Department of Defense
Fiscal Year (FY) 2018 Budget Estimates

May 2017

Army

Justification Book of

Research, Development, Test & Evaluation, Army

RDT&E − Volume I, Budget Activity 1

RESEARCH, DEVELOPMENT, TEST AND EVALUATION, ARMY

APPROPRIATION LANGUAGE

For expenses necessary for basic and applied scientific research, development, test and evaluation, including maintenance, rehabilitation, lease, and operation of facilities and equipment, $9,544,808,000 to remain available for obligation until September 30, 2019.

The following Justification Books were prepared at a cost of $250,916: Aircraft (ACFT), Missile (MSLS), Weapons & Tracked Combat Vehicles (WTCV), Ammunition (AMMO), Other Procurement Army (OPA) 1 - Tactical & Support Vehicles, Other Procurement Army (OPA) 2 - Communications & Electronics, Other Procurement Army (OPA) 3 & 4 - Other Support Equipment & Spares, Research, Development, Test and Evaluation (RDTE) for: Budget Activity 1, Budget Activity 2, Budget Activity 3, Budget Activity 4, Budget Activity 5A, Budget Activity 5B, Budget Activity 6, and Budget Activity 7.

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FY 2018 RDT&E, ARMY PROGRAM ELEMENT DESCRIPTIVE SUMMARIES

Introduction and Explanation of Contents

1. **General.** The purpose of this document is to provide summary information concerning the Research, Development, Test and Evaluation, Army program. The descriptive summaries are comprised of R-2 (Army RDT&E Budget Item Justification – program element level), R-2A (Army RDT&E Budget Item Justification – project level), R-3 (Army RDT&E Cost Analysis), R-4 (Schedule Profile Detail) and R-5 (Termination Liability Funding for MDAPs) Exhibits, which provide narrative information on all RDT&E program elements and projects through FY 2018.

2. **Relationship of the FY 2018 Budget Submitted to Congress to the FY 2017 Budget Submitted to Congress.** This paragraph provides a list of program elements/projects that are major new starts, restructures, developmental transitions, and terminated programs. Explanations for these changes can be found in the narrative sections of the Program Element R-2A Exhibits.

A. New Start Programs:

Budget Activity	OSDPE/Project	Project Title
01	0601104A/FF5	Distributed Collaborative Intelligent Systems CTA
01	0601104A/FF7	Internet of Battlefield Things CTA
03	0603001A/FF6	Individual Protection
03	0603009A/FH1	Tractor Hike
04	0603639A/XT5	30mm Anti-Personnel and Counter-Air
04	0603645A/EV7	Combat Vehicle Prototyping
04	0603807A/VS7	MEDEVAC Mission Equipment Package (MEP) - Adv Dev
04	0604017A/FD2	Soldier Robotics Systems
04	0604017A/FD3	Battery Modernization & Interface Standardization
04	0604017A/FD9	Robotics Systems

Budget Activity	OSDPE/Project	Project Title
04	0604117A/FI4	Maneuver – Short Range Air Defense (M-SHORAD)
04	0604120A/EJ3	ANTI-JAM ANTENNA
04	0604121A/FD6	Synthetic Training Environment Refine & Prototype
05	0604601A/FF2	Small Arms Fire Control
05	0604601A/FI2	Lightweight 30mm Cannon
05	0604604A/H07	Family Of Med Tac Veh
05	0604768A/688	ATACMS BLK II
05	0604768A/P01	MULTI - MODE SEEKER DEVELOPMENT AND TEST
05	0604802A/EW1	40mm LV High Explosive Air Burst, XM1166
05	0604802A/FA6	30mm Lethality
05	0604804A/FG4	Ultra-Lightweight Camouflage Net System (ULCANS)
05	0604818A/ER9	Expeditionary Army Command Post
05	0604823A/L87	Hypervelocity Projectile System
05	0604852A/FE8	Vehicle Protection Suite
05	0605013A/VR3	ASMIS-R (REPORTIT)
05	0605037A/EQ6	Evidence Collection and Detainee Processing
05	0605053A/FB2	Man Transportable Robotic System (MTRS) Inc II
05	0605053A/FB3	Robotics Architecture
05	0605053A/FB4	Common Robotic Systems
05	0605053A/FB6	Squad Multipurpose Equipment Transport (SMET)
05	0605053A/FB7	Robotics Enhanced Program (REP)
05	0605053A/FB8	Soldier Borne Sensor (SBS)

Budget Activity	**OSDPE/Project**	**Project Title**
05	0605053A/FB9	MTRS Standardization
05	1205117A/FG3	Tractor Bears
06	0606001A/FD4	Military Ground-Based CREW Technology
07	0203735A/280	RECOV VEH IMPROV PROG
07	0203735A/431	M113 IMPROVEMENTS
07	0203743A/FF9	PIM Improvement Program
07	0203802A/788	ATACMS PIP
07	0205412A/EE6	Environmental Information Tech Modernization
07	0303028A/FG2	Counterintelligence & Human Intel Modernization
07	0303140A/FF8	Unit Activity Monitoring (UAM)
07	0305172A/XT9	Combined Advanced Applications

B. Program Element/Project Restructures:

Budget Activity	Old OSDPE/Project: Title	New OSDPE/Project: Title
04	0603308A/990: Space and Missile Defense Integration	1206308A/FE5: Space and Missile Defense Integration
04	0603308A/EB7: Army Space System Enhancement/Integration	1206308A/FE6: Army Space System Enhancement/Integration
04	0305219AMQ1: MQ-1 Gray Eagle – Army UAV (MIP)	0603804A/EW8: Armored Engineer Vehicles
05	0604201A/VU3: Networking and Mission Planning	0604201A/EW7: Degraded Visual Environment
05	0603639A/EB8: OWL for Small Caliber Ammunition	0604802A/EP4: One-Way Luminescence For Small Caliber Ammo
05	0603639A/EU2: Improved Multi-Option Fuze (iMOFA/iMOFM)	0604802A/EU8: Improved Multi-Option Fuze
05	0604827A/S65: Platoon Power Generator	0604827A/EY2: Integrated Soldier Power Data System Core
05	0604827A/S65: Platoon Power Generator	0604827A/EY4: Universal Battery Charger
05	0203735A/EE2: Stryker Improvement	0604852A/XU9: Active Protection System
05	0605013A/738: AcqBiz	0605013A/FE9: ALTESS (P & R Forms)
05	0603627A/E79: Smoke/Obscurant System	0605038A/EQ7: NBC Reconnaissance Vehicle (NBCRV)
05	0605051A/ER8: Common Missile Warning System (CMWS)	0605049A/XT4: Advanced Threat Detection System (ATDS)
05	0303142A/EA3: Transportable Tactical Cmd Comms (T2C2)	0605766A/EX7: Air Vigilance System Development
06	0605898A/M03: Command HQ - MRDC	0605898A/XW7: Command HQ - ARI
06	0605301A/DX2: Army Kwajalein and Mission Support	0606002A/XW9: Reagan Test Site
07	0303142A/253: Dscs-Dcs (Phase II)	1203142A/FE1: Dscs-Dcs (Phase II)
07	0303142A/456: MILSATCOM System Engineering	1203142A/FE2: MILSATCOM System Engineering
07	0303142A/EA3: Transportable Tactical Cmd Comms (T2C2)	1203142A/FE4: Enroute Mission Command
07	0208053A/635: Joint Tact Grd Station P3I (MIP)	1208053A/FE7: Joint Tact Grd Station-P3I(MIP)
07	0305219A/RQ7: RQ-7 Shadow UAV	0607143A/EX1: Unmanned Aircraft Systems Universal Products

C. Program Terminations:

Budget Activity	OSDPE/Project	OSDPE Title/Project Title
01	0601104A/H53	University & Industry Rsch Ctrs / Army High Performance Computing Research Center
01	0601104A/H53	University & Industry Rsch Ctrs / Micro-autonomous Systems Technology (MAST) CTA
05	0604601A/S62	Infantry Support Weapons / Counter-Defilade Target Engagement - SDD

3. Classification: This document contains no classified data. Appropriately cleared individuals can obtain further information on Classified/Special Access Programs by contacting the Department of the Army (ASA(ALT)) Special Programs Office.

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Department of Defense
FY 2018 President's Budget Request
Exhibit R-1 FY 2018 President's Budget Request
Total Obligational Authority
(Dollars in Thousands)

26 Apr 2017

Appropriation	FY 2016 Base + OCO	FY 2017 PB Request with CR Adj Base	FY 2017 Total PB Requests* with CR Adj Base	FY 2017 PB Request with CR Adj OCO	FY 2017 Total PB Requests* with CR Adj OCO	FY 2017 Less Enacted Div B P.L.114-254** OCO	FY 2017 Remaining Req with CR Adj OCO
Research, Development, Test & Eval, Army	7,861,744	7,547,794	7,897,415	1,500	233,300	-78,700	154,600
Total Research, Development, Test & Evaluation	7,861,744	7,547,794	7,897,415	1,500	233,300	-78,700	154,600

Department of Defense
FY 2018 President's Budget Request
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26 Apr 2017

Appropriation	FY 2017 Total PB Requests** with CR Adj Base+OCO+SAA	FY 2017 Total PB Requests* with CR Adj Base + OCO	FY 2017 Less Enacted Div B P.L.114-254** OCO	FY 2017 Remaining Req with CR Adj Base + OCO	FY 2018 Base	FY 2018 OCO	FY 2018 Total
Research, Development, Test & Eval, Army	7,627,994	8,130,715	-78,700	8,052,015	9,425,440	119,368	9,544,808
Total Research, Development, Test & Evaluation	7,627,994	8,130,715	-78,700	8,052,015	9,425,440	119,368	9,544,808

Department of Defense
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(Dollars in Thousands)

26 Apr 2017

Summary Recap of Budget Activities	FY 2016 Base + OCO	FY 2017 PB Request with CR Adj Base	FY 2017 Total PB Requests* with CR Adj Base	FY 2017 PB Request with CR Adj OCO	FY 2017 Total PB Requests* with CR Adj OCO	FY 2017 Less Enacted Div B P.L.114-254** OCO	FY 2017 Remaining Req with CR Adj OCO
Basic Research	450,831	428,943	428,943				
Applied Research	1,070,349	907,574	907,574				
Advanced Technology Development	1,113,746	930,065	943,365				
Advanced Component Development & Prototypes	499,287	550,635	566,835	9,375	25,395		25,395
System Development & Demonstration	2,202,652	2,265,094	2,393,383	84,043	288,443	-78,700	209,743
RDT&E Management Support	1,259,926	1,136,134	1,161,991				
Operational Systems Development	1,264,953	1,296,954	1,462,929	7,104	18,484		18,484
Undistributed		32,395	32,395	-99,022	-99,022		-99,022
Total Research, Development, Test & Evaluation	7,861,744	7,547,794	7,897,415	1,500	233,300	-78,700	154,600
Summary Recap of FYDP Programs							
General Purpose Forces	802,086	618,038	697,138		4,530		4,530
Intelligence and Communications	400,329	238,711	268,755	7,104	8,854		8,854
Research and Development	6,596,225	6,591,738	6,832,215	93,418	318,938	-78,700	240,238
Central Supply and Maintenance	58,503	62,287	62,287				
Administration and Associated Activities	65	32,395	32,395	-99,022	-99,022		-99,022
Space							
Classified Programs	4,536	4,625	4,625				
Total Research, Development, Test & Evaluation	7,861,744	7,547,794	7,897,415	1,500	233,300	-78,700	154,600

R-1C1F: FY 2018 President's Budget Request (Published Version), as of April 26, 2017 at 08:46:19

Department of Defense
FY 2018 President's Budget Request
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(Dollars in Thousands)

26 Apr 2017

Summary Recap of Budget Activities	FY 2017 Total PB Requests** with CR Adj Base+OCO+SAA	FY 2017 Total PB Requests* with CR Adj Base + OCO	FY 2017 Less Enacted Div B P.L.114-254** OCO	FY 2017 Remaining Req with CR Adj Base + OCO	FY 2018 Base	FY 2018 OCO	FY 2018 Total
Basic Research	428,943	428,943		428,943	430,022		430,022
Applied Research	907,574	907,574		907,574	889,182		889,182
Advanced Technology Development	930,065	943,365		943,365	1,070,977		1,070,977
Advanced Component Development & Prototypes	560,010	592,230		592,230	890,889	18,000	908,889
System Development & Demonstration	2,427,837	2,681,826	-78,700	2,603,126	3,012,840	57,840	3,070,680
RDT&E Management Support	1,136,134	1,161,991		1,161,991	1,253,845		1,253,845
Operational Systems Development	1,304,058	1,481,413		1,481,413	1,877,685	43,528	1,921,213
Undistributed	-66,627	-66,627		-66,627			
Total Research, Development, Test & Evaluation	7,627,994	8,130,715	-78,700	8,052,015	9,425,440	119,368	9,544,808
Summary Recap of FYDP Programs							
General Purpose Forces	618,038	701,668		701,668	710,401	15,000	725,401
Intelligence and Communications	245,815	277,609		277,609	370,519	29,728	400,247
Research and Development	6,763,856	7,151,153	-78,700	7,072,453	8,215,942	74,640	8,290,582
Central Supply and Maintenance	62,287	62,287		62,287	60,877		60,877
Administration and Associated Activities	-66,627	-66,627		-66,627			
Space					60,547		60,547
Classified Programs	4,625	4,625		4,625	7,154		7,154
Total Research, Development, Test & Evaluation	7,627,994	8,130,715	-78,700	8,052,015	9,425,440	119,368	9,544,808

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Basic Research	450,831	428,943	428,943				
Applied Research	1,070,349	907,574	907,574				
Advanced Technology Development	1,113,746	930,065	943,365				
Advanced Component Development & Prototypes	499,287	550,635	566,835	9,375	25,395		25,395
System Development & Demonstration	2,202,652	2,265,094	2,393,383	84,043	288,443	-78,700	209,743
RDT&E Management Support	1,259,926	1,136,134	1,161,991				
Operational Systems Development	1,264,953	1,296,954	1,462,929	7,104	18,484		18,484
Undistributed		32,395	32,395	-99,022	-99,022		-99,022
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Central Supply and Maintenance	58,503	62,287	62,287				
Administration and Associated Activities	65	32,395	32,395	-99,022	-99,022		-99,022
Space							
Classified Programs	4,536	4,625	4,625				
Total Research, Development, Test & Evaluation	7,861,744	7,547,794	7,897,415	1,500	233,300	-78,700	154,600

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Basic Research	428,943	428,943		428,943	430,022		430,022
Applied Research	907,574	907,574		907,574	889,182		889,182
Advanced Technology Development	930,065	943,365		943,365	1,070,977		1,070,977
Advanced Component Development & Prototypes	560,010	592,230		592,230	890,889	18,000	908,889
System Development & Demonstration	2,427,837	2,681,826	-78,700	2,603,126	3,012,840	57,840	3,070,680
RDT&E Management Support	1,136,134	1,161,991		1,161,991	1,253,845		1,253,845
Operational Systems Development	1,304,058	1,481,413		1,481,413	1,877,685	43,528	1,921,213
Undistributed	-66,627	-66,627		-66,627			
Total Research, Development, Test & Evaluation	7,627,994	8,130,715	-78,700	8,052,015	9,425,440	119,368	9,544,808
Summary Recap of FYDP Programs							
General Purpose Forces	618,038	701,668		701,668	710,401	15,000	725,401
Intelligence and Communications	245,815	277,609		277,609	370,519	29,728	400,247
Research and Development	6,763,856	7,151,153	-78,700	7,072,453	8,215,942	74,640	8,290,582
Central Supply and Maintenance	62,287	62,287		62,287	60,877		60,877
Administration and Associated Activities	-66,627	-66,627		-66,627			
Space					60,547		60,547
Classified Programs	4,625	4,625		4,625	7,154		7,154
Total Research, Development, Test & Evaluation	7,627,994	8,130,715	-78,700	8,052,015	9,425,440	119,368	9,544,808

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Appropriation: 2040A Research, Development, Test & Eval, Army

Line No	Program Element Number	Item	Act	FY 2016 Base + OCO	FY 2017 PB Request with CR Adj Base	FY 2017 Total PB Requests* with CR Adj Base	FY 2017 PB Request with CR Adj OCO	FY 2017 Total PB Requests* with CR Adj OCO	FY 2017 Less Enacted Div B P.L.114-254** OCO	FY 2017 Remaining Req with CR Adj OCO	Sec
1	0601101A	In-House Laboratory Independent Research	01	12,525	12,381	12,381					U
2	0601102A	Defense Research Sciences	01	271,933	253,116	253,116					U
3	0601103A	University Research Initiatives	01	67,225	69,166	69,166					U
4	0601104A	University and Industry Research Centers	01	99,148	94,280	94,280					U
	Basic Research			450,831	428,943	428,943					
5	0602105A	Materials Technology	02	67,806	31,533	31,533					U
6	0602120A	Sensors and Electronic Survivability	02	57,202	36,109	36,109					U
7	0602122A	TRACTOR HIP	02	6,879	6,995	6,995					U
8	0602211A	Aviation Technology	02	58,497	65,914	65,914					U
9	0602270A	Electronic Warfare Technology	02	18,502	25,466	25,466					U
10	0602303A	Missile Technology	02	51,801	44,313	44,313					U
11	0602307A	Advanced Weapons Technology	02	36,906	28,803	28,803					U
12	0602308A	Advanced Concepts and Simulation	02	26,886	27,688	27,688					U
13	0602601A	Combat Vehicle and Automotive Technology	02	95,763	67,959	67,959					U
14	0602618A	Ballistics Technology	02	118,221	85,436	85,436					U
15	0602622A	Chemical, Smoke and Equipment Defeating Technology	02	3,713	3,923	3,923					U
16	0602623A	Joint Service Small Arms Program	02	5,270	5,545	5,545					U
17	0602624A	Weapons and Munitions Technology	02	81,447	53,581	53,581					U

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1	0601101A	In-House Laboratory Independent Research	01	12,381	12,381		12,381	12,010		12,010	U
2	0601102A	Defense Research Sciences	01	253,116	253,116		253,116	263,590		263,590	U
3	0601103A	University Research Initiatives	01	69,166	69,166		69,166	67,027		67,027	U
4	0601104A	University and Industry Research Centers	01	94,280	94,280		94,280	87,395		87,395	U
	Basic	Research		428,943	428,943		428,943	430,022		430,022	
5	0602105A	Materials Technology	02	31,533	31,533		31,533	29,640		29,640	U
6	0602120A	Sensors and Electronic Survivability	02	36,109	36,109		36,109	35,730		35,730	U
7	0602122A	TRACTOR HIP	02	6,995	6,995		6,995	8,627		8,627	U
8	0602211A	Aviation Technology	02	65,914	65,914		65,914	66,086		66,086	U
9	0602270A	Electronic Warfare Technology	02	25,466	25,466		25,466	27,144		27,144	U
10	0602303A	Missile Technology	02	44,313	44,313		44,313	43,742		43,742	U
11	0602307A	Advanced Weapons Technology	02	28,803	28,803		28,803	22,785		22,785	U
12	0602308A	Advanced Concepts and Simulation	02	27,688	27,688		27,688	28,650		28,650	U
13	0602601A	Combat Vehicle and Automotive Technology	02	67,959	67,959		67,959	67,232		67,232	U
14	0602618A	Ballistics Technology	02	85,436	85,436		85,436	85,309		85,309	U
15	0602622A	Chemical, Smoke and Equipment Defeating Technology	02	3,923	3,923		3,923	4,004		4,004	U
16	0602623A	Joint Service Small Arms Program	02	5,545	5,545		5,545	5,615		5,615	U
17	0602624A	Weapons and Munitions Technology	02	53,581	53,581		53,581	41,455		41,455	U

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18	0602705A	Electronics and Electronic Devices	02	62,654	56,322	56,322					U
19	0602709A	Night Vision Technology	02	37,501	36,079	36,079					U
20	0602712A	Countermine Systems	02	35,586	26,497	26,497					U
21	0602716A	Human Factors Engineering Technology	02	23,220	23,671	23,671					U
22	0602720A	Environmental Quality Technology	02	20,270	22,151	22,151					U
23	0602782A	Command, Control, Communications Technology	02	34,749	37,803	37,803					U
24	0602783A	Computer and Software Technology	02	12,266	13,811	13,811					U
25	0602784A	Military Engineering Technology	02	80,130	67,416	67,416					U
26	0602785A	Manpower/Personnel/Training Technology	02	22,474	26,045	26,045					U
27	0602786A	Warfighter Technology	02	38,420	37,403	37,403					U
28	0602787A	Medical Technology	02	74,186	77,111	77,111					U
		Applied Research		1,070,349	907,574	907,574					
29	0603001A	Warfighter Advanced Technology	03	54,606	38,831	38,831					U
30	0603002A	Medical Advanced Technology	03	103,753	68,365	68,365					U
31	0603003A	Aviation Advanced Technology	03	99,542	94,280	94,280					U
32	0603004A	Weapons and Munitions Advanced Technology	03	95,504	68,714	68,714					U
33	0603005A	Combat Vehicle and Automotive Advanced Technology	03	136,624	122,132	122,132					U
34	0603006A	Space Application Advanced Technology	03	5,384	3,904	3,904					U

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18	0602705A	Electronics and Electronic Devices	02	56,322	56,322		56,322	58,352		58,352	U
19	0602709A	Night Vision Technology	02	36,079	36,079		36,079	34,723		34,723	U
20	0602712A	Countermine Systems	02	26,497	26,497		26,497	26,190		26,190	U
21	0602716A	Human Factors Engineering Technology	02	23,671	23,671		23,671	24,127		24,127	U
22	0602720A	Environmental Quality Technology	02	22,151	22,151		22,151	21,678		21,678	U
23	0602782A	Command, Control, Communications Technology	02	37,803	37,803		37,803	33,123		33,123	U
24	0602783A	Computer and Software Technology	02	13,811	13,811		13,811	14,041		14,041	U
25	0602784A	Military Engineering Technology	02	67,416	67,416		67,416	67,720		67,720	U
26	0602785A	Manpower/Personnel/Training Technology	02	26,045	26,045		26,045	20,216		20,216	U
27	0602786A	Warfighter Technology	02	37,403	37,403		37,403	39,559		39,559	U
28	0602787A	Medical Technology	02	77,111	77,111		77,111	83,434		83,434	U
		Applied Research		907,574	907,574		907,574	889,182		889,182	
29	0603001A	Warfighter Advanced Technology	03	38,831	38,831		38,831	44,863		44,863	U
30	0603002A	Medical Advanced Technology	03	68,365	68,365		68,365	67,780		67,780	U
31	0603003A	Aviation Advanced Technology	03	94,280	94,280		94,280	160,746		160,746	U
32	0603004A	Weapons and Munitions Advanced Technology	03	68,714	68,714		68,714	84,079		84,079	U
33	0603005A	Combat Vehicle and Automotive Advanced Technology	03	122,132	122,132		122,132	125,537		125,537	U
34	0603006A	Space Application Advanced Technology	03	3,904	3,904		3,904	12,231		12,231	U

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35	0603007A	Manpower, Personnel and Training Advanced Technology	03	11,571	14,417	14,417					U
36	0603009A	TRACTOR HIKE	03	9,002	8,074	21,374					U
37	0603015A	Next Generation Training & Simulation Systems	03	16,735	18,969	18,969					U
38	0603020A	TRACTOR ROSE	03	11,912	11,910	11,910					U
39	0603125A	Combating Terrorism - Technology Development	03	32,430	27,686	27,686					U
40	0603130A	TRACTOR NAIL	03	2,381	2,340	2,340					U
41	0603131A	TRACTOR EGGS	03	2,431	2,470	2,470					U
42	0603270A	Electronic Warfare Technology	03	31,810	27,893	27,893					U
43	0603313A	Missile and Rocket Advanced Technology	03	102,490	52,190	52,190					U
44	0603322A	TRACTOR CAGE	03	10,999	11,107	11,107					U
45	0603461A	High Performance Computing Modernization Program	03	215,138	177,190	177,190					U
46	0603606A	Landmine Warfare and Barrier Advanced Technology	03	13,425	17,451	17,451					U
47	0603607A	Joint Service Small Arms Program	03	4,903	5,839	5,839					U
48	0603710A	Night Vision Advanced Technology	03	39,329	44,468	44,468					U
49	0603728A	Environmental Quality Technology Demonstrations	03	14,533	11,137	11,137					U
50	0603734A	Military Engineering Advanced Technology	03	26,247	20,684	20,684					U

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35	0603007A	Manpower, Personnel and Training Advanced Technology	03	14,417	14,417		14,417	6,466		6,466	U
36	0603009A	TRACTOR HIKE	03	8,074	21,374		21,374	28,552		28,552	U
37	0603015A	Next Generation Training & Simulation Systems	03	18,969	18,969		18,969	16,434		16,434	U
38	0603020A	TRACTOR ROSE	03	11,910	11,910		11,910				U
39	0603125A	Combating Terrorism - Technology Development	03	27,686	27,686		27,686	26,903		26,903	U
40	0603130A	TRACTOR NAIL	03	2,340	2,340		2,340	4,880		4,880	U
41	0603131A	TRACTOR EGGS	03	2,470	2,470		2,470	4,326		4,326	U
42	0603270A	Electronic Warfare Technology	03	27,893	27,893		27,893	31,296		31,296	U
43	0603313A	Missile and Rocket Advanced Technology	03	52,190	52,190		52,190	62,850		62,850	U
44	0603322A	TRACTOR CAGE	03	11,107	11,107		11,107	12,323		12,323	U
45	0603461A	High Performance Computing Modernization Program	03	177,190	177,190		177,190	182,331		182,331	U
46	0603606A	Landmine Warfare and Barrier Advanced Technology	03	17,451	17,451		17,451	17,948		17,948	U
47	0603607A	Joint Service Small Arms Program	03	5,839	5,839		5,839	5,796		5,796	U
48	0603710A	Night Vision Advanced Technology	03	44,468	44,468		44,468	47,135		47,135	U
49	0603728A	Environmental Quality Technology Demonstrations	03	11,137	11,137		11,137	10,421		10,421	U
50	0603734A	Military Engineering Advanced Technology	03	20,684	20,684		20,684	32,448		32,448	U

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51	0603772A	Advanced Tactical Computer Science and Sensor Technology	03	36,658	44,239	44,239					U
52	0603794A	C3 Advanced Technology	03	36,339	35,775	35,775					U
		Advanced Technology Development		1,113,746	930,065	943,365					
53	0603305A	Army Missle Defense Systems Integration	04	29,270	9,433	9,433					U
54	0603308A	Army Space Systems Integration	04	29,561	23,056	23,056	9,375	9,375		9,375	U
55	0603327A	Air and Missile Defense Systems Engineering	04			14,200					U
56	0603619A	Landmine Warfare and Barrier - Adv Dev	04	40,943	72,117	72,117					U
57	0603627A	Smoke, Obscurant and Target Defeating Sys-Adv Dev	04	12,894	28,244	28,244		16,020		16,020	U
58	0603639A	Tank and Medium Caliber Ammunition	04	42,272	40,096	42,096					U
59	0603645A	Armored System Modernization - Adv Dev	04								U
60	0603747A	Soldier Support and Survivability	04	5,035	10,506	10,506					U
61	0603766A	Tactical Electronic Surveillance System - Adv Dev	04	17,562	15,730	15,730					U
62	0603774A	Night Vision Systems Advanced Development	04	7,003	10,321	10,321					U
63	0603779A	Environmental Quality Technology - Dem/Val	04	8,464	7,785	7,785					U
64	0603790A	NATO Research and Development	04	5,835	2,300	2,300					U
65	0603801A	Aviation - Adv Dev	04		10,014	10,014					U

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51	0603772A	Advanced Tactical Computer Science and Sensor Technology	03	44,239	44,239		44,239	52,206		52,206	U
52	0603794A	C3 Advanced Technology	03	35,775	35,775		35,775	33,426		33,426	U
		Advanced Technology Development		930,065	943,365		943,365	1,070,977		1,070,977	
53	0603305A	Army Missle Defense Systems Integration	04	9,433	9,433		9,433	9,634		9,634	U
54	0603308A	Army Space Systems Integration	04	32,431	32,431		32,431				U
55	0603327A	Air and Missile Defense Systems Engineering	04		14,200		14,200	33,949	15,000	48,949	U
56	0603619A	Landmine Warfare and Barrier - Adv Dev	04	72,117	72,117		72,117	72,909		72,909	U
57	0603627A	Smoke, Obscurant and Target Defeating Sys-Adv Dev	04	28,244	44,264		44,264	7,135		7,135	U
58	0603639A	Tank and Medium Caliber Ammunition	04	40,096	42,096		42,096	41,452		41,452	U
59	0603645A	Armored System Modernization - Adv Dev	04					32,739		32,739	U
60	0603747A	Soldier Support and Survivability	04	10,506	10,506		10,506	10,157	3,000	13,157	U
61	0603766A	Tactical Electronic Surveillance System - Adv Dev	04	15,730	15,730		15,730	27,733		27,733	U
62	0603774A	Night Vision Systems Advanced Development	04	10,321	10,321		10,321	12,347		12,347	U
63	0603779A	Environmental Quality Technology - Dem/Val	04	7,785	7,785		7,785	10,456		10,456	U
64	0603790A	NATO Research and Development	04	2,300	2,300		2,300	2,588		2,588	U
65	0603801A	Aviation - Adv Dev	04	10,014	10,014		10,014	14,055		14,055	U

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66	0603804A	Logistics and Engineer Equipment - Adv Dev	04	20,271	20,834	20,834					U
67	0603807A	Medical Systems - Adv Dev	04	39,711	33,503	33,503					U
68	0603827A	Soldier Systems - Advanced Development	04	22,251	31,120	31,120					U
69	0604017A	Robotics Development	04								U
70	0604100A	Analysis Of Alternatives	04	7,533	6,608	6,608					U
71	0604114A	Lower Tier Air Missile Defense (LTAMD) Sensor	04		35,132	35,132					U
72	0604115A	Technology Maturation Initiatives	04	34,493	70,047	70,047					U
73	0604117A	Maneuver - Short Range Air Defense (M-SHORAD)	04								U
74	0604118A	TRACTOR BEAM	04								U
75	0604120A	Assured Positioning, Navigation and Timing (PNT)	04	26,967	83,279	83,279					U
76	0604121A	Synthetic Training Environment Refinement & Prototyping	04								U
77	0604319A	Indirect Fire Protection Capability Increment 2-Intercept (IFPC2)	04	149,222							U
78	0305251A	Cyberspace Operations Forces and Force Support	04		40,510	40,510					U
79	1206308A	Army Space Systems Integration	04								U
		Advanced Component Development & Prototypes		499,287	550,635	566,835	9,375	25,395		25,395	
80	0604201A	Aircraft Avionics	05	18,194	83,248	83,248					U

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66	0603804A	Logistics and Engineer Equipment - Adv Dev	04	20,834	20,834		20,834	35,333		35,333	U
67	0603807A	Medical Systems - Adv Dev	04	33,503	33,503		33,503	33,491		33,491	U
68	0603827A	Soldier Systems - Advanced Development	04	31,120	31,120		31,120	20,239		20,239	U
69	0604017A	Robotics Development	04					39,608		39,608	U
70	0604100A	Analysis Of Alternatives	04	6,608	6,608		6,608	9,921		9,921	U
71	0604114A	Lower Tier Air Missile Defense (LTAMD) Sensor	04	35,132	35,132		35,132	76,728		76,728	U
72	0604115A	Technology Maturation Initiatives	04	70,047	70,047		70,047	115,221		115,221	U
73	0604117A	Maneuver - Short Range Air Defense (M-SHORAD)	04					20,000		20,000	U
74	0604118A	TRACTOR BEAM	04					10,400		10,400	U
75	0604120A	Assured Positioning, Navigation and Timing (PNT)	04	83,279	83,279		83,279	164,967		164,967	U
76	0604121A	Synthetic Training Environment Refinement & Prototyping	04					1,600		1,600	U
77	0604319A	Indirect Fire Protection Capability Increment 2-Intercept (IFPC2)	04					11,303		11,303	U
78	0305251A	Cyberspace Operations Forces and Force Support	04	40,510	40,510		40,510	56,492		56,492	U
79	1206308A	Army Space Systems Integration	04					20,432		20,432	U
		Advanced Component Development & Prototypes		560,010	592,230		592,230	890,889	18,000	908,889	
80	0604201A	Aircraft Avionics	05	83,248	83,248		83,248	30,153		30,153	U

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81	0604270A	Electronic Warfare Development	05	20,586	34,642	37,242					U
82	0604280A	Joint Tactical Radio	05	4,415							U
83	0604290A	Mid-tier Networking Vehicular Radio (MNVR)	05	8,416	12,172	12,172					U
84	0604321A	All Source Analysis System	05	4,309	3,958	3,958					U
85	0604328A	TRACTOR CAGE	05	15,138	12,525	12,525					U
86	0604601A	Infantry Support Weapons	05	86,966	66,943	66,943					U
87	0604604A	Medium Tactical Vehicles	05								U
88	0604611A	JAVELIN	05	3,789	20,011	20,011					U
89	0604622A	Family of Heavy Tactical Vehicles	05		11,429	11,429					U
90	0604633A	Air Traffic Control	05	9,714	3,421	3,421					U
91	0604641A	Tactical Unmanned Ground Vehicle (TUGV)	05	13,599	39,282	39,282					U
92	0604642A	Light Tactical Wheeled Vehicles	05		494	494					U
93	0604645A	Armored Systems Modernization (ASM) - Eng Dev	05		9,678	9,678					U
94	0604710A	Night Vision Systems - Eng Dev	05	65,482	84,519	84,519					U
95	0604713A	Combat Feeding, Clothing, and Equipment	05	1,694	2,054	2,054					U
96	0604715A	Non-System Training Devices - Eng Dev	05	26,768	30,774	35,774	33	33		33	U
97	0604741A	Air Defense Command, Control and Intelligence - Eng Dev	05	33,619	53,332	61,532		143,900	-78,700	65,200	U

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81	0604270A	Electronic Warfare Development	05	34,642	37,242		37,242	71,671		71,671	U
82	0604280A	Joint Tactical Radio	05								U
83	0604290A	Mid-tier Networking Vehicular Radio (MNVR)	05	12,172	12,172		12,172	10,589		10,589	U
84	0604321A	All Source Analysis System	05	3,958	3,958		3,958	4,774		4,774	U
85	0604328A	TRACTOR CAGE	05	12,525	12,525		12,525	17,252		17,252	U
86	0604601A	Infantry Support Weapons	05	66,943	66,943		66,943	87,643		87,643	U
87	0604604A	Medium Tactical Vehicles	05					6,039		6,039	U
88	0604611A	JAVELIN	05	20,011	20,011		20,011	21,095		21,095	U
89	0604622A	Family of Heavy Tactical Vehicles	05	11,429	11,429		11,429	10,507		10,507	U
90	0604633A	Air Traffic Control	05	3,421	3,421		3,421	3,536		3,536	U
91	0604641A	Tactical Unmanned Ground Vehicle (TUGV)	05	39,282	39,282		39,282				U
92	0604642A	Light Tactical Wheeled Vehicles	05	494	494		494	7,000		7,000	U
93	0604645A	Armored Systems Modernization (ASM) - Eng Dev	05	9,678	9,678		9,678	36,242		36,242	U
94	0604710A	Night Vision Systems - Eng Dev	05	84,519	84,519		84,519	108,504		108,504	U
95	0604713A	Combat Feeding, Clothing, and Equipment	05	2,054	2,054		2,054	3,702		3,702	U
96	0604715A	Non-System Training Devices - Eng Dev	05	30,807	35,807		35,807	43,575		43,575	U
97	0604741A	Air Defense Command, Control and Intelligence - Eng Dev	05	132,032	205,432	-78,700	126,732	28,726		28,726	U

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98	0604742A	Constructive Simulation Systems Development	05	22,609	17,887	17,887					U
99	0604746A	Automatic Test Equipment Development	05	8,636	8,813	8,813					U
100	0604760A	Distributive Interactive Simulations (DIS) - Eng Dev	05	8,843	10,487	10,487					U
101	0604768A	Brilliant Anti-Armor Submunition (BAT)	05								U
102	0604780A	Combined Arms Tactical Trainer (CATT) Core	05	20,808	15,068	15,068					U
103	0604798A	Brigade Analysis, Integration and Evaluation	05	96,286	89,716	146,655					U
104	0604802A	Weapons and Munitions - Eng Dev	05	18,037	80,365	99,165					U
105	0604804A	Logistics and Engineer Equipment - Eng Dev	05	43,229	75,098	75,098					U
106	0604805A	Command, Control, Communications Systems - Eng Dev	05	2,780	4,245	4,245					U
107	0604807A	Medical Materiel/Medical Biological Defense Equipment - Eng Dev	05	39,295	41,124	41,124					U
108	0604808A	Landmine Warfare/Barrier - Eng Dev	05	63,028	39,630	39,630					U
109	0604818A	Army Tactical Command & Control Hardware & Software	05	125,107	205,590	205,590					U
110	0604820A	Radar Development	05	11,821	15,983	15,983					U
111	0604822A	General Fund Enterprise Business System (GFEBS)	05	20,533	6,805	6,805					U
112	0604823A	Firefinder	05	2,850	9,235	9,235					U

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98	0604742A	Constructive Simulation Systems Development	05	17,887	17,887		17,887	18,562		18,562	U
99	0604746A	Automatic Test Equipment Development	05	8,813	8,813		8,813	8,344		8,344	U
100	0604760A	Distributive Interactive Simulations (DIS) - Eng Dev	05	10,487	10,487		10,487	11,270		11,270	U
101	0604768A	Brilliant Anti-Armor Submunition (BAT)	05					10,000		10,000	U
102	0604780A	Combined Arms Tactical Trainer (CATT) Core	05	15,068	15,068		15,068	18,566		18,566	U
103	0604798A	Brigade Analysis, Integration and Evaluation	05	89,716	146,655		146,655	145,360		145,360	U
104	0604802A	Weapons and Munitions - Eng Dev	05	80,365	99,165		99,165	145,232		145,232	U
105	0604804A	Logistics and Engineer Equipment - Eng Dev	05	75,098	75,098		75,098	90,965		90,965	U
106	0604805A	Command, Control, Communications Systems - Eng Dev	05	4,245	4,245		4,245	9,910		9,910	U
107	0604807A	Medical Materiel/Medical Biological Defense Equipment - Eng Dev	05	41,124	41,124		41,124	39,238		39,238	U
108	0604808A	Landmine Warfare/Barrier - Eng Dev	05	39,630	39,630		39,630	34,684		34,684	U
109	0604818A	Army Tactical Command & Control Hardware & Software	05	205,590	205,590		205,590	164,409		164,409	U
110	0604820A	Radar Development	05	15,983	15,983		15,983	32,968		32,968	U
111	0604822A	General Fund Enterprise Business System (GFEBS)	05	6,805	6,805		6,805	49,554		49,554	U
112	0604823A	Firefinder	05	9,235	9,235		9,235	45,605		45,605	U

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113	0604827A	Soldier Systems - Warrior Dem/Val	05	15,694	12,393	12,393					U
114	0604852A	Suite of Survivability Enhancement Systems - EMD	05								U
115	0604854A	Artillery Systems - EMD	05	2,251	1,756	4,506					U
116	0605013A	Information Technology Development	05	48,028	74,236	74,236					U
117	0605018A	Integrated Personnel and Pay System-Army (IPPS-A)	05	116,215	155,584	155,584					U
118	0605028A	Armored Multi-Purpose Vehicle (AMPV)	05	213,034	184,221	184,221					U
119	0605029A	Integrated Ground Security Surveillance Response Capability (IGSSR-C)	05		4,980	4,980					U
120	0605030A	Joint Tactical Network Center (JTNC)	05	12,834	15,041	15,041					U
121	0605031A	Joint Tactical Network (JTN)	05	20,790	16,014	16,014					U
122	0605032A	TRACTOR TIRE	05	10,677	27,254	27,254		10,000		10,000	U
123	0605033A	Ground-Based Operational Surveillance System - Expeditionary (GBOSS-E)	05		5,032	5,032					U
124	0605034A	Tactical Security System (TSS)	05		2,904	2,904					U
125	0605035A	Common Infrared Countermeasures (CIRCM)	05	98,496	96,977	96,977	10,900	10,900		10,900	U
126	0605036A	Combating Weapons of Mass Destruction (CWMD)	05		2,089	2,089					U
127	0605037A	Evidence Collection and Detainee Processing	05								U

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113	0604827A	Soldier Systems - Warrior Dem/Val	05	12,393	12,393		12,393	16,127		16,127	U
114	0604852A	Suite of Survivability Enhancement Systems - EMD	05					98,600		98,600	U
115	0604854A	Artillery Systems - EMD	05	1,756	4,506		4,506	1,972		1,972	U
116	0605013A	Information Technology Development	05	74,236	74,236		74,236	81,776		81,776	U
117	0605018A	Integrated Personnel and Pay System-Army (IPPS-A)	05	155,584	155,584		155,584	172,361		172,361	U
118	0605028A	Armored Multi-Purpose Vehicle (AMPV)	05	184,221	184,221		184,221	199,778		199,778	U
119	0605029A	Integrated Ground Security Surveillance Response Capability (IGSSR-C)	05	4,980	4,980		4,980	4,418		4,418	U
120	0605030A	Joint Tactical Network Center (JTNC)	05	15,041	15,041		15,041	15,877		15,877	U
121	0605031A	Joint Tactical Network (JTN)	05	16,014	16,014		16,014	44,150		44,150	U
122	0605032A	TRACTOR TIRE	05	27,254	37,254		37,254	34,670	5,000	39,670	U
123	0605033A	Ground-Based Operational Surveillance System - Expeditionary (GBOSS-E)	05	5,032	5,032		5,032	5,207		5,207	U
124	0605034A	Tactical Security System (TSS)	05	2,904	2,904		2,904	4,727		4,727	U
125	0605035A	Common Infrared Countermeasures (CIRCM)	05	107,877	107,877		107,877	105,778	21,540	127,318	U
126	0605036A	Combating Weapons of Mass Destruction (CWMD)	05	2,089	2,089		2,089	6,927		6,927	U
127	0605037A	Evidence Collection and Detainee Processing	05					214		214	U

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128	0605038A	Nuclear Biological Chemical Reconnaissance Vehicle (NBCRV) Sensor Suite	05								U
129	0605041A	Defensive CYBER Tool Development	05		33,836	33,836		50,500		50,500	U
130	0605042A	Tactical Network Radio Systems (Low-Tier)	05		18,824	18,824					U
131	0605047A	Contract Writing System	05		20,663	20,663					U
132	0605049A	Missile Warning System Modernization (MWSM)	05								U
133	0605051A	Aircraft Survivability Development	05	77,395	41,133	51,133	73,110	73,110		73,110	U
134	0605052A	Indirect Fire Protection Capability Inc 2 - Block 1	05		83,995	83,995					U
135	0605053A	Ground Robotics	05								U
136	0605350A	WIN-T Increment 3 - Full Networking	05	32,187							U
137	0605380A	AMF Joint Tactical Radio System (JTRS)	05	10,143	5,028	5,028					U
138	0605450A	Joint Air-to-Ground Missile (JAGM)	05	79,897	42,972	42,972					U
139	0605456A	PAC-3/MSE Missile	05	2,201							U
140	0605457A	Army Integrated Air and Missile Defense (AIAMD)	05	222,074	252,811	272,811					U
141	0605625A	Manned Ground Vehicle	05	37,692							U
142	0605626A	Aerial Common Sensor	05	2							U
143	0605766A	National Capabilities Integration (MIP)	05	10,599	4,955	4,955					U

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128	0605038A	Nuclear Biological Chemical Reconnaissance Vehicle (NBCRV) Sensor Suite	05					16,125		16,125	U
129	0605041A	Defensive CYBER Tool Development	05	33,836	84,336		84,336	55,165		55,165	U
130	0605042A	Tactical Network Radio Systems (Low-Tier)	05	18,824	18,824		18,824	20,076		20,076	U
131	0605047A	Contract Writing System	05	20,663	20,663		20,663	20,322		20,322	U
132	0605049A	Missile Warning System Modernization (MWSM)	05					55,810		55,810	U
133	0605051A	Aircraft Survivability Development	05	114,243	124,243		124,243	30,879	30,100	60,979	U
134	0605052A	Indirect Fire Protection Capability Inc 2 - Block 1	05	83,995	83,995		83,995	175,069		175,069	U
135	0605053A	Ground Robotics	05					70,760		70,760	U
136	0605350A	WIN-T Increment 3 - Full Networking	05								U
137	0605380A	AMF Joint Tactical Radio System (JTRS)	05	5,028	5,028		5,028	8,965		8,965	U
138	0605450A	Joint Air-to-Ground Missile (JAGM)	05	42,972	42,972		42,972	34,626		34,626	U
139	0605456A	PAC-3/MSE Missile	05								U
140	0605457A	Army Integrated Air and Missile Defense (AIAMD)	05	252,811	272,811		272,811	336,420		336,420	U
141	0605625A	Manned Ground Vehicle	05								U
142	0605626A	Aerial Common Sensor	05								U
143	0605766A	National Capabilities Integration (MIP)	05	4,955	4,955		4,955	6,882		6,882	U

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144	0605812A	Joint Light Tactical Vehicle (JLTV) Engineering and Manufacturing Development Ph	05	31,197	11,530	11,530					U
145	0605830A	Aviation Ground Support Equipment	05	13,528	2,142	2,142					U
146	0210609A	Paladin Integrated Management (PIM)	05	136,353	41,498	41,498					U
147	0303032A	TROJAN - RH12	05	5,022	4,273	4,273					U
148	0303267A	Auctioned Spectrum Relocation Fund	05	71,823							U
149	0303367A	Spectrum Access Research and Development	05	125,283							U
150	0304270A	Electronic Warfare Development	05	12,686	14,425	18,425					U
151	1205117A	Tractor Bears	05								U
		System Development & Demonstration		2,202,652	2,265,094	2,393,383	84,043	288,443	-78,700	209,743	
152	0604256A	Threat Simulator Development	06	27,157	25,675	25,675					U
153	0604258A	Target Systems Development	06	16,163	19,122	19,122					U
154	0604759A	Major T&E Investment	06	65,059	84,777	84,777					U
155	0605103A	Rand Arroyo Center	06	20,014	20,658	20,658					U
156	0605301A	Army Kwajalein Atoll	06	200,393	236,648	236,648					U
157	0605326A	Concepts Experimentation Program	06	18,705	25,596	25,596					U
158	0605502A	Small Business Innovative Research	06	220,833							U
159	0605601A	Army Test Ranges and Facilities	06	273,275	293,748	307,882					U
160	0605602A	Army Technical Test Instrumentation and Targets	06	52,254	52,404	64,127					U

