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The Undersea Constellation: Providing Leap-Ahead Capabilities for the Third Offset Strategy

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Perspective

The United States' ability to project power globally has long been its key military advantage, serving as the cornerstone of American military strategy and power. Indeed, the 2014 *Quadrennial Defense Review*[1] outlines the three pillars of U.S. defense strategy, one of which is to "project power and win decisively." However, this ability to project power is predicated upon American technological superiority as its foundation – in particular, it relies upon our military's advanced platforms, systems, and networks. Unfortunately, this technological superiority can no longer be taken for granted.

Advanced technologies, which were once the sole province of just a small number of nations, have now proliferated widely amongst both non-state actors and less sophisticated military forces. Additionally, the United States' technological edge is being challenged by near-peer competitors such as China and Russia, who have been rapidly pursuing military modernization programs, especially in the last decade, while the United States has been conducting stability operations. Armed with advanced technology, these nations are adopting what has come to be termed anti-access/area denial (A2/AD) strategies, and addressing this challenge has rapidly become a priority amongst national and defense leaders.[2]

In response to this narrowing of the technological gap between the United States and potential adversaries, almost one year ago DoD officials announced the standup of the Defense Innovation Initiative, which will result in the Third Offset Strategy.[3] The Third Offset Strategy seeks to put "the competitive advantage firmly in the hands of American power projection over the coming decades."[4] It will do so through several interrelated pillars: new operational concepts; a technology effort through the Long Range Research and Development Plan; leadership development practices; a new approach towards wargaming; and a continued focus on more efficient and effective business practices. Of these five areas, then-Secretary Hagel argued that the integration of new concepts with new technology with will have the most far-reaching effects.

Of the new operational concepts that have been developed to address the A2/AD threat, the *Joint Operational Access Concept* (JOAC) is the overarching strategy document that describes how

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[1] *The Quadrennial Defense Review* (Washington, D.C.: Department of Defense, 2014).

[2] Anti-access is defined as "action intended to slow deployment of friendly forces into a theater or cause forces to operate from distances farther from the focus of conflict than they would otherwise prefer." Area denial is defined as "action intended to impede friendly operations within areas where an adversary cannot or will not prevent access." See Department of Defense, *Air-Sea Battle: Service Collaboration to Address Anti-Access & Area Denial Challenges*, (Air-Sea Battle Office May 2013).

[3] Secretary of Defense Chuck Hagel, "Reagan National Defense Forum Keynote," Simi Valley, California, November 15, 2014. Accessed at: <http://www.defense.gov/utility/printitem.aspx?print=http://www.defense.gov/Speeches/Speech.aspx?SpeechID=1903> and Secretary of Defense Charles Hagel, "The Defense Innovation Initiative," memorandum dated November 15, 2014.

[4] Secretary of Defense Charles Hagel, "The Defense Innovation Initiative," memorandum dated November 15, 2014.

the U.S. military will gain and maintain access forward. One level beneath the JOAC, two companion documents – the *Joint Concept for Access and Maneuver in the Global Commons* (formerly the AirSea Battle Concept) and the *Joint Concept for Entry Operations* describe how U.S. forces will employ "cross-domain synergy" – essentially, integration across domains – to operate within contested spaces.

These strategy documents outline ambitious concepts with real potential to ensure that future U.S. forces will enjoy the same degree of access as their predecessors did. However, these concepts will rely on technological leaps to make them a reality. The Third Offset strategy recognizes this, and has a pillar specifically targeting technological innovations – the Long Range Research and Development Plan (LRRDP). According to the LRRDP Request for Information, there are five key technology thrust areas: space dominance; undersea technology; air dominance and strike technology; air and missile defense technology; and other technology-driven concepts.[5]

The undersea domain will play a crucial role in both the operational concepts to counter A2/AD strategies, and in technology innovations. As Rear Admiral Jerry Holland explained in his recent *U.S. Naval Institute Proceedings* article, this is due to the fact that the United States still possesses a clear advantage in this domain; because pre-positioned submarines will feature prominently in any future maritime conflict; and because undersea forces are inherently flexible, offering the "freedom of movement and decision" that Secretary Hagel has emphasized.[6] It is therefore imperative that the undersea domain play a significant role in realizing the cross-domain synergy that the Joint Force aims to achieve.

