

CRS Report for Congress

Sea-Based Ballistic Missile Defense — Background and Issues for Congress

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Ronald O'Rourke
Specialist in Naval Affairs
Foreign Affairs, Defense, and Trade Division



Prepared for Members and
Committees of Congress

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Summary

As part of its effort to develop a global ballistic missile defense (BMD) system, the Department of Defense (DOD) has modified three Navy cruisers and 15 Navy destroyers for BMD operations, and has deployed a large BMD radar — the Sea-Based X-Band Radar (SBX) — on a modified floating oil platform. In August 2008 it was reported that the Navy has decided to increase the number of BMD-capable destroyers from 15 to at least 62. The eventual role of sea-based systems in the worldwide U.S. BMD architecture has not been determined. The overall issue for Congress discussed in this report is: What should be the role of sea-based systems in U.S. ballistic missile defense, and are DOD's programs for sea-based BMD capabilities appropriately structured and funded?

The Aegis BMD system in its current configuration is intended to track ballistic missiles of all ranges, including intercontinental ballistic missiles (ICBMs), and to intercept shorter-ranged ballistic missiles. The current configuration is not intended to intercept ICBMs. Future versions of the Aegis BMD system are to include a faster interceptor designed to intercept certain ICBMs. The Aegis BMD system has achieved 13 successful exo-atmospheric intercepts in 15 attempts. The system was also temporarily modified and used on February 20, 2008, to shoot down an inoperative U.S. surveillance satellite. Japan is acquiring the Aegis BMD system, and some other allied navies have expressed an interest in adding BMD capabilities to their ships.

For FY2009, the Missile Defense Agency (MDA) is requesting \$1,157.8 million in research and development funds for the Aegis BMD program. The program also receives some additional Navy funds.

Potential specific issues for Congress regarding sea-based BMD systems include technical risk in the Aegis BMD program, the number of Aegis BMD ships, the role of Aegis BMD in European missile defense, the number of SM-3 interceptors planned for procurement, the proposal to equip the SM-3 Block IIA missile with a Multiple Kill Vehicle (MKV), whether development a far-term sea-based terminal-defense BMD capability should be accelerated, the potential role of the Kinetic Energy Interceptor (KEI) in sea-based BMD operations, procurement of the planned CG(X) cruiser, development and testing of the Aegis BMD system, and potential allied sea-based BMD programs. This report will be updated as events warrant.

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Sea-Based Ballistic Missile Defense — Background and Issues for Congress

Introduction

As part of its effort to develop a global ballistic missile defense (BMD) system, the Department of Defense (DOD) has modified three Navy cruisers and 15 Navy destroyers for BMD operations, and has deployed a large BMD radar — the Sea-Based X-Band Radar (SBX) — on a modified floating oil platform. In August 2008 it was reported that the Navy has decided to increase the number of BMD-capable destroyers from 15 to at least 62.¹ The eventual role of sea-based systems in the worldwide U.S. BMD architecture has not been determined.

The overall issue for Congress discussed in this report is: What should be the role of sea-based systems in U.S. ballistic missile defense, and are DOD's programs for sea-based BMD capabilities appropriately structured and funded? Decisions that Congress reaches on this issue could affect U.S. BMD capabilities and funding requirements; the size, capabilities, and operational patterns of the Navy and the other services; and the shipbuilding industrial base.

Background

Rationale for Sea-Based BMD Systems

DOD's overall BMD plan includes ground-based, sea-based, airborne, and space-based systems, each of which have potential strengths and limitations. DOD believes that a combination of these systems will provide a more capable BMD architecture. For a discussion of the potential strengths and limitations of sea-based BMD systems, see **Appendix A**. For a discussion of arms control considerations relating to sea-based BMD systems, see **Appendix B**.

Aegis BMD Program In General

The Aegis Ballistic Missile Defense (Aegis BMD) program is DOD's primary sea-based BMD program.

Aegis BMD Program Office. The Aegis BMD program office is an MDA directorate that reports directly to the director of MDA. MDA provides direction, funding, and guidance to the Aegis BMD program office and is the acquisition

¹ Otto Kreisher, "BMD Boost," *Seapower*, August 2008: 12-14.

executive for the program. To execute the program, the Aegis BMD program office was established as a Naval Sea Systems Command (NAVSEA) field activity. NAVSEA provides administrative support (e.g., contracting, comptroller, and security) to the Aegis BMD program office.

Aegis Ships. The Aegis BMD program builds on the capabilities of the Navy's Aegis ship combat system, which was originally developed for defending ships against aircraft, anti-ship cruise missiles (ASCMs), surface threats, and subsurface threats.² The Aegis system was first deployed by the Navy in 1983, and has been updated several times since. The part of the Aegis combat system for countering aircraft and ASCMs is called the Aegis Weapon System. Key components of the Aegis Weapon System relevant to this discussion include the following:

- the SPY-1 radar — a powerful, phased-array, multifunction radar that is designed to detect and track multiple targets in flight, and to provide midcourse guidance to interceptor missiles;
- a suite of computers running the Aegis fire control and battle-management computer program; and
- the Standard Missile (SM) — the Navy's longer-ranged surface-to-air missile (SAM), so called because it was first developed many years ago as a common, or standard, replacement for a variety of older Navy SAMs.³

The version of the Standard Missile currently used for air-defense operations is called the SM-2 Block IV, meaning the fourth upgrade to the second major version of the Standard Missile. The Navy is developing a new version of the Standard Missile for future air-defense operations called the SM-6 Extended Range Active Missile (SM-6 ERAM).

U.S. Navy ships equipped with the Aegis system include Ticonderoga (CG-47) class cruisers and Arleigh Burke (DDG-51) class destroyers. A total of 27 CG-47s were procured for the Navy between FY1978 and FY1988; the ships entered service between 1983 and 1994. The first five, which were built to an earlier technical standard, were judged by the Navy to be too expensive to modernize and were removed from service in 2004-2005. The Navy currently plans to modernize the remaining 22 ships and keep them in service to age 35.

A total of 62 DDG-51s were procured for the Navy between FY1985 and FY2005; the first entered service in 1991 and the 62nd is scheduled to enter service

² The Aegis system is named after the mythological shield carried by Zeus.

³ For more on the Aegis system and its principal components as originally deployed, see CRS Report 84-180 F, *The Aegis Anti-Air Warfare System: Its Principal Components, Its Installation on the CG-47 and DDG-51 Class Ships, and its Effectiveness*, by Ronald O'Rourke. (October 24, 1984) This report is out of print and is available directly from the author.

in 2011. The Navy currently plans to modernize these ships and keep them in service to age 35 or 40.⁴

Between 2011, when the 62nd DDG-51 is to enter service, and 2021, when the first of the 22 remaining CG-47s reaches age 35, the Navy plans to maintain a force of 84 Aegis ships — 22 cruisers and 62 destroyers.

The Navy has recently begun a program for modernizing the 22 CG-47s and 62 DDG-51s that is intended to ensure that the ships can operate cost-effectively throughout their entire 35-year expected service lives.⁵

Sales of the Aegis system to allied countries began in the late 1980s. Allied countries that now operate, are building, or are planning to build Aegis-equipped ships include Japan (the first foreign buyer, with 6 destroyers in service), South Korea (3 destroyers under construction or planned), Australia (3 destroyers planned), Spain (4 frigates in service, 1 under construction, and possibly 1 more planned), and Norway (2 frigates in service and 3 more under construction or planned).⁶ The Norwegian frigates are somewhat smaller than the other Aegis ships, and consequently carry a reduced-size version of the Aegis system that includes a smaller, less-powerful version of the SPY-1 radar.

Aegis Midcourse and Sea-Based Terminal Programs. The Aegis BMD program includes the Aegis BMD midcourse program and the Aegis BMD sea-based terminal program. Each of these is discussed below.

Aegis BMD Midcourse Program

Program Origin. The Aegis BMD midcourse program was created by the Missile Defense Agency (MDA) in 2002. Earlier names for the program include the Sea-Based Midcourse program, the Navy Theater Wide Defense program, and the Sea-Based Upper Tier program. The program is the successor to earlier sea-based BMD development efforts dating back to the early 1990s.⁷

⁴ For more on the Navy's plan for modernizing the Aegis cruisers and destroyers, see CRS Report RS22595, *Navy Aegis Cruiser and Destroyer Modernization: Background and Issues for Congress*, by Ronald O'Rourke.

⁵ For additional information on this effort, see CRS Report RS22595, *Navy Aegis Cruiser and Destroyer Modernization: Background and Issues for Congress*, by Ronald O'Rourke.

⁶ Source: *Jane's Fighting Ships 2007-2008*.

⁷ The Aegis BMD program is the successor to the Aegis LEAP Intercept (ALI) Flight Demonstration Project (FDP), which in turn was preceded by the Terrier Lightweight Exo-Atmospheric Projectile (LEAP) Project, an effort that began in the early 1990s. Terrier is an older Navy SAM replaced in fleet use by the Standard Missile. Although succeeded by the Standard Missile in fleet use, the Navy continued to use the Terrier missile for development and testing.

As mentioned in an earlier footnote (see section on arms control considerations), the ABM Treaty, which was in force until 2002, prohibited sea-based defenses against strategic (i.e.,
(continued...))

Intended Capabilities. The Aegis BMD midcourse system in its current configuration is designed to:

- detect and track ballistic missiles of any range, including ICBMs, and
- intercept short- and medium-range ballistic missiles (SRBMs and MRBMs) above the atmosphere (i.e., exo-atmospherically) during their midcourse phase of flight.

When tracking ICBMs, Aegis BMD ships are to act as sensor platforms providing fire-control-quality tracking data to the overall U.S. BMD architecture.

The Aegis BMD midcourse system in its current configuration is *not* designed to:

- intercept intercontinental ballistic missiles (ICBMs) or
- intercept ballistic missiles inside the atmosphere, during either their initial boost phase of flight or their final (terminal) phase of flight.

In contrast to the current configuration of the Aegis BMD midcourse system, the ground-based midcourse BMD program, with interceptors based in Alaska and California, is designed to intercept ICBMs in the midcourse phase of flight. Discussions comparing the current configuration of the Aegis BMD midcourse system and the ground-based midcourse program have not always noted this basic difference in the kinds of ballistic missiles they are intended to intercept.

Modification Schedule and Initial Deployments. Modifying an Aegis ship for midcourse BMD operations involves making two principal changes:

- changing the Aegis computer program to permit the SPY-1 radar to detect and track high-flying ballistic missiles; and
- arming the ship with a BMD version of the Standard Missile called the SM-3 Block 1A.

A ship with the first modification is referred to as having a long-range search and track (LRS&T) capability. A ship with both modifications is referred to as an engage-capable ship. According to one report, modifying each ship takes about six weeks and costs about \$10.5 million.⁸

⁷ (...continued)

long-range) ballistic missiles. Navy BMD development activities that took place prior to 2002 were permissible under the ABM treaty because they were not aimed at developing technologies for countering long-range ballistic missiles.

⁸ Jack Dorsey, "Navy On Front Line Of Missile Defense," *Norfolk Virginian-Pilot*, October 21, 2006.

The SM-3 Block IA is equipped with a “hit-to-kill” warhead that is designed to destroy a ballistic missile’s warhead by colliding with it outside the atmosphere, during the enemy missile’s midcourse phase of flight. It is intended to intercept SRBMs and MRBMs. An improved version, the Block IB, is to offer some capability for intercepting intermediate-range ballistic missiles (IRBMs). The Block IA and IB do not fly fast enough to offer a substantial capability for intercepting ICBMs.⁹

A faster-flying version of the SM-3, called the Block IIA, is now being developed (see discussion below). The Block IIA version is intended to give Aegis BMD ships an improved capability for intercepting IRBMs and some capability for intercepting ICBMs.

DOD plans called for modifying 18 U.S. Aegis ships — three cruisers and 15 destroyers — with the Aegis BMD capability. The first LRS&T installations were completed in 2004, and the first engage-capable installations were completed in 2005.¹⁰ (LRS&T Aegis destroyers began operating in September 2004. Engage-capable Aegis cruisers began operating in September 2005.¹¹) All 18 ships are scheduled to be engage-capable by the end of calendar 2008.

In August 2008, it was reported that the Navy has decided to expand the scope of the DDG-51 modernization program to include the installation of a BMD capability, so that all DDG-51s would eventually be BMD-capable, and that the Navy has not committed to similarly expanding the scope of the CG-47 modernization program due to financial constraints.¹²

DOD plans call for procuring a total of 147 SM-3 Block IA and IB interceptors, of which 133 are to be deployed on Aegis ships. (The other 14 apparently are to be used for testing or research.) Of the 133 SM-3 Block IA and IB interceptors to be deployed on Aegis ships, 34 are to be deployed by the end of calendar 2008, and all 133 are to be deployed by 2013.¹³

⁹ Longer-range ballistic missiles generally fly faster than shorter-range ballistic missiles. Consequently, intercepting a longer-range missile generally requires a faster-flying interceptor than is required for intercepting a shorter-range ballistic missile. The SM-3 Block IA and IB fly fast enough to intercept TBMs, but not fast enough to provide an effective capability for intercepting ICBMs.

¹⁰ The first engage-capable installations, on two cruisers, were emergency (i.e., preliminary) installations. Non-emergency versions of the system were installed beginning in 2005.

¹¹ The engage-capable cruisers conducted their first operations with the emergency (i.e., preliminary) version of the engagement capability.

¹² Otto Kreisher, “BMD Boost,” *Seapower*, August 2008: 12-14.

¹³ Source: Slides 7, 12, and 14 in the 20-slide briefing entitled “Ballistic Missile Defense Program Overview For The Congressional Breakfast Seminar Series,” dated June 20, 2008, presented by Lieutenant General Trey Obering, USAF, Director, Missile Defense Agency. Source for briefing: *InsideDefense.com* (subscription required). Each slide in the briefing includes a note indicating that it was approved by MDA for public release on June 13, 2008.

Development, Testing, and Certification. *Block Development Strategy.* Consistent with the approach used for other parts of DOD's BMD acquisition effort, the Aegis BMD midcourse system is being developed and deployed in increasingly capable versions, or blocks. These blocks were previously named after their approximate anticipated years of deployment (e.g., Blocks 2004, 2006, 2008, 2010, and 2012). Under this structure, the current version of the Aegis system was known as the Block 2004 version.¹⁴

MDA has recently restructured the block development structure to move away from date-associated block names, and the Aegis BMD system consequently is now being developed in two blocks called Block 2.0 and Block 5.0. MDA states that Block 2.0 includes, among other things, 71 SM-3 Block 1 and 1A interceptors, of which 38 are to be in inventory by the end of calendar 2008, and that Block 5.0:

will increase the number of SM-3 ... interceptors and improve the performance of the Aegis BMD Weapons System and the SM-3 interceptor.

The SM-3 Block IB interceptor, a critical Block 5.0 development effort, will have major modifications to include a much improved seeker and a Throttleable Divert and Attitude Control System (TDACS). When combined with processing upgrades to the Aegis BMD Weapons System, the more capable Block IB interceptor will more readily distinguish between threat reentry vehicles and countermeasures. The Block IB expands the battle space and enables more effective and reliable engagements of more diverse and longer-range ballistic missiles. This year we look forward to completing design and testing for the two-color seeker and TDACS and commencing the element integration of the SM-3 Block IB missile in 2009.