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144	0605812A	Joint Light Tactical Vehicle (JLTV) Engineering and Manufacturing Development Ph	05	11,530	11,530		11,530	23,467		23,467	U
145	0605830A	Aviation Ground Support Equipment	05	2,142	2,142		2,142	6,930		6,930	U
146	0210609A	Paladin Integrated Management (PIM)	05	41,498	41,498		41,498	6,112		6,112	U
147	0303032A	TROJAN - RH12	05	4,273	4,273		4,273	4,431	1,200	5,631	U
148	0303267A	Auctioned Spectrum Relocation Fund	05								U
149	0303367A	Spectrum Access Research and Development	05								U
150	0304270A	Electronic Warfare Development	05	14,425	18,425		18,425	14,616		14,616	U
151	1205117A	Tractor Bears	05					17,928		17,928	U
		System Development & Demonstration		2,427,837	2,681,826	-78,700	2,603,126	3,012,840	57,840	3,070,680	
152	0604256A	Threat Simulator Development	06	25,675	25,675		25,675	22,862		22,862	U
153	0604258A	Target Systems Development	06	19,122	19,122		19,122	13,902		13,902	U
154	0604759A	Major T&E Investment	06	84,777	84,777		84,777	102,901		102,901	U
155	0605103A	Rand Arroyo Center	06	20,658	20,658		20,658	20,140		20,140	U
156	0605301A	Army Kwajalein Atoll	06	236,648	236,648		236,648	246,663		246,663	U
157	0605326A	Concepts Experimentation Program	06	25,596	25,596		25,596	29,820		29,820	U
158	0605502A	Small Business Innovative Research	06								U
159	0605601A	Army Test Ranges and Facilities	06	293,748	307,882		307,882	307,588		307,588	U
160	0605602A	Army Technical Test Instrumentation and Targets	06	52,404	64,127		64,127	49,242		49,242	U

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161	0605604A	Survivability/Lethality Analysis	06	33,069	38,571	38,571					U
162	0605606A	Aircraft Certification	06	4,571	4,665	4,665					U
163	0605702A	Meteorological Support to RDT&E Activities	06	8,104	6,925	6,925					U
164	0605706A	Materiel Systems Analysis	06	20,203	21,677	21,677					U
165	0605709A	Exploitation of Foreign Items	06	10,396	12,415	12,415					U
166	0605712A	Support of Operational Testing	06	49,128	49,684	49,684					U
167	0605716A	Army Evaluation Center	06	52,265	55,905	55,905					U
168	0605718A	Army Modeling & Sim X-Cmd Collaboration & Integ	06	901	7,959	7,959					U
169	0605801A	Programwide Activities	06	61,060	51,822	51,822					U
170	0605803A	Technical Information Activities	06	25,991	33,323	33,323					U
171	0605805A	Munitions Standardization, Effectiveness and Safety	06	48,335	40,545	40,545					U
172	0605857A	Environmental Quality Technology Mgmt Support	06	3,673	2,130	2,130					U
173	0605898A	Army Direct Report Headquarters - R&D - MHA	06	48,312	49,885	49,885					U
174	0606001A	Military Ground-Based CREW Technology	06								U
175	0606002A	Ronald Reagan Ballistic Missile Defense Test Site	06								U
176	0303260A	Defense Military Deception Initiative	06		2,000	2,000					U

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161	0605604A	Survivability/Lethality Analysis	06	38,571	38,571		38,571	41,843		41,843	U
162	0605606A	Aircraft Certification	06	4,665	4,665		4,665	4,804		4,804	U
163	0605702A	Meteorological Support to RDT&E Activities	06	6,925	6,925		6,925	7,238		7,238	U
164	0605706A	Materiel Systems Analysis	06	21,677	21,677		21,677	21,890		21,890	U
165	0605709A	Exploitation of Foreign Items	06	12,415	12,415		12,415	12,684		12,684	U
166	0605712A	Support of Operational Testing	06	49,684	49,684		49,684	51,040		51,040	U
167	0605716A	Army Evaluation Center	06	55,905	55,905		55,905	56,246		56,246	U
168	0605718A	Army Modeling & Sim X-Cmd Collaboration & Integ	06	7,959	7,959		7,959	1,829		1,829	U
169	0605801A	Programwide Activities	06	51,822	51,822		51,822	55,060		55,060	U
170	0605803A	Technical Information Activities	06	33,323	33,323		33,323	33,934		33,934	U
171	0605805A	Munitions Standardization, Effectiveness and Safety	06	40,545	40,545		40,545	43,444		43,444	U
172	0605857A	Environmental Quality Technology Mgmt Support	06	2,130	2,130		2,130	5,087		5,087	U
173	0605898A	Army Direct Report Headquarters - R&D - MHA	06	49,885	49,885		49,885	54,679		54,679	U
174	0606001A	Military Ground-Based CREW Technology	06					7,916		7,916	U
175	0606002A	Ronald Reagan Ballistic Missile Defense Test Site	06					61,254		61,254	U
176	0303260A	Defense Military Deception Initiative	06	2,000	2,000		2,000	1,779		1,779	U

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177	0909999A	Financing for Cancelled Account Adjustments	06	65							U
	RDT&E	Management Support		1,259,926	1,136,134	1,161,991					
178	0603778A	MLRS Product Improvement Program	07	21,202	9,663	34,763					U
179	0603813A	TRACTOR PULL	07	9,461	3,960	3,960					U
180	0605024A	Anti-Tamper Technology Support	07		3,638	3,638					U
181	0607131A	Weapons and Munitions Product Improvement Programs	07	5,678	14,517	14,517		5,100		5,100	U
182	0607133A	TRACTOR SMOKE	07	7,569	4,479	4,479					U
183	0607134A	Long Range Precision Fires (LRPF)	07		39,275	67,006					U
184	0607135A	Apache Product Improvement Program	07	62,964	66,441	66,441					U
185	0607136A	Blackhawk Product Improvement Program	07	64,011	46,765	46,765					U
186	0607137A	Chinook Product Improvement Program	07	31,122	91,848	91,848					U
187	0607138A	Fixed Wing Product Improvement Program	07	1,105	796	796					U
188	0607139A	Improved Turbine Engine Program	07	49,137	126,105	126,105					U
189	0607140A	Emerging Technologies from NIE	07	2,383	2,369	2,369					U
190	0607141A	Logistics Automation	07	1,318	4,563	4,563					U
191	0607142A	Aviation Rocket System Product Improvement and Development	07			8,000					U
192	0607143A	Unmanned Aircraft System Universal Products	07								U

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177	0909999A	Financing for Cancelled Account Adjustments	06								U
	RDT&E	Management Support		1,136,134	1,161,991		1,161,991	1,253,845		1,253,845	
178	0603778A	MLRS Product Improvement Program	07	9,663	34,763		34,763	8,929		8,929	U
179	0603813A	TRACTOR PULL	07	3,960	3,960		3,960	4,014		4,014	U
180	0605024A	Anti-Tamper Technology Support	07	3,638	3,638		3,638	4,094		4,094	U
181	0607131A	Weapons and Munitions Product Improvement Programs	07	14,517	19,617		19,617	15,738		15,738	U
182	0607133A	TRACTOR SMOKE	07	4,479	4,479		4,479	4,513		4,513	U
183	0607134A	Long Range Precision Fires (LRPF)	07	39,275	67,006		67,006	102,014		102,014	U
184	0607135A	Apache Product Improvement Program	07	66,441	66,441		66,441	59,977		59,977	U
185	0607136A	Blackhawk Product Improvement Program	07	46,765	46,765		46,765	34,416		34,416	U
186	0607137A	Chinook Product Improvement Program	07	91,848	91,848		91,848	194,567		194,567	U
187	0607138A	Fixed Wing Product Improvement Program	07	796	796		796	9,981		9,981	U
188	0607139A	Improved Turbine Engine Program	07	126,105	126,105		126,105	204,304		204,304	U
189	0607140A	Emerging Technologies from NIE	07	2,369	2,369		2,369	1,023		1,023	U
190	0607141A	Logistics Automation	07	4,563	4,563		4,563	1,504		1,504	U
191	0607142A	Aviation Rocket System Product Improvement and Development	07		8,000		8,000	10,064		10,064	U
192	0607143A	Unmanned Aircraft System Universal Products	07					38,463		38,463	U

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193	0607665A	Family of Biometrics	07	7,179	12,098	12,098					U
194	0607865A	Patriot Product Improvement	07	87,537	49,482	49,482					U
195	0202429A	Aerostat Joint Project - COCOM Exercise	07	10,171	45,482	45,482					U
196	0203728A	Joint Automated Deep Operation Coordination System (JADOCS)	07	30,669	30,455	30,455					U
197	0203735A	Combat Vehicle Improvement Programs	07	382,176	316,857	327,357					U
198	0203740A	Maneuver Control System	07	14,864	4,031	4,031					U
199	0203743A	155mm Self-Propelled Howitzer Improvements	07								U
200	0203744A	Aircraft Modifications/Product Improvement Programs	07		35,793	35,793					U
201	0203752A	Aircraft Engine Component Improvement Program	07	349	259	259					U
202	0203758A	Digitization	07	4,188	6,483	6,483					U
203	0203801A	Missile/Air Defense Product Improvement Program	07	3,029	5,122	53,722					U
204	0203802A	Other Missile Product Improvement Programs	07	49,191	7,491	7,491		1,080		1,080	U
205	0203808A	TRACTOR CARD	07	34,686	20,333	20,333					U
206	0205402A	Integrated Base Defense - Operational System Dev	07	10,324				3,450		3,450	U
207	0205410A	Materials Handling Equipment	07	386	124	124					U
208	0205412A	Environmental Quality Technology - Operational System Dev	07								U

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193	0607665A	Family of Biometrics	07	12,098	12,098		12,098	6,159		6,159	U
194	0607865A	Patriot Product Improvement	07	49,482	49,482		49,482	90,217		90,217	U
195	0202429A	Aerostat Joint Project - COCOM Exercise	07	45,482	45,482		45,482	6,749		6,749	U
196	0203728A	Joint Automated Deep Operation Coordination System (JADOCS)	07	30,455	30,455		30,455	33,520		33,520	U
197	0203735A	Combat Vehicle Improvement Programs	07	316,857	327,357		327,357	343,175		343,175	U
198	0203740A	Maneuver Control System	07	4,031	4,031		4,031	6,639		6,639	U
199	0203743A	155mm Self-Propelled Howitzer Improvements	07					40,784		40,784	U
200	0203744A	Aircraft Modifications/Product Improvement Programs	07	35,793	35,793		35,793	39,358		39,358	U
201	0203752A	Aircraft Engine Component Improvement Program	07	259	259		259	145		145	U
202	0203758A	Digitization	07	6,483	6,483		6,483	4,803		4,803	U
203	0203801A	Missile/Air Defense Product Improvement Program	07	5,122	53,722		53,722	2,723	15,000	17,723	U
204	0203802A	Other Missile Product Improvement Programs	07	7,491	8,571		8,571	5,000		5,000	U
205	0203808A	TRACTOR CARD	07	20,333	20,333		20,333	37,883		37,883	U
206	0205402A	Integrated Base Defense - Operational System Dev	07		3,450		3,450				U
207	0205410A	Materials Handling Equipment	07	124	124		124	1,582		1,582	U
208	0205412A	Environmental Quality Technology - Operational System Dev	07					195		195	U

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209	0205456A	Lower Tier Air and Missile Defense (AMD) System	07	61,653	69,417	73,417					U
210	0205778A	Guided Multiple-Launch Rocket System (GMLRS)	07	36,032	22,044	38,044					U
211	0208053A	Joint Tactical Ground System	07	28,015	12,649	12,649					U
213	0303028A	Security and Intelligence Activities	07	13,156	11,619	11,619					U
214	0303140A	Information Systems Security Program	07	31,032	38,280	38,280					U
215	0303141A	Global Combat Support System	07	25,304	27,223	28,667					U
216	0303142A	SATCOM Ground Environment (SPACE)	07	9,045	18,815	18,815					U
217	0303150A	WWMCCS/Global Command and Control System	07	6,810	4,718	4,718					U
219	0305127A	Foreign Counterintelligence Activities	07			4,100					U
220	0305172A	Combined Advanced Applications	07								U
221	0305179A	Integrated Broadcast Service (IBS)	07	750							U
222	0305204A	Tactical Unmanned Aerial Vehicles	07	15,370	8,218	8,218					U
223	0305206A	Airborne Reconnaissance Systems	07	20,725	11,799	11,799					U
224	0305208A	Distributed Common Ground/Surface Systems	07	25,592	32,284	32,284					U
225	0305219A	MQ-1C Gray Eagle UAS	07	22,285	13,470	30,970					U
226	0305232A	RQ-11 UAV	07		1,613	1,613					U
227	0305233A	RQ-7 UAV	07	11,797	4,597	7,597					U
228	0307665A	Biometrics Enabled Intelligence	07				7,104	8,854		8,854	U

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209	0205456A	Lower Tier Air and Missile Defense (AMD) System	07	69,417	73,417		73,417	78,926		78,926	U
210	0205778A	Guided Multiple-Launch Rocket System (GMLRS)	07	22,044	38,044		38,044	102,807		102,807	U
211	0208053A	Joint Tactical Ground System	07	12,649	12,649		12,649				U
213	0303028A	Security and Intelligence Activities	07	11,619	11,619		11,619	13,807		13,807	U
214	0303140A	Information Systems Security Program	07	38,280	38,280		38,280	132,438		132,438	U
215	0303141A	Global Combat Support System	07	27,223	28,667		28,667	64,370		64,370	U
216	0303142A	SATCOM Ground Environment (SPACE)	07	18,815	18,815		18,815				U
217	0303150A	WWMCCS/Global Command and Control System	07	4,718	4,718		4,718	10,475		10,475	U
219	0305127A	Foreign Counterintelligence Activities	07		4,100		4,100				U
220	0305172A	Combined Advanced Applications	07					1,100		1,100	U
221	0305179A	Integrated Broadcast Service (IBS)	07								U
222	0305204A	Tactical Unmanned Aerial Vehicles	07	8,218	8,218		8,218	9,433	7,492	16,925	U
223	0305206A	Airborne Reconnaissance Systems	07	11,799	11,799		11,799	5,080	15,000	20,080	U
224	0305208A	Distributed Common Ground/Surface Systems	07	32,284	32,284		32,284	24,700		24,700	U
225	0305219A	MQ-1C Gray Eagle UAS	07	13,470	30,970		30,970	9,574		9,574	U
226	0305232A	RQ-11 UAV	07	1,613	1,613		1,613	2,191		2,191	U
227	0305233A	RQ-7 UAV	07	4,597	7,597		7,597	12,773		12,773	U
228	0307665A	Biometrics Enabled Intelligence	07	7,104	8,854		8,854	2,537	6,036	8,573	U

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229	0310349A	Win-T Increment 2 - Initial Networking	07	3,649	4,867	4,867					U
230	0708045A	End Item Industrial Preparedness Activities	07	58,503	62,287	62,287					U
231	1203142A	SATCOM Ground Environment (SPACE)	07								U
232	1208053A	Joint Tactical Ground System	07								U
9999	9999999999	Classified Programs		4,536	4,625	4,625					U
		Operational Systems Development		1,264,953	1,296,954	1,462,929	7,104	18,484		18,484	
233	0901560A	Continuing Resolution Programs	20		32,395	32,395	-99,022	-99,022		-99,022	U
		Undistributed			32,395	32,395	-99,022	-99,022		-99,022	
Total Research, Development, Test & Eval, Army				7,861,744	7,547,794	7,897,415	1,500	233,300	-78,700	154,600	

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229	0310349A	Win-T Increment 2 - Initial Networking	07	4,867	4,867		4,867	4,723		4,723	U
230	0708045A	End Item Industrial Preparedness Activities	07	62,287	62,287		62,287	60,877		60,877	U
231	1203142A	SATCOM Ground Environment (SPACE)	07					11,959		11,959	U
232	1208053A	Joint Tactical Ground System	07					10,228		10,228	U
9999	9999999999	Classified Programs		4,625	4,625		4,625	7,154		7,154	U
		Operational Systems Development		1,304,058	1,481,413		1,481,413	1,877,685	43,528	1,921,213	
233	0901560A	Continuing Resolution Programs	20	-66,627	-66,627		-66,627				U
		Undistributed		-66,627	-66,627		-66,627				
Total Research, Development, Test & Eval, Army				7,627,994	8,130,715	-78,700	8,052,015	9,425,440	119,368	9,544,808	

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Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army I* BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601101A *I In-House Laboratory Independent Research*							
COST ($ in Millions)	**Prior Years**	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
Total Program Element	-	12.525	12.381	12.010	-	12.010	11.594	11.788	12.024	12.271	-	-
91A: *ILIR-AMC*	-	11.639	11.457	11.069	-	11.069	10.635	10.809	11.025	11.251	-	-
F16: *ILIR-SMDC*	-	0.886	0.924	0.941	-	0.941	0.959	0.979	0.999	1.020	-	-

A. Mission Description and Budget Item Justification

This Program Element (PE) supports basic research at the Army laboratories through the In-House Laboratory Independent Research (ILIR) program. Basic research lays the foundation for future developmental efforts by identifying fundamental principles governing various phenomena and appropriate pathways to exploit this knowledge. The ILIR program serves as a catalyst for major technology breakthroughs by providing laboratory directors flexibility in implementing novel research ideas, by nurturing promising young scientists and engineers, and is used to attract and retain top doctoral degreed scientists and engineers. The ILIR program also provides a source of competitive funds for peer reviewed efforts at Army laboratories to stimulate high quality, innovative research with significant opportunity for payoff to Army warfighting capability.

This PE supports ILIR at the Army Materiel Command's (AMC) six Research, Development, and Engineering Centers (Project 91A); at the six United States (U.S.) Army Medical Research and Material Command Laboratories (Project 91C); the seven laboratories within the Corps Of Engineers' U.S. Army Engineer Research and Development Centers (Project 91D); and at the U.S. Space and Missile Defense Command (SMDC) Technical Center (Project F16).

Work in the PE provides a foundation for applied research initiatives at the Army laboratories and research, development and engineering centers.

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas and the Army Modernization Strategy.

Work in this PE is performed by AMC, the Medical Research Materiel Command (MRMC), the Engineer Research and Development Center (ERDC) (multiple sites); and the SMDC Technical Center (Huntsville,AL).

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Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*			R-1 Program Element (Number/Name) PE 0601101A / *In-House Laboratory Independent Research*		
B. Program Change Summary ($ in Millions)	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**
Previous President's Budget	13.018	12.381	11.971	-	11.971
Current President's Budget	12.525	12.381	12.010	-	12.010
Total Adjustments	-0.493	0.000	0.039	-	0.039
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.493	-			
• Adjustments to Budget Years	0.000	0.000	-0.002	-	-0.002
• Civ Pay Adjustments	0.000	0.000	0.041	-	0.041

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601101A / *In-House Laboratory Independent Research*	Project (Number/Name) 91A / *ILIR-AMC*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
91A: *ILIR-AMC*	-	11.639	11.457	11.069	-	11.069	10.635	10.809	11.025	11.251	-	-

A. Mission Description and Budget Item Justification

This Project funds basic research within the Army Materiel Command's (AMC) Research, Development, and Engineering Centers (RDECs) and lays the foundation for future developmental efforts by identifying the fundamental principles governing various phenomena and appropriate pathways to exploit this knowledge.

The cited work is consistent with the Assistant Secretary of Defense, Research and Engineering Science and Technology focus areas and the Army Modernization Strategy.

Work in this Project is performed by the Edgewood Chemical and Biological Center, Aberdeen Proving Grounds, MD within AMC, the Armaments Research, Development, and Engineering Center, Picatinny, NJ, the Tank and Automotive Research, Development, and Engineering Center, Warren, MI, the Natick Soldier Research, Development, and Engineering Center, Natick, MA, the Aviation and Missile Research, Development, and Engineering Center, Huntsville, AL, and the Communications and Electronics Research, Development, and Engineering Center, Ft. Monmouth, NJ.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Edgewood Chemical Biological Center	0.979	1.033	1.056
Description: Funds basic research in chemistry, biology, biotechnology, and aerosol for countering improvised explosive devices (IEDs), obscurants, and/or target defeat. Work in this project provides theoretical underpinnings for Program Element (PE) 0602622A (Chemical, Smoke, and Equipment Defeating Technologies).			
FY 2016 Accomplishments: Continued to further fundamental research to understand rational molecular and nano-system design, synthetic biology, nano-scale chemical and biological sensing and signaling, molecular toxicology, interfacial phenomena of particulate matter (solid/ liquid) with chemical surfaces, and synthesis of new materials for protection, decontamination, and detection, and research the mathematics involved in data processing and interpretation.			
FY 2017 Plans: Will further fundamental research to understand rational molecular synthesis and novel materials, synthetic biology, nano-scale chemical and biological sensing, molecular toxicology, aerosol sciences, interfacial phenomena of particulate matter (solid/ liquid) with chemical surfaces, and synthesis of new materials for protection, decontamination, and detection, and research the mathematics involved in data processing and interpretation.			
FY 2018 Plans:			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will conduct fundamental research in synthetic biology focusing on understanding genetic drift, mutation rates, as well as the structure function relationships of proteins. Explorations into molecular toxicology will focus on developing the use of human and animal pluripotent stem cells to derive toxicological end points rather than using whole animal studies. Physical and mathematical investigations into aerosol particle behaviors will be used to help develop knowledge on their behavior during deposition into the atmosphere as well as in the respiratory tract.			
Title: Armaments Research, Development and Engineering Center ***Description:*** Funds basic research in weapons component development, explosives synthesis/detection and area denial. Work in this project provides theoretical underpinnings for PE 0602307A (Advanced Weapons Technology). ***FY 2016 Accomplishments:*** Continued further basic research in areas such as advanced materials and nanotechnologies, more powerful energetics including those with insensitive munitions properties, counter terrorism technologies, power and energy systems, smaller more lethal warheads and composite materials. ***FY 2017 Plans:*** Will solicit new innovative research proposals to conduct fundamental research for developing technologies for lighter structural materials, nano-materials, area denial technologies, more powerful explosives, more lethal compact warheads, efficient thermal batteries and material coating technologies. ***FY 2018 Plans:*** Will perform basic research in light-weight thermoplastic composites, compact and more lethal warheads, synthesis and characterization of more powerful and less sensitive explosives, area denial technologies, advanced structural materials and new materials for electronic sensing devices.	1.591	1.556	1.417
Title: Tank-Automotive Research, Development and Engineering Center ***Description:*** Funds basic research in ground vehicle technologies to include power, mobility, and unmanned systems. Work in this project provides theoretical underpinnings for PE 0602601A (Combat Vehicle and Automotive Technology). ***FY 2016 Accomplishments:*** Conducted research in off-road mobility and terramechanics, materials for shock wave mitigation, nano-lubricants, analytical framework for autonomy-enabled systems, combustion for military logistics fuels, and modeling of cognitive burdens. In-house research efforts address several Army-identified major research efforts for the future including materials science and multiscale modeling, intelligent/autonomous systems, and human sciences. ***FY 2017 Plans:***	1.396	1.350	1.306

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601101A / *In-House Laboratory Independent Research*	**Project (Number/Name)** 91A / *ILIR-AMC*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will solicit on a yearly basis new and continuing efforts to further basic research in Army-centric areas such as development of analytical methodologies for autonomous and autonomy-enabled systems such as latency compensation, shared control, modeling of human cognition, proprioception and perception, next-generation battery systems, advanced combustion, off-road mobility/terramechanics, materials and joining research as pertaining to lightweighting, armor materials/mechanisms, Big Data analytics, newtork security for autonomous systems, aeroacoustics computational fluid dynamics, bio-inspired approaches to waste-water treatment, multi-functional additives for fuels/lubricants, and pulse power applications to vehicle protection. ***FY 2018 Plans:*** Will conduct efforts to further basic research in areas of strategic importance to Army ground vehicles such as increased control/ mobility of autonomy enabled-systems involving latency compensation using innovative numerical techniques, teleoperation in high-speed, long distance scenarios, anticipatory dynamic Bayesian network for intelligent navigation, methods for detection of high velocity projectiles, real-time panorama generation in tele-immersive combat vehicle operations, deep incremental learning and trust algorithms, novel computationally-efficient numerical modeling of vehicle interactions with deformable terrain, diesel engine heat transfer model development, machine learning, quantum modeling and computation, etc.			
Title: Natick Soldier Research, Development, and Engineering Center ***Description:*** Funds basic research in food sciences, textiles, and lightweight materials with potential for individual protection. Work in this project provides theoretical underpinnings for PE 0601102A (Defense Research Sciences), Project H52 (Equipment for the Soldier). ***FY 2016 Accomplishments:*** Created a new two-dimensional (2D) computational modeling approach to enhance understanding of interactions between fluids (e.g., airflow) and structural forces to provide a foundation for design of parachutes and fabric shelters; examined novel approaches to tailor textile surface chemistry and/or integration of advanced materials to allow creation of surfaces exhibiting true multifunctionality. ***FY 2017 Plans:*** Assess newly modeled microrectenna arrays for their response to infrared (IR) illumination; assess efficiency and adaptability of these microrectenna arrays for application in IR detectors, communication, and energy harvesting applications; explore the incorporation of bioactive peptides for increased stability of thin films. ***FY 2018 Plans:*** Will explore the feasibility of creating a conductive fibrous platform through the integration of iridium oxide nanoparticles; characterize the structure and electrochemical properties of the iridium oxide nanoparticles and explore applicability to wearable sensing and power; design frequency selective surface antenna arrays tailored for chemical detection; explore discrimination	1.298	1.246	1.150

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601101A / *In-House Laboratory Independent Research*	**Project (Number/Name)** 91A / *ILIR-AMC*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
of surface antenna arrays through numerical electromagnetic simulations that explore parameters such as individual antenna element shape/dimensions, spacing between antenna elements, choice of metal, and spectral shifts produced by metal oxides.			
Title: Aviation and Missile Research, Development and Engineering Center: Missile Efforts ***Description:*** Funds basic research in guided missile and rocket systems, directed energy weapons, unmanned vehicles, and related components. Work in this project provides theoretical underpinnings for PE 0602303A (Missile Technology). ***FY 2016 Accomplishments:*** Continued experimental test of analytic density matrix models in precision pump-probe spectroscopy; demonstrated chaotic dynamics in hybrid and non-smooth systems; pioneered innovative THz imaging techniques by combining state-of-the-art coherent imaging hardware and computational imaging methodologies; and developed novel high performance signal processing techniques for chaotic waveforms in radar and communications. ***FY 2017 Plans:*** Will explore ultraviolet photocatalytic splitting of molecular bonds using plasmonic metal nanoparticles; investigate homomorphic encryption schemes (for tamper-proof signal processing); study new electromagnetic pulse propagation models that include nonlocal and quantum tunneling effects (to explore novel propagation phenomena and dramatically modify/enhance linear and nonlinear interactions with artificial, metal-based plasmonic materials and semiconductors); pioneer polarization-sensitive terahertz holographic imaging (for mapping strain in opaque materials); explore use of chaotic waveforms (for transformative high resolution radar and tactical data communications); develop microwave hyperbolic metamaterials (for subwavelength antennas and resonators); and study theoretically and experimentally linear and nonlinear optical properties of graphene-based layered and textured nanostructures. ***FY 2018 Plans:*** Will investigate chaotic dynamics in linear and piecewise linear systems; publish new paradigm in continuum electrodynamics by deriving self-consistent treatment that includes relativity and conservation of momentum and energy; conclude demonstration of proof-of-concept ultraviolet photocatalytic splitting of molecular bonds using plasmonic metal nanoparticles; complete work on polarization-sensitive terahertz holographic imaging (for mapping strain in opaque materials); and explore efficient opto-electro-plasmonic devices through electromagnetic interactions at artificial surfaces.	2.507	2.483	2.439
Title: Aviation and Missile Research, Development and Engineering Center: Aviation Efforts ***Description:*** Funds basic research for aviation enabling technologies in the areas of aerodynamics, structural dynamics, and material science. Work in this project provides theoretical underpinnings for PE 0602211A (Aviation Technology). ***FY 2016 Accomplishments:***	1.493	1.453	1.411

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601101A / *In-House Laboratory Independent Research*	**Project (Number/Name)** 91A / *ILIR-AMC*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Explored novel approaches to increase flow control authority for rotating wing applications using plasma; developed experimental techniques to better measure and understand flow structures in the wake of multi-rotor configurations and their performance in hover; and explored novel control allocation strategies to optimize pilot work load for future vertical lift configurations with redundant controls. ***FY 2017 Plans:*** Will combine visualization and measurements of the flow features in the wake of a wing interacting with a passing vortex (to better understand the structure and evolution of the trailing wake, and its relation to the lift distribution on the generating wing); apply novel fluidic actuators for adverse force reduction; and develop novel computational algorithms to dramatically speed up computations on newly emerging exascale computer architectures using techniques such as parallelization in both time and space. ***FY 2018 Plans:*** Will conduct interactional aerodynamics investigations of the wake physics and inflow dynamics of multiple rotor configurations; will explorer improved design of fluidic control actuators through boundary layer flow control studies; will extend higher order unstructured grid solvers that leverage emerging exascale computer architecture to flow over complex geometries.			
Title: Communications-Electronics Research, Development, and Engineering Center	2.375	2.336	2.290
Description: Funds basic research for communication and network enabling technologies in the areas of antenna design, network management, power generation and storage, and sensors. Work in this project provides theoretical underpinnings for PE 0602705A (Electronics and Electronic Devices). ***FY 2016 Accomplishments:*** Conducted research in data flow analysis as a supplemental theory for use in Satisfiability Modulo Theory (SMT) solvers to improve vulnerability detection by utilizing data-flow graphs coupled with SMT solvers; investigated an analytic method to calculate the probability and efficiency of message transmission via dynamic opportunistic devices across an undefined and uncooperative network; researched the ability to perform signal processing by manipulating modes within a multi-mode optical fiber by utilizing the statistics of transmission properties and techniques for spatial division multiplexing to perform single and multi signal filtering within the optical fiber; investigated the performance of infrared detectors by researching high quantum efficiency Gallium-free long wave infrared nBn detectors grown on an aluminum antimonide (AlSb) lattice; researched liquid phase heat transfer as a function of flow instability and vorticity intensity in microchannels with microcylinders with tip clearances to determine the optimum micro cylinder design in microchannels in three dimensional (3D) stacked circuit architectures for electro-optics, radar, electronic warfare, communication and intelligence systems; investigated the fundamental electrochemical properties of			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601101A / *In-House Laboratory Independent Research*	**Project (Number/Name)** 91A / *ILIR-AMC*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
applied composite solid electrolyte interface for lithium and divalent electrochemical cells; and investigated game theory based machine learning techniques to determine the feasibility of coordinating electronic warfare and tactical communications. ***FY 2017 Plans:*** Will conduct research focusing on the mathematical foundations of a pre-processing technique to facilitate fully homomorphic cryptosystems; research designs of packaging material used in solid state and bipolar batteries; investigate novel architectures that utilize photonic detection and beam forming concepts in the design of a highly capable beam-former/receiver (to alleviate the processing burden by exploring analog preprocessing and filtering techniques prior to digitization); create integratable thin film material heterostructures and explore novel process science techniques to enable high performance tunable filters for the next generation radar, electronic warfare and communications systems; research candidate target contrast metrics to improve parameters used in human vision model for high-contrast, low-contrast, and low-observable targets and investigate the psychophysics of noise in the Human Visual System (HVS) information processing chain by controlling “where” visual fusion takes place (e.g., temporal, left-right eye, or cognitive) to provide insight to how humans process fused image information and how the HVS filters information and noise; and research a planarization technique for infrared materials that yields a nearly flat surface with undamaged active layers. ***FY 2018 Plans:*** Will conduct research on the intrinsic efficiencies of non-foster matching methods at radio frequencies with a focus on full stability analysis; splitting of radio network traffic over multipath to maximize throughput performance for traffic flows by using new fluid-flow models to support dynamic topology; research 3D printing of tunable coils and matching networks with precisely controlled impedance and resonant frequencies resulting in tunable structures that can be activated in a controlled manner to change the shape or configuration of the solid in response to an external stimulus; determine the most effective information visualization methods and/or perspectives for commander understanding of the cyber domain and its relationship to mission command in the physical domain; research high performance, rechargeable, safe Lithium Sulphur (LiS) battery chemistry; experimentally confirm the performance of synthesized catalysts that can promote the production of synthesis gas (carbon monoxide (CO) and hydrogen (H2)) from carbon dioxide and hydrogen with high CO selectivity and high yield; research novel optical properties of retro-reflections, with an emphasis on polarization, to characterize and discriminate between different objects; research active and passive longwave infrared (LWIR) detection with a long term goal of produce focal plane arrays capable of passive longwave and active 3D imaging; research novel molecular beam epitaxy growth techniques that mitigate antimony (Sb) cross incorporation in Gallium-free superlattice detectors; research novel characterization techniques, investigate the inherent materials issues, and associated processes that limit the performance of LWIR focal plane arrays with diffraction-limited pixel-pitch.			
Accomplishments/Planned Programs Subtotals	11.639	11.457	11.069

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601101A / *In-House Laboratory Independent Research*	**Project (Number/Name)** 91A / *ILIR-AMC*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601101A / *In-House Laboratory Independent Research*	Project (Number/Name) F16 / *ILIR-SMDC*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
F16: *ILIR-SMDC*	-	0.886	0.924	0.941	-	0.941	0.959	0.979	0.999	1.020	-	-

A. Mission Description and Budget Item Justification

This Project provides In-house Laboratory Independent Research (ILIR) at the United States (U.S.) Army Space and Missile Defense Command/Army Forces Strategic Command (USASMDC/ARSTRAT), Technical Center. This basic research on lasers and directed energy lays the foundation for future developmental efforts on high energy lasers and directed energy systems by identifying the fundamental principles governing various directed energy phenomena.

Work in this project is related to, and fully coordinated with, efforts in Program Element (PE) 0602307A (Advanced Weapons Technology).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas and the Army Modernization Strategy.

Work is performed by the USASMDC/ARSTRAT, Technical Center, Huntsville, AL

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: SMDC In-house Laboratory Independent Research	0.886	0.924	0.941
Description: Funds basic research to investigate laser propagation phenomenology for application in modeling and simulation and future directed energy weapons design. Activities in this proproject transition to High Energy Laser Technology in PE 0602307A (Advanced Weapons Technology).			
FY 2016 Accomplishments: Completed inductive radio frequency (RF) line widths, absorption, plasma control, and lifetimes investigations for an efficient Xenon laser; developed a Xenon high power laser scaling model; and completed comparison of different RF pumping mechanisms.			
FY 2017 Plans: Will conduct experiments to measure quenching of electron energy states of various buffer gas concentrations; investigate potential high power laser designs that use only efficient diode lasers without an additional laser gain media; and conduct experiments to measure effects of different innovative adaptive optics techniques for laser propagation in the presence of particulates.			
FY 2018 Plans:			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601101A / *In-House Laboratory Independent Research*	**Project (Number/Name)** F16 / *ILIR-SMDC*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Complete experiments to verify the feasibility of a diode pumped Xenon gas laser; conduct an experiment of a direct diode concept to measure efficiency and beam quality and see how the results compare to traditional solid state lasers; and complete analysis of the beaconless adaptive optics approach for correcting a laser beam for propagation in the presence of particulates.			
Accomplishments/Planned Programs Subtotals	0.886	0.924	0.941

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Army											Date: May 2017	
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*							
COST ($ in Millions)	**Prior Years**	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
Total Program Element	-	271.933	253.116	263.590	-	263.590	277.166	290.818	295.100	304.156	-	-
305: *ATR Research*	-	1.993	2.057	2.102	-	2.102	2.142	2.186	2.231	2.276	-	-
31B: *Infrared Optics Rsch*	-	2.797	4.213	3.742	-	3.742	3.748	3.752	3.753	3.812	-	-
52C: *Mapping & Remote Sens*	-	1.996	2.057	2.101	-	2.101	2.141	2.185	2.228	2.273	-	-
53A: *Battlefield Env & Sig*	-	3.667	3.808	3.892	-	3.892	3.971	4.055	4.135	4.218	-	-
74A: *Human Engineering*	-	12.830	13.342	14.057	-	14.057	15.532	15.852	16.136	16.445	-	-
74F: *Pers Perf & Training*	-	5.260	5.540	5.485	-	5.485	5.586	5.699	5.812	5.930	-	-
ET6: *BASIC RESCH IN CLINICAL & REHABILITATIVE MED*	-	0.000	4.201	4.780	-	4.780	4.866	2.646	2.570	3.053	-	-
F20: *Adv Propulsion Rsch*	-	4.097	4.220	3.460	-	3.460	3.545	3.637	3.726	3.818	-	-
F22: *Rsch In Veh Mobility*	-	0.679	0.718	0.735	-	0.735	0.749	0.765	0.778	0.795	-	-
H42: *Materials & Mechanics*	-	8.329	8.731	9.748	-	9.748	12.211	12.262	12.556	12.868	-	-
H43: *Research In Ballistics*	-	8.211	8.531	11.319	-	11.319	11.723	12.032	12.304	12.659	-	-
H44: *Adv Sensors Research*	-	8.455	9.436	8.899	-	8.899	9.915	10.590	10.861	11.099	-	-
H45: *Air Mobility*	-	2.236	2.364	2.410	-	2.410	2.458	2.506	2.556	2.608	-	-
H47: *Applied Physics Rsch*	-	5.574	4.285	5.689	-	5.689	5.848	5.434	5.559	5.676	-	-
H48: *Battlespace Info & Comm Rsc*	-	24.710	28.276	31.394	-	31.394	32.292	36.816	37.397	38.249	-	-
H52: *Equip For The Soldier*	-	1.113	1.133	1.156	-	1.156	1.178	1.204	1.228	1.252	-	-
H57: *Single Investigator Basic Research*	-	84.464	94.519	96.081	-	96.081	101.690	105.185	106.679	110.878	-	-
H66: *Adv Structures Rsch*	-	2.008	2.061	3.108	-	3.108	3.153	3.197	3.240	3.285	-	-
H67: *Environmental Research*	-	0.877	0.928	1.036	-	1.036	1.056	1.076	1.099	1.121	-	-
S13: *Sci BS/Med Rsh Inf Dis*	-	10.951	11.318	11.039	-	11.039	11.272	11.509	11.501	12.253	-	-
S14: *Sci BS/Cbt Cas Care Rs*	-	8.923	5.699	5.296	-	5.296	5.610	6.559	7.042	7.077	-	-

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Army											Date: May 2017		
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*								
S15: *Sci BS/Army Op Med Rsh*	-	6.492	6.688	7.116	-	7.116	6.443	9.654	9.093	8.710	-	-
T14: *BASIC RESEARCH INITIATIVES - AMC (CA)*	-	40.000	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	-	-
T22: *Soil & Rock Mech*	-	4.334	4.520	4.606	-	4.606	4.695	4.788	4.883	4.982	-	-
T23: *Basic Res Mil Const*	-	1.679	1.747	1.781	-	1.781	1.815	1.850	1.887	1.929	-	-
T24: *Signature Physics And Terrain State Basic Research*	-	1.619	1.649	1.685	-	1.685	1.720	1.755	1.792	1.828	-	-
T25: *Environmental Science Basic Research*	-	6.744	7.081	6.708	-	6.708	6.845	6.990	7.139	7.797	-	-
T63: *Robotics Autonomy, Manipulation, & Portability Rsh*	-	6.947	8.764	8.847	-	8.847	9.546	11.112	11.281	11.516	-	-
T64: *Sci BS/System Biology And Network Science*	-	2.814	2.974	3.025	-	3.025	3.079	3.139	3.203	3.268	-	-
VR9: *Surface Science Research*	-	2.134	2.256	2.293	-	2.293	2.337	2.383	2.431	2.481	-	-

Note

In Fiscal Year (FY) 2015 and 2016 the funding for Clinical and Rehabilitative Medicine is in Project S14. The Clinical and Rehabilitative Medicine basic research effort moves to Project ET6 starting in FY17.

A. Mission Description and Budget Item Justification

This Program Element (PE) builds fundamental scientific knowledge contributing to the sustainment of United States (U.S.) Army scientific and technological superiority in land warfighting capability and to solving military problems related to long-term national security needs, investigates new concepts and technologies for the Army's future force, and provides the means to exploit scientific breakthroughs and avoid technological surprises. This PE fosters innovation in Army niche areas (e.g., lightweight armor, energetic materials, and night vision capability) and areas where there is no commercial investment due to limited markets (e.g., vaccines for tropical diseases). It also focuses university single investigator research on areas of high interest to the Army (e.g., high-density compact power and novel sensor phenomenologies). The in-house portion of the program capitalizes on the Army's scientific talent and specialized facilities to transition knowledge and technology into appropriate developmental activities. The extramural program leverages the research efforts of other government agencies, academia, and industry.

The cited work is consistent with the Assistant Secretary of Defense, Research and Engineering Science and Technology focus areas and the Army Modernization Strategy.

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Army	Date: May 2017
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*

Work in this PE is performed by: the U.S. Army Research Laboratory (ARL), Adelphi, MD; the U.S. Research, Development and Engineering Command (RDECOM), Aberdeen, MD; the U.S. Army Medical Research and Materiel Command (MRMC), Ft. Detrick, MD; the U.S. Army Engineer Research and Development Center (ERDC), Vicksburg, MS; and the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI), Arlington, VA.

B. Program Change Summary ($ in Millions)	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
Previous President's Budget	279.118	253.116	256.042	-	256.042
Current President's Budget	271.933	253.116	263.590	-	263.590
Total Adjustments	-7.185	0.000	7.548	-	7.548
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-7.185	-			
• Adjustments to Budget Years	0.000	0.000	7.040	-	7.040
• Civ Pay Adjustments	0.000	0.000	0.508	-	0.508

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2016	FY 2017
Project: T14: *BASIC RESEARCH INITIATIVES - AMC (CA)*		
Congressional Add: *Program Increase*	40.000	-
Congressional Add Subtotals for Project: T14	40.000	-
Congressional Add Totals for all Projects	40.000	-

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army									Date: May 2017			
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) 305 / *ATR Research*			
COST ($ in Millions)	**Prior Years**	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
305: *ATR Research*	-	1.993	2.057	2.102	-	2.102	2.142	2.186	2.231	2.276	-	-

A. Mission Description and Budget Item Justification

This Project fosters research for automatic target recognition (ATR) concepts to enhance the effectiveness of Army systems while simultaneously reducing the workload on the Soldier. This Project focuses on the fundamental underpinnings of aided and unaided target detection and identification techniques for land warfare scenarios. This research enables Army systems that can act independently of the human operator to detect and track targets including clandestine tracking of non-cooperative targets. Such capabilities are needed for smart munitions, unattended ground sensors, and as replacements for existing systems. Critical technology issues include low depression angle, relatively short range, and highly competing background clutter. The resulting research will provide a fundamental capability to predict, explain, and characterize target and background signature content, and reduce the workload on the analyst. This research is aimed at determining the complexity and variability of target and clutter signatures and ultimately utilizing that knowledge to conceptualize and design advanced ATR paradigms to enhance robustness and effectiveness of land warfare systems. ATR research strategies include emerging sensor modalities such as spectral and multi-sensor imaging. Research in this Project builds knowledge for several technology efforts including multi-domain smart sensors, third generation Forward Looking Infrared (FLIR), and advanced multi-function laser radar (LADAR).

Work in this Project complements and is fully coordinated with the United States (U.S.) Army Armaments Research, Development, and Engineering Center (ARDEC); the U.S. Army Communications-Electronics Research, Development, and Engineering Center (CERDEC); and the U.S. Army Edgewood Chemical Biological Center (ECBC).

Work is this Project supports key Army needs and provides the technical underpinnings to Program Element (PE) 0602270A (Electronic Warfare Technology)/Project 906 (Tactical Electronic Warfare Applied Research).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology focus areas and the Army Modernization Strategy.

