. very quiet targets at the required range and reduce the False Alarm Rate. Refinement of prototype algorithms will complete and then they will be tested and integrated into the Fixed Surveillance System (FSS) in preparation for demonstration at the PMS 485 Test Bed Facility. The desired outcome is to provide early warning of threat submarines intruding into the ocean commons to the warfighter via the Fixed Surveillance System (FSS) to aid in protecting the sea lines of communication between the United States and its allies and partners. This is directly supporting the CNO's "Design for Maintaining Maritime Superiority, version 2, Line of Effort Blue: Strengthen Navy Power at and from the Sea."				
High Frequency Ionospheric and Ocean Scatter for Tactical Maneuver (HIFIOS-TM): - Complete development of this FNC for the Ships Signal Exploitation Equipment (SSEE) Family of Systems (FoS) Medusa-Next program.				

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Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603673N / Future Naval Capabilities Advanced Tech Dev	Project (Number/Name) 3346 / Future Naval Capabilities Adv Tech Dev				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<p>Water-space Planning and Execution for Theater Undersea Warfare (WasP-ET) - Initiate development of a dynamic and adaptive Prevention of Mutual Interference / Water Space Management (PMI/WSM) application that works in a multi-level security environment, enabling integration of allied and coalition forces with a process that involves sound operations research, machine learning, and intelligent agent capabilities.</p> <p>Long Endurance Airborne Platform (LEAP) Decoy - Initiate development of a rapidly deployable, long endurance, unmanned, airborne advanced decoy with an advanced electronic warfare capability that can counter varied threats while maintaining continuous ship communications.</p> <p>DECAF - Initiate development of a new information warfare capability termed DECAF.</p>						
<p>FY 2021 OCO Plans: N/A</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: The decrease from FY20 to FY21 is primarily due to the completion in FY20 of multiple FNCs, including Communications as a Service (CaaS), Mission-based Networking for DDS (MiND), Deep Reliable Acoustic Path Exploitation System (DRAPES), Network Collaborative Precision Navigation and Timekeeping (NCPNT), Coordinated Radio Frequency EW (CRFEW) and Next Generation Surface Electronic Warfare User Interface.</p>						
<p>Title: Surface Warfare (SW)</p> <p>Description: The Surface Warfare R-2 Activity focuses on the advanced technology development of new capabilities that leverage the underlying applied research investments in Program Element (PE) 0602750N, Future Naval Capabilities (FNC) Applied Research. These advanced technology investments align to acquisition programs of record. Efforts include technologies that will provide mission visualization, network analysis, and training for operators in denied and degraded environments.</p> <p>FY 2020 Plans: The advanced technologies being developed under this R-2 Activity in FY20 include those efforts that focus on: a) high density, modular and configurable, high cycle rate, megawatt-scale multifunction energy storage systems</p>		32.436	44.474	44.965	0.000	44.965

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603673N / Future Naval Capabilities Advanced Tech Dev	Project (Number/Name) 3346 / Future Naval Capabilities Adv Tech Dev				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
	for electric weapons and sensor loads that are necessary to provide continuous operational availability, b) the integration testing necessary to implement attack resilient architectures and toolsets that can be retrofitted to both legacy and modern shipboard control systems, c) the incorporation of high density reactive materials into warheads such as the ALaMO 57mm round so as to significantly increase lethality without requiring changes to flight dynamics, guidance, and/or interaction with the respective weapon system, d) advanced alloys and airfoil coatings for Gas Turbine hot section components that will realize a 3X improvement in engine life at higher operating temperatures and pressures, improving the mean time between failure of these expensive ship engines, e) technologies that counter unmanned aerial surveillance drones, f) training for staffs and operators required to conduct command and control against peer threats in degraded and denied environments, g) a new electronic initiation safety device for energetic initiation for both SM-6 and SM-2 upgrades, h) a receive-only capability on SPY-6V1 for improved situational awareness during EMCON and improved radar timelines with advanced waveforms for communications and radar operation, and i) modular virtual-constructive simulation technologies, realistic phenomenology and behavior models for synthetic entities in support of warfighter command Ttam and platform operator staff multi-mission training, assessment and certification.					
FY 2021 Base Plans: Fleet Training Technologies (FleetT2): - Create a cross-platform, mission-centric, simulation for training and assessment of staff and operators in denied and degraded environments. Develop tools to permit more real-time debriefing of operators and command staff. Standard Missile Qualified Universal Initiation Baseline (SQUIB): - Finalize maturation of an Electronic Ignition Safety Device (EISD)/Safety Module Assembly and integrate it into prototypical Rocket Motors in STANDARD Missile 6 (SM-6) Block IB Demonstration Propulsion Units (DPUs). The resulting Technical Data Package (TDP) will serve as a basis to issue an Request for Proposals (RFP) for transition of the EISD/Safety Module Assembly to a contractor for industry upgrade, ensuring producibility and Design Verification Testing (DVT). SCRAM: - Complete development of SCRAM for Hull, Mechanical and Electrical (HM&E) systems, combat and navigation systems, and the NATO Sea Sparrow Missile System (NSSMS) program. Receive-Only Cooperative Radar (ROCR):						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603673N / Future Naval Capabilities Advanced Tech Dev	Project (Number/Name) 3346 / Future Naval Capabilities Adv Tech Dev				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<p>- Continue to develop a receive-only capability for the SPY-6 product line that improves situational awareness during Emissions Control (EMCON) and improves radar timelines with advanced waveforms for communications and radar operations.</p> <p>Hypersonic-threat Dynamic Reassessment and Adaptation (HyDRA):</p> <p>- Continue to develop modifications to the AEGIS Weapon System.</p> <p>Robust Combat Power Control (RCPC)</p> <p>- Initiate development of a power control system enabling tactical energy management within a ship's Integrated Power and Energy System (IPES), employing shared zonal energy storage to ensure power and energy accessibility to all mission critical equipment.</p> <p>Electronic MIMO Protection for Ensured Radar Effect (EMPIRE)</p> <p>- Initiate development of efficient computational techniques for signal processing on SPY-6 for a heterogeneous processing framework, improving resilience and situational awareness in contested electromagnetic environments and increasing the capacity for distributed maritime operations and the survivability of platforms.</p>						
<p>FY 2021 OCO Plans: N/A</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: No significant change from FY2020 to FY2021.</p>						
<p>Title: Undersea Warfare (UW)</p> <p>Description: The Undersea Warfare R-2 Activity focuses on the advanced technology development of new capabilities that leverage the underlying applied research investments in Program Element (PE) 0602750N, Future Naval Capabilities (FNC) Applied Research. These advanced technology investments align to acquisition programs of record. Efforts include improvements to a broad range of undersea warfare capabilities, including undersea weapons, submarine acoustic sensing and signal processing systems, communications, electro-optics systems, signature management, training, and decision aids.</p> <p>FY 2020 Plans: The advanced technologies being developed under this R-2 Activity in FY20 include those efforts that focus on a) simultaneous transmit and receive capabilities for radio frequency antenna apertures as well as the backend</p>		49.111	51.359	51.340	0.000	51.340

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603673N / Future Naval Capabilities Advanced Tech Dev	Project (Number/Name) 3346 / Future Naval Capabilities Adv Tech Dev				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
	processing that enable stealthy submarine information operation missions, b) an integrated combat capability to the Submarine Payload Control System that supports collaborative planning, payload coordination, briefing, and enhanced mission execution through seamless integration with the unmanned vehicle controller, c) reducing the signature of current and future submarines in order to enhance their military effectiveness, d) automated data analysis for expeditionary mine countermeasures, e) a modular and adaptive electronic warfare trainer, scenario generator and digital stimulator that's applicable to multiple training facilities and air, surface, and undersea platforms, f) high performance submersible radar absorbing structures that use advanced manufacturing techniques to improve affordability, durability, scalability, and the performance of submarine mast materials, and g) technologies offering a covert broadband acoustic signal structure with advanced processing algorithms that will increase an SSBN's ability to conduct bathymetric fixes in a wider range of operational environments.					
FY 2021 Base Plans: Submarine Propagation Channel Assessment and Prediction (subPCAP): - Specific effort will include algorithm maturation and building prototype software to incorporate observed and predicted atmospheric conditions, especially in the immediate air-ocean boundary layer, into a submarine's passive radio frequency (RF) sensor assessment. System for Non-Acoustic Control of Signatures (SNACS): - This effort will complete with vendor fabrication and delivery of six prototype radar camouflage units (RCU) to the Navy for mechanical, environmental and signature performance testing. Stern Area System: - This effort will initiate the first at-sea trial test series to evaluate system performance and begin testing and analysis. Trial data will be analyzed to inform system updates and preparations for FY 2022 trials which will complete testing and evaluation. System dock-side testing and shipbuilder trials will be completed in FY 2021 to confirm system installation and function to complete ship Post Shakedown Availability (PSA) period. Avalanche: - Continue activity on Unmanned Underwater Vehicle persistence and infrastructure. The specific effort will involve the development and maturation of technologies for autonomous, non-wet, mateable-transfer of energy and data in support of long endurance missions for unmanned undersea vehicles and seabed warfare. It will also include the development of long endurance autonomy and hardware solutions for fixed and deployable energy sources and heterogeneous communication networks.						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Compact Rapid Attack Weapon (CRAW) Upgrade: - This effort will continue the development of advanced ASW capability software and conduct in-water testing. It will also continue software and hardware modifications to enable integration with the host platform. During FY 2021, the ASW capability software baseline development and performance validation will occur.						
Diver Augmented Vision Display with Enhanced Communications (DAVD): - Further develop augmented and mixed reality interfaces for divers as well as software that provides top-down, real-time view of diver's environment for navigation and location of targets. Further develop telemetry system that a diver uses to enable communication and control of Remotely Operated Underwater Vehicle.						
Advanced Broadband Navigation Sonar System (ABNSS): - Continue development and transition of new sonar waveforms for the submarine force for employment in the navigation sonar system to improve performance and reduce operational constraints.						
Electronic Warfare Micro-Adaptive Trainer (EW-MAT): - Complete the advanced technology development of a submarine Electronic Warfare training capability that combines a digital RF simulation generator and a micro-adaptive training engine that emulates one-on-one human tutoring experience by adjusting instruction to target individual trainee needs.						
VIRGINIA Improved Propulsion Bearing (VIPB) - Initiate development of an improved propulsor bearing to be demonstrated on a VIRGINIA Class submarine in order to reduce the risk of introducing the bearing on the new COLUMBIA Class submarine.						
Submarine Tethered Expendable Buoy - Initiate development of a free-floating, tethered buoy for Intelligence, Surveillance and Reconnaissance (ISR) data collection and satellite communications in order to improve submarine stealth.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement:						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy			Date: February 2020		
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B. Accomplishments/Planned Programs (\$ in Millions) No significant change from FY2020 to FY2021.			FY 2019	FY 2020	FY 2021 Base
Accomplishments/Planned Programs Subtotals			203.391	221.277	246.054
C. Other Program Funding Summary (\$ in Millions)			0.000	246.054	
Remarks N/A					
D. Acquisition Strategy N/A					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity 1319 / 3					R-1 Program Element (Number/Name) PE 0603673N / Future Naval Capabilities Advanced Tech Dev				Project (Number/Name) 9999 / Congressional Adds				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
9999: Congressional Adds	0.000	7.240	1.200	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	8.440	
A. Mission Description and Budget Item Justification Congressional Interest Items not included in other projects													
B. Accomplishments/Planned Programs (\$ in Millions)													
<i>Congressional Add:</i> Advanced Development of High Yield Conventional Energetics										FY 2019	FY 2020		
<i>FY 2019 Accomplishments:</i> FY19 funds will be applied to the advanced demonstration of energetic materials in a variety of weapon system applications to include: high performance solid rocket and air breathing propulsion, reactive materials demonstrations and effects in advanced lethality, effectiveness models, advanced warhead concepts to include novel reactive shaped charge configurations, hybrid reactive material warhead demonstrations, and the development and demonstration of any necessary modeling and simulation capabilities for quantification of damage effects on adversary weapon systems, and other potential energetic technologies.										7.240	0.000		
<i>FY 2020 Plans:</i> N/A													
<i>Congressional Add:</i> Automated critical care system										0.000	1.200		
<i>FY 2019 Accomplishments:</i> N/A													
<i>FY 2020 Plans:</i> Conduct advanced technology development for Automated critical care systems													
Congressional Adds Subtotals										7.240	1.200		
C. Other Program Funding Summary (\$ in Millions)													
N/A													
Remarks													
D. Acquisition Strategy													
N/A													

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity					R-1 Program Element (Number/Name)								
1319: Research, Development, Test & Evaluation, Navy / BA 3: Advanced Technology Development (ATD)					PE 0603680N / Manufacturing Technology Program								
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
Total Program Element	0.000	57.322	65.138	60.122	-	60.122	61.318	62.582	63.840	65.117	Continuing	Continuing	
1050: Manufacturing Tech	0.000	57.322	60.138	60.122	-	60.122	61.318	62.582	63.840	65.117	Continuing	Continuing	
9999: Congressional Adds	0.000	0.000	5.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	5.000	

A. Mission Description and Budget Item Justification

The Office of Naval Research's (ONR) mission is to foster scientific research for the advancement of naval power. This work does not stop at the laboratory. Delivery of breakthrough capability often requires new technologies in manufacturing and supply chains of national security. The Manufacturing Technology (ManTech) Program is intended to improve the productivity and responsiveness of the U.S. defense industrial base by funding the development, optimization, and transition of enabling manufacturing technologies to key naval suppliers. In general, investments transition emerging Science and Technology (S&T) results to acquisition programs; improve industrial capabilities in production, maintenance, repair and industrial base responsiveness; and advance manufacturing technology to reduce cost, improve performance, and responsiveness. Currently, the ManTech Program is focused on affordability improvements for specific key acquisition platforms as defined in the Navy ManTech Investment Strategy. Key platforms currently targeted include: VIRGINIA Class Submarine (VCS)/OHIO Replacement Program (ORP); DDG 51 Class Destroyer; CVN 78 Class Carrier; Joint Strike Fighter (JSF); and CH-53K Heavy Lift Helicopter. Office of Naval Research (ONR) ManTech helps these Navy programs achieve their respective affordability goals by transitioning developed manufacturing technology which, when implemented, results in needed cost reduction or cost avoidance.

Today's Sailors and Marines are enabled by naval Science and Technology (S&T). Since 1946, the Office of Naval Research (ONR) has fostered scientific research related to the maintenance of maritime superiority and national defense. ONR manages the Department of the Navy's (DON) portfolio of naval Basic and Applied research, and Advanced Technology Development investments to ensure naval forces can effectively deter conflict, but when called upon, fight, win and come home safe. Current investments hedge against uncertainty, providing solutions to commanders today, and options for the future. The Naval S&T budget supports higher guidance defined by the National Defense Strategy, and responds to requirements identified by the Secretary of the Navy through research priorities set by the Chief of Naval Research, coordinated across the Naval Research Enterprise (NRE), and outlined in the Naval R&D Framework.

This Program Element (PE) funds Advanced Technology Development (ATD) that includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment. Efforts in this PE generally have Technology Readiness Levels TRL) of 4 (component and/or breadboard validation in laboratory environment.), 5 (component and/or breadboard validation in relevant environment.), or 6 (system/subsystem model or prototype demonstration in a relevant environment).

Due to the number of efforts in this Program Element (PE), the programs described herein are representative of the work included in this PE.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy					Date: February 2020
Appropriation/Budget Activity 1319: <i>Research, Development, Test & Evaluation, Navy / BA 3: Advanced Technology Development (ATD)</i>		R-1 Program Element (Number/Name) PE 0603680N / <i>Manufacturing Technology Program</i>			
B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	58.657	60.138	60.122	-	60.122
Current President's Budget	57.322	65.138	60.122	-	60.122
Total Adjustments	-1.335	5.000	0.000	-	0.000
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	5.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-1.335	0.000		-	
• Rate/Misc Adjustments	0.000	0.000	0.000	-	0.000
Congressional Add Details (\$ in Millions, and Includes General Reductions)					
Project: 9999: Congressional Adds					
Congressional Add: <i>Modern shipbuilding manufacturing</i>					
Congressional Add Subtotals for Project: 9999					
Congressional Add Totals for all Projects					
	FY 2019	FY 2020			
	0.000	5.000			
	0.000	5.000			
	0.000	5.000			

Change Summary Explanation

funding: No significant change.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity					R-1 Program Element (Number/Name)				Project (Number/Name)				
1319 / 3					PE 0603680N / Manufacturing Technology Program				1050 / Manufacturing Tech				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
1050: Manufacturing Tech	0.000	57.322	60.138	60.122	-	60.122	61.318	62.582	63.840	65.117	Continuing	Continuing	

A. Mission Description and Budget Item Justification

The Office of Naval Research's (ONR) mission is to foster scientific research for the advancement of naval power. This work does not stop at the laboratory. Delivery of breakthrough capability often requires new technologies in manufacturing and supply chains of national security. The Manufacturing Technology (ManTech) Program is intended to improve the productivity and responsiveness of the U.S. defense industrial base by funding the development, optimization, and transition of enabling manufacturing technologies to key naval suppliers. In general, investments transition emerging Science and Technology (S&T) results to acquisition programs; improve industrial capabilities in production, maintenance, repair and industrial base responsiveness; and advance manufacturing technology to reduce cost, improve performance, and responsiveness. Currently, the ManTech Program is focused on affordability improvements for specific key acquisition platforms as defined in the Navy ManTech Investment Strategy. Key platforms currently targeted include: VIRGINIA Class submarine (VCS)/COLUMBIA Class submarine (CLB); DDG 51 Class destroyer; CVN 78 Class carrier; F-35 Lightning II aircraft (F-35); and CH-53K Heavy Lift Helicopter. Currently, ManTech will also focus on affordability improvements for FFG(X) and wind down investments in the CH-53K program. Through its affordability efforts, ManTech helps these Navy programs achieve their respective affordability goals by transitioning developed manufacturing technology which, when implemented, results in needed cost reduction or cost avoidance. In addition to addressing affordability for key naval platforms, ManTech also addresses manufacturing technology to aid in capability acceleration to the fleet.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Composites Processing and Fabrication Description: The primary technical goal of the Composites Processing and Fabrication activity is improving weapon systems affordability, enhancing weapon system effectiveness and improving reliability/war-fighter readiness through the increased utilization of composite materials and structures. This is being achieved through the development, maturation, and transition of affordable and robust manufacturing, assembly, and repair processes that fully exploit the benefits of composite materials. Concentration is on affordability for the following platforms: VIRGINIA Class submarine (VCS)/COLUMBIA Class submarine (CLB), DDG 51 Class destroyer, CVN 78 Class carrier, F-35 Lightning II aircraft (F-35), and CH-53K Heavy Lift Helicopter. Composites processing and fabrication technology areas include but are not limited to fiber-reinforced polymeric (organic) resin composites; ceramic-matrix, metal-matrix, and carbon-carbon composites; composite internal stiffening core materials such as foam, ceramic, balsa wood, polymeric or metallic honeycomb, or other materials; composite external stiffening concepts such as hat and blade stiffeners and methodologies to manufacture them; materials for radomes and other electrical applications; composite manufacturing and similar processes and related equipment technology; and adhesives, adhesive bonding, and related technologies (i.e., surface	8.000	8.000	7.954	0.000	7.954