While there are a number of impressive inventions being developed for the undersea domain, taken individually, they fall short of the innovation that the Third Offset Strategy calls for. In order to be truly innovative, these technologies must be able to combine seamlessly into a network. The Undersea Constellation promises to do just that, by connecting submarines, unmanned subsurface and surface autonomous vehicles, distributed sensor networks, undersea cables and a variety of other systems into a seamless networked force.[7]

The United States' Eroding Technological Advantage and the Third Offset Strategy

While the United States has been entrenched in ongoing stability operations in the Middle East, other nations have aggressively sought to acquire and/or develop advanced military capabilities, thereby narrowing the technological gap between them and the United States. In particular, Secretary Hagel has stressed the threat posed by technology proliferation, noting that "[d]isruptive technologies and destructive weapons once solely possessed by only advanced nations have proliferated widely, and are being sought or acquired by unsophisticated militaries

[5] Under Secretary of Defense for Acquisition, Logistics, and Technology Frank Kendall, "Long Range Research and Development Plan (LRRDP) Direction and Tasking," memorandum dated October 29, 2014, accessed at: <http://www.defenseinnovationmarketplace.mil/resources/LRRDP_DirectionandTaskingMemoClean.pdf>
[6] Rear Admiral W. J. Holland Jr., USN (Retired), "Submarines: Key to the Offset Strategy," *U.S. Naval Institute Proceedings*, June 2015.
[7] George Galdorisi, "We Need an Undersea Constellation," *U.S. Naval Institute Proceedings*, June 2015.

and terrorist groups."[8] He also identified the threat from near-peer competitors China and Russia, stating that they have been heavily investing in military modernization programs in order "to blunt our military's technological edge."[9] In particular, Secretary Hagel emphasized that "they are … developing anti-ship, anti-air, counter-space, cyber, electronic warfare, and special operations capabilities that appear designed to counter traditional U.S. military advantages – in particular, our ability to project power to any region across the globe by surging aircraft, ships, troops, and supplies."[10] Meanwhile, budgetary constraints facing the DoD have made this threat environment even more challenging, limiting the Department's ability to respond through an increase in the size of our military or simply outspending adversaries.

While in the past, U.S. strategy documents have been careful to use terms like "near-peer competitor" to describe the nations pursuing these capabilities, more recent official documents are forthright in acknowledging that China is at the forefront of those nations, with Russia a close second.[11] These advanced technologies have allowed China, and to a lesser extent Russia, to adopt anti-access/area denial strategies. In doing so, these potential adversaries seek to deny U.S forces the sanctuary of forward bases, hold aircraft carriers and their air wings at risk, and cripple U.S. battle networks. In other words, they seek to strike at the weak point of U.S. power projection capability and deny access to U.S. forces operating forward to protect U.S. equities and reassure allies.

In response to the growing A2/AD threat as well as increasing risks to the United States' technological superiority, late last year U.S. defense officials unveiled the Third Offset Strategy – a plan to leverage innovation in order to ensure that the U.S. maintains its competitive technological edge. This approach has its roots in the offset strategies developed by national security professionals in the 1950s and the 1970s to ensure America's military's superiority. The first of these was President Eisenhower's "New Look Strategy" in the 1950s, which prioritized nuclear deterrence. This was followed in the 1970s by the "offset strategy" of the Long-Range Research & Development Planning Program, which shaped future investments in leap-ahead capabilities such as standoff precision strike, stealth aircraft, wide-area surveillance, and networked forces.

