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"C2 in Underdeveloped, Degraded and Denied Operational Environments"

Fourth Generation Undersea Warfare:

Getting C2 for Undersea Connectivity Right

Topics:

Topic 7: Architectures, Technologies, and Tools

Topic 8: Networks and Networking

Topic 1: Autonomy

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Abstract

To prepare for Fourth Generation Undersea Warfare, the U.S. Navy must to embrace emerging technologies that are adaptable in the challenging degraded undersea environment. Given the rapid emergence of cutting-edge technologies in undersea vehicles and sensors, the full potential of these technologies to provide information dominance (ID) will not be realized unless undersea connectivity issues are given the same priority as the vehicles and sensors themselves. Said another way, failure to establish an effective C2 architecture in this degraded and austere environment will be a de facto surrender to the adversary's attempts to deny access.

One way the U.S. Navy has moved forward to address this issue is by changing the programmatic organization that supports this vehicle and sensor integration. As Executive Agent for the Navy's undersea connectivity efforts, PMW-770 has developed an Undersea Connectivity Roadmap (UCR) to instantiate C2 and define ways in which vehicles, sensors, and communications networks can seamlessly work together to deliver ID to the undersea warfighter.

Our paper demonstrates how the UCR provides the C2 framework for technological developments in the area and how the Navy can turn an otherwise under-developed and degraded operating environment into one where our forces have ID over all potential adversaries.

Perspective

The United States Navy has a long tradition of operating forward for all the reasons outlined in the Navy's maritime strategy *A Cooperative Strategy for 21st Century Seapower* (*CS-21*).[1] This has been reinforced under the tenure of the current Chief of Naval Operations, Admiral Jonathan Greenert, in a series of documents and articles ranging from his *Sailing Directions*, to his *Navigation Plan*, to articles in a wide range of professional publications.[2] Further, U.S. Navy leadership has clearly articulated the importance of operating forward in the undersea domain, most recently in an article by the then-Commander of the Navy's submarine forces, Vice Admiral John Richardson, where he focuses on, "…our historic role of controlling the global commons on the seas while facilitating naval and joint force access…[and] the pivotal role that undersea forces must play in the future security environment.[3]

But given the strategic environment facing the United States, its allies, and its coalition partners today, and especially the increasingly sophisticated anti-access/area denial (A2/AD) environment – perhaps the most challenging **denied operational environment** – United States Joint Forces and their coalition partners must operate in to ensure the Nation's security and prosperity as outlined in the *National Strategic Narrative* as well as a host of other documents, this ability to operate forward is *not* assured.[4] And given the A2/AD challenges defined in the *Joint Operational Access Concept* (*JOAC*) as well as a series of publications defining the Nation's emerging Air-Sea Battle Concept (ASBC), the Navy in particular will be especially hard-pressed to operate forward. Further, in light of the fact that undersea forces will likely *lead* the push into the contested littorals as the Navy and the other Services execute the ASBC, undersea forces will likely encounter – and must be prepared to deal with – the full spectrum of A2/AD challenges.

Adding to the challenge – but also presenting opportunities – is the emergence of Fourth Generation Warfare. In the maritime arena, Fourth Generation Warfare is largely defined by two macro-trends. The first trend is the ongoing persistence of simple weapons – salvos of rockets, groups of mines, swarms of small craft, and other threats – that can impose an asymmetric cost on a forward-deployed, advanced force in a close-quarters fight. The second trend is the transition towards increasingly pervasive combat networks that combine ubiquitous intelligence, surveillance, and reconnaissance; longer-range, responsive, and precise weapons; and increasingly high-bandwidth command and control networks to connect the ubiquitous sensors with longer-range weapons.[5]

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."[6] And this commitment to unmanned vehicles is unlikely to a4bate given the success unmanned systems (UxS) of all types are having in the operational environment today, as well as the Department of Defense long-term commitment to supporting UxS development and fielding.[7]

As pointed out by Vice Admiral Richardson, as well as by others, the Nation and the Navy are now working in an era of "Fourth Generation Warfare."[8] In order continue to be ready for Joint

Undersea Fourth Generation Warfare – and to prepare for Fifth Generation Undersea Warfare – the Joint Force in general and the U.S. Navy specifically, must be prepared to innovatively embrace emerging technologies that are flexible and adaptable in always-challenging **denied operational environment** the undersea domain presents. But with the rapid emergence of cutting-edge technologies in manned and unmanned undersea vehicles as well as undersea sensors, the full potential of these technologies will not be realized unless or until integration and connectivity issues are addressed in new and innovative ways and given the same priority as the vehicles and sensors themselves.

The U.S. Navy has moved forward to address this issue by dramatically changing the programmatic organization that supports these vehicles and sensors. Within the Program Executive Office Command, Control, Communications, Computers and Intelligence (PEO C4I) the Submarine Communications Program Office has been reconstituted into the Undersea Integration Program Office (PMW-770). Working with academia, Navy laboratories and industry partners, PMW-770 is developing an Undersea Connectivity Roadmap (UCR) to explore ways that vehicles, sensors, and communications networks can work together effectively to deliver information dominance to the joint undersea warfighter.

But this is a daunting challenge, made all-the-more challenging by the multiple means of communicating in the underwater environment, among them; acoustics, radio frequency, blue-green laser, and undersea cable networks, as well as others. As industry attempts to meet the Navy's needs in this area, the UCR 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. And while the UCR currently provides a framework and technical vision for how the Navy will move forward to meet this challenge, the art of achieving this desired end state will require innovation and "visioneering" on the part of all stakeholders because the end state is as yet undefined – until we know what the final UCR 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." But this innovation and visioneering is essential if the Navy is to meet the challenge of delivering information dominance to the joint undersea warfighter in the **denied operational environment**.

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. Therefore, in order to understand how the UCR can be leveraged to ensure that it facilitates the ability to seize and control the undersea domain when, where, and however required for decisive competitive advantage across a range of warfare missions, we must understand the strategic context for undersea integration.