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy			Date: February 2020		
Appropriation/Budget Activity 1319 / 3		R-1 Program Element (Number/Name) PE 0603680N / Manufacturing Technology Program		Project (Number/Name) 1050 / Manufacturing Tech	
B. Accomplishments/Planned Programs (\$ in Millions)					
FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	
preparation techniques), as well as mechanical fastening, and other methodologies for joining composites to other composites or metals, and similar assembly technologies.					
FY 2020 Plans: Technical activities include (1) Design / develop a flexible, robotic composites manufacturing cell for CH-53K fabrication for improved process repeatability, increased part quality, and reduced risk as production rates increase; (2) Develop an improved and more affordable false deck panel concept for use in equipment spaces on DDG 51 Class destroyers constructed at both Bath Iron Works and HII-Ingalls and CVN 78 Class carriers constructed at HII-Newport News Shipbuilding; (3) Develop and proof manufacturing technology for composite exhaust uptakes for the DDG 51 Class destroyers (for both Bath Iron Works and HII-Ingalls ships) for cost neutral or better acquisition cost, 60% reduction in maintenance costs, and 30% weight reduction; (4) Develop equipment, processes, and methods needed to implement a system capable of fully automated optical inspection of MOD's (minor optical defects) on F-35 production transparencies and eliminate subjective, variable visual analysis currently done by individual operators.					
FY 2021 Base Plans: - Develop and transition composites manufacturing technology improvements that result in cost reduction for key affordability platforms: VCS/CLB, DDG 51, CVN 78, FFG(X), and F-35. - Develop and transition composites manufacturing technology improvements that accelerate capability to the fleet. Areas of concentration include (1) transparencies for the F-35 Lightning II aircraft, (2) submarine coatings, (3) flares, and (4) High Energy Laser (HEL) weapon systems.					
FY 2021 OCO Plans: N/A					
FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant change between FY 2020 and FY 2021.					
Title: Electronics Processing and Fabrication			12.000	12.000	11.930
Description: The primary technical goal of the Electronics Processing and Fabrication activity is improving electronic weapon systems affordability by developing and transitioning affordable, robust manufacturing processes and capabilities for electronics critical to defense applications over their full life-cycle. Efforts create new and improved electronics / electro-optics manufacturing processes for transition to the production floor. Emphasis is on affordability for the following platforms: VIRGINIA Class submarine (VCS)/COLUMBIA Class			0.000	11.930	

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603680N / Manufacturing Technology Program	Project (Number/Name) 1050 / Manufacturing Tech				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
submarine (CLB), DDG 51 Class destroyer, CVN 78 Class carrier, F-35 Lightning II aircraft (F-35), and CH-53K Heavy Lift Helicopter. Electronics processing and fabrication technology areas include but are not limited to Electronics manufacturing technology (materials, devices, circuits, modules, subsystems); Semiconductor devices/vacuum electronics/passive components; compound semiconductors/wide bandgap semiconductors; low-cost, high-throughput manufacturing and assembly techniques; nanoelectronics; electronics packaging technologies (including tamper proof and non-hermetic approaches); optics manufacturing technology (materials devices, circuits, modules, subsystems); optical interconnects; fiber optics and photonics; technologies for electronics and electro-optics testing and evaluation; optical imaging for manufacturing operations; and directed energy weapons.						
FY 2020 Plans: Technical activities include (1) Develop technology to repurpose digital electronics currently used in the F-35 Active Electronically Scanned Array (AESA) radar system to accommodate F-35 global positioning system (GPS) system functions with significantly improved anti-jamming capabilities; (2) Develop a reduced cost manufacturing process for two of the most costly of seven elements in the optical train of the F-35 Helmet Mounted Display (HMD) Relay Optical Assembly (ROA) for the F-35; (3) Develop drone technology for the inspection of CVN 78 Class carrier tanks to replace currently used manual inspection techniques which are labor intensive, inefficient, and risky from a safety perspective; (4)Develop a prototype for a modern radar system architecture with open and common Radio Frequency (RF) components that demonstrate the capability to implement requirements for two significantly different radar systems to support the baseline for the Next Generation Surface Search Radar (NGSSR) for both CVN 79 Class carrier and DDG 51 Class destroyer.						
FY 2021 Base Plans: - Develop and transition electronics and electro-optics manufacturing technology improvements that result in cost reduction for key affordability platforms: VCS/CLB, DDG 51, CVN 78, FFG(X), and F-35. - Develop and transition electronics and electro-optics manufacturing technology improvements that accelerate capability to the fleet. Areas of concentration include (1) High Energy Lasers (HEL) weapon systems, (2) Surface Electronic Warfare Improvement Program (SEWIP) for FFG(X) and Large Surface Combatant, and (3) unmanned vehicles.						
FY 2021 OCO Plans:						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603680N / Manufacturing Technology Program	Project (Number/Name) 1050 / Manufacturing Tech				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant change between FY 2020 and FY 2021.						
Title: Metals Processing and Fabrication Description: The primary technical goal of the Metals Processing and Fabrication activity is to develop affordable, robust manufacturing and repair processes/capabilities for metals and special materials critical to Navy weapon system applications. Emphasis is on affordability for the following platforms: VIRGINIA Class submarine (VCS)/COLUMBIA Class submarine (CLB), DDG 51 Class destroyer, CVN 78 Class carrier, F-35 Lightning II aircraft (F-35), and CH-53K Heavy Lift Helicopter. This activity also includes the development, optimization, and transition of repair technology for the repair, overhaul, and sustainment of key navy systems. Metals processing and fabrication technology areas include but are not limited to: processing methods; metals additive manufacturing; metallic materials-based systems; casting; joining techniques; machining; surface and heat treatments; coating/cladding; assembly; metal/non-metals interfaces issues; and inspection and compliance verification.		12.000	12.000	11.930	0.000	11.930
FY 2020 Plans: Technical activities include: (1) Develop a manufacturing cell concept for the automated welding of submarine appendages (for both VIRGINIA and COLUMBIA construction) to replace the currently used manual approaches that are both labor-and time-intensive; (2) Develop improvements for hull frame fabrication for the VIRGINIA and COLUMBIA Class submarines by developing and implementing a robotic solution that increases weld quality, decreases out-of-circularity fit up issues, and reduces the amount of welding and inspection man hours; (3) Develop improvements for foundry castings at HII-Newport News for CVN 78 Class carriers and VIRGINIA Class submarines by validating the use of shrouds to minimize air exposure of the molten metal and developing devices, procedures, and processes needed to implement the process with NNS legacy equipment and processes.						
FY 2021 Base Plans: <ul style="list-style-type: none"> - Develop and transition metals manufacturing technology improvements that result in cost reduction for key affordability platforms: VCS/CLB, DDG 51, CVN 78, FFG(X), and F-35. - Develop and transition metals manufacturing technology improvements that accelerate capability to the fleet. Areas of concentration include (1) High Energy Lasers (HEL) weapon systems and (2) unmanned vehicles. 						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603680N / Manufacturing Technology Program	Project (Number/Name) 1050 / Manufacturing Tech				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<p>- Continue Repair Technology (RepTech) Thrust to develop, optimize, and transition repair technology for key naval platforms at depots and logistics centers.</p> <p>FY 2021 OCO Plans: N/A</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant change between FY 2020 and FY 2021.</p>						
<p>Title: Manufacturing Enterprise/Other</p> <p>Description: The Manufacturing Enterprise/Other activity includes: (1) efforts targeted towards improving, in general, the manufacturing enterprise for the production of key naval platforms (both shipbuilding and aircraft); (2) energetic efforts; (3) naval research enterprise and laboratory support for key projects; and (4) technical program support. Manufacturing Enterprise addresses the development, optimization, and transition of manufacturing enterprise technology to key naval platform suppliers. Emphasis is on affordability for the following shipbuilding platforms: VIRGINIA Class submarine (VCS)/COLUMBIA Class submarine (CLB), DDG 51 Class destroyer, CVN 78 Class carrier, F-35 Lightning II aircraft (F-35), and CH-53K Heavy Lift Helicopter. Manufacturing enterprise technology areas include, but are not limited to design for easier production/design for manufacturability; development of build/assembly strategies; modeling and simulation technologies; model-based tools and approaches to optimize ease of production; intelligent manufacturing planning and factory execution; elimination of inefficiencies in design optimization, material usage, labor utilization, work flow, etc.; supply chain procedures and improvements (such as network centric manufacturing capabilities to facilitate resilient and adaptable supply chains); development of more efficient structural fabrication product lines; streamlining of outfitting operations; prediction and reduction of welding distortion; advanced automation and robotics for manufacturing; advanced data analytics, artificial intelligence and machine learning for production environments; and inspection technologies such as digital radiography and ultrasonic technologies. Energetics efforts concentrate on developing energetics solutions to ensure the availability of safe, affordable, and quality energetics products largely in support of Program Executive Office (PEO) Integrated Warfare Systems (IWS).</p> <p>FY 2020 Plans: Technical activities include (1) Develop augmented reality (AR) and virtual reality (VR) manufacturing technology by exploiting product model data to improve shipbuilding affordability for VIRGINIA Class and COLUMBIA Class (VCS and CLB) submarines, CVN 78 Class carrier, and DDG 51 Class destroyer; (2) Develop a digital build</p>		25.322	28.138	28.308	0.000	28.308

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy			Date: February 2020		
Appropriation/Budget Activity 1319 / 3		R-1 Program Element (Number/Name) PE 0603680N / Manufacturing Technology Program		Project (Number/Name) 1050 / Manufacturing Tech	
B. Accomplishments/Planned Programs (\$ in Millions)			FY 2019	FY 2020	FY 2021 Base
sequence from the legacy VCS model to include the operations, material, joints, and views a worker needs to accomplish a particular unit of work to streamline both development time and rework required; (3) Develop Rapid Automated Technology Evaluation (RATE) capabilities for high rate automated F-35 aircraft assembly line automation processes to identify and predict any corrective actions necessary to not impact production schedules and product quality.					FY 2021 OCO
<p>FY 2021 Base Plans:</p> <ul style="list-style-type: none"> - Develop and transition advanced manufacturing enterprise technology improvements that result in cost reduction for key affordability platforms: VCS/CLB, DDG 51, CVN 78, FFG(X), and F-35. - Develop and transition advanced manufacturing enterprise technology improvements that accelerate capability to the fleet. An area of concentration includes manufacturing improvements for unmanned vehicles. - Develop and transition energetics manufacturing technology improvements that result in cost reduction for Naval Systems. - Develop and transition energetics manufacturing technology improvements that accelerate capability to the fleet. An area of concentration includes manufacturing improvements for flares and energetics. <p>FY 2021 OCO Plans:</p> <p>N/A</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement:</p> <p>There is no significant change between FY 2020 and FY 2021.</p>					FY 2021 Total
Accomplishments/Planned Programs Subtotals			57.322	60.138	60.122
C. Other Program Funding Summary (\$ in Millions)			0.000	60.122	
<p>Remarks</p> <p>D. Acquisition Strategy</p> <p>Efforts are focused on affordability improvements (both acquisition and life-cycle) for specific key acquisition platforms as defined in the Navy ManTech Investment Strategy. Currently, the majority of Navy ManTech efforts are focused on affordability improvements for: VIRGINIA Class submarine (VCS)/COLUMBIA Class submarine (CLB), DDG 51 Class destroyer, CVN 78 Class carrier, F-35 Lightning II aircraft (F-35), and CH-53K Heavy Lift Helicopter.</p>					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity 1319 / 3					R-1 Program Element (Number/Name) PE 0603680N / Manufacturing Technology Program				Project (Number/Name) 9999 / Congressional Adds				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
9999: Congressional Adds	0.000	0.000	5.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	5.000	
A. Mission Description and Budget Item Justification Congressional Interest Items not included in other Projects.													
B. Accomplishments/Planned Programs (\$ in Millions)													
<i>Congressional Add:</i> Modern shipbuilding manufacturing										FY 2019	FY 2020		
<i>FY 2019 Accomplishments:</i> N/A										0.000	5.000		
<i>FY 2020 Plans:</i> Conduct technology development research in Modern shipbuilding manufacturing.										Congressional Adds Subtotals	0.000	5.000	
C. Other Program Funding Summary (\$ in Millions)													
N/A													
Remarks													
D. Acquisition Strategy													
N/A													

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy											Date: February 2020	
Appropriation/Budget Activity					R-1 Program Element (Number/Name)							
1319: Research, Development, Test & Evaluation, Navy / BA 3: Advanced Technology Development (ATD)					PE 0603729N / Warfighter Protection Adv Tech							
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	0.000	39.949	34.149	4.851	-	4.851	4.949	5.049	5.151	5.254	Continuing	Continuing
2914: Warfighter Protection Adv Tech	0.000	4.713	4.849	4.851	-	4.851	4.949	5.049	5.151	5.254	Continuing	Continuing
9999: Congressional Adds	0.000	35.236	29.300	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	64.536

A. Mission Description and Budget Item Justification

This PE supports the advanced development and demonstration of technologies to improve warfighter performance, safety and survivability. Naval investment in these areas is essential in order to improve the ability to enhance, maintain, and sustain Warfighter effectiveness. Programs are coordinated with other Services through the Office of the Secretary of Defense Communities of Interest.

Today's Sailors and Marines are enabled by naval Science and Technology (S&T). Since 1946, the Office of Naval Research (ONR) has fostered scientific research related to the maintenance of maritime superiority and national defense. ONR manages the Department of the Navy's (DON) portfolio of naval Basic and Applied research, and Advanced Technology Development investments to ensure naval forces can effectively deter conflict, but when called upon, fight, win and come home safe. Current investments hedge against uncertainty, providing solutions to commanders today, and options for the future. The Naval S&T budget supports higher guidance defined by the National Defense Strategy, and responds to requirements identified by the Secretary of the Navy through research priorities set by the Chief of Naval Research, coordinated across the Naval Research Enterprise (NRE), and outlined in the Naval R&D Framework.

This Program Element (PE) funds Advanced Technology Development (ATD) that includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment. Efforts in this PE generally have Technology Readiness Levels TRL) of 4 (component and/or breadboard validation in laboratory environment.), 5 (component and/or breadboard validation in relevant environment.), or 6 (system/subsystem model or prototype demonstration in a relevant environment).

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy					Date: February 2020
Appropriation/Budget Activity		R-1 Program Element (Number/Name)			
1319: <i>Research, Development, Test & Evaluation, Navy / BA 3: Advanced Technology Development (ATD)</i>		PE 0603729N / <i>Warfighter Protection Adv Tech</i>			
B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	41.377	4.849	4.851	-	4.851
Current President's Budget	39.949	34.149	4.851	-	4.851
Total Adjustments	-1.428	29.300	0.000	-	0.000
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	29.300			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-1.428	0.000			
• Rate/Misc Adjustments	0.000	0.000	0.000	-	0.000
Congressional Add Details (\$ in Millions, and Includes General Reductions)					
Project: 9999: Congressional Adds					
Congressional Add: <i>Novel Therapeutic Interventions Research</i>					
Congressional Add: <i>Bone Marrow Registry Program</i>					
			Congressional Add Subtotals for Project: 9999		
			Congressional Add Totals for all Projects		
				FY 2019	FY 2020
				4.827	5.000
				30.409	24.300
				35.236	29.300
				35.236	29.300

Change Summary Explanation

funding: No significant change.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020				
Appropriation/Budget Activity					R-1 Program Element (Number/Name)				Project (Number/Name)						
1319 / 3					PE 0603729N / Warfighter Protection Adv Tech				2914 / Warfighter Protection Adv Tech						
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost			
2914: Warfighter Protection Adv Tech	0.000	4.713	4.849	4.851	-	4.851	4.949	5.049	5.151	5.254	Continuing	Continuing			
A. Mission Description and Budget Item Justification															
This Program Element supports the advanced development and demonstration of technologies to improve warfighter performance, safety and survivability. Naval investment in these areas is essential in order to improve the ability to enhance, maintain, and sustain Warfighter effectiveness. Programs are coordinated with other Services through the Office of the Secretary of Defense Communities of Interest.															
B. Accomplishments/Planned Programs (\$ in Millions)											FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Naval Noise-Induced Hearing Loss (NIHL) and Warfighter Performance											4.713	4.849	4.851	0.000	4.851
Description: Improve technologies in Warfighter performance and protection in austere (e.g., high noise, hyperbaric, hypobaric) training and operational environments.															
FY 2020 Plans: Develop advanced communication systems and platform quieting approaches for training and operational environments; develop in-ear dosimetry technologies to support the prediction of susceptibility/incidence of auditory damage, as well as the assessment of personal protective equipment; and advance infra-red therapy for the prevention and treatment of auditory injuries.															
FY 2021 Base Plans: Auditory Neuroscience and Performance															
Develop mitigation technologies to protect Warfighters in high-noise environments. Further advance therapeutic approaches for treatment of auditory injuries. Enhance auditory processing augmentation strategies for communication in high-noise environments, including the development and assessment of personal protective equipment, advanced communication systems, and equipment / platform quieting.															
Warfighter Performance															
- Conduct advanced development research to enhance Warfighter performance and protection in extreme pressure (hypobaric to hyperbaric), thermal (hot/cold), sensory and electromagnetic environments.															
FY 2021 OCO Plans:															

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603729N / Warfighter Protection Adv Tech	Project (Number/Name) 2914 / Warfighter Protection Adv Tech		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base
N/A FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant change between FY 2020 and FY 2021.				FY 2021 OCO
		Accomplishments/Planned Programs Subtotals	4.713	4.849
			4.851	0.000
				FY 2021 Total
C. Other Program Funding Summary (\$ in Millions)				
N/A				
Remarks				
D. Acquisition Strategy				
N/A				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity 1319 / 3					R-1 Program Element (Number/Name) PE 0603729N / Warfighter Protection Adv Tech				Project (Number/Name) 9999 / Congressional Adds				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
9999: Congressional Adds	0.000	35.236	29.300	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	64.536	
A. Mission Description and Budget Item Justification Congressional Interest Items not included in other Projects.													
B. Accomplishments/Planned Programs (\$ in Millions)											FY 2019	FY 2020	
Congressional Add: Novel Therapeutic Interventions Research											4.827	5.000	
FY 2019 Accomplishments: Novel Therapeutic Interventions Program conducts research on therapies that address readiness challenges by reducing battlefield mortality and improving quality of life. FY 19 efforts include utilizing a wearable garment to estimate strains/stresses in lower limbs during extreme exercises to determine joint susceptibility to microfractures, stress fractures, and potential ligament damage; development of a model of fluid resuscitation and physiology algorithm, and development in the use of platelet rich plasma (PRP) and bone marrow concentrate (BMC) for poly-traumatic injuries sustained during field operations													
FY 2020 Plans: Novel Therapeutic Interventions Program will continue to conduct research on therapies that address readiness challenges by reducing battlefield mortality and improving quality of life. FY 20 efforts include utilizing a wearable garment to estimate strains/stresses in lower limbs during extreme exercises to determine joint susceptibility to microfractures, stress fractures, and potential ligament damage; development of a model of fluid resuscitation and physiology algorithm, and development in the use of platelet rich plasma (PRP) and bone marrow concentrate (BMC) for poly-traumatic injuries sustained during field operations													
Congressional Add: Bone Marrow Registry Program											30.409	24.300	
FY 2019 Accomplishments: Bone Marrow program will develop, test and mature the ability to address contingency events wherein civilian or military personnel are exposed to marrow toxic agents, primarily ionizing radiation or chemical weapons containing nitrogen mustard in four focus areas: Contingency Preparedness, Development of Science and Technology for Rapid Identification of Matched Donors, Immunogenetic Studies in Transplantation and Clinical Research in Transplantation.													

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy			Date: February 2020
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603729N / Warfighter Protection Adv Tech	Project (Number/Name) 9999 / Congressional Adds	
B. Accomplishments/Planned Programs (\$ in Millions) <p>Conduct efforts to develop and integrate framework, sensors and hardware platform for the real-time detection of acute ionizing radiation exposure and prediction of bone marrow injury to assist in the rapid identification of high risk personnel, assessment and triage, and pre-emptive donor matching for those requiring transplantation.</p> <p>FY 2020 Plans: Bone Marrow program will continue develop, test and mature the ability to address contingency events wherein civilian or military personnel are exposed to marrow toxic agents, primarily ionizing radiation or chemical weapons containing nitrogen mustard in four focus areas: Contingency Preparedness, Development of Science and Technology for Rapid Identification of Matched Donors, Immunogenetic Studies in Transplantation and Clinical Research in Transplantation.</p> <p>Conduct efforts to develop and integrate framework, sensors and hardware platform for the real-time detection of acute ionizing radiation exposure and prediction of bone marrow injury to assist in the rapid identification of high risk personnel, assessment and triage, and pre-emptive donor matching for those requiring transplantation.</p>	FY 2019	FY 2020	
Congressional Adds Subtotals	35.236	29.300	
C. Other Program Funding Summary (\$ in Millions) N/A			
Remarks			
D. Acquisition Strategy N/A			

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity					R-1 Program Element (Number/Name)								
1319: Research, Development, Test & Evaluation, Navy / BA 3: Advanced Technology Development (ATD)					PE 0603758N / Navy Warfighting Exp & Demo								
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
Total Program Element	0.000	64.422	67.739	40.709	-	40.709	41.302	57.585	57.697	58.851	Continuing	Continuing	
2918: Navy Warfighting Experiments and Demo	0.000	64.422	67.739	40.709	-	40.709	41.302	57.585	57.697	58.851	Continuing	Continuing	

A. Mission Description and Budget Item Justification

The Office of Naval Research (ONR) guides ongoing research in the pursuit of innovative, decisive capabilities for our Sailors and Marines. ONR manages a broad, but priority-driven investment portfolio of near to long-term basic and applied research. This Program Element (PE) addresses the development of recent Science and Technology (S&T) breakthroughs to meet current operational needs from a subscale proof-of-principle into a full-scale prototype for warfighter experimentation during laboratory and operational demonstrations including Fleet Battle Problems (FBP), Limited Objective Experiments (LOEs) and Fleet/Force exercises. The key aspects of this PE are divided into five areas supporting the continuum of S&T from discovery to delivery: (1) Naval Warfare Experimentation develops rapid prototypes and provides them to the warfighter for experimentation during operational demonstrations and exercises; (2) Operations Analysis provides the Navy and Marine Corps the means to identify capability needs that can be addressed with science and technology solutions and inform future investment; (3) SwampWorks develops and demonstrates newly invented or recently discovered technologies that address emergent and enduring operational problems in an accelerated timeframe; (4) TechSolutions develops rapid response science and technology prototypes addressing Fleet/Force needs identified by Sailors and Marines at the deckplate level; and (5) support for the Naval Precision Strike Operations, providing the Navy capability to quickly locate, target, and strike critical targets.

