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BASIC Backgrounder

What's next with Trident in the United States?

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Introduction

The United States and the United Kingdom are both in the process of making key decisions about the backbone of their nuclear deterrent: the Trident submarine ballistic missile system. While the United Kingdom has delayed by a few years the timetable for commencing construction to replace its Vanguard fleet,¹ the United States is moving ahead with working out plans for replacing its Ohio-class submarines.

Although the strategic nuclear submarines are a major part of the United States' nuclear forces, they comprise the sole nuclear system for the United Kingdom. Cooperation around the submarine systems is deep. Some warhead components for British Trident are manufactured in the United States,² the British submarine fleet is serviced at the Kings Bay naval base in Georgia, and the British Vanguard fleet is based upon the current Ohio-class submarines.

U.S.-U.K. collaboration over the submarines' ballistic missiles started with the Polaris Sales Agreement in 1963. This original agreement was followed by subsequent arrangements that ensured cooperation over the Trident I (C4) and II (D5) generations of submarine-launched ballistic missiles (SLBMs).³ The British and U.S. administrations exchanged letters in 2006 to extend the service life of the current Trident II (D5) missile.⁴ The United Kingdom and the United States have been working on a Common Missile Compartment (CMC) for the Vanguard and Ohio-class replacements to make certain that the new submarines will be able to carry the successor to the current Trident II missile.⁵ U.S. Navy testimony in March 2010 reaffirmed the practice, stating, "The U.S. will continue to maintain its strong strategic relationship with the U.K. for our respective follow-on platforms, based upon the Polaris Sales Agreement."⁶

As such, the developments around U.S. Trident are bound to have an impact on decisions in Britain amid the renewed debate on the like-for-like replacement of the Vanguard-class. Following a tense period of cost reviews during an economic recession, the Government came down in favor of

delaying the critical decisions surrounding Trident renewal⁷ until after the next General Election, which must occur by May 2015. Prime Minister David Cameron (Conservative) has stated that “We can extend the life of the Vanguard-class submarines so the first replacement submarine isn’t needed until 2028.”⁸ The issue of replacement was raised in part by the presence of the Liberal Democrats in the coalition government, who had pledged during the 2010 campaign to fight against renewal. Thus, Trident may loom large in the next General Election.

This briefing reviews some of the issues around the purpose of, and costs for replacing, the United States’ Ohio-class system; issues which may ultimately influence the debate in the United Kingdom.

U.S. nuclear ballistic missile submarine forces: present and future

The U.S. Navy currently maintains 14 Ohio-class nuclear powered ballistic missile submarines (“fleet ballistic missile submarines,” or SSBNs). Twelve of those submarines are deployed, with the remaining two submarines undergoing service at any one time.

The Obama Administration’s Nuclear Posture Review⁹ (NPR) committed the United States to retaining indefinitely SSBNs, deeming them to “represent the most survivable leg” of a nuclear triad that also includes long-range bombers and inter-continental ballistic missiles (ICBMs).¹⁰ The NPR concluded that the current alert posture of the strategic forces must be maintained and that keeping “a significant number of SSBNs at sea at any given time” is necessary for sustaining this posture.¹¹ The NPR set the minimum number for the fleet at 12 boats by 2020. Currently, the 12 deployed SSBNs are estimated to carry 288 Trident II (D5) SLBMs.¹² Under the New Strategic Arms Reduction Treaty (START) with Russia, the United States will eventually go down to 240 SLBMs.¹³ (Each Ohio-class submarine has 24 missile tubes.¹⁴)

