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Section VII. Minimum Deterrence: SSBN Invulnerability

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Introduction

Over the past half century, ballistic missile submarines (SSBNs) have served a prominent role in the U.S. nuclear triad. The United States and several other countries have valued SSBNs for a variety of reasons, foremost of which is survivability when at sea. One common theme among proponents of Minimum Deterrence is that a small, assured, second-strike capability will deter any adversary and—because submarines are invulnerable when at sea—the bulk of the U.S. nuclear force can be based on SSBNs. In reports proposing Minimum Deterrence, the assumed survivability of SSBNs for the foreseeable future is not examined further. In addition, these proposals do not even consider the potential implications of, and corrective actions that might be needed in response to, future adversary capabilities that could invalidate that planning assumption.

This report examines the importance of survivability for the nuclear force of the United States, and, in particular, the role of SSBNs for providing a survivable, assured, nuclear weapon capability. Since the assumption of SSBN invulnerability for the foreseeable future is an important element of the Minimum Deterrence narrative, this report tests that assumption in several ways to judge whether putting all or almost all nuclear eggs in the SSBN basket is a prudent approach for the future force. Finally, this report examines the potential implications of developments—technological and operational—in the decades ahead that would invalidate the assumption of SSBN invulnerability.

Background: The Importance of Nuclear Force Survivability for the United States and Others

Survivability is an attribute of the nuclear force that has been valued highly by senior U.S. officials of both parties. The desire for nuclear force survivability represents a continuity spanning the Cold War and post-Cold War environments. For example, in July 1980, during the height of the Cold War, President Jimmy Carter signed Presidential Directive 59 which, among other things, called for improvements to nuclear forces and supporting command and control to "achieve flexibility, enduring survivability, and adequate performance in the face of enemy actions."[1] In 1984, President Reagan's Secretary of Defense, Caspar Weinberger, reported, "We cannot overemphasize the importance of a multiplicity of survivable strategic forces. Over the last 20 years, we have maintained a triad of land-based ICBMs, manned bombers, and submarine launched ballistic missiles as an effective means of preserving a stable deterrent."[2]

Even as late as 1990, the Department of Defense (DoD) was intent on modernizing strategic nuclear forces to enhance survivability. Then-Secretary of Defense Frank C. Carlucci, in the Fiscal Year 1990 Annual DoD report to the President and the Congress, stated, "The U.S. strategic modernization program is increasing the capability and survivability of our offensive forces." Some of that enhanced survivability was to accrue from the introduction of "mobile basing modes [for ICBMs] in the early 1990s."[3] The Fiscal Year 1991 report, issued just months before the breakup of the Soviet Union, continued to include plans for mobile ICBMs. It stated, "Adding mobility to our ICBM force would greatly improve survivability without significantly reducing responsiveness and reliability. Therefore, ... [DoD] continues development of the Small ICBM ..."[4] (However, after the breakup of the Soviet Union late in 1991, President George H. W. Bush cancelled all U.S. plans for mobile ICBMs.)

Even in the seemingly benign security environment of the mid-1990s, the survivability of nuclear forces was stated to be an important attribute for the DoD. For example, in 1997, President Clinton's Under Secretary of Defense for Policy, Walter Slocombe testified: "For the foreseeable future, we will continue to need a reliable and flexible nuclear deterrent, survivable against the most aggressive attack, under highly confident constitutional command and control,

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[1] President Jimmy Carter, Presidential Directive/NSC-59, Subject: Nuclear Weapons Employment Policy, July 25, 1980, p. 2. (Underline added for emphasis.)

[2] Caspar W. Weinberger, Secretary of Defense, *Annual Report to the Congress: Fiscal Year 1984,* p. 54. (Underline added for emphasis.)

[3] Frank C. Carlucci, Secretary of Defense, *Annual Report to Congress: Fiscal Year 1991*, Department of Defense, p. 53. (Underline added for emphasis.)

[4] Dick Cheney, Secretary of Defense, *Annual Report to the President and the Congress: Fiscal Year 1990,* Department of Defense. (Underline added for emphasis.)

..."[5] And recently, in June 2013 President Obama forwarded a report to Congress outlining his administration's nuclear weapon employment guidance. It said,

> The new employment guidance directs that the DoD will maintain a sufficient, diversified, and survivable capability to provide at all times with high confidence the capability to convince any potential adversary that the adverse consequences of attacking the United States or our allies and partners far outweigh any potential benefit they might seek to gain from such an attack. It also preserves the flexibility to respond with a wide range of options to meet the President's stated objectives should deterrence fail.[6]

During the Cold War, U.S. defense planners gave serious consideration to the survivability of all legs of the nuclear triad. For land-based intercontinental-range ballistic missiles (ICBMs), the large number of silo-based missiles and the rugged design of missile silos and launch control facilities provided some confidence that not all fixed-site ICBMs would be destroyed, even by a large-scale attack on the United States. During the final decade of the Cold War, the deployment of large, heavily MIRV'ed Soviet ICBMs called into question this planning assumption. As a result, during the 1980s, U.S. defense planners examined innovative ICBM basing concepts and options to develop and deploy mobile ICBMs in order to provide an additional degree of survivability for the ICBM force. Both highly-MIRV'ed rail-mobile and single-warhead road-mobile ICBMs were considered to enhance the survivability of land-based missiles. However, the end of the Cold war preceded the deployment of U.S. mobile ICBMs.[7] The Soviet Union ceased to exist on December 26, 1991. A few weeks later President George H. W. Bush cancelled the Small ICBM program as one element of the second Presidential Nuclear Initiatives (PNI) agenda. This PNI was announced during his January 28, 1992 State of the Union address.[8]

For bombers, from 1957 until September 1991, a number of heavy bombers from multiple airfields were fueled, loaded with nuclear weapons, and kept on airborne or ground alert.[9] This

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[5] Walter B. Slocombe, Under Secretary of Defense for Policy, "The Future of Nuclear Deterrence," Testimony before the Subcommittee on International Security, Proliferation, and Federal Services of the Committee on Governmental Affairs, United States Senate, February 12, 1997, p. 2. (Underline added for emphasis.)

[6] President Barack Obama, Report on Nuclear Employment Strategy of the United States Specified in Section 491 of 10 U.S.C., June 2013, pp. 7-8. (Underline added for emphasis.)

[7] Lauren Caston, Robert S. Leonard, Christopher A. Mouton, Chad J. R. Ohlandt, S. Craig Moore, Raymond E. Conley, Glenn Buchan, *The Future of the U.S. Intercontinental Ballistic Missile Force* (Santa Monica, CA: RAND Corporation, 2014), p. 22.

[8] Susan J. Koch, *The Presidential Nuclear Initiatives of 1991 - 1992* (Washington, D.C.: National Defense University Press, 2012) pp. 17-18.

[9] Susan J. Koch, *The Presidential Nuclear Initiatives of 1991 - 1992*, op.cit., p. 1.

provided a degree of survivability for bombers that were airborne or ready to launch quickly in the event of warning of an incoming strike. The design of the B-1b bomber included attributes intended to enhance survivability. In 1984, then-Secretary of Defense Caspar W. Weinberger reported, "The B-1B will be able to escape from its bases quickly and so be far less vulnerable to destruction on the ground than the B-52."[10] And, SSBNs by the very nature of the difficulty of detecting and tracking submarines when at sea and submerged, provided a highly survivable component of the nuclear force.

The end of the Cold War led to a revised assessment of the threat—that a surprise attack by Russia was remote. In the environment of the early 1990s, neither Russia nor China posed a credible first-strike threat to the U.S. nuclear force. As a result, for the past two decades, the important task of ensuring that a portion of the triad was deployed and survivable has been largely the purview of the SSBN force.

The U.S. SSBN Force. Ballistic missile submarines were developed by the United States in the late 1950s and first deployed in 1960. From 1960 to 1966 the U.S. Navy completed the production of 41 SSBNs which were referred to as the "41 for Freedom." Each of these SSBNs carried 16 relatively short-range Polaris nuclear-armed ballistic missiles. The short range of the first few generations of submarine-launched ballistic missiles (SLBMs) required U.S. SSBNs to patrol in close proximity to their intended targets.

The first operational patrol of a U.S. ballistic missile submarine began in November 1960. SSBN deterrent patrols were conducted from forward bases in Scotland, Spain, and Guam, and early SSBNs operated in tactically dangerous environments. The short ranges of early SLBMs also mandated relatively small patrol areas in proximity to the Soviet Union and concern over the threat of detection and attack from enemy antisubmarine forces—aircraft, surface ships, and attack submarines. The challenges of operating in a forward-deployed, high-threat operational environment called for U.S. first-generation SSBNs to be capable of high speeds, deep diving depths, and self-defense capabilities. Submariners are reportedly fond of saying that the best evasion device is a well-aimed Mk48 torpedo.[11]

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[10] Caspar W. Weinberger, Secretary of Defense, *Annual Report to the Congress: Fiscal Year 1984*, p. 53.
[11] Michael J. Dobbs, "The Incredible Shrinking SSBN(X)," Naval Institute *Proceedings*, June 2012, p. 35-39.