Today's Sailors and Marines are enabled by naval Science and Technology (S&T). Since 1946, the Office of Naval Research (ONR) has fostered scientific research related to the maintenance of maritime superiority and national defense. ONR manages the Department of the Navy's (DON) portfolio of naval Basic and Applied research, and Advanced Technology Development investments to ensure naval forces can effectively deter conflict, but when called upon, fight, win and come home safe. Current investments hedge against uncertainty, providing solutions to commanders today, and options for the future. The Naval S&T budget supports higher guidance defined by the National Defense Strategy, and responds to requirements identified by the Secretary of the Navy through research priorities set by the Chief of Naval Research, coordinated across the Naval Research Enterprise (NRE), and outlined in the Naval R&D Framework.

This Program Element (PE) funds Advanced Technology Development (ATD) that includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment. Efforts in this PE generally have Technology Readiness Levels TRL) of 4 (component and/or breadboard validation in laboratory environment.), 5 (component and/or breadboard validation in relevant environment.), or 6 (system/subsystem model or prototype demonstration in a relevant environment).

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy					Date: February 2020
Appropriation/Budget Activity	R-1 Program Element (Number/Name) PE 0603758N / Navy Warfighting Exp & Demo				
B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	65.885	67.739	67.925	-	67.925
Current President's Budget	64.422	67.739	40.709	-	40.709
Total Adjustments	-1.463	0.000	-27.216	-	-27.216
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-1.463	0.000			
• Program Adjustments	0.000	0.000	-27.216	-	-27.216
• Rate/Misc Adjustments	0.000	0.000	0.000	-	0.000
Change Summary Explanation					
Funding: The reduction in FY 2021 is due to the realignment of Advanced Technology Development efforts and the realignment of resources administered through ONR Global to higher priority Navy requirements.					
Technical: Not applicable.					
Schedule: Not applicable.					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020				
Appropriation/Budget Activity					R-1 Program Element (Number/Name)				Project (Number/Name)						
1319 / 3					PE 0603758N / Navy Warfighting Exp & Demo				2918 / Navy Warfighting Experiments and Demo						
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost			
2918: Navy Warfighting Experiments and Demo	0.000	64.422	67.739	40.709	-	40.709	41.302	57.585	57.697	58.851	Continuing	Continuing			
A. Mission Description and Budget Item Justification															
This project focuses on the application of recent technology breakthroughs to meet current operational needs from a subscale proof-of-principle into a full-scale prototypes for warfighter experimentation during laboratory and operational demonstrations, Fleet Battle Problems (FBPs), Limited Objective Experiments (LOEs) and Fleet/Force exercises.															
B. Accomplishments/Planned Programs (\$ in Millions)											FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Naval Warfare Experimentation Description: The objective of this activity is to capitalize on recent technology breakthroughs to develop and integrate components including subsystems into prototypes quickly. These technologies are provided to the warfighter for experimentation, field experiments, and/or tests in simulated or actual environments. The use of Navy Warfare Development Command (NWDC) Fleet Experimentation (FLEX) events is encouraged. The net results are knowledge that only an experiment can provide and that will inform future Science and Technology (S&T) development and transition of capabilities. An example of Naval Warfare Experimentation efforts is funding participation of the SeaHunter Medium Displacement Unmanned Surface Vessel (MDUSV) in a recent Pacific Fleet Battle Problem to determine its ability to conduct operations as part of a larger naval force transiting autonomously from California to Hawaii. FY 2020 Plans: Expand operational experimentation efforts through the creation and maintenance of an Experimentation and Analysis Opportunities catalog for use by the Naval Research Enterprise (NRE) in order to develop a prioritized list of concept investigations that will result in operational experimentation in the form of tests, demonstrations, and large and small scale experimentation that will address emerging operational needs. Early Technology Readiness Level concept investigations with Fleet and Force input will be conducted to establish concept potential, and inform NRE investment decisions. Additionally, experimentation will be used as an excursion to address additional warfighter needs or mitigate capability delivery risk. FY 2021 Base Plans:											20.145	20.608	7.518	0.000	7.518

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603758N / Navy Warfighting Exp & Demo	Project (Number/Name) 2918 / Navy Warfighting Experiments and Demo				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Maintain and leverage a Naval Research Enterprise (NRE) Experimentation and Analysis Opportunities catalogue to guide prioritized concept investigations in support of fleet/force needs and strategic S&T initiatives. Invest in operational experimentation such as tests, demonstrations, and large and small scale experimentation that will address emerging operational needs. Manage a NRE experimentation plan which will guide multi-year S&T experimentation efforts in response to emerging concepts and doctrine. Conduct early Technology Readiness Level concept investigations with Fleet and Force input to establish concept potential, and inform NRE investment decisions. Leverage experimentation as an excursion to traditional programs to address additional warfighter needs and/or mitigate capability delivery risk.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The reduction from FY 2020 to FY 2021 is due to the realignment of Advanced Technology Development efforts and the realignment of resources administered through ONR Global to higher priority Navy requirements.						
Title: Operations Analysis Description: The objective of this project is to provide operational analysis through studies, analyses, gaming, modeling and simulation (M&S), and experimentation to identify Navy and Marine Corps capability needs that can be addressed with S&T solutions. The effort includes core analysis of Science and Technology (S&T) programs, military utility/capability gaps analyses, war gaming, structured experimentation events, the articulation of the results of that analysis and war gaming, and the development of innovation strategies and messages resulting from these analyses. An example of an Operations Analysis effort would be conducting an Artificial Intelligence Technology Innovation Game (TIG) with the Naval Warfare Development Command and representatives from the fleet, force, and NRE to determine where application of AI can have the most significant, near term impact on warfighting capability which allows the NRE to more accurately focus its S&T investments.		2.167	2.204	0.804	0.000	0.804
FY 2020 Plans: Conduct warfighter workshops to discover new concepts and issues and identify new focus areas for S&T development guided by the warfighter. Additionally, conduct Concept of Employment Development to explore existing or new S&T into training or exercises to improve effectiveness. Also conduct Concept of Operations development to explore how operational objectives or capabilities can be met with existing or new S&T.						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603758N / Navy Warfighting Exp & Demo	Project (Number/Name) 2918 / Navy Warfighting Experiments and Demo				
<u>B. Accomplishments/Planned Programs (\$ in Millions)</u>		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Additionally, work with the Navy Warfare Development Command in order to conduct Technology Innovation Games that help inform Science and Technology program capabilities.						
FY 2021 Base Plans: Conduct warfighter workshops to discover and/or refine new concepts and issues and identify new focus areas for Science and Technology (S&T) development guided by the warfighter. Commission studies to investigate emerging areas for S&T investment and determine the naval specific challenges requiring NRE investment. Conduct Concept of Employment investigations to explore incorporating existing or new S&T into training or exercises to improve effectiveness. Conduct Concept of Operations investigations to explore how operational objectives or capabilities can be met with existing or new S&T. Work with the Navy Warfare Development Command in order to conduct Technology Innovation Games that help inform Science and Technology program capabilities.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The reduction from FY 2020 to FY 2021 is due to the realignment of Advanced Technology Development efforts and the realignment of resources administered through ONR Global to higher priority Navy requirements.						
Title: Swampworks Description: The SwampWorks portfolio explores high-risk, disruptive, and innovative technologies and concepts that advance naval warfighters capabilities. The program has substantial programmatic flexibility and is not limited to any set of technology areas. Ultimately, the goal is to provide a dramatic improvement for the warfighter at a rapid pace. Some of these technologies may become part of a follow-on technology development, may end up in the hands of the warfighter for Fleet/ Force experimentation, or may culminate in a significant Fleet/Force exercise that demonstrates capability that transitions into the Acquisition Program of Record (POR).		21.886	22.430	14.950	0.000	14.950
FY 2020 Plans: The balance of the S&T projects that will start in FY20 will be identified during FY20 as the needs of the warfighters, for investments in this portfolio, evolve or change. SwampWorks projects will be based on input from Naval Research Enterprise stakeholders (including the Naval enterprises, the combatant commands, OPNAV and Headquarters Marine Corps) and will be designed to exploit breakthroughs in science and technology in order to deliver maximum warfighting benefit to our sailors and marines. SwampWorks projects						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603758N / Navy Warfighting Exp & Demo	Project (Number/Name) 2918 / Navy Warfighting Experiments and Demo				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
will be aligned with shared priorities throughout the whole of RDT&E in order to quickly advance new capabilities from discovery to deployment across the warfighting domains.						
<p>FY 2021 Base Plans: Complete Digital Twin for USS JOHN F. KENNEDY (CVN 79) Advanced Weapons Elevator. Continue development of Quantum Gravimeter Navigation System. The remaining Science and Technology (S&T) projects that start in FY21 will be identified during FY21 as emerging warfighters needs are realized. Swampworks projects will continue to be aligned with National Defense Strategy, OSD Modernization Priorities and CNO / CMC Guidance.</p> <p>FY 2021 OCO Plans: N/A</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: The reduction from FY 2020 to FY 2021 is due to the realignment of Advanced Technology Development efforts and the realignment of resources administered through ONR Global to higher priority Navy requirements.</p>						
<p>Title: Tech Solutions</p> <p>Description: TechSolutions develops rapid response Science and Technology (S&T) solutions to immediate Fleet/Force needs identified by individual Sailors at the deckplate level and Marines in the field. TechSolutions links warfighters to the government science and technology community to develop needed technologies as quickly as possible. Sailors, Marines and Science Advisors submit their issues throughout the year via the TechSolutions web portal. Projects are initiated directly from such requests and a prototype solution is developed collaboratively with the warfighter. Within 12 months the prototype is delivered into the hands of the warfighter and demonstrated in an operationally relevant context.</p> <p>Historical examples of technology requests have included an enhancement to weapons training for security forces that was satisfied by development of an Augmented Reality headset and instrumented weapons, and a request for automated video recording of interactions at sea that was satisfied by the development of 360 degree visible and infrared cameras and DVR for quickly generating reports with video documentation to transmit up the chain of command.</p> <p>FY 2020 Plans: This program will conduct new S&T developments based on Fleet/Force interactions and expressed warfighter needs. The program will be readily available to support the mission of the fleet by responding to Sailors/Marines</p>		9.958	10.126	5.064	0.000	5.064

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603758N / Navy Warfighting Exp & Demo	Project (Number/Name) 2918 / Navy Warfighting Experiments and Demo				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
need for technology. Developments will be undertaken to deliver rapid response solutions so warfighters can achieve mission success and perform their duties safer, more effectively and more efficiently by leveraging technology that has recently been developed or is emergent. Demonstrations will be conducted with warfighters at the conclusion of developments to assess the utility of the technology and understand what steps remain to achieve transition.						
FY 2021 Base Plans: This program will conduct new Science and Technology (S&T) developments based on Fleet/Force interactions and expressed warfighter needs. The program will be readily available to support the mission of the fleet by responding to Sailors/Marines need for technology. Developments will be undertaken to deliver rapid response solutions so warfighters can achieve mission success and perform their duties safer, more effectively and more efficiently by leveraging technology that has recently been developed or is emergent. Demonstrations will be conducted with warfighters at the conclusion of developments to assess the utility of the technology and understand what steps remain to achieve transition.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The reduction from FY 2020 to FY 2021 is due to the realignment of Advanced Technology Development efforts and the realignment of resources administered through ONR Global to higher priority Navy requirements.						
Title: Precision Strike Technology Description: Efforts in this area support Naval Precision Strike Operations, providing the Navy capability to quickly locate, target, and strike critical targets. Ongoing efforts include conducting kill-chain studies to identify and recommend engineering trades to enable weapon system interoperability and data fusion alternatives. These studies assess engineering feasibility of various kill-chain options and assess the capability provided. Classified addendum includes further program details.		10.266	12.371	12.373	0.000	12.373
FY 2020 Plans: Efforts in this area support Naval Precision Strike Operations, providing the Navy capability to quickly locate, target, and strike critical targets. Ongoing efforts include conducting kill-chain studies to identify and recommend						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020
Appropriation/Budget Activity 1319 / 3		R-1 Program Element (Number/Name) PE 0603758N / Navy Warfighting Exp & Demo	Project (Number/Name) 2918 / Navy Warfighting Experiments and Demo	
B. Accomplishments/Planned Programs (\$ in Millions)				
FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
engineering trades to enable weapon system interoperability and data fusion alternatives. These studies assess engineering feasibility of various kill-chain options and assess the capability provided.				
FY 2021 Base Plans: Efforts in this area support Naval Precision Strike Operations, providing the Navy capability to quickly locate, target, and strike critical targets. Ongoing efforts include conducting kill-chain studies to identify and recommend engineering trades to enable weapon system interoperability and data fusion alternatives. These studies assess engineering feasibility of various kill-chain options and assess the capability provided.				
FY 2021 OCO Plans: N/A				
FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant change from FY 2020 to FY 2021.				
Accomplishments/Planned Programs Subtotals				64.422 67.739 40.709 0.000 40.709
C. Other Program Funding Summary (\$ in Millions)				
N/A				
Remarks				
D. Acquisition Strategy Not applicable.				

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy											Date: February 2020	
Appropriation/Budget Activity					R-1 Program Element (Number/Name)							
1319: Research, Development, Test & Evaluation, Navy / BA 3: Advanced Technology Development (ATD)					PE 0603782N / Mine and Expeditionary Warfare Advanced Technology							
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	0.000	38.541	13.335	1.948	-	1.948	1.987	2.027	2.068	2.109	Continuing	Continuing
2917: Shallow Water MCM Demos	0.000	12.959	13.335	1.948	-	1.948	1.987	2.027	2.068	2.109	Continuing	Continuing
9999: Congressional Adds	0.000	25.582	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	25.582

A. Mission Description and Budget Item Justification

Explosive ordnance disposal is a critical naval mission vital to the safety of service members and civilians. Highly trained Sailors and Marines utilize their knowhow and courage combined with state-of-the-art technology to remove unexploded ordnance, land/sea mines and even chemical, biological and nuclear weapons. The Department of Defense (DoD) Directive 5160.62 "Single Manager Responsibility for Military Explosive Ordnance Disposal Technology and Training (EODT&T)" approved by the DoD Explosive Ordnance Disposal (EOD) Program Board (Sep 2012) guides research in this Program Element (PE). Unique needs and capabilities identified by the Joint Requirements Oversight Council (JROC) and the DoD EOD Program Board are also addressed by this PE, and provide the vision and key objectives for the essential science and technology efforts that will enable the continued supremacy of U.S. Naval and Joint EOD forces in the 21st century. The strategy focuses and aligns Naval S&T with Naval missions, DoD EOD S&T with Joint EOD missions and future capability needs that address the complex challenges presented by both rising peer competitors and irregular/asymmetric warfare.

This PE primarily develops and demonstrates prototype Mine Countermeasures (MCM), Expeditionary Warfare and Joint EOD system components that support capabilities enabling Naval and Joint EOD Forces to influence operations ashore. Adversarial nations have the capability to procure, stockpile and rapidly deploy all types of naval mines, including new generation mines having sophisticated performance characteristics, throughout the littorals. They also have the capability to develop or modify explosive devices such as mines and unexploded ordnance to construct Improvised Explosive Devices (IEDs) for the purpose of targeting Joint Forces. Real world operations have demonstrated the requirement to quickly counter the mine threat. Current operations have also demonstrated the requirement to quickly counter the threat from explosive hazards and IEDs during DoD operations. Advanced technologies must rapidly detect and neutralize all mine types, from deep water to the inland objective. Advanced technologies must enable Joint EOD forces to detect/locate, gain access, diagnose, render safe, neutralize, recover, exploit and dispose of a broad spectrum of explosive hazards including unexploded ordnance and IEDs. This program supports the advanced development and integration of sensors, processing, warheads, and delivery vehicles to demonstrate improved Naval Warfare capabilities. It supports the advanced development and integration of sensors and tools for standoff capabilities such as detection and location of IEDs (particularly in dismounted operations), dismounted diagnosis of buried munitions and other explosive hazards, precision render safe and neutralization of surface munitions and other explosive hazards, and enhanced access to IEDs. It supports the MCM-related FNC Enabling Capabilities (ECs).

Today's Sailors and Marines are enabled by naval Science and Technology (S&T). Since 1946, the Office of Naval Research (ONR) has fostered scientific research related to the maintenance of maritime superiority and national defense. ONR manages the Department of the Navy's (DON) portfolio of naval Basic and Applied research, and Advanced Technology Development investments to ensure naval forces can effectively deter conflict, but when called upon, fight, win and come home safe. Current investments hedge against uncertainty, providing solutions to commanders today, and options for the future. The Naval S&T budget supports higher

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy	Date: February 2020				
Appropriation/Budget Activity 1319: <i>Research, Development, Test & Evaluation, Navy / BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603782N / <i>Mine and Expeditionary Warfare Advanced Technology</i>				
guidance defined by the National Defense Strategy, and responds to requirements identified by the Secretary of the Navy through research priorities set by the Chief of Naval Research, coordinated across the Naval Research Enterprise (NRE), and outlined in the Naval R&D Framework.					
This Program Element (PE) funds Advanced Technology Development (ATD) that includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment. Efforts in this PE generally have Technology Readiness Levels TRL) of 4 (component and/or breadboard validation in laboratory environment.), 5 (component and/or breadboard validation in relevant environment.), or 6 (system/subsystem model or prototype demonstration in a relevant environment).					
Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.					
B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	39.672	13.335	1.948	-	1.948
Current President's Budget	38.541	13.335	1.948	-	1.948
Total Adjustments	-1.131	0.000	0.000	-	0.000
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-1.131	0.000			
• Rate/Misc Adjustments	0.000	0.000	0.000	-	0.000
Congressional Add Details (\$ in Millions, and Includes General Reductions)	FY 2019	FY 2020			
Project: 9999: Congressional Adds					
Congressional Add: <i>Sensor for Maritime Capabilities Demonstration</i>	22.686	0.000			
Congressional Add: <i>Additive Manufacturing</i>	2.896	0.000			
	Congressional Add Subtotals for Project: 9999				
	Congressional Add Totals for all Projects				
Change Summary Explanation					
funding: No significant change.					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity					R-1 Program Element (Number/Name)				Project (Number/Name)				
1319 / 3					PE 0603782N / Mine and Expeditionary Warfare Advanced Technology				2917 / Shallow Water MCM Demos				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
2917: Shallow Water MCM Demos	0.000	12.959	13.335	1.948	-	1.948	1.987	2.027	2.068	2.109	Continuing	Continuing	

A. Mission Description and Budget Item Justification

This Project develops and demonstrates prototype technology for Mine Countermeasures (MCM), US Naval sea mining, and Expeditionary Warfare and Joint EOD system components that support capabilities enabling Naval and Joint EOD Forces to influence operations ashore. Adversarial nations have the capability to procure, stockpile and rapidly deploy all types of naval mines, throughout the littorals including new generation mines having sophisticated performance characteristics. They also have the capability to develop or modify explosive devices such as mines and unexploded ordnance to construct Improvised Explosive Devices (IEDs) for the purpose of targeting Joint Forces. Real world operations have demonstrated the requirement to quickly counter the mine threat. Current operations have also demonstrated the requirement to quickly counter the threat from explosive hazards and IEDs during DoD operations. Advanced technologies must rapidly detect and neutralize all mine types, from deep water to the inland objective. Advanced technologies must enable Joint EOD forces to detect/locate, gain access, diagnose, render safe, neutralize, recover, exploit and dispose of a broad spectrum of explosive hazards including unexploded ordnance and IEDs. This program supports the advanced development and integration of sensors, processing, warheads, and delivery vehicles to demonstrate improved Naval Warfare capabilities.