Work in this project is performed by the U.S. Army Research Laboratory (ARL), Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2016**	**FY 2017**	**FY 2018**
Title: ATR Algorithms	1.993	2.057	2.102
Description: Investigate new algorithms to improve aided/unaided target detection and identification.			
FY 2016 Accomplishments: Expanded investigation of human and vehicle activity detection methods to include joint exploitation of text and video data; extended biometric research techniques to enable automated face recognition using low resolution imagery and multimodal data sets; investigated methods for synthesizing scene understanding from multi-viewpoint imagery including three-dimensional (3D)			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 305 / *ATR Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
models for face recognition; investigated image processing methods for detecting unmanned aircraft systems (UAS) in electro-optical/infrared (EO/IR) data for use in counter-unmanned aircraft systems (CUAS); and investigated algorithms for use in target detection and recognition. ***FY 2017 Plans:*** Will investigate methods for automatic object recognition from multi-perspective/multi-platform image data and assess their expected performance improvement over existing single perspective methods; investigate methods for improved vehicle tracking using 3D scene reconstructions; research methods for multi-pose detection of humans in images which are expected to extend robustness of previous methods that have been demonstrated to work only on upright human postures; investigate methods for semantic classification of human actions in video; and investigate joint representations of polarimetric and visible face data for increased accuracy of face recognition using thermal data. ***FY 2018 Plans:*** Will investigate approaches for image and video analytics and scene understanding at the tactical edge using resource constrained computation platforms for Soldiers and unmanned vehicle/robotic systems; will investigate joint text and video approaches for semantic summarization of unconstrained videos; will create methods for augmented 3-D scene segmentation and unsupervised labeling of objects viewed at different perspectives in geo-located areas of interest; and will create algorithms for producing and fusing photogrammetry-based point clouds and hyperspectral data collected from multiple flying platforms.			
Accomplishments/Planned Programs Subtotals	1.993	2.057	2.102

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) 31B / *Infrared Optics Rsch*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
31B: *Infrared Optics Rsch*	-	2.797	4.213	3.742	-	3.742	3.748	3.752	3.753	3.812	-	-

A. Mission Description and Budget Item Justification

This Project supports Army research in materials and devices for active and passive infrared (IR) imaging systems; radio frequency (RF) photonics for radar, communications, and electronic warfare applications; and laser technology for missile threat countermeasure protection. This research aims to generate new technologies for unprecedented battlefield situational awareness and to continue the dominance of Army units during night operations. To achieve these objectives, IR focal plane arrays (FPAs) and lasers with significantly improved performance, lower cost, and increased operating temperatures are required. This research has direct application to Army ground vehicles, aviation platforms, weapon systems, and the individual Soldier. Research is focused on material growth, detector and laser design, and processing for large-area, multicolor IR FPAs, ultraviolet (UV) avalanche photodiodes (APDs), and mid-wavelength IR and UV lasers. The principal efforts are directed towards novel materials for detectors and lasers, and investigating energy band-gap structures in semiconductor materials to enhance the performance of lasers, IR FPAs and UV APDs. In the area of RF Photonics, near-IR modeling and nanofabrication techniques are applied to the design and fabrication of IR photonic-crystal waveguide structures having customized IR properties. This research also is intended to lay the foundation for the development of integrated optoelectronic circuits using active and passive devices and components such as lasers, waveguides, and detectors in conjunction with fiber optic interconnects for the generation, distribution, processing, and control of microwaves. The fundamental physics of signal processing and noise generation as well as the conversion between the time and frequency domains and the optical and electrical domains in these optoelectronic circuits/systems will also be studied. The technical goals are to: 1) manage and control defects in the raw, unprocessed materials, maintaining quality control in the fabrication of the devices and arrays, 2) limit introduction of impurities in the material, shielding device surfaces so that they are resistant to degradation over time and 3) thermal management, particularly as it applies to lasers. This work is coordinated with the United States (U.S.) Army Communications Electronics Research, Development, and Engineering Center (CERDEC). In the area of Advanced Materials, the research is to investigate the fundamental physics of energy, charge, and spin transport along and across active heterogeneous interfaces such as topological insulators, van der Waals heterostructures, solid/liquid interfaces, and bio/a-bio interfaces, and in new materials to achieve new electronic/optoelectronic device functionalities.

Work in this Project supports key Army needs and provides the technical underpinning to Program Element (PE) 0602709A (Night Vision Technology)/Project H95 (Night Vision and Electro-Optic Technology).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology focus areas.

Work in this Project is performed by the Army Research Laboratory (ARL), Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Optoelectronic and Integrated Photonic Materials and Device Research	2.797	4.213	1.005

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 31B / *Infrared Optics Rsch*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Description: Conduct research into materials and structures used for IR devices, UV emitters and detectors, and integrated photonic devices to increase situational awareness in open and complex terrains; improve target detection, identification, and discrimination; and create new device functionality while reducing size, weight, and power requirements. ***FY 2016 Accomplishments:*** Studied engineered IR sensing semiconductor materials processed with micron-scale resonant surface features for improved single color, dual color, and higher operating temperature devices that add functionality in degraded visual environments and reduced system cost; studied diode performance of semiconductor materials composed of indium arsenide antimonide (InAsSb) for improved long wavelength IR performance; researched and advanced optoelectronic oscillator technology for fiber-based acoustic sensor applications and better-than-global positioning system (GPS) clock precision; studied photonics integration for biological and chemical sensing applications; and performed studies and developed and provided fundamental technologies to build UV sources (e.g., light emitting diodes and lasers) with increased output power. ***FY 2017 Plans:*** Will explore new concepts in heterojunction and superlattice design, growth, and fabrication for improved long-wave infrared detection; conduct studies of indium gallium nitride materials for use in achieving large area, high brightness, high power emitters in the near ultraviolet; pursue free-space optical time and frequency transfer using phase noise induced by air turbulence and other environmental effects; investigate techniques for improving the signal-to-noise ratio for standoff detection of chemical/ explosive hazards; and explore the modeling, growth, and fundamental physical properties of novel alloy heterostructures for topological insulators, low power/multifunctional electronics, and high performance thermoelectrics, as well as for highly efficient solar energy harvesting and fuel generation. ***FY 2018 Plans:*** Will perform fundamental studies of carrier transport and vertical light emission in near-UV heterostructures in III-Nitrides to address the challenges associated with device efficiency; will demonstrate reduction in surface and side-wall charge accumulation in IR devices through novel passivation using atomic layer deposition; will design and develop semiconductor-based integrated photonic devices using new metamaterial or device architectures to obtain new and multiple functionalities such as processing microwave signals in the optical domain.			
Title: Advanced Materials	-	-	2.737
Description: Investigation of the fundamental physics of energy, charge, and spin materials with an emphasis on understanding the transport along and across novel designed surfaces and active heterogeneous interfaces to achieve new electronic/ optoelectronic device functionalities. Additionally, study beta-photovoltaic and beta-voltaic energy capture.			
FY 2018 Plans:			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 31B / *Infrared Optics Rsch*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will explore surface properties of InAsSb to study the topological state phenomenon on the surfaces of this material; will study the external field dependence of topological insulator phase transition of Indium Nitride (InN) structures as a function of gate bias and study the bulk bandgap tunability and its effect on bulk conductivity; will study the role of hot electron effects which affect the current and catalytic over-potential in a photoelectrode necessary for water splitting; will study the relevant electrical properties of Gallium Nitride Antimonide (GaNSb) for water splitting power generation applications; will study diamond surface conduction channels to enable ultra-high frequency and high power-density RF devices; will explore complex crystal properties in hybrid one-dimensional (1D) molecular chains and two-dimensional (2D) van der Waals-stacked layered solids to serve as building blocks for high performance and low power electronics; and will investigate beta-photovoltaic and beta-voltaic hybrid energy conversion efficiencies.			
Accomplishments/Planned Programs Subtotals	2.797	4.213	3.742

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army										Date: May 2017		
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) 52C / *Mapping & Remote Sens*			
COST ($ in Millions)	**Prior Years**	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
52C: *Mapping & Remote Sens*	-	1.996	2.057	2.101	-	2.101	2.141	2.185	2.228	2.273	-	-

A. Mission Description and Budget Item Justification

This Project increases knowledge of terrain and human geography with a focus on improving the generation, management, analysis/reasoning, and modeling of geospatial data, and the exploitation of multi-source data. This fundamental knowledge forms the scientific "springboard" for the future development of applications, techniques, and tools to improve the tactical commander's knowledge of the operating environment. Results of this research are used to: extract and characterize natural and man-made features from reconnaissance imagery in near-real time; understand socio-cultural influences; exploit terrain analysis and reasoning techniques; and explore the potential of space, airborne, and terrestrial geospatial sensor technologies to provide real-time geospatial intelligence to all Army Warfighting functions. This research uses terrain and socio-cultural data to improve situational awareness and enhance information dominance, leading to increased survivability, lethality, and mobility.

Work in this Project provides theoretical underpinnings for Program Element (PE) 0602784A (Military Engineering Technology), Project 855 (Topographical, Image Intel & Space).

The cited work is consistent with the Assistant Secretary of Defense, Research and Engineering Science and Technology focus areas.

Work in this Project is performed by the Army Engineer Research and Development Center (ERDC), Vicksburg, MS.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Sensor Phenomenology and Spatial-Temporal Pattern Discovery	1.996	2.057	2.101
Description: Conduct fundamental research to inform the development of applications, techniques, and tools to improve the tactical commander's knowledge of the operating environment.			
FY 2016 Accomplishments: Investigated algorithms to index and query massive amounts of data with spatial and temporal context; theorized and explored framework of pattern learning tasks to rapidly analyze geospatial and temporal data; investigated quantifiable relationships between plant physiology and soil crust biology; explored relationship between biogeochemistry of permafrost in arctic soils and remote sensing signatures; and explored uncertainty in seismic signatures due to both the source and propagation mediums (i.e., soil and rock).			
FY 2017 Plans: Will investigate remotely measurable signatures of polysaccharide content of biological soil crusts for assessment of soil stability and potential of dust lofting; investigate the observable biogeochemical and remote sensing signals from permafrost wetlands to understand the impact of these unique terrain attributes on military training (e.g., sensor performance, operational mobility), and			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 52C / *Mapping & Remote Sens*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
infrastructure stability; and investigate novel statistical approaches to characterize uncertainty for seismic wave propagation due to military activity of interest in regions where detailed local ground characterization is not possible. ***FY 2018 Plans:*** Will characterize seismic sources caused by human activity; will link biogeochemical measurements and remote sensing signals from permafrost bog systems that are in transition and from stable bogs; and will explore the radiometric complexities between illumination and look angles of natural soils.			
Accomplishments/Planned Programs Subtotals	1.996	2.057	2.101

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) 53A / *Battlefield Env & Sig*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
53A: *Battlefield Env & Sig*	-	3.667	3.808	3.892	-	3.892	3.971	4.055	4.135	4.218	-	-

A. Mission Description and Budget Item Justification

This Project focuses on research to seek an in-depth understanding of the complex atmospheric boundary layer associated with high-resolution meteorology; the transport, dispersion, optical properties and characterization of chemical and biological aerosols; and the propagation of full-spectrum electro-magnetic and acoustic energy. The future Army will operate in very complex environments (e.g., urban, mountainous, forested and jungle terrain) requiring new approaches to understand, characterize, and depict environmental phenomena and their effects on military systems, personnel and operations. The lack of a complete understanding of the meteorological aspects of the complex microscale boundary layer in which the Army operates continues to impact our ability to provide predictable, actionable, accurate and timely tactical environmental intelligence to battlefield commanders and small Soldier units. This Project focuses on producing the foundational environmental science research to characterize the atmospheric boundary layer and deliver novel capabilities and techniques including urban turbulence characterization for its effects on micro platforms and sensor payloads, high resolution urban wind flow modeling for more efficient and accurate prediction of the transport and dispersion of obscurants and chemicals, battlefield aerosol characterization and the interaction between aerosols and meteorological processes for Soldier health initiatives, characterization and detection of bio-warfare agent aerosols, environmental effects on acoustic and electromagnetic signal propagation in urban and other complex domains for improved target location and imaging, exploration of previously unexploited regions of the acoustic and electro-magnetic spectrum, and formulation of objective analysis tools that can assimilate on-scene all-source weather observations, atmospheric composition, and fuse this information with forecasts to provide immediate Nowcast products and actionable information. These capabilities will have a direct impact on ensuring Soldier survivability, weapon system lethality, effective surveillance and reconnaissance, and the mobility required for future warfighter mission planning and execution operations.

Work in this Project supports key Army needs and provides the theoretical underpinnings for Program Element (PE) 0602784A (Military Engineering Technology)/Project H71 (Meteorological Research for Battle Command).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas.

Work in this Project is performed by the Army Research Laboratory (ARL), Adelphi, MD and White Sands Missile Range, NM.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Predictive Modeling of the Boundary Layer	3.667	3.808	3.892
Description: Increase survivability and improve situational awareness for a variety of sensors, optics, and flying objects (e.g., projectiles, unmanned aircraft systems, etc.) through research to enhance accuracy of predictive modeling of the atmospheric boundary layer and improve the ability to function effectively in adverse conditions.			
FY 2016 Accomplishments: Investigated boundary layer aerosol fate chemistry (i.e., how an aerosol moves and transforms in the atmosphere/environment) in support of chemical/biological detection methods, transport and dispersion; investigated boundary layer aerosol effect on			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 53A / *Battlefield Env & Sig*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
surface energy budget; used the field observed data to improve both the Weather Running Estimates–Nowcast (WRE-N) and the microscale numerical model accuracy for complex terrain, especially for thermal-driven flows due to differential heating; initiated research of large turbulent eddies in the atmospheric boundary layer using the microscale model so that turbulent transport of momentum, energy and moisture between the boundary layer and the free atmosphere could be be better predicted and parameterized in microscale and mesoscale models; developed a data assimilation approach for WRE-N and extended the finest mesh to hundreds-of-meters grid spacing; began efforts to integrate WRE-N and Atmospheric Boundary Layer Environment (ABLE), and developed improved surface energy budget and multi-scale turbulence models that enhanced the accuracy of predictive diurnal and vertical profile models of optical and mechanical turbulence in the boundary layer. ***FY 2017 Plans:*** Will research active and passive sensing methodologies for microscale boundary layer modeling to predict and correct turbulent image distortion; combine ultra-high-resolution microscale modeling methodologies into ABLE (to provide a full-physics microscale predictive system); conduct experiments using WRE-N/ABLE mesoscale-microscale modeling system with varying forecast resolutions (ranging from hundreds down to tens of meters); develop model enhancements for urban and complex terrain flows, and new data assimilation capabilities (to improve accuracy in battlefield domains); research novel computational methods for fielding on small, tactical computer platforms and Soldier-hosted mobile handheld devices; research the transport and diffusion of atmospheric aerosols, to include background haze, that potentially confounds chemical and biological sensors/detectors/warning systems; research chemical and biological fate when exposed to various naturally-occurring ambient atmospheric aerosols, using both single-particle and bulk sample spectroscopic techniques; and research acoustic and electro-optical propagation for use in characterizing the atmospheric state of the atmospheric boundary layer using both in situ and remote sensing techniques. ***FY 2018 Plans:*** Will identify new methods of enhancing electro-optical communication signal transmission through atmospheric “channels” that are created by ultra-short laser pulses; will create an approach to conduct multi-modal wind sensing by merging Doppler wind Light Detection and Ranging (LiDAR) and radar data together to create highly accurate and detailed, remotely-sensed wind observations; will investigate a new capability to optically trap atmospheric aerosol particles, allowing very precise measurement and characterization of their composition; will research numerical techniques for estimating atmospheric effects on the propagation of acoustic signals; will investigate and incorporate a comprehensive atmospheric radiation algorithm into a microscale numerical weather prediction model, enhancing the accuracy of the forecasts by accounting for both dense urban and forest canopy domains; will expand datasets and investigate correlations between meteorological conditions/observations and significant threat activities; and will explore microscale model initialization and physics refinements based on boundary layer urban and complex terrain discoveries from the Meteorological Sensor Array and other high-resolution atmospheric sensing experiments.			
Accomplishments/Planned Programs Subtotals	3.667	3.808	3.892

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 53A / *Battlefield Env & Sig*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army										Date: May 2017		
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) 74A / *Human Engineering*			
COST ($ in Millions)	**Prior Years**	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
74A: *Human Engineering*	-	12.830	13.342	14.057	-	14.057	15.532	15.852	16.136	16.445	-	-

A. Mission Description and Budget Item Justification

This Project focuses on research that improves Soldier-system performance in future force environments by looking at key phenomena underlying Soldier performance such as auditory spatial orientation (e.g., perception of azimuth, elevation and distance of sounds) within uncertain, degraded acoustic conditions; extending and protecting auditory and cognitive performance; human performance in automated, mixed-initiative (human control-machine control) environments; communications in hearing-degraded conditions; visual scanning and target detection; Soldier emotion and fatigue states; integration across multiple sensory modalities; perceptual-motor behavior; collaborative (team) and independent multi-task, multi-modal, multi-echelon Soldier-system performance - all cast against the influx of emerging transformation-driven technological solutions and opportunities. Technical barriers include lack of methods for describing, measuring, modeling, analyzing and managing the interplay of these phenomena due to the dynamic nature of human behavior and to the situational complexity and ambiguity that characterize operations in the future force. Technical solutions are being pursued in the areas of data generation and algorithm development in these emerging environments in order to update and improve our understanding of performance boundaries and requirements and enable neuroengineering. These solutions include multi-disciplinary partnerships, metrics, simulation capabilities, and modeling tools for characterizing Soldier-system performance, and provide a shared conceptual and operational framework for militarily relevant research on cognitive and perceptual processes. In the area of translational neuroscience, which is the transition of basic neuroscience research to relevant applications, research is carried out to examine leading edge methodologies and technologies to improve the measurement and classification of neural states and behavior in operationally-relevant environments, to examine the potential application of neuroscience theories to autonomous systems to improve Soldier-system interactions, to model the relationship between brain structure and cognitive performance for understanding individual differences and injury, and to assess how neural pathways implicated in functional processing can be enhanced through dynamic system interface technologies for improving in-theatre performance and training. In the area of cybernetics, which is a scientific discipline that bridges the fields of control theory and communication theory for the study and modeling of behavior in complex systems, research is carried out to examine the complex human-system-environment relationships that define, constrain, and influence the interactions between Soldier and system. Research efforts are pursued to advance theory, models, and methodological approaches that capture the dynamic and multidimensional nature of human behavior, including the temporal dependencies inherent to human behavior, through an integrated program of research efforts focused on: novel cybernetic models of human multisensory integration and human-system communication; neuro-inspired, bio-inspired, and engineering approaches to computational algorithms for multisensory integration and multi-sensor fusion to enable enhanced and augmented Soldier perception in human-system interactions; new methodological approaches for the design of multisensory displays and human-system communications; and multisensory test bed platforms for examining experimental hypotheses driven by model predictions and proof-of-principle applications of identified algorithms and methods.

Work in this Project supports key Army needs and provides the technical underpinnings to several Program Elements (PEs) to include PE 0601104A (University and Industry Research Centers)/Project H09 (Robotics Collaborative Technology Alliance) and PE 0602716A (Human Factors Engineering Technology)/H70 (Human Factors Engineering System Development).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology focus areas.

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 74A / *Human Engineering*

Work in this project is performed by the United States (U.S.) Army Research Laboratory (ARL), Human Research and Engineering Directorate, Aberdeen Proving Ground, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Research to Characterize and Enhance Soldier Performance ***Description:*** Characterize and enhance human auditory performance of the dismounted warrior in complex environments while protecting the hearing of the Soldier. ***FY 2016 Accomplishments:*** Conducted Soldier-oriented research to understand the auditory conditions that determine recognition and identification of relevant auditory events; and expanded basic psychophysical research paradigms by incorporating elements that reflect the complexity of the military context, such as sound class categories and semantic assessments of relevance.	1.586	-	-
Title: Soldier Performance ***Description:*** Conduct fundamental research on human performance in military-relevant environments to include operations, command, and training. Use approaches such as computational cognitive modeling and social network analyses to investigate the factors affecting the information flow, situational understanding and prediction, and technology-mediated collaboration under conditions of stress and uncertainty. Determine the environmental and context factors affecting performance, learning, and retention in immersive and simulated environments; establish realism/fidelity boundary conditions for perceptual, cognitive, and physical parameters for experimentation and for training. ***FY 2016 Accomplishments:*** Investigated integrative aspects of key psycho-social factors of cyber security to understand behaviors of attackers, defenders, and users in operational settings; created a scientific experimental infrastructure of game-modeling and empirical studies to examine risk to operation completeness and to study strategic decision-making for responding to human-machine attacker units; and enhanced basic understanding of big data implications on distributed team communications and decision making by refining task network models to study the feasibility of the doctrinal tenets surrounding network-enabled warfare (e.g., more data leads to enhanced situational awareness).	1.586	-	-
Title: Translational Neuroscience ***Description:*** Integrating neuroscience with traditional approaches to understanding Soldier behavior to enable systems designs that maximize Soldier performance. ***FY 2016 Accomplishments:*** Developed algorithms to detect changes in brain state during long-term performance of a task for a non-invasive brain-computer interface; collected novel neurophysiological datasets based on real-world measurements of stress and fatigue; collected	3.485	3.639	3.715

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 74A / *Human Engineering*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
innovative structural imaging data from a large cohort (N>100) of participants to quantify sensitivity of measurement and variability between individuals; and investigated signatures of brain networks that capture changes in task performance. ***FY 2017 Plans:*** Will develop adaptive algorithms to enable semi-supervised learning of brain states in support of human-in-the-loop systems; analyze the reliable relationships between objective physiological measurements and subjective assessments of fatigue; assess the sensitivity in the structural topology or shape of connections between brain regions in a large cohort (N<100) to characterize human variability. ***FY 2018 Plans:*** Will identify novel functional models of visual search using combined measures of gaze position and neural activity in real-word tasks to quantify the effect of cognitive state on task performance; will investigate data-driven classification methods to predict emergent behavior in complex tasks with time-evolving brain states; and will utilize innovations in community detection analyses to link allegiance and flexibility of functional brain networks to variability in task performance.			
Title: Human System Integration – Cybernetics ***Description:*** Apply a cybernetic approach (i.e., a theoretical study and comparison of communication and control processes in biological and artificial systems) to human systems integration to achieve tighter control of devices and communications among humans and between machines and humans. Use social, computational, and information approaches to extend the scope of interaction beyond individual systems to the full network context. ***FY 2016 Accomplishments:*** Examined computational models consistent with cybernetic principles, including feedback models of adaptive mechanisms in human multisensory integration for sensor and motor systems control; implemented and studied novel neuro- and bio-inspired architectures for cybernetic models that can be applied to the critical challenge of multisensory integration across sensory features that cannot be measured on the same metric dimensions; designed a multi-model platform to support human multisensory research efforts in augmented reality and perception; examined critical parameters of multisensory displays to enhance and support human perceptual performance in human-system interactions; explored novel methodologies for identifying and integrating variables in cybernetic models to improve human-system communications; and explored methods for the design of novel, dynamic, and adaptive human-system interactions through methods for mutual human-system communications that leverage information and social science approaches. ***FY 2017 Plans:*** Will advance conceptual, theoretical, and computational closed-loop models (such as neuro-inspired and bio-inspired models) of adaptive behavior and multisensory integration; develop and assess statistical and computational methods to account for variability in and improve prediction of human performance by leveraging temporal dependencies inherent to human neural, physiological, and/or behavioral data; advance display and multi-aspect measurement capabilities for highly-mobile, immersive,	4.984	5.157	5.205

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 74A / *Human Engineering*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
multimodal platforms to support human performance research efforts in augmented perception in real-world contexts; develop and extend novel methodologies for metrics to capture the complex interrelationships in dynamic unisensory and multisensory parameters that drive human adaptive behavior; implement and assess novel, cybernetic approaches to human-system communication and interaction that induce or support adaptive and/or mutually adaptive behavior to improve human performance. ***FY 2018 Plans:*** Will extend the complexity of conceptual and theoretical closed-loop models of complex, functional, and adaptive behaviors focused on large-scale computational and neuronal models, including exploration of high-performance computing implementations; will advance statistical models to improve human performance characterization and prediction, leveraging temporal dependencies inherent to closed-loop systems in human perception and human-system interactions; will explore closed-loop (e.g., neuro- and bio-feedback, augmented reality) human-computer interactions for adaptive interfaces that account for individual differences in brain and behavioral dynamics; and will apply machine learning and big data approaches to capture higher dimensional features in complex data for implementation in novel cybernetic approaches to human-system communications and interactions.			
Title: Continuous Multi-Faceted Soldier Characterization for Adaptive Technologies ***Description:*** This effort will investigate technologies that provide the foundation for future Army systems to adapt to individual Soldier's states, behaviors, and intentions in real-time. Enable high fidelity, continuous prediction that can account for continuous changes in Soldier's physical, cognitive, and social states, such as stress, fatigue, task difficulty, trust, and situational awareness. ***FY 2017 Plans:*** Will advance theories for dynamically integrating asynchronously recorded data from multiple sources with different temporal resolution and time-varying levels of information quality; understand relationships between behavioral, physiological, environmental, and task-based factors and human variability in task performance in real-world environments; and characterize quality of information recorded from behavioral, physiological, environmental, and task-based sensors continuously used in real-world environments. ***FY 2018 Plans:*** Will develop algorithms to predict changes in task performance in controlled environments on the basis of behavioral, physiological, environmental, and task-based factors; will develop algorithms for interpreting state variability in pseudo-controlled environments; will collect novel longitudinal, low-resolution, multi-faceted dataset from a large cohort (N > 50) of individuals for several months to characterize state variability in real-world environments	-	3.306	3.873
Title: Training and Soldier Performance ***Description:*** Research relationship between training environment fidelity/level of immersion and Soldier performance and behavior. Determine the level of physical, perceptual, and cognitive interaction necessary for a simulated environment to affect	1.189	1.240	1.264

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 74A / *Human Engineering*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
performance similar to that in an operational environment. Characterize the appropriate use of different classes of simulated environments to ensure valid results. Develop guidelines for using mobility platforms in simulators to induce physical and cognitive stress representative of the operational environment. Implementation of these guidelines will enhance training effectiveness. ***FY 2016 Accomplishments:*** Explored effects of mobility platform and training environment on route selection during training scenarios; manipulated level of information in the environment to determine how information influences route selection, traversal time, and other Soldier performance parameters; used results from these studies to augment current models and develop new models of Soldier performance and behavior using empirical data to predict Soldier behavior based on training environment. ***FY 2017 Plans:*** Will explore state-of-the-art techniques in immersion, presence, and fidelity with regard to simulation-based training effectiveness to identify appropriate theories of how these factors might be used to predict training outcomes; and develop conceptual-based models that can predict training outcomes. ***FY 2018 Plans:*** Will explore the impact of state and trait measures in empirically-driven conceptual models that describe and predict the relationships between training environment design elements, individual user differences, and training outcomes.			
Accomplishments/Planned Programs Subtotals	12.830	13.342	14.057

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army									Date: May 2017			
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) 74F / *Pers Perf & Training*			
COST ($ in Millions)	**Prior Years**	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
74F: *Pers Perf & Training*	-	5.260	5.540	5.485	-	5.485	5.586	5.699	5.812	5.930	-	-

A. Mission Description and Budget Item Justification

This Project provides the funding to develop innovative theories, models, and methods to improve personnel assessment, training, and leader development, as well as provide a better understanding of individual, unit, and organizational behavior and performance within the context of complex organizational and operational environments. The research within these domains will enable advances in psychometrics to support the development of the next generation of psychological assessments for selection, classification, and assignment. The research also will target how to improve the assessment of difficult-to-measure skills and enable theoretical advances to inform and support the accelerated development of complex cognitive and social skills. This research lays the foundation for future applications that address the behavioral and organizational dynamics that impact Army flexibility, effectiveness, and resilience.

Work in this Project complements and is fully coordinated with Program Element (PE) 0602785A (Project 790) and PE 0603007A (Project 792).

The cited work is consistent with the Assistant Secretary of Defense, Research and Engineering Science and Technology focus areas and the Army Human Capital Strategy.

Work in this Project is performed by the Army Research Institute for the Behavioral and Social Sciences (ARI), Ft. Belvoir, VA.

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2016**	**FY 2017**	**FY 2018**
Title: Personnel Measures (previously Human Behavior)	1.727	1.900	1.915
Description: Funding is provided for basic research to develop innovative theories, models, and methods to improve personnel assessment, training, and leader development. ***FY 2016 Accomplishments:*** Investigated the integration of psychological and neurometric approaches for improving individual difference assessment and personnel testing methods ***FY 2017 Plans:*** Will initiate research to develop assessment methods for difficult to measure skills & attributes related to complex organizational behaviors. ***FY 2018 Plans:*** Will conduct research to advance theoretical knowledge of leadership development during deployment and in garrison.			
Title: Climate, Readiness, and Resilience (previously Human in Complex Organizations)	3.533	3.640	3.570

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 74F / *Pers Perf & Training*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Description: Funding is provided for basic research that will provide a better understanding of individual, unit, and organizational behavior and performance within the context of complex organizational and operational environments. ***FY 2016 Accomplishments:*** Investigated integrated approaches to understanding and assessing systematic contextual moderators of behavior in organizations with primary emphasis on improving prediction of mistreatment and inclusion ***FY 2017 Plans:*** Will initiate research to develop models to better understand organizational processes needed to achieve maximal organizational flexibility, effectiveness, and resilience. ***FY 2018 Plans:*** Will initiate research to advance theoretical understanding of how best to apply the learning of complex tactical/technical and interpersonal skills (in both formal & informal learning environments) to on-the-job performance to maximize unit readiness.			
Accomplishments/Planned Programs Subtotals	5.260	5.540	5.485

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) ET6 / *BASIC RESCH IN CLINICAL & REHABILITATIVE MED*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
ET6: *BASIC RESCH IN CLINICAL & REHABILITATIVE MED*	-	0.000	4.201	4.780	-	4.780	4.866	2.646	2.570	3.053	-	-

Note

In Fiscal Year (FY) 2015 and 2016 the funding for Clinical and Rehabilitative Medicine was in Project S14. The Clinical and Rehabilitative Medicine basic research effort moves to Project ET6 starting in FY17. This is not a new start.

A. Mission Description and Budget Item Justification

This Project supports basic research on experimental models that are developed to support in-depth trauma research studies. This Project includes studies to understand the healing of burned or traumatically injured tissues including eye, bone, nerve, skin, muscle, organs and composite tissues. Such efforts will minimize lost duty time and provide military medical capabilities for post-evacuation restorative and rehabilitative care.

Research conducted in this Project focuses on Clinical and Rehabilitative Medicine.

Work in this Project complements and is fully coordinated with Program Element (PE) 0602787A (Medical Technology).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology, priority focus areas and the Army Modernization Strategy.

Work in this Project is performed by the United States (U.S.) Army Institute of Surgical Research (USAISR), Joint Base San Antonio, TX; and the Armed Forces Institute of Regenerative Medicine (AFIRM), which has multiple Institutes.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Clinical and Rehabilitative Medicine	-	4.201	4.780
Description: This effort conducts basic studies of mechanisms of tissue growth and traumatic injury to gain an understanding that will assist or facilitate the healing or transplantation process. The focus is placed on severe blast trauma to the limbs, head, face (including eye), and genitalia (organs of reproduction), and abdomen.			
FY 2017 Plans: Will characterize and define the post-injury cellular mechanisms resulting in functional deficits of the eyes; will formulate concepts and identify promising novel therapies and strategies to treat traumatically injured eyes; will assess and characterize the future threats and battlefield logistics impacting eye injuries and treatments; and will continue to define innovative strategies to			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** ET6 / *BASIC RESCH IN CLINICAL & REHABILITATIVE MED*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
regenerate and reconstruct hard (e.g. bone) and soft (e.g. skin, muscle, nerve, vascular) tissues to enable promising approaches to advance into the applied research phase through directed experimentation in the laboratory to address injuries of the extremities, face (including eyes), genital, and abdominal body regions. Will identify novel immunomodulation (modification of the immune response / immune system functioning) technologies as well as vascular technologies that reduce the requirement for vein harvest and nerve regeneration technologies that address nerve gap injuries. ***FY 2018 Plans:*** Will investigate stem-cell released factors to identify promising and innovative therapies to regenerate damaged eye tissue. Will characterize cellular mechanisms leading to vision dysfunction. Will define and characterize cellular mechanisms that encourage growth of microvasculature (part of the circulatory system made up of the smallest vessels) for multiple tissue types such as hand transplants. Will develop innovative biologics (pharmaceutical drug made from biological sources) to encourage improved regeneration of craniofacial tissues. Will define biological markers for prognosis (predicting the likely outcome) of wound healing and scarring. Will analyze immunomodulatory (modification of the immune response/immune system functioning) technologies that reduce the need for long term immune suppression following transplantation.			
Accomplishments/Planned Programs Subtotals	-	4.201	4.780

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) F20 / *Adv Propulsion Rsch*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
F20: *Adv Propulsion Rsch*	-	4.097	4.220	3.460	-	3.460	3.545	3.637	3.726	3.818	-	-

A. Mission Description and Budget Item Justification

This Project fosters research to increase the performance of small air-breathing engines and power-trains to support improved system mobility, reliability, and survivability for air and/or ground vehicles; and ultimately serves to reduce the logistics cost burden for the future force. Problems addressed include the need for greater fuel efficiency and reduced weight in these propulsion systems. Technical barriers to advanced propulsion systems are the inadequacy of existing materials to safely withstand higher temperature demands, the lack of capability to accurately simulate the flow physics and the mechanical behavior of these systems, including the engine and drive train. The Army is the lead Service in these technology areas and performs basic research in propulsion, as applicable to rotorcraft as well as tracked and wheeled vehicles. Technical solutions are being pursued through analysis, code generation, and evaluations to improve engine and drive train components and investigate advanced materials. Component level investigations include compressors, combustors, turbines, energy sources and conversion, injectors, pistons, cylinder liners, piston rings, gears, seals, bearings, shafts, and controls.

Work in this Project provides the technical underpinnings for Program Element (PE) 0602211A (Aviation Technology).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology focus areas.

Work in this Project is performed by the Army Research Laboratory (ARL) at Aberdeen Proving Ground, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Thermal Materials	2.367	4.220	-
Description: Investigate new materials needed to withstand the higher temperature regimen of advanced high performance engines, and evaluate improved tools and methods that will accurately simulate the flow physics and the mechanical behavior of future engines and drive trains, which will contribute to the design of more fuel efficient and reliable propulsion systems.			
FY 2016 Accomplishments: Formulated and validated physics-based model of 1) calcium–magnesium–alumino-silicate (CMAS) degradation on thermal barrier coating in a gas turbine environment, and 2) the thermal softening and oxidation degradation on advanced gear steel surfaces. This work provided the foundation for developing physics-based full-length scale concept-to-design of high-speed thermomechanical turbomachinery and mechanical energy transfer for future rotorcraft.			
FY 2017 Plans: Will formulate and validate physics-based model of 1) CMAS degradation on thermal barrier coating in a gas turbine environment, and 2) the thermal softening and oxidation degradation on advanced gear steel surfaces. This work will provide the foundation for			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** F20 / *Adv Propulsion Rsch*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
developing physics-based full-length scale concept-to-design of high-speed thermomechanical turbomachinery and mechanical energy transfer for future rotorcraft.			
Title: Reliable Small Engines for Unmanned Systems ***Description:*** Develop improved tools and methods to enhance the reliability and fuel efficiency of small engines for air and ground vehicles and to enable the use of heavy fuels. ***FY 2016 Accomplishments:*** Evaluated liquid and vapor partitioning in transient spray phenomenon to discover injection-kinetic dependency of spray and combustion events, analyzed droplet size distributions in transient spray, and assess ignition, combustion intensity and radical dependency on transient spray; characterized spray and combustion processes of Jet Propellant 8 (JP-8), Jet A, and alternative jet fuels for fuel property correlation with spray and combustion parameters; and researched modeling and simulation methodologies (both semi-empirical and physics-based) that predicted spray and combustion characteristics under complex fluid dynamics conditions.	1.730	-	-
Title: Vehicle Propulsion & Power Research ***Description:*** Basic research investigating engine and drivetrain technologies for Army manned-and-unmanned vehicles. Research investigates concepts and theories to provide enhanced tools, methods, and innovative concepts to enable improvements in propulsion power density, energy efficiency, reliability, and lifecycle cost for increased performance and capabilities in future Army systems. ***FY 2018 Plans:*** Will investigate engine and drivetrain technologies to enable improved performance and reduced maintenance costs for Army vehicles including: 1) Fuel ignition behavior at Army-relevant altitude and low-temperature conditions for fundamental understanding of multi-regime, multi-mode high-pressure turbulent combustion; 2) Tailored gradient ceramic coating concepts for high-temperature, low thermal conductivity, sand resistance, and low particulate adherence for Army turboshaft engine hot section component performance and debris tolerance; and 3) Advanced lubricant additives and corresponding chemistry interactions to protect highly-loaded mechanical interfaces, such as gear and bearing surfaces, to meet Army needs for extended operation during loss-of-lubrication events.	-	-	3.460
Accomplishments/Planned Programs Subtotals	4.097	4.220	3.460

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** F20 / *Adv Propulsion Rsch*

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) F22 / *Rsch In Veh Mobility*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
F22: *Rsch In Veh Mobility*	-	0.679	0.718	0.735	-	0.735	0.749	0.765	0.778	0.795	-	-

A. Mission Description and Budget Item Justification

This Project conducts research in support of advanced military vehicle technology with emphasis on advanced propulsion, sophisticated vehicle dynamics and simulation, vehicle-terrain interaction, vehicle control, and advanced track and suspension concepts. Advanced propulsion research will dramatically improve power density, performance and thermal efficiency for advanced engines, transient heat transfer, high temperature materials and thermodynamics. This Project also supports state-of-the-art simulation technologies to achieve a more fundamental understanding of advanced mobility concepts. The subject research is directed at unique, state-of-the-art phenomena in specific areas such as: non-linear ground vehicle control algorithms, using off-road terrain characteristics; and unique mobility approaches, using advanced analytical and experimental procedures.

Work in this Project provides the theoretical underpinnings for Program Element (PE) 0602601A (Combat Vehicle and Automotive Technology).

Work in this Project is performed by the Tank and Automotive Research, Development and Engineering Center (TARDEC).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Advanced Mathematical Algorithms for Improved Vehicle Efficiency	0.679	0.718	0.735
Description: Research in support of advanced military mobility technologies with emphasis on Terramechanics (vehicle-terrain interaction), and complex vehicle dynamics and simulation. Research is directed at development of advanced mathematical and computational methodologies using state-of-the-art analytical and empirical procedures.			
FY 2016 Accomplishments: Researched development of North Atlantic Treaty Organization (NATO) Reference Mobility Model mobility metrics using new physics-based analytical tools for more accurately and rapidly predicting vehicle terrain interaction effects (off-road mobility); continued to explore new methodologies/relationships for improving autonomous mobility including latency; and researched math modeling human driver actions/responses critical to predicting vehicle dynamics and interactions with the environment.			
FY 2017 Plans: Will continue to develop the framework for the next-generation NATO Reference Mobility Model methodology, a tool-agnostic solution which can be tailored by the various NATO nations based on their software tools of choice; adapt National Aeronautics Space Administration (NASA) Jet Propulsion Laboratory's Rover Analysis Modeling and Simulation methodology to autonomous and tele-operated ground vehicles; develop detailed models for different off-road terrains (sand, loam, clay) using Discrete Elements Method, finite elements analysis and mesh-free method approaches; develop multi-scale computational algorithms that			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** F22 / *Rsch In Veh Mobility*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
can model both large ground vehicle systems and fine soil particles in an integrated mobility simulation; and investigate high-speed mobility of tele-operated vehicles in transcontinental scenarios. ***FY 2018 Plans:*** Will mature the development of the framework for the next-generation NATO Reference Mobility Model methodology with the end objective of establishing it as a NATO Standardization Agreement (STANAG document) for use by all NATO nations in development of tools that predict more accurate, operational evaluations for mobility and traversability. The research activity will focus on 6 key thrust areas: Geographic Information System (GIS) Terrain and Mobility Map, Simple Terramechanics, Mobility Standards, Complex Terramechanics, Intelligent Vehicle, Uncertainty treatment, and Verification and Validation.			
Accomplishments/Planned Programs Subtotals	0.679	0.718	0.735

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) H42 / *Materials & Mechanics*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
H42: *Materials & Mechanics*	-	8.329	8.731	9.748	-	9.748	12.211	12.262	12.556	12.868	-	-

A. Mission Description and Budget Item Justification

This Project conducts basic research in materials science, which includes research into key phenomena enabling the creation and production of revolutionary materials that will provide higher performance, lighter weight, lower cost, improved reliability, and environmental compatibility for Army unique applications. The current methodology of using materials to gain added functionality for Army systems is to use a layered approach, whereby each layer provides added capability (e.g., ballistic, chemical/biological, signature, etc.), but ultimately makes the system too heavy and too expensive. Technical solutions are being pursued through understanding the fundamental aspects of chemistry and microstructure that influence the performance and failure mechanisms of ceramics, advanced polymer composites, and advanced metals, with the goal of creating hierarchically organized materials systems that possess multifunctional attributes at greatly reduced weight and cost. These advanced materials will enable revolutionary lethality and survivability technologies for the future.

Work in this Project supports key Army needs and provides the technical underpinnings for several Program Elements (PE) to include PE 0602105A (Materials Technology)/ Project H84 (Materials) and PE 0602786A (Warfighter Technology)/H98 (Clothing & Equipment Technology).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology focus areas.

Work in this Project is performed by the Army Research Laboratory (ARL), Aberdeen Proving Ground, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Microscopic/Nanostructural Materials	2.267	2.375	3.072
Description: Devise new materials and design capabilities based upon fundamental concepts derived at the microscopic and nanostructural levels for the future force.			
FY 2016 Accomplishments: Developed computational capabilities and methods to explore grain boundary structure-property relationships for predicting the strength and failure response of metals and ceramics; and continued thermodynamic stability research of micro/nanomaterials including synthesis of new nanocrystalline iron-based alloys that employ novel particulate oxide strengthening mechanisms.			
FY 2017 Plans: Will advance development of computational methods to discover and exploit interfacial structure-property relationships at grain boundaries in metals and ceramics to improve strength and fracture resistance; and develop a series of model fibers to investigate structure-property relationships as a function of processing.			
FY 2018 Plans:			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H42 / *Materials & Mechanics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will complete the development of an advanced computational model that will predict optimal processing parameters and chemistries for alloys and ceramics with improved strength and fracture toughness; and will fully characterize a series of model fibers to determine the structure-property relationship as a function of processing.			
Title: High Deformation Rate Materials ***Description:*** Develop the fundamental understanding necessary to design, process, and characterize materials specifically intended for high loading-rate applications, as in armor and armaments. ***FY 2016 Accomplishments:*** Enhanced multiscale, multidisciplinary materials research to include 1) the investigation of methods that couple electromagnetic and continuum mechanics (i.e., modeling behaviors of materials as a continuous mass rather than discrete particles) theories and algorithms that help model the transition of micro-cracks at small length scales to macro-cracks at larger scales and 2) experimental and modeling capabilities to capture the high-rate response and failure of polymer materials under extreme loading conditions. ***FY 2017 Plans:*** Will advance multiscale, multidisciplinary materials research by developing 1) computational methods to link electromagnetics and continuum mechanics theories and bridge length scales to model crack growth, and 2) experimental and modeling capabilities to capture the high rate and pressure-dependent response of polymer materials. ***FY 2018 Plans:*** Will develop and validate a fully coupled model that predicts the evolution of a failure event based on the dependence of initial microstructure and viscoelastic behavior of an alloy undergoing high-rate and extreme loading.	3.008	3.153	3.211
Title: Materials Research and Processing at Small Scale ***Description:*** Elucidate and exploit unique structure, processing, and property relationships that occur in materials at small length scales and develop methods to tailor the physical, chemical and mechanical response of these materials to enable unprecedented performance improvements in materials properties. ***FY 2016 Accomplishments:*** Explored fundamental effects of alloying elements on atomic level structure and resulting properties and dynamic (i.e., high-rate) response to enable new lightweight alloys; developed novel modeling capabilities to capture physics at small scales in protective fibers and composite materials; and began new foundational research on next-generation protective fibers with controlled nano/ microscale structures. ***FY 2017 Plans:***	3.054	1.089	1.110

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H42 / *Materials & Mechanics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will perform research into high energy processing techniques to consolidate metal powders to form thermodynamically stable, nano-grained alloy materials, that exhibit high strength, ductility, and toughness. ***FY 2018 Plans:*** Will produce bulk material from optimized metal powders using hot-isostatic-press and fully characterize its microstructure and mechanical properties.			
Title: Materiel Research and Processing Using High Energy Fields ***Description:*** Explore interactions between materials and intense energy fields (magnetic, electric, pressure, etc.) to discover new pathways and mechanisms for controlling and altering material structure, enabling the development of new materials with unique property combinations and abilities to respond adaptively to battlefield conditions. ***FY 2017 Plans:*** Will develop new models and experimental capabilities to understand effects of electromagnetic (EM) fields on multiscale structure of armor ceramics during processing, including using EM fields to control engineer grain boundaries for enhanced energy dissipation and fracture resistance under high-rate loading. ***FY 2018 Plans:*** Will characterize new ceramic armor material produced using experimental parameters identified by preliminary models and iteratively refine models based on validation results.	-	2.114	2.355
Accomplishments/Planned Programs Subtotals	8.329	8.731	9.748

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) H43 / *Research In Ballistics*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
H43: *Research In Ballistics*	-	8.211	8.531	11.319	-	11.319	11.723	12.032	12.304	12.659	-	-

A. Mission Description and Budget Item Justification

This Project seeks to improve the understanding of the chemistry and physics controlling the propulsion, launch, and flight of gun-launched projectiles and missiles, and to understand the interaction of these weapons with armored targets. This research results in basic new knowledge, which allows the formulation of more energetic propellants, more accurate and non-lethal (NL)/lethal projectiles and missiles, and advanced armors for increased survivability of Army combat systems. This effort supports the Office of the Secretary of Defense Advanced Energetics Initiative to mature the fundamental technologies required to transition the next generation of energetic materials into field use.

Work in this Project supports key Army needs and provides the theoretical underpinnings for Program Element (PE) 0602618A (Ballistics Technology)/Project H80 (Survivability and Lethality Technology).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology focus areas.