The Strategic Context for Undersea Integration

The *National Strategic Narrative*, the highest level statement of U.S. strategic interests – and the one that undergirds all other national, intelligence community and defense documents – notes

that, "In the 21st century we want to become the strongest competitor and most influential player in a deeply inter-connected global system, which requires that we invest less in defense and more in sustainable prosperity and the tools of effective global engagement."[9]

This narrative goes on to show how National policy decisions regarding investment, security, economic development, the environment, and engagement well into this century are built upon the premise that the United States must sustain our enduring national interests – prosperity and security – within a "strategic ecosystem," at home and abroad; that in complexity and uncertainty, there are opportunities and hope, as well as challenges, risk, and threat. The primary approach this Strategic Narrative advocates to achieve sustainable prosperity and security, is through the application of credible influence and strength, the pursuit of fair competition, acknowledgement of interdependencies and converging interests, and adaptation to complex, dynamic systems – all bounded by our national values.[10]

While achieving the goals outlined in *National Strategic Narrative* clearly requires a whole-of-government approach, it falls to the Department of Defense to be a primary agent for *securing* the Nation's prosperity and security. But understanding the context within which DoD must work is an important – and necessary – first step in understanding the ways, means, and ends the undersea forces in general – and the UCR specifically – must support.

The Strategic Environment in 2013

Introduction

In an environment where the only constant *is* change, it is important to reach forward in time and assess what might be over the horizon in the foreseeable future. The following assessment of the international security environment twenty years in the future (circa 2030 – 2035) is provided to do what the Duke of Wellington famously said *must* be done, "All the business of war, and indeed all the business of life, is to endeavor to find out what you don't know by what you do; that's what I called 'guessing what was at the other side of the hill.'" But what follows is much more than a guess. It is an assessment based on an exhaustive and analysis of National, Department of Defense (DoD), Department of the Navy (DoN), and other publications relating to the future security environment.

Future Trends

Given these strategic drivers that will characterize the international security domain in the future, the question at hand is what trends will these drivers combine together to create. While there are many possible futures, with a wide degree of uncertainty, there are three **primary** trends that will characterize the international system. The analysis from each of these seven primary source categories, distilled into the six drivers above, is reflected in the *Navy's Strategic Plan* (NSP). The NSP is the most important source for the Navy's strategic planning, and it is produced for every Program Objective Memorandum budget cycle. While the NSP is a classified document, the Navy's publication *Navigating an Uncertain Future: Navy Alternative Futures Process* provides an unclassified look at some of the analysis provided by OPNAV N513 which authors the NSP for each POM cycle as well as this unclassified publication. According to *Navigating an Uncertain Future*, N513 "conducted an environmental assessment to determine the key 'forces' that would drive the U.S. Navy's future strategic environment." They identified three

clear trends at the unclassified level that the Navy believes will characterize the future security environment. According to their analysis, these three trends have the greatest potential impact on the future environment and are additionally very likely to characterize the future. These overarching trends consolidate and corroborate the analyses discussed earlier, both from within government and outside government. The trends are:

- The U.S. military will see its relative power decline as other militaries gain in power.
- Worldwide energy demand will continue to increase, amplifying the importance of energy security and efficiency.
- The world will become even more dependent on cyberspace networks.

Each of these trends has important and unique consequences for the U.S. Navy's strategic future when operating forward in the undersea **denied operational environment**.

Decline:

In the first scenario outlined in *Navigating an Uncertain Future*, the U.S. military will see its *relative* power decline as other militaries gain in power. The U.S. military remains the largest and most well-funded military force as compared to those of other nations. However, there are two emerging issues that are behind this U.S. Navy assessment of the relative decline in U.S. military power – the increasingly shrinking U.S. defense budget and the increasing dependence of many nations on the international global market.

Energy:

The continued growth and dependence on worldwide energy usage in the future has strong implications for the types of technologies and strategies the U.S. military must pursue. According to *Navigating an Uncertain Future*, "Worldwide energy demand will continue to increase, amplifying the importance of energy security and efficiency."[11] Vice Admiral Cullom, Deputy Chief of Naval Operations for Fleet Readiness and Logistics, has echoed this belief by stating, "This [energy security and efficiency] is not a fad. This truly is commitment; it is here to stay."[12] As Chief of Naval Operations Admiral Greenert has stated, "Energy is a gap. It's a vulnerability. [We're working toward energy security and efficiency] for one thing: to be better war fighters."[13]

Cyber:

As *Navigating an Uncertain Future* notes, "the world will become more dependent on cyberspace as the future strategic environment unfolds, breeding new opportunities to leverage the cyberspace domain while simultaneously increasing threats that the U.S. Navy will be required to manage." This increasing focus on cyberspace has been reflected in almost all recent high-level strategy documents, including the *National Security Strategy*, the *Quadrennial Defense Review*, the *National Military Strategy*, and the *Joint Operational Access Concept* (JOAC). The *JOAC* identifies cyberspace as an emerging trend that is of "critical importance in projecting military force" into contested domains. The identification of cyberspace as a critical emerging trend has prompted the DoD to take concrete action in signaling its commitment to investing in cyber-security, such as declaring the cyber realm a new domain of warfare, standing up U.S. Cyber Command, and moving to implement a comprehensive "Cyber 3.0" strategy. In

contrast to the DoD topline budget, investments and spending in cyber and cyber-security are anticipated to gradually increase in the coming years.

The Compelling Anti-Access/Area-Denial Challenge

The National – and by way of focus, Navy-Air Force – AirSea Battle Concept, modeled after the Army-Air Force Air Land Battle Doctrine of a previous generation, has been heralded by some as the answer to compelling strategic and operational challenges facing the U.S. military today. This new strategy is designed to enable the United States to deal with compelling world-wide challenges, including substantial challenges posed by near-peer competitors. The then-nascent, underlying thesis behind this concept was developed two decades ago and articulated by then-Commander James Stavridis in a prescient thesis written at the National Defense University. He noted; "We need an air sea battle concept centered on an immediately deployable, highly capable, and fully integrated force – an Integrated Strike Force."[14]

As this quote, by the current European Commander, suggests, neither the term "AirSea Battle Concept (ASBC)," nor the concept itself are brand new. Throughout the Cold War, the potential fight on the plains of Europe dominated U.S. strategic thinking. The military element of this strategy, primarily carried out by the Army and Air Force, had, by the 1980's, evolved to what became known as the Air-Land Battle Doctrine.[15] But for nearly a decade after the collapse of the Soviet Union, U.S. military-strategic planners had little motivation to develop a broad fighting doctrine and the services had even less incentive to collaborate. The one notable exception to this was during Desert Storm – but in that case, the opposing air and sea forces were minimal and the core doctrine only tangentially employed. But by the early 1990s, analysis by the Pentagon's Office of Net Assessment began to examine whether a "dramatic shift in the character of military competitions was underway." Their prescient conclusion now resonates as they highlighted the real possibility of the rise of potential challenge from a "peer competitor" (i.e. China), and a "second order challenge from a 'non-peer' competitor" (i.e. Iran). [16]

In the 1990s, Pentagon strategists examining the changing nature of warfare were given new impetus by the Congressionally-mandated National Defense Panel (NDP) 1997 report's conclusion that "The United States 'must radically alter' the way in which its military projects power."[17] However, this momentum slowed as the attacks of September 11, 2001 dramatically changed the focus of the U.S. military to the exigencies of the global war on terrorism (GWOT).