This Project supports the advanced development and integration of sensors and tools for standoff capabilities such as detection and location of IEDs (particularly in dismounted operations), dismounted diagnosis of buried munitions and other explosive hazards, precision render safe and neutralization of surface munitions and other explosive hazards, and enhanced access to IEDs. It supports advanced development for battlespace shaping weapons including advanced undersea weapons. It supports the MCM related FNC Enabling Capabilities (ECs).

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<p>Title: Joint EOD Demos</p> <p>Description: This activity focuses on developing and demonstrating technologies to support a standoff or remote capability for detection and location, diagnosis, render safe, neutralization and enhanced access. Efforts include: electromagnetic, electro-optical, and acoustic sensors and systems for detection of explosive threat components including explosives, device housings/containers, and triggering mechanisms, standoff identification and confirmation of trace explosives, fusion of multi-sensor input for high confidence detection and diagnosis of buried threats, highly dexterous manipulators and imitative controllers for lightweight, efficient (strength/weight ratio) dual manipulator systems integrated onto EOD robots for enhanced access, enhanced robotic autonomy to support EOD missions, data compression and visualization techniques to support precise render safe and neutralization, and neutralization devices containing reactive materials to neutralize devices with low collateral damage. This S&T investment supports the Joint Requirements Oversight Council (JROC) and DoD EOD Program Board validated requirements for Joint EOD missions. This S&T investment provides critical S&T</p>	1.878	1.946	1.948	0.000	1.948

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603782N / Mine and Expeditionary Warfare Advanced Technology	Project (Number/Name) 2917 / Shallow Water MCM Demos				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
transitions to acquisition programs. This investment in Joint EOD S&T is reported annually to the DoD EOD Program Board. This S&T investment is documented in the DoD EOD Applied Research Program Plan which is reviewed and approved annually by the DoD EOD Program Board.						
FY 2020 Plans: Conduct advanced technology development and demonstration in electro-optic & acoustic technologies for buried mine detection, robotic manipulation for ordnance exploitation & neutralization, standoff detection and classification for ordnance, and identification of explosives. Efforts in this thrust include prototype and demonstration of laser interferometric sensor / systems for detection of buried objects, highly dexterous dual manipulator systems (manipulators, controllers) for EOD robots for precision render safe and neutralization missions, technologies for low-observable underwater ordnance neutralization and technologies for the inspection of underwater explosive threats.						
FY 2021 Base Plans: - Joint Explosive Ordnance Disposal (JEOD), Advanced Technology: Conduct advanced technology development and demonstration for JEOD functional areas including detect, access, diagnose, and render safe/neutralize. - Joint Explosive Ordnance Disposal (JEOD), Detection: Further efforts in the detection functional area. Specific efforts will include development and demonstration of advanced electro-optical and spectroscopic sensors for detection of explosives. The objective is to remotely detect bulk and trace explosives. - Joint Explosive Ordnance Disposal (JEOD), Remote Access: Maintain efforts the access functional area. Specific efforts will include robotic manipulators, end effectors and haptics. The objective is to enable remote access to explosive threats and unexploded ordnance. - Joint Explosive Ordnance Disposal (JEOD), Acoustic Sensor: Conclude detection of buried explosive threats with seismic-acoustic sensor. Specific effort includes demonstration of a robot mounted seismic acoustic sensor. The objective is to enable standoff detection of buried explosive threats with improved detection and classification statistics. - Joint Explosive Ordnance Disposal (JEOD), Man-Portable Prototypes: Initiate efforts in diagnose and render safe/neutralize functional areas. Specific efforts will include the development and demonstration of man-portable						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603782N / Mine and Expeditionary Warfare Advanced Technology	Project (Number/Name) 2917 / Shallow Water MCM Demos				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
prototypes. The objective is to assess the status of explosive threats and ordnance and render safe/neutralize at standoff.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant change between FY 2020 and FY 2021.						
Title: Mine Technology Description: This activity focuses on developing and demonstrating technology to support on-demand battlespace shaping through advanced undersea weapons. Efforts include command & control (C2), remote control, advanced sensing technologies, compatibility with unmanned delivery options, detection & classification, and targeting solutions. The program, Modular Undersea Effector System (MUSE), is a limited duration effort for advanced mining and responds to recent request for capability from the fleet.		11.081	11.389	0.000	0.000	0.000
FY 2020 Plans: Conduct advanced technology development in advanced mining technologies for clandestine, flexible, and scalable minefield deployment, longevity, and endurance, to include remote control, advanced sensing for detection and classification, command & control (C2), and more discriminative targeting solutions. Efforts in this thrust include prototyping and demonstration of advanced sensors and sensor configuration technologies for improved discrimination as well as communications, command, and control technologies. Continue prototyping and demonstration for next-generation target detection devices and mine effects.						
FY 2021 Base Plans: N/A						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The funding decrease from FY 2020 to FY 2021 is due to the conclusion of all research efforts in the Mine Technology Activity in PU 2917.						
Accomplishments/Planned Programs Subtotals		12.959	13.335	1.948	0.000	1.948

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy	Date: February 2020	
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603782N / <i>Mine and Expeditionary Warfare Advanced Technology</i>	Project (Number/Name) 2917 / <i>Shallow Water MCM Demos</i>
C. Other Program Funding Summary (\$ in Millions)		
N/A		
Remarks		
D. Acquisition Strategy		
N/A		

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity 1319 / 3					R-1 Program Element (Number/Name) PE 0603782N / Mine and Expeditionary Warfare Advanced Technology				Project (Number/Name) 9999 / Congressional Adds				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
9999: Congressional Adds	0.000	25.582	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	25.582	
A. Mission Description and Budget Item Justification Congressional Interest Items not included in other Projects.													
B. Accomplishments/Planned Programs (\$ in Millions)													
<i>Congressional Add:</i> Sensor for Maritime Capabilities Demonstration										FY 2019	FY 2020		
<i>FY 2019 Accomplishments:</i> Development of an airborne, multi-spectral sensor to demonstrate potential for long range detection, increased persistence, and ability to operate on different ISR platforms.										22.686	0.000		
<i>FY 2020 Plans:</i> N/A													
<i>Congressional Add:</i> Additive Manufacturing										2.896	0.000		
<i>FY 2019 Accomplishments:</i> Development of new advanced manufacturing technologies, such as additive manufacturing, friction stir welding and surface processing, and laser thermal and mechanical surface treatments to improve performance, increase reliability, and reduce costs for small turbojet and turbofans engines.													
<i>FY 2020 Plans:</i> N/A										Congressional Adds Subtotals	25.582	0.000	
C. Other Program Funding Summary (\$ in Millions)													
N/A													
Remarks													
D. Acquisition Strategy													
N/A													

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy											Date: February 2020			
Appropriation/Budget Activity					R-1 Program Element (Number/Name)									
1319: Research, Development, Test & Evaluation, Navy / BA 3: Advanced Technology Development (ATD)					PE 0603801N / Innovative Naval Prototypes (INP) Adv Tec Dev									
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost		
Total Program Element	0.000	196.092	129.003	141.948	-	141.948	134.163	126.888	126.696	129.230	Continuing	Continuing		
2480: SSL-TM	0.000	0.000	8.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	8.000		
2481: EMRG	0.000	0.000	7.368	9.500	-	9.500	0.000	0.000	0.000	0.000	0.000	16.868		
2731: High Energy Laser Counter ASCM Project (HELCAP)	0.000	0.000	0.000	29.500	-	29.500	14.000	4.000	0.000	0.000	0.000	47.500		
2958: Cyberspace Activities	0.000	0.000	14.498	16.489	-	16.489	15.939	0.000	0.000	0.000	0.000	46.926		
3400: Innovative Naval Prototypes (INP) Adv Tech Dev	0.000	156.512	91.137	0.000	-	0.000	8.501	10.482	49.760	50.756	Continuing	Continuing		
3416: HIJENKS	0.000	0.000	0.000	14.465	-	14.465	7.656	0.000	0.000	0.000	0.000	22.121		
3423: LOCUST	0.000	0.000	0.000	12.750	-	12.750	3.396	0.000	0.000	0.000	0.000	16.146		
3450: AMOS	0.000	0.000	0.000	4.524	-	4.524	3.480	4.525	0.000	0.000	0.000	12.529		
3451: CLAWS	0.000	0.000	0.000	15.300	-	15.300	14.339	0.000	0.000	0.000	0.000	29.639		
3452: ELEKTRA	0.000	0.000	0.000	10.869	-	10.869	12.926	9.946	4.973	5.072	Continuing	Continuing		
3453: Hypersonic Booster	0.000	0.000	0.000	0.000	-	0.000	0.000	20.000	30.000	30.600	Continuing	Continuing		
3454: MDUSV	0.000	0.000	0.000	1.115	-	1.115	0.000	0.000	0.000	0.000	0.000	1.115		
3455: MINERVA	0.000	0.000	0.000	10.936	-	10.936	12.926	11.935	6.963	7.102	Continuing	Continuing		
3457: Long Range Targeting	0.000	0.000	0.000	10.000	-	10.000	21.000	33.000	35.000	35.700	Continuing	Continuing		
3458: Undersea Warfare Efforts	0.000	0.000	0.000	2.500	-	2.500	0.000	0.000	0.000	0.000	0.000	2.500		
3459: Super Swarm (SS)	0.000	0.000	0.000	4.000	-	4.000	20.000	33.000	0.000	0.000	0.000	57.000		
9999: Congressional Adds	0.000	39.580	8.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	47.580		

Note

In FY 2020, three new stand alone project units were created for three Innovative Naval Prototypes (INP) major focus areas to better consolidate and coordinate the acceleration of these efforts. The three project units are: 2480 Solid State Laser Technology Maturation (SSL TM), 2481 the Electro-Magnetic Railgun, and 2958 Cyberspace Activities.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy		Date: February 2020
Appropriation/Budget Activity 1319: <i>Research, Development, Test & Evaluation, Navy / BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603801N / <i>Innovative Naval Prototypes (INP) Adv Tec Dev</i>	
In FY 2021, a new stand alone project unit, High Energy Laser Counter ASCM Project (HELCAP) will be established as Project 2731 to specifically differentiate HELCAP efforts from other efforts in the Directed Energy R-2 Activity under Project 3400.		
The FY 2020 Appropriation Act directed ONR to establish appropriate projects for prototyping efforts to provide additional acquisition oversight, fiscal clarity and adherence to financial management practices. Within this PE, INP funding was moved from Proj 3400 Innovative Naval Prototypes (INP) Adv Tech Dev to new stand-alone projects as indicated below starting in FY 2021.		
<ul style="list-style-type: none">- Proj 3416: HIJENKS- Proj 3423: LOCUST- Proj 3450: AMOS- Proj 3451: CLAWS- Proj 3452: ELEKTRA- Proj 3453: Hypersonic Booster- Proj 3454: MDUSV- Proj 3455: MINERVA- Proj 3457: Long Range Targeting- Proj 3458: Undersea Warfare Efforts- Proj 3459: Super Swarm (SS)		
A. Mission Description and Budget Item Justification The Office of Naval Research (ONR) portfolio includes efforts that solve problems and respond to mission requirements, as well as, exploratory research for new ideas and breakthrough capabilities. Larger in scope, scale and risk Innovative Naval Prototypes (INP) are selected for their high-payoff and potential to revolutionize operational concepts. The efforts described in this Program Element (PE) continue the Applied Research work in PE 0602792N for promising INPs with Advanced Technology Development activities. INP investments define the future of U.S. naval forces. Due to high technical risk, INPs often have long trial-and-error timeframes to work through challenges, but typically no more than three years between decision points. INP efforts mature technologies from a Technology Readiness Level (TRL) of 2 or 3 to a TRL of 6. As such, INPs require applied and advanced technology development funding to bridge from concept to working prototype. INPs prove technological and capability potential, validate production feasibility, and acquisition potential. ONR demonstrates INPs in relevant environments. Successful experimentation and demonstrations present the Department of the Navy with disruptive capabilities that may lead to a new acquisition programs. INPs are selected by senior leadership in the Department of the Navy. This Program Element (PE) funds Advanced Technology Development (ATD) that includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment. Efforts in this PE generally have Technology Readiness Levels (TRL) of 4 (component and/or breadboard validation in laboratory environment.), 5 (component and/or breadboard validation in relevant environment.), or 6 (system/subsystem model or prototype demonstration in a relevant environment).		

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy		Date: February 2020																																																																								
Appropriation/Budget Activity 1319: <i>Research, Development, Test & Evaluation, Navy / BA 3: Advanced Technology Development (ATD)</i>		R-1 Program Element (Number/Name) PE 0603801N / <i>Innovative Naval Prototypes (INP) Adv Tec Dev</i>																																																																								
Because to the nature of these projects described, technology development plans have been written with limited details due to information security concerns. Specific information on each project will be provided separately to the Congressional oversight committees.																																																																										
B. Program Change Summary (\$ in Millions)																																																																										
<table> <thead> <tr> <th></th> <th align="right">FY 2019</th> <th align="right">FY 2020</th> <th align="right">FY 2021 Base</th> <th align="right">FY 2021 OCO</th> <th align="right">FY 2021 Total</th> </tr> </thead> <tbody> <tr> <td>Previous President's Budget</td><td align="right">202.394</td><td align="right">133.303</td><td align="right">141.948</td><td align="right">-</td><td align="right">141.948</td></tr> <tr> <td>Current President's Budget</td><td align="right">196.092</td><td align="right">129.003</td><td align="right">141.948</td><td align="right">-</td><td align="right">141.948</td></tr> <tr> <td>Total Adjustments</td><td align="right">-6.302</td><td align="right">-4.300</td><td align="right">0.000</td><td align="right">-</td><td align="right">0.000</td></tr> <tr> <td> • Congressional General Reductions</td><td align="right">-</td><td align="right">-</td><td align="right"></td><td align="right"></td><td align="right"></td></tr> <tr> <td> • Congressional Directed Reductions</td><td align="right">-</td><td align="right">-12.300</td><td align="right"></td><td align="right"></td><td align="right"></td></tr> <tr> <td> • Congressional Rescissions</td><td align="right">-</td><td align="right">-</td><td align="right"></td><td align="right"></td><td align="right"></td></tr> <tr> <td> • Congressional Adds</td><td align="right">-</td><td align="right">8.000</td><td align="right"></td><td align="right"></td><td align="right"></td></tr> <tr> <td> • Congressional Directed Transfers</td><td align="right">-</td><td align="right">-</td><td align="right"></td><td align="right"></td><td align="right"></td></tr> <tr> <td> • Reprogrammings</td><td align="right">-</td><td align="right">-</td><td align="right"></td><td align="right"></td><td align="right"></td></tr> <tr> <td> • SBIR/STTR Transfer</td><td align="right">-6.302</td><td align="right">0.000</td><td align="right"></td><td align="right"></td><td align="right"></td></tr> <tr> <td> • Rate/Misc Adjustments</td><td align="right">0.000</td><td align="right">0.000</td><td align="right">0.000</td><td align="right">-</td><td align="right">0.000</td></tr> </tbody> </table>			FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	Previous President's Budget	202.394	133.303	141.948	-	141.948	Current President's Budget	196.092	129.003	141.948	-	141.948	Total Adjustments	-6.302	-4.300	0.000	-	0.000	• Congressional General Reductions	-	-				• Congressional Directed Reductions	-	-12.300				• Congressional Rescissions	-	-				• Congressional Adds	-	8.000				• Congressional Directed Transfers	-	-				• Reprogrammings	-	-				• SBIR/STTR Transfer	-6.302	0.000				• Rate/Misc Adjustments	0.000	0.000	0.000	-	0.000	
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Change Summary Explanation																																																																										
funding: No significant change.																																																																										
Schedule: Not applicable.																																																																										

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity					R-1 Program Element (Number/Name)				Project (Number/Name)				
1319 / 3					PE 0603801N / Innovative Naval Prototypes (INP) Adv Tec Dev				2480 / SSL-TM				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
2480: SSL-TM	0.000	0.000	8.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	8.000	

Note

Solid State Laser Technology Maturation (SSL TM) plans and associated resources are realigned from Project 3400 in Program Element (PE) 0603801N Innovative Naval Prototype (INP) Adv Tech Dev into this new Project 2480 within PE 0603801N effective FY 2020.

A. Mission Description and Budget Item Justification

Solid State Laser Technology Maturation (SSL TM) is a multi-year effort in various stages of research and development within the Navy's Innovative Naval Prototypes (INP) Program. SSL-TM will develop a maritime laser weapons system prototype and test it on a representative test platform for a naval surface combatant, and conduct the required laser weapon system engineering, design, integration and testing necessary to have a testable, experimental prototype. This system will be capable of supporting missions such as defense against small boat and Unmanned Aerial Vehicle (UAV) swarms and Intelligence, Surveillance and Reconnaissance (ISR) disruption and defeat. The project will conduct at-sea testing on the full laser weapon system demonstrator (i.e., prototype) from a representative test platform for a naval surface combatant.

INP investments represent game changing technologies with the potential to revolutionize operational concepts. They are disruptive in nature, as they would dramatically change the way naval forces fight. Due to high technical risk, INPs typically have long duration but have no more than three years between decision points. INPs do not develop hardware for service use, rather they prove technological and production feasibility, and show naval utility and acquisition potential. The Office of Naval Research (ONR) demonstrates INPs in relevant environments. Successful experimentation and demonstrations present the Department of the Navy with disruptive capabilities that may lead to the obsolescence of existing capabilities and acquisition programs. The Department of the Navy would have to make significant acquisition decisions to integrate the new technological capabilities into naval warfighting systems. INPs are selected by a process that involves senior leadership in the Department of the Navy.

Information security concerns preclude fully detailed descriptions of project efforts, research activities, and technology development plans. Specific information on each project and activity will be provided separately to the Congressional oversight committees.

B. Accomplishments/Planned Programs (\$ in Millions)

FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
0.000	8.000	0.000	0.000	0.000

Title: Solid State Laser Technology Maturation (SSL TM)

Description: Solid State Laser Technology Maturation (SSL-TM) is a multi-year effort to develop a maritime laser weapons system prototype and test it on a representative test platform for a naval surface combatant, and conduct the required laser weapon system engineering, design, integration and testing necessary to have a

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy										Date: February 2020								
Appropriation/Budget Activity 1319 / 3			R-1 Program Element (Number/Name) PE 0603801N / Innovative Naval Prototypes (INP) Adv Tec Dev				Project (Number/Name) 2480 / SSL-TM											
B. Accomplishments/Planned Programs (\$ in Millions)										FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total				
testable, experimental prototype. This system will be capable of supporting missions such as defense against small boat and Unmanned Aerial Vehicle (UAV) swarms.																		
FY 2020 Plans: At-sea testing and experimentation will be conducted with full laser weapon system demonstrator (i.e. prototype) on an active duty navy surface combat ship. During this period the technical performance will be evaluated in various atmospheric and sea state conductions while conducting operational missions and exercises. Lessons learned from operations and maintenance will be documented to inform development of future laser weapons systems development efforts.																		
FY 2021 Base Plans: N/A																		
FY 2021 OCO Plans: N/A																		
FY 2020 to FY 2021 Increase/Decrease Statement: The decrease in funding from FY 2020 to FY 2021 is due to the completion of Advanced Technology Development efforts under this Activity.																		
Accomplishments/Planned Programs Subtotals										0.000	8.000	0.000	0.000					
C. Other Program Funding Summary (\$ in Millions)																		
Line Item	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost							
• RDTEN/0603382N/2480: SSL-TM	0.000	3.922	11.909	-	11.909	5.434	3.992	0.000	0.000	0.000	25.257							
Remarks																		
D. Acquisition Strategy																		
N/A																		

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020	
Appropriation/Budget Activity					R-1 Program Element (Number/Name)				Project (Number/Name)			
1319 / 3					PE 0603801N / Innovative Naval Prototypes (INP) Adv Tec Dev				2481 / EMRG			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
2481: EMRG	0.000	0.000	7.368	9.500	-	9.500	0.000	0.000	0.000	0.000	0.000	16.868

Note

Electro-Magnetic Railgun (EMRG) plans and associated resources are realigned from Project Unit 3400 in Program Element (PE) 0603801N Innovative Naval Prototype (INP) Adv Tec Dev into this new Project Unit 2481 effective FY 2020.