Work in this Project is performed by the Army Research Laboratory (ARL), Aberdeen Proving Ground, Adelphi, MD; and Research Triangle Park, NC.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Advanced Energetics Initiative	3.081	3.203	3.565
Description: Expand and confirm physics based models and validation techniques to enable design of novel insensitive propellants/explosives with tailored energy release for revolutionary future force survivability and weapons effectiveness.			
FY 2016 Accomplishments: Explored novel high-nitrogen carbon, hydrogen, nitrogen and oxygen (CHNO) synthesis methodologies to create unique energetic molecular structures while maintaining stability of reactive properties; expanded investigation and explored novel extended solid energetic materials, in particular poly-carbon monoxide (CO), and alternatives to high-pressure synthesis methods; developed predictive models and associated experimental methods to enable precise control of energy release in shear-mediated acceleration of solid-solid chemical reactions.			
FY 2017 Plans: Will develop novel small scale experimental strategies to release and measure the energy and power stored in structural bond energy release materials (e.g., nanodiamonds), extended solids (e.g., poly-CO), and other types of disruptive energetic materials; and develop computational models to guide understanding of potential materials, methods and mechanisms to enable release of energy to be converted to work, both in terms of propulsion of a flight body and lethal effects on a target.			
FY 2018 Plans:			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H43 / *Research In Ballistics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will explore experimental techniques to maximize energy release of chemical formulations for either propulsive or energetic applications; will explore methods for larger-scale production: will create new computational models which can be used to predict solid-state reaction rates for energetic materials at extreme conditions for upscaling to higher-order models; and will develop and validate detailed reaction chemistry representations of plasticizer blends for propulsive applications.			
Title: Launch and Flight of Gun Launched Projectiles as well as Missiles ***Description:*** Improve the fundamental understanding of the mechanisms controlling the launch and flight of gun-launched projectiles and missiles, and understand the interaction of these weapons with armored targets. ***FY 2016 Accomplishments:*** Investigated dynamics and controls of extreme aerodynamic maneuvers and assessed transient effects and potential for maneuver without the use of sensors; and explored and created capabilities for prescribing favorable forces and moments on flight bodies across multiple Mach regimes. ***FY 2017 Plans:*** Will develop unique modeling and experimental capabilities to predict and characterize the flight physics associated with complex rapid maneuvering of a flight body as well as the nonlinear control algorithms required for navigation in constrained environments (e.g., global positioning system denied). ***FY 2018 Plans:*** Will derive mathematical frameworks and proofs of convergence for estimation of flight vehicle swarm states in absence of global positioning system; and will conduct numerical experiments to demonstrate increased maneuverability of air vehicles using thrust-vector control or enhanced aerodynamic control.	1.689	2.020	2.892
Title: Armor Research ***Description:*** Develop fundamental knowledge of mechanisms that can be exploited to ensure the next generation of lightweight and efficient armor technologies. ***FY 2016 Accomplishments:*** Developed analytic and numerical methods and associated experiments for rigorous coupling of electromagnetic and solid dynamic models; explored the validity of phase-field methods to track coupled deformation mechanisms in polycrystalline solids under rapid deformation; and assessed accuracy and ability of multi-scale computations that account for material-scale mechanisms during penetration events. ***FY 2017 Plans:***	3.441	2.558	3.711

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H43 / *Research In Ballistics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will develop computational methods to capture multiple deformation and failure mechanisms occurring simultaneously that occur under ballistic and blast loading conditions; and develop novel experiments to probe and quantify high-rate deformation mechanisms at small length scales to improve multi-scale computations. ***FY 2018 Plans:*** Will further advance computational methods that predict and explain simultaneous deformation and failure occurring under various ballistic and blast loading conditions; and will perform recently developed experiments to validate multi-scale computations that quantify the cause of high-rate deformation.			
Title: Humans in Extreme Ballistic Environments Research ***Description:*** Provide physics-based discovery of novel protection mechanisms through increased understanding of wave propagation through tissue, and the resulting deformation and damage of tissue during ballistic and blast events. ***FY 2017 Plans:*** Will develop novel experimental techniques to explore cell-level response of neuronal tissue as a function of various potential high-rate loading variables. ***FY 2018 Plans:*** Will experimentally evaluate blast effects on tissues; will model simulation techniques to produce three-dimensional (3D) shock environments; and will experimentally evaluate 3D shock model and use results to refine model.	-	0.750	1.151
Accomplishments/Planned Programs Subtotals	8.211	8.531	11.319

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army										Date: May 2017		
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) H44 / *Adv Sensors Research*			
COST ($ in Millions)	**Prior Years**	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
H44: *Adv Sensors Research*	-	8.455	9.436	8.899	-	8.899	9.915	10.590	10.861	11.099	-	-

A. Mission Description and Budget Item Justification

This Project supports basic research to produce future generations of sensors with capabilities beyond those currently being employed. Technical barriers include the fundamental speed and bandwidth limitations of current materials and devices, the efficiency of current algorithms, current computing architectures, organic material lifetimes, the understanding of the fundamental concepts of quantum cryptography, and the spatial resolution of current radio frequency (RF) sensors. The technical approach is to exploit large-scale electromagnetic (EM) models to predict and explain target and clutter scattering behavior, and research new digital and image processing modules and algorithms, beam propagation and material models of nonlinear optical effects, remote sensing and intelligent system distributive interactive simulations, and battlefield acoustic signal processing algorithms for improved, hazardous material detection and sensor data feature and information fusion under, unique sensor development, and survivable sensor systems. This Project also funds research in the development of biologically inspired materials for use as sensors as well as for power generation and storage; and physics-based multi-scale models for electronic, optical, mechanical, and chemical materials. Payoffs include high-data-rate military communications, improved radar signal processing techniques that will allow existing systems to improve spatial resolution, improved ultra-wideband radar technology for detection of explosives including mine detection, through-the-wall sensing and improved robotics perception, improved sensor approaches and signal processing techniques for enhanced acoustic/seismic sensing systems in noisy environments, distributed sensor data fusion in ad hoc networks, improved cryptography techniques, improved understanding of the physics and atomic properties of materials, and improved capabilities in hazardous material and event sensing.

Work in this Project supports key Army needs and provides the theoretical underpinnings to Program Element (PE) 0602786A (Warfighter Technology)/Project H98 (Clothing & Equipment Technology).

Work in this project complements and is fully coordinated with research at the Army Armaments Research, Development, and Engineering Center (ARDEC); the Army Communications Electronics Research, Development, and Engineering Center (CERDEC), the Army Natick Soldier Research, Development, and Engineering Center (NSRDEC) and the Army Edgewood Chemical Biological Center (ECBC).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology focus areas.

Work in this Project is performed by the Army Research Laboratory (ARL), Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Improving Sensor Research (previously Improving Sensor and Photonics Research (Nano))	2.783	2.393	1.547
Description: Create more survivable and secure sensors and displays, and investigate new magnetic- and electric-field sensor technologies for personnel, activity, and improvised explosive device (IED) detection. Develop novel algorithms and electromagnetic models to investigate radio frequency (RF) propagation and exploitation in complex clutter environments for improved RF and radar sensing.			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H44 / *Adv Sensors Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
FY 2016 Accomplishments: Researched design of electrically-small antennas using adaptive metamaterials and adaptive surfaces; developed foliage penetrating (FOPEN) tree clutter model; developed low-frequency acoustic transducers to enhance signatures for improved tracking and classification algorithms that also compensate for signature variances due to channel and target motion effects; investigated enhanced performance magnetic tunnel junctions for low-frequency noise rejection and increased detection bandwidth and range; researched distributed processing and fusion of gunfire signatures from disparate sensors; and examined the efficacy of surface-enhanced Raman scattering (SERS) sensor elements based on paper and flexible substrates impregnated with noble metal nano-photonic materials. ***FY 2017 Plans:*** Will investigate detection and tracking algorithms using a high fidelity foliage penetrating radar target and clutter model; develop radio frequency interference mitigation algorithms; investigate low-frequency, quasi-static, magnetic-, and electric-field interactions between a sensor and its environment to improve overall sensor performance; investigate sensor and algorithmic methodologies to differentiate infrasound from wind-turbulence to better understand the phenomenology of noise generation and develop strategies for mitigating the effects of wind-turbulence; research distributed processing and fusion methods using shared decision-making processes over low-power, short-lifetime sensors with limited communication capabilities for efficient battlefield situational awareness to the dismounted Soldiers; and examine efficacy of a hybrid, surface-enhanced biosensor. ***FY 2018 Plans:*** Will investigate notch-filling techniques in the RF spectrum for wideband radar application; will investigate micro-Doppler effects and algorithms for threat unmanned air system (UAS) modeling and detection research; will apply infrasound propagation theory and develop new algorithms to enhance localization accuracy and classification in complex wind and flow environments and propagation channels; will develop modeling and simulation techniques and algorithms for electrical- and magnetic-field sensing of targets, terrain, power lines, sensors and sensor platforms influenced by complex field interaction; will explore distributed change detection by fusion of sensor and open source text; and will research adaptive distributed multiple target tracking over bandwidth constrained networks.			
Title: Multi-scale Modeling for Novel Materials	2.729	2.840	2.899
Description: Explore and develop multi-scale modeling techniques to support fundamental studies of electronic and structural materials properties from the atomistic to the continuum. Resulting models will be used to design and develop materials for more efficient, longer lifetime sensors and power and energy devices, and lighter materials for vehicle and soldier protection. This effort includes research that leverages two 5-year Collaborative Research Alliances (CRAs): the Materials in Extreme Dynamic Environments CRA and the Multi-scale/Multidisciplinary Modeling of Electronic Materials CRA. These CRAs are funded under PE 0601104A/Project VS2 (Multi-scale Materials Modeling Centers).			
FY 2016 Accomplishments:			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H44 / *Adv Sensors Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Developed algorithms/theories that further advance the state-of-the art and understanding of electronic materials with regards to interactions of electrons, photons, phonons, defects and impurities; evaluated the comprehensive set of material characteristics and properties at length and time scales that govern high-rate deformation; evaluated the modeling of fracture and failure phenomena in metallic, polymeric, ceramic, and composite material systems through both computational and experimental techniques; and expanded computational modeling methods to exploit newly emerging high performance computing capability. ***FY 2017 Plans:*** Will create validation methods for new state-of-the-art algorithms developed for the understanding of electronic materials with regards to interactions of electrons, photons, phonons, defects, and impurities; investigate methods to quantify uncertainty for a comprehensive set of material characteristics and properties at length and time scales that govern high-rate deformation; develop scalable numerical algorithms for modeling of failure, fracture, and fragmentation phenomena in metallic, polymeric, ceramic, and composite material systems through computational and experimental techniques; and implement multi-scale computational material modeling methods on massively parallel computers. ***FY 2018 Plans:*** Will create numerical methods and algorithms to enable new high-fidelity multi-scale computer simulations of materials capable of taking full advantage of emerging large-scale heterogeneous computing environments; and will develop computational methodologies to advance the state-of-the-art of at-scale computer models of materials, from the electronic scale through atomistic- and meso-scale to continuum, to take full advantage of emerging large-scale heterogeneous computing environments.			
Title: Biological and Bio-inspired Materials and Devices Research	2.943	4.203	4.453
Description: Create synthetic biological materials for devices and sensors that can be used by the Army to improve force protection and reduce logistical burden. ***FY 2016 Accomplishments:*** Developed computational models of bacterial metabolism that included synthetically engineered pathways and used synthetic biology to manipulate that metabolism for production of commodity chemicals necessary for waste to energy applications; studied and developed fundamental synthetic biology tools enabling biomaterials discovery with enhanced features (e.g., integrated reporting and high temperature discovery) to allow for better understanding and control of biological material interfaces for sensor and electronic integration, bio-adhesives and other applications ***FY 2017 Plans:*** Will investigate the addition of complementary natural microorganisms to current experimental protocols for microbial-derived fuels (i.e., a microbial consortium), with the goal of improving system stability over time and robustness to food source variability for waste-to-energy applications; establish models of cell membrane potential to better understand its role in controlling and optimizing biological reactions; create advanced computational protocols to model synthetic peptides for material discovery and maturation for improved biosensors; investigate the diversity of synthetic peptide libraries and develop first generation			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H44 / *Adv Sensors Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
bioinformatic and modeling tools for genetically engineered peptides for inorganics and multifunctional materials; and extend peptide material discovery with integrated optical reporting to new material sets to enable active bio/abio heterogeneous interfaces. ***FY 2018 Plans:*** Will explore improved large-scale models of microbial consortia in concert with improved experimental protocols monitoring consortium evolution for future applications such as waste-to-energy; will identify second generation bioinformatic and modeling tools that integrate experimentally monitored dynamics of the diversity of synthetic peptide library development for inorganic and multifunctional materials; will establish synthetic biology methods to engineer cell systems for improved and programmable control of interactions of biological/abiological heterogeneous interfaces; will develop protocols for systems-level analysis of multi-organism communities; will extend metabolic and transcriptional network reconstruction to additional organisms; and will research available systems biology tools for use in microbial consortia members.			
Accomplishments/Planned Programs Subtotals	8.455	9.436	8.899

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army										Date: May 2017		
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) H45 / *Air Mobility*			
COST ($ in Millions)	**Prior Years**	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
H45: *Air Mobility*	-	2.236	2.364	2.410	-	2.410	2.458	2.506	2.556	2.608	-	-

A. Mission Description and Budget Item Justification

This Project supports basic research in aerodynamics for manned and unmanned rotary wing aircraft. The goal of this effort is to develop improved tools and methods to analyze, evaluate, and assess rotorcraft-unique aerodynamic properties in conventional helicopter and tilt-rotor aircraft. The efforts in this Project will result in a better understanding of rotorcraft aeromechanics and will result in improved performance, safety and, ultimately, improved combat effectiveness of the manned and unmanned rotorcraft in the future force. This Project supports the future force by providing research into technologies that can improve tactical mobility, reduce logistics footprint, and increase survivability for rotary wing aircraft.

Work in this Project provides the theoretical underpinnings for Program Element (PE) 0602211A (Aviation Technologies).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas and the Army Modernization Strategy.

Work in this Project is performed by the Army Aviation & Missile Research, Development and Engineering Center, Aeroflightdynamics Directorate at the National Aeronautics and Space Administration (NASA) Ames Research Center, CA and Langley Research Center, VA.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Rotary Wing Aerodynamics	2.236	2.364	2.410
Description: Funding is provided for the following effort			
FY 2016 Accomplishments: Continued fundamental research in rotary-wing aeromechanics to lay the foundation for technologies with long-term relevance to future vertical lift encompassing areas such as automation; exploit high-performance computing to research three-dimensional structural dynamics and advanced flow control techniques; and conducted experimental and computational investigations to better understand interactional aerodynamics of multi-rotor configurations by developing pioneering flow measurement techniques and novel numerical algorithms/methods.			
FY 2017 Plans: Will leverage knowledge gained from earlier computational aero-science investigations (aimed at developing novel numerical methods) for rotorcraft blade structural load investigations; conduct experimental investigation of rotor blade structural loads; develop and improve flow measurement techniques such as infra-red thermography for transition, pressure sensitive paint for			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H45 / *Air Mobility*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
surface loads, and particle image velocimetry for flow field velocities; and explore interactional aerodynamic effects on multi-rotor configurations including the rotor downwash/outwash. ***FY 2018 Plans:*** Will conduct experimental investigations to better understand the flow field surrounding a rotor hub to enable drag reduction using active and passive flow control technology; will continue computational aero-science investigations on both high-fidelity and mid/low fidelity numerical methods including work on validation and developmental testing of the physical assumptions forming the building blocks of the underlying theory.			
Accomplishments/Planned Programs Subtotals	2.236	2.364	2.410

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) H47 / *Applied Physics Rsch*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
H47: *Applied Physics Rsch*	-	5.574	4.285	5.689	-	5.689	5.848	5.434	5.559	5.676	-	-

A. Mission Description and Budget Item Justification

This Project performs basic research on electronic materials and structures as well as technologies in energy harvesting and energetic materials, batteries and fuel cells to enable higher performance and more efficient electronic systems. This includes nanoelectronic devices for low-power and high-frequency applications; sensors, emissive nonlinear and nanophase electrodes, and electronic materials; advanced battery materials, thermoelectric devices, photovoltaic devices, as well as more efficient fuel cells for hybrid power; and the manipulation of cold atoms on a chip for improved gyroscopes and accelerometers for inertial navigation units in global positioning system (GPS)-denied environments, very sensitive gravitational sensors for detecting underground facilities, low-phase noise precision oscillators for low-velocity Doppler radar, and ultra-stable atomic clocks for GPS-denied environments, as well as for future space-based timing applications. These investigations will also impact the development of power sources and specialty electronic materials for the Army's future force, including improved wide band gap semiconductor performance for more electric platforms, nanomaterials for batteries and fuel cells, quantum dots for increased photovoltaic efficiency and advanced radar systems. Technical barriers affecting performance, weight, cost, and power consumption will be addressed.

Work in this Project supports key Army needs and provides the technical underpinnings to Program Elements (PE) 0602705A (Electronics and Electronic Devices)/ Project H94 (Electronics & Electronic Devices). Work in this project complements and is fully coordinated with research at the Army Armaments Research, Development, and Engineering Center (ARDEC); the Army Communications Electronics Research, Development, and Engineering Center (CERDEC); and the Army Natick Soldier Research, Development, and Engineering Center (NSRDEC).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas.

Work in this Project is performed by the Army Research Laboratory (ARL), Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Nanoelectronic Devices and Sensors	2.948	1.836	1.490
Description: Conduct research on advanced battery materials; fuel cells and reformers for Soldier and vehicle power; electronic materials structures and defects in high-temperature, wide-bandgap semiconductors for high-power electronic and photonic applications; materials for advanced nano- and micro-devices; and integration of nano-energetics and Micro-Electro-Mechanical Systems (MEMS) for fusing and micro-robotic applications.			
FY 2016 Accomplishments: Constructed an ultrafast laser spectroscopy experimental testbed to detect surface contamination by hazardous materials; investigated a detection method based on photothermal vibrometry using tunable quantum cascade laser (QCL) sources for surface contamination detection, and conducted ongoing investigations of other promising candidate spectroscopic detection technologies; analyzed processes and materials for the realization of thin film deposited three-dimensional (3D) piezoelectric			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H47 / *Applied Physics Rsch*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
materials for novel and high performance MEMS actuators; developed processes and characterized on-chip energetic materials for optimization of slow reaction rates for energy generation and thermal source applications; developed growth techniques and fabrication processes for stacked two-dimensional (2D) materials optimized for radio frequency (RF) electronic properties and used in flexible substrates to enable vertical RF active devices resulting in higher frequency RF circuits (to increase performance with less size, weight and power); characterized devices and integrated circuits made using 2D electronic materials such as transition metal dichalcogenides in order to enable conformable, high performance electronics; assessed performance prospects for application of such materials for high frequency and low power analog, RF, and digital electronics for communications and sensing; and researched one-dimensional (1D) and 2D phenomena for alternative device architectures for operations in extreme environments. ***FY 2017 Plans:*** Will investigate the viability of photoacoustic sensing using tunable quantum cascade laser sources for chemical hazard detection at standoff distances; investigate electrical performance of stacked 2-D materials and develop 2-D flexible integrated circuit analysis methodologies for the design of low-power and flexible RF and electronic circuits; develop and validate thermal models for the design of on-chip, energetic thermal sources and other thermally responsive on-chip materials for zero-power actuation applications; and analyze the integration of high performance piezoelectric materials with multi-layer structures to enable tunable, adaptable RF MEMS devices and inertial sensors. ***FY 2018 Plans:*** Will investigate underlying reliability limitations of ultra-wide band gap materials and devices; will research and compare electron mobilities in state-of-the-art dielectrics on gallium nitride (GaN) for gate dielectric and passivation in 600-V class devices; will develop computational transport models for bipolar ionic conducting membranes for use in high energy density fuel cells using liquid fuels; will analyze techniques for improving piezoelectric material properties and integration strategies to enable tunable, adaptable RF MEMS devices and inertial sensors; will study radiative efficiency in microcavities for high power, single aperture near-ultraviolet (UV) lasers; and will study indium gallium nitride (InGaN on GaN) structures for improved gain in near-UV laser structures.			
Title: Fundamentals for Energy Efficient Electronic Components (previously Advanced Energy Efficient Science Research)	2.626	2.449	1.880
Description: This program addresses the power draw of RF front ends for communication and the digital back-end from electronic materials. This work explores new materials with inherently higher energy efficiencies, while improving upon the current state-of-the-art. These materials will be used in conjunction with advances in circuits and systems to provide improvements in power efficiencies, linearity and noise at the subsystem level which are unique needs of the military. Conduct materials, components, and multi-scale modeling research that will lead to advances in energy storage, harvesting, conversion, and efficiency for a wide range of Army applications such as Soldier and vehicle power, microgrids, communications, radar and electronic warfare. ***FY 2016 Accomplishments:***			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H47 / *Applied Physics Rsch*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Investigated plasmonic arrays and effect of array structure on catalysis of oxygen reduction, carbon dioxide electroreduction and ethanol oxidation as routes to producing fuel on the battlefield; investigated the effect of electromagnetic radiation (EM) at several frequencies on catalysis rate and selectivity to determine impact on power generation; and investigated the use of metamaterials to enhance EM effects on catalysis for higher conversions to useful fuels. ***FY 2017 Plans:*** Will investigate structures that have plasmonic resonance in the infrared; fabricate aluminum gallium nitride (AlGaN) structures that are bandgap-matched with ultraviolet phosphors; investigate 3D GaN structures for beta-voltaic and beta-photovoltaic power sources; develop understanding of failure mechanisms and methods of assessing wide bandgap device reliability in extreme operating regimes that will enable reliable Army sub-systems with improved power, weight and size efficiencies; study robustness and long-term reliability and related failure mechanisms of the AlGaN/GaN metal-insulator-semiconductor interface under accelerated electric fields and elevated temperatures; use multi-scale modeling to improve battery energy density and fuel cell performance; investigate electronic materials classes showing high potential for improved efficiency and frequency response through modeling, simulation, and characterization of electronic performance and metrology; investigate materials growth and fundamental device fabrication processes for energy efficiency and reduced parasitic losses; and develop new thermodynamic cycles for increased power and energy density in pyroelectrics, and determine effective acoustic energy transfer modes for wireless power transfer. ***FY 2018 Plans:*** Will explore chip level integration of active devices made using 2D and surface conduction electron transport for high conductivity channels that enable more efficient RF performance; Will develop underlying principles for vertical GaN device/material issues (more efficient vs lateral). Will investigate high-electron-mobility transistor (HEMT) devices in multiple geometries.			
Title: Fundamentals for Precision Measurement for Contested Environments ***Description:*** Develop new materials, novel device architectures, and unique processing techniques to successfully maintain communication and information sharing protocols in GPS-denied, actively jammed, or austere environments. ***FY 2018 Plans:*** Will explore new materials and novel device architectures to reduce the phase noise and environmental sensitivity of microwave-photonic oscillators in order to improve the performance of the Army's radar and position, navigation, and timing (PNT) systems; will investigate a compensation locking concept in order to interlock oscillator cavities with different characteristics to increase long-term timing stability of the overall system.	-	-	0.539
Title: Fundamentals for Alternative Energy	-	-	1.780

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H47 / *Applied Physics Rsch*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Description: Explore novel concepts in energy generation and capture, and in technologies for efficient conversion of ambient energy to electrical energy for use and storage. Design novel structures to include microscale power devices for multimodal harvesting and efficient distributed power conversion. ***FY 2018 Plans:*** Will investigate atomic-nuclear effect by isomer depletion, and study the nuclear structure for enhanced energy release; will explore semiconductor structures by substrate and epitaxial growth conditions; will investigate new materials to optimize plasmonically augmented performance; will investigate the mechanism of plasmonic enhancement found in the structures built previously; will develop 3-D plasmonic arrays and examine alternative field effects to enhance plasmonic reactions and decouple the electron transfer process to further elucidate the mechanism and will investigate electrochemical oxidation of high energy density liquid fuels with carbon-carbon bonds at low temperatures.			
Accomplishments/Planned Programs Subtotals	5.574	4.285	5.689

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) H48 / *Battlespace Info & Comm Rsc*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
H48: *Battlespace Info & Comm Rsc*	-	24.710	28.276	31.394	-	31.394	32.292	36.816	37.397	38.249	-	-

A. Mission Description and Budget Item Justification

This Project supports basic research to enable intelligent and survivable command and control, communication, computing, and intelligence (C4I) systems for the future force. As the combat force structure decreases and operates in more dispersed formations, information systems must be more robust, intelligent, interoperable, and survivable if the Army is to retain both information and maneuver dominance. This research supports the Army's Network Science initiative and addresses the areas of information assurance, signal processing for wireless battlefield communications, document and speech machine translation, and intelligent systems for C4I. Major barriers to achieving the goals are the inherent vulnerabilities associated with using standardized protocols and commercial technologies while addressing survivability in a unique hostile military environment that includes highly mobile nodes and infrastructure, bandwidth-constrained communications at lower echelons, resource-constrained sensor networks, diverse networks with dynamic topologies, high-level multi-path interference and fading, jamming and multi-access interference, levels of noise in speech signals and document images, new low-density languages, and information warfare threats. These C4I technologies must accommodate heterogeneous security infrastructures and information exchange/security mechanisms between multiple levels of security. The intelligent systems for C4I research focuses on providing the agent technology capabilities that will produce highly relevant tactical events for mounted or dismounted commanders, leaders and Soldiers; improve the timeliness, quality and effectiveness of actions; and speed the decision-making process of small teams operating in complex natural or urban terrain.

Work in this Project supports key Army needs and provides the technical underpinnings to Program Element (PE) 0602783A (Computer and Software Technology) / Project Y10 (Computer/Information Science Technology).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas.

Work in this Project is performed by the Army Research Laboratory (ARL), Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Communications in Complex Dynamic Networks	1.848	1.963	1.110
Description: Perform research to provide communications capability for a fully-mobile, fully-communicating, and situationally-aware force operating in a highly dynamic, wireless, mobile networking environment populated by hundreds to thousands of networked nodes. ***FY 2016 Accomplishments:*** Researched theories, models and experimental approaches towards new communications networking capabilities (e.g., control and signal processing algorithms for adaptive hybrid networks comprised of microwave and very high frequencies (VHF) with active adaptations) in harsh tactical environments; investigated approaches to integrated agent-based node relocation and			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
communications planning that enhances network connectivity; and developed modeling and analysis methods that support the design of hybrid networks able to maintain communications in highly disruptive, hostile environments. ***FY 2017 Plans:*** Will investigate and create theories, models, and adaptive algorithms for robust and efficient communications under varied conditions using cognitive and dynamic spectrum access techniques in a hostile tactical environment; research new modeling and analysis methods for hybrid networks that support mobile networking infrastructures to ensure communications in highly disruptive and hostile environments; and define analytical tradeoffs between different performance metrics for multi-modal communications. ***FY 2018 Plans:*** Will create theories, algorithms, and models to enable cognitive hybrid networks that utilize radio frequencies (RF) (e.g. Very High Frequency (VHF) and ultra-high frequency (UHF)), as well as higher frequencies ranges in non-RF bands; will research novel energy efficient methods for controlling autonomous communications infrastructures to maintain network operations in disruptive environments; will develop adaptive point-and-track algorithms and techniques for the modeling and design of multiplexed systems for networking both RF and non-RF physical layer technologies; and will develop formal theories, models and algorithms for decentralized and distributed software-defined networking control plane architectures across heterogeneous mobile networks.			
Title: Data-to-Knowledge to Support Decision-Making ***Description:*** Design and implement a laboratory-scale common information processing infrastructure, inclusive of cloud computing, for networking processes that aids the transformation of data into actionable intelligence to support decision-making under uncertainty. Perform research to utilize real-time, tactical, soldier-centric information for improved decision-making and situational awareness. Perform research in support of rapidly enhancing long-duration, complex, dynamic decision-making capabilities of individual Warfighters and units through the integration of cognitive augmentation and course of action recommender technologies. ***FY 2016 Accomplishments:*** Developed a framework and algorithms for multi-modal information fusion of representative tactical elements from text, video and imagery; investigated the impact to situational awareness when using integrated multi-modal analytics versus independent analytics; studied the value of information construct as a measure of the contribution of multimodal analytics; and investigated algorithms for intelligent mission planning and task allocation for heterogeneous teams of mobile platforms in tactical environments. ***FY 2017 Plans:*** Will study and evaluate the effectiveness of multi-media information processing techniques on user understanding while adapting the presentation of information to various user parameters, including mission and physiological measures; experiment with methods for integrating user/mission concepts (e.g., user fatigue or humanitarian versus mine-clearing missions) to adapt how	2.430	4.503	5.055

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
and when information is provided to the user. Measures of effectiveness will include decrease in communications delay and increase in situational awareness. ***FY 2018 Plans:*** Will explore techniques for utilizing active and passive feedback from information consumers to enhance and customize multi-media information processing, knowledge presentation and querying for improved decision-making and situational awareness; will research text and video analytic approaches to associate information from text with information derived from video sources to improve the collection, processing and exploitation of tactical battlefield data.			
Title: Information Protection for Mobile Dynamic Networks ***Description:*** Perform research on protecting information in highly mobile, wireless tactical environments, where networks must operate under severe bandwidth, energy, and processing constraints, and without reliance on centralized security services. Beginning in fiscal year 2015, includes work previously conducted under Network Science for Mobile Ad Hoc Networks (MANETs) and Tactical Communications. ***FY 2016 Accomplishments:*** Investigated techniques for novel, stealthy communications that are less likely to be detected and intercepted by the adversary than conventional radio frequency communications; investigated methods for mission-focused, network analysis and prediction of cyber risks; and designed innovative techniques to collect, detect and actively mitigate low-observable, highly sophisticated cyber threats in complex heterogeneous networks comprised of wireless and wired technologies. ***FY 2017 Plans:*** Will investigate emerging technologies and their underlying communication protocols focusing on computational complexity; establish techniques to empirically quantify the complexity of a protocol for future application in network security risk assessments; research and derive fundamental methods to automatically generate provably-secure networking protocols that are suitable for deployment on resource-constrained devices and wireless/wired networks; and explore machine learning and statistical methods to improve situational awareness through event and data reasoning. ***FY 2018 Plans:*** Will investigate distributed, energy efficient techniques to enhance network survivability in the presence adversarial attacks at both the physical (RF) and network layers (cyber); will develop quantitative models of information semantics trust and quality; will create models, theories and algorithms for secure, content-based software-defined networking in dynamic coalition environments; will investigate and create secure techniques for distributed composition, positioning, and adapting of information services based on user context and state, device processing capabilities, and security policies; will explore and quantify cyber risk accurately in real-time to provide security and mission assurance; will explore dynamically risk, exploit likelihood, and impact of vulnerability exploitation, as cyber sensor observations are received for a system with known vulnerabilities; will investigate, detect, analyze, and assess temporal and spatial causality of cyber events representing attacker activities, attack provenance, exploits, and	5.634	5.992	4.704

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H48 / *Battlespace Info & Comm Rsc*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
vulnerabilities, and investigate methods to attribute the authorship of source code and binary samples using machine learning techniques.			
Title: Multi-Cultural Computational Linguistics ***Description:*** Establishes formal methods for bridging language barriers in tactical environments, incorporating state-of- the-art techniques in machine translation and natural language processing. ***FY 2016 Accomplishments:*** Identified tractable elements of social meaning reflected in text, based on sociolinguistic theory, and developed algorithms to extract basic elements from social media; examined contribution of social information to entity- and event-based information extracted from text; evaluated and extended Natural Language Processing (NLP) semantic underpinnings for spatial and temporal representation and linked them with logical formalisms for reasoning and action planning; and investigated the role of pragmatics in both supporting language interaction with autonomous systems, and interpreting social meaning extracted from text. ***FY 2017 Plans:*** Will explore techniques for extending NLPconcepts to social media analytics for author/programmer identification, summarization, and enhanced video analytics. ***FY 2018 Plans:*** Will investigate machine learning techniques that support rapid, high quality text analysis in sparse data environments; and will investigate knowledge representation techniques for automated dialect identification, linguistic analysis, and summarization for low-resource languages and social media data.	1.069	1.136	1.158
Title: Advanced Computing Architectures and Algorithms ***Description:*** Investigate advanced computing and high performance computing (HPC) networking architectures, memory/storage architectures, algorithms and visualization techniques to support advanced battle command applications for C4I systems. ***FY 2016 Accomplishments:*** Developed novel programming models using emerging programming languages for dynamically evolving mobile heterogeneous computing/networking architectures to solve high fidelity battle command applications; and developed validation methods for these mobile heterogeneous computing/networking devices. ***FY 2017 Plans:*** Will develop programming methods to support the next generation of computing hardware systems (e.g., heterogeneous, parallel, and non-traditional computing architectures such as neuro-synaptic); research new algorithmic methods for tactical HPC to address power, performance, and portability in emerging computational resources; research and create novel capabilities	3.562	4.116	4.186

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
based on increased computing capacity; and explore and evaluate novel, soldier-centric distributed computing and information architectures at the tactical edge for real-time human uniqueness assessment applications. ***FY 2018 Plans:*** Will identify gaps in the next generation computing hardware systems in relation to power, performance, portability, and programmability; will create interdisciplinary mathematical algorithms and models for execution on advanced and high performance computing systems; will investigate the use of traditional high-level to low-level compiler transformations and approaches to reduce the time for algorithm deployment on advanced systems; will perform fundamental research into novel applications that will benefit from the deployment of tactical high performance computers for increased Soldier effectiveness and algorithms devoted to scalable and temporal data analytics for machine learning, real-time detection, and predictive analytics.			
Title: Quantum Information Sciences ***Description:*** Perform research to enable quantum networks, which necessitates research in efficient light / matter interfaces and long-lived, robust quantum memories. Additionally, the study of quantum techniques for sensing and ultra-precise navigation, timing, and communications will be undertaken. Conventional techniques for sensing magnetic fields, gravity, and timing have reached a plateau in their performance, and will be severely impacted in future contested-battlefield environments. This research brings new insights regarding the use of quantum science to enhance Warfighter effectiveness. ***FY 2016 Accomplishments:*** Investigated quantum node-to-node communications along optical fibers and free-space via entangled single photon generation and capture; evaluated the quantum effects and entanglement (i.e., two particles together describe a single quantum state and can't be independently measured or the state of the whole changes) processes of laser-cooled atoms and studied and characterized unique trapping processes to hold and exploit the quantum properties of ions; and studied frequency conversion processes to link disparate quantum systems that generate single photons at different wavelengths of light (e.g., microwave or ultraviolet to visible or infrared). Regardless of the mode of communications, quantum tagging and/or encryption may be used to provide robust information security and viability. ***FY 2017 Plans:*** Will investigate use of integrated photonics and nanotechnology as potentially highly compact components in a quantum network; investigate solid-state systems for controlled, high-rate photon emission, and hybrid ion/neutral atom, solid-state entangled systems as potential interfaces between mixed quantum state systems, which is essential to realizing noise reduction in networked quantum sensors relative to classical systems; establish network protocols with enhanced quantum capacities and rates that integrate classical networking, and assess associated fidelities and the role of error correction in a distributed entangled system; investigate a versatile quantum controller for managing input and output of quantum memory and nodes; and pursue on-chip, Bell-state measurements between quantum memories and repeaters for distributed quantum information systems. ***FY 2018 Plans:***	5.277	5.359	5.402

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will investigate optical nanofibers with strong evanescent fields embedded in cold atom systems; cold-atom ensembles in optical cavities; nanophotonic integration with solid-state defects; and solid-state stoichiometric crystals in cryogenic environments; additionally, qubit manipulation will be investigated in ion trap systems and solid-state defects, and an advanced control system for qubit manipulation will be employed for benchmark standardization; methods for coupling these different platforms via wavelength conversion will be examined, and experimental systems will be analyzed theoretically and the enhancements to sensing using distributed, entangled sensors will be studied theoretically and computationally; and will investigate protocols and algorithms for quantum networks and increasing quantum channel capacity using exotic spatial modes of light.			
Title: Experimental Methods in Network Science	4.890	5.207	4.443
Description: Supports in-house Network Science studies in conjunction with the Network Sciences Collaborative Technology Alliance and Distributed Analytics and Information Science for United States / United Kingdom (U.S. / U.K.) Coalition Operations Information (PE 0601104A).			
FY 2016 Accomplishments: Conducted experimental and theoretical investigations of novel in-network information discovery, storage, pre-processing, integration and routing approaches that enhance quality and trust in information in the presence of disruptions and kinetic and cyber attacks; characterized and developed theoretical models of behaviors of heterogeneous networks that combine traditional radio frequency communication links with novel channels that are more stealthy and exhibit different propagation features; developed theoretical foundations for security properties in complex heterogeneous networks; and extended and refined mathematical methods and models that anticipate dynamic changes in collaboration and decision making in networks comprised of human and artificial agents.			
FY 2017 Plans: Will investigate novel techniques to model, characterize, and control information delivered through multi-genre networks (e.g., communications, information, or socio-cognitive) based on the semantics and context of information requests, and requisite composite quality-of-information measures; derive theories, representations, and models for discovering patterns in network data, to include inferring new phenomena from incomplete and noisy network data, and predicting properties of multi-genre networks; research methods to measure and enhance human trust in decision-making contexts involving information provided by networked sources, both human and automated systems, and experimentally verify them; explore methods for simulating and emulating the impact of quality-of-information on decision-making in networks comprised of humans and physical and virtual agents; and create models and tools for the formal study, verification, and analysis of software-defined, information-centric algorithms that support interoperability, adaptability, and resilience of heterogeneous networks.			
FY 2018 Plans: Will investigate methods for network design that consider tradeoffs between current optimality and long-term behavior as well as adversarial dynamics; will explore the impact of quality-of-information and semantics knowledge on distributed decision-			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H48 / *Battlespace Info & Comm Rsc*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
making in physical and virtual agents as network size increases; will develop optimal methods to configure multi-genre networks in the presence of highly dynamic operational environment based on the information quality requirements derived from semantic understanding of the mission; will develop novel techniques to model and influence the evolution of complex adaptive groups and networks, and the diffusion of opinions in dynamic multi-genre networks; and will develop formal theories, techniques and frameworks to enable multi-level integrated fusion of disparate information sources in context of decision support objectives in coalition operations.			
Title: Assured Operations in the Physical, Social and Cyber Domain ***Description:*** Conduct research that will enhance the survivability of information by radically dispersing and continuously moving data across a multitude of inter-networked devices. This effort seeks to address the growing demands on information assurance, reliability and transmission in resource constrained environments. Theories and methods will be developed for securing information across heterogeneous devices/sources and networks, detecting and creating information obfuscation and deception techniques, managing risk of information quality and trust, and fusing and regenerating needs-relevant information from highly fragmented and dispersed data. ***FY 2018 Plans:*** Will identify and extend models that characterize the complex trade-offs inherent in radical dispersion of information among mobile tactical edge devices, such as communications, energy consumption, and security; will investigate approaches to minimize impact of dispersion on timely, secure, and efficient re-gathering of information, especially semantic-based techniques, that support situational awareness that is timely and mission relevant; will formulate requirements for formal models, theories and methods to execute and manage successful obfuscation of information within an environment of highly dispersed information; and will explore algorithms for adversarial-context-adaptive aggregation and presentation of information from distributed sources.	-	-	4.283
Title: Mobile Network Modeling ***Description:*** This research focuses on novel computational models, data structures, computational architectures, and techniques that enable predictions of performance and stability of large, complex communications networks. It takes into account the impact of Soldiers' information needs, modalities of access and use of communication networks in complex adversarial environments, high mobility, and adversarial effects such as jamming or cyber-attacks. Also to be considered are computational modeling approaches that capture dynamics of information that flows through the network and/or is stored within the network, and undergoes continual changes as new information arrives and other information ages or is refuted/superseded by newly arrived information ***FY 2018 Plans:*** Will develop scalable, high fidelity models for high capacity aerial networks in contested and benign environments; will develop HPC enabled finite difference time domain (FDTD) based approach to directly solve Maxwell's equations in the time	-	-	1.053

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
domain in order to provide high fidelity propagation loss models in complex environments, e.g., through large buildings, urban canyons, indoor/outdoor, tree canopy and tunnels; will develop heterogeneous network models that encapsulate the diverse characteristics and configurations of nodes supporting multimodal (RF and non–RF) waveforms based on actual multi-user channel measurements; and will develop appropriate metrics and analytical tools to characterize node- and network-level performance metrics such as data throughput, security, priority, and latency.			
Accomplishments/Planned Programs Subtotals	24.710	28.276	31.394

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army										Date: May 2017		
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) H52 / *Equip For The Soldier*			
COST ($ in Millions)	**Prior Years**	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
H52: *Equip For The Soldier*	-	1.113	1.133	1.156	-	1.156	1.178	1.204	1.228	1.252	-	-

A. Mission Description and Budget Item Justification

This Project supports basic research to achieve technologies for the Soldier of the future. This research is focused on core technology areas which include mathematical modeling, physical and cognitive performance, polymer science/textile technology, nanotechnology, biotechnology, and combat ration research. Research efforts are targeted at enhancing the mission performance, survivability, and sustainability of the Soldier by advancing the state-of-the-art in the sciences underlying human performance, clothing, and protective equipment to defend against battlefield threats and hazards such as ballistics, chemical agents, lasers, environmental extremes, and ration shortfalls.

Work in this Project provides theoretical underpinnings for Program Element (PE) 0602786A (Warfighter Technology).

The cited work is consistent with the Assistant Secretary of Defense, Research and Engineering Science and Technology focus areas and the Army Modernization Strategy.

Work in this Project is performed and managed by the Army Natick Soldier Research, Development, and Engineering Center (NSRDEC), Natick, MA.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Equipment for the Soldier	1.113	1.133	1.156
Description: This Project supports basic research to achieve technologies that support the Soldier of the future. Research areas include mathematical modeling, physical and cognitive performance, polymer science/textile technology, nanotechnology, biotechnology, and combat rations.			
FY 2016 Accomplishments: Explored enhancement of cognitive skills via trans-cranial direct current stimulation (t-DCS) and examined associated neural mechanisms responsible for skill improvement, with the goal of understanding whether t-DCS can complement Soldier training in improving cognitive and motor skills required for enhanced battle space awareness; examined a novel in-vitro gut fermentation model to gain fundamental understanding of dietary component influence on gut health as it relates to improving Soldier performance through nutrition.			
FY 2017 Plans: Explore the feasibility of creating materials with seemingly dissimilar functionalities such as water-requiring catalysis and water repellency; understand the effects of a three-dimensional (3D) surface structure on material multifunctional performance via the			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H52 / *Equip For The Soldier*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
use of nanoparticles and nanoparticulate films; explore the thermal responsive behavior of silver nanowire enhanced hydrogels to determine the feasibility of integration into protective materials that manage thermal properties such as body heat loss. ***FY 2018 Plans:*** Will assess the use of single-layer graphene as a universal substrate for flexible, conformable sensors with future application to textiles, wearable materials, food safety, and Soldier performance sensing platforms; create materials with orthogonal functionalities using nanoparticles and thin films to understand the molecular and surface structural phenomena which define compatibility; continue to explore the effects of silver nanowire in hydrogel substrates on conductive and thermal properties with a focus on 3D architecture arrangements.			
Accomplishments/Planned Programs Subtotals	1.113	1.133	1.156

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army											Date: May 2017	
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) H57 / *Single Investigator Basic Research*			
COST ($ in Millions)	**Prior Years**	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
H57: *Single Investigator Basic Research*	-	84.464	94.519	96.081	-	96.081	101.690	105.185	106.679	110.878	-	-

A. Mission Description and Budget Item Justification

This Project fosters extramural basic research to create and exploit new scientific discoveries and technology breakthroughs, primarily from universities, that will improve the Army's transformational capabilities. The Army Research Office of the Army Research Laboratory (ARL) maintains a strong peer-reviewed scientific research program through which leap-ahead technological solutions may be discovered, matured, and transitioned to overcome the technological barriers associated with next generation capabilities. Included are research efforts for increasing knowledge and understanding in fields related to long-term future force needs in the physical sciences (i.e., physics, chemistry, life sciences, and social sciences), the engineering sciences (i.e., mechanical sciences, electronics, materials science, and environmental science , and information sciences (i.e., mathematical sciences, computing sciences, and network sciences). Targeted research programs in nanotechnology, training and simulation, smart structures, multifunctional and micro-miniature sensors, intelligent systems, countermine, compact power, and other mission-driven areas will lead to a future force that is more strategically deployable, more agile, more lethal, and more survivable. The breadth of this basic research program covers approximately 800 active, ongoing research grants and contracts with leading academic researchers and approximately 1,600 graduate students yearly, supporting research at nearly 210 institutions in 50 states.

