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

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Summary

As part of its effort to develop an integrated global ballistic missile defense (BMD) system, the Department of Defense (DOD) has modified or is modifying several Navy Aegis cruisers and many Navy Aegis destroyers for BMD operations. DOD has also deployed a large BMD radar—the Sea-Based X-Band Radar (SBX)—on a modified floating oil platform.

The proposed FY2010 defense budget requests a total of $1,859.5 million for the Aegis BMD program, including $1,690.8 million in research and development funding for the program and $168.7 million in procurement funds for the SM-3 interceptor missile. The proposed FY2010 budget would fund, among other things, the installation of BMD capability on six Aegis ships, which would increase the total number of Aegis BMD ships to 27. The proposed FY2010 budget also requests $174.6 million for continued operations of the SBX.

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 14 successful exo-atmospheric intercepts in 18 attempts. This total includes one successful intercept and one unsuccessful intercept by Japanese Aegis ships in two Japanese test flights.The Aegis BMD system has also achieved 3 successful endo-atmospheric intercepts in 3 attempts, for a combined total of 17 successful exo- and endo-atmospheric intercepts in 21 attempts. The Aegis BMD system was also temporarily modified and used on February 20, 2008, to shoot down an inoperative U.S. surveillance satellite. Japan has acquired the Aegis BMD system, and some other allied navies have expressed an interest in adding BMD capabilities to their ships.

Potential issues for Congress regarding sea-based BMD systems include the number of SM-3 interceptors planned for procurement, whether development a far-term sea-based terminal-defense BMD capability should be accelerated, technical risk in the Aegis BMD program, the number of Aegis BMD ships, the role of Aegis BMD in European missile defense, potential allied sea-based BMD programs, and whether development and testing of the Aegis BMD system offers any lessons for development and testing of other BMD systems.

The House Armed Services Committee, in its report (H.Rept. 111-166 of June 18, 2009) on the FY2010 defense authorization bill (H.R. 2647), recommends approving the administration's request for $1,859.5 million for the Aegis BMD program.

The FY2010 defense authorization bill (S. 1390) as reported by the Senate Armed Services Committee (S.Rept. 111-35 of July 2, 2009) recommends reducing by $30 million the administration's request for $1,690.8 million in research and development funding for the Aegis BMD program and approving the administration's request for $168.7 million in procurement funds for the SM-3 interceptor missile.

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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 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.[1] 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 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.[2]

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.
- 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 in 2011. As part of its proposed FY2010 budget, the Navy has requested funds to restart DDG-51 procurement with the procurement of a 63rd DDG-51 in FY2010 and two more DDG-51s in FY2011.[3]

The Navy has recently begun a program for modernizing existing CG-47s and DDG-51s that is intended to ensure that the ships can operate cost-effectively throughout their entire 35-year expected service lives.[4]

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[1] The Aegis system is named after the mythological shield carried by Zeus.

[2] For more on the Aegis system and its principal components as originally deployed, see CRS Report 84-180, *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.

[3] For additional discussion of the navy's proposal to restart DDG-51 procurement in FY2010, see CRS Report RL32109, *Navy DDG-1000 and DDG-51 Destroyer Programs: Background, Oversight Issues, and Options for Congress*, by Ronald O'Rourke.

[4] For additional information on this effort, see CRS Report RS22595, *Navy Aegis Cruiser and Destroyer*
(continued...)

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).[5] 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.[6]

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:

(...continued)

Modernization: Background and Issues for Congress, by Ronald O'Rourke.

[5] Source: *Jane's Fighting Ships 2007-2008*.

[6] 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., 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.

- 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.

Aegis BMD Modifications 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.