A. Mission Description and Budget Item Justification

Electro-Magnetic Railgun (EMRG) is a high-power, kinetic energy weapon capable of launching precision guided projectiles using electricity instead of chemical propellants. This multi-year effort will build a Railgun Weapon System (RGWS) by designing, fabricating and integrating EMRG subsystems and components into a weapon system that brings new capabilities, increased capacity and improved operational economy to fleet operations at sea. With its increased velocity and extended range, EMRG provides multi-mission potential for hypersonic missile defense, anti-air & surface warfare, and naval surface fire support. The Activity identified in Project Unit 2481 specifically addresses Advanced Technology Development in support of the EMRG high-power, kinetic energy weapon prototype development Innovative Naval Prototype (INP) effort.

INP investments represent game changing technologies with the potential to revolutionize operational concepts. They are disruptive in nature, as they would dramatically change the way naval forces fight. Due to high technical risk, INPs typically have long duration but have no more than three years between decision points. INPs do not develop hardware for service use, rather they prove technological and production feasibility, and show naval utility and acquisition potential. The Office of Naval Research (ONR) demonstrates INPs in relevant environments. Successful experimentation and demonstrations present the Department of the Navy with disruptive capabilities that may lead to the obsolescence of existing capabilities and acquisition programs. The Department of the Navy would have to make significant acquisition decisions to integrate the new technological capabilities into naval warfighting systems. INPs are selected by a process that involves senior leadership in the Department of the Navy.

Information security concerns preclude fully detailed descriptions of project efforts, research activities, and technology development plans. Specific information on each project and activity will be provided separately to the Congressional oversight committees.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Electro-Magnetic Railgun (EMRG)	0.000	7.368	9.500	0.000	9.500

Description: The Electro-Magnetic Railgun (EMRG) is a high-power, kinetic energy weapon capable of launching precision guided projectiles using electricity instead of chemical propellants. This multi-year effort will build a Railgun Weapon System (RGWS) by designing, fabricating and integrating EMRG subsystems and components into a weapon system that brings new capabilities, increased capacity and improved operational

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603801N / Innovative Naval Prototypes (INP) Adv Tec Dev	Project (Number/Name) 2481 / EMRG				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
economy to fleet operations at sea. With its increased velocity and extended range, EMRG provides multi-mission potential for hypersonic missile defense, anti-air & surface warfare, and naval surface fire support.						
<p>FY 2020 Plans: Design, fabricate and integrate Electro-Magnetic Railgun (EMRG) subsystems and components into a system prototype including fully trainable, elevatable mount capable of rep-rate operations. Continue developing and testing prototype rep-rate railgun launcher that is suitable for installation in a prototype railgun gun mount. Conduct system level assessments of a Railgun Weapon System that is capable of closing the fire control loop. Demonstrate integration and use of Hyper Velocity Projectile (HVP) in a fixed elevation Railgun located at White Sands Missile Range. Conduct preliminary prototype system tests and demonstrations to prove the technological feasibility of the EMRG capability and assess sub-system and component operability under stressing rep-rate conditions. Develop next generation pulsed power (NGPP) system performance specifications for shipboard applications. Perform full-scale testing of long-life railgun launcher material solutions inserted in laboratory launchers. Design, build, test, and evaluate iterative electromagnetic railgun composite launcher prototypes to demonstrate the technological feasibility, performance, multi-shot life, and suitable firing rate of the system.</p>						
<p>FY 2021 Base Plans: Complete Anti-Air Warfare (AAW) demonstrations to prove capability of Hyper Velocity Projectile (HVP) when fired from a railgun to engage stressing air threats. Complete risk reduction activities started in FY 2020 to document requirements for a future tactical shipboard Railgun Weapon System (RGWS). Complete system functional requirements and performance specifications for a shipboard RGWS.</p>						
<p>FY 2021 OCO Plans: N/A</p>						
<p>FY 2020 to FY 2021 Increase/Decrease Statement: The increase in funding from FY 2020 to FY 2021 is due to additional efforts required for the demonstration of a Railgun Weapon System (RGWS) with prototype mount.</p>						
Accomplishments/Planned Programs Subtotals		0.000	7.368	9.500	0.000	9.500

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020
Appropriation/Budget Activity			R-1 Program Element (Number/Name)				Project (Number/Name)				
1319 / 3			PE 0603801N / Innovative Naval Prototypes (INP) Adv Tec Dev				2481 / EMRG				
C. Other Program Funding Summary (\$ in Millions)											
Line Item	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
• 1319/0602792N/0000: EM Railgun (EMRG)	13.463	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	13.463
• RDTEN/0602792N/2481: EM Railgun (EMRG)	0.000	7.632	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	7.632
• 1319/0603801N/3400: EM Railgun (EMRG)	14.557	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	14.557
Remarks											
D. Acquisition Strategy											
N/A											

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020	
Appropriation/Budget Activity					R-1 Program Element (Number/Name)				Project (Number/Name)			
1319 / 3					PE 0603801N / Innovative Naval Prototypes (INP) Adv Tec Dev				2731 / High Energy Laser Counter ASCM Project (HELCAP)			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
2731: High Energy Laser Counter ASCM Project (HELCAP)	0.000	0.000	0.000	29.500	-	29.500	14.000	4.000	0.000	0.000	0.000	47.500

Note

High Energy Laser Counter ASCM Project (HELCAP) plans and associated resources are realigned from Project 3400 in Program Element (PE) 0603801N Innovative Naval Prototypes (INP) Adv Tec Dev into this new Project 2731 within PE 0603801N effective FY 2021. This is not a new start.

A. Mission Description and Budget Item Justification

High Energy Laser Counter ASCM Project (HELCAP): Defeating Anti-Ship Cruise Missiles (ASCMs) with a laser weapon system presents several technical challenges. The High Energy Laser Counter ASCM Project HELCAP will assess, develop, experiment, and demonstrate the various laser weapon system technologies and methods of implementation required to defeat ASCMs.

HELCAP will leverage the knowledge gained in the Navy Laser Family of Systems (NLFoS) efforts that include:

- Alternative Laser Sources for higher powers, also known as the Ruggedized High Energy Laser (RHEL) activities;
- Solid State Laser Tech Maturation activities that provides initial key enabling technical solutions in high power lasers and beam control, and will provide opportunities for single ship operational and sustainment learning;
- Surface Navy Laser Weapon System Increment 1 (SNLWS Inc. 1) project that provides the initial combat system integration and installation knowledge for Aegis platforms, and multi-ship battle force operations knowledge;
- Optical Dazzling Interdictor Navy (ODIN) that provides Counter-ISR technical and fleet operational knowledge.

This leveraged knowledge and new HELCAP technical solutions to the C-ASCM problem will enable a fully informed decision to rapidly field an integrated, fleet ready, HEL Weapon.

HELCAP activities being conducted in this project include technology assessments, laser lethality investigations, and advanced beam control. This project passes technology to follow on HELCAP activities being conducted under Program Element (PE) 0603925N Directed Energy and Electric Weapon Systems.

INPs investments represent game changing technologies with the potential to revolutionize operational concepts. They are disruptive in nature, as they would dramatically change the way naval forces fight. Due to high technical risk, INPs typically have long duration but have no more than three years between decision points. INPs do not develop hardware for service use, rather they prove technological and production feasibility, and show naval utility and acquisition potential. The Office of Naval Research (ONR) demonstrates INPs in relevant environments. Successful experimentation and demonstrations present the Department of the Navy with disruptive capabilities that may lead to the obsolescence of existing capabilities and acquisition programs. The Department of the Navy would have to make significant acquisition decisions to integrate the new technological capabilities into naval warfighting systems. INPs are selected by a process that involves senior leadership in the Department of the Navy.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)				
1319 / 3	PE 0603801N / Innovative Naval Prototypes (INP) Adv Tec Dev	2731 / High Energy Laser Counter ASCM Project (HELCAP)				
Information security concerns preclude fully detailed descriptions of project efforts, research activities, and technology development plans. Specific information on each project and activity will be provided separately to the Congressional oversight committees.						
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: HELCAP		0.000	0.000	29.500	0.000	29.500
Description: The High Energy Laser Counter ASCM Project (HELCAP) will expedite the development, experimentation, integration and demonstration of critical technologies to defeat crossing Anti-Ship Cruise Missiles (ASCM) by addressing the remaining technical challenges, e.g.: atmospheric turbulence, automatic target identification and aim point selection, precision target tracking with low jitter in high clutter conditions, advanced beam control, and higher power HEL development. HELCAP will assess, develop, experiment, and demonstrate the various laser weapon system technologies and methods of implementation required to defeat ASCMs in a crossing engagement.						
FY 2020 Plans: See related HELCAP FY 2020 plans shown in Project 3400 / Innovative Naval Prototypes (INP) AdvTech Dev						
FY 2021 Base Plans: Continue in the development phase and enter the integration phase of an overall multi-year effort whose objective is to conduct development, experimentation, and demonstration of critical technologies to defeat crossing Anti-Ship Cruise Missiles (ASCM) including laser lethality, advanced beam control, and high energy laser sources. Continue ASCM defeat analysis and assessments including lethality, engagement modeling, atmospheric propagation characterization, and beam control. Complete fabrication and factory acceptance testing of a beam control testbed. Implement testbed technology insertion, and perform additional laser/materiel component interaction testing						
Related FY 2021 HELCAP project plans in with BA 04 funds under Program Element (PE) 0603925N Directed Energy and Electric Weapon Systems Project 2731 include systems engineering, mission analysis, and the design completion, fabrication, and integration of major components of a HELCAP prototype system. Planning and preparations for FY 2022-FY 2023 system experimentation and demonstrations utilizing the prototype system will also continue.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement:						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy								Date: February 2020						
Appropriation/Budget Activity 1319 / 3			R-1 Program Element (Number/Name) PE 0603801N / Innovative Naval Prototypes (INP) Adv Tec Dev				Project (Number/Name) 2731 / High Energy Laser Counter ASCM Project (HELCAP)							
B. Accomplishments/Planned Programs (\$ in Millions)									FY 2019	FY 2020				
The increase in funding in this Project Unit is due to the realignment of efforts related to HELCAP from PE 0603801N, Project Unit 3400 Directed Energy/Electric Weapons R-2 Activity, in order to differentiate the HELCAP efforts from the other directed energy/ electric weapon efforts.									FY 2021 Base	FY 2021 OCO				
The funding increase associated with HELCAP from FY 2020 to FY 2021 is due to increased investment to accelerate HELCAP technology development to counter the ASCM threat to Naval platforms.									FY 2021 Total					
Accomplishments/Planned Programs Subtotals									0.000	0.000				
									29.500	0.000				
									29.500	29.500				
C. Other Program Funding Summary (\$ in Millions)														
Line Item	FY 2019	FY 2020	FY 2021	FY 2021	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete				
• 1319/ 0603925N/ 2731: High Energy Laser Counter ASCM Project	0.000	6.750	38.012	-	38.012	29.952	15.462	6.506	3.251	0.000				
										99.933				
Remarks														
D. Acquisition Strategy														
N/A														

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020	
Appropriation/Budget Activity 1319 / 3					R-1 Program Element (Number/Name) PE 0603801N / Innovative Naval Prototypes (INP) Adv Tec Dev				Project (Number/Name) 2958 / Cyberspace Activities			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
2958: Cyberspace Activities	0.000	0.000	14.498	16.489	-	16.489	15.939	0.000	0.000	0.000	0.000	46.926

Note

Project 2958 was established separately in this Program Element (PE) beginning in FY 2020 to better isolate and identify Innovative Naval Prototype (INP) efforts addressing Cyberspace INP advanced technology development.

A. Mission Description and Budget Item Justification

This Project contains all Advanced Technology Development Innovative Naval Prototype (INP) investments that are developing new technologies for cyber warfare. Potential adversaries are investing in advanced technologies that will challenge our advantages in the critical information domain. Nation states and non-state actors seek to degrade our command and control capabilities, networks and computer systems. Cyber threats continue to grow and rapidly proliferate. Technologies developed in this Project will enable the warfighter to take immediate, appropriate action at any time against any desired adversary, target or network by assuring that autonomous, continuous analyses of intelligence, persistent surveillance and open information sources have, at all times, optimized the possible courses of action based on commander's guidance. Technologies within this activity will foster operational endurance and enable sustained operations and resiliency for warfighters and platforms through enhanced cyber security/protection.

INP investments represent game changing technologies with the potential to revolutionize operational concepts. They are disruptive in nature, as they would dramatically change the way naval forces fight. Due to high technical risk, INPs typically have long duration but have no more than three years between decision points. INPs do not develop hardware for service use, rather they prove technological and production feasibility, and show naval utility and acquisition potential. The Office of Naval Research (ONR) demonstrates INPs in relevant environments. Successful experimentation and demonstrations present the Department of the Navy with disruptive capabilities that may lead to the obsolescence of existing capabilities and acquisition programs. The Department of the Navy would have to make significant acquisition decisions to integrate the new technological capabilities into naval warfighting systems. INPs are selected by a process that involves senior leadership in the Department of the Navy.

Information security concerns preclude fully detailed descriptions of project efforts, research activities, and technology development plans. Specific information on each project and activity will be provided separately to the Congressional oversight committees.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Cyber	0.000	14.498	16.489	0.000	16.489

Description: This R2 Activity contains all Advanced Technology Development Innovative Naval Prototype (INP) investments that are developing new technologies for cyber warfare. Potential adversaries are investing in advanced technologies that will challenge our advantages in the critical information domain. Nation states and non-state actors seek to degrade our command and control capabilities, networks and computer systems.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603801N / Innovative Naval Prototypes <i>(INP) Adv Tec Dev</i>	Project (Number/Name) 2958 / Cyberspace Activities				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Cyber threats continue to grow and rapidly proliferate. Technologies developed in this R2 Activity will enable the warfighter to take immediate, appropriate action at any time against any desired adversary, target or network by assuring that autonomous, continuous analyses of intelligence, persistent surveillance and open information sources have, at all times, optimized the possible courses of action based on commander's guidance. Technologies within this activity will foster operational endurance and enable sustained operations and resiliency for warfighters and platforms through enhanced cyber security/protection.	FY 2020 Plans: Conduct Advanced Technology Development of tools and techniques to achieve an automated, systematic reduction of any computing system's attack surface across all its layers of computing. Continue development and demonstration of tools and techniques enabling powerful tailoring of an end-system computing environment to match the needs of deployed applications and users, removing software bloat and unused features, resulting in significantly reduced cyber attack surface for both known and unknown vulnerabilities. FY 2021 Base Plans: Continue Advanced Technology Development of tools and techniques to achieve an automated, systematic reduction of any computing system's attack surface across all its layers of computing. Continue to mature the suite of tools and techniques that enable a powerful tailoring of an end-system computing environment to reduce cyber attack surface. Conduct rapid demonstrations of the technologies in various systems within the Navy to evaluate the efficacy of the tools. Complete initial debloat tool feasibility analysis. Early results of the analysis have validated technological feasibility of the approaches and are beginning to quantify the highly compelling operational impact for cyber protection. Initiate advanced capability analysis of software debloat projects for Java, compiled C/C++, and low-level system firmware. This task is necessary to study system integration techniques for the tooling and to demonstrate capabilities for acquisition programs. Continue development of communications protocol subsetting and automated dialect generation to reshape cyber attack surface. Continue development of non-destructive microelectronics inspection methods that would provide a critical new capability for scalable cyber supply chain protection. FY 2021 OCO Plans:					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy										Date: February 2020	
Appropriation/Budget Activity 1319 / 3			R-1 Program Element (Number/Name) PE 0603801N / Innovative Naval Prototypes <i>(INP) Adv Tec Dev</i>					Project (Number/Name) 2958 / Cyberspace Activities			
B. Accomplishments/Planned Programs (\$ in Millions)											
					FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total		
N/A											
FY 2020 to FY 2021 Increase/Decrease Statement: The increase in funding from FY 2020 to FY 2021 is due to the planned ramp-up in the Advanced Technology Development effort under this Activity.											
Accomplishments/Planned Programs Subtotals										0.000 14.498 16.489 0.000 16.489	
C. Other Program Funding Summary (\$ in Millions)											
Line Item	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
• RDTEN/0602792N/2958: CYBERSPACE ACTIVITIES	0.000	27.269	28.511	-	28.511	26.061	0.000	0.000	0.000	0.000	81.841
Remarks											
D. Acquisition Strategy											
N/A											

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020	
Appropriation/Budget Activity					R-1 Program Element (Number/Name)				Project (Number/Name)			
1319 / 3					PE 0603801N / Innovative Naval Prototypes (INP) Adv Tec Dev				3400 / Innovative Naval Prototypes (INP) Adv Tech Dev			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
3400: Innovative Naval Prototypes (INP) Adv Tech Dev	0.000	156.512	91.137	0.000	-	0.000	8.501	10.482	49.760	50.756	Continuing	Continuing

Note

In FY 2020, three new stand alone project units were created for three INP major focus areas to better consolidate and coordinate the acceleration of these efforts. The three project units are: 2480 Solid State Laser Technology Maturation (SSL TM), 2481 the Electro-Magnetic Railgun, and 2958 Cyberspace Activities. These projects were moved from Project Unit 3400.

The FY 2020 Appropriation Act directed ONR to establish appropriate projects for prototyping efforts to provide additional acquisition oversight, fiscal clarity and adherence to financial management practices. Within this PE, INP funding was moved from Proj 3400 Innovative Naval Prototypes (INP) Adv Tech Dev to new stand-alone projects as indicated below starting in FY 2021.