But by the end of the first decade of the 21st Century several trends converged that demanded a new focus on an ASBC. One was the Obama administration's shift in emphasis away from the GWOT and decision to draw down the U.S. commitment to Iraq and Afghanistan on a finite timeline. A second was the startlingly rapid rise of China over this decade. As the former-Pacific Command Commander, Admiral Robert Willard, has noted, "Elements of China's military modernization appear designed to challenge our freedom of action in the region."[18] And a third was the unanticipated economic recession faced by the United States.

On the heels of the deepest economic crisis since the 1930's, and with massive federal budget deficits, the age-old "guns versus butter" debate has brought into sharper focus the consistent theme that the U.S. military may not have the strategic assets needed to deter, and if necessary

prevail, against a high-end peer competitor like China. A key assumption underpinning the ASBC is that without better coordination between and among the U.S. military Services, especially the Navy and the Air Force, this outcome is all but guaranteed. Moreover, the ASBC will have limited or no impact unless these joint Air and Naval planners tie actual operational requirements to specific capabilities.

Faced with a rising threat of peer and near-peer competitors with alarming anti-access/area denial capabilities – as well as long-term budget pressures – the ASBC can be viewed as more than an attempt to "do more with less." Rather, it is a return to historical precedents when, like today, compelling strategic and operational realities created a perfect storm that forced U.S. naval and air forces to work together in a truly *integrated* fashion to project power against a determined foe. But a skeptic, who doubts the ability of the current procurement system to respond in a meaningful way to this rising challenge, may opine that ASBC will only result in a rearrangement of existing doctrine and systems – and not be a truly adaptive and dynamic approach.

At this stage, it is important to ask, just what *is* the AirSea Battle Concept? At the request of Defense Secretary Robert Gates, the Chief of Naval Operations and the Air Force Chief of Staff directed an effort to explore how U.S air and naval forces could combine and integrate their capabilities to confront increasingly complex threats to U.S. freedom of action.[19]

To gain a global perspective, this joint team interviewed each U.S. combatant commander to understand the scope of threats they are likely to face over the next 10 to 20 years, particularly at the "high-end of warfare." Ultimately, the goal is to identify how combined Air Force and Navy capabilities can address these threats.[20]

After months of teasers and speculation in defense journals and conferences, the release of the 2010 Quadrennial Defense Review (QDR) provided greater clarity on the scope and *raison d'être* behind this concept. As part of its guidance to rebalance the force, the QDR directed the development of the air-sea battle concept in order to:

> [Defeat] adversaries across the range of military operations, including adversaries equipped with sophisticated anti-access and area denial capabilities. The concept will address how air and naval forces will integrate capabilities across all operational domains—air, sea, land, space, and cyberspace—to counter growing challenges to U.S. freedom of action.[21]

Independent analysts have been less reticent in naming specific regional adversaries. Notably, two studies by the Center for Strategic and Budgetary Assessment (CSBA) highlight the efforts of China and Iran as catalysts behind the AirSea Battle Concept. As the first of these studies lays out, both nations are investing in capabilities to "raise precipitously over time – and perhaps prohibitively – the cost to the United States of projecting power into two areas of vital interest: the Western Pacific and the Persian Gulf."[22] By adopting anti-access/area-denial capabilities, 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, strike at the weak point of U.S. power projection capability. To be effective, ASBC must change that

through a combination of capabilities and operational warfighting. If it doesn't, adversaries will still be able to deny access to US forces.

In its second study, *AirSea Battle: A Point-of-Departure Operational Concept*, CSBA analyzes possible options to counter the A2/AD threat posed by the Chinese People's Liberation Army (PLA). First and foremost, CSBA argues, the AirSea Battle Concept should help "set the conditions" to retain a favorable military balance in the Western Pacific.[23] By creating credible capabilities to defeat A2/AD threats, the U.S. can enhance stability in the Western Pacific and lower the possibility of escalation by deterring inclinations to challenge the U.S. or coerce regional allies.[24] *Air Sea Battle: A Point of Departure Operational Concept* sums it up by noting, "The most important question proponents of the AirSea Battle Concept must answer is whether the concept would help to restore and sustain a stable military balance in the Western Pacific."[25]

The precise nature of the ASBC will not be known until Pentagon planners complete their work, and that work is well-underway as DoD has formally stood up an Air-Sea Battle Office and Air Force and Navy planners are working to operationalize this concept. But based on the broad outlines of the CSBA's *Point-of-Departure Operational Concept* study, it is likely that in the initial stages of hostilities, the U.S. would need to withstand an initial attack and limit damage to U.S. and allied forces while executing a blinding campaign against the People's Liberation Army (PLA) battle networks. However, the need withstand an initial attack is a potential flaw in the CSBA plan. Prudence and technical reality would suggest that the ASBC should find a way to make U.S. forces less visible and targetable while retaining the ability to be forward with credible combat power. Being less visible and targetable raises the risk of initiating a first strike and contributes to deterring a potential foe.

Failing deterrence, the ASBC assumes that a conflict with China would involve a protracted campaign where U.S-led forces would then sustain and exploit the initiative in various domains, conduct distant blockade operations against ships bound for China, maintain operational logistics, and ramp up industrial production of needed hardware, especially precision-guided munitions. However, it is important to note that in a shorter – perhaps more likely conflict – blockade, logistics and procurement will have minimal impact on the outcome.