Under Secretary of Defense for Acquisition, Technology, and Logistics, Frank Kendall, has explained that these two previous offset strategies yielded an impressive set of military capabilities, comprising a "revolution that we unleashed on the world in the first Gulf War."[12]

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[8] Secretary of Defense Charles Hagel, "Defense Innovation Days Opening Keynote," Newport, Rhode Island, September 03, 2014. Accessed at: <http://www.defense.gov/Speeches/Speech.aspx?SpeechID=1877>

[9] Secretary of Defense Chuck Hagel, "Reagan National Defense Forum Keynote," Simi Valley, California, November 15, 2014. Accessed at: <http://www.defense.gov/utility/printitem.aspx?print=http://www.defense.gov/Speeches/Speech.aspx?SpeechID=1903>

[10] Secretary of Defense Charles Hagel, "Defense Innovation Days Opening Keynote," Newport, Rhode Island, September 03, 2014. Accessed at: <http://www.defense.gov/Speeches/Speech.aspx?SpeechID=1877>

[11] See, for example, *The Quadrennial Defense Review* (Washington, D.C.: Department of Defense, 2014), the *Annual Report to Congress on Military and Security Developments Involving the People's Republic of China 2015* (Washington, D.C.: Department of Defense, 2015), and *The PLA Navy New Capabilities and Missions for the 21st Century* (Washington, D.C.: Office of Naval Intelligence, 2015).

[12] Claudette Roulo, "DoD Seeks Next-Generation Technologies, Kendall Says," DoD News, October 07, 2014. Accessed at: <http://www.defense.gov/news/newsarticle.aspx?id=123355>.

He went on to state that while the United States has continued to rely on this set of capabilities in the decades since, adversaries have had time and space to respond by building similar capabilities, which has spurred focus on the development of a Third Offset Strategy.

Rising to this challenge to the United States' technological and military superiority, the Third Offset Strategy – as instantiated in the Defense Innovation Initiative – seeks to put "the competitive advantage firmly in the hands of American power projection over the coming decades."[13] It will do so through several interrelated areas: operational concepts; a technology effort through the Long Range Research and Development Plan; leadership development practices; a new approach towards wargaming; and a continued focus on more efficient and effective business practices. Of these five areas, the integration of new concepts with technology will have the most far-reaching effects. As Secretary Hagel emphasized in assessing the previous two offset strategies, "The critical innovation was to apply and combine these new systems and technologies with new strategic operational concepts, in ways that enable the American military to avoid matching an adversary "tank-for-tank or soldier-for-soldier."[14]

Leveraging Innovation in Concepts and Technology: The Undersea Domain Will Be Key

Of the operational concepts that the Third Offset Strategy references, a family of documents has been developed specifically to address the A2/AD threat. The *Joint Operational Access Concept* (JOAC) is the overarching strategy document that describes how the U.S. military will gain and maintain access forward. One level beneath the JOAC, two companion documents – the *Joint Concept for Access and Maneuver in the Global Commons* (formerly the AirSea Battle Concept) and the *Joint Concept for Entry Operations* describe how U.S. forces will employ "cross-domain synergy" – essentially, integration across domains – to operate within contested spaces.

Indeed, as the document that describes how the U.S. military will gain and maintain access forward, the *Joint Operational Access Concept* (JOAC) lays out a broad strategy for how U.S. forces will deal with the A2/AD challenge and points out how important these networks are to success. As JCS Chairman Martin Dempsey makes clear in the JOAC's Foreword:

> The *Joint Operational Access Concept* (JOAC) describes in broad terms how joint forces will operate in response to emerging anti-access and area denial security challenges. Its central thesis is Cross-Domain Synergy—the complementary vice merely additive employment of capabilities in different domains such that each enhances the effectiveness and compensates for the vulnerabilities of the others. The JOAC envisions a greater degree of integration across domains.[15]

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[13] Secretary of Defense Charles Hagel, "The Defense Innovation Initiative," memorandum dated November 15, 2014.