- Proj 3416: HIJENKS
- Proj 3423: LOCUST
- Proj 3450: AMOS
- Proj 3451: CLAWS
- Proj 3452: ELEKTRA
- Proj 3453: Hypersonic Booster
- Proj 3454: MDUSV
- Proj 3455: MINERVA
- Proj 3457: Long Range Targeting
- Proj 3458: Undersea Warfare Efforts
- Proj 3459: Super Swarm (SS)

A. Mission Description and Budget Item Justification

The efforts described in this Project address the Advanced Technology Development associated with the Innovative Naval Prototypes (INP) Program. These investments represent game changing technologies with the potential to revolutionize operational concepts. They are disruptive in nature, as they would dramatically change the way naval forces fight. INP investments do not necessarily lead to subsequent development or procurement phases, but they do have the goal of moving into the acquisition process within the Future Years Defense Program (FYDP). Due to high technical risk, INPs typically have long duration but have no more than three years between decision points. They mature technologies from a Technology Readiness Level (TRL) of 2 or 3 to a TRL of 6. As such, INPs require both Budget Activity (BA) 2 and BA3 funding. The BA2 INP funds are specified in a separate Program Element (PE), 0602792N Innovative Naval Prototypes (INP) Applied Res. INPs do not develop hardware for service use, rather they prove technological and production feasibility, and show naval utility and acquisition potential. The Office of Naval Research (ONR) demonstrates INPs in relevant environments. Successful experimentation and demonstrations present the Department of the Navy with disruptive

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020				
Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)							
1319 / 3	PE 0603801N / Innovative Naval Prototypes (INP) Adv Tec Dev	3400 / Innovative Naval Prototypes (INP) Adv Tech Dev							
capabilities that may lead to the obsolescence of existing capabilities and acquisition programs. The Department of the Navy would have to make significant acquisition decisions to integrate the new technological capabilities into naval warfighting systems. INPs are selected by a process that involves senior leadership in the Department of the Navy.									
Information security concerns preclude fully detailed descriptions of project efforts, research activities, and technology development plans. Specific information on each project and activity will be provided separately to the Congressional oversight committees.									
B. Accomplishments/Planned Programs (\$ in Millions)			FY 2019	FY 2020	FY 2021 Base				
<i>Title:</i> Cyber			12.273	0.000	0.000				
Description: This R2 Activity contains all Advanced Technology Development Innovative Naval Prototype (INP) investments that are developing new technologies for cyber warfare. Potential adversaries are investing in advanced technologies that will challenge our advantages in the critical information domain. Nation states and non-state actors seek to degrade our command and control capabilities, networks and computer systems. Cyber threats continue to grow and rapidly proliferate. Technologies developed in this R2 Activity will enable the warfighter to take immediate, appropriate action at any time against any desired adversary, target or network by assuring that autonomous, continuous analyses of intelligence, persistent surveillance and open information sources have, at all times, optimized the possible courses of action based on commander's guidance. Technologies within this activity will foster operational endurance and enable sustained operations and resiliency for warfighters and platforms through enhanced cyber security/protection.					0.000				
FY 2020 Plans: N/A									
FY 2021 Base Plans: N/A									
FY 2021 OCO Plans: N/A									
<i>Title:</i> Directed Energy / Electric Weapons			95.484	33.142	0.000				
Description: The FY 2020 Appropriation Act directed ONR to establish appropriate projects for prototyping efforts to provide additional acquisition oversight, fiscal clarity and adherence to financial management practices. Within this PE, INP funding was moved from Proj 3400 Innovative Naval Prototypes (INP) Adv Tech Dev to new stand-alone projects as indicated below starting in FY 2021.					0.000				
- Proj 2731: HELCAP									

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603801N / Innovative Naval Prototypes (INP) Adv Tec Dev	Project (Number/Name) 3400 / Innovative Naval Prototypes (INP) Adv Tech Dev				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
- Proj 3416: HIJENKS - Proj 3453: Hypersonic Booster						
FY 2020 Plans: <p>Develop technology for High Energy Laser Counter Anti-Ship Cruise Missile (ASCM) Project (HELCAP) by conducting development, experimentation, and demonstration of critical technologies to defeat crossing Anti-Ship Cruise Missiles (ASCM). This Applied Technology Development effort will include the following activities: assess development requirements including ASCM lethality and engagement parametric analysis, atmospheric propagation characterization, and beam control; design and fabricate a beam control testbed; and perform laser/materiel component interaction testing. HELCAP activities being conducted with 6.3 funds in this PE are focused on the assessment, development, and experimentation associated with lethality, advanced beam control, and laser sources. Related HELCAP project plans in PE 0603925N Directed Energy and Electric Weapon System Project 2731 include technology integration to support automated laser weapon control in integrated detect to defeat demonstrations.</p> <p>Continue Advanced Technology Development efforts associated with a Radio Frequency (RF) effects payload (a joint USAF/USN project) that has scalable electromagnetic effects.</p>						
FY 2021 Base Plans: N/A						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: <p>The decrease in FY 2021 is due to the realignment of the HELCAP and HIJENKS INP efforts from this Activity in Project Unit 3400, Program Element (PE) 0603801N Innovative Naval Prototypes (INP) Adv Tec Dev, to new stand-alone Project Units as follows:</p> <ul style="list-style-type: none">- Proj 2731: HELCAP- Proj 3416: HIJENKS						
Title: Electromagnetic Maneuver Warfare		15.561	16.091	0.000	0.000	0.000
Description: This R-2 Activity contains all 6.3 Innovative Naval Prototype (INP) investments that are developing new technologies for Electromagnetic Maneuver Warfare (EMW). The electromagnetic spectrum is a key operational maneuver space enabled by continuous, real-time awareness of all spectrum activity. This R-2						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)				
1319 / 3	PE 0603801N / Innovative Naval Prototypes (INP) Adv Tec Dev	3400 / Innovative Naval Prototypes (INP) Adv Tech Dev				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base		
<p>Activity supports spectrum dominance which included efforts that focus on communications, surveillance, Electronic Warfare (EW) and electronics to understand and shape the battle space. The ability to assure access to the full spectrum is essential for battle space awareness and threat surveillance/weapon sensor engagement. Technologies within this activity will provide for integrated and distributed forces capable of dynamic synchronized actions through interoperable forces by incorporation of autonomous/disaggregated systems to increase flexibility and reach within the electromagnetic spectrum.</p> <p>FY 2020 Plans: Conduct Advanced Technology Development efforts, demonstrating continuous spectrum monitoring for real-time prioritization and use of the electro-magnetic spectrum for shipboard systems and information operations, electronic warfare, surface warfare, undersea warfare, and air warfare missions across the entire battlegroup in a contested environment. Conduct a final at-sea Flexible Distributed Array (FlexDAR) demonstration.</p> <p>FY 2021 Base Plans: N/A</p> <p>FY 2021 OCO Plans: N/A</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: The decrease in funding from FY 2020 to FY 2021 is due to the completion of Electromagnetic Maneuver & Control Capability (EMC2) program in FY 2020.</p>	<p>Title: Undersea Warfare</p> <p>Description: The FY 2020 Appropriation Act directed ONR to establish appropriate projects for prototyping efforts to provide additional acquisition oversight, fiscal clarity and adherence to financial management practices. Within this PE, INP funding was moved from Proj 3400 Innovative Naval Prototypes (INP) Adv Tech Dev to new stand-alone projects as indicated below starting in FY 2021.</p> <ul style="list-style-type: none"> - Proj 3450: AMOS - Proj 3458: Undersea Warfare Efforts <p>FY 2020 Plans: Initiate Advanced Technology Development efforts associated with a mobile sensing system that can be deployed anywhere in the Arctic via a sea ice-based buoy that enables the critical infrastructure necessary to</p>	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
		1.441	4.493	0.000	0.000	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603801N / Innovative Naval Prototypes (INP) Adv Tec Dev	Project (Number/Name) 3400 / Innovative Naval Prototypes (INP) Adv Tech Dev				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
support persistent sensing at a lower cost than via manned platforms. This Arctic Mobile Observing System (AMOS) will operate via a sea ice-based buoy that enables the critical infrastructure necessary to support persistent sensing at a lower cost and with less risk than deploying manned platforms in the Arctic. Activities include buoy node construction and testing, software development, vehicle acquisition, and Arctic-hardening of sensors and platforms. The project includes domain-specific engineering development, upgrading UUV platform designs for the Arctic environment, developing the power and communication buoy node for the Arctic domain, incorporating mature and maturing UUV sensing capabilities into vehicles and ensure suitability for Arctic operations. The project will also develop under-ice CONOPS for the autonomous UUV network, building on capabilities developed under previous efforts for vehicle autonomy, re-charging, sensing, communication, and Command, Control, Communication & Computers (C4I), and develop new capabilities for operating under sea ice. A key thrust will be to enable an under-ice acoustic navigation system for unmanned platforms, suitable for use in any GPS-denied operational area.						
FY 2021 Base Plans: N/A						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The decrease in FY 2021 is due to the realignment of the AMOS and Undersea Warfare INP efforts from this Activity in Project Unit 3400, Program Element (PE) 0603801N Innovative Naval Prototypes (INP) Adv Tec Dev, to new stand-alone Project Units as follows: - Proj 3450: AMOS - Proj 3458: Undersea Warfare Efforts						
Title: Unmanned and Autonomous Systems Description: The FY 2020 Appropriation Act directed ONR to establish appropriate projects for prototyping efforts to provide additional acquisition oversight, fiscal clarity and adherence to financial management practices. Within this PE, INP funding was moved from Proj 3400 Innovative Naval Prototypes (INP) Adv Tech Dev to new stand-alone projects as indicated below starting in FY 2021. - Proj 3451: CLAWS - Proj 3423: LOCUST		31.753	24.654	0.000	0.000	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603801N / Innovative Naval Prototypes (INP) Adv Tec Dev	Project (Number/Name) 3400 / Innovative Naval Prototypes (INP) Adv Tech Dev				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<ul style="list-style-type: none"> - Proj 3454: MDUSV - Proj 3459: Super Swarm (SS) 						
FY 2020 Plans: Conduct Advanced Technology Development efforts associated with: The development of autonomous payloads for extra-large unmanned undersea vehicles and complete first CLAWS autonomy/payload demo; A robust, scalable, flexible, multi-functional swarming unmanned UxS vehicle systems providing cross-domain capability, human-swarm interdependence/interaction that is employable from surface, sub-surface, airborne, and ground manned and unmanned systems; A long endurance, unmanned surface vehicle with medium displacement that can be autonomously controlled in high sea states with a demonstrated multi-mission/multi-payload capability, including support for the Sea Hunter 2 builder's trial.						
FY 2021 Base Plans: N/A						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The decrease in FY 2021 is due to the realignment of the CLAWS, LOCUST, MDUSV and Super Swarm (SS) INP efforts from this Activity in Project Unit 3400, Program Element (PE) 0603801N Innovative Naval Prototypes (INP) Adv Tec Dev, to new stand-alone Project Units as follows: <ul style="list-style-type: none"> - Proj 3451: CLAWS - Proj 3423: LOCUST - Proj 3454: MDUSV - Proj 3459: Super Swarm (SS) 						
Title: Artificial Intelligence		0.000	12.757	0.000	0.000	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020			
Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)					
1319 / 3	PE 0603801N / Innovative Naval Prototypes (INP) Adv Tec Dev	3400 / Innovative Naval Prototypes (INP) Adv Tech Dev					
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	
<p>Description: The FY 2020 Appropriation Act directed ONR to establish appropriate projects for prototyping efforts to provide additional acquisition oversight, fiscal clarity and adherence to financial management practices. Within this PE, INP funding was moved from Proj 3400 Innovative Naval Prototypes (INP) Adv Tech Dev to new stand-alone projects as indicated below starting in FY 2021.</p> <ul style="list-style-type: none"> - Proj 3452: ELEKTRA - Proj 3457: Long Range Targeting - Proj 3455: MINERVA <p>FY 2020 Plans: In collaboration with the applied research supporting this same INP research, actions are being taken to rapidly mature the advanced technology development efforts required to demonstrate machine speed battle management tools to support continuous analysis and planning at the operational and tactical levels, enabling the dynamic synchronization of forces and actions across intelligence, surveillance and reconnaissance, and combat systems. Conduct developmental efforts of Long Range Targeting, which directly accelerates and reduces risks to multiple programs.</p> <p>FY 2021 Base Plans: N/A</p> <p>FY 2021 OCO Plans: N/A</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: The decrease in FY 2021 is due to the realignment of the ELEKTRA, Long Range Targeting and MINERVA INP efforts from this Activity in Project Unit 3400, Program Element (PE) 0603801N Innovative Naval Prototypes (INP) Adv Tec Dev, to new stand-alone Project Units as follows:</p> <ul style="list-style-type: none"> - Proj 3452: ELEKTRA - Proj 3457: Long Range Targeting - Proj 3455: MINERVA 	Accomplishments/Planned Programs Subtotals		156.512	91.137	0.000	0.000	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy	Date: February 2020	
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603801N / <i>Innovative Naval Prototypes (INP) Adv Tec Dev</i>	Project (Number/Name) 3400 / <i>Innovative Naval Prototypes (INP) Adv Tech Dev</i>
C. Other Program Funding Summary (\$ in Millions)		
N/A		
Remarks		
D. Acquisition Strategy		
N/A		

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020	
Appropriation/Budget Activity 1319 / 3					R-1 Program Element (Number/Name) PE 0603801N / Innovative Naval Prototypes (INP) Adv Tec Dev				Project (Number/Name) 3416 / HIJENKS			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
3416: HIJENKS		0.000	0.000	0.000	14.465	-	14.465	7.656	0.000	0.000	0.000	22.121

Note

High-power Joint Electromagnetic Non-Kinetic Strike (HIJENKS) plans and associated resources are realigned from Project Unit 3400 in Program Element (PE) 0603801N Innovative Naval Prototype (INP) Adv Tec Dev into this new Project Unit 3416 effective FY 2021. This is not a new start.

A. Mission Description and Budget Item Justification

The High-power Joint Electromagnetic Non-Kinetic Strike (HIJENKS) INP effort is a non-kinetic High Power Microwave (HPM) payload integrated on an airborne platform will enable the prosecution of multiple targets with area coverage across each target and open targets previously restricted due to collateral damage. HIJENKS increases operational access by disrupting land-based infrastructure facilities tied to adversary systems, decreases cost exchange ratios through non-kinetic engagement, and addresses targets previously restricted due to collateral damage concerns/moral hardening. It expands the competitive space in the electromagnetic spectrum to disrupt, degrade, and destroy critical electronic targets. The Activity identified in Project Unit 3416 specifically addresses Advanced Technology Development in support of the HIJENKS INP effort.

INP investments represent game changing technologies with the potential to revolutionize operational concepts. They are disruptive in nature, as they would dramatically change the way naval forces fight. Due to high technical risk, INPs typically have long duration but have no more than three years between decision points. INPs do not develop hardware for service use, rather they prove technological and production feasibility, and show naval utility and acquisition potential. The Office of Naval Research (ONR) demonstrates INPs in relevant environments. Successful experimentation and demonstrations present the Department of the Navy with disruptive capabilities that may lead to the obsolescence of existing capabilities and acquisition programs. The Department of the Navy would have to make significant acquisition decisions to integrate the new technological capabilities into naval warfighting systems. INPs are selected by a process that involves senior leadership in the Department of the Navy.

Information security concerns preclude fully detailed descriptions of project efforts, research activities, and technology development plans. Specific information on each project and activity will be provided separately to the Congressional oversight committees.

B. Accomplishments/Planned Programs (\$ in Millions)

Title: HIJENKS	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Description: The High-power Joint Electromagnetic Non-Kinetic Strike (HIJENKS) INP effort is a non-kinetic High Power Microwave (HPM) payload integrated on an airborne platform will enable the prosecution of multiple targets with area coverage across each target and open targets previously restricted due to collateral damage. HIJENKS increases operational access by disrupting land-based infrastructure facilities tied to adversary systems, decreases cost exchange ratios through non-kinetic engagement, and addresses targets	0.000	0.000	14.465	0.000	14.465

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy										Date: February 2020	
Appropriation/Budget Activity 1319 / 3			R-1 Program Element (Number/Name) PE 0603801N / Innovative Naval Prototypes (INP) Adv Tec Dev					Project (Number/Name) 3416 / HIJENKS			
B. Accomplishments/Planned Programs (\$ in Millions)											
FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total							
previously restricted due to collateral damage concerns/moral hardening. It expands the competitive space in the electromagnetic spectrum to disrupt, degrade, and destroy critical electronic targets.											
FY 2020 Plans: N/A											
FY 2021 Base Plans: Continue Joint USAF/USN project for High Powered Microwave (HPM) payload integration into an airborne platform to enable dynamic demonstration and testing of a multi-target HPM payload to provide non-kinetic strike options for electronic target degrade/disrupt/disable capability. Focus on payload integration and platform modifications to enable testing along with range development.											
FY 2021 OCO Plans: N/A											
FY 2020 to FY 2021 Increase/Decrease Statement: The increase in FY 2021 is due to the realignment of the High-power Joint Electromagnetic Non-Kinetic Strike (HIJENKS) effort from Project Unit 3400 in Program Element (PE) 0603801N Innovative Naval Prototype (INP) Adv Tec Dev into this new Project Unit 3416.											
Accomplishments/Planned Programs Subtotals										0.000 0.000 14.465 0.000 14.465	
C. Other Program Funding Summary (\$ in Millions)											
Line Item	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
• RDTEN/0602792N/3416: HIJENKS	0.000	0.000	22.320	-	22.320	9.943	0.000	0.000	0.000	0.000	32.263
• RDTEN/0603382N/3416: HIJENKS	0.000	0.000	14.981	-	14.981	16.945	24.690	0.000	0.000	0.000	56.616
Remarks											
D. Acquisition Strategy N/A											

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020	
Appropriation/Budget Activity 1319 / 3					R-1 Program Element (Number/Name) PE 0603801N / Innovative Naval Prototypes (INP) Adv Tec Dev				Project (Number/Name) 3423 / LOCUST			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
3423: LOCUST		0.000	0.000	0.000	12.750	-	12.750	3.396	0.000	0.000	0.000	16.146

Note

Low-Cost UAV Swarming Technology (LOCUST) plans and associated resources are realigned from Project Unit 3400 in Program Element (PE) 0603801N Innovative Naval Prototype (INP) Adv Tec Dev into this new Project Unit 3423 effective FY 2021.

A. Mission Description and Budget Item Justification

Adversary military modernization and increasing contested domains require a shift in approach "...to strike diverse targets inside adversary air and missile defense networks to destroy mobile power-projection platforms. This will include capabilities to enhance close combat lethality in complex terrain." LOCUST will develop and deliver autonomy, C2 architecture, and a series of modular payloads on a robust, scalable, flexible, multifunctional UAV system; employable from surface, sub-surface, airborne, and ground manned and un-manned systems to provide a dispersed, resilient, and adaptive capability to gain a competitive military advantage. LOCUST will provide ISR and precision loitering munitions capable of being launched from air, surface, ground, and sub-surface platforms to conduct both singular and swarm operations across battlespace in conjunction with Joint and manned operations. It will demonstrate multi-domain launch and strike operations, heterogeneous air platform payloads, unmanned from unmanned operations, distributed control of the strike mission, and refined cost elements for critical technologies that have supply chain assurance addressed. The Activity identified in Project Unit 3423 specifically addresses Advanced Technology Development in support of the LOCUST INP effort.

INP investments represent game changing technologies with the potential to revolutionize operational concepts. They are disruptive in nature, as they would dramatically change the way naval forces fight. Due to high technical risk, INPs typically have long duration but have no more than three years between decision points. INPs do not develop hardware for service use, rather they prove technological and production feasibility, and show naval utility and acquisition potential. The Office of Naval Research (ONR) demonstrates INPs in relevant environments. Successful experimentation and demonstrations present the Department of the Navy with disruptive capabilities that may lead to the obsolescence of existing capabilities and acquisition programs. The Department of the Navy would have to make significant acquisition decisions to integrate the new technological capabilities into naval warfighting systems. INPs are selected by a process that involves senior leadership in the Department of the Navy.

Information security concerns preclude fully detailed descriptions of project efforts, research activities, and technology development plans. Specific information on each project and activity will be provided separately to the Congressional oversight committees.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: LOCUST Description: Adversary military modernization and increasing contested domains require a shift in approach "...to strike diverse targets inside adversary air and missile defense networks to destroy mobile power-projection platforms. This will include capabilities to enhance close combat lethality in complex terrain." LOCUST will	0.000	0.000	12.750	0.000	12.750

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy								Date: February 2020							
Appropriation/Budget Activity 1319 / 3		R-1 Program Element (Number/Name) PE 0603801N / Innovative Naval Prototypes (INP) Adv Tec Dev			Project (Number/Name) 3423 / LOCUST										
B. Accomplishments/Planned Programs (\$ in Millions)								FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total			
<p>develop and deliver autonomy, C2 architecture, and a series of modular payloads on a robust, scalable, flexible, multifunctional UAV system; employable from surface, sub-surface, airborne, and ground manned and un-manned systems to provide a dispersed, resilient, and adaptive capability to gain a competitive military advantage. LOCUST will provide ISR and precision loitering munitions capable of being launched from air, surface, ground, and sub-surface platforms to conduct both singular and swarm operations across battlespace in conjunction with Joint and manned operations. It will demonstrate multi-domain launch and strike operations, heterogeneous air platform payloads, unmanned from unmanned operations, distributed control of the strike mission, and refined cost elements for critical technologies that have supply chain assurance addressed.</p>															
<p>FY 2020 Plans: N/A</p> <p>FY 2021 Base Plans: Continue Advanced Technology Development efforts associated with development and flight testing of mission-oriented payloads in which cost, size, weight, and power reductions play a significant role in their utility. The "swarm architecture facing" portion of each of these payloads is a significant departure from traditional payload development and will also be investigated through evaluations of ability of payloads to request or drive a behavior from the swarm in addition to more traditional payload utilization approaches. Integration onto a range of platforms will be considered and appropriate design and certifications will be addressed.</p> <p>FY 2021 OCO Plans: N/A</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: The increase in FY 2021 is due to the realignment of the Low-Cost UAV Swarming Technology (LOCUST) effort from Project Unit 3400 in Program Element (PE) 0603801N Innovative Naval Prototype (INP) Adv Tec Dev into this new Project Unit 3423.</p>															
Accomplishments/Planned Programs Subtotals								0.000	0.000	12.750	0.000	12.750			
C. Other Program Funding Summary (\$ in Millions)															
Line Item	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost				
• RDTEN/0602792N/3423: LOCUST	0.000	0.000	22.046	-	22.046	5.553	0.000	0.000	0.000	0.000	27.599				
• RDTEN/0603382N/3423: LOCUST	1.879	2.960	3.561	-	3.561	6.425	5.949	0.000	0.000	0.000	20.787				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy								Date: February 2020		
Appropriation/Budget Activity 1319 / 3				R-1 Program Element (Number/Name) PE 0603801N / <i>Innovative Naval Prototypes (INP) Adv Tec Dev</i>				Project (Number/Name) 3423 / <i>LOCUST</i>		
C. Other Program Funding Summary (\$ in Millions)										
<u>Line Item</u>	<u>FY 2019</u>	<u>FY 2020</u>	<u>FY 2021</u> <u>Base</u>	<u>FY 2021</u> <u>OCO</u>	<u>FY 2021</u> <u>Total</u>	<u>FY 2022</u>	<u>FY 2023</u>	<u>FY 2024</u>	<u>FY 2025</u>	<u>Cost To Complete</u>
Remarks										
D. Acquisition Strategy N/A										

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity 1319 / 3					R-1 Program Element (Number/Name) PE 0603801N / Innovative Naval Prototypes (INP) Adv Tec Dev				Project (Number/Name) 3450 / AMOS				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
3450: AMOS	0.000	0.000	0.000	4.524	-	4.524	3.480	4.525	0.000	0.000	0.000	12.529	

Note

Arctic Mobile Observing System (AMOS) plans and associated resources are realigned from Project Unit 3400 in this Program Element (PE) 0603801N Innovative Naval Prototype (INP) Adv Tec Dev into this new Project Unit 3450 effective FY 2021. This is not a new start.