Work on this Project is performed extramurally by the ARL located in Research Triangle Park, NC.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Basic Research in Life Sciences	9.392	8.868	5.605
Description: Pursues fundamental discoveries in life sciences with the ultimate goal of facilitating the development of novel biomaterials to greatly enhance Soldier protection and performance. More specifically, i) molecular genetics research pursues fundamental studies in molecular and systems biology, and genetics, ii) neurosciences research investigating the physiology underlying perception, neuro-motor output, and potential methods of monitoring cognitive states during activity, iii) biochemistry research focuses on studies in structural and cell biology, metabolic processes, and biophysics, iv) research in microbiology pursues studies in microbial physiology, ecology, and evolution, v) social science research aims to elucidate the social, cultural, and other influences to human actions, and vi) auditory and signal processing research to map the cognitive implications of multisensory information integration.			
FY 2016 Accomplishments: Researched and designed neuro-cognitive computational models that detect a single-sound source(amongst multiple audible stimuli) to determine whether it is possible to link brain data to the segregated/isolated sound sources from noisy environments (may lead to new applications for effective auditory prostheses, automatic speech recognition, and other tools for enhanced Soldier auditory situational awareness in distracting environments); screened analogs of cellular cyclic diguanylate to identify and characterize a key potential pathway that mediates the formation of bacterial persister cells, a unique state that is known to			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H57 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
allow bacteria to survive exposure to antibiotics or environmental changes (may lead to new methods for the rapid and efficient treatment of wounds or systemic infections, particularly those caused by antibiotic-resistant bacteria); determined whether damage after acute myocardial infarction can be reduced by modulating oxygen demand (may lead to a metabolic-reduction strategy to reduce mortality on the battlefield); and evolved artificial enzymes, synthesized by assembling metal catalysts on protein scaffolds, to provide site-selectivity and precision not possible with traditional chemical catalysts (may provide new synthetic routes for advanced, well-defined materials including functionalized polymers and responsive materials, such as new fabrics to protect the Soldier and coatings to strengthen materiel). ***FY 2017 Plans:*** Will develop an analytical method to non-invasively characterize and predict the adaptation of neural circuits (may provide the critical and fundamental groundwork for improved rehabilitation from traumatic brain injury); explore the relationships between ApoE (a protein critical for cholesterol metabolism), mitochondrial function, and brain function (may have implications in the prevention and treatment of traumatic brain injury); investigate mechanisms of protein repair and maintenance that enables some organisms to produce hydrogen continuously in the presence of light (may enable improved hydrogen-producing engineered systems that could ultimately could be used to convert hydrogen to electricity through field-ready hydrogen fuel cells); and characterize and modify bacterial micro-compartments for potential use as an engineered organelle (specialized structure within a cell) (may provide a platform for the production of polymers or antimicrobials that normally require significant infrastructure to produce synthetically). ***FY 2018 Plans:*** Will develop a yeast-based system using a non-canonical amino acid incorporation technique to impart chemical modifications into putative adhesive proteins for the generation and selection of novel adhesive properties that, if successful, may enable new adhesive proteins for future uses ranging from next-generation therapeutics or transdermal drug delivery patches on or near the battlefield; will investigate and validate new candidate brain circuits, predicted to be involved in sleep and wake cycles, by identifying the distribution and dynamics of transcription-factor binding (as a proxy to assess gene expression), that if successful may reveal physiological functions of sleep-regulatory regions in a manner that has never been done before and, in the long term, may enable non-invasive methods for reducing sleep deficit and sleep need for Soldiers who operate in conditions not conducive to restful sleep; will investigate the potential of the insect-specific cysteine in acetylcholinesterase as a unique, unexplored, and viable target to develop insecticides with reduced insecticide resistance and minimal toxicity to mammals for the control of disease vectors, that if successful this should lead to new and more effective methods to control the spread of diseases such as malaria and Zika virus; will identify the proteins and pathways in the bacterium A. baumanii, responsible for maintaining cell viability under conditions of desiccation to review new methods for the engineering of bacterial cells capable of surviving harsh environmental conditions, that if successful may enable the development of sustainable in-field bio manufacturing processes.			
Title: Basic Research in Environmental Sciences	1.474	1.550	0.578

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H57 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Description: Basic research in the environmental sciences is needed for the Army to operate effectively because terrestrial and atmospheric conditions and processes affect virtually all aspects of Army activities. The earth's surface environment is a multifaceted and dynamic system, and there is an increasing need for multidisciplinary approaches to address important research questions within the atmospheric and terrestrial sciences. ***FY 2016 Accomplishments:*** Performed analysis of hill slopes using high-resolution topography to test the hypothesis that sharp breaks in topographic scaling metrics exist across climate and erosion rate gradients to generate high resolution information about terrain, vegetation, drainage, and erosion and have implications for change detection. ***FY 2017 Plans:*** Will develop a novel micro-optical sensor platform for the characterization and monitoring of atmospheric gases and aerosols (may lead to new methods for the characterization of aerosol particle shape and composition for rapidly identifying biological warfare agents); and explore and demonstrate a valid approach for short-term dating of heated structures and sediment burial events based on natural mineral luminescence (may provide a crucial tool for calibrating various detection methods for Improvised Explosive Devices (IEDs) and tunnels). ***FY 2018 Plans:*** Will design and utilize chamber experiments to determine partition coefficients for volatile organic compounds (VOCs) between soil, air, and airborne particles under various temperatures, and relative humidity settings that mimic real world conditions, that if successful, will provide data that may ultimately enable new tools for protecting the Soldier and other first-responders from exposure to toxic chemicals, or to sequester and remove VOCs; will design and synthesize simulated soil using synthetic colloids, demonstrate tunable inter-particle attraction to then examine the mechanical properties and flow of earth surface materials such as soils in dynamic environments that if successful may ultimately lead to future methods for safer infrastructure development, economical erosion control, efficient route planning.			
Title: Basic Research in Chemical Sciences	9.184	12.950	13.761
Description: Basic research to achieve advanced energy control, improved threat detection, and novel responsive materials for Soldier protection. Research efforts will lead to: light-weight, reliable, compact power sources, more effective, lower vulnerability propellants and explosives for tailored precision strikes with minimum collateral damage, new approaches for shielding the Soldier and Army platforms from ballistic, chemical, and biological threats, and reducing signatures for identification by the enemy, and advance warning of explosive, chemical, and biological weapons and dangerous industrial chemicals. ***FY 2016 Accomplishments:*** Investigated and characterized the decomposition mechanisms in methyl nitrate, an important high-energy material, which may lead to the engineering of explosives that are safer for transport and use by the Soldier; elucidated the basic mechanisms by			

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
which ion concentration and ion type affect the ordering and properties of micrometer-sized droplets of liquid crystals and the potential for these mechanisms to provide large-scale measurable changes (may lead to new capabilities for sense-and-respond chemical systems including self-healing, self-cleaning, and adaptive materials); synthesized new polymers composed of functional block copolymer membranes containing a high density of tailored pores and characterize the kinetics of the membrane transport properties to changes in external stimuli (may enable new applications in sensing, water purification, and breathable chem/bio protective clothing); and identified and characterized the active sites and intermediates in the electrochemical and photocatalytic reactions that occur in metal / semiconductor electrodes (may improve energy generation and storage). ***FY 2017 Plans:*** Will explore the fundamental aspects of oxygen and hydrogen transport gas diffusion electrodes (may enable new higher-performing power generation and energy storage technologies); devise new methods to synthesize infinite coordination polymers, that are a class of materials that possess tailorable properties and high surface areas (may provide novel materials with applications in sensing and catalysis); evaluate the role of the recently-discovered chemical reaction pathway termed “roaming mechanisms” in the decomposition of energetic molecules such as explosives (may enable improved control and development of next-generation propellants and explosives); and push the current boundaries of mechanical-chemical reactivity by designing and demonstrating new modes for activating molecules called mechanophores, which convert mechanical to chemical energy using pre-defined mechanisms (may lead to regenerative materials and controlled drug delivery). ***FY 2018 Plans:*** Will devise a new approach to fabricate precise conjugated polymers with controlled monomer sequences that in the long term, if successful, may lead to new semi-conducting materials with applications in sensing and detection; will establish the relationship between the 3D interphase structure, the interface impedance, and the electrochemical behavior of all-garnet solid-state systems, to enable the characterization of different sources of interfacial resistance and advance the current understanding of the solid-solid electrode/electrolyte interface that, if successful, could lead to new solid-state high-performance batteries with increased safety and reduced weight; will devise new methods to fabricate multifunctional nanostructures with features that can be dynamically regulated in space and time that in the long term, if successful, may ultimately lead to novel materials with applications in protection such as dynamic camouflage; will prepare a population of molecular hydrogen and determine the quantum state of the ensemble using multiphoton ionization-mass spectrometry that, if successful, may provide results ultimately leading to new methods in quantum computation for ultra-secure communication.			
Title: Basic Research in Physics ***Description:*** Focuses on research in many subfields of physics, including condensed matter physics, optical physics, atomic and molecular physics and quantum information, with an emphasis on discovering new realms of quantum and optical phenomena. Pursuit of fundamental physics in these subfields provides new opportunities for future developments in superior optics, ultra-sensitive sensors, and novel electronic architectures for classical and quantum computing.	16.295	18.678	17.861

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
FY 2016 Accomplishments: Developed new imaging methods such as non-linear optical spectroscopies for detecting spin-orbit coupling in advanced materials (may lead to new electronic technologies for sensors and computational hardware); investigated novel photon-photon interactions in a strongly-interacting cold atomic gas (may enable the first observation of the crystallization of a gas of strongly interacting photons, and in the long term, may lead to improvements in computation, measurement, and sensing); developed robust techniques for quantum sensing and measurement to overcome the fragility of quantum information due to unwanted environmental interactions (may provide unprecedented computation and communication capabilities); and characterized the unique electron dynamics of a particular class of magnetic materials known as ferroplasmons and develop theories to effectively model this behavior (may lead to lighter and smaller electronic components). ***FY 2017 Plans:*** Will characterize and devise methods to control the unique structural, orbital, and magnetic order in a particular structure of oxygen-containing compounds called isovalent oxide superlattices (may lead to unique advances in computing, passive sensors, and low-power electronics); systematically study and simulate the long-range interaction of quantum defects in materials (may lead to the development of new materials with properties previously inaccessible by traditional synthesis methods); utilize recently developed quantum algorithms for quantum chemistry to investigate new algorithms (may provide tools for the next-generation of communication devices); and develop a comprehensive theoretical framework of photonic metamaterials that control light in ways impossible with any natural material (may lead to a new class of lightweight electronics and photonics, such as low-power lasers and new imaging techniques). ***FY 2018 Plans:*** Will investigate a new class of photonic structures called photonic topological metamaterials that, if successful, will provide for better control of light in materials and in the long term will enable the design and creation of metamaterials to bend light in ways previously impossible and with lower loss, potentially providing new tools for microscopy, sensing, and power harvesting; will induce and demonstrate superconductivity in a material in which electrons behave in a way not achievable in traditional semiconductors, that in the long term may enable new electronics with dramatically-reduced power consumption; will use ultra-cold atoms in highly-excited states, called Rydberg atoms, to achieve quantum simulation of the Ising model of optical lattices (gaseous-phase atoms in a specialized ordered state) whereby certain atoms are in competition for spin state, that if successful may provide a method for predicting and measuring defects in materials, enabling the rapid development of new materials with desired properties; will demonstrate entanglement between neutral atoms and microwave photons in a superconducting cavity that, if successful, may enable the development hybrid quantum systems for use in ultra-secure communication devices.			
Title: Basic Research in Electronics and Photonics	10.706	11.260	8.634

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Description: Pursues discoveries in electronic sensing, optoelectronics, solid state and high frequency science, electromagnetics, microwaves, and power electronics for situational awareness, communications, information processing, electro-magnetic warfare, and power efficiency. ***FY 2016 Accomplishments:*** Established infrared and optical response in a carbon nanotube-oxide-metal rectenna for room temperature infrared detection; showed coaxial nanolasers scalable to deep-subwavelength dimensions suitable for on-chip interconnects; initiated metasurface control of THz radiation emission (direction and beam width) without external antenna, used variable surface wave propagation for chemical and biological agent sensing; and created a novel gallium nitride graphene hot electron transistor structure with THz frequency response for high data rate communications capable of transmitting greater amounts of data in a similar timeframe. ***FY 2017 Plans:*** Will show that thermal field gradients can be used to create additional stress in flexoelectric materials for improved energy harvesting and self-powered wireless sensors; show route to high modulation bandwidth surface emitting lasers with oxide-free vertical cavity approaches for high bandwidth photonic circuits; demonstrate radio frequency filters with unmatched quality factors nearing 400 (a factor of 5 better than the best previously reported, for ground mobile wireless communications); and create a gallium nitride based semiconductor/biomolecular platform for investigating guided growth of neuronal cells and hybrid functional neural circuits with both regular electronics and artificial neuronal circuit components for brain/machine interfaces. ***FY 2018 Plans:*** Will investigate photocurrent generation in new nanohybrid, carbon-based systems for ultraviolet (UV) and infrared (IR) detection; will create AlGaN nanowire arrays for deep UV electrically controlled lasers; will identify complementary metal–oxide–semiconductor (CMOS) nano-electrode arrays that interface with mammalian neuronal networks for potential restoration of neural functions; will create new capabilities for beam steering, beam forming, and waveform control in the terahertz range, by use of electrically switchable metasurfaces.			
Title: Basic Research in Materials Sciences ***Description:*** Research that provides innovations in materials design and process through the elucidation of fundamental relationships linking composition, microstructure, defect structure, processing and properties of materials. Revolutionary materials provide support for the Army in firepower, mobility, communications, personnel protection, infrastructure and installations, and will directly affect virtually all mission areas. ***FY 2016 Accomplishments:*** Enabled control of chemical and electrochemical reactions through the rational design of material architectures that control the spatial and temporal pathways of precursors, intermediates, and products in order to achieve dramatically enhanced efficiency and extraordinary energy production and storage; created stable free-standing single monomer thick novel two-dimensional	6.974	7.334	7.882

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
(2D) crystalline organic polymer nanosheets and covalent organic frameworks with unprecedented physical properties to enable tunable band gaps and high carrier mobility and enable polymer electronics; and developed a fundamental understanding of how to propagate a molecular-level detection event to a macroscopic material property change across multiple length and time scales to achieve revolutionary sensors with record sensitivity and selectivity. ***FY 2017 Plans:*** Will establish a new generation of spin-based devices based on optimized spin-orbit coupling heterostructures, such as nanoscale terahertz oscillators and ultrafast, low power spin logic/memory (for potential applications in non-volatile memory, high-speed logic and information processing, chemical sensing, and high-frequency communications); and utilize driven periodic excitation to systematically explore, demonstrate, and stabilize hidden phases of materials with unique physics and properties, enable the theoretical predictive capacity for such hidden phases, and synthesize strongly correlated (thin film) materials based upon these phases (for disruptive electrical, optical, thermal and magnetic applications). ***FY 2018 Plans:*** Will establish the design and directed assembly of nano-building blocks into complex, hierarchical 3D architectures capable of long-range control over multifunctional behavior and smart/dynamic responses using an additive 3D material assembly approach (for applications in manufacturing, novel electronics and communications); will create new systems exhibiting the physics of anyons (a type of quasiparticle that only occurs in two-dimensional systems) and topologically protected states (for unique communication, sensing and logic applications); and will develop a novel theory-experiment feedback loop to accelerate discovery of optimized novel polymer nanocomposites (PNCs) (for structural, durability, and light-weighting applications).			
Title: Basic Research in Computing Sciences ***Description:*** Provides the backbone for performing complex, multi-system analysis, modeling and simulation for understanding information systems. Advancements in computer sciences have a direct impact on enhancing the Warfighters' decision-making, situation awareness, command and control, as well as on the overall performance of weapon, intelligence, transportation and logistics systems. ***FY 2016 Accomplishments:*** Established novel representations, non-commutative information theory, and dimensionality reduction of multimodal data that enabled effective large scale multimodal data analyses, particularly image/video data analytics to extract actionable intelligence that supported Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR); created new techniques for the optimal realization of real-time multi-core systems as well as future hybrid and exascale systems through the asymptotic analysis of scheduling approaches and new energy efficient algorithms and architectures for efficient and timely processing of Army big data analytics and timely field information processing; investigated metrics for determining information	7.660	8.558	6.761

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
trustworthiness and for detecting deception in social data; and established new analytical models that quantify the resiliency of computing systems. ***FY 2017 Plans:*** Will create methods to allow message-passing distributed applications to efficiently solve problems in which data and/or memory requirements far exceed the amount of physical memory available in the underlying computer system (for efficient and timely processing of Army big data analytics, and efficiently solving large Army problems on computer clusters); establish unified visual data representation and methods for face recognition using low quality images and videos taken from unconstrained and multi-spectrum visual sources to achieve reliable performance of face recognition; establish guiding principles for cyber system maneuvering; and establish models and quantification metrics to analyze and evaluate the effectiveness of cyber system adaptation for better defense. ***FY 2018 Plans:*** Will create a new set of algorithms and software environments to perform scientific and geometric computations on heterogeneous processors to address issues related to load balancing between central processing unit (CPU) and graphics processing unit (GPU) cores, programmability, and power management that can be applied to enhance data processing capabilities for Army big data challenges; will establish new methodologies for modeling multimodal neural activity to design closed-loop adaptive algorithms for optimized brain-computer communication; and will develop novel cyber system adaptation techniques that will make Department of Defense (DoD) cyber systems more resilient and robust against potential cyber attacks.			
Title: Basic Research In Network Sciences ***Description:*** Focuses on gaining an understanding of the fundamental aspects of how networks develop, function, and adapt to the environment and the rate of information flow in man-made and naturally occurring networks. This understanding will have a direct impact on net-centric force operations, such as better communication system design and operations, and more efficient logistics or communications support. ***FY 2016 Accomplishments:*** Researched design mechanisms for deriving consensus, use in crowd-sourcing based solutions for resource allocation problems; studied how to design teams to optimize performance and diversify capabilities by building mathematical models that explain and predict how teams organize, exchanged information, build knowledge, influence, adapt, learn, and build consensus, resulting in actionable findings that create effective teams; studied how information from social networks was used to design and build adaptive, predictive solutions for managing load, mobility, and connectivity of communication networks; developed new control theory that facilitated task allocation and efficient exploration by autonomous teams; and developed spectral methods that determined important properties of random graphs and different classes of dynamics on networks related to flows/advection and	8.250	10.578	11.574

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
consensus processes that enabled the shaping and manipulation of networks to achieve dynamically reconfigurable desired information processing and energy distribution properties. ***FY 2017 Plans:*** Will investigate traffic flows under various conditions of communications service degradation to determine effect on the message throughput and delay; research interactions between systems requiring finite delay to improve real-time video and facilitate robotic control over disadvantaged communications networks; research modeling and control of finite-sized, far-from-equilibrium systems and bio-inspired information for perception and sensory motor control; research quantifiable informative models of team behavior as dynamical systems interacting over multiple networks to advance the network science of teams, and examination of the antecedents and effects of knowledge hoarding on team performance; and research modeling and detection of spurious and deceptive data in decisions based on crowd-sourcing. ***FY 2018 Plans:*** Will compare the performance of a reservoir computer, a novel neuromorphic self-timed computer architecture to state-of-the-art time series analysis and prediction methods using nonlinear Gaussian process regression to understand dynamics of systems with multiple time scales, multivariate data, and whether a hybrid reservoir Gaussian regression architecture surpasses the performance of either algorithm alone; will develop new algorithms and tools to design/re-design teams for improved performance over time, and discover the underlying mechanisms behind cyber flash mob behaviors as a manifestation of interconnected networks; will investigate the use of the software defined networking paradigm to adapt to rapidly changing network conditions without operator intervention to enable delay intolerant communications (voice, real-time video, and facilitate robotic control), and improve overall throughput to maximize situational awareness; and discover game theory principles in the world of biochemistry as it relates to strategies for leading tumor cells to degrade to a benign state.			
Title: Basic Research in Mechanical Sciences ***Description:*** Focuses on improved understanding of propulsion and combustion for improved efficiency and fuel flexibility, energetics initiation for insensitive munitions, fluid dynamics for rotorcraft, complex dynamic systems for novel sensors, energy generation and multi-dimensional systems, and solid mechanics especially at high strain rates in composite materials for novel armor and protection systems. ***FY 2016 Accomplishments:*** Gained understanding of dynamic responses of reactive metallic alloys (RMA) -- how they deform, fracture and combust to enable novel energetic material behaviors; developed microstructure-failure-strength relationships at mesoscales in lightweight metallic systems under dynamic loading conditions and bridge the gap between atomistic and continuum simulations for fundamental understanding of the processes governing the strength and toughness properties of solids; determined effectiveness of near-Kolmogorov & Kolmogorov scale forcing of shear layers for re-distributing energy from large scale turbulent structures to	6.671	6.977	6.556

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
small scales dominated by viscous dissipation for improved understanding of flow separation and control; and determined the biophysical principles underlying muscle's capability to store, dissipate, generate, and transfer energy. ***FY 2017 Plans:*** Will develop scientific principles for a new framework to enable new capabilities for programming deformable structures to perform dexterous interactions (deformable structures provide more accurate modeling); perform experimental measurements and develop theoretical models for the dynamics of anisotropic (i.e., non-spherical) particles in turbulent flows in order to elucidate and describe small-scale vorticity (i.e., curl of the velocity field) mechanisms in large-scale flows; develop reduced models for the combustion of alkane based fuels using a novel computational approach based on the synergy between atomistic simulations and network analysis of complex systems; and develop conceptual and analytical-computational models, based on the energy dissipated by interface fracture simulated by artificial equivalent shear viscosity and capable of effectively representing failure in complex composite materials subjected to high-strain rate dynamic loading. ***FY 2018 Plans:*** Will investigate an electrokinetic instability mechanism as an explanation for observed banding of microparticles which may lead to a novel process for microscale self-assembly of particles based on surface charge characteristics rather than bulk properties for novel material characteristics; will develop a detailed liquid-phase decomposition mechanism of RDX (a white solid explosive) which includes only elementary reactions which in turn will be used to predict the burn-rate and flame structure of RDX and the burn-rate modifier for future design of enhanced energetic materials; will derive a hierarchy of tractable analytical models of actuated elastica to enable distributed estimation and control of the intrinsic curvature and contact deformation/ adhesion properties of continuous media which will lead to enhanced robotic mobility; will investigate mechanics of dynamically growing crack interacting with an interface and associated stress wave attenuation in transparent layered material for potential development of blast resistant transparent material systems for future soldier system protection.			
Title: Basic Research in Mathematical Sciences	5.893	5.700	5.750
Description: Pursue the creation of new mathematical tools and methods for performing complex, multi-system analysis and modeling to enhance soldier and weapon-system performance. More specifically, the focus is on creating mathematical principles and practical algorithms for stochastic analysis and control, analysis and control of biological systems, numerical computation of infinite-dimensional systems, and modeling of irregular geometric and social phenomena. ***FY 2016 Accomplishments:*** Initiated basic research efforts that developed a theory of information at the quantum level that developed advanced geometric models of social processes as an alternative to network models, and developed mathematical models that achieved a two-way flow of information in the computational modeling of materials. These new mathematical areas brought new modeling capabilities in secure communications, the prediction of collective behavior, and enable designer materials. ***FY 2017 Plans:***			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will conduct basic research efforts to outline the major areas of the fundamental laws of quantitative biology, and develop fractional-order mathematical models (used in the study of anomalous behavior of dynamical systems) and corresponding computational methods for sharply-featured flows. Development of these new mathematical areas is expected to bring new modeling and predictive capabilities into biology, littoral flows, and in fluid-structure applications, such as turbines and windmills. ***FY 2018 Plans:*** Will initiate and conduct basic research efforts to develop the stochastic mathematics that underlie and enable the analysis of mean field games, and develop interdisciplinary approaches to reduce the order of the huge systems of equations generated for modeling the control of open quantum systems. Development of these new mathematical areas is expected to provide new mathematical tools to social scientists for modeling strategic decisions in reasoning about cultural norms and emergence of non-state adversarial groups among large populations and enable the design of more efficient quantum computation algorithms.			
Title: Basic Research in Simulation and Training	1.965	2.066	2.032
Description: Advances in simulation and training require basic research to understand neuronal changes that occur in the brain during successful and unsuccessful simulations and training. An interdisciplinary approach involving chemistry, computer science, engineering, mathematics, physics, and network science will be required to understand the molecular, cellular, developmental, structural, functional, and computational aspects of the brain during learning, simulation, and training. It will be necessary to determine how neural circuits develop and are arranged physiologically in individuals to produce cognitive computations during simulation and training. This research will also include extensive studies to discover and map the neural circuitry that enables cognitive adaptation, and the dynamic mechanisms of neural network modification need to be established. ***FY 2016 Accomplishments:*** Furthered the research in the design of mathematical models and experimental methods that map how the brain processes and integrates data received from all senses simultaneously (e.g., auditory, visual, olfactory), and determined the implications of this process in human decision making. In the long term, this research will provide tools to select individuals best suited for particular tasks and the development of more rapid and cost-effective methods to train warfighters for a range of complex tasks. ***FY 2017 Plans:*** Will elucidate the neural mechanisms underlying the perception of camouflaged objects (may provide new simulation methods for camouflaging personnel and material, and new training methods to help observers detect hidden objects); and research the neural code underlying auditory attention by mapping activity in multiple auditory-related sites simultaneously (may provide a new paradigm for enhancing Warfighter performance and caring for injured personnel). ***FY 2018 Plans:*** Will perform data fusion of electroencephalogram and functional magnetic resonance imaging data to yield spatial and temporal resolution of brain activity during search tasks, to test candidate mechanism developed in prior year in which data suggested area of brain was previously thought not to be involved in visual search may have role in camouflage-breaking, that in the long term,			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
if validated, may provide new simulation methods for camouflaging personnel and materiel, and new training methods to help observers detect hidden objects; will develop and validate new models of risks of error in human interaction in complex systems to determine risk points at which human behavior undermines system performance that in the long term, if successful, may lead to new automated methods to detect and mitigate human error in complex systems that could otherwise lead to catastrophic failures.			
Title: Expeditionary Materials Processing Science ***Description:*** Basic research coupling materials, innovative design, and manufacturing science to enable conversion of resources for meeting an expeditionary Army's requirements. This research will enable predictive material-to-materiel models for high-confidence, certifiable article production, high-fidelity expeditionary and versatile material-to-materiel processing capabilities, and a new generation of materials responsive to applied field for shape shifting and phase transformation. ***FY 2018 Plans:*** Will demonstrate proof-of-concept through design, synthesis, and validation of adaptive compounds that elicit activated remodeling via mechanochemistry to create synthetic materials with stress-responsive behavior analogous to that observed in biological systems. If successful, this approach may provide a method for creating materials that enhance protection for the Soldier by strengthening or changing shape in response to external stresses.	-	-	5.117
Title: Basic Research in Social Sciences ***Description:*** Social science research focuses on generating fundamental understanding of how social dynamics unfold, taking into account individual-level biophysiological factors contributing to social interaction (e.g., genetics, health, cognition, perception), group processes (e.g., interpersonal forces that determine influence, power, conformity), and the impacts of social institutions (e.g., economic processes, legal/governance structures, religious/belief systems, kin networks), with attention to the interconnections among these levels of analyses, and to the physical and natural environments in which human social dynamics are situated. This scientific understanding will improve situational awareness for Warfighters and analysts, improving efficacy of decision-making to achieve mission objectives. ***FY 2018 Plans:*** Will research to improve measurement and modeling of social dynamics by tying biometric measurement (e.g., facial thermography, neural imaging, nervous system monitoring, voice acoustic sensing) to interpersonal dynamics and perception networks in small and large groups in localized and dispersed environments; develop new analytic approaches to capture interdependence of actions and precursors of action as well as spatial and temporal dependencies across levels of analyses (i.e., individual-to-group-to-society) to improve predictive accuracy of models of social interaction; advance ecological modeling approaches developed to capture organizational and group dynamics to better understand human social dynamics at population levels; assess impact of media and information technology on cross-cultural diffusion of information, opinion, and influence.	-	-	3.970
Accomplishments/Planned Programs Subtotals	84.464	94.519	96.081

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
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C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) H66 / *Adv Structures Rsch*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
H66: *Adv Structures Rsch*	-	2.008	2.061	3.108	-	3.108	3.153	3.197	3.240	3.285	-	-

A. Mission Description and Budget Item Justification

This Project funds basic research for improved tools and methods to advance structural health monitoring capabilities and enable condition-based maintenance for sustainment of rotorcraft and ground vehicles. This research also enables the design and use of composite structures that can better address the cost, weight, performance, and dynamic interaction requirements of future platforms identified by the Army Modernization Strategy. Ultimately, these technologies result in safer, more affordable vehicles with a greatly reduced logistics footprint. This Project is a collaborative Army and National Aeronautics and Space Administration (NASA) effort that includes structures technology research into: structural integrity analyses; failure criteria; inspection methods which address fundamental technology deficiencies in both metallic and composite Army rotorcraft structures; use of composite materials in the design and control of structures through structural tailoring techniques; rotorcraft aeroelastic modeling and simulation; helicopter vibration (rotating and fixed systems); and the design and analyses of composite structures with crashworthiness as a goal. The problems in structural modeling are inaccurate structural analysis and validation methods to predict durability and damage tolerance of composite and metallic rotorcraft structures and inadequate structural dynamics modeling methods for both the rotating and fixed system components to address reliability issues for future aircraft. The technical barriers include a lack of understanding of failure mechanisms, damage progression, residual strength, high-cycle fatigue, the transfer of aerodynamic loads on the rotor to the fixed system, and impact of these unknown loads on aircraft components. Technical solutions are focused on: advanced fatigue methodologies for metallic structures, improved composites technology throughout the vehicle, long-term investigation of integrated stress-strength-inspection, advanced methods for rotor system vehicle vibratory loads prediction, improved methods to predict vehicle stability, and improved analyses to address Army Aviation requirements. These advancements will extend service life, reduce maintenance costs, enhance durability, and reduce the logistics footprint of existing and future Army vehicles. This is the only basic research Project supporting investigations for rotorcraft and ground vehicle structures within the Department of Defense.

Work in this Project supports key Army needs and provides the technical underpinnings to Program Element (PE) 0602211A (Aviation Technology).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas.

Work in this Project is performed by the Army Research Laboratory (ARL) at Aberdeen Proving Ground, MD and NASA Langley Research Center, Hampton, VA.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Structural Analysis and Vibration Methods	2.008	2.061	-
Description: This research explores new structural analyses and validation methods to achieve more accurate predictions of durability and damage tolerance in composite and metallic rotorcraft structures and evaluates structural dynamics modeling methods to address critical reliability issues in the rotating and fixed system components of future aircraft.			
FY 2016 Accomplishments:			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Investigated (experimentally and theoretically) the electrical, thermal, magnetic, and mechanical property changes for structural materials and composites under complex loading conditions for the purpose of assessing the practicality of damage-detection sensing modes, and for developing damage progression models; and researched novel processes to enhance the electrical, thermal, mechanical and magnetic performance. ***FY 2017 Plans:*** Will develop innovative theoretical models that accurately predict material crack growth and structural fatigue life for use in increasing the fatigue-failure resistance of metallic and composite structural components for Army platforms; and investigate and identify materials damage precursors in structures by utilizing material electrical, thermal, mechanical, and/or magnetic response to enable strategies to extend the life of critical structural components by tailoring usage based upon early damage detection.			
Title: Air Vehicle Structures & Dynamics Research ***Description:*** Conduct basic research in advanced analytical methodologies and techniques for understanding and predicting the health and performance of rotorcraft structures. Develop and experimentally validate technologies, models, and approaches to increase the reliability, useful life, or performance of components in vertical takeoff and landing systems. ***FY 2018 Plans:*** Will investigate rotor blade morphing technology by comparing and improving analytical predictions with data collected from low-speed wind tunnel tests as an approach to reducing vibration and potentially enable swashplate-less flight; will investigate structure fatigue models to correlate damage indicators and more accurately predict the remaining useful life of structural components; and will improve theoretical computational algorithms to more accurately predict structural durability and damage tolerance.	-	-	2.104
Title: Reconfigurable Platform Mechanics & Propulsion ***Description:*** Conduct basic research in reconfigurable platform mechanics and propulsion science technologies to enable high-speed Vertical Take-Off and Landing (VTOL). Investigate reconfigurable technologies for improved performance, stability, and handling qualities ***FY 2018 Plans:*** Will investigate aeromechanic characteristics of morphing structures and reconfigurable propulsion concepts such as engine cycles and propulsor drive system configurations.	-	-	1.004
Accomplishments/Planned Programs Subtotals	2.008	2.061	3.108

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
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C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) H67 / *Environmental Research*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
H67: *Environmental Research*	-	0.877	0.928	1.036	-	1.036	1.056	1.076	1.099	1.121	-	-

A. Mission Description and Budget Item Justification

This Project focuses basic research on innovative technologies for industrial pollution prevention (P2) that directly supports the Army production base and weapon systems and also addresses non-stockpile chemical warfare (CW) site remediation. Work in pollution prevention invests in next generation manufacturing, maintenance, and disposal methods that will result in significantly reducing the usage of hazardous and toxic substances and their associated costs. The goal is to decrease the overall life-cycle costs of Army systems by 15-30% through the application of advanced pollution prevention technologies. Non-stockpile CW efforts include establishing the ecotoxicity of CW compounds, environmental fate and effect of CW compounds in soils and biodegradation of CW compounds. Pollution prevention thrusts include: environmentally acceptable, advanced, non-toxic processes to manufacture lightweight alternative structural materials to enhance weapon system survivability; clean synthesis of more powerful and improved energetic compounds to eliminate the use of hazardous materials and minimize the generation of wastes; and surface protection alternatives to hazardous paints, cadmium, chromium, and chromate conversion metal and composite surfaces.

Work in this Project complements and is fully coordinated with the Army Environmental Requirements Technology Assessment (AERTA) requirements and contains no duplication with any effort within the Military Departments.

The cited work provides the technical underpinnings for Program Element 0602618A (Ballistics Technology).

Work in this Project is performed by the Army Armament, Research, Development and Engineering Center, Picatinny, NJ.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Industrial Pollution Prevention	0.877	0.928	1.036
Description: This effort conducts research on innovative environmentally-friendly technologies that support the warfighter (focusing on pollution prevention technologies).			
FY 2016 Accomplishments: Performed research involving hazardous materials and wastes generated from production of energetic materials, additive manufacturing, and weapon systems; investigated efforts to enhance technologies to support Soldier systems; and investigated selected projects to comply with the Office of the Secretary of the Army's environmental initiatives.			
FY 2017 Plans: Will investigate and perform basic research for the reduction of hazardous materials generated from energetic materials formulations, additive manufacturing, and weapon systems designs focusing on pollution prevention technologies. This includes			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
investigating new innovative energetic materials, as well as analyzing selected projects and their respective technologies for their compliance to the Office of the Secretary of the Army's environmental initiatives. ***FY 2018 Plans:*** Will investigate and perform basic research on the development of novel energetics for the reduction of hazardous materials in the processing of energetics. Additional research will include the investigation of airborne lead reduction for Army weapon systems as well as investigating new advanced surface coating products to minimize human health, environmental and long-term sustainable risks.			
Accomplishments/Planned Programs Subtotals	0.877	0.928	1.036

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) S13 / *Sci BS/Med Rsh Inf Dis*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
S13: *Sci BS/Med Rsh Inf Dis*	-	10.951	11.318	11.039	-	11.039	11.272	11.509	11.501	12.253	-	-

Note

In Fiscal Year (FY) 2017: Prevention/Treatment of Parasitic (organism living in or on another organism) Diseases research area and the Vaccines for Prevention of Malaria research area are merged into one task area titled Parasitic Diseases – Drugs and Vaccines

A. Mission Description and Budget Item Justification

This Project fosters basic research leading to medical countermeasures for naturally occurring diseases impacting military operations. Basic research for this project provides an understanding of the mechanisms that make organisms infectious and mechanisms that render the human body response effective, preventing diseases caused by infectious agents. Understanding the biological characteristics of infectious organisms also enables the development of point-of-care and laboratory-based diagnostic tools (used to identify the nature and cause of a particular disease). Understanding of disease transmission by insects and other organisms helps in developing new interventions to prevent transmission of such diseases. Infectious disease threats from malaria, diarrhea, and dengue (a severe debilitating disease transmitted by mosquitoes), common where Warfighters are stationed across all Unified Combatant Commands, are the highest priorities for basic research.

Research conducted in this Project focuses on the following four areas:

(1) Prevention/Treatment of Parasitic (organism living in or on another organism) Diseases
(2) Bacterial Disease Threats
(3) Viral Disease Threats
(4) Vector Identification and Control

Work is managed by the Medical Research Materiel Center (MRMC) in coordination with the Naval Medical Research Center (NMRC). The Army is responsible for programming and funding all Department of Defense naturally occurring infectious disease research requirements, thereby precluding duplication of effort within the Military Departments.

Work in this Project complements and is fully coordinated with Program Element (PE) 0602787A (Medical Technology).

The cited work is consistent with the Assistant Secretary of Defense, Research and Engineering Science and Technology, focus areas and the Army Modernization Strategy.

Work in this Project is performed by the Walter Reed Army Institute of Research (WRAIR) and NMRC, Silver Spring, MD, and their overseas laboratories.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Prevention/Treatment of Parasitic (organism living in or on another organism) Diseases	3.872	-	-

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Description: This effort is to better understand the biology of malaria and leishmaniasis (a skin-based disease transmitted by sand flies predominantly exhibited as skin sores) parasites and to gain the necessary foundation for discovering medical countermeasures to protect military personnel from infection. Malaria, which can cause fatal and chronic disease, is the most significant military infectious disease threat. Because the malaria parasite becomes resistant to drugs over time, it is necessary to continually search for parasite weaknesses that can be exploited by different drugs and vaccines. In FY17 this research area and the Vaccines for Prevention of Malaria research area are merged into one task area titled Parasitic Diseases – Drugs and Vaccines. ***FY 2016 Accomplishments:*** Optimized the safety and effectiveness of next generation malarial prophylaxis (measures taken to prevent health problems) candidate drugs based on lead candidates identified in FY15, through structural modifications of selected compounds (Triazine and Pyrimidinylguanidine); and will identify new lead candidates.			
Title: Vaccines for Prevention of Malaria ***Description:*** This effort is to better understand and identify new proteins in the design of candidate vaccines for various types of malaria including the severe form of malaria (Plasmodium falciparum) and the less severe but relapsing form (Plasmodium vivax). A highly effective vaccine could reduce/eliminate the use of anti-malarial drugs and also reduce the development of drug resistance to current/future drugs. In FY17 this research area and the Drugs to Prevent/Treat Parasitic Diseases research area are merged into one task area titled Parasitic Diseases – Drugs and Vaccines. ***FY 2016 Accomplishments:*** Identified and characterized mechanisms of protective immunity elicited by new candidate malaria protein-based antigens; define a strategy to develop a candidate vaccine against falciparum malaria that contains several different kinds of antigens, to improve vaccine effectiveness; and identify new recombinant (artificially produced via genetic engineering) protein-based vaccine candidate(s) against vivax malaria.	2.493	-	-
Title: Basic Research on drugs and vaccines against parasitic diseases ***Description:*** Malaria, which can cause fatal and chronic disease, is the most significant military infectious disease threat. This effort seeks to better understand the biology of malaria and leishmaniasis (a skin-based disease transmitted by sand flies predominantly exhibited as skin sores) parasites and to gain the necessary foundation for discovering medical countermeasures to protect military personnel from infection. Because the malaria parasite becomes resistant to drugs over time, it is necessary to continually search for parasite weaknesses that can be exploited by different drugs and vaccines. This effort seeks to better understand small molecule therapeutics and prophylactics, to overcome drug resistant organisms and identify new proteins in the design of candidate vaccines for various types of malaria including the severe form (caused by Plasmodium falciparum) and the less severe but relapsing form (caused by Plasmodium vivax). In FY17 the Prevention/Treatment of Parasitic Diseases research	-	6.583	6.188

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
area and the Vaccines for Prevention of Malaria research area are merged into one task area titled Parasitic Diseases – Drugs and Vaccines. ***FY 2017 Plans:*** Will identify new formulations (increase/decrease drug quantity in single administered dose, change chemical structure to increase circulating dose) of selected compounds Will identify new lead candidates from the 8-aminoquinoline class of compounds used to treat malaria. Will continue to identify and select additional methods to formulate new recombinant (artificially produced via genetic engineering) protein-based vaccine candidate(s) against vivax malaria (the most common of four types of malaria species) to initiate assessment of its immunogenicity (ability to provoke an immune response) in small animals. ***FY 2018 Plans:*** Will assess new lead candidates from the Triazine class of compounds. Will identify and assess new lead candidates from the pyrimidinylguanidine class of compounds (a newly discovered family of similar chemical compounds that are active against malaria parasites in experimental animals) and a new primaquine-like compound used to prevent or treat malaria. Will continue to monitor for emergence of drug resistant malaria in Asia, Africa and South America. Will fabricate newly discovered malaria proteins (artificially produced via genetic engineering) to characterize their ability to prevent malaria in experimental animals. Will continue to identify new formulations or delivery methods of malaria proteins for inclusion into malaria vaccines.			
Title: Bacterial Disease Threats ***Description:*** This effort is to better understand the biology of bacterial organisms and their effects on humans, how to prevent wound infections, prevent/treat diarrhea (a significant threat during initial deployments), and scrub typhus (a debilitating mite-borne disease that has in recent history been the leading rickettsial disease to impact US military operations and is developing resistance to currently available antibiotics). ***FY 2016 Accomplishments:*** Identified and explore various methods to develop a combination vaccine against three bacterial agents (Campylobacter, Shigella, and enterotoxigenic E. coli.) that together are responsible for most diarrhea cases in deployed Warfighter's; and continue epidemiological studies on various deployed populations with regard to disease-causing microorganisms of the digestive system. These epidemiological studies aid the planning and evaluation of strategies to prevent diarrhea in deployed Warfighters. Define indicators of vaccine effectiveness (correlates of protection) in animal models of bacterial diarrhea. The correlates of protection aid in vaccine development; Continue to identify additional therapies and tools for preventing and treating wound infection and improving wound healing; and evaluate novel technologies for treatment and prevention of multi-drug resistant bacteria most commonly encountered in trauma-associated infections. ***FY 2017 Plans:***	1.496	1.532	1.582

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will continue to identify new antigen (substance that causes your immune system to produce antibodies) targets and explore their immunogenicity potential for the development of vaccines against Campylobacter, Shigella, and enterotoxigenic E. coli. (ETEC) which together are responsible for most of the cases of diarrhea in deployed Warfighters. Will continue to perform epidemiological studies in various deployed populations to identify relevant types of pathogens to inform vaccine development and include these in vaccine formulations. Will continue to identify indicators of vaccine effectiveness (correlates of protection) in animal models of bacterial diarrhea in order to predict vaccine effectiveness in humans. Will continue identification and characterization of potential therapeutics and/or diagnostic targets within the host or pathogen associated with multi-drug resistant wound infections and/or biofilm (a group of microorganisms that stick to each other, on a surface) formation. ***FY 2018 Plans:*** Will characterize the newly-identified antigens (substances derived from the agent which stimulate immune systems to produce antibodies) from Campylobacter, Shigella, and ETEC which together are responsible for most of the cases of diarrhea in deployed Warfighters. Will review epidemiology data from deployed populations to determine which pathogens should be included in future vaccines. Will continue to discover/identify indicators of vaccine effectiveness (correlates of protection) identified in animal models of bacterial diarrhea for protection from disease.			
Title: Viral Threats Research ***Description:*** This effort is to better understand highly lethal or incapacitating viruses, including those that cause hemorrhagic diseases (viral infection that causes severe internal bleeding) such as dengue hemorrhagic fever (life-threatening form if disease caused by the Dengue virus, transmitted by mosquitoes) and Hantaviral pulmonary syndrome (caused by hantavirus infection resulting in internal bleeding; can be transmitted by exposure to rodents or their droppings). Basic research includes understanding risk to the Warfighter of contracting a viral disease based on its prevalence in the respective area of operations, viral biology (structure, function, life cycle of the virus and its ecological factors), the disease process, and disease interaction (symptomology) with the human body. ***FY 2016 Accomplishments:*** Assessed host and viral determinants of dengue fever disease severity among populations at risk; continue to explore innovative vaccine designs, adjuvant systems and delivery methods for a dengue virus vaccine; and continue studies to identify and evaluate the role of human cells and antibodies in developing medical countermeasures to prevent and/or treat diseases caused by hantaviruses and other lethal viruses (i.e. Crimean Congo Hemorrhagic Fever (CCHF) virus. ***FY 2017 Plans:*** Will continue to identify regions of the virus particles that induce protective immune response against all four serotypes of dengue fever virus; Will study the role of human cells and antibodies recovered from patients vaccinated during dengue vaccine trials in Asia and Latin America and dengue human infection model studies conducted in the United States to identify new methods of vaccine formulations. Will investigate the possible role of nonspecific defense mechanisms that come into play immediately	1.595	1.653	1.688

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S13 / *Sci BS/Med Rsh Inf Dis*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
or within hours of a pathogen's appearance in the body to develop protective countermeasures. Will identify viral sequence based determinants (particles that cause infection) obtained from dengue viruses recovered from patient populations enrolled in expanded (FDA) safety/efficacy/dosing study in humans to understand protection mechanisms. Will identify and validate viral particle neutralization assay that will be used to measure neutralizing antibodies against Hantavirus. Will determine an optimal delivery device for the Hantavirus vaccine. ***FY 2018 Plans:*** Will continue to characterize the role of human cells and antibodies recovered from patients vaccinated during dengue vaccine trials in Asia and Latin America and dengue human infection model studies conducted in the United States to identify new methods of vaccine formulations. Will continue assessment of host immune responses against dengue virus proteins from patient populations enrolled in expanded Food and Drug Administration (FDA) safety/efficacy/dosing vaccine studies and dengue virus challenge studies in humans to understand protection mechanisms. Will use molecular approaches (recombinant Deoxyribonucleic Acid (DNA) based techniques) to determine structures of protective antibodies against dengue. Will identify vaccine technologies to produce antibody products that might be used to prevent or treat disease by lethal viruses such as Hantavirus, South American and African Hemorrhagic viruses.			
Title: Vector Identification and Control	1.495	1.550	1.581
Description: This effort conducts research to investigate the biology of biting arthropods (i.e. mosquitoes and sand flies) and other vectors (organisms that transmit disease) and their control. This effort also expands identification of infectious disease pathogens in vectors and disease surveillance capabilities in the field. This research will help to direct new interventions into preventing disease transmission. ***FY 2016 Accomplishments:*** Leveraged worldwide capabilities utilizing an information exchange program involving site visits to museums (e.g. United Kingdom (UK)/ Museum Natural History, London; Belgium/Royal Museum of Central Africa, Tervuren) to compare and exchange insect type specimens assisting development of tools to identify wild-caught insects; complete the Identification Guide to the Culex mosquitoes of East, West and Central Africa; leverage studies with the Defense War Fighter Program and Global Emerging Infectious Systems to develop novel pesticide application strategies and passive repellent systems/strategies for vector control. ***FY 2017 Plans:*** Will explore the current gaps in the area of vector control. Will explore the latest technology in vector-borne disease risk assessment tools to manage data and support decision making for vector control operations. Will explore integrated vector control strategies, new insecticides or unique formulations, application equipment, and non-chemical control methods. Will identify novel molecular markers or antigens that can be used to produce better detection tools. This will be a crucial component for the successful development of multiplexed detection assays to identify multiple pathogens in a vector population. ***FY 2018 Plans:***			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S13 / *Sci BS/Med Rsh Inf Dis*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will identify unique biological markers (e.g., proteins, genes) that can be used to produce improved detection tools that can identify multiple pathogens in a vector population. Will identify technology in vector-borne disease risk assessment tools to manage data and support decision making for vector control operations. Will explore integrated vector control strategies to include new insecticides or unique formulations, application equipment, and non-chemical control methods.			
Accomplishments/Planned Programs Subtotals	10.951	11.318	11.039

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) S14 / *Sci BS/Cbt Cas Care Rs*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
S14: *Sci BS/Cbt Cas Care Rs*	-	8.923	5.699	5.296	-	5.296	5.610	6.559	7.042	7.077	-	-

Note

In Fiscal Year (FY) 2015 and 2016 the funding for Clinical and Rehabilitative Medicine was located in this Project. The Clinical and Rehabilitative Medicine basic research effort moves to Project ET6 starting in FY17.

A. Mission Description and Budget Item Justification

This Project supports basic research to understand the fundamental mechanisms of severe trauma to advance treatment and surgical procedures to save lives and improve medical outcomes for the Warfighter. Experimental models are developed to support in-depth trauma research studies. This Project includes studies of predictive indicators and decision aids for life-support systems, studies to heal and repair burned or traumatically injured hard and soft tissues of the eye, face, mouth, and extremities, control of severe bleeding, and traumatic brain injury (TBI). Such efforts will minimize lost duty time and provide military medical capabilities for far-forward medical/surgical care of injuries.