Block 5.0 includes delivery of 23 SM-3 Block IA interceptors, [and] 53 SM-3 Block IB interceptors....¹⁵

¹⁴ The **Block 2004** version included the SM-3 Block IA missile and a version of the Aegis computer program called Aegis BMD 3.6, which allows the ship to perform BMD operations and other warfare operations (such as air defense) at the same time. (The previous 3.0 version of the computer program did not permit this.) The Block 2004 version was intended to counter SRBMs and MRBMs. The **Block 2006/2008** versions were to have included various improvements, including the Block IB version of the SM-3 and the Aegis BMD signal processor (Aegis BSP) — a radar signal and data processor that improves the SPY-1's ballistic missile target-discrimination performance. The improvements were intended to, among other things, give the system a limited ability to intercept IRBMs. The **Block 2010/2012/2014** versions were to have included further improvements, including the Block II version of the SM-3 around 2013, and the Block IIA version in 2015. The improvements were intended to, among other things, give the system and improved ability to intercept IRBMs and some ability to counter ICBMs. This version was also to have incorporated changes intended to make the system suitable for broader international ship participation.

¹⁵ [Statement of] Lieutenant General Henry A. Obering III, USAF, Director, Missile Defense Agency, [on] Missile Defense Program and Fiscal Year 2009 Budget, Before the Senate Armed Services Committee, Subcommittee on Strategic Forces, April 1, 2008, pp. 15-16.

“Test A Little, Learn A Lot” Development Approach. The Aegis BMD program is employing a development approach that the program office characterizes as “test a little, learn a lot.” MDA has stated that:

The test program for Aegis BMD has focused on the philosophy of “test a little, learn a lot” since its inception in the early 1990’s with the TERRIER Lightweight Exo-Atmospheric Projectile (LEAP) Project. TERRIER LEAP included four flight tests between 1992 and 1995, and was successful in demonstrating that LEAP technology could be integrated into a sea-based tactical missile for exoatmospheric ballistic missile defense.

The lessons learned from TERRIER LEAP evolved into the Aegis LEAP Intercept (ALI) Flight Demonstration Project (FDP), the goal of which was to utilize the Aegis Weapons System and Standard Missile 3 (SM-3) to hit a ballistic missile in the exoatmosphere. The ALI test objectives were achieved with two successful descent phase intercepts of a ballistic missile during Flight Mission 2 (FM-2) and FM-3 in January 2002 and June 2002 respectively firing an SM-3 from the [Aegis cruiser] USS LAKE ERIE.

The transition of ALI to an Aegis BMD capability commenced with FM-4 in November of 2002 with USS LAKE ERIE, executing the first successful ascent phase intercept of a short range ballistic missile (SRBM) by the Aegis BMD element.¹⁶

Flight Tests. From January 2002 through September 2008, the Aegis BMD midcourse system has achieved 13 successful exo-atmospheric intercepts in 15 attempts.¹⁷ This total includes a successful intercept by a Japanese Aegis ship in a Japanese test flight conducted on December 17, 2007. For details on all these flight tests, see **Appendix C**. Regarding upcoming tests, MDA stated in April 2008 that:

We plan three Aegis BMD intercept tests in 2008 and 2009. In 2008 we will demonstrate an intercept of a unitary, short-range ballistic missile target in the terminal phase of flight using a SM-2 Block IV interceptor. Later this year we will conduct the second Japanese intercept test against a medium-range target

¹⁶ “Aegis Ballistic Missile Defense,” MDA fact sheet, January 30, 2004.

¹⁷ Another CRS report, based on historical flight test data provided by MDA to CRS in June 2005, summarizes early sea-based BMD tests as follows:

The Navy developed its own indigenous LEAP program, which flight tested from 1992-1995. Three non-intercept flight tests achieved all primary and secondary objectives. Of the five planned intercept tests, only the second was considered a successful intercept, however. Failures were due to various hardware, software, and launch problems. Even so, the Navy determined that it achieved about 82% of its primary objectives (18 of 22) and all of its secondary objectives in these tests.

warhead. And in 2009 we will conduct an intercept flight test against a medium-range target to demonstrate an expanded battle space.¹⁸

Certification. On September 11, 2006, the Navy and MDA certified the version of the Aegis BMD system using the Aegis BMD 3.6 computer program for tactical deployment.¹⁹

February 2008 Shoot-Down of Malfunctioning Satellite. On February 20, 2008, an engage-capable Aegis cruiser operating northwest of Hawaii used a modified version of the Aegis BMD midcourse system to shoot down an inoperable U.S. surveillance satellite that was in a deteriorating orbit. The modifications to the ship's Aegis BMD midcourse system reportedly involved primarily making changes to software. DOD stated that the modifications were of a temporary, one-time nature. Three SM-3 missiles reportedly were modified for the operation. The first modified SM-3 fired by the cruiser successfully intercepted the satellite at an altitude of about 133 nautical miles (some sources provide differing altitudes). The other two modified SM-3s (one carried by the cruiser, another carried by an engage-capable Aegis destroyer) were not fired, and the Navy stated it would reverse the modifications to these two missiles.²⁰ MDA states that the incremental cost of the shoot-down operation was \$112.4 million when all costs are included. MDA states that this cost is to be paid by MDA and the Pacific Command (PACOM), and that if MDA is directed to absorb the entire cost, "some realignment or reprogramming from other MDA [program] Elements may be necessary to lessen significant adverse impact on [the] AEGIS [BMD program's] cost and schedule."²¹

SM-3 Block IIA Missile (Cooperative Program With Japan). Under a memorandum of agreement signed in 1999, the United States and Japan have

¹⁸ [Statement of] Lieutenant General Henry A. Obering III, USAF, Director, Missile Defense Agency, [on] Missile Defense Program and Fiscal Year 2009 Budget, Before the Senate Armed Services Committee, Subcommittee on Strategic Forces, April 1, 2008, p. 20.

¹⁹ See Missile Defense Agency, "Aegis Ballistic Missile Defense Weapon System Gains Fleet Certification," September 1, 2006 (06-FYI-0082); and Lockheed Martin, "Aegis Ballistic Missile Defense Weapon System Gains Fleet Certification," September 11, 2006.

²⁰ For additional information, see Peter Spiegel, "Navy Missile Hits Falling Spy Satellite," *Los Angeles Times*, February 21, 2008; Marc Kaufman and Josh White, "Navy Missile Hits Satellite, Pentagon Says," *Washington Post*, February 21, 2008; Thom Shanker, "Missile Strikes A Spy Satellite Falling From Its Orbit," *New York Times*, February 21, 2008; Bryan Bender, "US Missile Hits Crippled Satellite," *Boston Globe*, February 21, 2008; Zachary M. Peterson, "Navy Hits Wayward Satellite On First Attempt," *NavyTimes.com*, February 21, 2008; Dan Nakaso, "Satellite Smasher Back At Pearl," *Honolulu Advertiser*, February 23, 2008; Zachary M. Peterson, "Lake Erie CO Describes Anti-Satellite Shot," *NavyTimes.com*, February 25, 2008; Anne Mulrine, "The Satellite Shootdown: Behind the Scenes," *U.S. News & World Report*, February 25, 2008; Nick Brown, "US Modified Aegis and SM-3 to Carry Out Satellite Interception Shot," *Jane's International Defence Review*, April 2008: 35.

²¹ MDA information paper dated March 7, 2008, provided to CRS on June 6, 2008. See also Jason Sherman, "Total Cost for Shoot-Down of Failed NRO Satellite Climbs Higher," *InsideDefense.com*, May 12, 2008.

cooperated in researching technologies for the Block IIA version of the SM-3.²² The cooperative research has focused on risk reduction for four parts of the missile: the sensor, an advanced kinetic warhead, the second-stage propulsion, and a lightweight nose cone. Japan has funded a significant share of the effort.

In contrast to the Block IA/IB version of the SM-3, which has a 21-inch-diameter booster stage but is 13.5 inches in diameter along the remainder of its length, the Block IIA version would have a 21-inch diameter along its entire length. The increase in diameter to a uniform 21 inches provides more room for rocket fuel and is to give the missile a burnout velocity (a maximum velocity, reached at the time the propulsion stack burns out) that is 45% to 60% greater than that of the Block IA/IB version.²³ The Block IIA version would also include an improved kinetic (hit-to-kill) warhead.²⁴ MDA states that the Block IIA version could “engage many [ballistic missile] targets that would outpace, fly over, or be beyond the engagement range” of earlier versions of the SM-3, and that

the net result, when coupled with enhanced discrimination capability, is more types and ranges of engageable [ballistic missile] targets; with greater probability of kill, and a large increase in defended “footprint” or geography predicted.... The SM-3 Blk II/IIA missile with it[s] full 21-inch propulsion stack provides the necessary fly out acceleration to engage IRBM and certain ICBM threats.²⁵

The first Block IIA delivery is scheduled for the end of 2015. The estimated development cost of the Block IIA missile is \$2.1 billion, of which Japan is to finance \$1 billion, or about 50%.²⁶

²² The Block IIA development effort includes the development of a missile, called the Block II, as a stepping stone to the Block IIA. As a result, the Block IIA development effort is sometimes called the Block II/IIA development effort. The Block II missile is not planned as a fielded capability.

²³ The 13.5-inch version has a reported burnout velocity of 3.0 to 3.5 kilometers per second (kps). See, for example, J. D. Marshall, *The Future Of Aegis Ballistic Missile Defense*, point paper dated October 15, 2004, available at [<http://www.marshall.org/pdf/materials/259.pdf>]; “STANDARD Missile-3 Destroyers a Ballistic Missile Target in Test of Sea-based Missile Defense System,” Raytheon news release circa January 26, 2002, available at [http://www.prnewswire.com/cgi-bin/micro_stories.pl?ACCT=683194&TICK=RTN4&STORY=/www/story/01-26-2002/0001655926&EDATE=Jan+26,+2002]; and Hans Mark, “A White Paper on the Defense Against Ballistic Missiles,” *The Bridge*, summer 2001, pp. 17-26, available at [[http://www.nae.edu/nae/bridgecom.nsf/weblinks/NAEW-63BM86/\\$FILE/BrSum01.pdf?OpenElement](http://www.nae.edu/nae/bridgecom.nsf/weblinks/NAEW-63BM86/$FILE/BrSum01.pdf?OpenElement)]. See also the section on “Sea-Based Midcourse” in CRS Report RL31111, *Missile Defense: The Current Debate*, coordinated by Steven A. Hildreth.

²⁴ Source for information on SM-3: Missile Defense Agency, “Aegis Ballistic Missile Defense SM-3 Block IIA (21-Inch) Missile Plan (U), August 2005,” a 9-page point paper provided by MDA to CRS, August 24, 2005.

²⁵ “Aegis Ballistic Missile Defense SM-3 Block IIA (21-Inch) Missile Plan (U), August 2005,” op. cit, pp. 3-4.

²⁶ Slide 28 in briefing entitled “Aegis Ballistic Missile Defense,” dated August 12, 2008, presented by Rear Admiural Alan B. Hick, Aegis BMD Program Director. Source for (continued...)

Aegis BMD Sea-Based Terminal Program

In addition to the midcourse program described above, which is intended to intercept ballistic missiles outside the atmosphere, during the midcourse phase of flight, the Aegis BMD program includes a second effort, called the sea-based terminal capability, to develop a complementary sea-based capability for intercepting TBMs in the final, or descent, phase of flight, after the missiles have reentered the atmosphere,²⁷ so as provide local-area defense of U.S. ships as well as friendly forces, ports, airfields, and other critical assets ashore.

Successor to Canceled NAD System. The sea-based terminal effort is the successor to an earlier effort to achieve such a capability that was called the Navy Area Defense (NAD) program or Navy Area TBMD (Theater BMD) program, and before that, the Sea-Based Terminal or Navy Lower Tier program.²⁸ The NAD system was canceled in December 2001.²⁹

Block 2.0 Version. MDA divides the sea-based terminal effort into two blocks: the Block 2.0 version and a far-term sea-based terminal capability that MDA places beyond Block 5.0.

The Block 2.0 sea-based terminal capability includes a fuze-modified SM-2 Block IV interceptor with a blast-fragmentation warhead. The missile is intended to be capable of intercepting a finite set of SRBMs inside the atmosphere. The Navy (not MDA) is funding the modification of 100 SM-2 Block IV missiles into this configuration. Installations of the Block 2.0 capability were scheduled to commence in FY2008. Of the planned total of 100 SM-2 Block IV missiles, 40 are to be deployed on Aegis ships by the end of calendar 2008.³⁰

²⁶ (...continued)
briefing: *InsideDefense.com* (subscription required).

²⁷ The sea-based terminal defense capability could also be used to intercept, in the terminal phase of flight, short-range ballistic missiles whose flight paths remain entirely within the atmosphere.

²⁸ The NAD system was to have been deployed on Navy Aegis ships. The program involved modifying the SM-2 Block IV air-defense missile. The missile, as modified, was called the Block IVA version. The system was designed to intercept descending missiles endo-atmospherically (i.e., within the atmosphere) and destroy them with the Block IVA missile's blast-fragmentation warhead.

²⁹ In announcing its decision to cancel the program, DOD cited poor performance, significant cost overruns, and substantial development delays, and cited the Nunn-McCurdy provision (10 USC §2433), a defense acquisition law first enacted in 1981. This was the first defense acquisition program that DOD officials could recall having been canceled under the Nunn-McCurdy provision. ("Navy Area Missile Defense Program Cancelled," Department of Defense News Release No. 637-01, December 14, 2001; James Dao, "Navy Missile Defense Plan Is Canceled By the Pentagon," *New York Times*, December 16, 2001; Gopal Ratnam, "Raytheon Chief Asks DOD To Revive Navy Program," *Defense News*, January 14-20, 2002: 10.)

³⁰ Source: Slide 7 in the 20-slide briefing entitled "Ballistic Missile Defense Program (continued...)"

Far-Term Version. The far-term sea-based terminal capability is envisioned as including a new type of missile, the design of which is not yet determined, that is to provide a more capable sea-based terminal capability. Under current plans, the far-term sea-based terminal capability is scheduled to be delivered in 2015. Potential candidates for the far-term sea-based terminal interceptor include a modified version of the Army's Patriot Advanced Capability-3 (PAC-3) interceptor, called the PAC-3 Missile Segment Enhancement (MSE), or a modified version of the SM-6 Extended Range Active Missile (SM-6 ERAM) air defense missile being developed by the Navy.³¹

Flight Tests. The Block 2.0 version of the sea-based terminal capability has achieved two successful endo-atmospheric intercepts in two at-sea attempts, one occurring on May 24, 2006,³² the other on June 5, 2008.³³

Aegis BMD Program Funding

Table 1 shows actual or programmed annual funding for the Aegis BMD program from FY1995 through FY2013. The figures in **Table 1** do not include Navy funding for efforts such as modifying up to 100 SM-2 Block IV missiles for the near-term (Block 2.0) sea-based terminal capability. As shown in the Table 1, MDA is requesting \$1,157.8 million in FY2009 research and development funds for the Aegis BMD program.

³⁰ (...continued)

Overview For The Congressional Breakfast Seminar Series," dated June 20, 2008, presented by Lieutenant General Trey Obering, USAF, Director, Missile Defense Agency. Source for briefing: *InsideDefense.com* (subscription required). Each slide in the briefing includes a note indicating that it was approved by MDA for public release on June 13, 2008.

³¹ See, for example, Bettina H. Chavanne, "Aegis Ships To Get Protection From Ballistic Missile Threats," *Aerospace Daily & Defense Report*, March 20, 2008: 2; Jason Ma and Christopher J. Castelli, "Adaptation Of PAC-3 For Sea-Based Terminal Missile Defense Examined," *Inside the Navy*, July 19, 2004; Malina Brown, "Navy Rebuilding Case For Terminal Missile Defense Requirement," *Inside the Navy*, April 19, 2004.