U.S. SSBN (Ohio-class) in 2010

Pacific homeport: Bangor, Washington	Atlantic homeport: Kings Bay, Georgia
<i>USS Henry M. Jackson</i> , SSBN 730	<i>USS Alaska</i> , SSBN 732
<i>USS Alabama</i> , SSBN 731	<i>USS Tennessee</i> , SSBN 734
<i>USS Nevada</i> , SSBN 733	<i>USS West Virginia</i> , SSBN 736
<i>USS Pennsylvania</i> , SSBN 735	<i>USS Maryland</i> , SSBN 738
<i>USS Kentucky</i> , SSBN 737	<i>USS Rhode Island</i> , SSBN 740
<i>USS Nebraska</i> , SSBN 739	<i>USS Wyoming</i> , SSBN 742
<i>USS Maine</i> , SSBN 741	
<i>USS Louisiana</i> , SSBN 743	

Source: U.S. Navy, “Fleet Ballistic Missile Submarines,” U.S. Navy Fact File, last updated September 10, 2010, http://www.navy.mil/navydata/fact_display.asp?cid=4100&tid=200&ct=4. The United States has 12 of these submarines deployed at any one time.

Reflecting changes in U.S. strategic assessments, the United States has shifted its emphasis to the Pacific over the years, and currently with two more submarines home-ported at Bangor than at Kings Bay. While the annual number of patrols in the Atlantic has declined considerably since the end of the Cold War, the annual number of patrols in the Pacific has remained about the same, according to information obtained by the Federation of American Scientists through a Freedom of Information Act request.¹⁵

The first “retirement” of an Ohio-class submarine is scheduled for 2027¹⁶ and the Navy plans to replace the Ohio-class with new submarines starting in 2029.¹⁷ Both the Navy and Strategic Forces Command are to conclude an examination of military requirements for the new boats, currently called SSBN(X), by the end of 2011.¹⁸ The Navy

and Strategic Forces Command (Stratcom) had apparently debated how many missile tubes the SSBN(X) should carry, with the former favoring 16 missiles and the latter calling for 20.¹⁹ With 16 missiles on 12 submarines, the fleet would carry 48 fewer missiles in total.²⁰ However, the new head of Stratcom, Gen. Robert Kehler, said before a House Armed Services Strategic Forces Subcommittee hearing in March that the new submarine design will go with the 16-tube option and still meet strategic requirements 20 years from now, especially taking into account Trident's multiple warhead capability.²¹

At one point, military leaders wanted to expand the flexibility of the new fleet, by requiring it to have the ability to carry both nuclear and conventional-tipped Trident missiles, in line with the "Conventional Trident Modification" plans that would have assigned some Ohio-class submarines to Prompt Global Strike (PGS). Congress has so far rejected this initiative because of the potential for risking a deleterious response from China and Russia if they were to misinterpret a conventional, for a nuclear, threat.²² Moreover, the Navy recently indicated that it would probably limit the replacement submarines to a nuclear-only platform because of cost concerns,²³ but often there remains a preference for keeping all options open.²⁴

Deployed U.S. SLBMs and warheads (estimated, 2010)

Trident II D5 Missiles	Warhead Type	Nuclear Warheads Deployed
Mk-4	W76	568
Mk-4A	W76-1	200
Mk-5	W88	384
Total 288		1,152

Source: Robert S. Norris and Hans M. Kristensen, U.S. Nuclear Forces 2010, *Bulletin of the Atomic Scientists*, May/June 2010, p. 58; and U.S. Navy, "Fleet Ballistic Missile Submarines," U.S. Navy Fact File, last updated September 10, 2010, http://www.navy.mil/navydata/fact_display.asp?cid=4100&tid=200&ct=4.

The Defense Department's Defense Acquisition Board completed a design review of the SSBN(X) in December 2010,²⁵ seeming to favor the creation of a new design over programs that would have essentially followed the design of the current Ohio or Virginia-class submarines. The Navy announced in its press release of early February 2011 that the SSBN(X) program is on target for lead ship procurement in 2019.²⁶ The statement also said that the SSBN(X) program would "leverage the successful Virginia-class acquisition program" and affirmed that the new submarines would carry the Trident II (D5) "Life Extension" missile. The final design phase for the first SSBN(X) is to begin in 2015.²⁷