A. Mission Description and Budget Item Justification

The Arctic Mobile Observing System (AMOS) INP effort will develop a prototype mobile sensing system that can be deployed anywhere in the Arctic via the development of a sea ice-based buoy node that will enable the critical infrastructure (power, communication, environmental intelligence) to provide the Navy with a persistent Arctic presence at lower cost than manned platforms. AMOS is a mobile observing system of systems node that enables 2-way communications, under-ice vehicle navigation, and extended-duration autonomy in the complex Arctic environment. AMOS will provide a persistent, mobile, autonomous capability to monitor the operational environment and maritime operations of potential adversaries in the Arctic Ocean. The Activity identified in Project Unit 3450 specifically addresses Advanced Technology Development in support of the AMOS INP effort.

INP investments represent game changing technologies with the potential to revolutionize operational concepts. They are disruptive in nature, as they would dramatically change the way naval forces fight. Due to high technical risk, INPs typically have long duration but have no more than three years between decision points. INPs do not develop hardware for service use, rather they prove technological and production feasibility, and show naval utility and acquisition potential. The Office of Naval Research (ONR) demonstrates INPs in relevant environments. Successful experimentation and demonstrations present the Department of the Navy with disruptive capabilities that may lead to the obsolescence of existing capabilities and acquisition programs. The Department of the Navy would have to make significant acquisition decisions to integrate the new technological capabilities into naval warfighting systems. INPs are selected by a process that involves senior leadership in the Department of the Navy.

Information security concerns preclude fully detailed descriptions of project efforts, research activities, and technology development plans. Specific information on each project and activity will be provided separately to the Congressional oversight committees.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: AMOS Description: The Arctic Mobile Observing System (AMOS) INP effort will develop a prototype mobile sensing system that can be deployed anywhere in the Arctic via the development of a sea ice-based buoy node that will enable the critical infrastructure (power, communication, environmental intelligence) to provide the Navy with a persistent Arctic presence at lower cost than manned platforms. AMOS is a mobile observing system of systems node that enables 2-way communications, under-ice vehicle navigation, and extended-duration autonomy in	0.000	0.000	4.524	0.000	4.524

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy										Date: February 2020	
Appropriation/Budget Activity 1319 / 3			R-1 Program Element (Number/Name) PE 0603801N / Innovative Naval Prototypes (INP) Adv Tec Dev				Project (Number/Name) 3450 / AMOS				
B. Accomplishments/Planned Programs (\$ in Millions)											
FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total							
the complex Arctic environment. AMOS will provide a persistent, mobile, autonomous capability to monitor the operational environment and maritime operations of potential adversaries in the Arctic Ocean.											
FY 2020 Plans: N/A											
FY 2021 Base Plans: Continue advanced technology development efforts associated with the following: - Integrating Command, Control, Communication and Computers (C4I) into the primary AMOS buoy node. - Constructing prototype nodes for deployment in Arctic field experiments. - Testing extended-duration survivability of AMOS nodes and platforms through year-long Arctic deployments. - Testing and evaluating UUV docking and recharge systems under sea ice in the Arctic. - Demonstrating domain-specific autonomous behaviors in a simulated environment to enable long-duration Arctic deployment.											
FY 2021 OCO Plans: N/A											
FY 2020 to FY 2021 Increase/Decrease Statement: The increase in FY 2021 is due to the realignment of the Arctic Mobile Observing System (AMOS) effort from Project Unit 3400 in this Program Element (PE) 0603801N Innovative Naval Prototype (INP) Adv Tec Dev into this new Project Unit 3450.											
Accomplishments/Planned Programs Subtotals										0.000 0.000 4.524 0.000 4.524	
C. Other Program Funding Summary (\$ in Millions)											
Line Item	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
• RDTEN/0602792N/3450: AMOS	0.000	0.000	8.401	-	8.401	6.463	8.404	0.000	0.000	0.000	23.268
Remarks											
D. Acquisition Strategy N/A											

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity 1319 / 3					R-1 Program Element (Number/Name) PE 0603801N / Innovative Naval Prototypes (INP) Adv Tec Dev				Project (Number/Name) 3451 / CLAWS				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
3451: CLAWS	0.000	0.000	0.000	15.300	-	15.300	14.339	0.000	0.000	0.000	0.000	29.639	

Note

CLAWS plans and associated resources are realigned from Project Unit 3400 in this Program Element (PE) 0603801N Innovative Naval Prototype (INP) Adv Tec Dev into this new Project Unit 3451 effective FY 2021. This is not a new start.

A. Mission Description and Budget Item Justification

The CLAWS INP effort will develop an autonomous unmanned undersea weapon system capable of providing offensive effects to the Combatant Commanders beyond Phase 0 inside the first island chain. It will clandestinely extend the reach of large UUVs and increase the mission areas into kinetic effects. CLAWS will deliver algorithms to enable all families of UUVs to operate in complex, dynamic and degraded environments. CLAWS will demonstrate autonomous missions in denied waters, develop and demonstrate autonomous technologies for survivability of large UUVs, and develop autonomy and launch capabilities for special mission payloads. CLAWS will be able to complete missions 1&2 against near peer adversary defenses, maintain critical communication with Navy C2/Fires and provide critical ISR information. The Activity identified in Project Unit 3451 specifically addresses Advanced Technology Development in support of the CLAWS INP effort.

INP investments represent game changing technologies with the potential to revolutionize operational concepts. They are disruptive in nature, as they would dramatically change the way naval forces fight. Due to high technical risk, INPs typically have long duration but have no more than three years between decision points. INPs do not develop hardware for service use, rather they prove technological and production feasibility, and show naval utility and acquisition potential. The Office of Naval Research (ONR) demonstrates INPs in relevant environments. Successful experimentation and demonstrations present the Department of the Navy with disruptive capabilities that may lead to the obsolescence of existing capabilities and acquisition programs. The Department of the Navy would have to make significant acquisition decisions to integrate the new technological capabilities into naval warfighting systems. INPs are selected by a process that involves senior leadership in the Department of the Navy.

Information security concerns preclude fully detailed descriptions of project efforts, research activities, and technology development plans. Specific information on each project and activity will be provided separately to the Congressional oversight committees.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: CLAWS	0.000	0.000	15.300	0.000	15.300

Description: The CLAWS INP effort will develop an autonomous unmanned undersea weapon system capable of providing offensive effects to the Combatant Commanders beyond Phase 0 inside the first island chain. It will clandestinely extend the reach of large UUVs and increase the mission areas into kinetic effects. CLAWS will deliver algorithms to enable all families of UUVs to operate in complex, dynamic and degraded environments. CLAWS will demonstrate autonomous missions in denied waters, develop and demonstrate autonomous

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy										Date: February 2020						
Appropriation/Budget Activity 1319 / 3				R-1 Program Element (Number/Name) PE 0603801N / Innovative Naval Prototypes <i>(INP) Adv Tec Dev</i>				Project (Number/Name) 3451 / CLAWS								
B. Accomplishments/Planned Programs (\$ in Millions)										FY 2019	FY 2020					
technologies for survivability of large UUVs, and develop autonomy and launch capabilities for special mission payloads. CLAWS will be able to complete missions 1&2 against near peer adversary defenses, maintain critical communication with Navy C2/Fires and provide critical ISR information.										FY 2021 Base	FY 2021 OCO	FY 2021 Total				
FY 2020 Plans: N/A																
FY 2021 Base Plans: Continue Adv Tech Dev effort in CLAWS autonomy development: - Conduct an autonomy/payload demonstration for an extra-large unmanned undersea vehicle. - Develop and mature the autonomy and payload technology for contested littoral environments.																
FY 2021 OCO Plans: N/A																
FY 2020 to FY 2021 Increase/Decrease Statement: The increase in FY 2021 is due to the realignment of the CLAWS effort from Project Unit 3400 in this Program Element (PE) 0603801N Innovative Naval Prototype (INP) Adv Tec Dev into this new Project Unit 3451.																
Accomplishments/Planned Programs Subtotals										0.000	0.000	15.300				
C. Other Program Funding Summary (\$ in Millions)										Cost To Complete	Total Cost					
Line Item		FY 2019	FY 2020	FY 2021	Base	OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Complete	Total Cost			
• RDTEN/0602792N/3451: CLAWS		0.000	0.000	26.456	-		26.456	23.445	0.000	0.000	0.000	0.000	49.901			
Remarks																
D. Acquisition Strategy																
N/A																

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020	
Appropriation/Budget Activity 1319 / 3					R-1 Program Element (Number/Name) PE 0603801N / Innovative Naval Prototypes (INP) Adv Tec Dev				Project (Number/Name) 3452 / ELEKTRA			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
3452: ELEKTRA		0.000	0.000	0.000	10.869	-	10.869	12.926	9.946	4.973	5.072	Continuing

Note

ELEKTRA Non-Kinetic plans and associated resources are realigned from Project Unit 3400 in this Program Element (PE) 0603801N Innovative Naval Prototype (INP) Adv Tec Dev into this new Project Unit 3452 effective FY 2021. This is not a new start.

A. Mission Description and Budget Item Justification

Complex multi-domain threats can overwhelm the operator and individual platforms ability to defend the force. The ELEKTRA INP effort is developing "Human on the Loop" Artificial Intelligence (AI) enabled algorithms to perform force level kinetic/non-kinetic kill chain optimization and coordination across multiple domains at machine to machine speeds to increase the lethality and survivability of the Force. ELEKTRA will demonstrate AI/ML ability to coordinate kinetic/non kinetic effects autonomously with heterogeneous platforms, the ability to operate in degraded environments for hours and the ability to coordinate and execute domain kill chains simultaneously. It will deploy artificial intelligent (AI) and machine learning (ML) architecture, neural networked computing and large data handling to enable real time, force level effects assignment, coordination and resource management. The Activity identified in Project Unit 3452 specifically addresses Advanced Technology Development in support of the ELEKTRA INP effort.

INP investments represent game changing technologies with the potential to revolutionize operational concepts. They are disruptive in nature, as they would dramatically change the way naval forces fight. Due to high technical risk, INPs typically have long duration but have no more than three years between decision points. INPs do not develop hardware for service use, rather they prove technological and production feasibility, and show naval utility and acquisition potential. The Office of Naval Research (ONR) demonstrates INPs in relevant environments. Successful experimentation and demonstrations present the Department of the Navy with disruptive capabilities that may lead to the obsolescence of existing capabilities and acquisition programs. The Department of the Navy would have to make significant acquisition decisions to integrate the new technological capabilities into naval warfighting systems. INPs are selected by a process that involves senior leadership in the Department of the Navy.

Information security concerns preclude fully detailed descriptions of project efforts, research activities, and technology development plans. Specific information on each project and activity will be provided separately to the Congressional oversight committees.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: ELEKTRA	0.000	0.000	10.869	0.000	10.869

Description: Complex multi-domain threats can overwhelm the operator and individual platforms ability to defend the force. The ELEKTRA INP effort is developing "Human on the Loop" Artificial Intelligence (AI) enabled algorithms to perform force level kinetic/non-kinetic kill chain optimization and coordination across multiple domains at machine to machine speeds to increase the lethality and survivability of the Force. ELEKTRA will

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy										Date: February 2020				
Appropriation/Budget Activity 1319 / 3		R-1 Program Element (Number/Name) PE 0603801N / Innovative Naval Prototypes (INP) Adv Tec Dev				Project (Number/Name) 3452 / ELEKTRA								
B. Accomplishments/Planned Programs (\$ in Millions)										FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
demonstrate AI/ML ability to coordinate kinetic/non kinetic effects autonomously with heterogeneous platforms, the ability to operate in degraded environments for hours and the ability to coordinate and execute domain kill chains simultaneously. It will deploy artificial intelligent (AI) and machine learning (ML) architecture, neural networked computing and large data handling to enable real time, force level effects assignment, coordination and resource management.														
FY 2020 Plans: N/A														
FY 2021 Base Plans: Conduct Advanced Technology Development efforts to mature and demonstrate more complex kinetic/non-kinetic kill chains and Human-Machine interactive battle management tools working at machine to machine speeds to support continuous analysis, planning and execution at the operational and tactical levels that will enable the dynamic synchronization of forces and actions across intelligence, surveillance and reconnaissance, and combat systems.														
FY 2021 OCO Plans: N/A														
FY 2020 to FY 2021 Increase/Decrease Statement: The increase in FY 2021 is due to the realignment of the ELEKTRA Non-Kinetic effort from Project Unit 3400 in this Program Element (PE) 0603801N Innovative Naval Prototype (INP) Adv Tec Dev into this new Project Unit 3452.														
Accomplishments/Planned Programs Subtotals										0.000	0.000	10.869	0.000	10.869
C. Other Program Funding Summary (\$ in Millions)														
Line Item	FY 2019	FY 2020	FY 2021	FY 2021	FY 2021	Cost To								
• RDTEN/0602792N/3452: <i>ELEKTRA</i>	0.000	0.000	6.032	Base	OCO	Total	FY 2022	FY 2023	FY 2024	FY 2025	Complete	Total Cost		
				-		6.032	3.977	0.000	0.000	0.000	0.000	10.009		
Remarks														
D. Acquisition Strategy														
N/A														

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020	
Appropriation/Budget Activity 1319 / 3					R-1 Program Element (Number/Name) PE 0603801N / Innovative Naval Prototypes (INP) Adv Tec Dev				Project (Number/Name) 3453 / Hypersonic Booster			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
3453: Hypersonic Booster	0.000	0.000	0.000	0.000	-	0.000	0.000	20.000	30.000	30.600	Continuing	Continuing

Note

Hypersonic Booster plans and associated resources are realigned from Project Unit 3400 in this Program Element (PE) 0603801N Innovative Naval Prototype (INP) Adv Tec Dev into this new Project Unit 3453 effective FY 2021.

A. Mission Description and Budget Item Justification

The Navy currently lacks the ability to demonstrate a ship-launched, DARPA-developed HAWC Cruiser as the original USAF-RAAF air-launch effort did not address naval capabilities. Hypersonic Booster will develop a CVN-capable HAWC AUR for air-launched flight demonstration that will require a 25% reduction in overall length to enable fitment in CVN weapons elevators). The goal from the outset will be to leverage DARPA-developed HAWC program for naval applications. It will flight test a CVN compliant, Hypersonic Air-breathing Weapon Concept (HAWC) All-Up-Round (AUR) to demonstrate airframe and booster propulsion technologies. The Activity identified in Project Unit 3453 specifically addresses Advanced Technology Development in support of the Hypersonic Booster INP effort.

INP investments represent game changing technologies with the potential to revolutionize operational concepts. They are disruptive in nature, as they would dramatically change the way naval forces fight. Due to high technical risk, INPs typically have long duration but have no more than three years between decision points. INPs do not develop hardware for service use, rather they prove technological and production feasibility, and show naval utility and acquisition potential. The Office of Naval Research (ONR) demonstrates INPs in relevant environments. Successful experimentation and demonstrations present the Department of the Navy with disruptive capabilities that may lead to the obsolescence of existing capabilities and acquisition programs. The Department of the Navy would have to make significant acquisition decisions to integrate the new technological capabilities into naval warfighting systems. INPs are selected by a process that involves senior leadership in the Department of the Navy.

Information security concerns preclude fully detailed descriptions of project efforts, research activities, and technology development plans. Specific information on each project and activity will be provided separately to the Congressional oversight committees.

B. Accomplishments/Planned Programs (\$ in Millions)

N/A

C. Other Program Funding Summary (\$ in Millions)

Line Item	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
• RDTEN/0602792N/3453: <i>HYPersonic BOOSTER</i>	0.000	0.000	10.000	-	10.000	30.000	15.000	0.000	0.000	0.000	55.000

Remarks

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy	Date: February 2020	
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603801N / <i>Innovative Naval Prototypes (INP) Adv Tec Dev</i>	Project (Number/Name) 3453 / <i>Hypersonic Booster</i>
D. Acquisition Strategy N/A		

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity 1319 / 3					R-1 Program Element (Number/Name) PE 0603801N / Innovative Naval Prototypes (INP) Adv Tec Dev				Project (Number/Name) 3454 / MDUSV				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
3454: MDUSV		0.000	0.000	0.000	1.115	-	1.115	0.000	0.000	0.000	0.000	1.115	

Note

Medium Displacement Unmanned Surface Vehicle (MDUSV) plans and associated resources are realigned from Project Unit 3400 in this Program Element (PE) 0603801N Innovative Naval Prototype (INP) Adv Tec Dev into this new Project Unit 3454 effective FY 2021. This is not a new start.

A. Mission Description and Budget Item Justification

The Medium Displacement Unmanned Surface Vehicle (MDUSV) Project will develop and test a 132 ft. unmanned surface vehicle with ocean-spanning range, months of endurance, good seakeeping, and substantial payload. The vessel will have a high level of autonomy for independent operations under sparse supervisory control and have utility for a variety of Navy missions. MDUSVs capable of deployed blue-water operations with operator trust in safe, reliable operation, long-range and endurance autonomous operations. This will create a new paradigm for Navy surface force, a hybrid manned/unmanned force, and enable new tactics in performing naval missions. The Activity identified in Project Unit 3454 specifically addresses Advanced Technology Development in support of the MDUSV INP effort.

INP investments represent game changing technologies with the potential to revolutionize operational concepts. They are disruptive in nature, as they would dramatically change the way naval forces fight. Due to high technical risk, INPs typically have long duration but have no more than three years between decision points. INPs do not develop hardware for service use, rather they prove technological and production feasibility, and show naval utility and acquisition potential. The Office of Naval Research (ONR) demonstrates INPs in relevant environments. Successful experimentation and demonstrations present the Department of the Navy with disruptive capabilities that may lead to the obsolescence of existing capabilities and acquisition programs. The Department of the Navy would have to make significant acquisition decisions to integrate the new technological capabilities into naval warfighting systems. INPs are selected by a process that involves senior leadership in the Department of the Navy.