[14] Secretary of Defense Chuck Hagel, "Reagan National Defense Forum Keynote," Simi Valley, California, November 15, 2014. Accessed at: <http://www.defense.gov/utility/printitem.aspx?print=http://www.defense.gov/Speeches/Speech.aspx?SpeechID=1903>

[15] Department of Defense, "Joint Operational Access Concept," January 17, 2012. The JOAC defines "anti-access" as "those capabilities, usually long-range, designed to prevent an advancing enemy from entering an operational

It is clear from Chairman's Dempsey's description of what will enable the Joint Operational Access Concept that achieving Cross-Domain Synergy will be dependent on effective networks—and networks the Joint force must build.

The Joint Concept for Access and Maneuver in the Global Commons (JAM-GC) – formerly the AirSea Battle Concept – is the organizing concept of operations describing how United States and allied forces will defeat the A2/AD threat, especially in the Western Pacific.[16] While this concept – now officially endorsed in U.S. strategic publications like the QDR and elsewhere – depends on the integration of all U.S. military forces, as the two Services most likely operating forward in the face of enemy A2/AD capabilities, the Navy and the Air Force are most vested in the JAM-GC. And one need not be a Clausewitz or a Sun Tzu to understand that as Navy and Air Force units operate across vast oceanic distances, networks will be a key to their effectiveness.

The undersea domain inherently offers a high degree of stealth, and paired with the fact that the U.S. still maintains a distinct advantage in this domain, it is clear that it will play a significant role in the counter-A2/AD concepts outlined above. Admiral Greenert stated as much in his *American Interest* article "Air-Sea Battle," when he explained that under AirSea Battle, deeper levels of Joint integration would allow "undersea operations to defeat air defense systems, or air attacks to eliminate submarine or mine threats."[17]

However, while these operational concepts offer impressive potential, their ultimate success will depend on how innovative and advanced their underlying technology is. The Long Range Research and Development Plan is the technical pillar of the Third Offset Strategy. According to the tasking memo, the LRRDP:

> Shall identify high-payoff enabling technology investments that could provide an opportunity to shape key future U.S. materiel investments, offer opportunities to shape the trajectory of future competition for technical superiority, and will focus on technology that can be moved into development programs within the next five years.[18]

The LRRDP Request for Information states that its five focus areas are: space dominance; undersea technology; air dominance and strike technology; air and missile defense technology; and other technology-driven concepts. Each of these areas has its own working group, and there is also an Integration working group to "oversee, coordinate, and integrate" the five core working groups.[19]

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area." It defines "area-denial" as "those capabilities, usually of shorter range, designed not to keep the enemy out but to limit his freedom of action within the operational area."

[16] The Joint Concept for Access and Maneuver in the Global Commons (JAM-GC) was introduced in an 8 January 2015 Joint Staff memorandum.

[17] Admiral Jonathan W. Greenert and General Norton A. Schwartz, "Air-Sea Battle," *The American Interest*, February 20, 2012.

[18] Under Secretary of Defense for Acquisition, Logistics, and Technology Frank Kendall, "Long Range Research and Development Plan (LRRDP) Direction and Tasking," memorandum dated October 29, 2014, accessed at: <http://www.defenseinnovationmarketplace.mil/resources/LRRDP_DirectionandTaskingMemoClean.pdf>

[19] Ibid.

As with the operational concepts, undersea technology will be a key component of the LRRDP. While there are a number of discrete inventions in this area – including the Large-Diameter Unmanned Undersea Vehicle (LDUUV), new passive sonar technology, and new means of communications, such as laser and fiber-optic systems – individually, they fall short of being truly innovative. That bar will only be reached when these separate capabilities can be seamlessly networked together, which is exactly what the Undersea Constellation proposes to do.