Cost of the SSBN(X) program

The Navy's preliminary cost estimates had put the average price of each new submarine at about \$6-7 billion,²⁸ with the total program estimated to reach over \$85 billion, at FY2010 levels.²⁹ Congressional Budget Office figures incorporated the inflation of shipbuilding costs, and research and development, for a program total of around \$110 billion.³⁰

U.S. Secretary of Defense Robert Gates warned a House panel in March 2010 that the costs of the SSBN(X) program could hit hard by the end of this decade, and lead to resource competition between surface and submarine fleets.³¹ Such figures can easily change depending on the requirements of the submarine, including whether it would serve as a conventional, in addition to nuclear, platform; the size of its missile tubes; and how quiet the submarine needs to be at various speeds.

If the Navy were required to remain within its anticipated budget, and without additional assistance, the SSBNs could take up almost half of its shipbuilding costs.³² However, much like U.K. Secretary of Defence Liam Fox has argued for the U.K. Trident system, some have suggested that other departments help carry the burden of replacing the Ohio-class fleet.³³ A *Congressional Research Service Report* has noted that options for reducing the cost of the SSBN(X) program and/or its effect on the Navy's budget have included:

“[P]rocurring fewer than 12 SSBN(X)s; reducing the number of submarine-launched ballistic missiles (SLBMs) to be carried by each SSBN(X); stretching out the schedule for procuring SSBN(X)s and making greater use of split funding (i.e., two-year incremental funding) in procuring them; and funding the procurement of SSBN(X)s in a part of the Department of Defense (DOD) budget that is outside the Navy’s budget.”³⁴

At least initially, the new submarines are to carry the Trident II missile.³⁵ Some have advocated changing the missile in order to save money. In April 2010, then-Chairman of the House Sea Power Subcommittee, Representative Gene Taylor (Democrat-Mississippi), criticized the Navy for the expense of the SSBN(X) program, and suggested that in order to lower the projected cost, it consider using smaller submarines that would carry missiles that are smaller than the Trident II.³⁶ But the Navy has said that it has no immediate plans to replace Trident II and has already initiated an effort to extend the lives of the missiles until 2042.³⁷

During an event at the Center for a New American Century on February 22, 2011, Under Secretary of Defense for Acquisition, Technology and Logistics, Ashton Carter, said that cost considerations have figured into the initial design decisions, and recounted how the program has moved the cost per submarine from about \$7 billion to about \$6 billion, by changing the general design requirements. The Defense Department has set a target cost of \$4.9 billion, and the Navy is to continue working toward this goal.³⁸

Issues to consider going forward

Building nuclear armed submarines is such a costly and massive undertaking that their development and construction programs have long timelines. However, projecting the threat environment into the distant future is difficult, and inclines military planners to build for worst-case scenarios as insurance against unknown threats. But the

eventual deployment of those systems will change the strategic calculations of leaders in other countries. Thus, the issues of strategy and operational planning, impact on nuclear non-proliferation and disarmament, and cost, are all intertwined.

The following could be a useful set of starter questions for consideration in the coming months as the more detailed strategic requirements are incorporated into the planning of the SSBN(X):

- To what extent are other current and emerging powers influenced by the level of U.S. commitment to the SSBNs?
- Does the emphasis on SSBNs help increase or reduce strategic stability in the post-Cold War world?³⁹
- If and when U.S. targeting plans change, could the number of required submarines and missiles be further reduced? Or would these possible reductions fall on the other legs of the nuclear triad?
- Similar to an idea floated recently in which France and the United Kingdom would share joint submarine patrols, could the United Kingdom and the United States share submarine patrols in a way that would enable them to reduce the number of submarines currently required?
- How would changes in the U.S. and U.K. SSBN programs affect their relationship with each other and the rest of NATO?
- Could the United States and the United Kingdom use their cooperation around the submarine programs, and possible changes to their fleets, in a way that bolsters their recent efforts toward the ultimate goal of a nuclear weapons-free world?
- How would changes in the submarine programs affect the defense industrial base in the United States? How difficult would it be to shift workers and other assigned resources to different projects?