China's impressive military buildup undergirds its anti-access/area denial (A2/AD) efforts in the Asia Pacific region. While some question China's strategic intent and downplay China's increasingly bellicose statements – especially toward the United States – regarding its maritime interests, a September 2011 Center for Naval Analysis study summarized the rationale for China's moves. It noted, in part: [26]

> China continues to have vital interests that touch on questions of sovereignty and territorial integrity in maritime areas near the mainland. Until these issues are resolved, a key component of how Chinese policy-makers think about maritime power is their need to develop the means necessary to prevent *de jure* independence for Taiwan, prevent an attack on the Chinese mainland from the sea, and defend China's territorial and exclusive economic zone (EEZ) claims. The United States is perceived as the single most important potential security

> threat and the one actor that could prevent China from attaining its goals with regard to Taiwan and other disputes in regional seas.

As widely reported in the international media, and as analyzed by institutions as diverse as the International Institute for Strategic Studies (IISS) and IHS Global Insight, China has dramatically increased its military spending. Its military budget rose by more than 11 percent this year, to over $100B for the first time ever.[27] Indeed, in the IISS annual publication, *The Military Balance*, which reported that Asia was set to spend more on defense than Europe for the first time in modern history, what was lost to many in the report was the fact that China alone accounts for 30 percent of Asian defense and that China's official military expenditure in 2011 was more than two-and-a-half times the 2001 level, growing by an average of approximately 11 percent per year in real terms over the period, even faster than the economy as a whole.[28] Further, IHS Global Insight predicts that China's defense budget will double over the next five years, reaching over $238B in 2015, and outstripping the combined spending of all other nations in the Asia-Pacific region.[29]

Much of the contention between the United States has been focused, of late, on the South China Sea. China's continuing conflict with its neighbors in this geographically-strategic and resource-rich oceanic zone has been well-documented in the international media and due to is alliances with several of these nations; the United States has important equities in the South China Sea.[30] In January 2012, a Center for a New American Security report, *Cooperation from Strength: The United States, China, and the South China Sea*, highlighted the complex issues that have led up 4to the current situation. It noted the important American interests at stake in this body of water, and recommended a number of actions to secure American interests. Of note, the report was replete with references to China's strategic intent as well as its substantial A2/AD capabilities, noting, in part: [31]

> The South China Sea is where a militarily rising China is increasingly challenging American naval preeminence – a trend that, if left on its present trajectory, could upset the balance of power that has existed since the end of World War II and threaten these sea lines of communications (SLOCs)…China continues to challenge this openness…by developing military capabilities that allow it to threaten access to this maritime region…American military dominance in the South China Sea will recede in relative terms as other nations, principally China, improve their naval and air forces to better integrate ballistic missiles…If China can tip the balance of power in its favor, it can increasingly dominate its smaller neighbors while incrementally nudging the U.S. Navy further and further out behind the Western Pacific's first island chain.

China has been increasingly strident regarding its claims to its near-shore waters; primarily as a buffer against what it states are moves by the United States to "encircle" it. As Michael Richardson explained in the *Japan Times*: [32]

> China evidently aims to dominate its "near seas" —the Yellow, East and South China seas—turning them into an extended security buffer protecting the Chinese mainland and enabling China to exploit valuable fisheries and seabed resources,

> including oil, gas and minerals. The three seas contain the vast majority of China's outstanding territorial claims against its neighbors, as well as its disputed maritime claims. Beijing's claims in the 3.5 mission square km of South China Sea are by far the most extensive. Beijing asserts sovereignty over the main contested archipelagos and their surrounding waters and seabed. It asserts other forms of jurisdiction in its claimed zone of control, which covers about 80 percent of the sea.

The compelling need to ensure that U.S. options are not foreclosed in a way that marginalizes its ability to, as articulated in The *National Strategic Narrative*, "the strongest competitor and most influential player in a deeply inter-connected global system,"[33] has impelled the U.S. military to 4move forward in operationalizing the ASBC.

And the evidence suggests that this ASBC *will*, indeed, gain traction throughout the U.S. military. Speaking at the U.S. Air Force Academy graduation and commissioning ceremony Joint Chiefs Chairman Admiral Michael Mullen noted, "The ASBC is a prime example of how we need to keep breaking down stovepipes between services, between federal agencies, and even between nations."[34]

More recently, the Air Force and the Navy have begun to speak publically about the A2/AD challenge and how they intend to implement the ASBC. This has occurred within the context inter-Service initiatives to operationalize the nation's strategic shift, such as Navy/Air Force implementation of the *Joint Operational Access Concept* (*JOAC*)[35] and the companion AirSea Battle Concept. These have been highlighted in professional journals, perhaps most notably in an article co-authored by Air Force Chief of Staff General Norton Schwartz and Navy Chief of Naval Operations Jonathan Greenert in *The American Interest* in February 2012.[36] Admiral Greenert gave the AirSea Battle Concept a prominent place in his December 2011 *U.S. Naval Institute Proceedings* article, "Navy 2025: Forward Warfighters," where he noted, "Over the next decade naval and air forces will implement the new AirSea Battle Concept and put in place the tactics, procedures, and systems of this innovative approach to the A2/AD challenge."[37]

More recently, in an article in *Joint Forces Quarterly*, Admiral Greenert emphasized the JOAC and the A2/AD challenge when he noted: [38]

> The new defense strategic guidance emphasizes the need to assure access to the global commons and retain the ability to project power despite threats to access. The new Joint Operational Access Concept (JOAC) highlights the importance of forward operations to access for the joint force, stating, "Geography, particularly distance, arguably determines the access challenge more than any other factor, as military power has tended to degrade over distance." By operating forward we mitigate the tyranny of distance and improve our ability to assure access. Partnerships also figure prominently in assuring joint access per the JOAC.

The fiscal and programmatic realities are "catching up" with this concept in a way that facilitates the DoD's – and especially the Air Force and Navy's – ability to operationalize it in the challenging undersea **denied operational environment**. But as the *Air Sea Battle: A Point of*

Departure Operational Concept notes, more needs to be done, "The Defense Department's Program of Record forces and current concepts of operations do not accord sufficient weight to the capabilities needed to successfully execute an AirSea Battle campaign."[39]

ASBC is as much about developing credible combat power and the military doctrine to support it as it is about long-term competition. Thus any concept must analyze the holistic impact and strategic costs to sustain and win the long term competition with any peer or near-peer state. The ultimate result of adjustments to doctrine, operational plans and system acquisition resulting from the ASBC are still emerging. Ultimately, ASBC must be more than simply a sharing of assets or cooperation for its own sake. It must integrate unique sets of capabilities from both services to create real synergistic effects that neither service can accomplish individually.