Research conducted in this Project focuses on the following five areas:
(1) Damage Control Resuscitation
(2) Combat Trauma Therapies
(3) Combat Critical Care Engineering
(4) TBI
(5) Clinical and Rehabilitative Medicine (moves to Project ET6 in FY17)

Work in this Project complements and is fully coordinated with Program Element (PE) 0602787A (Medical Technology).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology, priority focus areas and the Army Modernization Strategy.

Work in this Project is performed by the Walter Reed Army Institute of Research (WRAIR), Silver Spring, MD; the United States Army Dental Trauma Research Detachment (USADTRD) and the United States Army Institute of Surgical Research (USAISR), Joint Base San Antonio, TX.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Damage Control Resuscitation	1.262	1.644	1.669
Description: This effort conducts studies to define and identify cellular processes and metabolic (biochemical activity) mechanisms associated with blood clotting to understand the relationships between the human immune processes and bleeding in trauma.			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S14 / *Sci BS/Cbt Cas Care Rs*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
FY 2016 Accomplishments: Performed cell-based (in vitro) studies of drugs to assess their ability to protect cells and tissues from harmful effects of severe blood loss. ***FY 2017 Plans:*** As follow on to the FY16 work, will perform cell-based (in vitro) studies of small-volume cytoprotectant (protect cells from freezing effects) drugs as resuscitation adjuncts. Will characterize response of capillary function in tissue from traumatic bleeding and explore applications of stem cell technology for treatment of traumatic bleeding. ***FY 2018 Plans:*** Will use cell culture (cells grown under controlled conditions) techniques to understand the potential blood-clotting and anti-inflammatory effects of stem cells. Will use cell culture methods to screen small-volume cytoprotectant (protect blood-deprived cells from further damage and restore normal function) drugs. Will characterize response of tissue capillary (smallest of the body's blood vessels) function to traumatic bleeding.			
Title: Combat Trauma Therapies ***Description:*** This effort conducts studies of trauma to tissues and organs, including dental (facial and oral) injuries, extremity wounds and fractures, and burns, and ways to mitigate and/or repair this damage. ***FY 2016 Accomplishments:*** Developed models that identified optimal combinations of skin components for transplantation as a potential means to repair severe facial injuries. As follow on to FY15 work, study molecular, cellular and structural skin components to identify mechanisms to optimize healing, appearance and function following traumatic injury of hard and soft tissues. ***FY 2017 Plans:*** Will perform genetic analyses of bacteria to aid in developing improved products to prevent or treat infected facial, mouth, and extremity wounds. Will identify combinations of antiseptics and antimicrobial peptides (constituent parts of proteins) that interact together to eliminate bacterial infections in wounds of the face, mouth, and extremities. ***FY 2018 Plans:*** Will build upon work from FY17 to perform genetic analyses of wound bacteria to aid in identifying improved products to prevent or treat infected facial, mouth, and extremity wounds. Will continue to identify wound healing agents (including re-purposed drugs and combination products) that mitigate wound infection. Will begin work to identify ways to reduce injury progression and mitigate eschar (dead necrotic tissue formed on the surface of the skin after burn injury)-induced inflammation, and/or resolve dysregulated (impairment of a physiological regulatory mechanism) inflammation in burn wounds when early debridement (surgical removal of dead tissue) is not possible.	3.132	1.889	1.432
Title: Combat Critical Care Engineering	0.551	0.857	0.868

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S14 / *Sci BS/Cbt Cas Care Rs*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Description: This effort conducts basic science studies of vital sign (e.g. heart rate, blood pressure, blood oxygen concentration) responses to trauma as predictors of medical outcomes and as a basis for developing life-saving interventions. This effort also conducts basic science studies to support development of technologies to preserve function of vital organs following traumatic injury. ***FY 2016 Accomplishments:*** Validated sensitivity and specificity of blood-loss prediction algorithm under differing clinical and environmental conditions, for example heat, cold, low oxygen, and stress; start basic research examining potential use of stem-cell (primitive cells that give rise to more specialized cells of the body) based therapy for treatment of lung injury; and start basic research to explore means to safely provide oxygen to, and remove carbon dioxide from casualties with severe lung injuries without further damaging the lungs. ***FY 2017 Plans:*** Will develop physiological models to aid in solving current pre-hospital clinical problems as identified by the Committee on Tactical Combat Casualty Care. Will develop models to address airway management and early detection of tension pneumothorax (a trapping of air in the space between the lung and chest wall that if untreated will collapse the lung and push the heart and windpipe against the other side of the chest) and to address pain management in far forward areas and during transport. ***FY 2018 Plans:*** Will progress FY17 efforts to identify new methods to improve prehospital airway management and detection of tension pneumothorax (a life threatening condition caused by a collapsed lung). Will advance work from FY17 to develop animal models in which to study impact of pain and pain drugs on resuscitation and stabilization outcomes following traumatic injury. Will perform research to identify lung stem cells that may be used to treat lung injuries.			
Title: Traumatic Brain Injury ***Description:*** This effort conducts basic research in poly-trauma (multiple injuries)/TBI model, mechanisms of cell death, and the discovery of novel drugs and medical procedures to mitigate the effects of TBI. ***FY 2017 Plans:*** Will continue work from FY16 to apply systems biology methods to identify new proteins that appear in blood as result of TBI. Will examine metabolic changes (changes in the way the neuron assimilates nutrients and converts them to energy to support nerve function) as mechanisms or markers of TBI. Will develop models of acute, severe TBI in combination with severe bleeding and lung injury supporting studies to determine if these other injuries and their subsequent treatment may worsen TBI outcome. ***FY 2018 Plans:***	-	1.309	1.327

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S14 / *Sci BS/Cbt Cas Care Rs*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will apply systems biology methods to identify new proteins that appear in blood as a result of TBI. Will examine metabolic changes (changes in the way the neuron assimilates nutrients and converts them to energy to support nerve function) as mechanisms or markers of TBI.			
Title: Clinical and Rehabilitative Medicine ***Description:*** This effort conducts basic studies of mechanisms of tissue growth and traumatic injury to gain an understanding that will assist or facilitate the healing or transplantation process. The focus is placed on severe trauma to the limbs, head, face (including eye), genitalia (organs of reproduction), and abdomen. In FY15 and 16 the funding for this research effort is in Project S14. The Clinical and Rehabilitative Medicine basic research effort has a separate Project starting in FY17 (ET6). ***FY 2016 Accomplishments:*** Analyzed the cellular mechanisms and functional deficits of eye trauma injuries; advance promising therapies for eye trauma wounds into the applied research phase and correlate the epidemiology of eye trauma with clinical outcomes; and explore innovative strategies to regenerate and reconstruct hard (e.g. bone) and soft (e.g. skin and muscle) tissues to enable promising approaches to advance into the applied research phase through directed experimentation in the lab and in animal models to address injury of the extremities, face, genitalia, and abdominal regions. Advance novel immunomodulation (modification of the immune response / immune system functioning) technologies to treatment model development to enable improved outcomes in hand and face transplant procedures.	3.978	-	-
Accomplishments/Planned Programs Subtotals	8.923	5.699	5.296

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) S15 / *Sci BS/Army Op Med Rsh*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
S15: *Sci BS/Army Op Med Rsh*	-	6.492	6.688	7.116	-	7.116	6.443	9.654	9.093	8.710	-	-

A. Mission Description and Budget Item Justification

This Project fosters basic research on physiological and psychological factors that limit Warfighter effectiveness and on characterization of health hazards generated by military systems that result as a consequence of military operations; includes research on the neurobehavioral aspects of post-traumatic stress; develops concepts for medical countermeasures to prevent or mitigate the effects of muscle and bone injury to include reducing the effects of sleep loss and other stressors on Warfighter performance. The hazards of exposure to directed energy, repetitive use, fatigue, heat, cold, and altitude are also investigated under this Project.

Research conducted in this Project focuses on the following four areas:

(1) Injury Prevention and Reduction
(2) Physiological Health
(3) Environmental Health and Protection
(4) Psychological Health and Resilience

Work in this Project complements and is fully coordinated with Program Element (PE) 0602787A (Medical Technology).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology, priority focus areas and the Army Modernization Strategy.

Work in this Project is performed by the Walter Reed Army Institute of Research (WRAIR), Silver Spring, MD; United States Army Institute of Surgical Research (USAISR), Joint Base San Antonio, TX; and the United States Army Research Institute of Environmental Medicine (USARIEM), Natick, MA.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Injury Prevention and Reduction	1.458	1.304	1.229
Description: This effort identifies biological patterns of change in Warfighters during states of physical exertion, identifies physiological (human physical and biochemical functions) mechanisms of physical injury and exertion that will predict musculoskeletal (muscle, bone, tendons, and ligaments) injury. Also includes the characterization of ocular injury pathways resulting from blast exposure in small animal models.			
FY 2016 Accomplishments: Identified the mechanism of nerve remodeling to enhance functional neuromuscular (central nervous system control of muscle functioning) adaptation following muscle injury and determine the effect of inflammatory processes on muscle repair / regeneration, incomplete healing and subsequent risk of re-injury; and identify possible points of intervention to minimize			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S15 / *Sci BS/Army Op Med Rsh*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
musculoskeletal injuries or re-injury based on modifiable and non-modifiable risks. Collect ocular injury data from blast exposure in multiple animal species for the development of scaling models. ***FY 2017 Plans:*** Will use computational modeling to reveal mechanisms of control of the inflammatory and regenerative response to tissue damage. Will identify musculoskeletal damage markers that provide damage/injury resolution assessment and validation of those markers in mouse models of musculoskeletal injury. Will develop non-invasive tools capable of supporting decisions for treatment, prognosis and return to duty following tissue injury with applicability far forward. Will develop blast injury scaling laws for the eyes across species (including mice, rabbits and humans), which enables the development of a surrogate human ocular injury model. ***FY 2018 Plans:*** Will use computational analysis and modeling to define the inflammatory and regenerative response to tissue injury. Will formulate blast injury scaling laws for the eyes across species, completing studies on larger animals (rabbits, pigs), with the ultimate goal of developing a surrogate human ocular injury model. Will identify biochemical, physiological, and genetic markers of pro- and anti-inflammatory events in skeletal muscle and bone using cell, animal, and human models for eventual transition to clinical trials. Will identify molecular, pharmacological, and (or) nutritional interventions to reduce musculoskeletal injury and promote repair.			
Title: Physiological Health ***Description:*** This effort conducts research on the physiological mechanisms of sleep, fatigue, and nutrition on Warfighter performance and well-being. ***FY 2016 Accomplishments:*** Identified nutrients (carbohydrates, proteins, fats, vitamins, etc.) that could regulate the recovery of muscle cells after musculoskeletal injury; identify factors affecting the absorption of nutrients that contribute to bone structure and function; determine the impact on gut health of only eating operational rations; identify the brain neurochemistry (the interaction between small molecules and cells via signaling between and within cells) and functional pathophysiology (molecular and cellular signature of disease) associated with repeated blast exposures; and identify biomarkers (indicator of a process, event, condition or change within the body) of sleep debt and recuperation. ***FY 2017 Plans:*** Will continue to assess nutritional approaches that can enhance resistance to stress and augment tissue repair, wound healing and recovery from brain function. Will determine the feasibility of a prophylactic (preventative treatment) nutrient or dietary nutrient cocktail for preventing the deleterious effects of impact, acceleration, and/or blast –induced head injury in a rodent model. Will identify differences in baseline sleep pattern and duration, in the home environment, between mild traumatic brain injury (mTBI) patients, non-mTBI (controls) Warfighters and Warfighters who've recovered from mTBI. ***FY 2018 Plans:***	1.957	3.466	3.611

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S15 / *Sci BS/Army Op Med Rsh*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will characterize role of sleep in resilience to, and recovery from, mTBI events. Will characterize the impact of blast and/or impact-acceleration on the gut microbiome. Will investigate the impact of nutritionally optimized products on indicators of immune function in laboratory studies.			
Title: Environmental Health and Protection ***Description:*** This effort conducts research on the physiological (human physical and biochemical functions) mechanisms of exposure to extreme heat, cold, altitude, and other environmental stressors. This effort establishes scientific evidence for specific and sensitive diagnostics of exertional heat illness to optimize Warfighter performance in austere environments. ***FY 2016 Accomplishments:*** Used animal models and cellular-based tests to identify biomarkers of organ damage; and evaluate specific molecular pathways of heat injury and establish the time course, type and extent of organ damage following heat injury. ***FY 2017 Plans:*** Will use animal models to characterize improved (sex-specific and sensitive) circulating biomarkers of organ damage for diagnostics and assessment of severity of heat injury. Will establish scientifically based clinical criteria for return-to-duty status following heat illness. ***FY 2018 Plans:*** Will use animal models to identify novel circulating biomarkers of organ damage following exertional heat injury (EHI) and exertional heat stroke (EHS) for the diagnosis and assessment of severity of heat injury. Will discover biomarkers that are specific to the type and extent of organ damage during EHI/EHS exposure and recovery. Will determine the predictive power of various clinical biomarkers for the type and extent of organ damage that is observed at 7 days of recovery. Will target biomarkers for EHI/EHS assessment to characterize sensitivity and specificity in military working dogs.	0.824	0.821	1.053
Title: Psychological Health and Resilience ***Description:*** This effort conducts research into the basic mechanisms of the ability to overcome traumatic events including determination of underlying neurobiological mechanisms (nervous system control of cellular and molecular processes) related to Post-Traumatic Stress Disorder (PTSD) and depression. ***FY 2016 Accomplishments:*** Identified if Omega-3 fatty acids are capable of affecting vulnerability to and recovery time following a concussion; and establish a core set of procedures and outcome measures defining a validated animal model of PTSD appropriate for identifying candidate compounds and methods of PTSD treatment. ***FY 2017 Plans:***	2.253	1.097	1.223

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S15 / *Sci BS/Army Op Med Rsh*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will utilize an animal model to screen compounds for the treatment of PTSD, their ability to inhibit adverse memory formation and related disorders. Will identify vulnerable factors and diagnostic indicators of PTSD and co-existing mental health problems that overlap or complicate PTSD. Will explore and identify candidate compounds that can be administered in a prophylactic manner or post-trauma to mitigate the adverse biological and behavioral effects of trauma in an animal model. Will develop analytic techniques to evaluate neuroendocrine assays (clinical tests that evaluate relevant hormonal and neurotransmitter levels within the body) for stress effects. ***FY 2018 Plans:*** Will screen for additional compounds for the treatment of PTSD in an animal model, including investigating the ability of the compounds to inhibit adverse memory formation and related disorders. Will identify additional vulnerable factors and diagnostic indicators of PTSD and co-existing mental health problems that overlap or complicate PTSD. Will use an established rat model of mTBI with or without the addition of stress to identify nutritional and other targets for improved resolution or resilience to the trauma. Will identify at least two novel compounds that are active at the nociceptin/orphanin peptide (NOP) receptor (a receptor involved in the regulation of numerous brain activities, particularly instinctive and emotional behaviors) for their ability to mitigate the adverse behavioral effects of traumatic stress and for their impact on PTSD-related symptoms in an animal model.			
Accomplishments/Planned Programs Subtotals	6.492	6.688	7.116

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) T14 / *BASIC RESEARCH INITIATIVES - AMC (CA)*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
T14: *BASIC RESEARCH INITIATIVES - AMC (CA)*	-	40.000	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	-	-

A. Mission Description and Budget Item Justification

Congressional Interest Item funding provided for Defense Research Sciences.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017
Congressional Add: Program Increase	40.000	-
FY 2016 Accomplishments: Program increase for Defense Research Sciences		
Congressional Adds Subtotals	40.000	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army											Date: May 2017	
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) T22 / *Soil & Rock Mech*			
COST ($ in Millions)	**Prior Years**	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
T22: *Soil & Rock Mech*	-	4.334	4.520	4.606	-	4.606	4.695	4.788	4.883	4.982	-	-

A. Mission Description and Budget Item Justification

This Project fosters basic research to correlate the effects of the nano- and micro-scale behavior on the macroscale performance of geological and structural materials to provide a foundation for the creation of future revolutionary materials and to revolutionize the understanding of sensor data within heterogeneous geological systems. This research encompasses geologic and structural material behavior, structural systems, and the interaction with dynamic and static loadings. Research includes underlying physics and chemistry that control the mechanics and electromagnetic behavior of geological and structural materials, new techniques that provide measurements at the fundamental scale, and fundamental theories for relating nano- and micro-scale phenomena to macro-scale performance.

Work in this Project provides the basis for applied research in Program Element (PE) 0602784A (Military Engineering Technology), Project T40 (Mobility/Weapons Effects Technology).

The cited work is consistent with the Assistant Secretary of Defense, Research and Engineering science and technology focus areas.

Work in this Project is performed by the Army Engineer Research and Development Center (ERDC), Vicksburg, MS.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Military Engineering Basic Research	2.078	2.169	2.212
Description: Conduct fundamental research to determine how physical and chemical characteristics of materials affect their interactions with environment.			
FY 2016 Accomplishments: Determined the physical and chemical mechanisms that allow geopolymers to bond strongly to glass, ceramics, and metallic alloys with specific surface compositions; characterized the chemical structures that are involved in gels and thermal effects on gels; and provided fundamental theory for moisture effects on wave propagation in heterogeneous unsaturated soils.			
FY 2017 Plans: Will investigate soil moisture and density effects on signal to noise ratios in fiber optic sensors, signal diversity, and signal fading; quantify the transitions in soil stiffness with increasing saturation; and investigate the effect of soil organic matter and iron oxide content on quartz infrared response in natural soils.			
FY 2018 Plans:			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T22 / *Soil & Rock Mech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will construct a mechanistic process synthesis model for graphene-carbon nanotube metal nano-composites; will investigate new mass and energy transfer models across land-atmosphere boundaries; will evaluate novel wave breaking shape prediction models with in-situ experiments; and will conduct surf zone transit experiments using an experimental vessel.			
Title: Materials Modeling for Force Protection ***Description:*** Conduct fundamental research on material interactions at the micro- and nano-scales to determine how they affect macroscale properties ***FY 2016 Accomplishments:*** Investigated how the material interface prevents delamination for composites during impact and penetration loading; investigated the fundamental mechanisms of concrete composition that inhibit damage initiation and spread; determined calcium carbonate bonding strength in homogeneous mortar; and provided fundamental understanding of deformation and damage mechanisms provided by in-situ nano-mechanical testing and pre- and post-test characterization for metallic materials that exhibit strain rate insensitive stress-activated phase transformations and twinning. ***FY 2017 Plans:*** Will improve the understanding of damage in ultra-high performance concrete and will devise new methods to provide quantitative information about damage evolution; assess chemical and biological agent degradation potential by studying the photocatalytic activity of a biosynthetic polymer composite; and investigate the degradation mechanisms of sample composite systems. ***FY 2018 Plans:*** Will investigate and validate fuzzy logic tools to improve understanding of data fusion frameworks for predictive models; will characterize in-vivo and in-vitro microtubule morphologies to investigate relationships between microscale structure and macroscale material performance; will create synthetic analogues of alkali-silica reaction gels; and will determine silica fume effects on hydration, rheology, and hardened properties in cementitious materials.	2.256	2.351	2.394
Accomplishments/Planned Programs Subtotals	4.334	4.520	4.606

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) T23 / *Basic Res Mil Const*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
T23: *Basic Res Mil Const*	-	1.679	1.747	1.781	-	1.781	1.815	1.850	1.887	1.929	-	-

A. Mission Description and Budget Item Justification

Work in the Project fosters basic research and supports facilities research initiatives. The objective of Army installations basic research is to investigate, identify, and quantify the fundamental scientific principles that can be used to predict or influence the development of high performance facilities and sustainable installations, both fixed and contingency. Such basic research provides the requisite long term cost effective training and sustainment platforms for Army mission accomplishment. These efforts provide basic research leading to improved design in a range of facilities to optimize facility mission performance, enhance facility security, reduce design and construction errors and omissions, reduce resource requirements, and reduce the environmental burdens over the facility's life. This Project provides leap-ahead technologies to solve military-unique problems in the planning, programming, design, construction, and sustainment of deployed facilities, and energy and utility infrastructure.

Work in this Project provides the basic research basis for applied research in Program Element (PE) 0602784A (Military Engineering Technology) / Projects T41 (Military Facilities Engineering Technology) and T45 (Energy Technology Applied to Military Facilities).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering science and technology priority focus areas.

Work in this Project is performed by the Army Engineer Research and Development Center (ERDC), Vicksburg, MS.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Facilities Research	1.679	1.747	1.781
Description: Conduct fundamental research on innovative infrastructure technologies to optimize facility mission performance, through enhanced security and reduction in resource requirements, design errors and omissions, and environmental burdens.			
FY 2016 Accomplishments: Identified microbial and chemical distribution in a biofilm correlated to points of corrosion; assessed transport kinetics of self-assembling vesicles for photocatalytic hydrogen evolution in aqueous solutions; and interpreted the vortical structure thermal field with shape memory alloy materials used for inducing vortices to enhance solid-fluid and thermal interactions.			
FY 2017 Plans: Will replicate key nanostructural and chemical composition features present in natural cicada wings to study parameters leading to self-cleaning, anti-fouling surfaces; and tune bacteriophage-based nanofibers to understand fundamental properties leading to piezoelectric energy generation.			
FY 2018 Plans:			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T23 / *Basic Res Mil Const*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will fabricate nanopillar arrays on silicon substrates using nanosphere lithography and functionalize nanopillars with organic and inorganic compounds to investigate bactericidal properties; will create controlled oxide growth method and investigate thickness effect on adhesion; and will tune bacteriophage and crystalized nanofibers to understand how energy scavenging operates.			
Accomplishments/Planned Programs Subtotals	1.679	1.747	1.781

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) T24 / *Signature Physics And Terrain State Basic Research*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
T24: *Signature Physics And Terrain State Basic Research*	-	1.619	1.649	1.685	-	1.685	1.720	1.755	1.792	1.828	-	-

A. Mission Description and Budget Item Justification

This Project supports basic research to increase knowledge in the areas of terrain state and signature physics. It investigates the knowledge base for understanding and assessing environmental impacts critical to battlespace awareness. Projects include fundamental material characterization, investigation of physical and chemical processes, and examination of energy and mass transfer applicable to predicting state of the terrain, which control the effects of the environment on targets and target background signatures and mobility, in support of the materiel development community. The terrain state area of terrestrial sciences investigates weather-driven terrain material changes and the sensing and inferring of subsurface properties. The signature physics area of terrestrial sciences focuses on understanding the dynamic changes to electromagnetic, acoustic, and seismic signatures, and energy propagation in response to changing terrain state and near surface atmosphere.

Work in this Project provides a foundation for applied research in Program Element (PE) 0602784A (Military Engineering Technology)/ Project 855 (Topographical, Image Intel and Space) and T42 (Terrestrial Science Applied Research).

The cited work is consistent with the Assistant Secretary of Defense, Research and Engineering science and technology focus areas.

Work in this Project is performed by the Army Engineer Research and Development Center (ERDC), Vicksburg, MS.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Analysis for Signal and Signature Phenomenology (Previously titled - Terrain State and Signature Physics)	1.619	1.649	1.685
Description: Conduct fundamental research to examine the effects of environmental parameters on electromagnetic, acoustic, and seismic signatures as well as energy propagation with regard to terrain state and near surface atmosphere.			
FY 2016 Accomplishments: Determined controls on the broadband complex relative permittivities (a measure of resistance) of mixtures containing high salt content, such as ammonium nitrate, to determine the characteristic maximum frequency-domain that will establish the scientific basis for a subsurface geophysical technique for detection; established proof of subsurface target detection through new electromagnetic methodology by understanding the causes of asymmetric dispersive resonance within full diffraction signatures from buried targets; and investigated high-frequency wave propagation methods to determine in-situ near-surface micro-pore geometry parameters in surface materials (forest litter, soil, and snow) to improve Army sensor systems by adjusting to changes in environmental conditions.			
FY 2017 Plans:			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T24 / *Signature Physics And Terrain State Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will formulate theory and numerical modeling approaches for sound propagation along long range and slanted paths through forests, with realistic representation of the vegetation and layered structure, to enable future capability for predicting long range acoustic and other wave propagation through dense forests and multi-tiered canopies; research broadband radio frequency (RF) spread spectrum scattering in mountainous terrain to understand effects of terrain geometry and vegetation on band structure that may lead to prediction of viable frequencies for improved communications in mountainous regions; and investigate the statistical evolution of signatures (target source) and their probability of detection, given imperfect knowledge of the battlefield environment, to improve physics-based estimates of sensor and communication system performance. ***FY 2018 Plans:*** Will investigate seismic and acoustic wave transmission and reflection at the land-water boundary to characterize lake or river boundary effects on wave propagation; will derive empirical expressions of the boundary effects by wave type, wave shape, polarization, and amplitude; and will determine if the liquid water contents of frozen soils can be detected remotely (e.g., with airborne sensors) by exploiting polarization phenomena.			
Accomplishments/Planned Programs Subtotals	1.619	1.649	1.685

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) T25 / *Environmental Science Basic Research*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
T25: *Environmental Science Basic Research*	-	6.744	7.081	6.708	-	6.708	6.845	6.990	7.139	7.797	-	-

A. Mission Description and Budget Item Justification

This Project supports basic research to investigate fundamental scientific principles and phenomena necessary to ensure efficient development of the technologies needed to address Army sustainment issues in the restoration, compliance, conservation, and non-industrial pollution prevention areas. These efforts include: investigating and monitoring contaminated sites, including chemical contamination and unexploded ordnance (UXO) detection and discrimination; better characterization of contaminants through improved risk-based assessment; destruction, containment, or neutralization of organics resulting from military activities in water, soil, and sediments; adhering to applicable federal, state, and local environmental laws and regulations; monitoring and controlling noise generation and transport; protecting and enhancing natural and cultural resources; reducing pollution associated with military activities; and the study of ecosystem genomics and proteomics in support of the Army's Network Science initiative.

Work in this Project provides a fundamental basis for applied research in Program Element (PE) 0602720A (Environmental Quality Technology)/Project 048 (Industrial Operations Pollution Control Technology), Project 835 (Military Medical Environmental Criteria) and Project 896 (Base Facilities Environmental Quality).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering science and technology priority focus areas.

Work in this Project is performed by the Army Engineer Research and Development Center (ERDC), Vicksburg, MS.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Environmental and Ecological Fate of Explosives, Energetics, and Other Contaminants	2.700	3.781	3.446
Description: Conduct fundamental research to examine the effects of Army relevant compounds on the environment			
FY 2016 Accomplishments: Experimentally determined the fundamental environmental cues required to develop a workable multi-modular agent-based model decision network; determined the rate controlling physiological mechanisms in order to formulate a systems biology model which will improve ability to rapidly assess and predict the effects of individual chemicals and mixtures of chemicals; and described the fundamental relationship of perturbed biological pathways by toxicity of military materials and other chemicals across species.			
FY 2017 Plans: Will devise theoretical relationships between geomorphic specific nutrient and available water thresholds controlling the environmental persistence of munition constituents in soils as a foundation for site-specific predictions of munition constituents fate; will quantify chemical kinetic parameters for insensitive munition retention on soil mineral surfaces that can be used for			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T25 / *Environmental Science Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
predicting the long-term fate of inorganic and organic military relevant contaminants in the environment; and will determine mechanisms of zone migration and zone dispersion in a microfluidic separation (i.e. traveling-wave electrophoresis) that will lead to improved performance for separation and enrichment of toxicants, biomolecules, and military-specific compounds. ***FY 2018 Plans:*** Will correlate munition constituent environmental fate processes with soil horizon types and compare models to results from intact soil columns; understand fundamentals of photo-degradation pathways and kinetics of insensitive munitions formulations and individual components through a combination of computational chemistry methods, controlled lab experiments, and outdoor sample analysis; and construct and test an estrogen responsive promoter memory circuit and create and test an arsenic responsive yeast memory circuit.			
Title: Fundamental Understanding of Explosives, Energetics and UXO in the Environment ***Description:*** Conduct fundamental research to increase the understanding of the physical and chemical characteristics of insensitive munitions ***FY 2016 Accomplishments:*** Assessed the basics of physiological response to and toxicity of the IMX-101 mixture constituents and provided intensive characterization of the molecular and metabolic mechanisms for previously observed non-additive toxicity. ***FY 2017 Plans:*** Will increase understanding of insensitive munition photo-degradation pathways and kinetics through computational chemistry methods, lab experiments, and field sample analysis; and increase understanding of mechanistic sorption properties of insensitive munitions compounds on the surface of polysaccharide polymers, so the sorption properties can be tuned for selective binding of munitions compounds. ***FY 2018 Plans:*** Will determine chemical kinetic parameters for each insensitive munitions compound on different natural soils; functionalize and characterize cellulose and chitin using electron donating molecules; determine role of electrode surface area in electrode charging; and determine mechanisms of zone dispersion and their limits.	2.200	1.054	1.066
Title: Training Land Natural Resources ***Description:*** Conduct fundamental research on the molecular interactions of plants and animals with environmental stimuli. ***FY 2016 Accomplishments:***	0.959	1.327	1.249

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T25 / *Environmental Science Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Investigated molecular mechanisms behind foreign species invasion and interpret findings to preventative and proactive strategies towards the management and containment of these species on military lands. ***FY 2017 Plans:*** Will decode the molecular basis of frog olfaction for amphibian conservation to provide an understanding of chemical cues that frogs can sense; will join a tunable genetic memory capability to a novel odor-based reporter to create a bio-alarm usable in austere environments; and will examine the relationship of climate and habitation to biodiversity to enable better predictions of climate change. ***FY 2018 Plans:*** Will understand anuran olfactory receptor-odorant interaction at the molecular level; define and assess the composition and stability of the lizard microbiome; and determine effects of contaminants on microbiome composition.			
Title: Network Science ***Description:*** Conduct fundamental research to examine the behavior of environmental networks to inform data models and algorithms ***FY 2016 Accomplishments:*** Evaluated the basic effects of noise (e.g., extraneous molecules, temperature) and resources on performance of synthetic networks through direct observation and modeling with statistical comparison of the performance of different synthetic circuits. ***FY 2017 Plans:*** Will investigate how biological signals propagate through a highly interconnected network of alternative paths and barriers, such as noise, signal degradation, competing responses, or physical obstructions. ***FY 2018 Plans:*** Will understand information propagation through imperfect biological networks and how biology adapts to overcome obstacles; and determine the relationship between path length, information flow, and perturbation parameters in full-scale networks.	0.885	0.919	0.947
Accomplishments/Planned Programs Subtotals	6.744	7.081	6.708

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T25 / *Environmental Science Basic Research*

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) T63 / *Robotics Autonomy, Manipulation, & Portability Rsh*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
T63: *Robotics Autonomy, Manipulation, & Portability Rsh*	-	6.947	8.764	8.847	-	8.847	9.546	11.112	11.281	11.516	-	-

A. Mission Description and Budget Item Justification

This Project supports basic research in areas that expands the autonomous capabilities, utility, and portability of small robotic systems for military applications, with a focus on enhanced intelligence, biomimetic functionality, and robust mobility, to permit these systems to serve as productive tools for dismounted Soldiers. It enables future systems to support and unburden Soldiers by integrating technologies with an understanding of cognitive and physical needs, and the missions of the humans and (non-human) agents operating on the battlefield. The ability of the Warfighter to command a suite of small unmanned systems (e.g., air, ground, and hybrid vehicles) reduces exposure of the Soldier to harm and improves the efficiency by which a dismounted unit achieves tactical objectives such as securing a targeted zone. Example missions requiring enhanced autonomy, manipulation, and man-portability include rapid room clearing and interior structure mapping; detection of human presence, chemical/biological/nuclear/radiological/explosive (CBNRE), and booby-traps; surveillance; and subterranean passage detection and exploration. Because of their relatively small size, light weight, and service in dismounted environments, small unmanned systems have unique challenges in perception, autonomous processing, mobility mechanics, propulsive power, and multi-functional packaging that transcend similar challenges associated with large unmanned systems. The Army Research Laboratory (ARL) conducts research in related disciplines, including machine perception, intelligent control, biomimetic robotics, manipulator mechanics, and propulsive power and drives to foster the development of technologies for lightweight, small-volume, robotics applications for harsh environments. Machine perception research includes the exploration of lightweight ultra-compact sensor phenomenology and the maturation of basic machine vision algorithms that enable small unmanned systems to more fully understand their local environment. Intelligent control research includes the maturation of autonomous processing capabilities and the advancement of artificial intelligence techniques that lead to reliable autonomous behavior in a large-displacement, highly-dynamic environment and permit unmonitored task performance. Research in biomimetic robotics and manipulator mechanics includes the advancement of mechatronic and biomimetic appendages to enable agile high-speed locomotion, dexterous task-performance, and environmental-manipulation; and the maturing of nonlinear control algorithms to support robust, stable mobility. Propulsion power research includes investigations of engine cycles and alternative hybrid energy conversion techniques to provide compact, lightweight, quiet, low-emission, high-density power sources that support highly-portable unmanned systems capable of performing long-endurance missions.

Work in this Project supports key Army needs and provides the technical underpinnings to several Program Elements (PEs) to include PE 0601104A (University and Industry Research Center)/Project H54 (Micro-Autonomous Systems Technology Collaborative Technology Alliance) and PE 0602622A (Chemical, Smoke and Equipment Defeating Technology)/Project 552 (Smoke/Novel Effect Munition).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas.

Work in this Project is performed by ARL at the Aberdeen Proving Ground, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Robotics Autonomy and Human Robotic Interface Research	1.905	2.012	1.899

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T63 / *Robotics Autonomy, Manipulation, & Portability Rsh*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Description: In-house research with a focus on enabling robust autonomous mobility for small robotic systems, including autonomous operations in Global Positioning System (GPS) denied areas, planning, behaviors, intelligent control, and the interface of perception technologies to accomplish Army missions in the area of unmanned systems. These efforts include research activities in micromechanics conducted in association with the Micro Autonomous Systems and Technology Collaborative Technology Alliance (PE 0601104A/Project H54). ***FY 2016 Accomplishments:*** Explored the use of neuromorphic control (software systems that implement models of neural systems) employing analog elements to enable robust low-level control of microsystems; examined hybrid mobility concepts to enable robust maneuver in three dimensional environments, including biomimetic utilization of appendages, to achieve both functionality and efficiency; and explored control strategies to enable rapid, dynamic manipulation of objects. ***FY 2017 Plans:*** Will explore novel methods for learning and abstract reasoning to enhance understanding of the local environment by an intelligent unmanned vehicle; and explore novel methods for embedded control to facilitate intelligent manipulation of objects in the environment and modes of mobility. ***FY 2018 Plans:*** Will explore techniques for recognizing novel behaviors and circumstances that support generalized learning and long-term adaptability. Will continue efforts towards creating machine understanding of the purpose or intent for objects and behaviors. Will also explore the bridging of a cognitive architecture and control technology for disparate robotic systems.			
Title: Intelligent Systems	5.042	5.152	5.346
Description: Pursue in-house research that supports and unburdens Soldiers in a flexible, robust, survivable and comprehensive manner. This work will address the cognitive requirements of humans and (non-human) agents, both hardware and software based, operating individually or in collaboration, on the battlefield. Emphasis will be placed on perception, reasoning, and collaboration techniques that can apply to and transfer between a broad range of systems (such as: adaptive communication and data collection networks; cyber defense, crowd-sourcing and information retrieval software agents; and predictive and explanatory decision support systems). ***FY 2016 Accomplishments:*** Researched the use of language as a construct for a robot architecture in the development of a common model for the physical (e.g., weather, terrain/structure, and other elements that affect mobility and speed) and operational (e.g., mission description, commander's intent, friendly and enemy forces disposition, and non-combatant participants) environment; explored the use of semantic understanding and learning to enhance robotic behavior and perceptual capabilities; and explored the use of			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T63 / *Robotics Autonomy, Manipulation, & Portability Rsh*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
abstractions (i.e., using common model with smaller number of descriptors to convey complex picture or concept) to enable effective communication between teammates, both human and machine, with reduced bandwidth requirements. ***FY 2017 Plans:*** Will assess the scalability of semantic labeling of objects and behaviors to permit a more detailed description of the environment; expand research on collaborative problem solving across a set of human, robotic and software agents; explore concepts for exploiting most relevant imagery and video for enhanced system autonomy; develop control algorithms to better enable real-time decision-making; and explore intelligent control strategies that couple sensing, control algorithms, and actuation for unique mobility modes applicable to small unmanned vehicles (e.g., legged mobility, hybrid ground/air). ***FY 2018 Plans:*** Will develop novel techniques to simplify the semantic labeling methodology and increase its scalability using an on-line learning framework; and will develop intelligent system algorithms for prioritizing decisions based on the context of mission objectives.			
Title: Unmanned Air Vehicle Research ***Description:*** Conduct basic research focused on topics that contribute to the body of knowledge required to create future intelligent unmanned air systems that can effectively team with manned aircraft. Emphasis will be placed upon topics of control and aeromechanics that will expand the flight envelope for unmanned systems, manipulation of objects, and specialized topics relating to perception, reasoning, and creation of a common model of the surrounding environment and planning for behaviors in adversarial environments at high tempo.. ***FY 2017 Plans:*** Will explore algorithms and concepts for perception, planning, and reasoning that will enable manned-unmanned teaming for unmanned air vehicles; and examine control techniques for the manipulation of objects by unmanned air platforms. ***FY 2018 Plans:*** Will explore application of a cognitive architecture to manned-unmanned teaming of aircraft systems by initially using virtual environments.	-	1.600	1.602
Accomplishments/Planned Programs Subtotals	6.947	8.764	8.847

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T63 / *Robotics Autonomy, Manipulation, & Portability Rsh*

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) T64 / *Sci BS/System Biology And Network Science*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
T64: *Sci BS/System Biology And Network Science*	-	2.814	2.974	3.025	-	3.025	3.079	3.139	3.203	3.268	-	-

A. Mission Description and Budget Item Justification

This Project fosters research investigations through a systematic approach using iterative computer simulation with mathematical modeling and biological information to analyze and refine biological studies. Information gained from these studies has the potential to provide a better understanding of the overall biological system and its molecular network of interactions, leading to improved early strategic decision-making in the development of preventive and treatment solutions to diseases. This approach establishes a model for application of computational biology processes and knowledge of biological networks to discover medical products that prevent and/or treat diseases or medical conditions.

The cited work provides theoretical underpinnings for Program Element (PE) 0602787A (Medical Technology).

Work in this Project is performed by the Medical Research Materiel Command (MRMC), Fort Detrick, MD / Biotechnology High Performance Computing Software Applications Institute (BHSAI), Frederick, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Network Sciences Initiative	2.814	2.974	3.025
Description: This effort involves the use of mathematical models and data search algorithms to extract medical information from large-scale genomics (generated from the study of cellular genetic makeup, protein structures and function, and whole organism responses) to improve understanding, prevention, diagnostics, and treatments of traumatic brain injury (TBI), post-traumatic stress disorder (PTSD), uncontrolled bleeding, infections, and exposure to environmental stressors and hazards.			
FY 2016 Accomplishments: Develop new models of (a) underlying mechanisms of blast-induced TBI and (b) susceptibility to stress-related bone fracture in male and female Warfighters related to the high level of repeated physical activity experienced during basic combat training (BCT); and improve and refine algorithms and models for (a) identification of drug targets and drugs for conditions such as infectious disease, trauma-inducted coagulopathy, and biofilm-producing bacteria, (b) upper respiratory airflow patterns for the non-invasive diagnosis of lung diseases, and (c) standard vital-sign data to enable the non-invasive prediction of heat-stress injury to allow for timely counteractive measures.			
FY 2017 Plans: Will improve and refine algorithms to identify the susceptibility to stress-related bone fracture in male and female Warfighters related to the high level of repeated physical activity experienced during BCT; will develop computational algorithms to investigate			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T64 / *Sci BS/System Biology And Network Science*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
the association of genetic factors with neurological disorders, e.g., PTSD; will refine models to (a) predict drug targets for enhancing antibiotic sensitivity in wound pathogens that tend to be more antibiotic-resistant because they form biofilms, (b) identify key determinants that guide the evolution of viruses, and (c) identify molecular biomarkers of viral, e.g., Ebola virus, infection; will improve models to (a) identify cellular mechanisms of the inflammatory response, (b) predict blood coagulopathy genetic risk factors, and (c) investigate the underlying mechanisms of trauma-induced coagulopathy coupled with blood flow. ***FY 2018 Plans:*** Will design algorithms to identify the impact of load-carriage and activity intensity in stress-related bone fracture in Warfighters during basic combat training. Will formulate computational algorithms to investigate the association of genetic factors with neurological disorders, e.g., PTSD. Will develop models to (a) predict drug targets for enhancing antibiotic sensitivity in wound pathogens that tend to be more antibiotic-resistant because they form biofilms (a group of microorganisms that stick to each other and adhere to a surface), (b) understand how antibody responses may lead to neutralization or enhancement of viral infection, and (c) identify molecular biomarkers of viral infection. Will develop algorithms to model blood clotting processes under coagulopathic (inability for blood to clot) conditions and assess the ability of pharmacological (drug) interventions to mitigate trauma-induced coagulopathy (blood's ability to form clot is impaired).			
Accomplishments/Planned Programs Subtotals	2.814	2.974	3.025

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army										Date: May 2017		
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) VR9 / *Surface Science Research*			
COST ($ in Millions)	**Prior Years**	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
VR9: *Surface Science Research*	-	2.134	2.256	2.293	-	2.293	2.337	2.383	2.431	2.481	-	-

A. Mission Description and Budget Item Justification

This Project fosters basic research to establish and maintain a core capability to enable a molecular level understanding of properties and behaviors of materials relevant to the Army; by developing understanding and ability to manipulate nanostructured materials as a means to tune properties which meet desired performance requirements; by advancing the scientific understanding of surface properties and interfacial dynamics of complex materials; and by providing scalable processes grounded in a molecular understanding of materials. This Project funds basic research in the characterization of chemical and biochemical phenomena occurring at or near solid surfaces and interfaces; the interactions between chemical reactions and transport processes on surfaces; theory and modeling of processes at complex surfaces; and the synthesis and characterization of catalysts that function at the nanoscale. Investment in basic research centered on the surface science disciplines will enable growth of a knowledge base that will result in improved understanding of the interactions of complex materials in real world environments.

The cited work provides the theoretical underpinnings for Program Element (PE) 0602622A (Chemical, Smoke and Equipment Defeating Technology).

Work in this Project is performed by the Army Edgewood Chemical and Biological Center (ECBC), Research, Development and Engineering Command, in Aberdeen, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Surface Science Research	2.134	2.256	2.293
Description: The activities in this program are related to performing basic research in chemistry, biology, and physics on fundamental problems related to surfaces, interfacial dynamics, thin film materials, chemical-biological catalysis and opto-electronic/sensory technologies.			
FY 2016 Accomplishments: Conducted fundamental research related to the creation and synthesis of novel materials that allows for the precise control of chemical and biochemical phenomena occurring at surfaces and interfaces to include the effects of transport; research catalytic chemical reactions and transport processes on surfaces; further develop theory and multiscale modeling of processes at complex surfaces; and make physical measurements of surface structure, morphology, and properties.			
FY 2017 Plans: Will conduct fundamental research on the processes required to control transport of species across liquid-solid boundaries; research mechanisms associated with liquid-phase extraction of absorbed molecular species from polymers; and investigate techniques to enhance the charge transfer efficiency from a given absorbing molecule or material into semiconductor nanoparticles using theory and modeling of processes at complex nanostructured surfaces.			
FY 2018 Plans:			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** VR9 / *Surface Science Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will conduct fundamental research on chemical and biochemical phenomena occurring at or near solid surfaces and material interfaces; the effects of binding energy, reactions, transport and deposition; study the interactions between chemical reactions and transport processes on surfaces; theory and modeling of processes at complex surfaces; and experimental work focused on the systematic understanding of surface structure, morphology and surface group properties.			
Accomplishments/Planned Programs Subtotals	2.134	2.256	2.293

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Army											Date: May 2017	
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601103A / *University Research Initiatives*							
COST ($ in Millions)	**Prior Years**	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
Total Program Element	-	67.225	69.166	67.027	-	67.027	65.283	65.858	67.214	68.552	-	-
D55: *University Research Initiative*	-	64.315	66.090	66.201	-	66.201	65.283	65.858	67.214	68.552	-	-
V72: *Minerva*	-	2.910	3.076	0.826	-	0.826	0.000	0.000	0.000	0.000	-	-

A. Mission Description and Budget Item Justification

This Program Element (PE) supports the Multidisciplinary University Research Initiative (MURI), the Defense University Research Instrumentation Program (DURIP), the Presidential Early Career Awards for Scientists and Engineers (PECASE) program, and the Army's efforts in the Minerva Research Initiative (MRI). The MURI program funds university based basic research in a wide range of scientific and engineering disciplines pertinent to maintaining land combat technology superiority. Army MURI efforts involve teams of researchers investigating high-priority, transformational topics that intersect more than one traditional technical discipline (e.g., Intelligent Luminescence for Communication, Display, and Identification). For many complex problems, this multidisciplinary approach serves to accelerate research progress and expedite transition of results to application. The DURIP provides funds to acquire major research equipment to augment current, or devise new, research capabilities in support of Army transformational research. The PECASE program funds single-investigator research efforts performed by outstanding academic scientists and engineers early in their independent research careers. The MRI is a university-based social science research program.

Work in this PE provides a foundation for applied research initiatives at the Army laboratories and research, development and engineering centers.

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas and the Army Modernization Strategy.

Work on this PE is performed by the Army Research Laboratory (ARL) located in Research Triangle Park, NC.