Ultimately, the belt-tightening around the defense economies may tip the scale in favor of a more concerted debate about what is essential for U.S.

and U.K. nuclear forces, and this could mean change ahead for the submarine programs.

General time-frames for SSBN programs in the United States and the United Kingdom

U.S. Ohio-class and replacement	U.K. Vanguard-class and replacement
<ul style="list-style-type: none"> Commissioning: 1981-1997,⁴⁰ with first in fleet that remained SLBM-equipped: 1984.⁴¹ 	<ul style="list-style-type: none"> Commissioning: 1993-1999.⁴²
<ul style="list-style-type: none"> Estimated end of service life: first retirement: 2027; last retirement: around 2042. 	<ul style="list-style-type: none"> Estimated end of service life: beginning in 2028.
<ul style="list-style-type: none"> Replacement, SSBN (X) –Analysis of Alternatives (AoA) completed in December 2010. Technology Development Phase begun on January 10, 2011; Navy and Strategic Command to finish examination of military requirements by the end of 2011. Detailed design and “advanced procurement of critical components” in FY 2015 (calendar year October 2014-September 2015). 	<ul style="list-style-type: none"> Replacement, “Successor” - “Initial Gate” - assessment and initial design: originally planned for September 2009, delayed until some time in 2011. “Main Gate” - finalizing design, detailed acquisition plans and determining number of submarines⁴³ to commence production: pushed off until after next General Election, which must take place by May 2015.
<ul style="list-style-type: none"> Construction begins 2019. Completion of first sub by 2026, and first patrol by 2029. (Design (2015) to first deployment: 14 years.) SSBN(X) retirement: about 2080. 	<ul style="list-style-type: none"> First replacement submarine expected to enter service in 2028. (Design to deployment phases may take 14 years, but MoD has suggested it would be “imprudent to assume” this time period.⁴⁴)

For a comprehensive timeline of the SSBN replacement programs, see: Nick Ritchie, “Continuity/Change: Rethinking Options for Trident Replacement,” Bradford Disarmament Research Centre, Department of Peace Studies, University of Bradford, June 2010, pp. 95-96, <http://www.brad.ac.uk/acad/bdrc/nuclear/trident/change.pdf>.

*Thank you to David Adelman for additional research.

Notes

¹ For more information on decisions around the U.K. system, see BASIC’s webpages on: Trident Commission, <http://www.basicint.org/tridentcommission>. Although the Main gate phase for the Vanguard replacement fleet has been delayed, the Government has begun the process of purchasing material for their construction; a move that has come under some criticism. See: Nicholas Cecil, “Liam Fox risks Lib-Dem backlash with steel order for new nuclear sub,” *London Evening Standard*, February 17, 2011, <http://www.thisislondon.co.uk/standard/article-23924235-liam-fox-risks-lib-dem-backlash-with-steel-order-for-new-nuclear-sub.do>.