In the late 1960s, the Department of Defense (DoD) established a Vulnerability Task Force (VTF) to determine how safe U.S. SSBNs would be when at sea. According to the Navy, the VTF "quickly realized there were too many gaps in our knowledge of both the threat and the physical aspects of underwater detection, tracking, and engagement to arrive at a definitive answer." In October 1968, this led then-Director of Defense Research and Engineering, Dr. John S. Foster, to establish a requirement to investigate technical issues in the general area of SSBN vulnerability and survivability.[12] The SSBN Security Program is a highly classified program that continues to this day. It will be discussed later in this report as an important forward-looking activity that can help identify possible future threats and, when warranted, develop tactics and countermeasures before the threats are manifest. The SSBN Security Program has drawn praise from a 2013 report by the Naval Studies Board on the potential adaptability of naval forces for responding to strategic surprise.

During the last two decades of the twentieth century, two developments by the United States significantly reduced the strategic ASW threat to deployed U.S. SSBNs. The first significant development is the design of longer-range SLBMs—Trident C4 and later D5 missiles. These long-range SLBMs enabled U.S. SSBNs to operate in patrol areas measured in tens of millions of square miles and at distances well beyond the normal operating range of Soviet (and later Russian) anti-submarine forces. In addition, according to one naval officer, the second development, the extremely low acoustic signature of *Ohio*-class submarines, reduced the threat of detection when at sea and on patrol "to essentially nil."[13]

Views of Allies. U.S. allies, the United Kingdom (UK) and France, also saw great value in ballistic missile submarines and the attribute of survivability provided by these undersea forces. The UK built four *Resolution*-class SSBNs between 1964 and 1968. The French built six SSBNs with the first, the S609 *Le Redoutable*, launched in early 1967. In 1992, the UK launched its first *Vanguard*-class SSBN to replace the aging *Resolution*-class boats. Since the 1960s, both the UK and France have continued to modernize and deploy SSBNs. Currently, the UK and France each

[12] Michael L. McHugh, Captain U.S. Navy, "The SSBN Security Program," http://www navy.mil/navydata/cno/n87/usw/autumn98/ssbn.htm.

[13] Michael J. Dobbs, "The Incredible Shrinking SSBN(X), op.cit., p. 35-39.

possess inventories of four SSBNs with one submarine at sea and on patrol at any time. For the UK, its entire nuclear force has been SSBN-based since the early 1990's.

The UK has evaluated several options for its twenty-first century nuclear deterrent force as the *Vanguard*-class SSBNs approach end of life. Options evaluated included aircraft-delivered bombs and cruise missiles, silo-based ballistic missiles, and a follow-on SSBN. Criteria for the UK analysis of alternatives included: force credibility, readiness, reach, and survivability/invulnerability for each nuclear force option, as well as the appearance of "resolve" so "potential adversaries would think the UK's political leadership would actually be prepared to use them." These criteria came together in what the UK analysis referred to as "an assured ability to launch a second strike." Using that approach, in 2006 the follow-on SSBN was selected as the UK's preferred choice.[14]

If survivability is so important, how does the UK Government rationalize the potential vulnerability of a SSBN monad and keeping only one SSBN at sea at any one time? First, the ability to keep one SSBN (out of an inventory of four) patrolling at sea was assessed to provide the greatest degree of assured second strike potential of the options evaluated by the UK. Second, the UK White Paper recommending a follow-on SSBN also included the need to stay ahead of any potential ASW threat and to protect the submarine acoustic and electro-magnetic signatures throughout the life of their SSBNs. And finally, the UK White Paper discussed the importance of unspecified "fall-back options to provide the necessary resilience."[15] Clearly, one such fall-back option is the special relationship between the United States and the United Kingdom and the larger U.S. nuclear force which any adversary of the UK would likely have to consider. Thus the UK is in a unique position of being in a close relationship with the United States while, at the same time, possessing an independent deterrence force for "special circumstances." In December 2006, this is apparently what then-Prime Minister Blair, discussing the UK replacement SSBN decision, meant when he said, "Our co-operation with America is rightly very close. But close as it is, the independent nature of the British deterrent is

[14] "Trident Alternatives Review," UK White paper, July 16, 2013, pp. 23-24.
[15] Ibid., p. 24.

again an additional insurance against circumstances where we are threatened but America is not."[16]

Views of Others. Adversaries of the United States have also invested significant resources to develop SSBNs as well as other types of survivable nuclear forces. The Soviet Union is often credited with fielding the first rudimentary SSBN. In 1955, the Soviets launched a ballistic missile from a converted Zulu class submarine. This submarine was modified to carry a single missile in its sail and had to launch from the surface. Soviet Yankee-class SSBNs with 16 missiles per boat, analogous to early U.S. SSBNs, began to be built in 1964. More recently, China has developed an SSBN capability which, reportedly, will become operational this year (2014). According to China scholars John Wilson Lewis and Xue Litai, "For China, the main objective for the modernisation of its nuclear weapons is to increase survivability."[17] In addition, India is currently developing an SSBN capability and, in February 2014, the Director of India's Defense Research and Development Organization said that India's first SSBN would be "ready for induction" by next year (i.e., 2015).[18]

Based on the empirical evidence from nuclear-armed countries, nuclear force survivability is a highly-valued attribute. Because survivable nuclear forces are important assets for nuclear powers, many have filled this requirement by maintaining SSBNs at sea. However, some nuclear-armed countries, such as Russia,[19] have not been able to keep a significant portion of the nuclear force at sea in order to provide the desired degree of survivability and have chosen to pursue survivability through other means. For example, the Soviet Union, and later Russia, expended a great deal of effort to develop and deploy mobile, land-based ballistic missiles. Also, China, India, and Pakistan have each developed mobile, land-based ballistic missiles which provide a greater degree of survivability than missiles in fixed sites.

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[16] Statement by UK Prime Minister Tony Blair, "Parliamentary Statement on Trident," December 4, 2006, p. 3.

[17] John Wilson Lewis and Xue Litai, "Issues in Sino-US Relations: Survivability, Coercion, and Escalation," June 21, 2013, available on-line at: https://www.gov.uk/government/publications/issues-in-sino-us-nuclear-relations-survivability-coercion-and-escalation/issues-in-sino-us-nuclear-relations-survivability-coercion-and-escalation.

[18] "India's First Nuclear Submarine and ICBM Will Be Ready for Induction Next Year: DRDO," *The Economic Times (Online)*, February 9, 2014.

[19] Hans M. Kristensen, Russian SSBN Fleet: Modernizing But Not Sailing Much," Federation of American Scientists, May 3, 2013, http://fas.org/blogs/security/2013/05/russianssbns/.

This brief overview of past and current developments by the United States and others underscores the high value attributed to survivability for a nation's deterrent force. For the future, the issue of survivability is likely to remain an extremely important attribute for the U.S. nuclear force as well as for the nuclear forces of other countries.

The Shrinking U.S. SSBN Force. Over the past couple of decades, as a result of geopolitical developments, improved range and performance of SLBMs, and the stealthiness, payload capacity, and operating profile of newly produced *Ohio*-class SSBNs, the United States has been able to reduce the number of SSBNs while still maintaining a robust sea-based leg of the nuclear triad. The 18 ships of the *Ohio*-class replaced the "41 for Freedom." The 1994 Nuclear Posture Review (NPR) and the 2001 NPR both recommended further reducing the total number of SSBNs from 18 to 14 (at least two of which were expected to be in overhaul at any given time, leaving a maximum of 12 submarines deployable). Currently, the Department of Defense (DOD) plans to buy twelve *Ohio*-class replacement SSBNs which are slated to begin operational service in 2031 and to remain in service until the 2080 timeframe.[20]

As the United States has gradually reduced the number of SSBNs in the nuclear force, this has been done with the common perception that the submarines at sea cannot be detected and tracked by potential adversaries and survivability is assured. Certainly, the breakup of the Soviet Union and the general assessment of a very limited ASW threat from Russia or China have made this assumption plausible at present. Such confident assertions may be valid currently, but anyone expressing a similar opinion about the future cannot know what technical breakthroughs or other developments lie ahead.

Current Nuclear Policy and Survivability. Currently, the survivability of the SSBN force remains a unique attribute among the legs of the triad. This was underscored by the 2009 report of the bipartisan Strategic Posture Commission: "The Submarine Launched Ballistic Missile

[20] Rear Admiral Richard Breckenridge, "A History of Sea Based Strategic Deterrence Optimization, Platform Versatility, Cost Efficiency," Inside the Navy, August 26, 2013. http://navylive.dodlive.mil/2013/08/26/a-history-of-sea-based-strategic-deterrence-optimization-platform-versatility-and-cost-efficiency/.