While this description of ASBC has been necessarily short, what is clear is that in operationalizing and executing ASBC, the Navy will depend on undersea forces across the spectrum of conflict: from Phase Zero operations and preparing the battlespace to forward CSG- and ESG-focused combat and strike operations in support of overarching campaign plans. This, in turn, begins to suggest the types of systems, sensors and platforms needed by undersea forces to perform their role in support of ASBC.

But these types of systems are just part of the solution, not the entire solution. As Undersecretary of the Navy, the Honorable Robert Work, noted in July 2012 at the Third Annual Symposium on the State of Integrated Air and Missile Defense at Johns Hopkins University Applied Physics Laboratory, "AirSea Battle spurred the first move toward modern fleet battle networks." And latter in his briefing, quoting naval analyst Dr. Norman Freidman, he explained how a focus on battle networks is an important step toward modern fleet design and the integration of the task force, with individual units no longer carrying their own weapons, but rather achieving their effects in cooperation with the entire force. He noted further that sensors could no longer be considered mere auxiliaries to the weapons of a single ship, but rather contributions to the total information gathering capacity of the task force, which capacity would, in turn, contribute to the total combat capacity of the task force, directed in unison.[40]

It is clear from this strategic analysis that ASBC can be an effective strategy and operational concept to ensure that the United States remains, "the strongest competitor and most influential player in a deeply inter-connected global system," and especially in the strategically crucial Asia-Pacific region. And as pointed out by Undersecretary of the Navy, the Honorable Robert Work, battle networks make up the critical component of ensuring this success.

But establishing and maintaining effective battle networks is not a trivial undertaking. And while there are major initiatives underway at the DoD level to provide the Joint Force with effective battle networks, the U.S. Navy has, arguably been at the forefront of this effort with its reorganization of the Navy staff and more-importantly, strategic shift to making information dominance a weapon of war. Understanding this shift is essential to understanding how the UCR is crucial to facilitating undersea integration.

Securing the Information Dominance Advantage

To enable effective maritime superiority and maintain global maritime awareness in support of the Joint Force, the U.S. Navy has made information a "main battery" of its arsenal. Information, when networked across joint, allied, and coalition forces enables commanders to design a cooperatively-created common operating picture – to better able to see what is over the horizon faster than the adversary. As noted in the U.S. Navy's *2010 Vision for Information Dominance*, "[T]o be successful at 21st century warfare, the Navy will create a fully integrated C2, information, intelligence, cyberspace, environmental awareness, and networks operations capability and wield it as a weapon and instrument of influence."[41]

Enhancing its proficiency at operating within the information domain will also allow the U.S. Navy to better respond to a rapidly changing battlespace as it takes advantage of advanced IT and networks; develops a global enterprise through network centric operations and command and control (C2); and elevates the use of information as a main weapon alongside traditional weapons. Today, with the challenges facing the United States on a global scale, and with the ASBC coming into its own as a strategy and an operational concept, seizing and maintaining this Information Dominance advantage is more crucial than it has ever been.

At the highest levels of the Navy, Undersecretary of the Navy Work has consistently emphasized the importance of battle networks in addressing Fourth *and* Fifth generation warfare. He notes:[42]

> Fourth generation fleet design was focused on littoral combat and battle network communications and data exchange. In response to this evolving threat, Fifth Generation fleet design is all about building a "Total Force Battle Network." This shift to a Fifth Generation Total Force Battle Network is crucial to dealing with the operational problems of maintaining cost-effective global forward presence and defeating multi-dimensional A2/AD networks.

Undersecretary Work goes on to articulate the key design principles behind such a Total Force Battle Network, including, optimizing the network not the platform, having all platforms and sensors netted, having all relevant information available to the warfighter, building open architecture systems, and fielding multiple manned and unmanned "second-stage" (off-board) systems.[43] Thus, at the highest level, the Navy's mandate is to "operationalize" information dominance.

Nascent forms of this concept emerged as early as 2007 with the publication of the Navy's *A Cooperative Strategy for 21st Century Seapower*. The Navy's first new maritime strategy in a generation noted, in part:[44]

> Maritime forces will be forward deployed, especially in an era of diverse threats to the homeland. Operating forward enables familiarity with the environment, as well as the personalities and behavior patterns of regional actors. Mindful of the sovereignty of other nations, this influence and understanding contributes to effective responses in the event of crisis. Should peacetime operations transition to war, maritime forces will have already developed the environmental and

> operational understanding and experience to quickly engage in combat operations. Forward presence also allows us to combat terrorism as far from our shores as possible. Improved integration and interoperability to meet the combatant commanders' increased demand for mission-tailored force packages requires a more integrated approach to how maritime forces are employed.

Clearly, this emphasis on forward presence and integration has been given more shape and focus in the five years since the publication of *CS-21*. Former Chief of Naval Operations, Admiral Gary Roughead, has spoken extensively regarding the challenges the Navy will need to address as it integrates unmanned vehicles into its force structure, emphasizing in particular the need to enhance C2 capabilities.[45] The Deputy Chief of Naval Operations for Information Dominance (OPNAV N2/N6) has drafted a roadmap to "achieve integration and synchronization among manned and unmanned systems, and unattended sensors, and across all domains (air, surface, subsurface, and shore)."[46]

The current Chief of Naval Operations, Admiral Jonathan Greenert, has reinforced Admiral Roughead's imperatives regarding unmanned systems since becoming CNO in 2011. For example, his *Sailing Directions* state that "over the next 10 to 15 years … unmanned systems in the air and water will employ greater autonomy and be fully integrated with their manned counterparts." He expound further upon the importance of unmanned systems in his articles "Navy 2025: Forward Warfighters" and "Payloads Over Platforms: Charting a New Course," where he argues that payloads, including unmanned systems, will increasingly become more important than platforms themselves. 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."[47]

However, while these specific sources are important to understand the complete context of the Navy's strategy in this area, the fullest manifestation of the Navy's focused plan to secure the Information Dominance Advantage is articulated in the *U.S. Navy's 2010 Vision for Information Dominance*.[48] Understanding this landmark publication is crucial to a well-nuanced ability to see the ways in which the UCR will support undersea dominance. And while a complete summary of this comprehensive, 22-page, publication is well beyond the scope of this paper, it is important to capture some highlights of fully-understand what Information Dominance (ID) means to the Navy and the Joint warfighter.