² Both the United States and the United Kingdom have been updating the warheads assigned to the Trident missiles. The updated version, labeled W76-1/Mk-4A in the United States, includes a new fuse that changes the capability of the weapon – according to a U.S. Department of Energy (DOE) document obtained by the Federation of American Scientists through the U.S. Freedom of Information Act. The document says the modification allows the new warhead to “take advantage of [the] higher accuracy of [the Trident] D5 missile.” (U.S. Department of Energy, Office of Defense programs, Stockpile Stewardship and Management Plan: First Annual Update (U.S. Department of Energy, Washington, DC: October 1997, 1-14), partially declassified version, obtained by Hans Kristensen of the Federation of American Scientists through the Freedom of Information Act, <http://www.fas.org/blog/ssp/images/W76ssp.pdf>. According to a FAS report, the new fuse can allow “targeteers to set the Height of Burst (HOB) more accurately and significantly improve the ability to hold hard targets at risk” (Hans Kristensen, “Administration Increases Submarine Nuclear Warhead Production Plan,” FAS Strategic Security Blog, August 30, 2007, http://www.fas.org/blog/ssp/2007/08/us_tripplis_submarine_warhead.php). Thus, the warhead’s new feature could make Trident “... capable of inflicting a disarming strike against smaller powers. That dynamic could tempt an adversary nation to launch its weapons rather than lose them” (Grossman, January 7, 2010). Reports in early 2010 suggested that the United States and the United Kingdom might also undertake the joint development of a fuse that could be used for several warheads, including for the W88 warhead used on the Trident SLBM (Elaine M. Grossman, “U.S., British Might Share Firing Device to Update Nuclear Arms,” Global Security Newswire, January 7, 2010, http://gsn.nti.org/gsn/nw_20100107_9797.php). In the United Kingdom, a decision on a replacement warhead will be postponed until 2019. The current U.K. Trident warheads are expected to remain in service until the late 2030s (Claire Taylor, “Trident After the Strategic Defence and Security Review,” House of Commons Library Standard Note, SN/IA/5757, February 23, 2011).

³ Although the U.S.-U.K. nuclear relationship started before the end of World War II, it was formalized in 1958 with the Mutual Defense Agreement (MDA). The 1963 Polaris Sales Agreement (PSA) was “amended in 1980 to facilitate purchase of the Trident I (C4) missile and again in 1982 to authorize purchase of the more advanced Trident II (D5) in place of the C4. In return, the UK agreed to formally assign its nuclear forces to the defense of NATO, except in an extreme national emergency...” (House of Commons Foreign Affairs Committee, “Global Security: UK-US Relations,” Sixth Report of Session 2009–10 Report, together with formal minutes, oral and written evidence Ordered by the House of Commons to be printed March 18, 2010, see paragraph 133, p. 46).

⁴ See House of Commons Select Committee on Defence Ninth Report, Annex 2: Exchange of letters between the Prime Minister and the President of the United States of America, December 2006, <http://www.publications.parliament.uk/pa/cm200607/cmselect/cmdfence/225/22514.htm>; and “The Future of the United Kingdom’s Nuclear Deterrent,” Presented to Parliament by The Secretary of State for Defence and The Secretary of State for Foreign and Commonwealth Affairs By Command of Her Majesty (“White paper”), December 2006, p. 31.

⁵ “CMC Program to Define Future SSBN Launchers for UK, USA,” *Defense Industry Daily*, January 8, 2011, <http://www.defenseindustrydaily.com/CMC-contract-to-Define-Future-SSBN-Launchers-for-UK-USA-05221/>.

⁶ Ronald O’Rourke, “Navy SSBN(X) Ballistic Missile Submarine Program: Background and Issues for Congress,” Congressional Research Service Report R41129, July 27, 2010, pp. 6-7.

⁷ “Securing Britain in an Age of Uncertainty: The Strategic Defence and Security Review,” Presented to Parliament by the Prime Minister by Command of Her Majesty, October 2010, http://www.direct.gov.uk/prod_consum_dg/groups/dg_digitalassets/@dg/@en/documents/digitalasset/dg_191634.pdf

⁸ Kitty Donaldson and Howard Mustoe, “U.K. Delays Decision on Trident Deterrent as it Cuts Defence Spending By 8%,” Bloomberg, October 19, 2010, <http://www.bloomberg.com/news/2010-10-19/u-k-delays-decision-on-trident-deterrent-as-it-cuts-defense-spending-8-.html>

⁹ Nuclear Posture Review Report 2010, U.S. Department of Defense, April 2010, <http://www.defense.gov/npr/docs/2010%20Nuclear%20Posture%20Review%20Report.pdf>.

¹⁰ Nuclear Posture Review Report 2010, p. 20.

¹¹ Nuclear Posture Review Report 2010, p. 27.