(SLBM) force is currently the most survivable, meaning that no attacker could contemplate a nuclear attack on the United States without retaliation.[21]

Furthermore, the 2010 Nuclear Posture Review stated, "Strategic nuclear submarines (SSBNs) and the SLBMs they carry represent the most survivable leg of the U.S. nuclear triad within the constraints of the New START Treaty (NST). Today, there appears to be no viable near or mid-term threats to the survivability of U.S. SSBNs, but such threats—or other technical problems—cannot be ruled out over the long term." And, "Given the stakes involved, the Department of Defense will continue a robust SSBN Security Program that aims to anticipate potential threats and develop appropriate countermeasures to protect current and future SSBNs."[22]

The Obama administration's commitment to sustaining the SSBN leg of the triad is evident in its long-term plans which include deploying up to and including 240 Trident II D5 missiles at any time, sustaining the Trident II D5 missile through at least 2042, and funding the development of a next-generation SSBN to replace the *Ohio*-class SSBNs currently in service.[23]

The strategic goal of possessing an assured second-strike capability has been an important tenet of U.S. deterrence strategy. As the first-strike threat to the United States diminished with the end of the Cold War, the assured survivability of U.S. nuclear forces has been less of a concern and the need for survivable nuclear forces has been borne primarily by the SSBN force. Indeed, a former Commander of U.S. Strategic Command has written on the attributes needed in the future nuclear force. The first attribute on his list is *survivability*. His reasoning is straightforward: as a greater share of the eggs are placed in fewer baskets, survivability becomes "more and more important."[24]

The preceding discussion provides an overview of the importance the United States and other countries have attached to the attribute of survivability for nuclear forces, in general, and SSBNs,

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[21] William J. Perry, Chairman, and James R. Schlesinger, Vice-Chairman, America's Strategic Posture: The Final Report of the Congressional Commission on the Strategic Posture of the United States (Washington, D.C.: United States Institute of Peace Press, 2009), p. 26.

[22] Nuclear Posture Review Report, Department of Defense, April 6, 2010, pp. 22-23.

[23] Dr. James N. Miller, Principal Deputy Under Secretary of Defense for Policy, Prepared Statement before the Senate Committee on Armed Forces, Subcommittee on Strategic Forces, May 4, 2011, pp. 1, 5.

[24] Adm. Richard Mies, USN (Ret.), "Strategic Deterrence in the 21st Century," *Undersea Warfare*, Spring 2012, p. 18.

in particular. In the post-Cold War environment the SSBN force has born the burden of ensuring that a portion of the U.S. nuclear force is survivable and that any would be attacker would have to consider a significant second-strike response capability. In the relatively benign ASW environment that immediately followed the Cold War, the number of U.S. SSBNs was reduced and the survivability of the other legs of the nuclear triad has been given little attention.[25]

At the present time, should the nuclear threat to the United States and the survivability of U.S. nuclear forces become more of a concern, the existing triad and force structure provide a number of options that could enhance force survivability. These options include dispersing heavy bombers to a greater number of bases, returning some number of bombers to alert status, and retaining a large number of silo-based ICBMs while also taking steps to base the next-generation Ground-Based Strategic Deterrent (GBSD) in mobile or other configurations that provide enhanced survivability.

As will be illustrated later, Minimum Deterrence proponents appear to dismiss the possibility that the survivability of U.S. nuclear forces will become a concern in the future. This premise leads to recommendations for a relatively small "survivable" nuclear force based primarily on SSBNs.

Minimum Deterrence and SSBN Survivability

As discussed briefly in the NIPP 2013 report, *Minimum Deterrence: Examining the Evidence*, most Minimum Deterrence presentations assert that U.S. nuclear deterrence requirements can be met with a relatively small number of deployed forces based entirely or almost entirely on SSBN/SLBMs. These Minimum Deterrence proposals rely heavily on the assumption that SSBNs are invulnerable and will remain so for decades. This assumption allows Minimum Deterrence proposals to recommend that one or both of the other legs of the nuclear triad be eliminated or reduced significantly.[26]

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[25] The exception is the inclusion of two options in the Air Force Analysis of Alternatives study for a replacement for the Minuteman III ICBM. According to the Air Force, the study includes options for a new mobile ICBM as well as a concept that could be based in a tunnel system. Ref: Amy F. Woolf, "U.S. Strategic Nuclear Forces: Background, Developments, and Issues," Congressional Research Service Report for Congress, October 22, 2013, pp. 15-16.

[26] Keith B. Payne and James Schlesinger, *Minimum Deterrence: Examining the Evidence* (Fairfax, VA: National Institute Press, 2013), pp. 8, 45-49.

For example, the May 2012 Global Zero Commission report relies on the assumption of continued SSBN invulnerability to justify reducing the number of SSBNs to ten, eliminating the ICBM force, significantly downsizing the bomber force, and making deep cuts in U.S. nuclear force modernization plans.[27] This report proposed retaining only ten nuclear-capable bombers as a complement to the SSBN force. Another proposal for reducing nuclear forces, issued in 2012 by the Federation of American Scientists, recommends reducing the number of SSBNs to only eight or ten.[28]

Examples of assertions from contemporary Minimum Deterrence proposals regarding SSBN force survivability are listed below:

- "Today the United States can adopt a minimum deterrence strategy and draw down its nuclear arsenal to a relatively small number of survivable, reliable weapons."[29]

- "One option ... would envision the United States moving from a strategic triad of weapon systems ... to a strategic dyad of SLBMs and bombs. This likely would prove more cost-effective than the current arrangement and would provide latitude for the United States to address threats to national and international security that are less amenable to nuclear deterrence. ... Barring an unforeseen technical surprise, SLBMs always have been the most robust of the triad legs. Let them remain so."[30]

- " [I]f, for example, the United States maintained two submarines at sea, each armed with 24 missiles carrying three warheads each, that should be enough to ensure survivability. This approach might require four submarines, of which two would be in port or undergoing retrofitting at any given time. ... there is no reason to maintain a full triad of

[27] Gen. (Ret.) James Cartwright, Chair, *Global Zero U.S. Nuclear Posture Commission Report*, May 2012, pp. 12-13.

[28] Hans Kristensen, *Trimming Nuclear Excess*, Special Report, No. 5 (Washington, D.C.: Federation of American Scientists, December 2012), p. 30.

[29] Forsyth Jr., et al., "Remembrance of Things Past," op. cit., p. 82.

[30] Jeff Richardson, "Shifting from a Nuclear Triad to a Nuclear Dyad," *The Bulletin of the Atomic Scientists*, Vol. 65, No. 5, September / October 2009, pp. 37, 39.

forces. The high degree of redundancy in current forces is unnecessary for deterrence. "[31]

- "To eliminate the need to ever make a decision to launch nuclear weapons before the situation is completely clear, the bulk of U.S. nuclear forces should be deployed at sea, where they are invulnerable while on patrol and could ride out any attack."[32]

- "If we look for guidance from other nations, such as Great Britain, that have trimmed their nuclear arsenals over the years, it appears SLBMs will be the weapons system of choice. The primary advantage of the SLBM force is its likely survivability from a surprise first strike. "[33]

- "No state now threatens the survivability of the fourteen Ohio-class submarines, each of which carries 24 Trident II D-5 SLBMs ... The current plan is to replace these with 12 of the next generation SSBN. Given present Russian and Chinese ASW capabilities and their limited efforts to improve them, threats to the survivability of U.S. SSBNs at sea remain a distant prospect. ... A submarine monad puts all deterrent eggs in one basket, they say, and thus might cease to deter due to a technical failure or an adversary's ASW breakthrough. Neither worry is convincing. ... Our proposed monad would actually store the proverbial eggs in at least a dozen, mostly well-hidden baskets. "[34]

- "A submarine-based monad, along with conventional capability, can provide all the deterrence we need, and save roughly $20 billion a year."[35]

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[31] Bruce G. Blair *et al*, *Toward True Security*, Union of Concerned Scientists, February 2008, pp. 19-20, available at: http://www.ucsusa.org/assets/documents/nwgs /toward-true-security.pdf.

[32] Ivo Daalder and Jan Lodal, "The Logic of Zero: Toward a World Without Nuclear Weapons," *Foreign Affairs*, Volume 87, No. 6, November / December 2008, p. 85.

[33] David J. Baylor, "Considerations for a US Nuclear Force Structure below a 1,000-Warhead Limit," *Strategic Studies Quarterly*, Summer 2011, Vol. 5, No. 2, p. 67.

[34] Benjamin H. Friedman, Christopher Preble, and Matt Fay, "The End of Overkill? Reassessing U.S. Nuclear Weapons Policy," Cato Institute, 2013, p. 14, available at: http://object.cato.org/sites/cato.org/files/pubs/pdf/the_end_of_overkill_wp_ web.pdf.

[35] Ibid., p. 19.