³² See Missile Defense Agency, "First at-Sea Demonstration of Sea-Based Terminal Capability Successfully Completed," May 24, 2006 (06-FYI-0079); Gregg K. Kakesako, "Missile Defense System Makes History," *Honolulu Star-Bulletin*, May 25, 2006; Audrey McAvoy, "Ship Shoots Down Test Missile For The First Time," *NavyTimes.com*, May 25, 2006; "Navy, MDA Announce First Terminal Sea-Based Intercept," *Aerospace Daily & Defense Report*, May 26, 2006; Zachary M. Peterson, "Navy Conducts First Sea-Based Terminal Phase Missile Defense Test," *Inside the Navy*, May 29, 2006; and Jeremy Singer, "Sea-Based Terminal May Boost U.S. Missile Defense Capability," *Space News* (*www.space.com*), June 12, 2006.

³³ See Missile Defense Agency, "Successful Sea-Based Missile Defense Intercept," June 5, 2008 (08-NEWS-0068); Dave Ahearn, "Aegis, SM-2 Interceptors Kill Target Missile In Terminal-Phase Success," *Defense Daily*, June 6, 2008.

Table 1. Aegis BMD Program Funding, FY1995-FY2013
(millions of dollars, rounded to the nearest tenth)

FY95	75.0
FY96	200.4
FY97	304.2
FY98	410.0
FY99	338.4
FY00	380.0
FY01	462.7
FY02	476.0
FY03	464.0
FY04	726.2
FY05	1,159.8
FY06	893.0
FY07	1,125.4
FY08	1,126.3
<i>FY09</i>	<i>1,157.8</i>
<i>FY10</i>	<i>1,234.2</i>
<i>FY11</i>	<i>1,078.5</i>
<i>FY12</i>	<i>1,066.7</i>
<i>FY13</i>	<i>1,102.5</i>

Sources: For FY1995 through FY2005: DOD Information Paper provided to CRS by Navy Office of Legislative Affairs, November 14, 2006. For FY2006-FY2013: FY2008 and FY2009 MDA budget justification books for Aegis BMD program.

Allied Programs and Interest

Japan. Japan's interest in BMD, and in cooperating with the United States on the issue, was heightened in August 1998, when North Korea test-fired a Taepo Dong-1 ballistic missile that flew over Japan before falling into the Pacific.³⁴ In addition to cooperating with the United States on development of technologies for the SM-3 Block IIA missile, Japan is modifying four of its Aegis destroyers with the Aegis BMD midcourse system between FY2007 and early FY2011, at a pace of about one ship per year. Under this plan, Japan would have an opportunity in FY2011 and subsequent years to upgrade the ships' BMD capability to a later Block standard, and to install the Aegis BMD capability on its two remaining Aegis destroyers.

³⁴ For a discussion, see CRS Report RL31337, *Japan-U.S. Cooperation on Ballistic Missile Defense: Issues and Prospects*, by Richard P. Cronin. This archived report was last updated on March 19, 2002. See also CRS Report RL33436, *Japan-U.S. Relations: Issues for Congress*, by Emma Chanlett-Avery, Mark E. Manyin, and William H. Cooper.

A Japanese Aegis ship participated as a tracking platform in FTM-10, the June 22, 2006, flight test of the Aegis BMD system. This was the first time that an allied military unit participated in a U.S. Aegis BMD intercept test.³⁵ A Japanese ship again tracked a target missile in FTM-11, in December 2006. On December 17, 2007, in a test called Japan Flight Test Mission 1 (JFTM-1), a BMD-capable Japanese Aegis destroyer used an SM-3 Block IA missile to successfully intercept a ballistic missile target in a flight test off the coast of Hawaii. It was the first time that a non-U.S. ship had intercepted a ballistic missile using the Aegis BMD system.³⁶

Other Countries.³⁷ Other countries that DOD views as potential naval BMD operators include South Korea, Australia, the UK, Germany, the Netherlands, and Spain. As mentioned earlier, South Korea, Australia, and Spain either operate, are building, or are planning to build Aegis ships. The other countries operate destroyers and frigates with different combat systems that may have potential for contributing to BMD operations.³⁸

Sea-Based X-Band Radar (SBX)

The Sea-Based X-Band Radar (SBX) is DOD's other principal sea-based BMD element. It is a midcourse fire-control radar designed to support long-range BMD systems. Its principal functions are to detect and establish precise tracking information on ballistic missiles, discriminate missile warheads from decoys and debris, provide data for updating ground-based interceptors in flight, and assess the results of intercept attempts. SBX is intended to support more operationally realistic testing of the ground-based midcourse system and enhance overall BMD system operational capability.

SBX is a large, powerful, phased-array radar operating in the X band, a part of the radio frequency spectrum that is suitable for tracking missile warheads with high accuracy. The radar is mounted on a modified, self-propelled, semi-submersible oil

³⁵ Missile Defense Agency, "Missile Defense Test Results in Successful 'Hit To Kill' Intercept," June 22, 2006 (06-NEWS-0018).

³⁶ John Liang, "Japanese Destroyer Shoots Down Ballistic Missile Test Target," *Inside Missile Defense*, December 19, 2007; "Japanese Aegis Destroyer Wins Test By Killing Target Missile With SM-3 Interceptor," *Defense Daily*, December 18, 2007; Reuters, "Japanese Ship Downs Missile In Pacific Test," *New York Times*, December 18, 2007: 8; Audrey McAvoy, "Japan Intercepts Missile In Test Off Hawaii," *NavyTimes.com*, December 17, 2007.

³⁷ Primary sources for this section: Missile Defense Agency, Frequently Asked Questions, available at [<http://www.mda.mil/mdalink/html/faq.html>]; a briefing on the Aegis BMD program by Rear Admiral Brad Hicks, Aegis BMD Program Director, to the RUSI 8th Missile Defense Conference, February 27, 2007.

³⁸ For an article discussing six European nations that reportedly have an option for giving their ships an early-warning capability for maritime BMD (MBMD) operations, see "European AAW Ships Get MBMD Option," *Jane's International Defence Review*, February 2007: 8, 10, 12.

platform that can transit at a speed of 8 knots and is designed to be stable in high winds and rough seas.³⁹

SBX was completed in 2005 for the Missile Defense Test Bed. The semi-submersible platform was designed by a Norwegian firm and built in Russia. It was purchased for the SBX program, and modified and integrated with the SBX radar in Texas.⁴⁰ SBX underwent sea trials and high-power radiation testing in the Gulf of Mexico in 2005. It was then moved by a heavy transport vessel to Hawaii, arriving there in January 2006. Technical issues in 2006 with the SBX's semi-submersible platform delayed the SBX's transfer from Hawaii to its planned home port of Adak, Alaska.⁴¹ The SBX reportedly departed Hawaii on January 3, 2007, and arrived in Alaska's Aleutian Islands on February 7, 2007.⁴²

MDA announced on March 21, 2007, that on March 20, the SBX (and also the SPY-1 radars on two Aegis ships) had successfully tracked a target ballistic missile in a test of radars being incorporated into the overall U.S. BMD system.⁴³

In April 2007, it was reported that the Navy and MDA had reached a preliminary agreement for the Navy to assume control of the SBX program.⁴⁴

³⁹ The platform is 238 feet wide and 398 feet long. It measures 282 from its submerged keel to the top of the radar dome. The SBX has a total displacement of almost 50,000 tons — about one-half the full load displacement of a Navy aircraft carrier. SBX is operated by a crew of about 75.

⁴⁰ The platform was designed by Moss Maritime, a Norwegian firm, and built for Moss in 2001-2002 by Vyborg shipbuilding, which is located in Vyborg, Russia (a city north of St. Petersburg, on the Gulf of Finland, that is near the Finnish border). Vyborg Shipbuilding's products include semi-submersible oil platforms. Moss sold the platform to Boeing. Boeing and a subcontractor, Vertex RSI (a part of General Dynamics), modified the platform at the Keppel AMFELS shipyard in Brownsville, TX. The platform was then moved to Kiewit Offshore Services of Corpus Christi, TX, where the radar was added by a combined team of Boeing, Raytheon, Vertex RSI, and Kiewit. ("MDA Completes Integration of X-Band Radar On Sea-Going Platform," *Defense Daily*, April 5, 2005; and "Sea-Based X-band Radar," *GlobalSecurity.org*.)

⁴¹ Jonathan Karp, "A Radar Unit's Journey Reflects Hopes, Snafus In Missile Defense," *Wall Street Journal*, November 28, 2006: 1. See also Kirsten Scharnberg, "Radar Staying Longer Than Planned," *Chicago Tribune*, September 3, 2006. The article was also published in the *Honolulu Advertiser*. See also *SBX-1 Operational Suitability and Viability Assessment, An Independent Assessment*. Arlington (VA), SYColeman, 2006, pp. i-ii. (Final Report, June 2, 2006, Submitted to: Director, Mission Readiness Task Force, Missile Defense Agency, Submitted by: Independent Assessment Team, Prepared by: SYColeman, A Wholly Owned Subsidiary of L-3 Communications). The report is available at [<http://www.pogo.org/m/dp/dp-SBXOVA-06022006.pdf>]

⁴² "Way Up North," *Defense Daily*, February 12, 2007.

⁴³ Missile Defense Agency News Release, 07-NEWS-0028, 21 March 2007, "Missile Defense Flight Test Successfully Completed."

⁴⁴ Emelie Rutherford, "Navy To Assume Responsibility For Sea-Based X-Band Radar Program," *Inside the Navy*, April 16, 2007.

Regarding other potential uses of the SBX, a March 2006 press report stated:

Boeing missile defense officials refuse to answer questions about whether they are developing techniques to produce high-energy weapon effects from the SBX sea-based radar. However, since large distributed-array devices [like the SBX] can be focused to deliver large spikes of energy, powerful enough to disable electronic equipment, the potential is known to exist and is being fielded on a range of U.S., British and Australian aircraft.⁴⁵

Potential Issues for Congress

Technical Risk

How much technical risk is there in the Aegis BMD program?

One potential oversight issue for Congress is how much technical risk there is in the Aegis BMD program. A March 2008 Government Accountability Office (GAO) report assessing the technical risks of selected weapon programs stated of the Aegis BMD program:

Program officials report all Block IA critical technologies are mature. Our data indicate that one of the technologies is less mature. The Solid Divert and Attitude Control System (SDACS) pulse one has been successfully flight tested since our last report. However, the zero pulse mode of the missile's third stage rocket motor has not been demonstrated in an operational environment. Officials also report the missile's design is stable with 100 percent of its drawings released to manufacturing and they do not anticipate any design changes. The Block IA missile is in production but officials state that the contractor's processes are not mature enough to collect statistical data. Instead, other means are being used to gauge production readiness.

Technology Maturity

We reported last year that two of the three technologies critical to the SM-3 Block IA missile, the Solid Divert and Attitude Control System (SDACS) and the Third Stage Rocket Motor (TSRM), were not mature. Since our last report, one of the SDACS's pulse modes, pulse one, which allows the kinetic warhead to divert in order to adjust its aim, has flown three times, in April, June, and November 2007. Pulse one was used to shift the warhead's aim just prior to intercept and all tests resulted in successful intercepts. The other pulse mode of the SDACS, pulse two, is identical in technology and functionality as pulse one but has not been flight tested. Program officials state that both pulse modes have been successfully tested in four consecutive ground tests but that it is difficult for the SDACS to use both pulse modes in a flight test because the first pulse has provided sufficient divert capability to make the intercept. Program officials state that an artificiality would have to be built into the flight test in order to guarantee the use of pulse two. Additionally, program officials consider pulse two to be a margin to the system since it is designed to provide additional energy, if needed,

⁴⁵ "Radar Weapons," *Aerospace Daily & Defense Report*, March 20, 2006.

after employing pulse one, to make the necessary maneuvers to intercept the target in the desired spot for maximum destruction. Similarly, the zero pulse mode of the TSRM that increases the missile's capability against shorter-range threats has not been flight tested. Although the production design of the TRSM attitude control system passed qualification testing in February 2007 and has been integrated into the manufacturing line, the zero pulse mode is not scheduled for flight testing due to range safety limitations.

Design Stability

Program officials reported that the design for the SM-3 Block IA missiles being produced during Block 2006 is stable, with 100 percent of its drawings released to manufacturing. Program officials do not anticipate additional design changes.

Production Maturity

We did not assess the production maturity of the SM-3 missiles being procured for Block 2006. Program officials stated that the contractor's processes are not yet mature enough to statistically track production processes. The Aegis BMD program continues to use other means to assess progress in production and manufacturing, such as tracking rework hours, cost of defects per unit, and other defect and test data.

Other Program Issues

The original Aegis BMD program goals for Block 2006 included delivery of 19 SM-3 Block IA U.S. missiles. Last year, program officials reduced the goal to 15. Since that time, delivery goals have been reduced to 12, because the contractor did not have the production capacity to deliver both foreign military sales missiles and U.S. missiles. Although Raytheon reported no cost or schedule growth, because much of the SM-3 Block IA contract work was being reported as a level of effort, it was difficult to assess true performance since it could not be practically measured by discrete earned value techniques. According to American National Standards Institute guidelines adopted by DOD, only work that does not result in a product should be reported as level of effort under earned value management. However, in August 2007, Raytheon reported 73 percent of the contract work as level of effort, some of which was identified as possibly unjustified and appearing excessive by a team composed of technical and functional experts during a 2007 review. Since that time, program officials report that they were able to implement earned value management reporting on future delivery contracts and stated in January 2008 that Raytheon had reduced the contract level of effort work to 18 percent.

Agency Comments

Technical comments provided by the program office were incorporated as appropriate. In addition, program officials stated that they believe the TSRM is a mature technology and add that it has been successfully flown in multiple missions in increasingly realistic operational environments. Program officials consider the zero pulse mode of the third stage rocket motor to be marginal to the system and explain that the capability is difficult to demonstrate in an operational environment due to range safety limitations. Additionally, program officials state that all design verification tests for both the SDACS and the TSRM have been

completed, all requirements have been exceeded, and qualification tests for the capabilities have been completed and verified by Johns Hopkins University Applied Physics Laboratory and the Indian Head Division, Naval Warfare Center.⁴⁶

Number of Aegis BMD Ships

How many Aegis ships should be equipped for BMD operations?

Another potential oversight issue for Congress concerns the number of Aegis ships that should be equipped for BMD operations. The eventual U.S. BMD architecture is to be defined by U.S. Strategic Command (USSTRATCOM) — the U.S. military command responsible for “synchronized DoD effects to combat adversary weapons of mass destruction worldwide,” including integrated missile defense⁴⁷ — in consultation with MDA. Under the evolutionary acquisition approach adopted for the overall U.S. BMD program, it likely will be a number of years before USSTRATCOM and MDA define the eventual BMD architecture. Until then, the absence of an objective architecture might complicate the task of assessing whether the types and numbers of sea-based BMD systems being acquired are correct.

If the role of sea-based systems in the eventual U.S. BMD architecture turns out to be greater than what DOD has assumed deciding to equip 18 Aegis ships with BMD capabilities, then additional funding might be needed to expand the scope of the program to include more than 18 ships. The issue could also affect the required total number of Navy cruisers and destroyers. If the role of sea-based systems in the eventual U.S. BMD architecture turns out to be greater than what the Navy has assumed in calculating its 88-ship cruiser-destroyer requirement, then the requirement might need to be increased to something more than 88 ships.

A November 5, 2007 press report stated:

the admiral who runs the Aegis Ballistic Missile Defense program for the Missile Defense Agency is asking to expand the upgrade effort — even before the large-scale Aegis upgrade planned to start in 2012.

“The question right now is: With 18 ships, is that an adequate number? I’m not sure it is,” said Rear Adm. Alan Hicks, who noted that Navy plans call for basing all but two of the BMD ships in the Pacific. “One of the concerns I have today is that if we had to surge for both a North Korean and Iranian scenario, you would end up taking ships [that would be used for] defense against North Korea. You have to augment the two Atlantic fleet ships to do anything in either the [Persian] Gulf or Mediterranean if there was an Iranian threat.”