Modifying an Aegis ship to a basic BMD configuration called Aegis BMD 3.6 costs about $10.5 million; modifying an Aegis ship to a more-capable BMD configuration called Aegis BMD 4.0.1 costs about $45 million. The 4.0.1 configuration costs about $35 million more than the 3.6 configuration because it includes some additional components, such as a new BMD signal processor (BSP), additional adjunct computers, and a tactical missile downlink.[7]

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.[8]

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 originally 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

[7] Source: Missile Defense Agency/U.S. Navy information paper dated February 6, 2009, and provided to CRS by Navy Office of Legislative Affairs on February 20, 2009.

[8] 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 1B fly fast enough to intercept TBMs, but not fast enough to provide an effective capability for intercepting ICBMs.

2004, and the first engage-capable installations were completed in 2005.[9] (LRS&T Aegis destroyers began operating in September 2004. Engage-capable Aegis cruisers began operating in September 2005.[10]) All 18 ships are scheduled to be engage-capable by the end of calendar 2008.

In August 2008, it was reported that the Navy had 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.[11] In January 2009 it was reported that the Navy had decided to increase the number of BMD-capable cruisers from three to five.[12]

Planned SM-3 Procurement Quantity

DOD plans under the FY2009 budget called for procuring a total of 147 SM-3 Block IA and IB interceptors, of which 133 were to be deployed on Aegis ships. (The other 14 apparently were to be used for testing or research.) Of the 133 SM-3 Block 1A and IB interceptors that were to be deployed on Aegis ships, 34 were to be deployed by the end of calendar 2008, and all 133 were to be deployed by 2013.[13]

A June 20, 2008, briefing by MDA on BMD programs indicated that MDA anticipated 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.[14]

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[9] 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.

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

[11] Otto Kreisher, "BMD Boost," *Seapower*, August 2008: 12-14.

[12] Christopher P. Cavas, "3 More U.S. Ships To be Converted for BMD Role," *DefenseNews.com*, January 7, 2009; Dan Taylor, "Lockheed: Navy Opts To Add Aegis BMD Systems To Three More Ships," *Inside the Navy*, January 12, 2009. The reports stated that three additional ships – two cruisers and one destroyer – would receive a BMD capability. The additional destroyer, however, would appear to be part of the Navy's earlier-announced plan to make all of the Navy's DDG-51 class destroyers BMD capable.

[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.

[14] 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.

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. (H.Rept. 110-146, p. 235.)

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,

(continued...)

The House Armed Services Committee, in its report (H.Rept. 111-166 of June 18, 2009) on the FY2010 defense authorization bill (H.R. 2647), states that under the proposed FY2010, the planned number of SM-3s to be procured has increased to 329:

> The Joint Capabilities Mix Study II, conducted by the Joint Staff in 2007 to examine theater missile defense inventory requirements, concluded that combatant commanders required nearly double the 96 Terminal High Altitude Area Defense (THAAD) interceptors and the 133 Standard Missile-3 (SM–3) interceptors than originally planned to address the short- and medium-range ballistic missile threat. The committee notes its support for the Department's decision to increase funding for the THAAD and Aegis Ballistic Missile Defense programs by $900.0 million in fiscal year 2010. Under the revised program plan, the SM–3 interceptor inventory will grow from 133 to 329, and the THAAD interceptor inventory will grow from 96 to 287 over the Future Years Defense Program. [15]

The Senate Armed Services Committee, in its report (S.Rept. 111-35 of July 2, 2009) on the FY2010 defense authorization bill (S. 1390) similarly states "that the [FY2010] budget request would increase substantially the planned inventory of SM-3 interceptors, from a previously planned inventory of 147 to 329...."[16]

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.[17]

MDA subsequently 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,

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as indicated by the Commander, JFCC-IMD. (S.Rept. 110-77, p. 264.)

[15] H.Rept. 111-166, page 237.

[16] S.Rept. 111-35, page 92. See also page 96, which states: "In accordance with the budget request, the Department of Defense would plan to increase the SM–3 interceptor inventory from 147 to 329, and increase the THAAD interceptor inventory from 96 to 289."