- "A submarine-based monad is more than sufficient for America's deterrence needs, and would be considerably less expensive to modernize and maintain than the current force."[36]

For these Minimum Deterrence proposals, the heavy emphasis on a small number of SSBNs clearly is based on the expectation of their invulnerability. For example: "The submarine force would offer a high degree of survivability for many decades—no peer competitor currently has any effective anti-submarine warfare capability against US SSBNs at sea and technological breakthroughs that could threaten this survivability are several decades away."[37]

To be precise, not every Minimum Deterrence proposal places heavy reliance on SSBNs. One proposal, for example, endorses a nuclear force composed of 200 ICBMs, 250 gravity bombs for bombers, and no SSBNs. For this outlier among Minimum Deterrence proposals, the rational given for eliminating SSBNs is: "Due to their offensive and overt nature, we consider nuclear-armed SSBNs to be incompatible with a minimal deterrence posture and an obstacle to transparency and verification. Under our scenario, the SSBN force would gradually be reduced and retired by 2025, which would also greatly simplify the nuclear command and control system."[38] This Minimum Deterrence proposal to eliminate the SSBN leg of the triad is a distinct minority among contemporary Minimum Deterrence proposals. The overwhelming majority of proposals call for a small nuclear force with all or most weapons based on SSBNs. These proposals are based on the common assumption of SSBN invulnerability.

The Importance of Assured SSBN Invulnerability in the Minimum Deterrence Narrative. The assertion that SSBNs at sea will be survivable for the foreseeable future provides an important link in the Minimum Deterrence narrative. In general, that narrative leads to proposals for a small U.S. nuclear force following logically from a series of assertions or premises. Key

[36] Christopher Preble and Matt Fay, "To Save the Submarines, Eliminate ICBMs and Bombers," DefenseOne.com, October 14, 2013, available at: http://www.defenseone.com/ideas/2013/10/save-submarines-eliminate-icmbs-and-bombers/71879/?oref=d-interstitial-continue.

[37] Forsyth Jr., et al., "Remembrance of Things Past," op. cit., p. 7.

[38] Hans M. Kristensen, Robert S. Norris, Ivan Oelrich, *From Counterforce to Minimal Deterrence: A New Nuclear Policy on the Path Toward Eliminating Nuclear Weapons*, Federation of American Scientists and the National Resources Defense Council, Washington, D.C., April 2009, pp. 43-44, http://www.fas.org/pubs/_docs/ Occasional Paper7.pdf.

premises from most Minimum Deterrence proposals that call for basing all or most nuclear weapons on SSBNs include the following:

1. Nuclear deterrence considerations no longer are pertinent to U.S. relations with Russia and China.
2. For situations for which deterrence might be relevant, deterrence will function reliably and predictably at low U.S. nuclear force numbers, now and in the future.
3. Deterrence considerations alone determine the size and composition of the nuclear force.
4. SSBNs are invulnerable when at sea. And,
5. SSBNs can provide the basing mode for all or most of the small nuclear force needed.[39]

As can be seen by this purported logic trail, the premise that SSBNs are now and will remain invulnerable is a critical link to recommendations that Minimum Deterrence forces should be based primarily on SSBNs. This enables advocates of Minimum Deterrence to then recommend the elimination of the ICBM leg of the triad, the bomber leg, or both. This in turn leads to claims of large cost savings from the elimination of those forces. These issues were discussed briefly in the 2013 NIPP report *Minimum Deterrence: Examining the Evidence.* The issue of future SSBN invulnerability when at sea is examined in greater detail in this report.

As discussed earlier, the premise that U.S. SSBNs will remain invulnerable for many decades provides a convenient solution for basing a small number of nuclear weapons at sea in order to provide an assured second-strike capability. This Minimum Deterrence premise and the potential implications that follow are examined below in three ways.

1. Is there evidence to support or refute the premise of continued SSBN survivability for the foreseeable future?

2. If this premise proves unreliable and, at some point in the future U.S. SSBNs at sea are no longer invulnerable, what would be the implications for the United States? What actions would be needed to mitigate potential dangers? And,

3. Are there identifiable limitations or drawbacks associated with a nuclear force composed entirely or almost entirely of a small number of SSBNs?

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[39] For a complete list of common Minimum Deterrence claims, see Keith B. Payne and James Schlesinger, *Minimum Deterrence: Examining the Evidence* (Fairfax, VA: National Institute Press, 2013), pp. xiii-xix.

Future SSBN Invulnerability: How Confident?

Is the common Minimum Deterrence premise of future SSBN invulnerability defendable by empirical evidence and logic? Of the Minimum Deterrence proposals examined, in all but one case, proponents that asserted this premise do not provide justification for that planning assumption. In one of the very few reports that acknowledges that SSBN survivability might not be assured in the distant future, that acknowledgement is offered only in a footnote. The report asserts that the day-to-day force of SSBNs at sea "would be survivable under worst case conditions and versatile in providing prodigious target coverage of all prospective nuclear-armed aggressors."[40] A footnote provides the following qualification:

> There are potential threats on the distant horizon (30-50 years in future) that could dramatically alter this prognosis. Foremost among them is the prospect that sophisticated sensors coupled to supercomputing with advanced data filtering could strip away enough of the ocean's masking characteristics to expose the submerged boats.[41]

However, the planned service life of the next-generation SSBNs extends well beyond the 30-50 year "distant horizon" referred to by this proposal. And, neither that report nor others address the potential risks in the future or actions the United States would have to take to respond to technical advances by adversaries that invalidate the SSBN survivability premise.

Another proposal which recommends abandoning the nuclear triad in favor of a SSBN monad—or possible a dyad composed of SSBNs and some ICBMs—totally dismissed any concern that U.S. SSBNs might not be survivable. The proposal asserted that the United States could rely heavily, almost exclusively, on SSBNs and not worry about survivability. According to its authors:

> ".. hawks have been warning about future U.S. SSBNs' vulnerability to enemy forces since the 1960s, and it has not yet arrived. Moreover, the effort needed to achieve such technological progress is unlikely to be instant or unknown to U.S. intelligence. The United States would have time to adjust, if need be, by restoring another triad leg. If that case for the survivability of the SSBN fleet fails to allay concerns about its ability to deter, there are cheaper alternatives than fully maintaining a second triad leg. A small number of nuclear-armed cruise missiles or aircraft-deployable gravity bombs could be

[40] Cartwright, et al., *Global Zero U.S. Nuclear Posture Commission Report*, op. cit., p. 9.
[41] Ibid., p. 7.

maintained in secret locations at relatively low cost. That step would hedge against hypothetical trouble with SSBNs.[42]

Therefore, it is important to begin the examination of the SSBN invulnerability premise by stating that Minimum Deterrence proponents that assert the continued invulnerability of U.S. SSBNs in the future do so without explaining in any detail the basis for that key assumption. The technical details of this topic are appropriately highly classified. Still, several useful points can be gleaned from open sources and are worth including here.

First, as mentioned earlier, *Ohio*-Class Replacement SSBNs are currently slated to enter service in 2031 and to remain in service until about 2080. Given that the first *Ohio*-class replacement SSBN will not enter service for more than 15 years and is expected to be in operational service for about half a century, no confident predictions about possible technology breakthroughs and operational tactics involving ASW can be credible over a 65-year timeframe.

Second, concern over SSBN survivability in the future is not without merit. U.S. Navy officials have made public statements cautioning that the future survivability of undersea forces should not be taken for granted. For example, in 2012 the Chief of Naval Operations, Admiral Jonathan W. Greenert, said, "The rapid expansion of computing power also ushers in new sensors and methods that will make stealth and its advantages increasingly difficult to maintain above and below the water."[43] The Navy's Director of Submarine Warfare, Rear Admiral Barry Bruner, echoed this concern: "The threat is not so much from traditional sonar as from 'non-acoustic' systems, like magnetic detectors that can find the metal hull or satellites that can peer below the surface of the water."[44] As illustrated here, senior Navy leaders are alert to the potential of new developments that could threaten the ability of U.S. submarines at sea to be undetected. Senior naval officers do not appear to share the confidence expressed in the Minimum Deterrence proposal, quoted earlier, that the United States would have adequate intelligence and warning to

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[42] Benjamin H. Friedman, Christopher Preble, and Matt Fay, "The End of Overkill? Reassessing U.S. Nuclear Weapons Policy," Cato Institute, 2013, p. 14, available at http://object.cato.org/sites/cato.org/files/pubs/pdf/the_end_of_overkill_wp_ web.pdf.

[43] Adm. Jonathan W. Greenert, U.S. Navy, "Payloads Over Platforms: Charting a New Course," *U.S. Naval Institute Proceedings*, Vol. 138/7/1,313, July 2012.

[44] As reported by Sydney J. Freedberg, Jr., "Navy Fears Pentagon Neglects New Missile Sub; SSBN(X) Must Survive Almost 80 Years," October 18, 2012, http://defense.aol.com/2012/10/18/navy-fears-pentagon-neglects-new-missile-sub-ssbn-x-must-survi/.

devise countermeasures to such developments, and "cheaper alternatives" to SSBNs are readily available.[45]

Potential for Increased Threats to SSBNs. Theoretically, a variety of signatures from submerged, nuclear-powered submarines could be detectable by a technologically sophisticated adversary. A cursory review of conference papers from professional gatherings, such as the OCEANS 2010 conference[46] hosted by IEEE, reveals a wealth of ongoing research associated with the undersea domain. For example, signals that could potentially be detected, even in the complex underwater environment, include:

- Infrared emissions from the submarine and reactor that are at temperatures warmer than the ambient environment;
- Slight perturbations in the local gravitational, magnetic, and electric fields from the massive, moving SSBN;[47]
- Acoustic wave and other wake detection phenomena generated by the submarine's velocity and propeller motion;
- Faint acoustic signatures recorded by nearby hydrophones and SOSUS-like networks that perhaps include autonomous, long-dwell time undersea gliders[48] and wireless communications relays;[49]
- Use of multisensor detector fields that collect several types of environmental data that is communicated to remote sites for processing by high performance computers in order to detect signatures that correlate with the presence of a moving, nuclear-powered submarine.[50]

The examples listed above are not the product of an analysis of the most promising technologies for submarine detection—that is beyond the scope of this discussion. The point is that several types of signatures from submerged, moving submarines exist that could be detectable through

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[45] Friedman et. al, "The End of Overkill? Reassessing U.S. Nuclear Weapons Policy," op.cit., p. 14.