⁴⁶ Government Accountability Office, *Defense Acquisitions[:] Assessments of Selected Weapon Programs*, GAO-08-467, March 2008, pp. 37-38.

⁴⁷ For more on USSTRATCOM, see CRS Report RL33408, *Nuclear Command and Control: Current Programs and Issues*, by Robert D. Critchlow. See also USSTRATCOM’s website at [<http://www.stratcom.mil/>], from which the quoted passage is taken.

Hicks approached Adm. Mike Mullen when Mullen was the chief of naval operations about adding more BMD ships to handle simultaneous missile threats from North Korea and Iran. Mullen agreed to a series of discussions as the Navy builds its portion of the 2009 White House budget request.

Fifteen of the 18 ships in the current Aegis BMD plan are destroyers, and so the obvious option is to add more cruisers. “Right now, we have three BMD cruisers,” Hicks said. “Will [Navy officials] make a decision to upgrade any more of the cruisers? That’s what they’ll be discussing.”

So far, Lockheed Martin reports it has completed 16 Aegis BMD ships, with the final two scheduled to be ready by mid-2008. Hicks said the full contingent must be ready for fielding by early 2009.

These ships are a stopgap, or “pre-modernization,” measure until Navy and Pentagon officials decide how to incorporate ballistic missile defense into the massive Aegis modernization program scheduled to start in 2012. At that time, all 62 destroyers and 22 cruisers in the Aegis fleet will begin rotating into port for 40-week computer modernization programs. How many of those modernized ships will be equipped to fire missile interceptors is another topic for talks, Hicks said.⁴⁸

Similarly, in a speech in late-November 2007, Rear Admiral Alan Hicks reportedly

described the 18 ships as “inadequate” to meet missile defense needs, and said the Navy was trying to solve that problem.

“When the Aegis production line ends, I think there will be 84 ships — we’re looking at 2012, 2013,” he told ITN [*Inside the Navy*]. “How many of those ships needed to be BMD-capable is a decision for the chief of naval operations and the secretary of defense, but the Navy knows 18 is inadequate. Therefore, they’ve made a decision already that the ships that start DDG [destroyers] modernization, 2012 and out, will have BMD added to that.”

The Navy is also reviewing its [Aegis] cruiser modernization program to determine how many of them will get the system, he said.⁴⁹

A January 21, 2008 press report stated:

The Navy is looking into the possibility of adding Aegis Ballistic Missile Defense systems to its entire fleet of cruisers and destroyers, the service’s top surface warfare official said last week in a presentation to the Surface Navy Association’s annual symposium in Arlington, VA.

Fifteen destroyers and three cruisers will be equipped with the BMD capability “by the end of next year,” but the service wants to go well beyond

⁴⁸ Ben Iannotta, “Admiral Wants Bigger Anti-Missile Upgrade,” *NavyTimes.com*, November 5, 2007. Bracketed material as in the original.

⁴⁹ Dan Taylor, “Navy Still Interested in Second MKV, MDA Will Talk to Congress,” *Inside the Navy*, December 3, 2007.

those 18 ships, said Rear Adm. Victor Guillory, director of the surface warfare division (N86), in his Jan. 15 presentation to symposium attendees.

“The DDG modernization program is funded to add BMD capability to the remaining 47 destroyers, and we will be examining options [to add BMD to the] remaining cruisers in POM-10 [program objective memorandum],” he said.⁵⁰

A July 31, 2008, press report stated:

The U.S. Navy may eventually need as many as 90 Aegis Ballistic Missile Defense ships — far more than the 18 planned by the end of this year — especially if worldwide missile defense requirements help drive shipbuilding needs, a key three-star admiral said July 30.

Vice Adm. Barry McCullough, deputy chief of naval operations for integration of capabilities and resources, said combatant commanders (COCOMS) in areas like Europe and the Pacific would need far more Aegis BMD ships to meet continuous coverage needs. Officials in those locations, which watch Iran and North Korea among other countries, increasingly eye the naval system’s regional missile defense capabilities.

“The combatant commanders, the fleet commanders, want more of it; they want it all the time,” McCullough told a National Defense University Foundation breakfast audience. “That will drive our force structure requirements even higher.”⁵¹

Another July 31, 2008, press report similarly stated:

The current Navy program to convert 18 cruisers and destroyers to the Aegis ballistic missile defense (BMD) capability, which will be completed by the end of this year, will have to be expanded to cover roughly 90 ships, a senior Navy officer said yesterday.

“Eighteen ships is not enough to provide a robust missile defense capability,” said Vice Adm. Barry McCullough, deputy chief of naval operations, speaking before a National Defense University breakfast forum at the Capitol Hill Club.

“The real number is somewhere around 90,” he said, because there are increasing requests for BMD coverage coming from combatant commanders in the European theater, the Central Command theater and the Pacific theater.

Therefore, “it takes a lot more ships than the 18 we have” set for upgrade by the end of the calendar year, he said.

⁵⁰ Dan Taylor, “Navy Considering Equipping Cruiser and Destroyer Fleet With Aegis BMD,” *Inside the Navy*, January 21, 2008. Material in brackets as in original.

⁵¹ Michael Bruno, “Navy Acquisition Officer Sees Need For Bigger Aegis BMD Fleet,” *Aerospace Daily & Defense Report*, July 31, 2008.

Later, responding to a question from the audience, McCullough said, “I think we need on the order of 89 or more” ships.⁵²

As mentioned earlier, in August 2008, it was reported that the Navy has decided to expand the scope of the DDG-51 modernization program to include the installation of a BMD capability, so that all DDG-51s would eventually be BMD-capable, and that the Navy has not committed to similarly expanding the scope of the CG-47 modernization program due to financial constraints.

Potential oversight questions for Congress include the following: How many Aegis ships should be equipped for BMD operations? In the absence of a defined U.S. BMD architecture, what was the basis for MDA’s decision that 18 Aegis ships (3 CG-47s and 15 DDG-51s) should be equipped for BMD operations, and what was the basis for the Navy’s reported decision that at least 65 Aegis ships (3 CG-47s plus at least 62 DDG-51s) should be equipped for BMD operations? What kinds of BMD operations were factored into the Navy requirement for maintaining a force of at least 88 cruisers and destroyers? If BMD operations by Navy ships turn out to be more significant than what the Navy might have assumed in calculating the 88-ship figure, will the figure need to be increased, and if so, by how much?

Role of Aegis BMD in European Missile Defense

What should be the role of Aegis BMD in European missile defense?

Another potential oversight issue for Congress concerns the potential role of the Aegis BMD system as a partial or complete alternative, or supplement, to the ground-based midcourse defense (GMD) system that the Bush Administration has proposed to establish in Poland and the Czech Republic. Russian President Vladimir Putin opposes a ground-based GMD system in Europe and has suggested that the United States explore certain alternative approaches, including the use of BMD-capable Aegis ships. A June 21, 2007, press report stated:

The US has been less receptive to the idea of placing missile interceptors in Turkey, Iraq, or on Aegis ships, as Mr Putin suggested. The Missile Defence Agency says Turkey and Iraq are too close to Iran for interceptors to be able to catch an incoming missile from Iran.

But the idea of using Aegis ships has seen more debate. Duncan Hunter, the top Republican on the House armed services committee, recently said Mr Putin’s proposal about sea-based missile defences was “promising”, although only as an additional capability to ground-based missile interceptors in Poland.

“The Navy’s Aegis ship-based defensive systems could be based in existing Black Sea ports, either in Ukraine, Russia or Turkey,” said Mr Hunter.

General Trey Obering, MDA director, has argued that the Aegis ships are currently configured to intercept short- and medium-range threats, and could not

⁵² Dave Ahearn, “More Destroyers, Cruisers, Must Be Converted To Advanced Aegis BMD, Admiral Says,” *Defense Daily*, July 31, 2008.

counter against long-range intercontinental ballistic missiles that could target the US without costly modifications, which would take a considerable amount of time. His critics say the Iranian threat is far enough in the future to provide the US time.

Gen Obering also argues that the US would need to deploy tens of ships for the system to be feasible. But several people familiar with a study prepared by Raytheon, which is manufacturing missile interceptors for the Aegis ships, said it concluded that as few as five ships could provide a defence against an Iranian threat. Raytheon declined to comment.⁵³

A November 29, 2007, press report stated:

It would take a large number of U.S. Navy Aegis weapons system ships to shield Europe against enemy missiles from the Middle East, if the United States attempted to use the sea-based system to guard Europe instead of the Ground-based Midcourse missile Defense (GMD) system proposed for the Czech Republic and Poland.

That was the assessment yesterday of Rear Adm. Alan Hicks, program director of the Aegis ballistic missile defense (BMD) system, at a symposium of the George C. Marshall Institute, a Washington think tank, held at the National Press Club.

“Certainly by the near-term capability, between now and 2015, that’s a lot of ships, and I wouldn’t recommend it,” he said.

Further, those ships wouldn’t be stationed in an ideal location, so that the interceptors they would fire to take down enemy weapons would “run out of juice” in pursuing those threats.

He added, though, that the Aegis sea-based system could be deployed as a complement to the European GMD system when the ships aren’t needed for other missions. The European GMD system has yet to win final approval from the Czechs and Poles.

One key point is that it is not a stretch for the GMD system, with a radar in the Czech Republic and 10 interceptors in silos in Poland, to provide 24-7 protection of Europe. But it would be difficult to have a sufficient number of ships on station, on point, all the time, he said.⁵⁴

A July 16, 2008, press report stated:

U.S. Navy ships in the Mediterranean will provide ballistic missile defense to the Czech Republic under a commitment contained in the agreement to place a U.S. radar site in that country, according to State and Defense Department officials.

⁵³ Demetri Sevastopulo, Guy Dinmore, and Neil Buckley, “Experts Sceptical [sic] On Chances For Missile Deal,” *Financial Times*, June 21, 2007.

⁵⁴ Dave Ahearn, “Large Number of Aegis Ships Would Be Needed To Shield Europe: Admiral,” *Defense Daily*, November 29, 2007.

The United States “is committed to the security of the Czech Republic and to protect and defend, by means of its ballistic missile defense system, the Czech Republic against a potential ballistic missile attack,” according to the agreement signed July 8, the text of which was released by the Czech government.

In remarks at the signing ceremony in Prague, Secretary of State Condoleezza Rice said the Czech-based U.S. radar facility will “help protect” the Czech Republic when linked to an Aegis system, a sea-based antimissile system that combines radar and interceptors and is carried aboard a variety of U.S. Navy ships. Rice did not say at the time that the United States had committed to providing that defense.⁵⁵

An August 1, 2008, press report stated:

A U.S. Navy admiral this week said his service is examining a possible future need for Aegis warship patrols in the Baltic or Black seas to help protect proposed missile defense sites in Poland and the Czech Republic....

“As we go forward with [European-based missile defenses] and I hear the policy debates on it, I’ve been asked to look at what it would take to fulfill [sea-launched interceptor] requirements in the Baltic area or in the Black Sea area,” Vice Adm. Bernard [sic] McCullough said at a Wednesday breakfast forum on Capitol Hill.

The flag officer, who serves as deputy chief of naval operations for integration of capabilities and resources, was responding to an audience question about what Navy ships might do to help defend the Czech- and Polish-based assets.

McCullough’s response reflects the findings of a 2007 Navy study, a service spokesman told *Global Security Newswire*. The review laid out combatant commanders’ future requirements for sea-based ballistic missile defense capabilities.

An expanded naval presence in waters neighboring Eastern Europe might be necessary on the basis that the ground-based missile defense assets themselves could become among the first targets in a phased enemy attack.

If an adversary were to damage or destroy the Czech-based radar, interceptors stationed in neighboring Poland might be rendered useless. That, in turn, could provide an opening for subsequent enemy missile strikes against European or perhaps even U.S. targets, according to defense experts....

“I think we need on the order of 89 or more” BMD-capable ships, McCullough said this week.

Expanding Aegis ship presence to the Baltic or the Black seas would “drive our force structure requirements even higher for this particular capability,” McCullough said....

⁵⁵ Walter Pincus, “U.S. To Give Czechs Ballistic Missile Defense,” *Washington Post*, July 16, 2008: 11.

The notion of having to deploy interceptor-carrying ships to defend new land-based missile defense sites strikes some observers as a potentially complicated — and perhaps somewhat peculiar — endeavor.

“It’s a big Rube Goldberg type of thing,” said physicist Theodore Postol of the Massachusetts Institute of Technology, referring to the classic cartoons of absurdly complex machines. “You have to defend [the missile defense sites] because ... if you have a capable adversary, they will attack your radars, if they can.”

“That’s one of the reasons the Safeguard system was dismantled in the 1970s,” said David Wright, who co-directs the Global Security Program at the Union of Concerned Scientists in Cambridge, Mass. Based in North Dakota, the early U.S. missile defense system was deactivated in 1976 after operating for less than four months....

The Standard Missile interceptors, based on Aegis ships, fly at substantially slower speeds than their Ground-Based Interceptor counterparts and thus would have questionable capability against Russian ICBMs if based in the Baltic or Black seas, explained Postol, a professor of science, technology and national security policy.

Russia wants to stop the European ground-based interceptors “at almost any cost,” even if it means accepting a ship-based defense system that, at some point in the future, might be significantly improved, he said....

However, the Bush administration has rejected the Russian proposal and has pushed ahead with its land-basing scheme.

How Putin’s successor as president, Dmitry Medvedev, might now regard the idea of U.S. surface combatants in the Baltic and Black seas — bolstering rather than replacing ground-based missile interceptors in Europe — has yet to be seen.⁵⁶

An August 13, 2008, MDA briefing presented what it stated were highlights of a July 2008 report on European BMD with a briefing slide that stated:

- **IDA completed an independent assessment of proposed European deployments and alternatives for protecting the United States, Europe and forward deployed forces and radars**

- Study of alternatives focused on current baseline European Site Initiative, Aegis BMD SM-3 IB and SM-3 IIA

- **Interceptor Availability**

- Current baseline (2-stage GBI [ground-based interceptor]) is available in 2013

- SM-3 IB is also available in 2013, SM-3 IIA available in 2015

⁵⁶ Elaine M. Grossman, “U.S. Navy Eyes Rising Need to Defend Czechs, Poles,” *Global Security Newswire*, August 1, 2008.

- **Operational Effectiveness**

- Current baseline covers all portions of Europe vulnerable to long-range ballistic missile attack from Iran and provides redundant coverage of majority of U.S.

- Aegis BMD (SM-3 IB) provides no coverage of the U.S. against long-range attack and some coverage of Europe (improved when integrated with X-band radars)

- The Aegis BMD (SM-3 IIA) provides some defense of U.S. against long-range attacks and coverage of Europe (improved when integrated with X-band radars)

- **Cost**

- Aegis BMD options have higher acquisition costs than baseline option

- Life cycle cost for each Aegis BMD option over 35 years is two to three times greater than the estimated life cycle cost of the current baseline system⁵⁷

Potential oversight questions for Congress include the following: To what extent could sea-based BMD systems perform functions that would be carried out by the Administration's proposed European BMD system? How many Aegis BMD ships would be required? What would be the comparative advantages and disadvantages of the Aegis BMD system as a partial or complete alternative to the proposed European BMD system? What was the exact nature of the commitment reportedly made by the United States to the Czech government regarding the use of Aegis ships to provide BMD protection for the Czech Republic?

For more on the debate concerning the European-based BMD system, see CRS Report RL34051, *Long-Range Ballistic Missile Defense in Europe*, by Steven A. Hildreth and Carl Ek.

Number of SM-3 Missiles Planned for Procurement

Is the number of SM-3 interceptors that DOD plans to procure sufficient?

Another potential oversight issue for Congress is whether DOD is planning to procure a sufficient number of SM-3 interceptors.