[17] 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.

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.... [18]

"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.[19]

Flight Tests

From January 2002 through September 2008, the Aegis BMD midcourse system has achieved 14 successful exo-atmospheric intercepts in 18 attempts.[20] This total includes one successful

[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, pp. 15-16.

[19] "Aegis Ballistic Missile Defense," MDA fact sheet, January 30, 2004.

[20] Another CRS report, based on historical flight test data provided by MDA to CRS in June 2005, summarizes early (continued...)

intercept and one unsuccessful intercept by Japanese Aegis ships in two Japanese test flights. 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 warhead. And in 2009 we will conduct an intercept flight test against a medium-range target to demonstrate an expanded battle space.[21]

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.[22] 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."[23]

(...continued)

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.

[21] [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.

[22] 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.

[23] 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.

SM-3 Block IIA Missile (Cooperative Program With Japan)

Under a memorandum of agreement signed in 1999, the United States and Japan have cooperated in researching technologies for the Block IIA version of the SM-3.[24] 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/1B 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.[25] The Block IIA version would also include an improved kinetic (hit-to-kill) warhead.[26] 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.[27]

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%.[28]

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

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[24] 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.

[25] 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. See also the section on "Sea-Based Midcourse" in CRS Report RL31111, *Missile Defense: The Current Debate*, by Steven A. Hildreth et al.

[26] 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.

[27] "Aegis Ballistic Missile Defense SM-3 Block IIA (21-Inch) Missile Plan (U), August 2005," op. cit, pp. 3-4.

[28] Slide 28 in briefing entitled "Aegis Ballistic Missile Defense," dated August 12, 2008, presented by Rear Admiral Alan B. Hick, Aegis BMD Program Director. Source for briefing: *InsideDefense.com* (subscription required).

missiles have reentered the atmosphere,[29] 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.[30] The NAD system was canceled in December 2001.[31]

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 were to be deployed on Aegis ships by the end of calendar 2008.[32]

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.[33]

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[29] 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.

[30] 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.

[31] 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.)

[32] Source: Slide 7 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.

[33] See, for example, Bettina H. Chavanne, "Aegis Ships To Get Protection From Ballistic Missile Threats," *Aerospace*
(continued...)

Flight Tests

The Block 2.0 version of the sea-based terminal capability has achieved three successful endo-atmospheric intercepts in three at-sea attempts, the first occurring on May 24, 2006,[34] the second on June 5, 2008,[35] and the third between March 24 and March 26, 2009.[36]

Aegis BMD Program Funding

FY2010 Funding Request

The proposed FY2010 defense budget requests a total of $1,859.5 million for the Aegis BMD program, including $1,690.8 million in research and development funding and $168.7 million in procurement funds. The research and development funding request of $1,690.8 million is $456.5 million more than what was projected for FY2010 under the FY2009 budget.

The proposed FY2010 budget would fund, among other things, the installation of BMD capability on six Aegis ships, the procurement of 17 SM-3 Block IA interceptors and one SM-3 Block IB interceptor, and additional funding to support the future procurement of an additional 18 SM-3 Block IB interceptors. Between FY2009 and FY2010, the cumulative funded number of BMD-capable Aegis ships would grow from 21 to 27, and the cumulative funded inventory of SM-3 interceptors would grow from 54 to 80.

Funding History

Table 1 shows funding for the Aegis BMD program from FY1995 through FY2010. The figures in the table 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.

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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.

[34] 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.

[35] 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.*

[36] "Navy Completes Air and Ballistic Missile Exercise," *Navy News Service*, March 26, 2009.

Table 1. Aegis BMD Program Funding, FY1995-FY2010

(as shown in FY2010 budget; figures in 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	1,214.1
FY09	1,170.5
FY10	*1,859.5*

Sources: For FY1995 through FY2005: DOD Information Paper provided to CRS by Navy Office of Legislative Affairs, November 14, 2006. For subsequent years:: FY2008, FY2009, and FY2010 MDA budget justification books.