The Vision for ID is to, "Pioneer, field and employ game-changing capabilities to ensure Information Dominance over adversaries and Decision Superiority for commanders, operational forces and the nation." The purpose of instantiating ID is to foster a forward-looking view of information as a core warfighting capability of the U.S. Navy. The *U.S. Navy's 2010 Vision for Information Dominance* begins the translation of information dominance from a vision into a set of concepts that will be tied with strategies and architectures in a series of ID Roadmaps. These Roadmaps will guide the Navy's future budgets, acquisitions and operational employment of information capabilities. The scope is Navy-wide with direct linkage to the other Sea Services and Joint and allied maritime operations.

As *U.S. Navy's 2010 Vision for Information Dominance* makes clear, we have entered a new era. Echoing the strategic drivers and analysis presented earlier, it notes that globalization and the exponential growth in computing and communications capabilities have transformed the information environment from an enabling medium to a core element of warfighting capability, for both the U.S. Navy and our adversaries. Those adversaries, particularly al Qaeda and the Taliban, have skillfully applied information operations to achieve a temporary, asymmetric, tactical advantage, imposing tactical, if not operational and strategic costs on US and coalition forces. Potential state and non-state adversaries are investing in capabilities to fight in the information domain and hold at risk our network-dependent command and control capability. Indeed, on a daily basis, our nation's cyber networks are being relentlessly assaulted. Some even argue that we are already in the early phases of what will be a prolonged cyber war.

While the nature of warfare will endure, warfare modes are evolving to fit the unique characteristics of information age power, competition and conflict. Information technology and advanced warfighting concepts are creating new opportunities to enhance Navy's contribution to national security. To date, the role of information within the Navy has evolved without an overarching conceptual framework and guiding principles. We have invested in superb sensors, weapons and control systems, but sub-optimized their combat effectiveness by designing them for, and "welding" them to, single platform types and individual units. This legacy platform-centric approach to capability and force development unacceptably increases our operational risk. In too many cases, our kill-chain architectures cannot deliver data end-to-end.

We have the means to redress these gaps and the attendant operational risk. Reiterating the CNO's guidance regarding, **"Aligning intelligence and operations and optimizing the network in man4y ways takes priority over the platform. If we don't get the intelligence and information right, then the platform is sub-optimized. Therefore, we need to elevate the priority of the information...Since we already think and operate this way, it's time we finally aligned organizationally to sustain it...to achieve prominence and dominance."** The U.S. Navy will decouple – programmatically and functionally – its platform-sensor-processor-weapon artifacts to reconfigure them as distributed, adaptively networked, enterprise capabilities.

Navy's information capabilities will evolve from 20th century supporting functions to a main battery of 21st century American Seapower. To be successful at 21st century warfare, the Navy will create a fully integrated C2, information, intelligence, cyberspace, environmental awareness, and networks operations capability and wield it as a weapon and instrument of influence. Information will be treated as a weapon across the full range of military operations. The transition to an information-centric Navy represents a new vision of who we are as a sea power.

Information Dominance is the ability to seize and control the information domain "high ground" when, where and however required for decisive competitive advantage across the range of Navy missions. Information Dominance means freedom of action to maneuver and act – conduct offensive and defensive actions, kinetically and non-kinetically – at the intersection of maritime, information and cyberspace domains.

At this intersection, the Navy exploits deep penetration, expanded maneuver space, and information advantage to deliver warfighting options and effects. To achieve information

dominance, the Navy must radically realign our warfighting capabilities. We must transition from a Navy that relies on individual units managing their own electromagnetic spectrum, to fleets and battle forces collectively achieving command and control over the electromagnetic spectrum in an automated fashion. This will require us to re-engineer our Navy – our concepts, our weapons, our battle management systems, and our people.

Information is no longer limited to an enabling role – Navy information *in* warfare amplifies kinetic combat capabilities; Navy information *as* warfare delivers expanded maneuver space, new operational and strategic options, asymmetric operational effects, and capability for dominant control of the battlespace. Information as a weapon will be applied to influence, deny, degrade, disrupt or destroy across the full range of maritime and naval missions.

While what is presented above only "surfs the wave tops" of the breadth and depth of what ID means, and how deep and wide the Navy's commitment to this new warfighting capability is, it is now easier to understand why the Submarine Communications Program Office has been reconstituted into the Undersea Integration Program Office (PMW-770) and the imperatives that drive this office, Program Executive Office Command, Control, Communications Computers and Intelligence (PEO C4I), and the Navy writ large in order to make the UCR a key enabling – and even forcing – function to ensure success in Joint Undersea Fourth – and Fifth – Generation Warfare.

The Challenges – and Opportunities – for Undersea Integration

The *Defense Strategic Guidance*, when coupled with the CNO's *Sailing Directions* and *Navigation Plan*, amplify the Navy's historic role of controlling the global commons on the seas while facilitating naval and Joint Force access, while also emphasizing the pivotal role undersea forces must play in the future security environment. The *Defense Strategic Guidance* points out that the U.S. military will invest as required to ensure its ability to operate effectively in A2/AD environments, and also notes that this will include implementing the JOAC and sustaining our undersea capabilities, while the CNO's *Sailing Directions* notes that 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.

Such a mandate is as unambiguous as it is compelling. As pointed out by Vice Admiral Richardson, as the Nation and the Navy are now working to prepare for this era of "Fourth Generation Warfare the Joint Force in general, and the U.S. Navy specifically, must be prepared to embrace emerging technologies that are flexible and adaptable in the always-challenging undersea environment."[49] But with the rapid emergence of cutting-edge technologies in manned and unmanned undersea vehicles as well as undersea sensors, the full potential of these technologies will not be realized unless or until integration and connectivity issues are addressed and given the same priority as the vehicles and sensors themselves.

Clearly, in operationalizing and executing ASBC, the Navy will depend on undersea forces across the spectrum of conflict – from Phase Zero operations and preparing the battlespace to forward CSG- and ESG-focused combat and strike operations in support of overarching campaign plans. And since undersea forces will likely be the ones operating forward in the

contested littorals if and when Phase Zero operations morph into combat operations, the imperative for these forces to be completely integrated and combat-ready is arguably more compelling than in any other warfare domain.