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Army					Date: May 2017
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*		**R-1 Program Element (Number/Name)** PE 0601103A / *University Research Initiatives*			
B. Program Change Summary ($ in Millions)	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**
Previous President's Budget	72.603	69.166	69.339	-	69.339
Current President's Budget	67.225	69.166	67.027	-	67.027
Total Adjustments	-5.378	0.000	-2.312	-	-2.312
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-2.500	-			
• SBIR/STTR Transfer	-2.878	-			
• Adjustments to Budget Years	0.000	0.000	-2.312	-	-2.312

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601103A / *University Research Initiatives*	Project (Number/Name) D55 / *University Research Initiative*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
D55: *University Research Initiative*	-	64.315	66.090	66.201	-	66.201	65.283	65.858	67.214	68.552	-	-

A. Mission Description and Budget Item Justification

This Project supports the Multidisciplinary University Research Initiative (MURI), the Defense University Research Instrumentation Program (DURIP) and the Presidential Early Career Awards for Scientists and Engineers (PECASE) program. The MURI program funds university based basic research in a wide range of scientific and engineering disciplines pertinent to maintaining land combat technology superiority. Army MURI efforts involve teams of researchers investigating high-priority, transformational topics that intersect more than one traditional technical discipline (e.g. Intelligent Luminescence for Communication, Display, and Identification). For many complex problems, this multidisciplinary approach serves to accelerate research progress and expedite transition of results to application. The DURIP provides funds to acquire major research equipment to augment current, or devise new, research capabilities in support of Army transformational research. The PECASE program funds single-investigator research efforts performed by outstanding academic scientists and engineers early in their independent research careers.

Work in this Project provides a foundation for applied research initiatives at the Army laboratories and research, development and engineering centers.

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology focus areas.

Work on this Project is performed by the Army Research Laboratory (ARL) located in Research Triangle Park, NC.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Multidisciplinary University Research Initiative (MURI)	48.387	53.134	53.153
Description: MURI programs are typically 5 years in length at a cost of $1.25 million per year.			
FY 2016 Accomplishments: Provided support for MURI awards made in prior years and start six to eight new Fiscal Year (FY) 16 MURI awards critical to supporting the future force. Effective transition mechanisms included collaboration among principal investigators, participation by 6.2/6.3 program managers in MURI program reviews, and communication of the MURI research results to the ARL, Research, Development, and Engineering Centers (RDECs), Engineering Research and Development Center (ERDC), Medical Research and Materiel Command (MRMC), Army Research Institute (ARI) and industry.			
FY 2017 Plans: Will provide support for MURI awards made in prior years, and will start six to eight new FY17 MURI awards critical to supporting the future force. Effective transition mechanisms will include collaboration among principal investigators, participation by applied			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601103A / *University Research Initiatives*	**Project (Number/Name)** D55 / *University Research Initiative*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
research and advanced technology development program managers in MURI program reviews, and communication of the MURI research results to the ARL, RDECs, ERDC, MRMC, ARI and industry. ***FY 2018 Plans:*** Will provide support for MURI awards made in prior years and identify six to eight new FY18 MURI awards to support basic science and/or engineering research at institutions of higher education that is of critical importance to national defense.			
Title: Presidential Early Career Awards for Scientists and Engineers (PECASE) ***Description:*** Supports PECASE investigators started in prior years. ***FY 2016 Accomplishments:*** Continued support for prior year awardees and selected four new awards. ***FY 2017 Plans:*** Will continue support for prior year awardees and select four new awards. ***FY 2018 Plans:*** Will support prior year awardees and select four new PECASE candidates.	4.478	4.546	4.574
Title: Defense University Research Instrumentation Program (DURIP) ***Description:*** Supports basic research through competitive grants for research instrumentation. ***FY 2016 Accomplishments:*** Awarded competitive grants for research instrumentation that enhanced universities' capabilities to conduct world class research critical to Army transformation. ***FY 2017 Plans:*** Will award competitive grants for research instrumentation to enhance universities' capabilities to conduct world class research critical to Army transformation. ***FY 2018 Plans:*** Will evaluate proposals to award competitive grants for research instrumentation to enhance universities' capabilities to conduct world class research critical to Army transformation.	11.450	8.410	8.474
Accomplishments/Planned Programs Subtotals	64.315	66.090	66.201

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601103A / *University Research Initiatives*	**Project (Number/Name)** D55 / *University Research Initiative*

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601103A / *University Research Initiatives*	Project (Number/Name) V72 / *Minerva*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
V72: *Minerva*	-	2.910	3.076	0.826	-	0.826	0.000	0.000	0.000	0.000	-	-

A. Mission Description and Budget Item Justification

This Project supports the Minerva Research Initiative (MRI), a university-based social science research program initiated by the Secretary of Defense in Fiscal Year (FY) 2009. It focuses on areas in the social sciences that are of strategic importance to national security policy which have not been substantially pursued in the past. The Minerva research effort will be performed to understand the internal military-political dynamics of repressive regimes, the vulnerabilities of regimes and institutions to various kinds of disruption and instability, the nature of crowd dynamics, group violence, community belief structures, the potential to influence public opinion and attitudes in diverse cultures, cultural effects on network security and military operations, the influence of technology on military capabilities of potential adversaries and allies, and other intersections of social-cultural issues with military activities and national security. Predictive models and other analysis tools will be developed. Leveraging the expertise in the social sciences within the academic community is needed to provide understanding of the roots of terrorist organizations and the challenges and opportunities for military operations in a culturally diverse environment. Better understanding at a fundamental level and new computational tools will provide a beneficial impact on war fighting capabilities at the national policy, military strategy, operational, and tactical levels, and will enhance the capabilities of intelligence activities at all levels. All research results are open source.

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering science and technology priority focus areas and the Army Modernization Strategy.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: The Minerva Research Initiative (MRI)	2.910	3.076	0.826
Description: The MRI is a university-based social science research program initiated by the Secretary of Defense. It focuses on areas in the social sciences of strategic importance to national security policy. It seeks to increase the Department's intellectual capital in the social sciences and improve its ability to address future challenges and build bridges between the Department and the social science community. Minerva will bring together universities, research institutions, and individual scholars and support multidisciplinary and cross-institutional projects addressing specific topic areas determined by the Department.			
FY 2016 Accomplishments: Designed and validated new quantitative models to identify the antecedents of civil unrest and violence, to generate new predictive models of the relationship between social systems, natural systems, and sociopolitical instability worldwide, enabling enhanced Army capacity to detect emerging political instabilities; and developed integrated geo-coded databases and time series data sets from existing archives to serve as experimental test beds for developing and validating predictive theories to identify			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601103A / *University Research Initiatives*	**Project (Number/Name)** V72 / *Minerva*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
potential hotspots for violence and instability that will aid in Army development of strategies for early intervention and reduction of sociopolitical violence. ***FY 2017 Plans:*** Will develop and validate new computational models that represent how failures in telecommunications, energy, transportation, and economic, systems propagate into civil and governmental systems, thus putting nations and regions at risk of conflict and sociopolitical instability, Will build and validate new models for interdependence between natural resources and state power structures. This work will provide insight regarding national and regional risk of conflict, sociopolitical instability, and threat of violence resulting from studied failures allowing for the development of appropriate mitigation and intervention strategies. ***FY 2018 Plans:*** Will create new quantitative models to detect vulnerabilities in government systems throughout the world that engender sociopolitical instability and susceptibility to hostile movements from both within a nation and from outside. The models will focus on shifts in population movement that arise from interdependencies between economic markets, health, and natural resources needed to support social communities. This research will enable a capacity to detect emerging conflict zones before they erupt, and enabling an early capacity to stabilize at-risk regions.			
Accomplishments/Planned Programs Subtotals	2.910	3.076	0.826

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Army											Date: May 2017	
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*							
COST ($ in Millions)	**Prior Years**	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
Total Program Element	-	99.148	94.280	87.395	-	87.395	92.115	88.203	89.772	91.572	-	-
EA6: *Cyber Collaborative Research Alliance*	-	3.106	3.281	3.338	-	3.338	4.886	4.982	5.082	5.186	-	-
F17: *Neuroergonomics Collaborative Technology Alliance*	-	5.046	5.332	4.923	-	4.923	4.720	4.830	4.943	5.044	-	-
FF5: *Distributed Collaborative Intelligent Systems CTA*	-	0.000	0.000	4.178	-	4.178	5.820	6.131	6.295	6.436	-	-
FF7: *Internet of Battlefield Things CTA*	-	0.000	0.000	3.068	-	3.068	4.179	6.020	6.084	6.175	-	-
H04: *HBCU/MI Programs*	-	1.812	1.486	1.536	-	1.536	1.591	1.629	1.671	1.704	-	-
H05: *Institute For Collaborative Biotechnologies*	-	6.228	6.595	5.999	-	5.999	5.999	5.998	5.997	6.150	-	-
H09: *Robotics CTA*	-	4.587	4.040	4.136	-	4.136	4.240	2.957	3.076	3.139	-	-
H50: *Network Sciences Cta*	-	10.627	9.166	6.466	-	6.466	5.828	0.000	0.000	0.000	-	-
H53: *Army High Performance Computing Research Center*	-	5.434	4.404	0.000	-	0.000	0.000	0.000	0.000	0.000	-	-
H54: *Micro-Autonomous Systems Technology (MAST) CTA*	-	7.374	6.792	0.000	-	0.000	0.000	0.000	0.000	0.000	-	-
H59: *International Tech Centers*	-	6.735	6.563	6.682	-	6.682	6.556	6.742	7.081	7.225	-	-
H73: *Automotive Research Center (ARC)*	-	3.009	3.180	3.235	-	3.235	3.296	3.361	3.427	3.498	-	-
J08: *Institute For Creative Technologies (ICT)*	-	5.839	6.186	6.308	-	6.308	6.440	6.569	6.701	6.837	-	-
J12: *Institute For Soldier Nanotechnology (ISN)*	-	5.339	6.185	5.999	-	5.999	5.999	5.998	5.997	6.057	-	-

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Army											Date: May 2017	
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*							
J13: *UNIVERSITY AND INDUSTRY INITIATIVES (CA)*	-	4.000	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	-	-
J14: *Army Educational Outreach Program*	-	9.287	9.864	10.047	-	10.047	10.272	10.466	10.675	10.893	-	-
J15: *Network Sciences ITA*	-	3.909	4.078	4.082	-	4.082	4.111	4.151	4.233	4.320	-	-
J17: *Vertical Lift Research Center Of Excellence*	-	2.911	3.076	3.130	-	3.130	3.186	3.249	3.313	3.381	-	-
VS2: *Multi-Scale Materials Modeling Centers*	-	8.928	8.851	9.047	-	9.047	8.754	8.739	8.688	8.886	-	-
VS3: *Center For Quantum Science Research*	-	4.977	5.201	5.221	-	5.221	6.238	6.381	6.509	6.641	-	-

A. Mission Description and Budget Item Justification

This Program Element (PE) fosters university and industry based research to provide a scientific foundation for enabling technologies for future force capabilities. Broadly, the work in this PE falls into three categories: Collaborative Technology Alliances / Collaborative Research Alliances (CTAs/CRAs), University Centers of Excellence (COE), and University Affiliated Research Centers (UARCs). The Army formed CTAs to leverage large investments by the commercial sector in basic research areas that are of great interest to the Army. CTAs are industry-led partnerships between industry, academia, and the Army Research Laboratory (ARL) to incorporate the practicality of industry, the expansion of the boundaries of knowledge from universities, and Army scientists to shape, mature, and transition technology relevant to the Army mission. CTAs have been competitively established in the areas of Micro Autonomous Systems Technology (MAST), Network Sciences, Robotics, and Cognition and Neuroergonomics. CRAs are academia-led partnerships, which leverage the cutting-edge innovation found in the academic environment. CRAs have been established in the areas of Multi-Scale Materials Modeling (electronic materials and materials in extreme environments) and in cyber security. The COEs focus on expanding the frontiers of knowledge in research areas where the Army has enduring needs, and couples state-of-the-art research programs at academic institutions with broad-based graduate education programs to increase the supply of scientists and engineers in automotive and rotary wing technology. Also included are Army Educational Outreach Program (AEOP) and activities to stimulate interest in science, math, and technology among middle and high school students. This PE includes support for basic research at three Army UARCs, which have been created to exploit opportunities to advance new capabilities through a sustained long-term multidisciplinary effort. The Institute for Soldier Nanotechnologies focuses on Soldier protection by emphasizing revolutionary materials research for advanced Soldier protection and survivability. The Institute for Collaborative Biotechnologies focuses on enabling network centric-technologies, and broadening the Army's use of biotechnology for the development of bio-inspired materials, sensors, and information processing. The Institute for Creative Technologies is a partnership with academia and the entertainment and gaming industries to leverage innovative research and concepts for training and simulation. Examples of specific research of mutual interest to the entertainment industry and the Army are technologies for realistic immersion in synthetic environments, networked simulation, standards for interoperability, and tools for creating simulated environments. This PE also includes the Historically Black Colleges and Universities and Minority Institution (HBCU/MI) Centers of Excellence that address critical research areas for Army Transformation.

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Army	Date: May 2017
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*

The cited work is consistent with the Assistant Secretary of Defense, Research and Engineering Science and Technology focus areas and the Army Modernization Strategy.

Work in this PE is performed by the ARL in Adelphi, MD; the Army Tank Automotive Research, Development, and Engineering Center (TARDEC) in Warren, MI; the Army Aviation and Missile Research, Development and Engineering Center (AMRDEC), in Huntsville, AL, and the Army Research, Development and Engineering Command (RDECOM), in Aberdeen, MD.

B. Program Change Summary ($ in Millions)	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
Previous President's Budget	104.340	94.280	94.903	-	94.903
Current President's Budget	99.148	94.280	87.395	-	87.395
Total Adjustments	-5.192	0.000	-7.508	-	-7.508
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-1.250	-			
• SBIR/STTR Transfer	-3.942	-			
• Adjustments to Budget Years	0.000	0.000	-7.508	-	-7.508

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2016	FY 2017
Project: J13: *UNIVERSITY AND INDUSTRY INITIATIVES (CA)*		
Congressional Add: *Program Increase*	4.000	-
Congressional Add Subtotals for Project: J13	4.000	-
Congressional Add Totals for all Projects	4.000	-

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) EA6 / *Cyber Collaborative Research Alliance*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
EA6: *Cyber Collaborative Research Alliance*	-	3.106	3.281	3.338	-	3.338	4.886	4.982	5.082	5.186	-	-

A. Mission Description and Budget Item Justification

This Project fosters research performed through the Cyber Security Collaborative Research Alliance (CSEC CRA), a competitively selected consortium, formed to advance the theoretical foundations of cyber science in the context of Army networks. This CRA consists of academia, industry and government researchers working jointly with the objective of developing a fundamental understanding of cyber phenomena so that fundamental laws, theories, and theoretically grounded and empirically validated models can be applied to a broad range of Army domains, applications, and environments. This research focuses on three interrelated aspects of cyber security and is conducted using a trans-disciplinary approach that takes into account the human element of the network. The three aspects of cyber that are addressed are: 1) vulnerabilities and risks of cyber networks to malicious activities, 2) anticipating, detecting, and analyzing malicious activities, and 3) agile cyber maneuver to thwart and defeat malicious activities. Overarching goals of cyber security are to significantly decrease the adversary's return on investment when considering cyber attack on Army networks, and minimizing the impact on (Army) network performance related to implementing cyber security. The CRA research creates a framework that effectively integrates the knowledge of cyber assets and potential adversary capabilities and approaches, and provides defense mechanisms that dynamically adjust to changes related to mission, assets, vulnerability state, and defense mechanisms.

Work in this Project supports key Army needs and provides the technical underpinnings to Program Element (PE) 0602782A (Command, Control, Communications Technology)/Project H92 (Communications Technology).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas.

Work in this Project is performed by the Army Research Laboratory (ARL) in Adelphi and Aberdeen Proving Grounds, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Cyber Security Collaborative Research Alliance	3.106	3.281	3.338
Description: The CSEC CRA supports basic research to enable capabilities for rapid development and adaptation of cyber tools for dynamically assessing cyber risks, detecting hostile activities on friendly networks, and supporting agile maneuver in cyber space in spite of the continuous evolution and emergence of novel threats.			
FY 2016 Accomplishments: Developed theories and models relating fundamental properties of dynamic cyber threats to dynamic risk assessments and defensive maneuver algorithms; developed a mathematical formalism for representing cyber tasks or missions that will provide a common framework for reasoning about risk, maneuver, detection and the underlying socio-cognitive factors; developed approaches to assessment of aggregate risk in such a dynamic hostile environment; developed diagnosis-enabling detection			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** EA6 / *Cyber Collaborative Research Alliance*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
algorithms that can go from symptoms to root causes; developed and validated computational cognitive models that represent human processes of threat detection; and developed multi-party game-theory etic models and computational algorithms leading to pragmatic defense strategies. ***FY 2017 Plans:*** Will extend fundamental theories and models of dynamic cyber threats and defense developed in Fiscal Year (FY) 2015 and 2016, leading to practical defense strategies via analytical models of collaborative and composite risk, and appropriate communication of risk metrics; user/defender/attacker feedback models to capture interactions; optimized evidence collection and introspective detection; model-based generation and verification of cyber maneuvers; multi-party stealth games; and extensive validation on realistic data-sets and test-beds. ***FY 2018 Plans:*** Will develop a science of resilient detection in adversarial settings, leading to models of decision-making under uncertainty. Will develop theories, models and algorithms to execute maneuver at the software, system and network layers. Will research behavioral and game theoretical models to model user-defender-adversary interactions. Will enhance the analytical framework, integrating detection and risk assessment, to provide choices of agility maneuvers that minimize risk. Will experimentally validate the analytical framework on realistic testbeds.			
Accomplishments/Planned Programs Subtotals	3.106	3.281	3.338

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) F17 / *Neuroergonomics Collaborative Technology Alliance*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
F17: *Neuroergonomics Collaborative Technology Alliance*	-	5.046	5.332	4.923	-	4.923	4.720	4.830	4.943	5.044	-	-

A. Mission Description and Budget Item Justification

This Project fosters research through the Cognition and Neuroergonomics Collaborative Technology Alliance (CTA), a competitively selected industry and university consortium, to leverage world-class research in support of future force and Army transformation needs. Escalating levels of complexity and uncertainty on the current and future battlefield present conditions which have never existed before now. Solution strategies and approaches must be developed or tailored. The emerging field of neuroergonomics, which seeks to understand the brain at work and to leverage that understanding to optimize system design, offers tremendous potential for providing the solutions needed to meet the needs of Army forces in the future. This CTA addresses the solution strategies and approaches needed to design systems to fully exploit investments in revolutionary technological advances in areas such as robotics, microelectronics, and computer and network information systems. These technologies present significant opportunities to enhance Army mission capabilities, but impose significant burdens on the human brain, which will ultimately limit Soldier-system effectiveness, sustainability, and survivability. The technical barriers associated with this project include: immature knowledge base to guide the neuroergonomic approach to human-system integration; inadequate capabilities to sense and extract information about brain activity in dynamic, operational environments; lack of valid measures to robustly and uniquely characterize operationally-relevant cognitive performance; lack of techniques for integrating advanced understandings of brain activity into systems designs, including real-time use of measures of cognitive behavior as system inputs and the capability to account for individual differences in maximizing Soldier-system performance. This CTA conducts an intensive and accelerated program to formulate, validate, and transition basic research findings through multi-dimensional approaches focused in three areas: understanding fundamental principles underlying Soldier neurocognitive performance in operational environments, advancing computational approaches for the analysis and interpretation of neural functioning, and fundamental advancement in neurotechnologies that enhance Soldier-system interactions and performance.

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas and the Army Modernization Strategy.

Work in this Project is performed by the Army Research Laboratory (ARL) in Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Neurocognitive performance in operational environments	1.941	1.970	1.821
Description: This effort is intended to understand fundamental principles underlying Soldier neurocognitive performance in operational environments.			
FY 2016 Accomplishments:			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** F17 / *Neuroergonomics Collaborative Technology Alliance*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Developed novel set of algorithmic principles and approaches for integrating multiple, concurrently record data streams to enable interpretation and use of brain-based recordings in complex conditions; and enhanced estimates of confidence in environmental and human states for improved reliability of sensor information. ***FY 2017 Plans:*** Will develop models of neural activity to characterize performance in Army-relevant tasks; and investigate relationships between brain activity recorded on the scalp and brain activity recorded within the skull to improve understanding of how the skull and scalp affect recorded brain signals. ***FY 2018 Plans:*** Will utilize behavioral, physiological, and neural measures to explore emotional state and the emotional tone of interpersonal communication; will develop novel methods for improved trust and successful communication between vehicle operators, passengers, and autonomous agents based on emotional state			
Title: Computational neural analysis ***Description:*** This effort advances computational approaches for the analysis and interpretation of neural functioning. ***FY 2016 Accomplishments:*** Developed algorithms that use adaptive approaches to account for the gradual changes in the mean and variance of the underlying neural signatures that occur when participants perform the same task for an extended period of time. Adapting to these time-on-task effects increased the performance of brain computer interaction technology. ***FY 2017 Plans:*** Will develop algorithms for reliable comparisons between simple experimental tasks and operationally-relevant tasks; and develop analytical methods for automated characterization of within-subject, cognitive state fluctuations during long-term task performance. ***FY 2018 Plans:*** Will develop experimental paradigms and computational techniques to understand the brain circuits underlying shifts between decision-making and task-related actions; will develop novel methods for identifying changes in the statistics of the operational environment, task constraints, and arousal level.	1.438	1.622	1.477
Title: Neurotechnologies ***Description:*** This effort provides a fundamental advancement in neurotechnologies that enhance Soldier-system interactions and performance. ***FY 2016 Accomplishments:***	1.667	1.740	1.625

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** F17 / *Neuroergonomics Collaborative Technology Alliance*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Developed experimental mobile applications to monitor and track real-world fluctuations in sleep patterns and perceived levels of stress and fatigue in order to examine how these behavioral variations effect neural data; and developed novel big data mining methods to unite data on this effort that are collected at different research centers. ***FY 2017 Plans:*** Will investigate performance of dry electrode systems in high noise conditions inherent to real-world tasks for applications in mobile environments; and develop a combined hardware-software solution for mitigation of noise in the signal for enhanced interpretation of brain data. ***FY 2018 Plans:*** Will develop computational frameworks and systems for asynchronous brain-computer communication; Will identify, separate, and interpret brain activity during naturally occurring periods of stable eye position in both seated and ambulatory environments.			
Accomplishments/Planned Programs Subtotals	5.046	5.332	4.923

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) FF5 / *Distributed Collaborative Intelligent Systems CTA*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
FF5: *Distributed Collaborative Intelligent Systems CTA*	-	0.000	0.000	4.178	-	4.178	5.820	6.131	6.295	6.436	-	-

A. Mission Description and Budget Item Justification

This project fosters basic research through the highly Distributed and Collaborative Intelligent Systems and Technology (DCIST) Collaborative Technology Alliance (CTA), a competitively selected university consortium which leverages world-class research necessary to address future force and Army Transformation needs. The CTA links a broad range of government technology agencies, as well as industrial and academic partners with the Army Research Laboratory (ARL). The DCIST CTA focuses on systems with a large number of heterogeneous intelligent agents, including Soldiers that can be distributed over large areas and are required to move through contested environments and against peer capabilities at op-tempo. To meet these goals innovative research is performed in three main technical areas: distributed intelligence, large heterogeneous group control, and adaptive and resilient behaviors. The payoff to the warfighter will be extended reach, situational awareness, and operational effectiveness against dynamic threats in contested environments, and technical and operational superiority through intelligent, resilient and collaborative behaviors of Soldiers and intelligent systems. The CTA facilitates the exchange of people among the collaborating organizations to provide cross-organizational perspectives on basic research challenges, and to make available to the Alliance state-of-the-art facilities and equipment at the participating organizations.

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas and the Army Modernization Strategy.

Work in this project is performed by the ARL in Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Distributed Collaborative Intelligent Systems Technology	-	-	4.178
Description: Extend reach, situational awareness, and operational effectiveness against dynamic threats in contested environments through intelligent, resilient and collaborative behaviors of heterogeneous teams of Soldiers, intelligent systems, smart sensors, and knowledge sources. ***FY 2018 Plans:*** Will explore and develop the underpinning science and technology for highly distributed and collaborative intelligent systems along technical areas to include distributed intelligence, large heterogeneous group control, and adaptive and resilient behaviors.			
Accomplishments/Planned Programs Subtotals	-	-	4.178

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** FF5 / *Distributed Collaborative Intelligent Systems CTA*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) FF7 / *Internet of Battlefield Things CTA*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
FF7: *Internet of Battlefield Things CTA*	-	0.000	0.000	3.068	-	3.068	4.179	6.020	6.084	6.175	-	-

A. Mission Description and Budget Item Justification

This Project will foster research performed through the Internet of Battlefield Things Collaborative Research Alliance (IoBT CRA), a competitively selected consortium formed to advance the theoretical foundations of the Internet of Things in the context of Army Operations. The CRA will comprise academia, industry and government researchers working jointly with the objective of developing a fundamental understanding of phenomena of Internet of Things and cyber-physical systems in tactically relevant environments. The CRA will facilitate collaboration across organizations to provide multi-disciplinary perspectives on basic research challenges, as well as the use of state-of-the-art facilities and equipment at the participating organizations. This research focuses on three interrelated aspects of pervasive and converged cyber-physical complex information systems and is conducted using a trans-disciplinary approach that takes into account the information-theoretic and human elements of Army IoBT interactions. The three aspects of the emergent Internet of Battlefield Things topical areas addressed are: 1) dynamic discovery and adaptation of cyber-physical devices, networks, and information sources, 2) resilient re-purposing and re-tasking of devices and information capabilities, and 3) algorithmic, distributed and centralized information-stream processing. Overarching goals of the basic research on Army IoBT are to investigate foundational cross-cutting theories and methods leading towards a science of heterogeneous, self-adapting, complex cyber-physical systems. This research will lead to optimized real-time adversarial situation estimates in information-enabled warfare and greatly enhance the speed and precision for complex military operations involving converged sensing, communications, and resilient actuation.

Work in this Project builds fundamental knowledge for and accelerates the transition of communications and networks technology to Program Element (PE) 0602783A (Computer and Software Technology).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas and the Army Modernization Strategy.

Work in this Project is performed by the ARL in Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Internet of Battlefield Things Collaborative Research Alliance (IoBT CRA)	-	-	3.068
Description: The IoBT CRA seeks to gain fundamental understanding of IoT phenomena and its performance in tactical environments, ranging from sparse, remote settings to complex, dense urban environments. To enable an IoBT capability, research needs to address intelligent resourcing and influence in complex, constrained and uncertain networks (demand from massive numbers of dynamically connected devices, limited and unpredictable connectivity, shared civilian networks, computation			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** FF7 / *Internet of Battlefield Things CTA*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
at or near the device), heterogeneous sensing and actuation devices (efficient, smart devices with self-organizing/preservation/ directing capabilities), and variable, and unreliable provenance and dynamisms of information and device signals. ***FY 2018 Plans:*** Will competitively select a consortium consisting of academia, industry and government researchers; will investigate new theories for complex system effects that can be applied to dynamic, heterogeneous, adaptive systems-of-systems where the boundaries of control extend beyond personal, organizational, and political borders; will explore universal theoretical principles that span the multiple levels at which self-configuring and resilient systems can exist—from systems to enterprises; e.g., formalisms to support diverse nonlinear emergent system behaviors; will investigate methods for determining how to incorporate human behavior models into the formal methodology of feedback and just-in-time control; and will study theoretical foundations for information, leading to an understanding of tradeoffs (amount of information collected, opportunity for tampering, resource consumption, latency, etc.) and thus predictive resource allocation (sensing, computing, communications, etc.) taking into account risk and uncertainty			
Accomplishments/Planned Programs Subtotals	-	-	3.068

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) H04 / *HBCU/MI Programs*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
H04: *HBCU/MI Programs*	-	1.812	1.486	1.536	-	1.536	1.591	1.629	1.671	1.704	-	-

A. Mission Description and Budget Item Justification

This Project supports basic research through the Partnership in Research Transition (PIRT) program, the Army's research initiative focused on partnerships with Historically Black Colleges and Universities and Minority Institutions (HBCU/MI), and provides support to Department of Defense (DoD) HBCU/MI program providing support for research and collaboration with DoD facilities and personnel for research and collaboration with DoD facilities and personnel. The focus of this effort is to enhance programs and capabilities of high-interest scientific and engineering disciplines through innovative research performed: 1) at Centers of Excellence (CoE) established at HBCU/MIs, and 2) in collaboration with Collaborative Technology Alliances and Collaborative Research Alliances (CTA/CRAs). The COEs and CTA/CRAs work with Army, industry, and other academic partners to transition research to technology demonstration. In addition, the CoEs and CTA/CRA partnerships provide opportunities to recruit, educate, and train outstanding students and post-doctoral researchers in science and technology areas relevant to the Army.

Work in this Project if fully coordinated with the Office of the Secretary of Defense (OSD) program manager for HBCU/MI programs.

Work performed in this Project supports key Army needs and is coordinated with one or more of the following Projects: 0601104A (University and Industry Research Center)/Project EA6 (Cyber CRA), /Project F17 (Neuroergonomics CTA), /Project H09 (Robotics CTA), /Project H50 (Network Sciences CTA), Micro Autonomous Systems Technology CTA), and /Project VS2 (Multiscale Modeling of Materials).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas.

Work on this Project is performed by the Army Research Laboratory (ARL) in Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Centers of Excellence for Battlefield Capability Enhancements (BCE)	1.812	1.486	1.536
Description: Five new Partnership in Research Transition (PIRT) Centers of Excellence were established in 2011 at: Hampton Univ. (Lower Atmospheric Research Using Light Detection and Ranging (Lidar) Remote Sensing); NCA&T State Univ. (Nano to Continuum Multi-Scale Modeling Techniques and Analysis for Cementitious Materials Under Dynamic Loading); Delaware State Univ. (Center for Advanced Algorithms); Howard Univ.(2) (Bayesian Imaging and Advanced Signal Processing for Landmine and Improvised Explosive Device (IED) Detection Using Ground Penetrating Radar (GPR), and Extracting Social Meaning From Linguistic Structures in African Languages). These Centers were selected to: enhance programs and capabilities through Army-relevant, topic-focused, near-transition-ready innovative research; strengthen the capacity of the HBCUs to provide excellence in education; and to conduct research critical to the national security functions of the DoD.			
FY 2016 Accomplishments:			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** H04 / *HBCU/MI Programs*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Concluded support of research at the five PIRT Centers of Excellence; and continued research investigations with HBCU/MIs universities, through follow-on activity with PIRT Centers that enabled research/technology transition or funded new high interest research with HBCU/MIs through single-investigator efforts, new centers of excellence, or other grant or cooperative research mechanisms. ***FY 2017 Plans:*** Will conduct new research efforts with HBCU/MIs through ARL's CTA/CRAs. Projects will be within the scope of CTA/CRAs and will represent opportunities to pursue new, high quality research in areas of strategic importance to the Army. Areas of research will include: network science, cognition and neuroergonomics, multiscale modeling of materials, robotics, and/or cyber security. ***FY 2018 Plans:*** Will continue to conduct research with HBCU/MIs begun in FY17 and performed in collaboration with ARL's CTA/CRAs. Projects are within the scope of CTA/CRAs and will pursue high quality, collaborative research in areas of strategic importance to the Army. Areas of research will include: network science, cognition and neuroergonomics, multiscale modeling of materials, robotics, and/or cyber security.			
Accomplishments/Planned Programs Subtotals	1.812	1.486	1.536

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) H05 / *Institute For Collaborative Biotechnologies*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
H05: *Institute For Collaborative Biotechnologies*	-	6.228	6.595	5.999	-	5.999	5.999	5.998	5.997	6.150	-	-

A. Mission Description and Budget Item Justification

This Project supports research at the Army's Institute for Collaborative Biotechnologies (ICB), led by the University of California-Santa Barbara, and two major supporting partners, the California Institute of Technology and the Massachusetts Institute of Technology. The ICB was established as a University Affiliated Research Center (UARC) to support leveraging biotechnology for: advanced sensors; new electronic, magnetic, and optical materials; and information processing and bioinspired network analysis. The objective is to perform sustained multidisciplinary basic research supporting technology to provide the Army with biomolecular sensor platforms with unprecedented sensitivity, reliability, and durability; higher-order arrays of functional electronic and optoelectronic components capable of self-assembly and with multi-functions; and new biological means to process, integrate, and network information. These sensor platforms will incorporate proteomics (large scale study of proteins) technology, Deoxyribonucleic Acid (DNA) sequence identification and detection tools, and the capability for recognition of viral pathogens. A second ICB objective is to educate and train outstanding students and post-doctoral researchers in revolutionary areas of science to support Army Transformation. The ICB has many industrial partners, such as International Business Machine (IBM) and Science Applications International Corporation (SAIC), and has strong collaborations with Argonne, Lawrence Berkley, Lawrence Livermore, Los Alamos, Oak Ridge, and Sandia National Laboratories, the Army's Institute for Soldier Nanotechnologies, the Institute for Creative Technologies, and Army Medical Research and Materiel Command (MRMC) laboratories.

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas and the Army Modernization Strategy.

Work in this Project is performed extramurally by the Army Research Laboratory (ARL) in Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Institute for Collaborative Biotechnologies	5.544	5.872	5.342
Description: Perform sustained multidisciplinary basic research supporting technology to provide the Army with bio-inspired materials and biomolecular sensor platforms.			
FY 2016 Accomplishments: Assessed bacterial viability using ultra-high precision mass sensing for enhancement in Soldier protection against bacterial pathogens; experimentally engineered controlled biofeedback capability within cells to regulate cellular metabolic pathways and provide a basis for biosensing and environmental remediation; experimentally engineered scalable biological circuits in yeast cells that can provide sense-and-respond capabilities against harmful chemical and biological agents; experimentally designed and synthesized soft, hydrogel microparticles and characterized their properties as cell mimics in vascular networks as a potential vehicle for drug delivery; showed how the hierarchical and anisotropic structure of trabecular bone leads to its mechanical			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** H05 / *Institute For Collaborative Biotechnologies*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
properties and translated such understanding to the fabrication of artificial bone; elucidated and translated mechanisms of biological, hierarchical self-assembly to synthetic, stimuli-responsive, optoelectronic materials that can provide responsive antireflective capabilities for the Soldier; experimentally tested the ability of modified bacterial genes to enhance electron transfer within bacteria toward a novel means of energy generation; and using bio-inspired models, understood how shape, optical anisotropy and quasi-ordering at the nano-scale allow for control of the broad-band optical response of material interfaces toward improvements in infrared detection. ***FY 2017 Plans:*** Will conduct basic research efforts in systems and synthetic biology, photonic and electronic materials, cellular structural materials, and biotechnology tools; and increase research efforts in understanding and engineering microbial consortia for potential biological processing and manufacturing. Understanding microbial consortia and engineering them for biological processing/manufacture could provide the Army with the ability to produce complex chemical intermediates/feed stocks for material synthesis, bioremediation of toxic materials in the environment, probiotics for enhanced Solider health/performance, waste mitigation, and novel routes to energy generation for reduced logistics loads. ***FY 2018 Plans:*** Will continue to support basic research efforts in synthetic and systems biology, biotechnology tools, and designing microbial consortia. Cellular structural materials, and photonic and electronic materials projects will be combined into new bio-inspired materials effort. On-going research efforts will include bio-inspired optical and photonic materials for potential applications in controlling infrared response and improved energy conversion and storage; novel nanomaterial platform for in situ biomarker detection; and engineering microbial consortia for bio-production.			
Title: Neuroscience	0.684	0.723	0.657
Description: Perform multidisciplinary basic research in the area of neuroscience. ***FY 2016 Accomplishments:*** Investigated the potential of multi-brain computing and electroencephalogram (EEG) to better understand group decision making, to predict the outcome of future human group decisions in complex tasks, and to track collective cognitive and emotional responses when presented with a common visual stimulus; investigated whether neural markers can be used to indicate biases that may affect optimal decision-making; assessed the variable influences of physical fatigue on cognition and on decisions that require complex motor behavior; and developed an understanding of the effects of stress on cognition and adaptive decision-making on the neural level toward a characterization of the interaction between decision-making and attentional mechanisms. ***FY 2017 Plans:*** Will continue supporting basic cognitive neuroscience research efforts to better understand decision-making, the effect of fatigue on cognition, and identification of neural indicators/biomarkers for optimal decision making; understand how the brain achieves			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** H05 / *Institute For Collaborative Biotechnologies*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
accurate classification under high stress; and develop neuro-engineering techniques to make inferences about human's cognitive and attentional states that are particularly relevant to challenges faced by the Soldier. ***FY 2018 Plans:*** Will continue to support basic cognitive neuroscience research efforts to better understand the effect of fatigue and stress on cognition and on decision-making, and identification of neural indicators/biomarkers for optimal decision-making; and will develop neuro-engineering techniques to make inferences about a human's cognitive and attentional states that are particularly relevant to challenges faced by the Soldier.			
Accomplishments/Planned Programs Subtotals	6.228	6.595	5.999

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) H09 / *Robotics CTA*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
H09: *Robotics CTA*	-	4.587	4.040	4.136	-	4.136	4.240	2.957	3.076	3.139	-	-

A. Mission Description and Budget Item Justification

This Project supports a collaborative effort between the competitively selected industry and university consortium, the Robotics Collaborative Technology Alliance (CTA), and the Army Research Laboratory (ARL) for the purpose of leveraging world-class research in support of the future force and Army transformation needs. This project conducts basic research in areas that will expand the capabilities of intelligent mobile robotic systems for military applications with a focus on enhanced, innate intelligence, ultimately approaching that of a dog or other intelligent animal, to permit unmanned systems to function as productive members of a military team. Research is conducted in machine perception, including the exploration of sensor phenomenology, and the investigation of basic machine vision algorithms enabling future unmanned systems to better understand their local environment for enhanced mobility and tactical performance; intelligent control, including the advancement of artificial intelligence techniques for robot behaviors permitting future systems to autonomously adapt, and alter their behavior to dynamic tactical situations; understanding the interaction of humans with machines focusing upon intuitive control by Soldiers to minimize cognitive burden; dexterous manipulation of the environment by unmanned systems; and unique modes of mobility to enable unmanned systems to seamlessly navigate complex or highly constrained three dimensional environments. The program will conduct both analytic and validation studies.

Work in this Project builds fundamental knowledge for and complements the companion applied technology program, Program Element (PE) 0602120A, Project TS2 (Robotics).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas and the Army Modernization Strategy.

Work in this Project is performed by the Army Research Laboratory (ARL) at the Aberdeen Proving Ground, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Autonomous Systems	4.587	4.040	4.136
Description: Explore opportunities enabling revolutionary, autonomous, and highly mobile systems for the future force. Research focuses on unmanned systems operating as a team with human supervisors and displaying a high degree of adaptability to dynamic environmental and tactical situations.			
FY 2016 Accomplishments: Explored concepts and created algorithms to enable “peer-to-peer” teaming between humans and robots focused upon a flexible			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** H09 / *Robotics CTA*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
multi-agent teaming architecture, problem solving at a cognitive level, and dialog to engender trust; examined mechanisms for creating social and tactical "understanding" and fast, adaptive, on-line, and on-the-fly learning and interaction with complex 3D environments. ***FY 2017 Plans:*** Will develop "peer-to-peer" teaming between humans and robots through expanded fine grained semantic perception especially through the inclusion of contextual information, exploration of deep-learning techniques and techniques for learning based upon sparse data, modeling of basic human behaviors, and exploration of techniques for energy efficient mobility in complex environments. ***FY 2018 Plans:*** Will research the algorithmic infrastructure necessary to enable peer-to-peer teaming through intuitive mechanisms, e.g., communication of perceptual information and intelligent machine behaviors through language. Will explore methods to generalize machine intelligence for adaptation to new situations.			
Accomplishments/Planned Programs Subtotals	4.587	4.040	4.136

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) H50 / *Network Sciences Cta*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
H50: *Network Sciences Cta*	-	10.627	9.166	6.466	-	6.466	5.828	0.000	0.000	0.000	-	-

Note

The Mobile Network Modeling Institute moves to in-house basic research in Fiscal Year (FY) 2018 under Program Element (PE) 0601102A (Defense Research Sciences) \ H48 (Battlespace Info & Comm Rsc).

A. Mission Description and Budget Item Justification

This Project supports a competitively selected university and industry consortium, the Network Sciences Collaborative Technology Alliance (NS CTA), formed to leverage commercial research investments to provide solutions to Army's requirements for robust, survivable, and highly mobile wireless communications networks, while meeting the Army's needs for a state-of-the-art wireless mobile communications networks for command-on-the-move. The NS CTA performs foundational, cross-cutting network science research leading to: a fundamental understanding of the interplay and common underlying science among social/cognitive, information, and communications networks; determination of how processes and parameters in one network affect and are affected by those in other networks; and prediction and control of the individual and composite behavior of these complex interacting networks. This research will lead to optimized human performance in network-enabled warfare and greatly enhanced speed and precision for complex military operations. The CTA facilitates the exchange of people among the collaborating organizations to provide cross-organizational perspectives on basic research challenges, as well as the use of state-of-the-art facilities and equipment at the participating organizations. Many of the results of the NS CTA provide a foundation for a new Collaborative Research Alliance for the Internet of Battlefield Things to begin in FY18.

Work in this Project builds fundamental knowledge for and accelerates the transition of communications and networks technology to PE 0602783A (Computer and Software Technology).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas and the Army Modernization Strategy.

Work in this Project is performed by the Army Research Laboratory (ARL) in Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Network Sciences Collaborative Technology Alliance (NS CTA)	9.609	8.133	6.466
Description: The Network Sciences CTA focuses on four major research areas: Information Networks, Communication Networks, Social/Cognitive Networks, and Interdisciplinary Research to develop a fundamental understanding of the ways that information, social/cognitive, and communications networks can be designed, composed, and controlled to dramatically increase mission effectiveness and ultimately enable humans to effectively exploit information for timely decision-making. Information Networks research develops the fundamental understanding of autonomous network activities and its linkage to the physical and human domains as related to human decision making within the networked command and control (C2) structure. Social/Cognitive			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** H50 / *Network Sciences Cta*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Networks research is developing the fundamental understanding of the interplay of the various aspects of the social and cognitive networks with information and communications. Communications Networks research is developing the foundational techniques to model, analyze, predict, and control the behavior of secure tactical communication networks as an enabler for information and C2 networks. Integration is focused on achieving an integrated Information Networks, Social/Cognitive Networks, Communications Networks research program that significantly enhances the fundamental understanding of the underlying science of networks. ***FY 2016 Accomplishments:*** Developed an analytical framework for modeling the dynamics and evolution of interacting multi-genre networks, such as interacting communications, information, and socio-cognitive network components of a tactical network (this will lead to new models for group-to-group interactions and algorithms and performance metrics for discovering unusual patterns); developed approaches for controlling networks with time-varying structures; developed a foundational science to model, characterize and control information delivered through multi-genre networks (based on the semantics and context of information requests and requisite composite quality-of-information measures); developed fundamental understanding of how to transform data and observations from multi-genre networks into relevant situational understanding for the users in a highly constrained environment; and developed mathematical and computational models of human networks, leading to models for influencing individuals and communities within and between cultures. ***FY 2017 Plans:*** Will model dynamics and co-evolution of inter-genre networks and discovery, inference, and prediction in inter-genre networks; generate models for optimal design and decentralized control of time-varying, non-linear, composite networks; derive algorithms for context-aware knowledge synthesis and analytics over multi-genre (communications, information and socio-cognitive) networks that model uncertainty in distributed processing and user interactions for better situational understanding; create a unifying semantic framework, in the context of multi-genre needs, to address information capacity across multi-genre networks, and to characterize and control the trade-offs in semantic information delivery; and generate predictive models of social-cognitive aspects of multi-genre networks, and mechanisms for influencing networks across cultures, and augmentation of human performance in networked operations. ***FY 2018 Plans:*** Will explore game-theoretic and dynamic programming formulations for network redesign under adversarial dynamics by characterized and establishing conditions for pure and mixed equilibria and formulating algorithms that trades-off current optimality for long-term behavior; will develop a theory of reliable real-time social sensing for information extraction by constructing models of social media as noisy communication channels, establishing fundamental bounds on accuracy, and developing real-time algorithms for reliable information extraction; will obtain insights on the co-evolution of opinion diffusion and social networks by developing theoretical models of opinion diffusion in dynamic social networks and the impact of cultural and structural properties.			
Title: Mobile Network Modeling Institute	1.018	1.033	-

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** H50 / *Network Sciences Cta*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Description: This research focuses on novel computational models, data structures, computational architectures and techniques that enable predictions of performance and stability of large, complex communications networks. It takes into account the impact of Soldiers' information needs and modalities of access and use of communication networks in complex adversarial environments, high mobility, and adversarial effects such as jamming or cyber-attacks. Also considered are computational modeling approaches that capture dynamics of information that flows through the network and/or is stored within the network, and undergoes continual changes as new information arrives and other information ages or is refuted/superseded by newly arrived information; and the impact of clouds and local tactical cloudlets on network behaviors. In FY18, the funding for this research is in project 0601102A\ H48. ***FY 2016 Accomplishments:*** Develop high-fidelity scalable live-virtual simulation/emulation methods for large-scale networks on emerging large-scale high performance computing architectures; investigate uncertainty quantification methods to evaluate and improve highly dynamic live-virtual network modeling; and develop new validation mathematical methods and investigate how these methods can assist in training communication systems for Soldiers. ***FY 2017 Plans:*** Will validate high-fidelity scalable simulation methods for large-scale networks on emerging large-scale high performance computing architectures; use large-scale network experiments to observe and identify atypical behaviors with unknown ramifications; document methods for quantifying uncertainty (for large-scale networking modeling); and derive new mathematical algorithms on emerging heterogeneous computing that can assist in training communication systems for Soldiers.			
Accomplishments/Planned Programs Subtotals	10.627	9.166	6.466

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) H53 / *Army High Performance Computing Research Center*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
H53: *Army High Performance Computing Research Center*	-	5.434	4.404	0.000	-	0.000	0.000	0.000	0.000	0.000	-	-

A. Mission Description and Budget Item Justification

This Project supports critical research at the Army High Performance Computing Research Center (AHPCRC). Research at the AHPCRC is focused on the Lightweight Combat Systems Survivability, computational nano- and bio-sciences, computational battlefield network and information sciences including evaluating materials suitable for armor/anti-armor and sensor applications, defense from chemical and biological agents, and associated enabling technologies requiring computationally intensive algorithms in the areas of combat systems survivability, battlefield network sciences, chemical and biological defense, nanoscience and nanomechanics, and computational information sciences, scientific visualization enabling technologies that support the future force transition path. This program ends in Fiscal Year (FY) 17.