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.[37] 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.

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.[38] A Japanese ship again tracked a target missile in FTM-11, in

[37] 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*, coordinated by Emma Chanlett-Avery.

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

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.[39]

Other Countries [40]

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.[41]

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.

The proposed FY2010 budget also requests $174.6 million for continued operations of the SBX.

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 platform that can transit at a speed of 8 knots and is designed to be stable in high winds and rough seas.[42]

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.[43] SBX underwent sea trials and high-

[39] 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.

[40] 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.

[41] 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.

[42] 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.

[43] 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 (continued...)

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.[44] The SBX reportedly departed Hawaii on January 3, 2007, and arrived in Alaska's Aleutian Islands on February 7, 2007.[45]

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.[46]

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.[47]

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.[48]

Potential Issues for Congress

Number of SM-3 Missiles Planned for Procurement

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

As mentioned earlier (see "Planned SM-3 Procurement Quantity"), under the proposed FY2010 budget, the planned number of SM-3s to be procured appears to have increased to 329. In

(...continued)

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*.)

[44] 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.

[45] "Way Up North," *Defense Daily*, February 12, 2007.

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

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

[48] "Radar Weapons," *Aerospace Daily & Defense Report*, March 20, 2006.

considering whether this figure is appropriate, potential factors to consider include the Navy's future role in intercepting theater-range missiles and the planned number of BMD-capable Aegis ships. A January 2009 press report stated:

> While the current plan is to procure 240 to 250 of the interceptors by fiscal 2014 - 2015, [Aegis BMD program director Rear Admiral Brad] Hicks said, "we need at least double that," referring to the Standard Missile-3 Block IA and Block IB variants.
>
> "We need more capacity," he said, for a total buy of 450 to 500 SM-3s in the IA and IB versions "in order to effectively get them on ships,"
>
> That many interceptors should be in hand "sometime in the middle of the next decade," he said.
>
> Hicks was asked whether Raytheon has the production capacity to ramp up production to a double-time pace.
>
> Hicks said that to obtain the Raytheon infrastructure to increase production capacity sufficiently, that "requires some investment" in Raytheon production facilities. However, until a review of the situation by Navy and MDA leadership, the Navy will wait to articulate that need, he said.
>
> The situation will be decided after top-level consultations including major stakeholders in the Navy, and the combatant commanders who request Aegis missions, he said.[49]

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.[50]

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[49] Dave Ahearn, "Hicks: Current Aegis Ships Fleet Not Enough To Guard Europe If European Defense System Unbuilt," *Space & Missile Defense Report*, January 26, 2009.

[50] 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 (continued...)

Technical Risk

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

Another potential oversight issue for Congress is how much technical risk there is in the Aegis BMD program. A March 2009 Government Accountability Office (GAO) report assessing the technical risks of selected weapon programs stated of the Aegis BMD program:

> **Aegis BMD Element - Block 2004**
>
> Aegis program officials consider all four critical technologies for the SM-3 Block IA missile to be mature. However, we assessed two technologies—pulse two of the Solid Divert and Attitude Control System (SDACS) and the zero pulse mode of the Third Stage Rocket Motor (TSRM)—as nearing maturity. The other two technologies—the kinetic warhead seeker and the SDACS pulse one—are fully mature and have been successfully demonstrated during operational testing. Although pulse two is identical in technology and functionality as pulse one, pulse two has not been flight tested and cannot be considered fully mature. 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. Similarly, the zero pulse mode of the TSRM that increases the missile's capability against shorter-range threats has not been flight tested. According to the program, range safety limitations continue to preclude Aegis testing of the zero pulse mode. Officials from the Director, Operational Test and Evaluation state that operational testing for these two critical technologies is still an outstanding recommendation that the program has yet to address.
>
> **Design Maturity**
>
> Program officials reported that the design for the SM-3 Block IA missiles being produced is stable, with 100 percent of its drawings released to manufacturing. Program officials do not anticipate additional design changes. However, Aegis officials told us the TSRM had experienced a malfunction, which required the nozzles to be redesigned. The program has no plans to retrofit the SM-3 Block I missiles that have already been manufactured because their service life expires in 2009.
>
> **Production Maturity**
>
> We could not assess the production maturity of the SM-3 Block IA missiles because, according to program officials, the contractor's production processes are not yet mature enough to collect statistical control data. 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**
>
> Aegis encountered problems in development, testing, and transition to production of the SM-3 Block IA missile. As a result, MDA officials extended the development of the follow-on