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*, most recently published in July 2011.[50] This capstone document emphasizes the importance of undersea integration through its focus on unmanned underwater technology and cyber – and other – networks, with an overarching goal of employing platforms and systems capable of fully exploiting the undersea maneuver space.[51]

As *Design for Undersea Warfare* points out, with its strong emphasis on Phase Zero operations, "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,"[52] *Design for Undersea Warfare* provides a mandate for undersea forces to have robust, agile and secure networks in order to most effectively employ – and protect – these forces deployed forward in the contested and contentious littorals. 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**."[53]

And the need for undersea integration is perhaps even more compelling than any other need at this point. Such a mandate is as unambiguous as it is compelling. As Vice Admiral Richardson notes, "As we work to expand the concept from submarine force to undersea forces – networked and unmanned platforms and sensors – to achieve decisive effect, in Generation Four Warfare…We must do this with some urgency…The President, Secretary of Defense, and CNO have given us a clear call to action."[54]

And what is needed to achieve success in Fourth Generation undersea warfare is equally clear. It is not just "more of everything." **Rather, it is networks**. What is needed are pervasive combat networks that combine ubiquitous intelligence, surveillance, and reconnaissance; longer-range, responsive, and precise weapons (including cyber and space weapons with near-instantaneous global reach), and increasingly high-bandwidth command and control networks to connect the ubiquitous sensors with longer-range weapons in the **denied operational environment**.

This focus on networks is not something that has emanated from the technical or acquisition community as a grandiose solution for some future, as-yet-unknown hypothetical scenario, but comes from the compelling, real-world, experience of Fleet operators today. Writing in the *U.S. Naval Institute Proceedings* in September 2012, two Navy captains with extensive operational credentials, note in their article, "My Other Combat System is a Network," how, other than talented people to run them, networks have become the sine qua non of naval warfare:"[55]

> Since the 1990s, the Navy has taken great strides to embed networking and information technology (IT) to improve operational and fiscal efficiency. Under this net-centric umbrella, a fleet can operate more effectively in a distributed

> fashion and reduce the operational impacts imposed by the maritime domain's basic characteristic of distance.
>
> The Navy can take pride in having been the first service to truly embrace net-centric and cyber capabilities and put them into practice; it continues to optimize these capabilities with increasing investments in unmanned and autonomous systems, maturing the Maritime Operations Center concept, and providing enterprise-wide networking such as establishing the world's largest intranet. We must invest the right level of leadership and funding into raising operational C4I and combat-systems efficiency.

Nor is this dependence on naval networks an artifact of the Twenty-first Century. As Dr. Norman Friedman points out in his book, *Network-Centric Warfare: How Navies Learned to Fight Smarter through Three World Wars* as well as in the *Proceedings of the 2006 Royal Australian Navy Sea Power Conference*, and the *Proceedings of the 2007 King Hall Naval History Conference*, naval networks have been around for well over a century, noting, in part:[56]

> When John Fisher became First Sea Lord in 1904, his main pledge was to solve this intractable problem…Fisher in effect invented picture-based warfare. He created a pair of war rooms in the Admiralty, one built around a world (trade) map, the other around a North Sea map.
>
> Fisher used the information gleaned from shipping reports and reports from his own fleets to build a tactical picture of where pirates were attacking British merchant ships. Information from these sources was fed into two different war rooms—the first war room tracked ship movements around the world while the second war room tracked ship movements in the North Sea. Armed with this "picture-based" view of the world, Admiral Fisher was able to direct warships to the spots where British ships were being attacked by pirates.

But as the Navy works with current forces to succeed in today's Fourth Generation Undersea Warfare environment it must look ahead to Fifth Generation warfare, the broad outlines of which are already emerging. And while some may debate what this Fifth Generation warfighting environment may look like, at the highest levels of the Navy, this future is *not* opaque, but increasingly clear. Preparing for this future will take the combined efforts of the Fleet, the Navy staff, the Naval Acquisition Enterprise, and the Naval Research Enterprise.

In a presentation at the Third Annual Symposium on the State of Integrated Air and Missile Defense at Johns Hopkins University Applied Physics Laboratory, Undersecretary of the Navy, the Honorable Robert Work, **defined** the Fifth Generation warfighting environment by noting, "In response to this evolving threat, Fifth Generation fleet design is all about building a Total Force Battle Network. Key design principles optimize the network, not the platform."[57] But while Undersecretary Work clearly defined the warfighting environment, and provided a clear and compelling mandate, the art of providing what he identifies will require **both inspiration and innovation**. In the undersea environment, 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, will focus the Navy's efforts in this crucial area on the undersea **denied operational environment**.

PEO C4I and PMW-770 have a clear mandate to support the Nation's strategic imperatives and the Navy's undersea forces specifically. In order to better understand the scope of this responsibility, a few words on the undersea domain are appropriate here. Using stealth and survivability, the undersea domain enables our naval forces to use proximity, persistence, surprise, and uncertainty to our advantage and our enemies defeat; influencing their actions while exploiting their weaknesses. The ability to do so make U.S. naval undersea forces a highly formidable fighting force. The real question then becomes, as the challenges intensify, how do we attain the heightened level of capability needed to counter present and emerging threats and maintain our competitive advantage?

Deploying a ubiquitous intelligence, surveillance, and reconnaissance capability that feeds mission critical information into increasingly high-bandwidth command-and-control networks will provide the systems needed to achieve and maintain information superiority in the undersea **denied operational environment**. This is especially true in the undersea domain where the real challenges of a DIL environment…A Disadvantaged/Disconnected, Intermittent, Low-Bandwidth environment…complicate our ability to stay connected.

But 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.

By employing a netted undersea architecture that is linked with potential nodes operating outside of the undersea domain, we extend the ability to transmit sensor data beyond the organic capabilities inherent on the prosecuting platform and thereby minimize the submarine forces' vulnerability. Using this methodology, evolutionary developments possibly give way to revolutionary and disruptive technological advancements that allows the undersea forces to maintain undersea superiority and information dominance.

There are existing and emerging technologies that show great promise in this area. But in a challenging budgetary environment choices – often tough choices – will need to be made in a disciplined manner. What is needed is a vehicle to help make wise investment choices to overcome these difficulties so that naval forces can assertively conduct Fourth Generation Undersea Warfare today and Fifth Generation Undersea Warfare, tomorrow. **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. An Undersea Connectivity Roadmap will be the vehicle to help make investment choices moving forward to support the Joint warfighter in the undersea **denied operational environment**.