¹² Robert S. Norris and Hans M. Kristensen, “U.S. Nuclear Forces 2010,” *Bulletin of the Atomic Scientists*, May/June 2010, p. 64.

- ¹³ U.S. Secretary of Defense Robert Gates, Testimony before the Senate Foreign Relations Committee, May 18, 2010, <http://www.defense.gov/speeches/speech.aspx?speechid=1470>.
- ¹⁴ U.S. Navy, "Fleet Ballistic Missile Submarines," U.S. Navy Fact File, last updated September 10, 2010, http://www.navy.mil/navydata/fact_display.asp?cid=4100&tid=200&ct=4.
- ¹⁵ Estimate based upon figures from 2008 obtained by the Federation of American Scientists through the Freedom of Information Act, Hans Kristensen, "U.S. Submarine Patrols Continue at Near-Cold War Tempo," FAS Strategic Security Blog, March 16, 2010, <http://www.fas.org/blog/ssp/2009/03/usssbn.php>.
- ¹⁶ Nuclear Posture Review Report 2010, pp. 22 and 23.
- ¹⁷ Norris and Kristensen, May/June 2010, p. 64.
- ¹⁸ Elaine Grossman, "U.S. Navy Rejected Key Command's Specs for Next Nuclear-Armed Sub," Global Security Newswire, February 4, 2011, http://gsn.nti.org/gsn/nw_20110204_4436.php.
- ¹⁹ Grossman, February 4, 2011; Under the U.K. SDSR, the new Vanguard replacement will have eight operational missile tubes, instead of the originally-planned 12 (Claire Taylor, "Trident After the Strategic Defence and Security Review, February 23, 2011, House of Commons Library Standard Note: SN/IA/5757).
- ²⁰ Grossman, February 4, 2011.
- ²¹ "Military Grilled on Planned Submarine Capacity Cut," Global Security Newswire, March 15, 2011, http://gsn.nti.org/gsn/nw_20110315_1583.php.
- ²² Elaine Grossman, "Future Navy Submarine to Stick with Nuclear Mission," Global Security Newswire, August 10, 2010, http://gsn.nti.org/gsn/nw_20100810_2253.php.
- ²³ In a speech at the Capitol Hill Club, the Director of the Navy Strategic Systems Planning Office, Rear Admiral Terry Benedict said, "Right now the mission of the Ohio replacement program is nuclear strategic deterrence; we've made that clear in our discussions with both the House and the Senate. And we understand that very clearly, the direction that this is a single-mission platform" (Grossman, August 10, 2010).
- ²⁴ For a more detailed discussion about Prompt Global Strike and its potential impact on threat perceptions, and whether it could enable the reduction of emphasis on nuclear deterrence, see: M. Elaine Bunn and Vincent A. Manzo, "Conventional Prompt Global Strike: Strategic Asset or Unusable Liability?" Strategic Forum, National Defense University, February 2011, http://www.ndu.edu/inss/docUploaded/SF%20263%20Bunn_Manzo.pdf
- ²⁵ Elaine M. Grossman, "Pentagon Said Likely to Back New Design for Ballistic Missile Submarine," Global Security Newswire, December 21, 2010.
- ²⁶ Naval Sea Systems Command, U.S. Navy, Ohio Replacement Program Receives Milestone A Authority, Press Release, February 3, 2011.
- ²⁷ Director, Warfare Integration (OPNAV N8F), Office of the Chief of Naval Operations, "Report to Congress on Annual Long-Range Plan for Construction of Naval Vessels for FY 2011," February 2010, available online via the *Military Times*, <http://www.militarytimes.com/static/projects/pages/2011shipbuilding.pdf>.
- ²⁸ Ronald O'Rourke, "Navy SSBN(X) Ballistic Missile Submarine Program: Background and Issues for Congress," Congressional Research Service Report R41129, March 10, 2011, p. 12.
- ²⁹ Philip Ewing, "House panel: Navy could seek fleet funding help," *Navy Times*, January 23, 2010, http://www.navytimes.com/news/2010/01/navy_fleet_funding_012010w/.
- ³⁰ Statement of Eric J. Labs, Senior Analyst for Naval Forces and Weapons, Congressional Budget Office, "An Analysis of the Navy's Shipbuilding Plans," Testimony before the Subcommittee on Seapower and Projection Forces, Committee on Armed Services, U.S. House of Representatives, March 9, 2011, pp. 13-16, <http://www.cbo.gov/ftpdocs/120xx/doc12086/NavyShipbuilding.pdf>; Congressional Budget Office, "An Analysis of the Navy's Fiscal Year 2011 Shipbuilding Plan," May 2010, p. 16, <http://www.cbo.gov/ftpdocs/115xx/doc11527/05-25-NavyShipbuilding.pdf>.
- ³¹ Grossman, August 10, 2010.
- ³² Ewing, January 23, 2010.
- ³³ Ewing, January 23, 2010.
- ³⁴ Ronald O'Rourke, "Navy SSBN(X) Ballistic Missile Submarine Program: Background and Issues for Congress," Congressional Research Service Report R41129, March 10, 2011, "Summary."
- ³⁵ Grossman, August 10, 2010.
- ³⁶ Christopher P. Cavas, "Lawmaker Wants Key Submarine Document," *Navy Times*, April 26, 2010.