Undersea Warfare: New Capabilities—New Networks

For most of the Cold War, and for the entirety of the post-Cold War era, the undersea technology area where the United States has an enduring advantage was represented by one platform–the U.S. Navy's fast attack submarines. The diminishing number of submarines in the U.S. Navy inventory has been well-documented. And given the increasing strains on the U.S. defense budget, the still-spiraling cost of these extremely capable platforms, and the need to recapitalize the forces of *all* the U.S. military services after a decade-and-a-half of land wars in Iraq and Afghanistan, it is unlikely the U.S. submarine force will grow over the next several decades. To borrow a football analogy, the U.S. Joint force can no longer "flood the zone" with submarines. As technological advances have spawned other capabilities that can supplement and support the extant U.S. submarine force, a new approach to undersea warfare has evolved.

Under almost any scenario one could imagine, undersea forces will be operating forward during Phase Zero and Phase One operations.[20] This has been the traditional role U.S. Navy submarines have played across the spectrum of conflict. The overarching CONOPS for how undersea forces will organize to deliver effects against an enemy is articulated in the Commander, Submarine Forces, *Design for Undersea Warfare*. This publication has a strong emphasis on Phase Zero operations, noting, "Our undersea forces conduct peacetime operations to prevent war by deterring and dissuading our adversaries and by assuring our allies and partners…Peacetime operations help us to understand and shape the battlespace and to learn the capabilities of our potential adversaries."[21]

And perhaps most importantly, *Design for Undersea Warfare*, in discussing future force capabilities, identifies, as its *first* focus area, the goal of, "Developing an integrated approach to future undersea capabilities."[22] And if hostilities ratchet up, undersea forces will likely *lead* the push into the contested littorals as the Navy and the other Services execute the Joint Concept for Access and Maneuver in the Global Commons. Now, technology is changing the traditional paradigm of a single submarine operating "alone and unafraid," in the face of A2/AD challenges.

[20] As described in a variety of joint publications, there are six phases in the "continuum of military operations" across the spectrum of conflict. Phase Zero is focused on "shaping the environment" while Phase One is focused on "deterring the enemy."

[21] Department of the Navy, Commander Submarine Forces, *Design for Undersea Warfare*, July 2011, accessed at: http://www.public.navy.mil/subfor/hq/PDF/Undersea%20Warfare.pdf.

[22] *Design for Undersea Warfare*, 9.

In his *Sailing Directions* the CNO lays out the broad guidelines regarding how the U.S. Navy will support the Joint force in an A2/AD environment and especially how this will be addressed in the undersea environment. He notes, "The Navy will continue to dominate the undersea domain using a network of sensors and platforms—with expanded reach and persistence from unmanned autonomous systems."[23] He also notes that unmanned systems will be vital assets as they are fully integrated into an undersea network that also incorporates unattended sensors and traditional platforms in order to, "create a more complete and persistent common operational picture of the underwater environment when and where we need it."[24]

A generation ago, Navy carrier strike groups faced a daunting challenge from Soviet aircraft and anti-ship missiles. To counter this threat, the U.S. Navy evolved the airborne constellation of fighter aircraft and missile ships linked together by a robust network to form an effective shield for the Fleet. That airborne constellation remains in place today and continues to effectively shield U.S. Navy carrier strike groups.

As the number of U.S. Navy attack submarines has continued to decline, the Navy has embraced emerging technologies to complement its submarines in order to deal with A2/AD threats forward in the littorals. Subsurface and surface autonomous vehicles, distributed sensor networks, fixed and mobile arrays, and a variety of other systems bring the potential to overcome this challenge, especially during Phase Zero and Phase One operations. But as Admiral Greenert stated, in order to be effective, these discrete inventions must be netted together to form a new innovation – an *undersea constellation* as robust as today's airborne constellation. The technical challenges of instantiating this undersea constellation are more daunting than those of its airborne counterpart, but these must be overcome if the United States is to prevail in fourth generation undersea warfare.