As mentioned earlier, current DOD plans call for procuring a total of 147 SM-3 Block IA and IB interceptors, of which 133 are to be deployed on Aegis ships. (The other 14 apparently are to be used for testing or research.) Of the 133 SM-3 Block IA and IB interceptors to be deployed on Aegis ships, 34 are to be deployed by the end of calendar 2008, and all 133 are to be deployed by 2013.⁵⁸

⁵⁷ Slide 18 in briefing entitled "Missile Defense Program Overview For The 11th Annual Space & Missile Defense Conference," dated August 13, 2008, presented by Lieutenant General Trey Obering, USAF, Director, Missile Defense Agency. Source for briefing: *InsideDefense.com* (subscription required). Emboldening as in the original. Each slide in the briefing includes a note indicating that it was approved by MDA for public release on August 6, 2008.

⁵⁸ Source: Slides 7, 12, and 14 in the 20-slide briefing entitled "Ballistic Missile Defense (continued...)"

A June 20, 2008, briefing by MDA on BMD programs indicates that MDA anticipates increasing the planned number of SM-3 Block 1A and 1B interceptors to be deployed on Aegis ships from 133 to 249, and having all 249 interceptors deployed by 2016.⁵⁹ This apparent forthcoming increase in the planned total number of SM-3 Block 1A and 1B interceptors follows congressional report language and press reports on the issue of planned SM-3 inventory levels that are summarized below.

FY2008 Defense Authorization Act. The House Armed Services Committee, in its report (H.Rept. 110-146 of May 11, 2007) on the FY2008 defense authorization bill (H.R. 1585), stated that:

the recent Capabilities Mix Study completed by U.S. Strategic Command has indicated that combatant commanders require twice as many SM-3 interceptors than the 147 that are currently planned.⁶⁰

The Senate Armed Services Committee, in its report (S.Rept. 110-77 of June 5, 2007) on the FY2008 defense authorization bill (S. 1547), stated:

Currently MDA plans to procure only some 147 SM-3 missiles of all Block I varieties. The Commander, Joint Forces Component Command for Integrated Missile Defense (JFCC-IMD) testified in April 2007 that recent analyses indicate a need to nearly double the number of planned SM-3 interceptors. The committee urges MDA to plan and budget for increased numbers of SM-3 interceptors to meet the needs of regional combatant commanders, as indicated by the Commander, JFCC-IMD.⁶¹

Press Reports. A May 2007 press report stated that:

A preliminary DOD study points to the need for more Standard Missile-3 (SM-3) sea-based missile defense interceptors and Terminal High-Altitude Area Defense (THAAD) interceptors, according to Lt. Gen. Kevin Campbell, commander of U.S. Army Space and Missile Defense Command (SMDC).

⁵⁸ (...continued)

Program Overview For The Congressional Breakfast Seminar Series,” dated June 20, 2008, presented by Lieutenant General Trey Obering, USAF, Director, Missile Defense Agency. Source for briefing: *InsideDefense.com* (subscription required). Each slide in the briefing includes a note indicating that it was approved by MDA for public release on June 13, 2008.

⁵⁹ Source: Slide 14 in the 20-slide briefing entitled “Ballistic Missile Defense Program Overview For The Congressional Breakfast Seminar Series,” dated June 20, 2008, presented by Lieutenant General Trey Obering, USAF, Director, Missile Defense Agency. Source for briefing: *InsideDefense.com* (subscription required). Each slide in the briefing includes a note indicating that it was approved by MDA for public release on June 13, 2008. See also Emelie Rutherford, “Obering: MDA Seeking Efficiencies To Fit Significant SM-3, THAAD Boost In POM ‘10 Request,” *Defense Daily*, June 24, 2008.

⁶⁰ H.Rept. 110-146, p. 235.

⁶¹ S.Rept. 110-77, p. 264.

The study examined various major combat operations around the world, estimating the percentages of enemy missiles that would be taken out by conventional forces or felled by system failures. The current SM-3/THAAD interceptor inventory then was compared to a list of critical assets identified by DOD combatant commanders that need to be defended.

Near-term U.S. missile defense capabilities are “limited” primarily by interceptor inventory, Campbell said at a May 16 breakfast in Washington sponsored by National Defense University. In addition to SM-3s and THAAD interceptors, DOD also needs more Patriot battalions and ground-based interceptors, according to Campbell.⁶²

In late November 2007, Rear Admiral Alan Hicks, Aegis BMD program director, reportedly stated that

that even with 132 Standard Missiles (SMs) expected in the inventory by 2013, there should be more to meet potential global requirements.

“We need more than that,” he said Nov. 28. “Inventory is inadequate to meet our needs.” ...

But the admiral acknowledged that Aegis SM inventory also must be weighed against Theater High Altitude Area Defense and Patriot Advanced Capability missile inventories.⁶³

Another press report based on the same speech by Hicks stated that

Hicks observed that the military will have 153 short- and mid-term missile interceptors in the inventory by the end of 2009, but added that he believes the Navy needs to expand the program beyond current plans. “Is it enough? No,” Hicks said. “Inventory’s inadequate to meet our needs.”⁶⁴

An April 2008 press report stated that:

Two senior Pentagon officials said they are working to bolster ballistic missile defense fielding in the near term, an effort that could double the number of planned Aegis Ballistic Missile Defense and Terminal High Altitude Area Defense (THAAD) assets in the coming years.

Missile Defense Agency Director Air Force Lt. Gen. Trey Obering told reporters yesterday he wants the number of Aegis and THAAD interceptors to

⁶² Jefferson Morris, “Study Points To Need For More SM-3s, THAAD Interceptors,” *Aerospace Daily & Defense Report*, May 17, 2007: 3.

⁶³ Michael Bruno, “Aegis BMD Program Chief Calls for More Missiles,” *Aerospace Daily & Defense Report*, November 29, 2007: 1-2.

⁶⁴ Megan Scully, “FY08 Funding Boost To Help Navy Deploy Missile Defenses,” *National Journal’s CongressDailyPM*, November 28, 2007.

be increased during Pentagon discussions on Program Objective Memorandum 10 (POM '10).⁶⁵

He said plans now spelled out in the five-year future years defense plan running until fiscal year 2013 call for approximately 133 Standard Missile-3s (SM-3s) that are part of the Aegis system, and 96 THAADs. He said he would like to see those numbers “roughly” double starting with the FY '10 budget and going until the “‘15, '16 timeframe.”

“If you take a look at what’s in our budget today and you look over the FYDP, and double that, you come close,” to the number of Aegis and THAAD interceptors he would like, Obering said.

Specifically, he said he would like to roughly double the current production rate.

“How much that equates to across the FYDP depends on how much money the [Defense] Department allocates to them,” he said. “But if they allocate the money that we would recommend to do this, it would roughly double the number of missiles across the FYDP.”

Such an increase would not double the amount of needed money, he said, because economies of scale and running of production lines would control costs.

Pentagon acquisition executive John Young submitted written testimony to the House Armed Services strategic forces subcommittee yesterday talking about this desire to field additional ballistic missile defense assets in the near-terms.

“System elements like Aegis Ballistic Missile Defense and the Terminal High Altitude Area Defense could provide our Combatant Commanders as well as our friends and allies a significant defensive capability in just a few years,” Young wrote. “I am working with General Obering to achieve this goal through the [Defense] Department’s programming and budgeting process.”...

Obering told reporters that the warfighters — Joint Staff and U.S. Strategic Command — actually make decisions on the matter, and that MDA generally doesn’t make force-structure decisions.

“That’s up to the warfighters,” he said. “So they came in and they said this is the force structure we believe we need, looking at the scenarios that they may be faced with, that’s what they’re doing.”

As to where the extra money would come from for the additional ballistic missile defense interceptors, Obering said that would be hashed out during the POM '10 process.

⁶⁵ The Program Objective Memorandum is an internal DOD memorandum that provides guidance for the preparation of the defense budget for a future fiscal year. POM 10 is the POM for preparing the FY2010 defense budget.

“Whether we take it out of our portfolio, whether it is a combination of service money or our money, that’s what we have to go through this budget process and we’ll come up with our POM ‘10 number,” he said.⁶⁶

Another press report carrying the same date made similar points and stated that “The 2007 Joint Capabilities Mix Study II, recently approved by DOD’s Joint Requirements Oversight Council, concluded that combatant commanders required at least twice as many SM-3 and THAAD interceptors as currently planned.”⁶⁷

Multiple Kill Vehicle (MKV) for SM-3 Block IIA Missile

Should the Block IIA version of the Standard Missile 3 (SM-3) interceptor missile be equipped with the Multiple Kill Vehicle (MKV) now in development?

Another potential oversight issue for Congress is whether the SM-3 should be equipped with the Multiple Kill Vehicle (MKV) instead of the currently planned unitary (i.e., single-target-capable) warhead, and if so, what effect this might have on the cooperative program with Japan for developing the SM-3 Block IIA and the schedule for deploying the interceptor.

The MKV is a new BMD interceptor warhead being developed by MDA that would permit a single interceptor to attempt to destroy more than one BMD target. MDA is considering whether to equip certain interceptors, including the SM-3 Block IIA, with the MKV. The MKV is expected by DOD to achieve initial capability in 2017.⁶⁸

FY2008 Defense Authorization Act. The House Armed Services Committee, in its report (H.Rept. 110-146 of May 11, 2007) on the FY2008 defense authorization bill (H.R. 1585), stated that:

the current family of exo-atmospheric kill vehicles are capable of dealing with the near- to mid-term threats that the nation is likely to face from rogue nations such as Iran and North Korea. Additionally, in budget justification materials, the Missile Defense Agency (MDA) notes that it plans to replace the unitary warhead on the SM-3 Block IIA missile, which the United States is co-developing with Japan, with the MKV. The committee is concerned that MDA has taken this decision without fully consulting with the Japanese Government and that this decision has the potential to delay the fielding the SM-3 Block IIA missile, a system that the committee believes is vital to the security of the United States and our allies around the world.

⁶⁶ Emelie Rutherford, “Pentagon Officials Eye Increasing Near-Term Ballistic Missile Defense Assets In POM ‘10,” *Defense Daily*, April 18, 2008.

⁶⁷ Michael Bruno, “MDA Looks to Double Aegis, THAAD Interceptor Production,” *Aerospace Daily & Defence Report*, April 18, 2008: 1-2.

⁶⁸ For more on the MKV, see Government Accountability Office, *Defense Acquisitions[:] Assessments of Selected Weapon Programs*, March 2008 (GAO-08-467SP), pp. 133-134.

Section 224 of the conference report (H.Rept. 110-477 of December 6, 2007) on H.R. 1585 states:

SEC. 224. LIMITATION ON USE OF FUNDS FOR REPLACING WARHEAD ON SM-3 BLOCK IIA MISSILE.

None of the funds appropriated or otherwise made available pursuant to an authorization of appropriations in this Act may be obligated or expended to replace the unitary warhead on the SM-3 Block IIA missile with the Multiple Kill Vehicle until after the Secretary of Defense certifies to Congress that —

(1) the United States and Japan have reached an agreement to replace the unitary warhead on the SM-3 Block IIA missile; and

(2) replacing the unitary warhead on the SM-3 Block IIA missile with the Multiple Kill Vehicle will not delay the expected deployment date of 2014 — 2015 for that missile.

Regarding Section 224, the conference report states:

The conferees note that the Missile Defense Agency (MDA) has indicated an interest in replacing the unitary kill vehicle development program, which is specified in the agreement with Japan, with a new MKV development program. This would have undermined the agreed program of cooperation between the United States and Japan on joint development of the SM-3 Block IIA interceptor missile. It is important to support the joint development program in accordance with the agreed program of record, which currently specifies a unitary kill vehicle.

This provision does not restrict the MDA from conducting research, development, analysis, or testing of MKV technologies, including those which could be used in the future with the SM-3 Block IIA missile. It also does not restrict MDA from conducting analysis and discussions with Japanese officials to consider the possibility of including MKV on the SM-3 Block IIA.⁶⁹

FY2008 Defense Appropriations Act. The Senate Appropriations Committee, in its report (S.Rept. 110-155 of September 14, 2007) on the FY2008 defense appropriations bill (H.R. 3222), stated that:

the Committee is concerned that MDA has not fully consulted the Japanese about their intention to replace the Standard Missile-3 (SM-3) Block IIA program with MKV. The Japanese have already committed to funding half of the \$2,500,000,000 SM-3 Block IIA development effort with the United States. The Standard Missile is performing extremely well in the Aegis sea-based tests, and

⁶⁹ H.Rept. 110-477, p. 829. H.R. 1585 was vetoed by the President on December 28, 2008. A new bill, H.R. 4986, was passed with changes that took into account the President's objection to certain parts of H.R. 1585. The President's objection to certain parts of H.R. 1585 did not relate to Section 224 or the report language cited here. H.R. 4986 was signed into law as P.L. 110-181 of January 28, 2008. Except for the changes made by Congress to take into account the President's objection to certain parts of H.R. 1585, H.Rept. 110-477 in effect serves as the conference report for H.R. 4986.

upgrades to that system are less risky and will provide near-term capability sooner than moving to an unproven, technically immature MKV for the Aegis system.

The conference report (H.Rept. 110-434 of November 6, 2007) on H.R. 3222/P.L. 110-116 of November 13, 2007, reduced to zero the \$62.9 million FY2008 research and development funding request, within the line item for multiple kill vehicles, for the multiple engagement payload (MEP) for the SM-3. (Page 341). The report stated:

The conferees are concerned that the Missile Defense Agency (MDA) does not have the resources to adequately fund both MEP and the Multiple Kill Vehicle (MKV) for the Ground-Based Interceptor (GBI) and the Kinetic Energy Interceptor (KEI). Thus, the conferees agree to increase the MKV for the GBI [Ground-Based Interceptor] and KEI by \$25,000,000 in order to restore reductions that the MDA has annually taken out of this program. The conferees further agree with the Senate language that directs that no funding in the Aegis Ballistic Missile Defense program element can be used for the MKV program. Additionally, the conferees direct that the Multiple Kill Vehicle, PE 0603894 is designated as a congressional special interest item subject to prior approval reprogramming procedures.⁷⁰

Press Report. A December 3, 2007 press report stated:

The Missile Defense Agency likely will make another attempt next year to secure money for Raytheon's multiple kill vehicle (MKV) for the Navy's ballistic missile defense program, which had its funding axed by Congress in this year's budget, the Aegis BMD program director said during a talk at the National Press Club Nov. 28.

"Within the MDA, we're going to look for opportunities" to talk with Congress about the issue again in the near future, Rear Adm. Alan Hicks told attendees of the round table discussion, which was sponsored by the George C. Marshall Institute to discuss the status of the Aegis program....

"I think we will talk within the administration once the [fiscal year 2009] budget's all solidified and get a position, and then we will go to Congress and talk and see what they feel, how they feel," he said in an interview with *Inside the Navy* after his presentation.

The unitary version of the SM-3 missile was "priority one," but "to get an extra kill vehicle or two on top of the SM-3 and provide options against more advanced threats in the future is something, obviously, I'd like to have as an option," Hicks told attendees. "So we'll see how that plays out over the year."⁷¹

⁷⁰ H.Rept. 110-434, p. 346.

⁷¹ Dan Taylor, "Navy Still Interested in Second MKV, MDA Will Talk to Congress," *Inside the Navy*, December 3, 2007.

Far-Term Sea-Based Terminal Program

Should development of the far-term sea-based terminal capability be accelerated?

Another potential oversight question for Congress is whether development of the far-term sea-based terminal BMD capability should be accelerated. Supporters of DOD's sea-based terminal program could argue that the Block 2.0 sea-based terminal capability will provide Navy ships with a sufficient degree of terminal defense capability until the anticipated deployment of the far-term capability. They could also argue that accelerating development of the far-term capability could increase development risks or require reducing funding for other BMD programs or other DOD priorities, increasing operational risks in other areas.