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas and the Army Modernization Strategy.

Work in this Project is performed by the Army Research Laboratory (ARL) in Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Army High Performance Computing Research Center (AHPCRC)	5.434	4.404	-
Description: The AHPCRC research mission is to advance computational science and its application to critical Army technologies through an Army-university-industry collaborative research program in such areas as combat systems survivability, and chemical and biological defense. The cooperative agreement for the AHPCRC terminates in FY17. ***FY 2016 Accomplishments:*** Validated the innovative Model Order Reduction (MOR) method for underbody blast application with experimental data and demonstrated two orders of magnitude increased efficiency of MOR method; developed new programming models for emerging heterogeneous memory hierarchies for tactical High Performance Computing (HPC); and developed domain specific languages for mesh based and graph problems and explored these algorithmic approaches for exascale computers. ***FY 2017 Plans:*** Will investigate new scalable methods for data intensive sciences, specifically exploring next generation computing architectures (scalable algorithms development for data intensive sciences); research next generation computing and programming models and battle command software for emerging heterogeneous memory and storage hierarchies; and develop algorithmic approaches for exascale computers for physics based modeling.			
Accomplishments/Planned Programs Subtotals	5.434	4.404	-

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** H53 / *Army High Performance Computing Research Center*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) H54 / *Micro-Autonomous Systems Technology (MAST) CTA*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
H54: *Micro-Autonomous Systems Technology (MAST) CTA*	-	7.374	6.792	0.000	-	0.000	0.000	0.000	0.000	0.000	-	-

A. Mission Description and Budget Item Justification

This Project fosters basic research through the Micro Autonomous Systems and Technology (MAST) Collaborative Technology Alliance (CTA), a competitively selected industry-university consortium which leverages world-class research necessary to address future force and Army Transformation needs. The CTA links a broad range of government technology agencies, as well as industrial and academic partners with the Army Research Laboratory (ARL). The MAST CTA focuses on innovative research in four main technical areas related to the coherent and collaborative operation of multiple micro autonomous platforms: microsystem mechanics, processing for autonomous operation, microelectronics, and platform integration. Payoff to the warfighter will be advanced technologies to support future force requirements in situational awareness. The CTA facilitates the exchange of people among the collaborating organizations to provide cross-organizational perspectives on basic research challenges, and to make available to the Alliance state-of-the-art facilities and equipment at the participating organizations. The MAST cooperative research alliance terminates in Fiscal Year (FY) 17.

Work in this Project complements and is fully coordinated with the United States (U.S.) Army Tank and Automotive Research, Development, and Engineering Center (TARDEC); the U.S. Army Natick Soldier Research, Development, and Engineering Center (NSRDEC); and the U.S. Special Operations Command (SOCOM).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas and the Army Modernization Strategy.

Work in this Project is performed by the ARL in Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Micro-Autonomous Systems Technology (MAST) CTA	7.374	6.792	-
Description: Enhance tactical situational awareness in urban and complex terrain by enabling the autonomous operation of a collaborative ensemble of multifunctional mobile microsystems. The MAST cooperative research alliance terminates in FY17.			
FY 2016 Accomplishments: Investigated: 1) bio-inspired optic flow, sensors, and control algorithms for micro-aerial platforms with the goal of increasing platform stability and agility; 2) principles of transitions between surfaces for MAST-scale ambulatory robots to operate in complex three-dimensional (3D) terrains, and 3) an advanced 5 gram sub-millimeter radar for use in obstacle detection and platform navigation. Determined methods to enable: 1) cooperative control for teams of micro autonomous platforms; 2) rapid deployment			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** H54 / *Micro-Autonomous Systems Technology (MAST) CTA*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
of heterogeneous robot teams for exploration of unknown environments; 3) robust estimation and path planning for navigation in 3D environments; and 4) bio-inspired landing, perching and grasping for micro-aerial vehicles. ***FY 2017 Plans:*** Will analyze, integrate and experimentally validate bio-inspired optic flow and gust detection sensors and control algorithms for MAST-scaled aerial platforms; analyze, integrate, and experimentally validate increased platform stability and bio-inspired agility concepts for MAST-scale ambulatory robots in complex 3D terrains; characterize and experimentally validate an advanced 5 gram submillimeter radar concept for obstacle detection and platform navigation; develop and experimentally validate advanced optical methods to enable cooperative control for teams of MAST-scaled platforms; characterize methods and experimentally validate rapid deployment of heterogeneous robot teams for exploration of unknown environments and bio-inspired landing, perching, and grasping for micro-aerial vehicles; and develop and experimentally validate concepts for robust communications in complex radio frequency (RF) environments.			
Accomplishments/Planned Programs Subtotals	7.374	6.792	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) H59 / *International Tech Centers*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
H59: *International Tech Centers*	-	6.735	6.563	6.682	-	6.682	6.556	6.742	7.081	7.225	-	-

A. Mission Description and Budget Item Justification

This Project funds the International Technology Centers (ITCs), the Foreign Technology (and Science) Assessment Support (FTAS) program.

The nine ITCs located in in North America, South America, Asia, and Europe support the Army's goals of providing the best technology in the world to our Warfighters by leveraging the Science and Technology (S&T) investments of our international partners. The ITCs perform identification and evaluation of international technology programs to assess their potential impact on the Army's S&T investment strategy. ITC 'technology finds' are submitted as technology information papers (TIPs) to various Army S&T organizations for evaluation and consideration for further research and development. The FTAS program builds upon the TIPs submitted by the ITCs. In some cases the TIP is truly unique and may well meet an Army requirement or potentially support ongoing Army S&T investments. In such cases, the FTAS program can provide initial resources (seed money) to fund basic research in these technology areas identified by the TIPs as having potential relevance to the Army. The research will provide information useful in making early assessments of the technology's potential contributions to the Army's S&T strategy.

Work in this Project related to the United States Military Academy (USMA) Basic Research Center for Network Science is fully coordinated with and complementary to Program Element (PE) 0601104A (University and Industry Research Centers)/Project H50 (Network Science CTA).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus.

Work in this Project is performed by Headquarters, Army Research, Development and Engineering Command (RDECOM) and the Army Research Laboratory (ARL) in Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: International Technology Centers (ITC)	6.226	6.563	6.682
Description: This Project funds the ITCs and the FTAS program. The FTAS program builds upon the TIPs submitted by the ITCs. In some cases the TIP is truly unique and may well meet an Army requirement or potentially support ongoing Army S&T investments. In such cases, the FTAS program can provide initial resources (seed money) to fund basic research in these technology areas identified by the TIPs as having potential relevance to the Army. The research will provide information useful in making early assessments of the technology's potential contributions to the Army's S&T strategy.			
FY 2016 Accomplishments:			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** H59 / *International Tech Centers*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Continued to solicit projects and build on the success of the FTAS Program; continued to enhance and refine technology search capabilities using customer feedback (Research, Development and Engineering Centers (RDECs), Program Managers (PMs) and labs) to focus on near- and long-term capabilities. ***FY 2017 Plans:*** Will continue to solicit projects and build on the success of the FTAS Program; continue to enhance and refine technology search capabilities using customer feedback (RDECs, PMs and labs) to focus on near and long term capabilities. ***FY 2018 Plans:*** Will continue to solicit projects and build on the success of the FTAS Program; and will continue to enhance and refine technology search capabilities using customer feedback (RDECs, PMs and labs) to focus on near- and long-term capabilities.			
Title: Basic Research Center in Network Science at the United States Military Academy ***Description:*** Network science research at USMA in coordination with the Network Science CTA (0601104A/Project H50). ***FY 2016 Accomplishments:*** Built academic impact networks and military information networks (unit teams) and refined process algorithms that produced and enhanced advances in performance, collaboration and cooperation; validated systems using operational data to design and optimize network frameworks and processes to improve military systems and unit organizations. Theoretical work was connected with intelligence, surveillance, and reconnaissance and command and control systems (mission command) and results were used in Army Training and Doctrine Command (TRADOC)-supported exercises; researched subgroup measures, topological models and information security algorithms that supported the use of network science in cyber and intelligence processing systems; and refined economic development models and cultural and logical networks in Africa that assisted military decision makers and diplomatic policy makers.	0.509	-	-
Accomplishments/Planned Programs Subtotals	6.735	6.563	6.682

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) H73 / *Automotive Research Center (ARC)*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
H73: *Automotive Research Center (ARC)*	-	3.009	3.180	3.235	-	3.235	3.296	3.361	3.427	3.498	-	-

A. Mission Description and Budget Item Justification

This Project fosters basic research in novel, high payoff technologies that can be integrated into Army ground platforms. The Center of Excellence for Automotive Research is part of the basic research component of the National Automotive Center (NAC), a business group within the Army Tank-Automotive Research, Development, and Engineering Center (TARDEC). The Center of Excellence for Automotive Research is an innovative university/industry/government consortium leveraging commercial technology for potential application in Army vehicle systems through ongoing and new programs in automotive research, resulting in significant cost savings and performance enhancing technological opportunities. The research performed in this Project contributes to formulating and establishing the basic scientific and engineering principles for these technologies.

Work in this Project complements and is fully coordinated with work under Program Element (PE) 0602601A (Combat Vehicle and Automotive Technology). Selected university partners include: University of Michigan, Virginia Tech, Wayne State University, University of Iowa, Oakland University, and Clemson University. Key industry partners include all major US automotive manufacturers and suppliers. The Automotive Research Center (ARC) formulates and evaluates advanced automotive technologies and advances state-of-the-art modeling and simulation for the Army's future ground vehicle platforms.

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering science and technology priority focus areas and the Army Modernization Strategy.

Work in this Project is performed by TARDEC, Warren, MI.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Automotive Research Center (ARC)	3.009	3.180	3.235
Description: The ARC is an U.S. Army Center of Excellence for Modeling and Simulation of ground Vehicles. The Center relies on the collaboration of researchers from multiple universities and disciplines in order to bridge fundamental technology gaps in five research thrust areas of strategic importance to the Army, associated with conversion and management of power and energy within vehicles, mobility and survivability of the complete vehicle system, including the human operator, and vehicle integration/ optimization.			
FY 2016 Accomplishments: Researched and developed modeling and simulation methodologies for enabling autonomy in ground vehicle systems and increased force protection/survivability; researched tire and track modeling necessary for terramechanics advancements. Researched thrust areas focus on dynamics and control of vehicles with emphasis on autonomy-enabled systems, human-			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** H73 / *Automotive Research Center (ARC)*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
centered modeling and simulation, high performance structures and materials, advanced and hybrid power trains, and vehicle system integration, optimization and robustness. ***FY 2017 Plans:*** Will expand research and further develop modeling and simulation methodologies for enabling autonomy in ground vehicle systems and increased force protection/survivability focused on real-time obstacle avoidance, latency compensation and shared human-machine control; research tire and track modeling and other off-road mobility related topics necessary for terramechanics advancements. Research thrust areas will focus on dynamics and control of vehicles with emphasis on autonomous and autonomy-enabled systems, human-centered modeling and simulation, high performance structures and materials as it pertains to lightweighting/advanced battery systems/lubricants/fuels, next-generation propulsion systems, advanced and hybrid power trains, and vehicle system integration, multi-objective and multi-disciplinary design optimization and robustness focused on modular systems that are expeditionary in nature. ***FY 2018 Plans:*** Will continue to focus on dynamics and control of vehicles with emphasis on autonomy-enabled systems, and ground vehicle system integration of advanced powertrains, storage systems and lightweight structures/materials. Will research and develop modeling and simulation methodologies for vehicle dynamics-conscious real-time hazard avoidance in autonomous ground vehicles (AGV), improving inherent mobility through innovative latency compensation techniques and robotrust algorithms, increasing energy efficiency and mobility of connected vehicles, adaptive powertrain thermal management based on active monitoring and control, superior engine heat rejection using advanced materials, new fatigue reliability and random vibration methods for linear and nonlinear systems, etc. Project proposals for continuing and new projects will be solicited from all ARC consortium researchers in the first quarter of Fiscal Year (FY) 2018.			
Accomplishments/Planned Programs Subtotals	3.009	3.180	3.235

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) J08 / *Institute For Creative Technologies (ICT)*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
J08: *Institute For Creative Technologies (ICT)*	-	5.839	6.186	6.308	-	6.308	6.440	6.569	6.701	6.837	-	-

A. Mission Description and Budget Item Justification

This Project supports simulation and training technology research at the Army's Institute for Creative Technologies (ICT) at the University of Southern California. The ICT was established as a University Affiliated Research Center (UARC) to support Army training and readiness through research into simulation, mixed and virtual reality, artificial intelligence, computer graphics, and learning sciences. ICT applies the results of this research and proves its value in Army relevant applications such as training, mission rehearsal, leadership development, cultural awareness, negotiation, health and medical, and distance learning. The ICT actively performs research and engages industry and academic institutions internationally to incorporate the latest research results and hardware and software into its research program and application development and exploit dual-use technology. The ICT serves as a means for the military to learn about, benefit from, and facilitate the transfer of applicable technologies into military systems. In addition the ICT works with creative talent from the entertainment industry to advance and leverage techniques and capabilities and adapt concepts of story and character to increase the degree of participant immersion in synthetic environments in order to improve the realism and usefulness of these experiences. In developing a true synthesis of the creativity, research, technology, and capability of industry and the research and development community, the ICT is revolutionizing capabilities for the Army by making it more effective in terms of cost, time, range of experiences and the quality of the result and by producing research and applications that will benefit the Army of the 21st century. Resulting research, techniques, and technologies are transitioned for maturation to Program Element (PE) 0602308A (Advanced Concepts and Simulation) / Project D02 (Modeling & Simulation for Training and Design).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas and the Army Modernization Strategy.

Work in this Project is performed by the Army Research Laboratory (ARL) in Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Immersive Environments	2.130	2.347	2.394
Description: Conduct basic research in immersive environments, to include virtual humans, three-dimensional (3D) sound and visual media, to achieve more efficient and affordable training, modeling, simulation and application solutions and tools. Research includes investigation of techniques and methods to address the rapid development of synthetic environments and the study of perception and cognition to help direct the development of new technologies and techniques that evoke more realistic responses from users. Perform research into auditory aspects of immersion to provide the sound stimulus for increasing the realism for military training and simulation devices.			
FY 2016 Accomplishments:			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** J08 / *Institute For Creative Technologies (ICT)*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Continued investigation of techniques for creating immersive environments using mobile computing platforms such as tablet computers, smart phones, and other mobile devices for the purpose of training and mission rehearsal; and explored the creation of novel virtual reality training platforms using mixed reality techniques and coordinated quadrotor robots to expand virtual training operating space. ***FY 2017 Plans:*** Will conduct studies with immersive virtual reality environments to identify ways to induce users to react in realistic and naturalistic ways to support more effective training and learning experiences in virtual spaces; investigate research technologies to automatically recognize nonverbal behaviors and interpersonal dynamics in groups for improved human-computer and human-robot interactions; and investigate the use of machine learning techniques to acquire automatically through interaction with users a variety of linguistic features that support more natural and fluid language interaction. ***FY 2018 Plans:*** Will incorporate semantic, nonverbal human behaviors with verbal messages to increase realism of simulated face-to-face conversations between humans and virtual humans. Will develop algorithms to automatically analyze social simulation models for proactively identifying potential data gaps and eliciting data from both online and expert sources to fill in the identified gaps. Will create end-to-end neural network-inspired solutions for modeling entrainment for groups of individuals (mixed with virtual agents).			
Title: Graphics and Animations ***Description:*** Conduct basic research to identify new computational techniques in graphics for achieving real-time photo-realistic rendering of physical and synthetic environments for training and simulations. Research innovative methods for automatically generating animations and gestures for virtual humans based on what is being communicated. Research new technologies for scanning real people and rapidly generating virtual humans which look like these people significantly reducing the time, expense and effort required to develop virtual humans and virtual environments. ***FY 2016 Accomplishments:*** Developed finite element models to improve facial capture performance and animation of eyes and lips for virtual humans, allowing for enhanced non-verbal communications in social interactive training environments; and developed techniques to display life-sized, 3D virtual humans resulting in a high-fidelity, simulated social interactions for training and leader development. ***FY 2017 Plans:*** Will research new technologies for developing life-like, high definition novel performances that include the rapid synthesis of a wide range of facial animations by digital characters allowing for the creation of new performances even when the original (real) subject is no longer available; investigate methods and techniques for the autostereoscopic rendering and display of virtual humans in 3D shared spaces such that they can be viewed by multiple simultaneous viewers without the need for special glasses or headwear; research computational camera system techniques for the purpose of rapidly capturing photorealistic digital	1.409	1.434	1.462

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** J08 / *Institute For Creative Technologies (ICT)*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
characters and authoring performance-driven animations; conduct experiments to determine effectiveness of the human-virtual human interaction at varying levels of fidelity; and extend virtual character capture methods to extract and model hair and cloth to improve the photorealism of dynamic virtual characters. ***FY 2018 Plans:*** Will research hybrid approaches to tracking and creating high-definition facial and body performances of virtual humans for increased realism within virtual and mixed reality environments; will investigate techniques to rapidly capture and recreate objects and scenes within virtual reality environments; and will develop models for animated characters that include relevant aspects of actual human personalities such as gait, posture, and gestures.			
Title: Techniques and Human-Virtual Human Interaction ***Description:*** Will conduct basic research to investigate methods and techniques for creating virtual human computer-generated characters that look, communicate and behave like real people, meaning the virtual humans will be autonomous, use verbal and non-verbal communication, exhibit emotions, model their own beliefs, desires and intentions as well as those of others, and reason using advanced artificial intelligence. Investigate methods and techniques for improving the perception, communication, understanding, and responsiveness of virtual humans when interacting with live humans and explore how people relate to virtual humans. ***FY 2016 Accomplishments:*** Developed and validated theoretical framework to increase the effectiveness of human interactions with virtual humans and robots; developed algorithms and models for virtual humans to engage in multiple activities extending their conversational ability to beyond one specific scenario; and continued development of human cognitive architecture supporting virtual human learning. ***FY 2017 Plans:*** Will explore strategic use of emotion and how emotional displays can be used to manipulate negotiation outcomes and develop a dynamic computer model representation; extend research to explore in depth differences between how people respond to virtual humans, real humans and robots; create meta-dialogue strategies for controlling interactions between people and virtual humans and use online learning to enhance speech synthesis so that virtual humans engage in human-like interaction with people and other virtual human agents; and refine conceptual virtual humans architecture to validate advanced and more natural emotional behaviors, reasoning, and interactions via natural language and speech. ***FY 2018 Plans:*** Will examine and formalize multiple pathways that leaders can use to influence the emotions and motivations of others (in both negotiation and leadership settings). Will create models of motivation and personality within a cognitive architecture for virtual humans. Will develop a new theory of human-machine teaming focused on gaining a better understanding of the human-machine	2.300	2.405	2.452

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** J08 / *Institute For Creative Technologies (ICT)*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
social relationships. Will evaluate the use of meta-dialogue, on-line learning, story, culture, and knowledge-based interaction-enhanced capabilities within the context of long-term interactions between humans and artificial agents			
Accomplishments/Planned Programs Subtotals	5.839	6.186	6.308

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) J12 / *Institute For Soldier Nanotechnology (ISN)*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
J12: *Institute For Soldier Nanotechnology (ISN)*	-	5.339	6.185	5.999	-	5.999	5.999	5.998	5.997	6.057	-	-

A. Mission Description and Budget Item Justification

This Project supports sustained multidisciplinary research at the Army's Institute for Soldier Nanotechnologies (ISN) at the Massachusetts Institute of Technology. The ISN was established as a University Affiliated Research Center (UARC) to support research to devise nanotechnology-based solutions for the Soldier. The ISN emphasizes revolutionary materials research for advanced Soldier protection and survivability. The ISN works in close collaboration with the United States (U.S.) Army Research Laboratory (ARL), the Army Natick Soldier Research, Development and Engineering Center (NSRDEC), and other U.S. Army Research Development and Engineering Command (RDECOM) elements, as well as several major industrial partners, including Raytheon and DuPont, in pursuit of its goals. This project emphasizes revolutionary materials research toward an advanced uniform concept. The future uniform will integrate a wide range of functionality, including ballistic protection, responsive passive cooling and insulating, screening of chemical and biological agents, biomedical monitoring, performance enhancement, and extremities protection. The objective is to lighten the Soldier's load through system integration and multifunctional devices while increasing survivability. The new technologies will be compatible with other Soldier requirements, including Soldier performance, limited power generation, integrated sensors, communication and display technologies, weapons systems, and expected extremes of temperature, humidity, storage lifetimes, damage, and spoilage.

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas and the Army Modernization Strategy.

Work in this Project is performed by the ARL in Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Nanomaterials and Nanotechnologies for Soldier Application (formerly Nanomaterials)	1.250	1.540	5.999
Description: Nanomaterials research efforts focus on light-weight, multifunctional nanostructured fibers and materials.			
FY 2016 Accomplishments: Designed and chemically synthesized colloidal nanoparticles to efficiently convert Ultra-Violet (UV) to Short Wavelength Infrared (SWIR) light to enable night vision and secure communications with one, inexpensive device and to add capability to current SWIR commercial, off-the-shelf devices; devised novel chemistry for synthesis and functionalization of thin core-shell nanoparticle constructs to enable economical, highly efficient SWIR emission devices; developed piezo-electric fibers and fiber arrays for acoustic sensing and potential use in sniper detection; created crystalline semiconductors from high melting materials using novel lower temperature fiber drawing technology to enable novel, in-uniform fiber devices for communications and sensing; designed and produced, by fiber thermal drawing methods, all-in-fiber electrical capacitors of prescribed architectures for use in electric power and electronics applications with uniform and non-uniform devices; and developed and applied new computational			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** J12 / *Institute For Soldier Nanotechnology (ISN)*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
modeling and simulation tools to enable tractable design of high efficiency optical obscurant particles to enable better obscurant capabilities in smoke grenades. ***FY 2017 Plans:*** Will continue to fund basic nanomaterials research efforts, including functional nanocrystals for spectral applications, graphene integration for infrared (IR) detection, and nanoparticles with specified optical resonances for obscurant applications. ***FY 2018 Plans:*** Will conduct basic research projects in nanomaterials that can lead to development of novel nanophotonic and optical sensing and energy conversion platforms, and personal medicine platforms for the Soldier. Will explore novel nanomaterials and composites to improve Soldier protection against blast and ballistic threats, mitigate shock, and improve impact absorption. Will investigate multiscale modeling efforts for fracture process in novel nanomaterials. Will study novel strategies for treatment of incompressible wounds and improved vaccination/infection control strategies by leveraging targeted nanotherapies. Will research nanosystem integration efforts that could lead to development of novel electrical, photonic, and optical sensing platforms involving 2D materials. Will support innovative research efforts that can lead to portable and efficient energy conversion and storage strategies.			
Title: Blast Effects on Soldier ***Description:*** Blast Effects on Soldier research involves the areas of Battle Suit Medicine and Blast and Ballistic Protection. Will be discontinued as a separate task and will be merged with Nanomaterials and Nanotechnologies for Soldier Application task in Fiscal Year (FY) 18. ***FY 2016 Accomplishments:*** Designed, fabricated and tested experimental graphene polymer composites to provide lighter weight and higher strength protective materials for the Soldier; performed experiments, mathematical modeling, and simulation studies to enable the design and production of light weight, high strength nanocrystalline and superelastic metal alloys for blast and ballistic protection and damping of mechanical energy; developed improved fundamental understanding of the physics, biology, and physiology of blast-induced trauma and of the strengths and limitations of various materials to protect against blast related injuries; and developed computational tools for high-fidelity three-dimensional (3D) simulations of blast and ballistic impacts on human protective materials including crack formation and propagation, and materials failure. ***FY 2017 Plans:*** Will continue basic research to improve understanding of the physics, biology and physiology of blast-induced trauma and the strengths and limitations of various materials to protect against blast related injuries. Support efforts to develop computational	2.792	3.100	-

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** J12 / *Institute For Soldier Nanotechnology (ISN)*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
tools for high-fidelity 3D simulations of blast and ballistic impacts on human protective materials, including crack formation and propagation, and materials failure.			
Title: Soldier Protection ***Description:*** Soldier Protection research efforts focused on Soldier Survivability and Protection and Nanosystems Integration. Will be discontinued as a separate task and will be merged with Nanomaterials and Nanotechnologies for Soldier Application task in FY18. ***FY 2016 Accomplishments:*** Designed, constructed, and assessed compact devices to allow storage and rapid administration of pain relief and agents to treat battlefield injuries; devised compact, high sensitivity hollow-core photonic band gap fiber devices to extend the detection limits and range of improvised explosive devices that can be detected with compact hand-held and robot-borne devices; exploited the novel electronic properties of chemically and biologically functionalized nanocarbon structures to design compact, low power devices to sense food pathogens and to sense chemical-biological agents or other hazardous materials; created nanostructured capabilities to treat battlefield wounds including engineered hydrogels to rapidly stop bleeding, engineered bacteriophages and nanoparticles to combat antibiotic resistant wound pathogens, and nanoparticles to deliver anti-inflammatory agents into cells; performed theoretical, computational, and experimental studies of how photonic crystals interact with light waves that may enable the development of all-optical integrated circuits for more robust devices; designed, built, and assessed advanced thermo-photovoltaic power generation devices that exploit nanostructured photonic crystals to achieve much higher fuel-to-electricity conversion efficiencies and thus enable efficient portable power; employed analytical theory, high-fidelity computation, and experiments to enable practical applications of a recently discovered photonic crystal phenomenon, that may ultimately enable novel sensing applications. ***FY 2017 Plans:*** Will continue funding basic research efforts that could lead to development of novel therapeutic multifunctional materials and drug delivery vehicles. Support efforts in synthesis of nanoscale superelastic alloys and other novel nanomaterial systems for potential flexible protection application.	1.297	1.545	-
Accomplishments/Planned Programs Subtotals	5.339	6.185	5.999

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** J12 / *Institute For Soldier Nanotechnology (ISN)*

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) J13 / *UNIVERSITY AND INDUSTRY INITIATIVES (CA)*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
J13: *UNIVERSITY AND INDUSTRY INITIATIVES (CA)*	-	4.000	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	-	-

Note

Not applicable for this item.

A. Mission Description and Budget Item Justification

Congressional Interest Item funding provided for University and Industry Initiatives.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017
Congressional Add: Program Increase	4.000	-
FY 2016 Accomplishments: Congressional increase for basic research efforts.		
Congressional Adds Subtotals	4.000	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) J14 / *Army Educational Outreach Program*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
J14: *Army Educational Outreach Program*	-	9.287	9.864	10.047	-	10.047	10.272	10.466	10.675	10.893	-	-

A. Mission Description and Budget Item Justification

This Project supports science activities that encourage elementary/middle/high school and undergraduate youths to develop an interest in and pursue education and employment in the Science, Technology, Engineering, and Math (STEM) fields. These activities are coordinated within the Army Educational Outreach Program (AEOP) that links and networks appropriate components to derive the best synergies to present the Army to a larger pool of technical talent and to provide students with Army-unique practical experiences at Army laboratories, centers, and institutes to fill future Army Science and Technology workforce needs. AEOP increases interest and involvement of students and teachers across the nation in STEM at all proficiency levels and backgrounds to include under-represented and economically disadvantaged groups through exposure to Army sponsored research, education, competitions, internships, and practical experiences. This Project utilizes Army STEM assets to contribute to a STEM literate citizenry as well as enhances the national pool of science and engineering personnel that in turn supports defense industry and Army laboratory and research, development, and engineering center needs.

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus area, the Army Modernization Strategy, the Federal STEM Strategic Plan, and the President's "Educate to Innovate" campaign for STEM education.

Work in this Project is performed by the Army Research, Development, and Engineering Command (RDECOM), the Army Research Institute (ARI) for the Behavioral and Social Sciences, the Army Corps of Engineers' Engineer Research and Development Center (ERDC), the Army Medical Research and Materiel Command (MRMC), the Army Space and Missile Defense Command (SMDC), and the United States Military Academy (USMA).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: eCYBERMISSION	3.617	3.822	3.821
Description: This program supports a nation-wide, web-based STEM competition for students in grades 6 through 9, designed to stimulate interest and encourage continued education in these areas among middle and high school students nationwide.			
FY 2016 Accomplishments: Continued STEM activities with concentrated effort in reaching out to students from underserved populations; increased geographic diversity; sustained program growth; and implemented program enhancements based on prior years' evaluations outcomes.			
FY 2017 Plans:			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** J14 / *Army Educational Outreach Program*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will continue STEM activities with concentrated effort in reaching out to students from underserved populations; increase geographic diversity; sustain program growth; and will implement program enhancements based on prior years' evaluations outcomes. ***FY 2018 Plans:*** Will continue STEM activities with concentrated effort in reaching out to students from underserved populations; increase geographic diversity; sustain program growth; and will implement program enhancements based on prior years' evaluations outcomes.			
Title: Educational Outreach and Workforce Development ***Description:*** This effort aims to broaden STEM competencies through various outreach and workforce development initiatives at participating Army labs and research centers. ***FY 2017 Plans:*** Will continue AEOP support and outreach to under-represented and economically disadvantaged areas to enhance STEM education through student experiences in Army labs and academic partner institutions, and mentor students to broaden their interest in and their development of STEM education. ***FY 2018 Plans:*** Will continue AEOP support and outreach to under-represented and economically disadvantaged areas to enhance STEM education through student experiences in Army labs and academic partner institutions, and mentor students to broaden their interest in and their development of STEM education.	-	2.400	2.200
Title: Army Educational Outreach Program (AEOP) Cooperative Agreement ***Description:*** The Army Educational Outreach Program Cooperative Agreement encompasses a variety of outreach activities under AEOP. This activity supports a strong partnership with government, academia and industry to address the shortfall of clearable STEM skilled talent preparing for the workforce. These activities include Army-sponsored research, education, competitions, internships and practical experiences designed to engage and guide students and teachers in Army sponsored STEM programs. AEOP has targeted efforts to reach and engage underserved and underrepresented communities in STEM initiatives to build the pool of diverse STEM competitive talent. ***FY 2016 Accomplishments:*** Continued Army lab and research center sponsorship of students and STEM education opportunities; provided incentives in STEM competitions that include scholarships, experiences and mentorships as well as expose students to Department of Defense	5.377	3.332	3.711

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** J14 / *Army Educational Outreach Program*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
(DoD) career opportunities; streamlined processes, leveraged funding and built educational partnerships; and performed annual comprehensive review and educational assessments to support future decisions and best practices. ***FY 2017 Plans:*** Will continue Army lab and research center sponsorship of students and STEM education opportunities; provide incentives in STEM competitions that include scholarships, experiences and mentorships as well as expose students to DoD career opportunities; streamline processes, leverage funding and build educational partnerships; and perform annual comprehensive review and educational assessments to support future decisions and best practices. ***FY 2018 Plans:*** Will continue Army lab and research center sponsorship of students and STEM education opportunities; provide incentives in STEM competitions that include scholarships, experiences and mentorships as well as expose students to DoD career opportunities; streamline processes, leverage funding and build educational partnerships; and perform annual comprehensive review and educational assessments to support future decisions and best practices.			
Title: West Point Cadet Research ***Description:*** The West Point Cadet Research Program provides West Point Cadets an opportunity to work on Army research projects alongside Army and industry scientists and engineers. ***FY 2016 Accomplishments:*** Conducted West Point cadet research internship program to enhance cadet training through field experience in Army research labs and centers. ***FY 2017 Plans:*** Will conduct West Point cadet research internship program to enhance cadet training through field experience in Army research labs and centers. ***FY 2018 Plans:*** Will conduct West Point cadet research internship program to enhance cadet training through field experience in Army research labs and centers.	0.293	0.310	0.315
Accomplishments/Planned Programs Subtotals	9.287	9.864	10.047

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** J14 / *Army Educational Outreach Program*

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) J15 / *Network Sciences ITA*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
J15: *Network Sciences ITA*	-	3.909	4.078	4.082	-	4.082	4.111	4.151	4.233	4.320	-	-

A. Mission Description and Budget Item Justification

This Project supports research at a competitively selected United States (U.S.)/United Kingdom (U.K.) government, university, and industry consortium established to perform fundamental network and information science investigations in the areas of network theory, system-of-systems security, sensor processing and delivery, and distributed coalition planning and decision making. The focus is on enhancing distributed, secure, and flexible decision-making to improve coalition operations, and developing the scientific foundations for complex and dynamic networked systems-of-systems to support the complex human, social, and technical interactions anticipated in future coalition operations with the emphasis on integration of multiple technical disciplines in an international arena. The Army Research Laboratory (ARL) and the U.K. Ministry of Defense (MOD) established the jointly funded and managed U.S. and U.K. consortium, known as the International Technology Alliance (ITA) on Network and Information Sciences, in Fiscal Year (FY) 2006.

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas and the Army Modernization Strategy.

Work in this Project is performed by the ARL at Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Distributed Analytics and Information Science for U.S./U.K. Coalition Operations Information (formerly Network and Information Science Basic Research for U.S./U.K. Coalition Operations Information)	3.909	4.078	4.082
Description: This research will address the fundamental science underpinning the complex information network issues that are vital to future U.S./U.K. coalition military operations and to fully exploit the joint development of emerging technologies necessary to enable coalition operations. These efforts provide enhanced ability to perform adaptive, goal-driven, semantically-aware, distributed analytics for situational understanding in coalition operations.			
FY 2016 Accomplishments: Developed projective analysis techniques for hybrid networks that consider limitations on controllability; developed secure, content-based networking approaches that allow distributed information discovery, resiliency, and adaptability in heterogeneous coalition networks; developed abstract, physical, spatio-temporal analytical models and representations that support distributed processing of information; and developed distributed techniques for dynamically assembling information services in dynamic coalition environments to enable distributed analytics.			
FY 2017 Plans:			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** J15 / *Network Sciences ITA*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will cultivate a fundamental understanding of using distributed services to support coalition information processing in dynamic environments for building composite information infrastructures; develop information-centric networking that supports secure coalition operations via logically distributed and decentralized architectures across heterogeneous coalition networks; formulate dynamic policy-based autonomous management techniques to jointly control both coalition information and infrastructural services that dynamically adjust to mission changes, network dynamics and policy changes; develop formal theories, frameworks and mechanisms to dynamically match operational tasks to information resources for complex coalition operations; and investigate formal theories and techniques to enable multi-level integrated fusion of disparate information sources in context of decision support objectives for coalitions. ***FY 2018 Plans:*** Will model complex, adaptive human systems including group and sub-group reactions to external and internal stimuli to recognize and discriminate behaviors of interest. Will investigate software-defined information-centric networking that supports secure coalition operations via logically distributed and decentralized control plane architectures across heterogeneous, mobile networks; will create formal theories, techniques, and frameworks to enable multi-level integrated fusion of disparate information sources in the context of decision-support objectives; and will identify distributed learning techniques to compose and adapt distributed services in dynamic coalitions.			
Accomplishments/Planned Programs Subtotals	3.909	4.078	4.082

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) J17 / *Vertical Lift Research Center Of Excellence*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
J17: *Vertical Lift Research Center Of Excellence*	-	2.911	3.076	3.130	-	3.130	3.186	3.249	3.313	3.381	-	-

A. Mission Description and Budget Item Justification

This Project fosters research to provide vertical lift capability and engineering expertise for the Army. The focus of the Vertical Lift Research Center of Excellence (VLRCOE) is to couple state-of-the-art research programs with broad-based graduate education programs at academic institutions with the goal of increasing the supply of scientists and engineers who can contribute to Army Transformation. Work will provide research into technologies that can improve tactical mobility, reduce the logistics footprint, and increase survivability for rotary wing vehicles.

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas and the Army Modernization Strategy.

Work in this Project is performed extramurally by the Aeroflightdynamics Directorate of the Army Aviation and Missile Research, Development, and Engineering Center (AMRDEC) (located at the National Aeronautics and Space Administration (NASA) Ames Research Center, Moffett Field, CA).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Vertical Lift Research Center of Excellence (VLRCOE)	2.911	3.076	3.130
Description: VLRCOE agreements with Penn State University, University of Maryland, and Georgia Institute of Technology to supplement a robust experimental and analytic basic research program in rotorcraft technologies including: Aeromechanics, Structures, Flight Dynamics and Control, Rotorcraft Design and Concepts, Vibration and Noise Control, Propulsion, Affordability, Safety and Survivability, and Naval Operations.			
FY 2016 Accomplishments: Completed the final year of the VLRCOE technology interchange agreements by executing a robust experimental and analytic basic research program in rotorcraft technologies including: aeromechanics, structures, flight dynamics and control, rotorcraft design and concepts, vibration and noise control, propulsion, affordability, safety and survivability, and Naval operations. Identified research thrust areas of interest to Army Aviation for a new Center of Excellence (COE) program to support future vertical lift in the long term.			
FY 2017 Plans: Will initiate a new, five year COE program that supports the Future Vertical Lift program and focuses on graduate education and a robust experimental/computational/analytical basic research program in rotorcraft technologies including: aeromechanics, structures, flight dynamics and control, rotorcraft design and concepts, vibration and noise control, propulsion, affordability, safety			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** J17 / *Vertical Lift Research Center Of Excellence*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
and survivability, and Naval operations. Specific areas of interest and proposals will be selected based on evaluations by a consensus of government subject matter experts. ***FY 2018 Plans:*** Execute the second year of the five year cooperative agreements with the Centers of Excellence at Georgia Institute of Technology, Pennsylvania State University, and University of Maryland. The Centers will conduct basic research in areas of long term interest for the future vertical lift program, such as hub drag reduction, aeroelastic stability, and reduced order modeling for flight dynamics. The first annual review will be conducted by a group of government organizational leaders and subject matter experts (SME's) from the Army, the Navy and NASA to evaluate the research progress and provide technical direction. The basic research at the Centers will be highly collaborative in nature with government subject-matter-experts closely tied into the research performed at the universities.			
Accomplishments/Planned Programs Subtotals	2.911	3.076	3.130

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) VS2 / *Multi-Scale Materials Modeling Centers*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
VS2: *Multi-Scale Materials Modeling Centers*	-	8.928	8.851	9.047	-	9.047	8.754	8.739	8.688	8.886	-	-

A. Mission Description and Budget Item Justification

This Project supports two competitively awarded Collaborative Research Alliances (CRAs) to provide the Army with next generation multi-functional materials for ballistic and electronic applications and to address the extreme challenges associated with understanding and modeling materials subject to Army operational environments. The Materials in Extreme Dynamic Environments consortium, led by Johns Hopkins University partnered with CalTech, Rutgers University, and University of Delaware, focuses on understanding materials under high strain rates. The Multiscale Multidisciplinary Modeling of Electronic Materials consortium, led by University of Utah partnered with Boston University and Rensselaer Polytechnic Institute, focuses on microscale properties to design macroscale behavior for electronics. Research at both CRAs will address the modeling and experimental challenges associated with developing multidisciplinary physics simulations across multiple length scales for materials to include: a limited ability to relate materials chemistry, structure, and defects to materials response and failure under extreme conditions; an inadequate ability to predict the roles of materials structure, processing, and properties on performance in relevant extreme environments and designs; and the lack of experimental capabilities to quantify multiscale response and failure of materials under extreme conditions.

Work in this Project supports key Army needs and is coordinated with work performed in Program Element (PE) 0601102A (Defense Research Sciences)/Project H44 (Adv Sensor Research) and H42 (Materials and Mechanics).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas and the Army Modernization Strategy.

Work in this Project is performed by the Army Research Laboratory (ARL) in Aberdeen Proving Ground, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Collaborative Research Alliances in Materials in Extreme Dynamic Environments and Multiscale Multidisciplinary Modeling of Electronic Materials.	8.928	8.851	9.047
Description: Research will focus on the following areas: two-way multiscale modeling for predicting performance and designing materials, investigating analytical and theoretical analyses to effectively define the interface physics across length scales; advancing experimental capabilities for verification and validation of multiscale physics; and modeling and strategies for the synthesis of high loading rate tolerant materials so that all of the latter lead to the development of a comprehensive set of metrics that define high loading rate tolerant material systems. The multiscale modeling capability will be applied across multiple disciplines to facilitate revolutionary advances in materials for coupled environments (electromagnetic, high rate, high pressure and other extreme environments).			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** VS2 / *Multi-Scale Materials Modeling Centers*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018

FY 2016 Accomplishments:

Advanced the state of the art in multi-scale modeling for electronic materials by creating a capability to tailor properties and ultimately enable an increase in efficiency, lifetimes of sources and detectors and power density in electrochemical energy storage devices; developed complex multi-scale modeling techniques which are validated and verified across critical scales in time and space for tailored electronic materials and optimized band structure; developed algorithms/theories that further advance the state of the art of electronic materials with regards to interactions of electrons, photons, phonons, defects and impurities; and advanced the state of the art in interface physics with regards to strain, polarization, piezoelectric, electromagnetic phenomena and solid/liquid boundaries to predict electronic materials' behavior focused on Army relevant devices. Developed a proof-of-concept "materials-by-design" capability in designing materials and predicting key properties for materials in extreme dynamic environments based on the fundamental properties of the atomic and molecular components; synchronized novel experimental methodologies with multiscale computational approaches to enable unprecedented microstructure control and predictive capabilities; validated the comprehensive set of material characteristics and properties at length scales that govern high rate deformation (ballistic effects), fracture and failure phenomena in metallic, polymeric, ceramic and composite material systems through both computational and experimental techniques using representative materials; and began development of the fabrication technology for optimized polymeric, metallic, ceramic and composite systems.

FY 2017 Plans:

Will continue to advance the state-of-the-art in multi-scale modeling for electronic materials by further validation of the capability to tailor electronic materials' properties; develop the validation and verification techniques for models that cross or tie-together critical scales in time and space for tailored electronic materials and optimized band structure; develop additional algorithms/theories to advance the state-of-the-art of electronic materials with regards to interactions carriers and impurities; and further advance the state of the art in interface physics with regards to strain, polarization, piezoelectric, electromagnetic phenomena and solid/liquid boundaries to map and to predict electronic materials' behavior within Army relevant devices. Continue to develop and refine a proof-of-concept "materials-by-design" capability to predict key properties for materials in extreme dynamic environments based on the fundamental properties of the atomic and molecular components; assess the learning from the novel high rate experimentation results especially when combined with multiscale computational approaches and key visualization techniques; begin confirmation of the ability to predict and control microstructure; validate that we have defined the comprehensive set of material characteristics and properties at length scales that govern high rate deformation (ballistic effects), fracture and failure phenomena in metallic, polymeric, ceramic and composite material systems through both computational and experimental techniques using representative materials; and begin development of the fabrication technology for optimized polymeric, metallic, ceramic and composite systems.

FY 2018 Plans:

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** VS2 / *Multi-Scale Materials Modeling Centers*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will create data-sharing protocols and interfaces for sharing fundamental materials research data related high-strain materials. Will complete integrated multiscale models for high rate deformation and failure in all four material classes, metals, ceramics, polymers and composites. Will explore and characterize microstructure, high strain-rate behavior and failure mechanisms of the 1st iteration of the designed (controlled) materials. Will investigate grain boundary modification as related to icosahedral borides and their dynamic properties, and pioneer nanomechanical testing for microfibrils of polymer fibers that have been extracted from macrofibers. Will explore uncertainty quantification techniques created for specific materials, and examine their applicability across different materials classes and applications. Will integrate the ab initio calculations, atomistic and coarse-grained molecular dynamics (MD) simulations, and continuum level modeling into multiscale modeling framework that facilitates the design of novel: a) Si-based nanostructured anodes and b) three-dimensional (3D) interdigitated anode/cathode nanostructure for batteries. Will develop a framework and related codes to carry out simulations of materials and nanostructures from first principles and the description of electronic excitations. Will develop computationally efficient models to study non-ideal behavior of materials, specifically, the study of point and extended defects, interfaces and nano/microstructures in electronic and optoelectronic materials. Will develop multiscale modeling tools that accurately capture the coupling of redox reactions, the charge transport mechanisms, and the mesoscale morphological features in membrane structure.			
Accomplishments/Planned Programs Subtotals	8.928	8.851	9.047

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) VS3 / *Center For Quantum Science Research*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
VS3: *Center For Quantum Science Research*	-	4.977	5.201	5.221	-	5.221	6.238	6.381	6.509	6.641	-	-

A. Mission Description and Budget Item Justification

This Project supports an extramural research consortium, which will bring together a critical mass of preeminent university and industry researchers to explore and develop critical emerging concepts in Quantum Information Science (QIS). The focus will be on establishing a first of its kind, multi-site distributed quantum network based on quantum memories. The Center for Distributed Quantum Information will study and demonstrate both the physical backbone and network layer for a robust quantum information network that will provide secure and tamper-proof communications and exponentially greater information processing capabilities for the future Army. The Center for Distributed Quantum Information will perform collaborative research with Army in-house scientists and engineers to help accelerate the transition of the research. In addition to providing the required expertise and critical mass to the effort, the consortium will also bring together a broad but unified multi-disciplinary research team needed to accelerate progress in the field of quantum information sciences.

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology focus areas, and the Army Modernization Strategy.

Work in this Project is performed by the Army Research Laboratory (ARL) in Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Center for Distributed Quantum Information	4.977	5.201	5.221
Description: This work supports critical quantum science basic research at the United States (U.S.) ARL exploiting quantum effects to greatly enhance computing, communications, imaging, sensing, and security, ensuring Army dominance on the future battlefield.			
FY 2016 Accomplishments: Advanced the development of the physical layer and networking theory needed for a robust distributed quantum network, including investigation of novel network protocols, teleportation between quantum nodes and memories, quantum node-to-node communication along fibers, quantum node-to-node communication through free space, photon encoding protocols, frequency conversion, single photon detection, and entanglement verification protocols.			
FY 2017 Plans:			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** VS3 / *Center For Quantum Science Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will research and refine quantum network protocols and algorithms, as well as experimentally and theoretically investigate entanglement between two quantum nodes, entanglement verification protocols, teleportation of quantum state between two nodes, and frequency conversion to connect hybrid platforms. ***FY 2018 Plans:*** Will entangle two physically separate nodes, improve interfacing between nodes, and apply initial networking protocols. Will complete construction of third physical node within a quantum network.			
Accomplishments/Planned Programs Subtotals	4.977	5.201	5.221

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A