But the devil is in the details of just how this networking occurs. As Vice Admiral John Richardson described in his *U.S. Naval Institute Proceedings* article, "Preparing for Today's Undersea Warfare," "Networked undersea forces will act as the key to unlock the door for decisive force to enter the fight and seize and maintain the initiative."[25] Said another way, achieving this vision for networked undersea forces is what the Navy's Strategy for Information Dominance is all about: "Pioneer, field and employ game-changing capabilities to ensure Information Dominance over adversaries and Decision Superiority for commanders, operational forces and the nation."[26]

As one indicator of the Navy's commitment to building this undersea constellation, earlier this decade, the Chief of Naval Operations Strategic Studies Group (SSG XXXII) was charged to assess the ability of the Navy's undersea forces to dominate the contested littorals. Their report, *The Undersea Imperative*, pointed to the importance of building the undersea network—the

[23] Jonathan Greenert, *Sailing Directions*, accessed at: http://www.navy.mil/cno/cno_sailing_direction_final-lowres.pdf.
[24] Jonathan Greenert, "Navy 2025: Forward Warfighters," *U.S. Naval Institute Proceedings*, December 2011 and Jonathan Greenert, "Payloads Over Platforms: Charting a New Course," *U.S. Naval Institute Proceedings*, July 2012.
[25] John Richardson, "Preparing for Today's Undersea Warfare," *U.S. Naval Institute Proceedings*, June 2012.
[26] U.S. Navy, *The U.S. Navy's Strategy for Information Dominance* 2013-2017 (Washington, D.C.: Department of the Navy, 2013).

undersea constellation—as a key to allow sustained, large-area undersea joint operations. As Admiral Richardson noted in his *Proceedings* article, this is crucial if joint forces are to prevail in fourth generation undersea warfare.

Most recently, the maritime services' recently-revised Cooperative Strategy for 21st Century Seapower emphasized the importance of the nexus between naval presence, undersea dominance, unmanned systems, and networked forces, setting forth the maritime services' goal to:

> Advance naval capabilities that maintain our undersea dominance, especially in contested environments. We will continue to improve fixed and mobile undersea sensors, while also deploying advanced multi-functional sensors and protection systems on ships and aircraft, providing a high-altitude anti-submarine warfare capability, and developing unmanned undersea vehicles.[27]

Building the undersea constellation to connect submarines, unmanned subsurface and surface autonomous vehicles, distributed sensor networks, undersea cables and a variety of other systems is a daunting challenge. While the air constellation connects platforms via similar RF networks, the undersea constellation must network together systems employing acoustics, radio frequency, blue-green laser, undersea cable networks, as well as other communications means. But this work is moving forward *today* in the Navy's research and development and acquisition communities.[28]

By combining new operating concepts with innovative capabilities, the undersea constellation will enable and ultimately serve as the leading warfighting edge of the Third Offset Strategy. And since other joint forces will likely fall in on the undersea constellation as they arrive on scene, the U.S. Navy is, in effect, beta-testing the deep Joint integration that the JAM-GC calls for as it builds the undersea constellation. As Vice Admiral Ted Branch, Deputy Chief of Naval Operations for Information Dominance, noted, "The Navy's assured command and control chain depends on a resilient and secure information infrastructure. The way to achieve this goal is through reliable and secure networks."[29]

Building this undersea constellation offers capabilities for warfighting effectiveness not even imagined a decade ago. Rather than having a friendly submarine have to close an enemy surface combatant and put itself at substantial risk to fire a torpedo, with a robust undersea constellation in place—and one that links all undersea forces in high-speed, data-rich network—the range of shooters increases to include autonomous undersea vehicles, carrier strike group aircraft or missiles, or other weapons from other Services.

The Undersea Constellation—Making Information Dominance a Reality

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[27] *A Cooperative Strategy for 21st Century Seapower* (Washington, D.C.: Department of the Navy, March 2015).

[28] Program Executive Office Command, Control, Communications Computers and Intelligence (PEO C4I) and the Undersea Integration Program Office (PMW-770), in concert with their partners throughout the Fleet, the Navy Staff, the Naval Acquisition Enterprise, and the Naval Research Enterprise are focusing the Navy's efforts to design and deliver the undersea constellation.