Supporters of accelerating development of the far-term capability could argue that an improved terminal-defense capability could prove useful if not critical in the near term as well as the far term for intercepting missiles — such as SRBMs or ballistic missiles fired along depressed trajectories — that do not fly high enough to exit the atmosphere and consequently cannot be intercepted by the SM-3. They could also argue accelerating development of the far-term capability could improve the Navy's ability to counter Chinese TBMs equipped with maneuverable reentry vehicles (MaRVs) capable of hitting moving ships at sea.⁷²

Kinetic Energy Interceptor (KEI)

If the Kinetic Energy Interceptor (KEI) is developed for land-based BMD operations, should it also be based at sea? If so, what kind of sea-based platform should be used?

Another potential issue for Congress concerns the Kinetic Energy Interceptor (KEI) — a new BMD interceptor now in development that could be used as a ground- or sea-based BMD interceptor. Under current DOD plans, the land-based version of the KEI could become available use by the middle of the next decade.⁷³

Compared to the SM-3, the KEI would be much larger (reportedly 40 inches in diameter and almost 39 feet in length) and would have a much higher burnout velocity. Because of its much higher burnout velocity, it might be possible to use a

⁷² As discussed in another CRS report, China may now be developing TBMs equipped with maneuverable reentry vehicles (MaRVs). Observers have expressed strong concern about this potential development, because such missiles, in combination with a broad-area maritime surveillance and targeting system, would permit China to attack moving U.S. Navy ships at sea. The U.S. Navy has not previously faced a threat from highly accurate ballistic missiles capable of hitting moving ships at sea. Due to their ability to change course, MaRVs would be more difficult to intercept than non-maneuvering ballistic missile reentry vehicles. See CRS Report RL33153, *China Naval Modernization: Implications for U.S. Navy Capabilities — Background and Issues for Congress*, by Ronald O'Rourke.

⁷³ For more on the KEI, see Government Accountability Office, *Defense Acquisitions[:] Assessments of Selected Weapon Programs*, March 2008 (GAO-08-467SP), pp. 115-116.

KEI based on a forward-deployed ship to attempt to intercept ballistic missiles during the boost and early ascent phases of their flights.

The KEI could also be used by a ship to conduct midcourse intercepts. In the midcourse intercept role, the KEI, due to its higher burnout velocity, would appear capable of providing a larger defended footprint, and a greater capability to intercept ICBMs, than the SM-3 Block IIA. A June 20, 2008, MDA briefing on BMD programs indicates that MDA anticipates using the KEI as a sea-based midcourse interceptor, with an initial sea-based midcourse flight test in 2014 and the missile becoming operationally as a sea-based midcourse interceptor available in 2015.⁷⁴

The issue is whether the KEI, if developed, should be based at sea, and if so, what kind of sea-based platform should be used. Basing the KEI on a ship would require the ship to have missile-launch tubes that are bigger than those currently installed on Navy cruisers, destroyers, and attack submarines. Potential sea-based platforms for the KEI include, but are not necessarily limited to, the following:

- ballistic missile submarines (which have launch tubes large enough to accommodate the KEI);
- surface combatants equipped with newly developed missile-launch tubes large enough for the KEI; and
- a non-combat DOD ship (perhaps based on a commercial hull) or floating platform.

Supporters of deploying the KEI at sea could argue that it could enable Navy ships to attempt to intercept certain missiles during the boost phase of flight, and that in the midcourse intercept role, it would provide a greater defended footprint, and a greater capability for intercepting ICBMs, than the SM-3 Block IIA. Skeptics could argue that in light of other planned BMD capabilities, the need for basing the KEI at sea for either boost-phase or midcourse intercepts is not clear.

Among supporters of basing the KEI at sea, supporters of basing it on ballistic missile submarines could argue that submarines can operate close to enemy coasts, in positions suitable for attempting to intercept missiles during their boost phase of flight, while remaining undetected and less vulnerable to attack than surface platforms. Skeptics of basing the KEI on ballistic missile submarines could argue that communication links to submarines are not sufficiently fast to support boost-phase intercept operations, and that launching the KEI could give away the submarine's location, making it potentially vulnerable to attack.

⁷⁴ Source: Slide 14 in the 20-slide briefing entitled "Ballistic Missile Defense Program Overview For The Congressional Breakfast Seminar Series," dated June 20, 2008, presented by Lieutenant General Trey Obering, USAF, Director, Missile Defense Agency. Source for briefing: *InsideDefense.com* (subscription required). Each slide in the briefing includes a note indicating that it was approved by MDA for public release on June 13, 2008.

Supporters of basing the KEI on surface combatants equipped with missile-launch tubes large enough for the KEI could argue that surface ships have faster communication links than submarines and more capability to defend themselves than non-combat ships or floating platforms. Skeptics could argue that surface combatants might not be able to get close enough to enemy coasts to permit boost-phase intercepts, and that the defensive capabilities of a surface combatant are excessive to what would be needed for a KEI platform operating in the middle of the ocean, far from potential threats, for the purpose of using the KEI for midcourse intercepts.

Supporters of a non-combat ship or floating platform could argue that a non-combat ship or floating platform would be suitable for basing the KEI in mid-ocean locations, far from potential threats, for the purpose of using the KEI for midcourse intercepts. Skeptics could argue that using such a platform could not be used close to an enemy coast, for the purpose of attempting a boost-phase intercept, unless it were protected by other forces.

One potential surface-combatant candidate for carrying the KEI is the Navy's planned CG(X) cruiser (see discussion below).

FY2008 Defense Appropriations Act. The Senate Appropriations Committee, in its report (S.Rept. 110-155 of September 14, 2007) on the FY2008 defense appropriations bill (H.R. 3222), stated:

According to the budget justification materials, KEI has three objectives: “(1) to develop a midcourse interceptor capable of replacing the current fixed Ground-based interceptor (GBI) when the deployed GBIs become obsolete; (2) to develop this interceptor so that it could be strategically deployed as an additional midcourse capability with mobile land- or sea-based launchers; and (3) to assume the boost- and ascent-phase intercept mission within the Ballistic Missile Defense System (BMDS) if the Airborne Laser (ABL) fails to meet its performance objectives.” The Committee believes that these objectives are premature, that existing systems can achieve the same goals, and that the missile is not suitable for Navy platforms....

The Committee is concerned that MDA is developing KEI as a replacement for the GBI's prematurely since the GBI's are still under development, the fielded GBI's undergo continuous upgrades and retrofits, and the GBI's still have to undergo significant testing. Furthermore, additional midcourse capability can be achieved with upgrading current mobile systems, such as Theater High Altitude Area Defense [THAAD]. In addition, a study is currently underway on sea-basing the KEI, including an examination of Navy platforms suitable for hosting the large KEI. The Committee has not been informed that any current or future Navy ship will be outfitted with the KEI, and it appears that there are few, if any, viable platforms. Therefore, the Committee recommends a reduction of \$30,000,000 for the KEI program.⁷⁵

Press Report. According to a July 2007 press article, the CG(X) AOA will recommend that the CG(X) not carry the KEI:

⁷⁵ S.Rept. 110-155, p. 268.

[Sources] say the analysis will recommend dropping the Kinetic Energy Interceptor (KEI) from the CG(X) program....

The KEI is much larger than the SM-3 Standard missile developed by Raytheon to arm Navy cruisers and destroyers for the BMD role. The 40-inch diameter KEI is nearly 39 feet long, while the 21-inch diameter SM-3 stands just over 21 feet tall. Both missiles use a kinetic energy warhead, intended to ram an enemy missile.

Sources said a missile launch tube for a KEI would need to be so large it would take the place of six SM-3 launch cells.

“That’s a poor exchange ratio,” said one naval analyst familiar with the AoA.⁷⁶

CG(X) Cruiser

Should procurement of the planned CG(X) cruiser be accelerated?

As replacements for its 22 Aegis cruisers, the Navy plans to procure 19 new CG(X) cruisers. The radar capabilities of the CG(X) are to be greater than that of the Navy’s Aegis ships, and the CG(X) has been justified primarily in connection with future air defense and BMD operations. Under the Navy’s FY2009 budget submission, the first CG(X) is to be procured in FY2011, and the final ship in FY2023. It has been reported, however, that the Navy may defer the scheduled procurement of the first ship to FY2015 or later.⁷⁷ If procured as planned under the FY2009 budget, the first CG(X) might enter service in 2017, and the final ship might enter service in 2029.⁷⁸

A potential issue for Congress is whether the planned CG(X) procurement profile would be sufficient to achieve the desired level of sea-based BMD capability in a timely manner. If not, then one option would be to accelerate procurement of some of the later ships in the CG(X) program.⁷⁹

Development and Testing of Aegis BMD System

Are there lessons from development and testing of the Aegis BMD system that can be applied to programs for developing and testing BMD systems?

⁷⁶ Christopher P. Cavas, “U.S. May Build 25,000-Ton Cruiser, Analysis of Alternatives Sees Nuclear BMD Vessel,” *Defense News*, July 23, 2007.

⁷⁷ See, for example, Christopher P. Cavas, “DDG 1000 Destroyer Program Facing Major Cuts,” *DefenseNews.com*, July 14, 2008. See also Geoff Fein, “Navy Likely To Change CG(X)’s Procurement Schedule, Official Says,” *Defense Daily*, June 24, 2008; Rebekah Gordon, “Navy Agrees CG(X) By FY-11 Won’t Happen But Reveals Little Else,” *Inside the Navy*, June 30, 2008.

⁷⁸ For more on the CG(X) program, see CRS Report RL34179, *Navy CG(X) Cruiser Program: Background, Oversight Issues, and Options for Congress*, by Ronald O’Rourke.

⁷⁹ For a discussion of this option, see CRS Report RL34179, *op cit*.

With 13 successful exo-atmospheric intercepts in 15 attempts, the Aegis BMD program has achieved high rate of successful intercepts. At least some part of the Aegis BMD program's high success rate may be due to two factors:

- The configuration of the Aegis BMD system that has been tested to date is intended to shoot down shorter-range ballistic missiles. In general, shorter-range missiles fly at lower speeds than longer-ranged missiles, and interceptors intended to shoot down shorter-ranged ballistic missiles don't need to be as fast as interceptors intended to shoot down longer-ranged ballistic missiles. Consequently, the closing speeds⁸⁰ involved in intercepts of shorter-ranged ballistic missiles are generally lower than those for intercepts of longer-ranged ballistic missiles. Intercept involving lower closing speeds can be less difficult to attempt than intercepts involving higher closing speeds. In BMD tests over more than 20 years, tests of shorter-range kinetic-energy BMD systems has generally been more successful than tests of longer-range BMD systems.⁸¹
- The Aegis BMD system is being developed as an extension of the existing Aegis air defense system, and can thus benefit from the proven radar, software, and interceptor technology of that system, whereas the ground-based midcourse system is being developed essentially as a relatively new weapon system.

The potential question is whether these two factors account completely for the high success rates for testing of the Aegis BMD program. If they do not, then one potential issue for Congress is whether there is something about the approach adopted for developing and testing the Aegis BMD capability that accounts for part of the difference.

As mentioned earlier, the Aegis BMD program says it has focused since its inception on the philosophy of "test a little, learn a lot." It can also be noted that the Navy has a long history of air-defense missile development programs, and has established a record of technical discipline, rigorousness, and excellence in areas such as nuclear propulsion and submarine-launched ballistic missiles. Potential questions for Congress include the following:

- How does the Aegis BMD programs compare to other BMD development programs in terms of their approaches for system development and testing?
- Are there features of the Aegis BMD program's approach that, if applied to other U.S. BMD programs, could improve the development and test efforts for these other programs?

⁸⁰ Closing speed is the relative speed at which the missile warhead and the interceptor kinetic kill vehicle approach one another.

⁸¹ For a discussion, see CRS Report RL33240, *Kinetic Energy Kill for Ballistic Missile Defense: A Status Overview*, by Steven A. Hildreth.

Cooperation With Allies

Should current U.S. efforts for helping to establish BMD capabilities in allied navies be reduced, accelerated, or maintained at current levels?

An additional potential issue for Congress is whether U.S. efforts for helping to establish BMD capabilities in allied navies should be reduced, accelerated, or maintained at current levels. Potential oversight questions for Congress include the following:

- What are the potential military and political advantages and disadvantages of establishing BMD capabilities in allied navies?
- To what degree, if any, would these capabilities be integrated into the overall U.S. BMD architecture? How, in terms of technology, command and control, doctrine, and training, would such an integration be accomplished? If these capabilities are not integrated into the U.S. architecture, what kind of coordination mechanisms might be needed to maximize the collective utility of U.S. and allied sea-based BMD capabilities or to ensure that they do not work at cross-purposes?
- How might the establishment of BMD capabilities in allied navies affect U.S. requirements for sea-based BMD systems? To what degree, if any, could allied BMD ships perform BMD operations now envisaged for U.S. Aegis ships?
- What are the potential implications for regional security of missile proliferation and proliferation of BMD systems?

Legislative Activity for FY2009

FY2009 Defense Authorization Bill (H.R. 5658/S. 3001)

House. The House Armed Services Committee, in its report (H.Rept. 110-652 of May 16, 2008) on H.R. 5658, recommended a total of \$111 million in the Defense-Wide procurement account for procurement of SM-3 interceptors. This total includes the transfer into the Defense-Wide procurement account of \$56 million that was requested in the Defense-Wide research and development account, and an additional \$55 million that was not requested in the proposed FY2009 budget — \$20 million for facility upgrades, and \$35 million for procurement of long-leadtime items. (Page 136, line 95) In discussing this recommendation, the report states:

The budget request contained no funds for advanced procurement of Standard Missile-3 (SM-3) interceptors.

Consistent with the findings of the Joint Capabilities Mix Study II, which indicated that the combatant commanders require, at minimum, twice as many SM-3 interceptors than the 133 now planned, the committee strongly supports

efforts to increase production of SM-3 interceptors to counter the threat from short- and medium-range ballistic missiles.

In accordance with section 223 of the National Defense Authorization Act for Fiscal Year 2008 (Public Law 110-181), the committee recommends the transfer of \$56.0 million of the funds from PE 63892C for advanced procurement of SM-3 interceptors to be executed by the Missile Defense Agency.

Furthermore, the committee recommends an additional increase of \$55.0 million for SM-3 production. Of this amount, \$20.0 million is for facility upgrades that will increase the capacity to manufacture 4 or more SM-3 missiles per month in fiscal year 2010, and \$35.0 million is for long-lead procurement of an additional 12 SM-3 missiles.

Therefore, the committee recommends a total increase of \$111.0 million for procurement of SM-3 interceptors. (Page 137)

Within the Defense-Wide research and development account, the report recommends an additional \$20 million for the Aegis BMD program for BMD signal processors. The report at this point also notes the above-described transfer of \$56 million in funding for procurement for SM-3s from this account to the Defense-Wide procurement account. The net result of these two actions is a recommended \$36-million reduction to the request for FY2009 research and development funding for the Aegis BMD program. (Page 241, line 81) In discussing this recommendation, the report states:

The budget request contained [about] \$1.2 billion [note: \$1,157.8 million] in PE 63892C, for the sea-based Aegis Ballistic Missile Defense (BMD), which is designed to defend against short-, medium-, and intermediate-range ballistic missiles.

The committee notes its continuing concern that the Missile Defense Agency is not providing sufficient funds for Aegis BMD. Given the threat posed by short- and medium-range ballistic missiles, the committee is concerned that the 133 Standard Missile-3 (SM-3) interceptors that are currently planned will be insufficient. The committee's views are consistent with the results of the recently completed Joint Capabilities Mix Study II, which concluded that combatant commanders require nearly twice as many SM-3 interceptors than the 133 now planned. Elsewhere in this Act, the committee has increased funding for SM-3 production.