[46] For example, a summary of topics presented at the OCEAN 2010 Conference in Washington, DC in September 2010 can be found at: http://ieeexplore.ieee.org/xpl/mostRecentIssue.jsp?punumber=5651400.

[47] H. Sakaguchi, "Magneto-gravitational separation and magneto-gravitational chromatography - fundamental concepts and some examples," *IEEE Transactions on Applied Superconductivity*, Vol. 14; Issue 2, 2004, pp. 1547-1550. http://ieeexplore.ieee.org/xpl/articleDetails.jsp?tp=&arnumber=1325094&queryText%3Dgravitational.

[48] B.G. Ferguson, K.W. Lo, and J.D. Rodgers, "Sensing the underwater acoustic environment with a single hydrophone onboard an undersea glider," Conference Oceans 2010, IEEE Conference Proceedings, http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=5603889&refinements%3D4276766119%26sortType%3Dasc_p_Sequence%26filter%3DAND%28p_IS_Number%3A5603506%29.

[49] John Heidemann, Milica, and Michele Zorzi, " Underwater sensor networks: applications, advances and challenges," Philosophical Transactions of the Royal Society, 2012, Vol. 370, pp. 158-175.

[50] Committee on Distributed Remote Sensing for Naval Undersea Warfare, National Research Council, Distributed Remote Sensing for Naval Undersea Warfare: Abbreviated Version, p. 4.

sophisticated filtering algorithms, perhaps by using multiple sensors and signal processing by high performance computers at remote locations. Of course, detection is only one aspect of the hypothetical kill chain associated with any substantive threat to U.S. SSBNs.

A 2007 report from the National Research Council's (NRC) Committee on Distributed Remote Sensing for Naval Undersea Warfare concluded that "some selective short-term and many long-term opportunities [exist] to develop useful naval systems."[51] For U.S. applications, the committee recommended that the Navy focus on a limited number of pressing problems because the "design space" was so complex. The NRC report is insightful in that it identifies the many discrete tasks that an adversary would need address to develop an effective operational system for undersea warfare. Those challenges include the technologies and operational procedures for the following tasks:

- Cueing of sensors;
- Detection and classification;
- Communications and the power requirements for the transmission of large amounts of data;
- Distributed network controls to optimize sensor location;
- Rules of engagement; and,
- For effective attacks on U.S. SSBNs, the ability to attack multiple submarines at sea in a near simultaneous manner.[52]

The 2007 NRC report documents the complexity of detecting, classifying, and tracking objects in the undersea environment. However, the publicly released report was an abbreviated version of the committee's findings. Because of the sensitive nature of the subject, "[i]t was mutually determined by the Department of the Navy and the National Research Council that the full report contained information ... [that] could not be released to the public in its entirety."[53] This implies that the NRC study team identified some technologies that have the potential for militarily useful applications.

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[51] Ibid., p. 2.

[52] Ibid., pp. 3-4. Note: the last point in the list was not included in the NRC report which was limited to U.S. applications.

[53] Ibid., pp. *xi-xii*.

Staying Ahead of Adversaries. To help guard against being surprised by adversary developments that could threaten SSBNs at sea, the Navy is investing approximately $35M[54] per year to explore technologies related to SSBN security and to understand what capabilities others might be able to develop. The SSBN Security Program, mentioned earlier, exists to try and determine what technology developments and operational concepts might be possible to detect, track, and destroy submarines at sea. The objective is to implement countermeasures or other corrective actions as early as possible in order to stay ahead of any potential threat and protect the survivability of SSBNs (and other submarines) when at sea.

The SSBN Security Program was recently cited by the National Research Council's Naval Studies Board (NSB) as a positive example of efforts to anticipate "capability surprise." The NSB study[55] was initiated in response to a request from the Chief of Naval Operations, ADM Jonathan W. Greenert. He asked the NSB to examine the issues surrounding "capability surprise," both operational and technical, facing U.S. naval forces. The NSB concluded that "[c]apability surprise is both inevitable and inherently complex, and it requires U.S. naval forces to engage in a broad spectrum of issues, from horizon scanning to red teaming to experimentation and rapid prototyping, to exercising, fielding, and training." The NSB recommended that future weapon delivery systems be designed to facilitate resilience "to include the capacity for quickly adding or modifying capability." The report also cautioned against complacency stating that the force will likely need to adapt in ways that cannot currently be envisioned.[56]

The Navy's SSBN Security Program is one of three exemplar programs cited by the NSB report for its forward-looking focus on future ASW-related technologies and steps the United States could take to avoid or mitigate capability surprise. The report stated,

> The methodology for assessing and responding to surprise that is used by the SSBN security red team serves as an excellent representative approach ... for evaluating vulnerabilities in large programs of record. As an independent group that seeks to

[54] Navy Budget Item Justification: http://www.dtic.mil/descriptivesum/Y2013/Navy/stamped/0101224N_7_PB_2013.pdf.

[55] Jerry A. Krill and J. Paul Reason, Co-chairs, Committee on Capability Surprise on U.S. Naval Forces, "Responding to Capability Surprise: A Strategy for U.S. Naval Forces, Report of the Committee on Capability Surprise on U.S. Naval Forces," Naval Studies Board, Division on Engineering and Physical Sciences (Washington, D.C.: The National Academy Press, 2013).

[56] Ibid., pp. 3, 5, and 72-73.

> challenge the organization in order to improve effectiveness, the SSBN Security program leverages simulation, modeling, and analysis to assess risks to submarine security and recommends mitigation strategies.[57]

Military technology is not static. Potential adversaries are involved in intelligence gathering on U.S. SSBN operations[58] and are working to improve their undersea warfare capabilities. Just a decade ago China's undersea capabilities were regarded as rudimentary. Recently, however, observers have been surprised by the rapid progress that China is making in submarine design, production, and undersea technologies. According to a 2009 report from the Naval War College, "After a lengthy hiatus—lasting nearly six centuries—China is reemerging as a maritime power, this time with an emphasis on undersea warfare." The evidence cited for this assertion includes the following:

- Between 1995 and 2007, China placed 38 submarines into service.[59] While these submarines may not be as technologically advanced as are their U.S. counterparts, the rapid pace of submarine development and production is impressive.[60]
- China has begin installing sensitive hydrophones on the floor of the China Seas in an effort to detect and track submarines belonging to the U.S. and its allies. According to naval analysts, the announcement of China's "fixed ocean-floor acoustic array" was "most startling" and evidence that Beijing has begin to take seriously the incredible destructive power of enemy submarines—especially American ones.[61]

Analysts attribute these recent developments to the massive Chinese military-industrial complex that has begun focusing on "the great importance of ASW."[62] Yet, U.S. ASW analysts conclude, "Despite the rapid progress that China is making in submarine logistics, it has a long way to go before it can match the capability of western navies. The gap is very wide." These same

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[57] Ibid., pp. 21 and 44.

[58] Bill Gertz, "Pentagon: Russian Spy Ship, Tug Operating Near U.S., Ships Near Nuclear Submarine Base at Kings Bay, GA," http://freebeacon.com/national-security/pentagon-russian-spy-ship-tug-operating-near-u-s/.

[59] Andrew F. Krepinevich, *Why AirSea Battle?* (Washington, D.C.: Center for Strategic and Budgetary Assessments, 2010), p. 22.

[60] Andrew S. Erickson, Lyle J. Goldstein, and William S. Murray, *Chinese Mine Warfare: A PLA Navy 'Assassin's Mace' Capability*, Report by the China Maritime Studies Institute, Naval War College, Newport, RI, 2009, p. 1.

[61] Lyle Goldstein and Shannon Knight, "Wired for Sound in the 'Near Seas'," U.S. Naval Institute *Proceedings*, April 2014, pp. 56-61. Also see, David Axe, "China Has Begun Listening for American Submarines," https://medium.com/war-is-boring/448f7e04bbe1.

[62] Lyle Goldstein and Shannon Knight, "Wired for Sound in the 'Near Seas'," op.cit., pp. 56-61.

analysts also note that none of the relevant submarine and ASW capabilities "really existed in China until just a decade ago; since then, China has been making ever-more-rapid gains." And, "If the current pace of reform and steady improvements is merely sustained, China will have one of the world's leading undersea forces within one to two decades."[63]

As of this writing, it appears that Chinese ASW efforts are focused primarily on defensive missions to protect Chinese forces, including China's emerging SSBN capability, in the "near seas."[64] However, in the decades ahead China may very well pursue technology and operational capabilities for offensive undersea missions in more distant waters.