[29] Vice Admiral Ted Branch, remarks to the AFCEA Symposium, March 6, 2014.

An oft-quoted phrase, "To every problem, there is a simple solution, which is usually wrong," is apt when defining the undersea warfare challenge. This is *not* a simple problem, but rather is a challenge requiring a disciplined approach to evolve a long-term and sustainable solution. To be effective as a networked force, we need to transform from a submarine-centric architecture where all undersea assets are homed to the submarine in a hub-and-spoke architecture to a dynamic network of fixed and mobile, surface and subsurface heterogeneous nodes supporting multiple data sources and destinations. Establishing this undersea network would then allow naval forces to employ platforms and systems that are capable of fully exploiting the undersea maneuver space.

The undersea constellation is now moving from the conceptual stages to a stage where military, industry and academic professionals are working together to design this entity. Indeed, earlier this year, a consensus definition of the undersea constellation emerged:

> The "Undersea Constellation" is a System of Systems encompassing undersea communications, networks, sensors, manned and unmanned platforms, and weapons that provides Command and Control (C2) and resilient data sharing. The Undersea Constellation bridges the data and communications gap among the undersea and above sea domains, also known as the air-water interface. The Undersea Constellation operates with undiminished effectiveness in an Anti-Access, Area Denial (A2/AD) environment to enable third party targeting, sharing of the common operational picture and C2 of unmanned sensors and platforms.
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> The Undersea Constellation System of Systems is characterized by its self-forming, self-healing and ad-hoc networking capability operating in a (Disruptive Intermittent Low bandwidth) DIL environment. Undersea Constellation data handling provides data acquisition, processing, dissemination, and storage through use of distributed applications to produce actionable knowledge from data. This enables a robust and reliable C2 architecture in the undersea domain for all entities, manned and unmanned. The communications capability is survivable and resilient by design with provisions for unmanned communications relays where physical connections are disabled or not possible.

To some, phrases like "Information Dominance" are vague terms that do little to describe how U.S. military forces will defeat a determined foe in the 21st Century. For others, they are merely buzzwords describing some unachievable future goal and are terms that will soon join the ash heap of jettisoned military jargon. But as a real-world instantiation of the Third Offset Strategy, the undersea constellation has the potential to deliver on the promise of delivering Information Dominance and Decision Superiority to the warfighter when and where it is needed.

As the Navy evolves the undersea constellation as the leading edge of the Third Offset Strategy, it is likely the success of the undersea constellation will garner additional support for the overarching offset strategy. And as the Navy and industry work to take on the challenges in this area, the architects of the undersea constellation must address the multi-modal adaptability of these undersea networks, that is, how vehicles and sensors using different communications

networks will be able to communicate between and among each other to deliver information dominance. As Edward Lundquist pointed out in the pages of the *U.S. Naval Institute Proceedings*, "Communications between underwater maritime systems is complex because of the sheer physics involved, and is limited by low bandwidth and prone to frequent disruptions."[30]

The roadmap to put an undersea constellation in place that is every bit as effective as the Navy's current air constellation provides a framework and technical vision for how the Navy will move forward to meet this challenge. However, the "art" of achieving this desired end state will require innovation and visioneering on the part of all stakeholders because the end state is not yet fully defined. Until we know what the final undersea constellation looks like, scientists and engineers in academia, Navy laboratories and industry partners can't begin to, in Albert Einstein's words, "Figure out how to think about the problem."[31] But the work to build a robust and effective undersea constellation must begin *now*. Anything less would put U.S. Joint forces at risk.

[30] Edward Lundquist, "In Search of the Standard Answer," *U.S. Naval Institute Proceedings*, February 2014, 40-45.
[31] Wilber Shramm and William Porter, Men, *Women, Messages and Media: Understanding Human Communication* (New York: Harper and Rowe, 1982).