The committee also notes its strong support for the United States-Japan Cooperative Development Program, which is co-developing the SM-3 Block IIA missile designed to counter longer-range ballistic missile threats. The committee expects the Missile Defense Agency to continue to support the development of the current unitary kill vehicle for that interceptor.

The committee recommends an increase of \$20.0 million in PE 63892C for the purchase of additional ballistic missile signal processors. Furthermore, in accordance with section 223 of the National Defense Authorization Act for Fiscal Year 2008 (Public Law 110-181), the committee recommends the transfer of \$56.0 million for procurement of SM-3 interceptors to title 1 [procurement].

The committee, therefore, recommends a total of [about] \$1.1 billion [note: \$1,121.8 million], a decrease of \$36.0 million, in PE 63892C for Aegis BMD. (Pages 255-256)

Senate. The Senate Armed Services Committee, in its report (S.Rept. 110-335 of May 12, 2008) on S. 3001, recommended a total of \$77 million in the Defense-Wide procurement account for procurement of long-leadtime items for SM-3 interceptors. This total includes the transfer into the Defense-Wide procurement account of \$57 million that was requested in the Defense-Wide research and development account, and an additional \$20 million that was not requested in the proposed FY2009 budget. (Page 110, line 001a) In discussing this recommendation, the report states:

The budget request included no procurement funds for long lead procurement of Standard Missile-3 (SM-3) interceptors for the Aegis Ballistic Missile Defense (BMD) system. Contrary to the law, the budget request included \$57.0 million in research and development (R&D) funds in PE 63892C for long lead procurement of SM-3 Block IA missiles. The committee recommends transferring the requested \$57.0 million in R&D funds to a new defense-wide procurement funding line for procurement of long lead items for SM-3 interceptors, consistent with the law. The committee also recommends an increase of \$20.0 million in the new Procurement, Defense-wide line for long lead procurement of an additional 15 SM-3 interceptor missiles.

Section 223(b) of the National Defense Authorization Act for Fiscal Year 2008 (Public Law 110-181) required the Department of Defense to request any long lead procurement funding for SM-3 interceptors, and THAAD Fire Units 3 and 4, in the fiscal year 2009 budget request using procurement funds, rather than R&D funds. In addition, section 223(c) of that act prohibits the use of fiscal year 2009 R&D funds for procurement of long lead items for SM-3 interceptors and THAAD Fire Units 3 and 4.

The committee is deeply disappointed that the Department of Defense chose not to comply with the requirements of section 223 of the National Defense Authorization Act for Fiscal Year 2008 (Public Law 110-181), and directs the Director of the Missile Defense Agency and the Under Secretary of Defense (Comptroller) to jointly provide a report to the congressional defense committees by no later than October 1, 2008, providing a detailed explanation of the reasons the Department chose not to comply with the law, and an explanation of the Department's plans to comply with the law.

The committee notes that the Joint Capabilities Mix (JCM) study, conducted by the Joint Staff, concluded that U.S. combatant commanders need about twice as many SM-3 and THAAD interceptors as currently planned to meet just their minimum operational requirements for defending against the many hundreds of existing short- and medium-range ballistic missiles. The committee is deeply disappointed that the Missile Defense Agency (MDA) has not planned or budgeted to acquire more than a fraction of the SM-3 interceptors needed to meet the warfighters' minimum operational needs, and that it does not plan to fund additional procurement beyond fiscal year 2010. The committee believes that achieving at least the JCM levels of upper tier interceptors in a timely manner should be the highest priority for MDA, and expects the Agency to modify its plans and budgets to meet our combatant commanders' current

operational needs. In section 223 of the John Warner National Defense Authorization Act for Fiscal Year 2007 (Public Law 109-364), Congress specified the Aegis BMD system and its SM-3 interceptor as a high priority near-term program for the Department to focus on. As the JCM study makes clear, the Department has failed to do so.

To address these concerns, the committee recommends an increase of \$20.0 million in the new defense-wide procurement funding line for long lead procurement of an additional 15 SM-3 missiles to start to address the need to meet the requirements identified in the JCM analysis. As described elsewhere in this report, the committee also recommends increases of \$80.0 million for increasing the production rate of the SM-3 missile, reducing schedule risk for the SM-3 Block IB missile, and for improving the capability of the Aegis BMD system to conduct engagements using offboard sensors, known as “engage on remote,” and to engage missiles in the ascent phase of midcourse flight. (Pages 119-120)

Within the Defense-Wide research and development account, the report recommends an additional \$80 million for the Aegis BMD program for “Aegis BMD/SM-3 enhancement.” The report at this point also notes the above-described transfer of \$57 million in funding for procurement for SM-3s from this account to the Defense-Wide procurement account. The net result of these two actions is a recommended \$23-million increase to the request for FY2009 research and development funding for the Aegis BMD program. (Page 233, line 81) In discussing this recommendation, the report states:

The budget request included \$1.2 billion in PE 63892C for the Aegis Ballistic Missile Defense (BMD) program, including \$57.0 million for long lead procurement of Standard Missile-3 (SM-3) Block IA interceptor missiles. The committee notes that the Aegis BMD system with its SM-3 interceptor is the only midcourse defense system currently being deployed to provide defense against short- and medium-range ballistic missile threats to our forward-deployed forces, allies, and other friendly nations. The Aegis BMD system has had an impressive record of successful tests against short- and medium-range targets, including a multi-mission test against a ballistic missile and an air-breathing threat, and a multiple target intercept against two ballistic missile targets.

The SM-3 missile is being developed to have increasing capability with each successive version, from Block IA, to Block IB, to the Block IIA version being developed jointly with Japan. The Aegis BMD system and its SM-3 interceptor have the potential to provide a significant measure of defensive capability in various regions of the world, and to increase its capability to conduct intercepts based on radar tracks from offboard sensors, known as “engage on remote,” and to engage missiles early in their midcourse flight, including in the ascent phase.

The committee notes that the Joint Capabilities Mix (JCM) study, conducted by the Joint Staff, concluded that U.S. combatant commanders need about twice as many SM-3 and THAAD interceptors as currently planned to meet just their minimum operational requirements for defending against the many hundreds of existing short- and medium-range ballistic missiles. The committee is deeply disappointed that the Missile Defense Agency (MDA) has not planned or budgeted to acquire more than a fraction of the SM-3 interceptors needed to

meet the warfighters' minimum operational needs. The committee believes that achieving at least the JCM levels of upper tier interceptors in a timely manner should be the highest priority for MDA, and expects the Agency to modify its plans and budgets to meet our combatant commanders' current operational needs. In section 223 of the John Warner National Defense Authorization Act for Fiscal Year 2007 (Public Law 109-364), Congress specified the Aegis BMD system and its SM-3 interceptor as a high priority near-term program for the Department of Defense to focus on. As the JCM study makes clear, the Department has failed to do so.

Section 223(b) of the National Defense Authorization Act for Fiscal Year 2008 (Public Law 110-181) requires that any long lead or advance procurement for SM-3 Block IA missiles in the fiscal year 2009 budget be requested in procurement funds, rather than in research and development (R&D) funds. Section 223(c) of that act prohibits the use of fiscal year 2009 R&D funds for procurement of long lead items for SM-3 Block IA missiles. The Department chose not to comply with the law, and requested R&D funds for procuring long lead items for the SM-3 missiles. This is not acceptable. The committee notes that the Department is obliged to comply with the law, and expects the Department to do so.

To be consistent with the law, and to correct the Department's failure to comply with the law, the committee recommends that all long lead funds for SM-3 missiles be authorized and appropriated in a new defense-wide procurement line described elsewhere in this report. Accordingly, the committee recommends a transfer of \$57.0 million from PE 63892C to the new procurement line for long lead procurement of SM-3 Block IA missiles. The committee also recommends an increase of \$20.0 million in that new procurement line for the procurement of long lead items for an additional 15 SM-3 interceptors, to begin the process of increasing the inventory of SM-3 missiles toward the JCM levels. The committee notes that MDA does not plan any procurement of SM-3 Block IB missiles after fiscal year 2010, which is inconsistent with the JCM study conclusions concerning the need for about twice as many SM-3 and THAAD missiles as are currently planned. The committee expects MDA to modify its plans and budgets for the fiscal year 2010 budget submission to address the inventory levels indicated by the JCM study.

To address these numerous concerns, the committee recommends an increase of \$80.0 million in PE 63892C for the following projects: \$20.0 million for facilitating an increase in SM-3 production capacity to four missiles per month; \$20.0 million to reduce schedule risk for the Block IB missile; and \$40.0 million for accelerated development of enhanced Aegis BMD capability for "engage on remote" and ascent-phase engagement. (Pages 259-260)

Regarding the MKV, the report states:

The committee also notes that the Missile Defense Agency (MDA) plans to fund two contractor teams with competing technology approaches, but does not plan to have a competitive selection of the best technology in the future. Although MDA is pursuing development of MKV technologies for long-range midcourse defense interceptors and for the Standard Missile-3 Block II interceptor, keeping two contractor teams for the indefinite future is both expensive and possibly unnecessary. The committee urges MDA to consider a

competitive selection process to determine which of the two contractor teams has the best technology, and to select that team as the only team to fund in the future.

The committee is also concerned that the consolidation of all kinetic kill vehicle technology development in one office may have the unintended effect of removing continued focus on developing or improving existing and planned unitary kinetic kill vehicles, such as the unitary kill vehicle planned for the Standard Missile-3 Block IIA missile being developed jointly by the United States and Japan. (Page 262)

Regarding the February 2008 shoot-down of the malfunctioning satellite, the report states:

The committee notes that the Aegis Ballistic Missile Defense (BMD) system was used in February for a one-time mission to intercept and destroy a decaying U.S. satellite before it re-entered the earth's atmosphere. This mission, which cost more than \$90.0 million, used considerable Aegis BMD assets and funding. The committee is concerned that the Aegis BMD program will not be fully reimbursed for its expenses in preparing for, testing for, and conducting the mission, as well as for restoring the system's components to their normal missile defense configuration, and replacing the Standard Missile-3 interceptor used for the mission. If the Aegis BMD program is not reimbursed for these expenses, it would not be able to perform some \$90.0 million worth of planned and budgeted activities that have been approved by Congress. This would not be acceptable.

The committee directs the Missile Defense Agency (MDA) and the Department of Defense to ensure that the Aegis BMD program is fully reimbursed for all expenses related to the one-time satellite intercept mission, so that all previously planned, funded, and approved Aegis BMD work will proceed without delay. The committee directs MDA to report to the congressional defense committees by no later than October 1, 2008 on the status of the full reimbursement of the Aegis BMD program. (Page 267)

Appendix A. Strengths and Limitations of Sea-Based BMD Systems

Potential Strengths. Potential strengths of sea-based BMD systems compared to other BMD systems include the following:

- **Advantageous locations at sea.** Sea-based systems can conduct BMD operations from locations at sea that are potentially advantageous for BMD operations but inaccessible to ground-based BMD systems.
- **Base access and freedom of action.** Sea-based systems can be operated in forward (i.e., overseas) locations in international waters without need for negotiating base access from other governments, and without restrictions from foreign governments on how they might be used.
- **Visibility.** Sea-based systems can operate over the horizon from observers ashore, making them potentially less visible and less provocative.
- **Mobility.** Navy ships with BMD systems can readily move themselves to respond to changing demands for BMD capabilities or to evade detection and targeting by enemy forces, and can do so without placing demands on U.S. airlift assets.

Regarding the first of these potential strengths, there are at least four ways that a location at sea can be advantageous for U.S. BMD operations:

- The location might lie along a ballistic missile's potential flight path, which can facilitate tracking and intercepting the attacking missile.
- The location might permit a sea-based radar to view a ballistic missile from a different angle than other U.S. BMD sensors, which might permit the U.S. BMD system to track the attacking missile more effectively.
- If a potential adversary's ballistic missile launchers are relatively close to its coast, then a U.S. Navy ship equipped with BMD interceptors that is operating relatively close to that coast could attempt to defend a large down-range territory against potential attack by ballistic missiles fired from those launchers.⁸² One to four Navy ships operating in the Sea of Japan, for example, could attempt

⁸² The ship's potential ability to do this is broadly analogous to how a hand casts a shadow in a candle-lit room. The closer that the hand (i.e., the Navy ship) is moved to the candle (the ballistic missile launcher), the larger becomes the hand's shadow on the far wall (the down-range area that the ship can help defend against ballistic missile attack). In BMD parlance, the area in shadow is referred to as the defended footprint.

to defend most or all of Japan against theater-range ballistic missiles (TBMs)⁸³ fired from North Korea.

- If a Navy ship were equipped with very fast interceptors (i.e., interceptors faster than those the Navy is currently deploying), and if that ship were deployed to an overseas location relatively close to enemy ballistic missile launchers, the ship might be able to attempt to intercept ballistic missiles fired from those launchers during the missiles' boost phase of flight — the initial phase, during which the ballistic missiles' rocket engines are burning. A ballistic missile in the boost phase of flight is a relatively large, hot-burning target that might be easier to intercept (in part because the missile is flying relatively slowly and is readily seen by radar), and the debris from a missile intercepted during its boost phase might be more likely to not fall on or near the intended target of the attacking missile.

Potential Limitations. Potential limitations of sea-based BMD systems compared to other BMD systems include the following:

- **Conflicts with other ship missions.** Using multimission Navy cruisers and destroyers for BMD operations might reduce their ability to perform other missions, such as air-defense operations against aircraft and anti-ship cruise missiles (ASCMs), land-attack operations, and anti-submarine warfare operations, for four reasons:
 - Conducting BMD operations might require a ship to operate in a location that is unsuitable for performing one or more other missions.
 - Conducting BMD operations may reduce a ship's ability to conduct air-defense operations against aircraft and cruise missiles due to limits on ship radar abilities.
 - BMD interceptors occupy ship weapon-launch tubes that might otherwise be used for air-defense, land-attack, or anti-submarine weapons.
 - Launching a BMD interceptor from a submarine might give away the submarine's location, which might make it more difficult for the submarine to perform missions that require stealthy operations (and potentially make the submarine more vulnerable to attack).
- **Costs relative to ground-based systems.** A sea-based system might be more expensive to procure than an equivalent ground-based system due to the potential need to engineer the sea-based

⁸³ TBMs include, in ascending order of range, short-range ballistic missiles (SRBMs), which generally fly up to about 600 kilometers (about 324 nautical miles), medium-range ballistic missiles (MRBMs), which generally fly up to about 1,300 kilometers (about 702 nm), and intermediate-range ballistic missiles (IRBMs), which generally fly up to about 5,500 kilometers (about 2,970 nm). Intercontinental ballistic missiles (ICBMs) are longer-ranged missiles that can fly 10,000 kilometers (about 5,400 nm) or more. Although ICBMs can be used to attack targets within their own military theater, they are not referred to as TBMs.

system to resist the corrosive marine environment, resist electromagnetic interference from other powerful shipboard systems and meet shipboard safety requirements, or fit into a limited space aboard ship. A BMD system on a ship or floating platform that is dedicated to BMD operations might be more expensive to operate and support than an equivalent ground-based system due to the maintenance costs associated with operating the ship or platform in the marine environment and the need for a crew of some size to operate the ship or platform.

- **Ship quantities for forward deployments.** Maintaining a standing presence of a Navy BMD ship in a location where other Navy missions do not require such a deployment, and where there is no nearby U.S. home port, can require a total commitment of several Navy ships, due to the mathematics of maintaining Navy ship forward deployments.⁸⁴
- **Vulnerability to attack.** A sea-based BMD system operating in a forward location might be more vulnerable to enemy attack than a ground-based system, particularly a ground-based system located in a less-forward location. Defending a sea-based system against potential attack could require the presence of additional Navy ships or other forces.
- **Rough waters.** Very rough waters might inhibit a crew's ability to operate a ship's systems, including its BMD systems, potentially creating occasional gaps in BMD coverage.