PEO C4I and PMW-770 have primary stewardship for evolving this Roadmap and focusing and coordinating the Navy's and industry's efforts in this important undertaking. PMW-770s charter, issued by PEO C4I in 2008, explains the scope of PMW-770s responsibilities in providing stewardship for the undersea portion of the Navy's Total Force Battle Network, integration of programs supporting Fourth Generation undersea warfare today and for innovative concepts to design networks to support Fifth Generation undersea warfare tomorrow, noting, in part, "PMW 770 is the submarine integration agent to PEO C4I. PMW 770 provides leadership and management for developing, acquiring, fielding, and supporting integrated submarine C4I solutions for Naval, National, Joint, and Coalition operations."[58]

PEO C4I's and PMW-770's overarching goal, to provide Undersea Information Dominance; Anytime, Anywhere, is supported by a clear **Mission Statement**, "To deliver state-of-the-art systems and capabilities to enhance the Navy's manned and unmanned undersea mission accomplishment," and an innovative **Vision** "To be the Nation's pre-eminent provider of information dominance in the undersea battlespace." In concert with its partners in the Fleet, the Navy staff, the Naval Acquisition Enterprise, and the Naval Research Enterprise, PEO C4I and PMW-770 are providing the stewardship *today* for innovative undersea integration *tomorrow*.

The Way Ahead for Joint Undersea Integration

In executing their charter to ensure information dominance in the undersea domain, PEO C4I and PMW-770 have identified over 50 stakeholders who have stewardship over various aspects of this important effort. While these stakeholders are, in principle, supportive of this effort, each organization brings its own culture, doctrinal underpinning, tactics, techniques, and procedures to how it conceptualizes, designs, and builds platforms, systems, sensors and weapons. This naturally induces stovepipes that will require the aforementioned inspiration and innovation to break down these stovepipes to ensure that when these platforms, systems, sensors and weapons are fielded, they are integrated in a manner that assures both information dominance and warfighting success.

The principal vehicle for securing this information dominance and warfighting success is the Undersea Connectivity Roadmap (UCR) developed by PEO C4I and PMW-770 in concert with the aforementioned stakeholders. As part of the process of evolving the UCR, these stakeholders met multiple times to validate the undersea community's mission threads and operational needs statements. This group then translated the mission statements into operational capability statements. Finally, technologists then validated the system architecture and identified seven primary technology investment areas.

In the past decade, and with the onset of 21st century technologies, the submariner's responsibilities and operational environment have become increasingly complex and demanding. It is with this increasing responsibility that a formal science and technology (S&T) road-mapping process was undertaken in 2011-2012, to define the "as is" and to predict in best fashion, the "to be" status of technology development for enhanced undersea connectivity and, ultimately, information dominance in the undersea domain. The process itself was also designed to engage and educate all participants in the undersea warfare arena regarding the challenges and opportunities regarding providing information dominance in the undersea domain.

The imperative to accelerate this organized, disciplined, and repeatable technology development process stems from what was presented earlier regarding the rapidly-changing security environment, especially the increasingly robust (A2/AD) challenge, combined with the Navy's growing commitment to establish and maintain information dominance, especially in the undersea domain. Importantly, establishing this information dominance in the undersea domain presumes an increasingly sophisticated ability to provide situational awareness and connectivity under all C2 conditions, using all the assets available, from submarines, to unattended sensors, to autonomous vehicles; all interfacing with the strike group, air assets and land-based forces. And in this UCR effort, PEO C4I and PMW-770 are mindful that they are working in an increasingly-constrained – and uncertain – budget environment.

A formal road-mapping process imparts discipline and focus, defining the vision necessary to achieve a desired objective and ensuring that the required capabilities and resources are in place at the time needed. Road-mapping as an activity is therefore both a group learning process and a communication tool, and the resultant group understanding is often as important as the document itself, hence the push for inclusivity and active participation.

Once the UCR is fully developed, it will then be validated against concepts and focus areas contained in extant published documents. The PEO C4I Acquisition Requirements for Science and Technology, the PEO C4I Master plan, the Navy's Information Dominance Roadmap, and Undersea Warfare Chief Technology Officer Science and Technology Objectives are but a few of the guidance documents that will be reviewed on a periodic basis to validate the technology efforts identified in the Undersea Connectivity Roadmap as the directly support the Joint warfighter in the **denied operational environment**.

To support this ongoing effort, PEO C4I and PMW-770 will continue to engage key stakeholders in this iterative process. The Undersea Connectivity Roadmap has never been intended to be a tool that is solely used by PEO C4I and PMW-770. Instead, it is envisioned as an enduring tool that enables greater collaboration amongst the community of undersea stakeholders. Over the next several months, under the stewardship of the Commander, Naval Submarine Forces, the Navy Undersea Enterprise (USE) will use this roadmap to determine technology insertion points and "on-ramps" to inject technologies ranging from underwater sensors, to unmanned undersea vessels, to distributed arrays, to a wide range of other technologies into the Navy's POM and FYDP in order to ensure Navy's – and the Nation's – undersea forces remain dominant in the **denied operational environment**. In support of this effort, PEO C4I and PMW-770 will work with their key stakeholders to ensure the UCR remains a pioneering and visionary endeavor that promotes innovation, revolutionary concepts, and disruptive technologies.

Unlike all other "long term" planning efforts that are driven by validated requirements, the UCR serves to *establish* the basis for validating future requirements. The UCR therefore serves as a nexus point for industry to push technology in response to identified operational needs and operational capabilities that are driven by mission requirements and CONOPS; and not just push the "latest and greatest" thing that they may be pursuing. As grassroots efforts to unify strategic mindset increase collaboration throughout the undersea community – but one that has been

vetted and validated at the submarine force leadership level – it represents a document industry can use to guide in-house R&D efforts.

As the UCR evolves to become the Undersea Connectivity appendix to the Information Dominance Roadmap, it will continue to define the "as is" and predict the "to be" in the undersea information dominance arena in order to create a common undersea connectivity architecture for technology development. This will reduce variance and stove-pipe solutions and ultimately lead to undersea connectivity that will enable the Navy and the Joint Force to prevail, not only in Fourth Generation Undersea Warfare, but in the emerging Fifth Generation Warfare environment in the undersea **denied operational environment**.

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