Russia also is apparently recovering from its post-Cold War stasis in undersea warfare technology development. Russian submarine development and construction, for example, appears to be accelerating. One new type of Russian submarine, the Varshavyanka-class Novorossiysk, is reported to be an extremely quiet diesel-electric design—an improved version of the older Kilo-class. Another, the Borei-class SSBN, is powered by a newly-designed nuclear reactor, will carry 20 SLBMs, and can dive deeper than 1,200 feet.[65] Also, the K-329 Severodvinsk, the first of Russia's Yasen-class nuclear attack submarine and successor to the Akula-class, has finally been inducted into Russia's Northern Fleet.[66]

As potential adversaries such as Russia and China pursue new technologies and operational concepts to confront U.S. military strengths, declining U.S. defense budgets and growing personnel costs will likely constrain the ability of the United States to anticipate and respond promptly. In January 2014, a senior DoD acquisition official testified before the House Armed Services Committee on this issue. He concluded, "First and foremost, from the perspective of technological superiority, the Department of Defense is being challenged in ways I have not seen for many years. Second, our ability within the Department to respond to that challenge is

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[63] Lyle Goldstein and Shannon Knight, "Sub Force Rising," U.S. Naval Institute *Proceedings*, April 2013, p. 44.
[64] Ibid.
[65] "Silent Sub: Russian Noiseless Borei Class Nuclear Submarine Immersed," RT.com news, December 30, 2012, http://rt.com/news/russian-noiseless-borei-submarine-106/ Also see: http://www.naval-technology.com/projects/borei-class/.
[66] "Russian Navy Welcomes Most Advanced Nuclear-Powered Attack Sub, rt.com news, June 17, 2014. http://rt.com/news/166480-yasen-class-submarine-severodvinsk/ Also, http://rt.com/news/russia-severodvinsk-nuclear-submarine-036/.

severely limited by the current budget situation."[67] In August 2014, this same DoD official spoke to U.S. industry executives. His remarks included a plea for innovation:

> We've been complacent. ... Our technological superiority is very much at risk, there are people designing systems [specifically] to defeat us in a very thoughtful and strategic way, and we've got to wake up, frankly.[68]

Decreased U.S. Emphasis on ASW after the end of the Cold War. Early in the post-Cold War era, the United States reduced the priority afforded to undersea warfare. One former career submariner referred to this reprioritization as "an ill-advised post-Cold War lapse in attention."[69] At the time, it may have made sense to reduce funding for ASW technologies and training and to divert shrinking defense dollars to other priorities. Today, however, potential adversaries are devoting considerable resources to undersea technologies and warfare. As recently as early 2013, naval officers were writing about the need to reclaim dominance in undersea warfare. for example, in January 2013, one naval officer stated that the United States needs to find a solution of its ASW "proficiency gap" and provide junior officers with "a deeper understanding of ASW fundamentals and tactics."[70] In May 2014, Aviation Week military technology analyst Bill Sweetman wrote about advances in submarine quieting and detection by other countries. Regarding the United States, Sweetman wrote, "Antisubmarine warfare (ASW) has not stagnated, but it shows signs of disarray."[71]

In addition, new technologies that enable the detection of submarines may emerge from unexpected sources. For example, Chief of Naval Operations Jonathan Greenert reportedly asked the Strategic Studies Group at the Naval War College to focus on challenges associated with undersea warfare. Greenert cautioned, "A growing number of nations are developing capabilities to find and defeat submarines and exploit the undersea domain for their own purposes. At the same time, commercial and academic interests are monitoring and exploring

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[67] Frank Kendall, Under Secretary of Defense, Acquisition, Technology, and Logistics, prepared statement before the House Armed Services Committee, January 28, 2014, p. 4.

[68] As reported by Sydney J. Freedberg, Jr., "'We've Got To Wake Up': Frank Kendall Calls for Defense Innovation," August 6, 2014, http://breakingdefense.com/2014/08/weve-got-to-wake-up-frank-kendall-calls-for-defense-innovation/.

[69] James H. Patton,, Jr., "Submarines Have Special Connectivity Needs," U.S. Navel Institute *Proceedings*, June 2010, p. 77.

[70] Stephen J. Coughlin, "Reclaiming Antisubmarine Dominance," U.S. Navel Institute *Proceedings*, January 2013, p. 40.

[71] Bill Sweetman, "Silence is Not Golden," Aviation Week & Space Technology, May 12, 2014, p. 15.

the undersea domain to unprecedented degrees."[72] The possibility exists that the myriad activities underway in other countries, possibly aided by developments from commercial and academic enterprises and enabled by high performance computing, might result in some unforeseen breakthrough for detecting submarines at sea.

Other Concerns Regarding The Assumption of Future SSBN Survivability. A variety of other issues are pertinent regarding the common Minimum Deterrence premise of assured SSBN invulnerability. These concerns involve the geography of SSBN bases, the ability of future SSBNs to survive if they are detected, and the need for assured connectivity to SSBNs when at sea.

Geography. The United States currently has only two SSBN bases—one on each coast. Deployment of SSBNs involves the transit on the surface of narrow channels for egress and return. While this geography for U.S. SSBN bases is helpful for implementing defensive measures, it also makes SSBN deployments highly visible and the initial egress path somewhat predictable for observant adversaries.

Limited self-defense capabilities. Plans for *Ohio*-class Replacement SSBNs appear to rely primarily on quieting and other stealthy features for survivability. Previous generations of U.S. SSBNs were designed as multi-mission submarines. That meant they were fully outfitted with both sensors and weapons to perform as attack submarines as well as ballistic missile platforms. However, the *Ohio*-class replacement submarines, despite being the Navy's top priority, is not being designed for multiple missions. According to the Navy's program executive for the new SSBN, "This is a single function submarine that does strategic deterrence."[73] This means that sensors and a weapons complement that would equip the submarine for an attack role will not be included fully in the sub's design. According to a July 2014 report by the Congressional Research Service on the Ohio-class replacement SSBN program, "the Navy is investing heavily in an electric-drive propulsion train, as opposed to the mechanical-drive propulsion train used on other Navy submarines. The electric-drive system is expected to be quieter than a mechanical-

[72] Vice Admiral Michael J. Connor, U.S. Navy, Commander, Submarine Force, U.S. Atlantic Fleet, U.S. Naval Institute *Proceedings*, June 2013, p. 25.

[73] Kris Osborn, "Ohio Replacement Submarine Starts Early Construction," October 24, 2013, http://defensetech.org/2013/10/24/ohio-replacement-submarine-starts-early-construction/.

drive system."[74] Improving quieting for propulsion and other features for stealthiness seems appropriate. However, if these submarines are detected and have to fight to survive, cutting back on offensive features may prove costly.

Connectivity/Assured Communications. ICBMs have been valued because of the assured connectivity and prompt communications channels between the president and these weapon systems. In contrast, SSBNs must rely on the accurate receipt of securely transmitted messages when at sea and submerged. If an adversary devised methods to interfere with and prevent receipt of secure messages transmitted to SSBNs at sea, the timely and accurate receipt of orders to deployed SSBNs would be in question. After the end of the Cold War, the United States scaled back its nuclear command and control systems and dismantled completely some backup communications capabilities, such as the Extremely Low Frequency Communications System designed for deployed SSBNs. For its general purpose missions, the Navy has already acknowledged that it must be able to function in a "satellite-deprived environment."[75] If SSBNs comprise most or all of the U.S. nuclear force, the United States would probably need to invest in additional nuclear command and control capabilities, in addition to the TACAMO aircraft, to ensure additional non-SATCOM connectivity with deployed SSBNs.

Implications of a Minimum Deterrence Force Composed of SSBNs That are Not Invulnerable

Predictions about long-term undersea warfare capabilities appear speculative. Some naval analysts worry about future antisubmarine technology developments, while others assert that "in general warfare conditions ... the safest place will be under the waves - not on or above them."[76] It is not possible to peer into the future to determine which view is correct. Given this uncertainty, the United States should not willingly put itself into a position in which a single development could have extremely adverse consequences.

The prospect of the future vulnerability of U.S. SSBNs and the kinds of actions needed (and available) to the United States in that event are not addressed in detail by Minimum Deterrence

[74] Ronald O'Rourke, "Navy Ohio Replacement (SSBN[X]) Ballistic Missile Submarine Program: Background and Issues for Congress, Congressional Research Service," July 18, 2014, p. 13.

[75] James H. Patton, Jr., "The Submarine's Role in Reprioritizing Antisubmarine Warfare Tasks," U.S. Naval Institute *Proceedings*, June 2012, p. 78.

[76] Victor L. Vescovo, "Deterring the Dragon ... From (Under) the Sea," U.S. Naval Institute *Proceedings*, February 2014, p. 53.

advocates. Surely recommendations for a topic as important as the survivability of the nuclear force should include contingency plans that could be initiated to respond to evidence that the SSBN invulnerability premise is no longer valid. The discussion that follows, considers the implications of such a situation. What types of actions would be needed? What would be possible in a short time span?