³⁷ O'Rourke, March 10, 2011, p. 3.

³⁸ Cheryl Pellerin, "Carter: 'Better Buying Power' Drives Defense Acquisitions," American Forces Press Service, February 23, 2011.

³⁹ Some consider the SSBN's flexibility and stealth capabilities to be important in maintaining stability. The SSBN(X) replacement is intended to survive past 2080, and as some have argued, its deterrent value means that if the world actually reaches near zero nuclear weapons, then the United States should ensure that its submarines are the last leg of the triad eliminated (For example, see Stephen Herzog, "Obama, Nuclear Disarmament, and Ballistic Missile Subs," *Bellum: A Project of the Stanford Review*, August 6, 2010, <http://bellum.stanfordreview.org/?p=2632>). Others hold that the submarines detract from stable security relationships and that in a world going down to zero, SSBNs should be the first leg eliminated (See Hans Kristensen, Robert S. Norris, and Ivan Oelrich, "From Counterforce to Minimal Deterrence: A New Nuclear Policy on the Path Toward Eliminating Nuclear Weapons," Occasional Paper No. 7, April 2009; and Robert D. Glasser, "Enduring Misconceptions of Strategic Stability: The Role of Nuclear Missile-Carrying Submarines," *Journal of Peace Research*, Vol. 29, No. 1, February, 1992, pp. 23-37).

⁴⁰ SSBN-726 Ohio-Class FBM Submarines, Federation of American Scientists, http://www.fas.org/programs/ssp/man/uswpns/navy/submarines/ssbn726_ohio.html

⁴¹ The Ohio-class submarines started entering service in 1981, but the four oldest submarines in the fleet were converted to guided missile submarines.

⁴² Royal Navy website, U.K. Ministry of Defence, <http://www.royalnavy.mod.uk/operations-and-support/submarine-service/ballistic-submarines-ssbn/index.htm>.

⁴³ "Securing Britain in an Age of Uncertainty: The Strategic Defence and Security Review," Presented to Parliament by the Prime Minister by Command of Her Majesty, October 2010, p. 38, http://www.direct.gov.uk/prod_consum_dg/groups/dg_digitalassets/@dg/@en/documents/digitalasset/dg_191634.pdf.

⁴⁴ Defence Select Committee, "The Future of the UK's Strategic Nuclear Deterrent: the Strategic Context: Government response to the Committee's Eighth Report of Session 2005-06, HC1558," p. 8, <http://www.publications.parliament.uk/pa/cm200506/cmselect/cmdfence/1558/1558.pdf>.

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