Information security concerns preclude fully detailed descriptions of project efforts, research activities, and technology development plans. Specific information on each project and activity will be provided separately to the Congressional oversight committees.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: MDUSV	0.000	0.000	1.115	0.000	1.115

Description: The Medium Displacement Unmanned Surface Vehicle (MDUSV) Project will develop and test a 132 ft. unmanned surface vehicle with ocean-spanning range, months of endurance, good seakeeping, and substantial payload. The vessel will have a high level of autonomy for independent operations under sparse supervisory control and have utility for a variety of Navy missions. MDUSVs capable of deployed blue-water operations with operator trust in safe, reliable operation, long-range and endurance autonomous operations. This

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy										Date: February 2020								
Appropriation/Budget Activity 1319 / 3			R-1 Program Element (Number/Name) PE 0603801N / Innovative Naval Prototypes (INP) Adv Tec Dev				Project (Number/Name) 3454 / MDUSV											
B. Accomplishments/Planned Programs (\$ in Millions)										FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total				
will create a new paradigm for Navy surface force, a hybrid manned/unmanned force, and enable new tactics in performing naval missions.																		
FY 2020 Plans: N/A																		
FY 2021 Base Plans: Continue Adv Tech Dev for integration, demonstration, and transition of autonomous control for medium displacement unmanned surface systems, focusing on common behaviors across multiple missions, additional perception capability and modalities, and testing methodologies for developing trust in the performance of autonomous systems.																		
FY 2021 OCO Plans: N/A																		
FY 2020 to FY 2021 Increase/Decrease Statement: The increase in FY 2021 is due to the realignment of the Medium Displacement Unmanned Surface Vehicle (MDUSV) effort from Project Unit 3400 in this Program Element (PE) 0603801N Innovative Naval Prototype (INP) Adv Tec Dev into this new Project Unit 3454.																		
Accomplishments/Planned Programs Subtotals										0.000	0.000	1.115	0.000	1.115				
C. Other Program Funding Summary (\$ in Millions)																		
Line Item	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost							
• RDTEN/0602792N/3454: MDUSV	0.000	0.000	4.850	-	4.850	0.000	0.000	0.000	0.000	0.000	4.850							
Remarks																		
D. Acquisition Strategy																		
N/A																		

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity 1319 / 3					R-1 Program Element (Number/Name) PE 0603801N / Innovative Naval Prototypes (INP) Adv Tec Dev				Project (Number/Name) 3455 / MINERVA				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
3455: MINERVA		0.000	0.000	0.000	10.936	-	10.936	12.926	11.935	6.963	7.102	Continuing	

Note

MINERVA - Artificial Intelligence (AI) Enhanced Warfighter Decision Superiority Capability plans and associated resources are realigned from Project Unit 3400 in this Program Element (PE) 0603801N Innovative Naval Prototype (INP) Adv Tec Dev into this new Project Unit 3455 effective FY 2021. This is not a new start.

A. Mission Description and Budget Item Justification

The need to operate in a multiple domain environment against highly capable peers requires improved decision quality and reduced decision timelines. MINERVA will develop AI and Machine-Learning (ML) capabilities to improve mission planning, intelligence gathering, execution and assessment. Minerva will deliver next-generation decision aids by combining operations research with emerging AI capabilities to create learning, self-adaptive automation that supports Composite Warfare Commander's (CWC) and their staffs at the Fleet, Force and Group echelons. It will establish a DevOps environment that includes warfighter staffs in the development and integration of new capabilities. The Activity identified in Project Unit 3455 specifically addresses Advanced Technology Development in support of the MINERVA INP effort.

INP investments represent game changing technologies with the potential to revolutionize operational concepts. They are disruptive in nature, as they would dramatically change the way naval forces fight. Due to high technical risk, INPs typically have long duration but have no more than three years between decision points. INPs do not develop hardware for service use, rather they prove technological and production feasibility, and show naval utility and acquisition potential. The Office of Naval Research (ONR) demonstrates INPs in relevant environments. Successful experimentation and demonstrations present the Department of the Navy with disruptive capabilities that may lead to the obsolescence of existing capabilities and acquisition programs. The Department of the Navy would have to make significant acquisition decisions to integrate the new technological capabilities into naval warfighting systems. INPs are selected by a process that involves senior leadership in the Department of the Navy.

Information security concerns preclude fully detailed descriptions of project efforts, research activities, and technology development plans. Specific information on each project and activity will be provided separately to the Congressional oversight committees.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: MINERVA	0.000	0.000	10.936	0.000	10.936
Description: The need to operate in a multiple domain environment against highly capable peers requires improved decision quality and reduced decision timelines. MINERVA will develop AI and Machine-Learning (ML) capabilities to improve mission planning, intelligence gathering, execution and assessment. Minerva will deliver next-generation decision aids by combining operations research with emerging AI capabilities to create learning, self-adaptive automation that supports Composite Warfare Commander's (CWC) and their staffs at the					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy										Date: February 2020						
Appropriation/Budget Activity 1319 / 3			R-1 Program Element (Number/Name) PE 0603801N / Innovative Naval Prototypes (INP) Adv Tec Dev					Project (Number/Name) 3455 / MINERVA								
B. Accomplishments/Planned Programs (\$ in Millions)										FY 2019	FY 2020					
Fleet, Force and Group echelons. It will establish a DevOps environment that includes warfighter staffs in the development and integration of new capabilities.										FY 2021 Base	FY 2021 OCO					
FY 2020 Plans: N/A										FY 2021 Total						
FY 2021 Base Plans: Conduct advanced development research on Artificial Intelligence and Machine Learning (AI/ML) methods to infer an enemy course of action and predict enemy locations. In addition, measure mission planning services, mission execution and adjustment services; and human acceptance of AI/ML decision aid services. Develop methods to test and validate AI/ML enabled decision aiding services.																
FY 2021 OCO Plans: N/A																
FY 2020 to FY 2021 Increase/Decrease Statement: The increase in FY 2021 is due to the realignment of the MINERVA - Artificial Intelligence (AI) Enhanced Warfighter Decision Superiority Capability effort from Project Unit 3400 in this Program Element (PE) 0603801N Innovative Naval Prototype (INP) Adv Tec Dev into this new Project Unit 3455.																
Accomplishments/Planned Programs Subtotals										0.000	0.000					
10.936										0.000	10.936					
C. Other Program Funding Summary (\$ in Millions)																
Line Item	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost					
• RDTEN/0602792N/3455: <i>MINERVA</i>	0.000	0.000	5.965	-	5.965	3.977	0.000	0.000	0.000	0.000	9.942					
Remarks																
D. Acquisition Strategy																
N/A																

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020	
Appropriation/Budget Activity 1319 / 3					R-1 Program Element (Number/Name) PE 0603801N / Innovative Naval Prototypes (INP) Adv Tec Dev				Project (Number/Name) 3457 / Long Range Targeting			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
3457: Long Range Targeting	0.000	0.000	0.000	10.000	-	10.000	21.000	33.000	35.000	35.700	Continuing	Continuing

Note

Long Range Targeting (LRT) plans and associated resources are realigned from Project Unit 3400 in this Program Element (PE) 0603801N Innovative Naval Prototype (INP) Adv Tec Dev into this new Project Unit 3457 effective FY 2021. This is not a new start.

A. Mission Description and Budget Item Justification

Long Range Targeting emphasizes the specific naval use of AI in an integrated system that addresses a warfighting challenge. This project contains coordinated investments in Applied Research that contribute to the Long Range Targeting (LRT) Innovative Naval Prototype (INP). This Advanced Technology Development, in coordination with a complimentary Applied Research investment in Program Element (PE) 0602792N Innovative Naval Prototypes (INP) Applied Res, will create an overall capability for LRT. Technologies within this activity will enable integrated and distributed forces capable of dynamic synchronized actions. Investments include technologies for sense and sense making and Artificial Intelligence for predictive mission-focused analytics that autonomously gather, analyze, compile, interpret, and visualize a fused tactical and national all source data picture to improve planning and decision making speeds. Investments will also establish a distributed Artificial Intelligence capability that can function in a harsh and adversarial environment, determine an optimal response and react in real-time. The Activity identified in Project Unit 3457 specifically addresses Advanced Technology Development in support of the LRT INP effort.

INP investments represent game changing technologies with the potential to revolutionize operational concepts. They are disruptive in nature, as they would dramatically change the way naval forces fight. Due to high technical risk, INPs typically have long duration but have no more than three years between decision points. INPs do not develop hardware for service use, rather they prove technological and production feasibility, and show naval utility and acquisition potential. The Office of Naval Research (ONR) demonstrates INPs in relevant environments. Successful experimentation and demonstrations present the Department of the Navy with disruptive capabilities that may lead to the obsolescence of existing capabilities and acquisition programs. The Department of the Navy would have to make significant acquisition decisions to integrate the new technological capabilities into naval warfighting systems. INPs are selected by a process that involves senior leadership in the Department of the Navy.

Information security concerns preclude fully detailed descriptions of project efforts, research activities, and technology development plans. Specific information on each project and activity will be provided separately to the Congressional oversight committees.

B. Accomplishments/Planned Programs (\$ in Millions)

Title: Long Range Targeting	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Description: Long Range Targeting emphasizes the specific naval use of AI in an integrated system that addresses a warfighting challenge. This project contains coordinated investments in Applied Research that contribute to the Long Range Targeting (LRT) Innovative Naval Prototype (INP). This Advanced Technology	0.000	0.000	10.000	0.000	10.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy			Date: February 2020		
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603801N / Innovative Naval Prototypes <i>(INP) Adv Tec Dev</i>			Project (Number/Name) 3457 / Long Range Targeting	
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO
<p>Development, in coordination with a complimentary Applied Research investment in Program Element (PE) 0602792N Innovative Naval Prototypes (INP) Applied Res, will create an overall capability for LRT. Technologies within this activity will enable integrated and distributed forces capable of dynamic synchronized actions. Investments include technologies for sense and sense making and Artificial Intelligence for predictive mission-focused analytics that autonomously gather, analyze, compile, interpret, and visualize a fused tactical and national all source data picture to improve planning and decision making speeds. Investments will also establish a distributed Artificial Intelligence capability that can function in a harsh and adversarial environment, determine an optimal response and react in real-time.</p> <p>FY 2020 Plans: N/A</p> <p>FY 2021 Base Plans: Complete Adv Tech Dev on framework/architecture studies for Long Range Targeting; Initiate development efforts for sensor and communication technologies and prototypes to fill the gaps identified and needed to achieve the Long Range Targeting capability; Initiate planning for test, integration, demonstration and experiment activities for Long Range Targeting.</p> <p>FY 2021 OCO Plans: N/A</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: The increase in FY 2021 is due to the realignment of the Long Range Targeting (LRT) effort from Project Unit 3400 in this Program Element (PE) 0603801N Innovative Naval Prototype (INP) Adv Tec Dev into this new Project Unit 3457.</p>					
Accomplishments/Planned Programs Subtotals		0.000	0.000	10.000	0.000
C. Other Program Funding Summary (\$ in Millions)					
N/A					
Remarks					
D. Acquisition Strategy					
N/A					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020	
Appropriation/Budget Activity					R-1 Program Element (Number/Name)				Project (Number/Name)			
1319 / 3					PE 0603801N / Innovative Naval Prototypes (INP) Adv Tec Dev				3458 / Undersea Warfare Efforts			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
3458: Undersea Warfare Efforts	0.000	0.000	0.000	2.500	-	2.500	0.000	0.000	0.000	0.000	0.000	2.500

Note

Undersea Warfare Efforts plans and associated resources are realigned from Project Unit 3400 in this Program Element (PE) 0603801N Innovative Naval Prototype (INP) Adv Tec Dev into this new Project Unit 3458 effective FY 2021. This is not a new start.

A. Mission Description and Budget Item Justification

The Undersea Warfare Efforts Project will develop new technology for offensive and defensive warfare conducted on the seabed, in the sea (i.e. subsea), and from the sea. Undersea Warfare Efforts will address three thrusts identified in the Undersea Warfare Development Command's document, "Full Spectrum Undersea Warfare Concept of Operations (CONOPS)". These thrusts are: advanced offensive missions for submarines, subsea and seabed warfare, and distributed undersea warfare. Distributed undersea warfare technology will enable full participation of all undersea warfare assets in the Navy's Distributed Maritime Operations concept. Undersea Warfare missions this Project addresses include Anti-Submarine Warfare (ASW), Anti Surface Warfare, Strike, Intelligence, Surveillance, and Reconnaissance, Mine Warfare, and Subsea and Seabed Warfare (SSW). The Activity identified in Project Unit 3458 specifically addresses Advanced Technology Development in support of the Undersea Warfare INP effort.

INP investments represent game changing technologies with the potential to revolutionize operational concepts. They are disruptive in nature, as they would dramatically change the way naval forces fight. Due to high technical risk, INPs typically have long duration but have no more than three years between decision points. INPs do not develop hardware for service use, rather they prove technological and production feasibility, and show naval utility and acquisition potential. The Office of Naval Research (ONR) demonstrates INPs in relevant environments. Successful experimentation and demonstrations present the Department of the Navy with disruptive capabilities that may lead to the obsolescence of existing capabilities and acquisition programs. The Department of the Navy would have to make significant acquisition decisions to integrate the new technological capabilities into naval warfighting systems. INPs are selected by a process that involves senior leadership in the Department of the Navy.

Information security concerns preclude fully detailed descriptions of project efforts, research activities, and technology development plans. Specific information on each project and activity will be provided separately to the Congressional oversight committees.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Undersea Warfare Efforts	0.000	0.000	2.500	0.000	2.500

Description: The Undersea Warfare Efforts Project will develop new technology for offensive and defensive warfare conducted on the seabed, in the sea (i.e. subsea), and from the sea. Undersea Warfare Efforts will address three thrusts identified in the Undersea Warfare Development Command's document, "Full Spectrum Undersea Warfare Concept of Operations (CONOPS)". These thrusts are: advanced offensive missions for

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy					Date: February 2020	
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603801N / Innovative Naval Prototypes (INP) Adv Tec Dev	Project (Number/Name) 3458 / Undersea Warfare Efforts				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
submarines, subsea and seabed warfare, and distributed undersea warfare. Distributed undersea warfare technology will enable full participation of all undersea warfare assets in the Navy's Distributed Maritime Operations concept. Undersea Warfare missions this Project addresses include Anti-Submarine Warfare (ASW), Anti Surface Warfare, Strike, Intelligence, Surveillance, and Reconnaissance, Mine Warfare, and Subsea and Seabed Warfare (SSW).						
FY 2020 Plans: N/A						
FY 2021 Base Plans: Initiate development of concepts, identification of enabling technologies, and analysis and testing of existing technologies for insertion into subsea and seabed warfare efforts. Initiate development of concepts for advanced offensive missions for submarines. Initiate concepts, identification of new enabling technologies and testing of existing technologies to enable distributed undersea warfare.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The increase in FY 2021 is due to the realignment of the Undersea Warfare Efforts effort from Project Unit 3400 in this Program Element (PE) 0603801N Innovative Naval Prototype (INP) Adv Tec Dev into this new Project Unit 3458.						
Accomplishments/Planned Programs Subtotals		0.000	0.000	2.500	0.000	2.500
C. Other Program Funding Summary (\$ in Millions)						
N/A						
Remarks						
D. Acquisition Strategy						
N/A						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity 1319 / 3					R-1 Program Element (Number/Name) PE 0603801N / Innovative Naval Prototypes (INP) Adv Tec Dev				Project (Number/Name) 3459 / Super Swarm (SS)				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
3459: Super Swarm (SS)	0.000	0.000	0.000	4.000	-	4.000	20.000	33.000	0.000	0.000	0.000	57.000	

Note

Super Swarm (SS) plans and associated resources are realigned from Project Unit 3400 in this Program Element (PE) 0603801N Innovative Naval Prototype (INP) Adv Tec Dev into this new Project Unit 3459 effective FY 2021. This is not a new start.

A. Mission Description and Budget Item Justification

Swarming is a concept that allows for multi-domain, heterogeneous swarms of unmanned systems capable of rendering the counter's ability to scale either inadequate or irrelevant and includes offensive and defensive operations, own and adversarial employment, and a physical battlespace ranging from open ocean to ashore. The Super Swarm (SS) INP effort will develop an autonomous control system for multiple USV's consisting of cooperative task allocation, cooperative route planning/behaviors and shared situational awareness. The Swarm autonomy technology is leveraged by other programs including the Medium Displacement Unmanned Surface Vehicle (MDUSV) and the Autonomous USV FNC program. It will consist of the employment of sustainable large-scale robotic swarm warfare across all domains ahead of our adversaries to obviate costly and vulnerable legacy platforms and to gain a competitive advantage. The Activity identified in Project Unit 3459 specifically addresses Advanced Technology Development in support of the Super Swarm INP effort.

INP investments represent game changing technologies with the potential to revolutionize operational concepts. They are disruptive in nature, as they would dramatically change the way naval forces fight. Due to high technical risk, INPs typically have long duration but have no more than three years between decision points. INPs do not develop hardware for service use, rather they prove technological and production feasibility, and show naval utility and acquisition potential. The Office of Naval Research (ONR) demonstrates INPs in relevant environments. Successful experimentation and demonstrations present the Department of the Navy with disruptive capabilities that may lead to the obsolescence of existing capabilities and acquisition programs. The Department of the Navy would have to make significant acquisition decisions to integrate the new technological capabilities into naval warfighting systems. INPs are selected by a process that involves senior leadership in the Department of the Navy.

Information security concerns preclude fully detailed descriptions of project efforts, research activities, and technology development plans. Specific information on each project and activity will be provided separately to the Congressional oversight committees.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Super Swarm (SS)	0.000	0.000	4.000	0.000	4.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020		
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603801N / Innovative Naval Prototypes (INP) Adv Tec Dev	Project (Number/Name) 3459 / Super Swarm (SS)				
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
	for multiple USV's consisting of cooperative task allocation, cooperative route planning/behaviors and shared situational awareness. The Swarm autonomy technology is leveraged by other programs including the Medium Displacement Unmanned Surface Vehicle (MDUSV) and the Autonomous USV FNC program. It will consist of the employment of sustainable large-scale robotic swarm warfare across all domains ahead of our adversaries to obviate costly and vulnerable legacy platforms and to gain a competitive advantage.					
FY 2020 Plans: N/A						
FY 2021 Base Plans: Continue Advanced Technology Development efforts associated with robust, scalable, flexible, multi-functional swarming unmanned UxS vehicle systems providing cross-domain capability, human-swarm interdependence/interaction that is employable from surface, sub-surface, airborne, and ground manned and unmanned systems. Continue with efforts to deliver large numbers of UxS conducting extended-range maneuver and delivery of effects on targets.						
FY 2021 OCO Plans: N/A						
FY 2020 to FY 2021 Increase/Decrease Statement: The increase in FY 2021 is due to the realignment of the Super Swarm (SS) effort from Project Unit 3400 in this Program Element (PE) 0603801N Innovative Naval Prototype (INP) Adv Tec Dev into this new Project Unit 3459.						
Accomplishments/Planned Programs Subtotals		0.000	0.000	4.000	0.000	4.000
C. Other Program Funding Summary (\$ in Millions)						
N/A						
Remarks						
D. Acquisition Strategy						
N/A						

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy											Date: February 2020		
Appropriation/Budget Activity 1319 / 3					R-1 Program Element (Number/Name) PE 0603801N / Innovative Naval Prototypes (INP) Adv Tec Dev				Project (Number/Name) 9999 / Congressional Adds				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost	
9999: Congressional Adds	0.000	39.580	8.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	47.580	
A. Mission Description and Budget Item Justification													
Congressional Interest Items not included in other Projects.													
B. Accomplishments/Planned Programs (\$ in Millions)											FY 2019	FY 2020	
Congressional Add: Electromagnetic Railgun											9.654	0.000	
FY 2019 Accomplishments: These funds will advance development towards a tactical system with investment in the mount and Next Generation Pulsed Power (NGPP) required for shipboard operation. Funding will advance mount development to meet specifications for future shipboard application and develop modular concepts for evaluation and shipboard qualification testing.													
FY 2020 Plans: N/A													
Congressional Add: Railgun with Hypervelocity Projectile											29.926	0.000	
FY 2019 Accomplishments: Funds will be used in the development of the tactical Railgun mount; development and testing Hypervelocity Projectile (HVP) components and all up rounds in a Railgun launch; and to support simulated operational scenarios to quantify the value of HVP fired from a Railgun.													
FY 2020 Plans: N/A													
Congressional Add: Advanced thermal and power technology for improved DEW SWAP											0.000	8.000	
FY 2019 Accomplishments: N/A													
FY 2020 Plans: Conduct advanced technology development in C538: Advanced thermal and power technology for improved DEW SWAP.													
Congressional Adds Subtotals											39.580	8.000	
C. Other Program Funding Summary (\$ in Millions)													
N/A													
Remarks													
D. Acquisition Strategy													
N/A													