If typical Minimum Deterrence recommendations were implemented and most U.S. nuclear weapons were based on SSBNs, an adversary of the United States might be determined to develop methods to be able to detect and track submarines at sea. If successful in developing such a capability, the prospect of destroying or neutralizing the entire U.S. nuclear force could appear feasible.

Take for example the proposed Minimum Deterrence nuclear force structure that consists of only ten SSBNs and ten nuclear capable B-2 bombers.[77] Support bases for submarines and heavy bombers for this force would be limited to, at most, three sites—one or two SSBN bases and a single B-2 air base. If the small number of SSBNs at sea could be destroyed or neutralized by an adversary, the remaining U.S. nuclear force could be destroyed, or at least incapacitated, by a small attack with nuclear or even conventional weapons on these three bases. For an attack designed to deliver two nuclear warheads to each base, only six warheads would be required. Even an attack with chemical or other weapons could immobilize U.S. nuclear forces at these three bases for a significant period of time. As illustrated by this example, if the U.S. nuclear force was reduced to one of the proposed SSBN-heavy force postures, enemy planning for a disarming first strike on the United States could be greatly simplified—perhaps with potentially adverse consequences for deterrence.

In contrast, for an adversary to try and destroy the strategic nuclear forces that are part of a more diverse nuclear force posture, such as that currently planned by the United States under the New START Treaty, a much more complex nuclear strike would be required. A 2014 RAND report considered ICBM survivability versus Russian nuclear forces. In order to achieve a fairly high probability (e.g., approximately ninety percent) of damaging each U.S. ICBM silo and launch control facility, two Russian ICBMs or SLBMs would have to be targeted against each. The study concluded that to attack just the U.S. ICBM force "more than 900 Russian RVs are required of an

[77] Cartwright, et al., *Global Zero U.S. Nuclear Posture Commission Report*, op.cit., pp. 12-13.

attacker."[78] No matter how well planned the attack, and even if U.S. SSBNs at sea could be destroyed or neutralized, the adversary could expect about 50 silo-based ICBMs to survive and to provide a reasonably significant nuclear response. This analysis contrasts starkly with the Minimum Deterrence force for which only six warheads would be needed for a two-on-one disarming attack on the three bases for SSBNs and bombers.

Restoring Survivability. If future adversary developments negate the stealthiness of *Ohio*-class replacement SSBNs and put those boats at risk, a crash program would likely have to be initiated to quickly restore survivability for a portion of the U.S. nuclear force. Relatively short-term options available to the United States would include implementing a bastion[79] defensive strategy for SSBNs[80] or returning some number of bombers to alert status.

Longer-term options would include designing and building a new generation of SSBNs with improved stealth characteristics and more robust self-defense capabilities, designing and deploying mobile ICBMs as a replacement for, or to augment, silo-based missiles, and developing long-range, nuclear-armed, sea-launched missiles that could be deployed and launched from ships and submarines. Crash development programs would be extremely expensive and may involve considerable risk.

Another concern would be over the timeliness of an effective U.S. response. The ability to implement a timely response would depend upon the readiness of the industrial base. The 2009 report of the bipartisan Strategic Posture Commission expressed concern that "the infrastructure that supports two thirds of the strategic deterrent triad—the SLBMs and ICBMs—is not being sustained. There are no new missile production programs planned for more than a decade ..."[81] If recommendations by Minimum Deterrence advocates are implemented, some existing nuclear modernization programs would be eliminated. As a result, the readiness of the supporting infrastructure for strategic weapon systems would be even less capable of responding to new

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[78] RAND, *The Future of the U.S. Intercontinental Ballistic Missile Force*, op.cit., pp. 31-32.

[79] A bastion strategy for SSBNs would involve limiting SSBNs deployments to the close proximity of the continental United States where they could be protected by SSNs and other U.S. capabilities. One extreme version of a bastion involves deploying SSBNs in the Great Lakes.

[80] Michael J. Dobbs, "The Incredible Shrinking SSBN(X)," op.cit., pp. 38-39.

[81] William J. Perry, Chairman, and James R. Schlesinger, Vice-Chairman, America's Strategic Posture: The Final Report of the Congressional Commission on the Strategic Posture of the United States (Washington, D.C.: United States Institute of Peace Press, 2009), p. 27.

challenges; even “crash programs” to develop new types of nuclear capabilities would not produce deployable forces quickly.

In summary, for a Minimum Deterrence force composed solely or primarily of SSBNs, the implications of future developments that invalidate the SSBN invulnerability premise could be extremely serious. As explained above, an adversary’s task of destroying all U.S. nuclear forces could appear to be greatly simplified and a determined or desperate adversary may be emboldened to try to disarm the U.S. nuclear force. From a determined adversary’s perspective, the potential gains could justify the risk. In contrast, the daunting task of conducting a disarming first strike against the more diversified nuclear force, such as that planned for the New START Treaty, should certainly appear more risky to potential adversaries. Putting all or most of the nuclear eggs into SSBN baskets appears to be an imprudent plan for the future.

Concerns with a Nuclear Force Comprised Primarily of SSBNs. A variety of other issues are also of concern regarding Minimum Deterrence proposals to deploy all or most nuclear weapons on SSBNs.

Vulnerability to Single Point Reliability Failures. The consequences of a single point reliability failure that could cripple the nuclear force is, perhaps, the greatest single concern with proposals for putting all or most nuclear weapons on SSBNs. Deploying most of the nuclear force on a single type of weapon would pose a concern over the consequences of a reliability failure associated with that weapon system. For the weapon system under discussion, a high consequence reliability failure could occur in the submarine, the missile, or the nuclear warhead. System-wide failures in SLBM systems are not without precedence. For example, in the early 1960s, during routine maintenance, W47 Polaris warhead primaries were observed to have unexpected corrosion in a component of the mechanical warhead arming system. The affected warheads would have been duds. The entire stockpile of W47 warheads had to be rebuilt. Also, years later, W68 warheads on Poseidon SLBMs were found to be defective. The high explosive in the warhead primaries had decomposed beyond acceptable limits. Reliability of all W68s was suspect and the entire stockpile of W68 warheads had to be rebuilt.[82]

[82] John R. Harvey and Stefan Michalowski, “Nuclear Weapons Safety: The Case of Trident,” *Science and Global Security*, 1994, Vol. 4, p. 292.

Modern nuclear warheads are complex systems and are composed of several thousand parts, many of which are made from exotic materials. Many of the components and subassemblies can be tested in nonnuclear experiments. However, since 1992, the United States has not conducted a nuclear test that fully validates the proper end-to-end function of all system components. Relying on only one or two nuclear warheads for the entire nuclear force in the absence of nuclear testing appears to involve unwarranted risk. In addition to the added risk from the failure of warheads, the potential for systemic reliability failures within key SLBM or SSBN systems would seem to add to the potential risk. U.S. plans to life extend and maintain strategic nuclear capabilities for lengthy periods of time would seem to call of a diversity of weapons and warheads to guard against the potentially catastrophic effects from any single failure of reliability or effectiveness.

Limited Adaptability. Admiral Richard Mies (USN Ret.), a submariner and former Commander of U.S. Strategic Command has stressed the importance of being able to respond to surprises in the future. In 2012, Mies wrote, "[W]e must preserve sufficient deterrent capabilities to respond to future challenges, to provide a cushion against imperfect intelligence and technological surprises, and to provide a reconstitution capability as a hedge against unwelcome geopolitical developments."[83]

If in the future, new and different types (or a greater number) of nuclear weapons are needed to deter adversaries and assure allies, the nuclear force structure and supporting infrastructure would need be able to meet the evolving needs. Extra payload capacity (i.e., hedge capacity) of weapon delivery systems and the ability of industry to modify existing weapons and warheads could prove invaluable. Heavy reliance on only one kind of nuclear weapon, such as ballistic missiles on SSBNs, would significantly limit the options available to defense planners.

Of the three legs of the nuclear triad, SLBMs are the nuclear delivery vehicles which have the greatest constraints on the weight and volume for nuclear payloads. Bomber-delivered nuclear weapons can, in general, be heavier and larger in size than those carried by either ICBMs or SLBMs. For example, one special purpose nuclear weapon currently carried by heavy bombers is the B61-11

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[83] Adm. Richard Mies, USN (Ret.), "Strategic Deterrence in the 21st Century," *Undersea Warfare*, Spring 2012, p.18.

earth penetrating weapon (EPW). Currently, several constraints involving both carriage (i.e., weight and volume) and delivery prevent existing EPWs from being adapted to SLBMs.[84]

Adversary Motivations. If most or all of the U.S. nuclear force was deployed on SSBNs, adversaries could be highly motivated to allocate additional resources to explore technologies and procedures to detect, track, and destroy them. The potential for very high payoff here could encourage U.S. adversaries to invest heavily in technologies for anti-SSBN operations. The issue of potential game-changing adversary developments is discussed next.