⁸⁴ For more on the mathematics of Navy ship forward deployments, see CRS Report RS21338, *Navy Ship Deployments: New Approaches — Background and Issues for Congress*, by Ronald O'Rourke.

Appendix B. Arms Control Considerations

No arms control treaty currently in force limits sea-based BMD systems. The U.S.-Soviet Anti-Ballistic Missile (ABM) Treaty, which was in force from 1972 until the United States withdrew from the treaty in 2002, prohibited sea-based defenses against strategic (i.e., long-range) ballistic missiles. Article V of the treaty states in part: “Each Party undertakes not to develop, test, or deploy ABM systems or components which are sea-based, air-based, space-based, or mobile land-based.” Article II defines an ABM system as “a system to counter strategic ballistic missiles or their elements in flight trajectory...” For more on the ABM Treaty, see CRS Report RL33865, *Arms Control and Nonproliferation: A Catalog of Treaties and Agreements*, by Amy F. Woolf, Sharon Squassoni, and Steve Bowman. The United States withdrew from the ABM Treaty in 2002, according to the treaty’s procedures for doing so. For a discussion, see CRS Report RS21088, *Withdrawal from the ABM Treaty: Legal Considerations*, by David M. Ackerman.

Appendix C. Aegis BMD Midcourse Flight Tests

From January 2002 through September 2008, the Aegis BMD midcourse system has achieved 13 successful exo-atmospheric intercepts in 15 attempts.⁸⁵ This total includes a successful intercept by a Japanese Aegis ship in a Japanese test flight conducted on December 17, 2007. This appendix provides details on these flight tests.

Seven Tests Between January 2002 and November 2005. Table 2 below summarizes seven ALI and Aegis BMD midcourse flight tests (called FTM-2 through FTM-8, with the FTM standing for “flight test mission”⁸⁶) conducted between January 2002 and November 2005. As shown in the table, six of the seven tests resulted in successful intercepts.

Eighth Test (June 2006). On June 22, 2006, an Aegis BMD midcourse flight test called FTM-10 resulted in a seventh successful exo-atmospheric intercept in eight attempts. This was the first test to use the Aegis 3.6 computer program.⁸⁷

Ninth Test (December 2006). On December 7, 2006, an Aegis BMD midcourse flight test called FTM-11 was not successful, and was the first unsuccessful flight test since June 2003. MDA stated that the ninth test

was not completed due to an incorrect system setting aboard the Aegis-class cruiser USS Lake Erie prior to the launch of two interceptor missiles from the ship. The incorrect configuration prevented the fire control system aboard the ship from launching the first of the two interceptor missiles. Since a primary test objective was a near-simultaneous launch of two missiles against two different targets, the second interceptor missile was intentionally not launched.

The planned test was to involve the launch of a Standard Missile 3 against a ballistic missile target and a Standard Missile 2 against a surrogate aircraft target. The ballistic missile target was launched from the Pacific Missile Range Facility, Kauai, Hawaii and the aircraft target was launched from a Navy aircraft.

⁸⁵ Another CRS report, based on historical flight test data provided by MDA to CRS in June 2005, summarizes early sea-based BMD tests as follows:

The Navy developed its own indigenous LEAP program, which flight tested from 1992-1995. Three non-intercept flight tests achieved all primary and secondary objectives. Of the five planned intercept tests, only the second was considered a successful intercept, however. Failures were due to various hardware, software, and launch problems. Even so, the Navy determined that it achieved about 82% of its primary objectives (18 of 22) and all of its secondary objectives in these tests.

(CRS Report RL33240, *Kinetic Energy Kill for Ballistic Missile Defense: A Status Overview*, by Steven A. Hildreth.)

⁸⁶ In some presentations, the flight tests are referred to as FM-2, etc., without the “T.”

⁸⁷ Missile Defense Agency, “Missile Defense Test Results in Successful ‘Hit To Kill’ Intercept,” June 22, 2006 (06-NEWS-0018).

The USS Lake Erie (CG 70), USS Hopper (DDG 70) and the Royal Netherlands Navy frigate TROMP were all successful in detecting and tracking their respective targets. Both targets fell into the ocean as planned.

After a thorough review, the Missile Defense Agency and the U.S. Navy will determine a new test date.⁸⁸

Table 2. ALI and Aegis BMD Flight Tests

Test name	FTM-2	FTM-3	FTM-4	FTM-5	FTM-6	FTM-7	FTM-8
Date	1/22/02	6/13/02	11/21/02	6/18/03	12/11/03	2/24/05	11/17/05
Target apogee	300km	300km	160km	160km	160km	160km	227km
Target range	500km	500km	600km	600km	600km	600km	925km
Aegis computer program	ALI 1.2	ALI 1.2	ALI 2.0	ALI 2.0	ALI 2.2.2	BMD 3.0	BMD 3.0
SM-3 version	Block 0	Block 0	Block 0	Block 0	Block 0	Block 1	Block 1
Engagement sequence	Uncued	Uncued	Uncued	Cued ^a	Cued ^a	Uncued	Uncued
Intercept down range	430km	430km	250km	250km	482km	250km	462km
Intercept cross range	240km	240km	200km	150km	248km	150km	150km
Crew disclosure	Yes	Yes	Yes	Yes	No	No	No
Ship's heading	Steady	Steady	Steady	Steady	Maneuvering	Maneuvering	Maneuvering
Target flight phase	Descent	Descent	Ascent	Ascent	Descent	Descent	Descent
Lethal aimpoint	No	No	Aimpoint shift	Yes	Yes	Yes	Yes
Kinetic warhead intercept	Yes	Yes	Yes	No	Yes	Yes	Yes

Source: "Aegis Ballistic Missile Defense, Aegis BMD Update and Plans," Briefing to the Future Naval Plans & Requirements Conference, Scott Perry, Aegis BMD [Program], April 26, 2006, slide 11.

a. Aegis ship to Aegis ship and external sensor to Aegis ship.

A news article about the ninth test stated:

"You can say it's seven of nine, rather than eight of nine," Missile Defense Agency spokesman Chris Taylor said of the second failure in tests of the system by the agency and the Navy....

The drill was planned to demonstrate the Navy's ability to knock down two incoming missiles at once from the same ship.

"In a real world situation it is possible, maybe even probable, that in addition to engaging a ballistic missile threat that was launched, you may be engaging a surface action," said Joe Rappisi before the test. He is director for the Aegis Ballistic Missile Defense system at Lockheed Martin, the primary contractor for the program.

⁸⁸ Untitled Missile Defense Agency "For Your Information" statement dated December 7, 2006 (06-FYI-0090).

The test would have marked the first time a ship has shot down one target in space and another target in the air at the same time.

The test presented a greater challenge to the ship's crew and the ballistic missile defense system than previous tests, Rappisi said. The multiple target scenario is also closer to what sailors might actually face in battle.

The U.S. Pacific Fleet has been gradually installing missile surveillance and tracking technology on many of its destroyers and cruisers amid concerns about North Korea's long-range missile program.

It is also installing interceptor missiles on many of its ships, even as the technology to track and shoot down incoming missiles is being developed and perfected.

The Royal Netherlands Navy joined the tracking and monitoring off Kauai to see how its equipment works. The Dutch presence marked the first time a European ally has sent one of its vessels to participate in a U.S. ballistic missile defense test.⁸⁹

A subsequent news article stated that:

the test abort of the Aegis Ballistic Missile Defense system Dec. 7 resulted from human error, [MDA Director USAF Lt. Gen. Henry] Obering says.... Both the ballistic missile and aircraft targets launched as planned, but the first interceptor failed to fire because an operator had selected an incorrect setting for the test. Officials then aborted before the second could boost.

Aegis missile defense system tests are at a standstill until officials are able to identify an appropriate ballistic missile target. The one used Dec. 7 was the last of its kind, Obering says, leaving them empty handed in the near future.⁹⁰

Another article stated:

Philip Coyle, a former head of the Pentagon's testing directorate, gives the Navy credit for "discipline and successes so far" in its sea-based ballistic missile defense testing program. Coyle is now a senior adviser at the Center for Defense Information.

"The U.S. Navy has an enviable track record of successful flight intercept tests, and is making the most of its current, limited Aegis missile defense capabilities in these tests," Coyle told [*Inside the Navy*] Dec. 7.

"Difficulties such as those that delayed the latest flight intercept attempt illustrate the complexity of the system, and how everything must be carefully

⁸⁹ David Briscoe, "Test Interceptor Missile Fails To Launch," *NavyTimes.com*, December 8, 2006.

⁹⁰ Amy Butler, "GMD Trial Delayed Until Spring; Aegis Failure Human Error," *Aerospace Daily & Defense Report*, December 19, 2006.

orchestrated to achieve success,” Coyle added. “Nevertheless, this particular setback won’t take the Navy long to correct.”⁹¹

Tenth Test (April 2007). On April 26, 2007, an Aegis BMD midcourse flight test called FTM-11b (or FTM Event 4) resulted in the eighth successful exo-atmospheric intercept in ten attempts. MDA states that the test

involved the simultaneous engagements of a ballistic missile “unitary” target (meaning that the target warhead and booster remain attached) and a surrogate hostile air target....

The test demonstrated the [Aegis ship’s] ability to engage a ballistic missile threat and defend itself from attack at the same time. The test also demonstrated the effectiveness of engineering, manufacturing, and mission assurance changes in the solid divert and attitude control system (SDACS) in the kinetic kill weapon. This was the first flight test of all the SM-3 Block IA’s upgrades, previously demonstrated in ground tests.⁹²

A press report on the test stated that the hostile air target was an anti-ship cruise missile. The article stated that the scenario for the test

called for the [Aegis ship] to come under attack from a cruise missile fired by an enemy plane.... A Navy plane fired the cruise missile target used in the test.⁹³

Eleventh Test (June 2007). On June 22, 2007, an Aegis BMD midcourse flight test called FTM-12 resulted in the ninth successful exo-atmospheric intercept in 11 attempts. MDA states that the test

was the third intercept involving a separating target and the first time an Aegis BMD-equipped destroyer was used to launch the interceptor missile. The USS Decatur (DDG 73), using the operationally-certified Aegis Ballistic Missile Defense Weapon System (BMD 3.6) and the Standard Missile-3 (SM-3) Block IA missile successfully intercepted the target during its midcourse phase of flight....

An Aegis cruiser, USS Port Royal (CG 73), a Spanish frigate, MÉNDEZ NÚÑEZ (F-104), and MDA’s Terminal High Altitude Area Defense (THAAD) mobile ground-based radar also participated in the flight test. USS Port Royal used the flight test to support development of the new Aegis BMD SPY-1B radar signal processor, collecting performance data on its increased target detection and discrimination capabilities. MÉNDEZ NÚÑEZ, stationed off Kauai, performed long-range surveillance and track operations as a training event to assess the future capabilities of the F-100 Class. The THAAD radar tracked the target and exchanged tracking data with the Aegis BMD cruiser.

⁹¹ Zachary M. Peterson, “Sea-Based Missile Defense Test Fails Due To ‘Incorrect Configuration,’” *Inside the Navy*, December 11, 2006.

⁹² Missile Defense Agency, “Successful Sea-Based Missile Defense ‘Hit to Kill’ Intercept,” April 26, 2007 (07-NEWS-0032).

⁹³ Audrey McAvoy, “Aegis Missile Test Successful,” *NavyTimes.com*, April 27, 2007.

This event marked the third time that an allied military unit participated in a U.S. Aegis BMD test, with warships from Japan and the Netherlands participating in earlier tests.⁹⁴

Twelfth Test (August 2007). On August 31, 2007, an Aegis BMD midcourse flight test resulted in the 10th successful exo-atmospheric intercept in 12 attempts. MDA has publicly noted the occurrence of this test and the fact that it resulted in a successful intercept,⁹⁵ but states that the details about the test are classified.⁹⁶ MDA does not appear to have issued a news release about this flight test following the completion of the test, as it has for other Aegis BMD flight tests.⁹⁷

Thirteenth Test (November 2007). On November 6, 2007, an Aegis BMD midcourse flight test called FTM-13 that involved intercepting two SRBMs resulted in the 11th and 12th successful exo-atmospheric intercepts in 14 attempts. MDA states that the test:

a multiple simultaneous engagement involving two ballistic missile targets.... For the first time, the operationally realistic test involved two unitary “non-separating” targets, meaning that the target’s warheads did not separate from their booster rockets....

At approximately 6:12 p.m. Hawaii Standard Time (11:12 p.m. EST), a target was launched from the Pacific Missile Range Facility (PMRF), Barking Sands, Kauai, Hawaii. Moments later, a second, identical target was launched from the PMRF. The USS Lake Erie’s Aegis BMD Weapon System detected and tracked the targets and developed fire control solutions.

Approximately two minutes later, the USS Lake Erie’s crew fired two SM-3 missiles, and two minutes later they successfully intercepted the targets outside the earth’s atmosphere more than 100 miles above the Pacific Ocean and 250 miles northwest of Kauai....

A Japanese destroyer also participated in the flight test. Stationed off Kauai and equipped with the certified 3.6 Aegis BMD weapon system, the guided missile destroyer JS Kongo performed long-range surveillance and tracking

⁹⁴ Missile Defense Agency, “Sea-Based Missile Defense ‘Hit to Kill’ Intercept Achieved,” June 22, 2007 (07-NEWS-0037).

⁹⁵ See for example, slide 8 in the 20-slide briefing entitled “Ballistic Missile Defense Program Overview For The Congressional Breakfast Seminar Series,” dated June 20, 2008, presented by Lieutenant General Trey Obering, USAF, Director, Missile Defense Agency. Source for briefing: *InsideDefense.com* (subscription required). Each slide in the briefing includes a note indicating that it was approved by MDA for public release on June 13, 2008. Slide 8 lists Aegis BMD midcourse flight tests conducted since September 2005, including a test on August 31, 2007. The slide indicates with a check mark that the flight test was successful. A success in this test is also needed to for the total number of successful intercepts to match the reported figure.

⁹⁶ An email from MDA to CRS dated June 30, 2008, states that the flight test “was a hit to kill intercept test but details about the test are classified.”

⁹⁷ MDA’s website, when accessed on June 30, 2008, did not show a news release issued on or soon after August 31, 2007, that discusses this test.

exercises. The Kongo used the test as a training exercise in preparation for the first ballistic missile intercept test by a Japanese ship planned for later this year. This event marked the fourth time an allied military unit participated in a U.S. Aegis BMDS test.⁹⁸

Fourteenth Test (December 2007 — Japanese Test). On December 17, 2007, in a test called Japan Flight Test Mission 1 (JFTM-1), a BMD-capable Japanese Aegis destroyer used an SM-3 Block IA missile to successfully intercept a ballistic missile target in a flight test off the coast of Hawaii. This was 13th successful exo-atmospheric intercept for the Aegis BMS system in 15 attempts. It was the first time that a non-U.S. ship had intercepted a ballistic missile using the Aegis BMD system.⁹⁹

⁹⁸ Missile Defense Agency, “Sea-Based Missile Defense “Hit to Kill” Intercept Achieved,” November 6, 2007 (07-NEWS-0051).

⁹⁹ John Liang, “Japanese Destroyer Shoots Down Ballistic Missile Test Target,” *Inside Missile Defense*, December 19, 2007; “Japanese Aegis Destroyer Wins Test By Killing Target Missile With SM-3 Interceptor,” *Defense Daily*, December 18, 2007; Reuters, “Japanese Ship Downs Missile In Pacific Test,” *New York Times*, December 18, 2007: 8; Audrey McAvoy, “Japan Intercepts Missile In Test Off Hawaii,” *NavyTimes.com*, December 17, 2007.