Future Developments. Many technological and operational developments could occur during the lifetime of *Ohio*-class replacement submarines that puts at risk their assured survivability when at sea. For decades, the Department of Defense, led primarily by the Office of Net Assessments, has sponsored studies to better understand trends in military affairs and potential game changers.[85] A 1999 RAND research report,[86] sponsored by the Defense Advanced Research Projects Agency (DARPA), examined past revolutions in military affairs (RMAs) and provides some insights for the future. Examples discussed in the RAND report include:

- The blitzkrieg paradigm developed by Germany during the 1930s combined technology advancements with radically new military doctrine. Highly mobile armored forces, supported by tactical aircraft, rendered obsolete static defenses in prepared positions.
- The development of aircraft carriers by Britain, the United States, and Japan during the 1920s and 1930s made possible long-range aviation strikes from sea-based platforms. This led to the eventual obsolescence of naval gunfire exchanges between heavily armored battleships and cruisers.
- The development of the atomic bomb by the United States in the early 1940s made possible a new generation of incredibly destructive military capabilities. When coupled with multi-

[84] "Effects of Nuclear Earth-Penetrator and Other Weapons," *Report of the National Research Council of the National Academies* (Washington, D.C.: The National Academies Press, 2005), pp. 19-29. See also "U.S. Conventional Prompt Global Strike: Issues for 2008 and Beyond," *Report of the National Research Council of the National Academies* (Washington, D.C.: The National Academies Press, 2008), pp. S-12 and S-13.

[85] For example, see: Andrew W. Marshall, Director of Net Assessments, Office of the Secretary of Defense, "Revolutions in Military Affairs," Prepared statement for the Subcommittee on Acquisition & Technology, Senate Armed Services Committee, May 5, 1995.

[86] Richard O. Hundley, "Past Revolutions, Future Transformations: What can the history of revolutions in military affairs tell us about transforming the U.S. military" (Santa Monica, CA: RAND, 1999).

stage rockets and inertial guidance systems, a new type of extremely expensive arms race was ignited.

For skeptics who doubt that any single technology will ever be developed that turns the complex environments of the world's oceans transparent, several key findings from the RAND study should provide additional insight. Important findings include the following:

- "[A]ll successful technology-driven RMAs appear to have three common components: technology, doctrine, and organization."[87]
- "Technology-driven RMAs are usually brought about by combinations of technologies, rather than individual technologies."[88]
- "RMAs frequently bestow an enormous and immediate military advantage on the first nation to exploit them in combat."[89] And,
- "RMAs are rarely brought about by the dominant players."[90]

The obvious implication of this last finding is that dominant players can become complacent, while other less capable players may be more highly motivated to be innovative. Today, the United States is clearly the world's dominant military power. These findings provide a general warning that less capable militaries may be highly motivated to be innovative in developing technologies, doctrine, and organizing principles for asymmetric capabilities to counter core U.S. strengths.

This issue is also the focus of a recent book by human behavior researcher, Malcolm Gladwell. The book is entitled *David and Goliath: Underdogs, Misfits, and the Art of Battling Giants*.[91] This book focuses more on human behavior than on trends in military affairs, but underscores the RAND finding that innovation most often comes from the underdogs. Therefore, the challenge for the United States is to not become over-confident and base its military plans on unwarranted assumptions of continued technical superiority.

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[87] Ibid., p. 15.
[88] Ibid., p. 14.
[89] Ibid., p. 13.
[90] Ibid., p. 11.
[91] Malcolm Gladwell, *David and Goliath: Underdogs, Misfits, and the Art of Battling Giants* (New York: Little, Brown and Company, 2013).

If all of the U.S. nuclear eggs are concentrated in a few deployed SSBNs,[92] adversaries could be motivated to be extremely creative regarding anti-SSBN concepts. Each of the RMA examples cited in the RAND report were developed in two decades or less. For example, carrier-based aviation developed into an effective warfare capability in about two decades; some developments occurred over much shorter periods of time (e.g., the atomic bomb developed by the Manhattan Project).

Findings from Examining the SSBN Survivability Premise. Several factors discussed above should caution against unwarranted confidence in long-term SSBN invulnerability or concentrating U.S. nuclear capabilities in a single type of weapon delivery system. Senior U.S. leaders express caution about assuming long-term SSBN survivability. Other countries and academic/commercial interests are investing in undersea technology development for a variety of non-military applications. These technologies could also prove useful for military applications. And, history informs us of numerous examples of rapid transformations in military affairs. Taken together, the findings lead to the conclusion that the common Minimum Deterrence recommendation of deploying all or most nuclear weapons on SSBNs based on the assumption of long-term SSBN invulnerability appears to lack analytical basis and involves considerable risk. Three types of increased risk are apparent:

1. *Single point failure risk*: Perhaps the most worrisome risk would be the vulnerability of the nuclear force to a single system-wide reliability failure. A debilitating reliability failure that would have system-wide implications could occur in key SSBN systems, the SLBM, or a nuclear warhead.
2. *Adversary innovation risk*: The deployment of all or most U.S. nuclear weapons on a single type of delivery system could motivate adversaries to focus research and analysis on techniques to attack that type of weapon system. Over time, given some advancements in undersea technologies, a disarming first strike on U.S. nuclear forces could appear feasible to a determined or desperate adversary.
3. *Adaptability risk*: The flexibility and resilience of the U.S. nuclear force would be severely constrained. The ability to adapt nuclear weapon capabilities to changing needs would be limited by the weight, volume and other constraints of the SLBM design.

As noted earlier, the projected service life of Ohio-class SSBNs is expected to last until at least 2080. Clearly, there cannot be an analytical basis for claims that no adversary would be confident in

[92] Friedman et.al., "The End of Overkill? Reassessing U.S. Nuclear Weapons Policy," op.cit., p. 14

its ability to threaten U.S. SSBNs at sea between now and 2080. If Minimum Deterrence proposals are implemented, such a breakthrough capability by one or more adversaries could potentially prove catastrophic for the United States. By deploying a more diverse and adaptable nuclear force, the United States can prudently guard against any single adversary development or U.S. reliability failure being catastrophic.

Overall Conclusions and Recommendations

Today, the strategic nuclear triad provides a significant degree of diversity that makes a disarming strike on U.S. nuclear forces extremely complex. In addition, reliability risk is mitigated by not being dependent on any single type of weapon delivery system or warhead.

The difficulty of detecting and tracking SSBNs at sea and the current assessment of no serious threat to deployed SSBNs are important attributes for the SSBN leg of the triad. Navy officials seem confident of no significant threats in the near-term, but caution against complacency over the loner-term. This current state of affairs allows the United States to avoid the effort and expense of enhancing the survivability of the other legs of the triad. (Although, plans should exist for that contingency.)

Given the technical challenges and complexity of developing an operationally effective system to detect, track, and target all SSBNs at sea, there is some basis for confidence, at least in the near-term. To help guard against surprise, the Navy continues to support the SSBN Security Program which has drawn praise for its forward-looking approach.

However, *Ohio*-class replacement submarines, now in development, are not scheduled to enter operational service until 2031 and are slated to remain in service until sometime in the 2080 timeframe. Many technological and operational developments will occur during the lifetime of those submarines and some combination of developments could put at risk their survivability when at sea. Military history is replete with developments that made other military capabilities obsolete. Earlier in this report, examples were provided of developments that changed the nature of warfare in less than two decades. Therefore, there can be no confidence in long-term nuclear force planning that is based on the premise that future developments will not threaten the survivability of submarines at sea.

If the United States followed the recommendations of some Minimum Deterrence advocates and put all or most nuclear forces on SSBNs, future adversaries could be highly motivated to invest heavily in anti-submarine capabilities. In the event that some combination of technology developments and doctrinal/operational innovations result in the invalidation of the SSBN survivability premise, an adversary could find the prospect of a disarming first strike to be feasible and, perhaps, even attractive. The implications for deterrence could be severe.

Of perhaps the greatest single concern with Minimum Deterrence proposals to deploy all or most nuclear weapons on SSBNs is the potential for single-point reliability failures that could cripple the U.S. nuclear force. Should such a reliability failure occur, senior U.S. officials would likely have to initiate a crash program to restore confidence in the nuclear force. Needed corrective actions could take years to implement.

Therefore, this investigation concludes that it is not prudent for the United States to implement Minimum Deterrence proposals to deploy all or almost all of its nuclear weapons on SSBN/SLBMs. A more diversified force structure, such as that planned for the New START Treaty, provides protection against any single reliability failure as well as greater flexibility and resilience against future capability developments by adversaries. From this analysis, recommendations for the future U.S. nuclear force include the following:

- Retain a diverse nuclear force, such as a triad of nuclear forces, that includes SSBNs, to complicate planning for any enemy considering a surprise attack on U.S. nuclear forces;
- Do not foreclose the option of building additional SSBNs beyond the twelve planned for the *Ohio*-class follow-on;
- Continue to assign high priority to the SSBN Survivability program; and
- Develop contingency plans to enhance the survivability of the other legs of the strategic nuclear force in the event of technological surprise that puts at risk the deployed SSBN force.