(...continued)

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.

Block IB missile by 1 year, delaying its procurement by 1 year as well. The 1 year development extension caused a future missile buy to change from an SM-3 Block IB configuration to Block IA. MDA will buy 23 more Block IA missiles than originally planned. MDA plans to buy 82 SM-3 Block IA missiles by fiscal year 2011. Finally, the program had a goal to deliver 20 Block IAs by the end of fiscal year 2008, which was met ahead of schedule.

The Block IB is planned to provide more capability than the Block IA. The Aegis program is developing new technologies for Block IB that would provide a two-color seeker capability for better target discrimination and an adjustable divert and attitude control system.

Block IIA critical design review, under a cooperative agreement with the government of Japan, has been delayed more than 1 year. Block IIA design collaboration on the TSRM has taken longer than Aegis officials expected because U.S. and Japanese engineers followed different approaches during the design phase. The Block IIA missile is intended to be faster and have an advanced discrimination seeker. The first operational test of the Block IIA is planned for July 2014.

Program Office Comments

Technical comments provided by the program office were incorporated as appropriate. In addition, program officials acknowledged that the zero-pulse mode of the TSRM is yet untested, but consider overall system performance as more than satisfactory. Because of test range safety constraints, officials stated that it is unclear when that testing will occur.[51]

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 defense[52]—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.

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.

The issue of how many ships should be equipped for BMD operations could affect the required total number of Navy cruisers and destroyers. If the role of sea-based systems in the eventual U.S.

[51] Government Accountability Office, *Defense Acquisitions[:] Assessments of Selected Weapon Programs*, GAO-09-326SP, March 2009, p. 42.

[52] 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.

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.

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 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 too 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 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.

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

> "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.
>
> 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.

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

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

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....

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]

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

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 SiteInitiative, 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
>
> **• 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 system[57]

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.

[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.

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?

Another 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?

Development and Testing of Aegis BMD System

Does development and testing of the Aegis BMD system offer any lessons for development and testing of other BMD systems?

Another potential issue for Congress is whether development and testing of the Aegis BMD system offers any lessons for development and testing of other BMD systems. The Aegis BMD program has achieved a fairly high rate of successful intercepts. At least some part of this 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 speeds[58] involved in intercepts of shorter-ranged ballistic missiles are generally lower than those for intercepts of longer-ranged ballistic missiles. Intercepts involving lower closing speeds can be less difficult to attempt than intercepts involving higher closing speeds. In BMD tests over

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

more than 20 years, tests of shorter-range kinetic-energy BMD systems has generally been more successful than tests of longer-range BMD systems.[59]

- 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?

Legislative Activity for FY2010

FY2010 Funding Request

The proposed FY2010 defense budget requests a total of $1,859.5 million for the Aegis BMD program, including $1,690.8 million in research and development funding for the program and $168.7 million in procurement funds for the SM-3 interceptor missile. The proposed FY2010 budget would fund, among other things, the installation of BMD capability on six Aegis ships, which would increase the total number of Aegis BMD ships to 27. The proposed FY2010 budget also requests $174.6 million for continued operations of the SBX.

FY2010 Defense Authorization Bill (H.R. 2647/S. 1390)

House

The House Armed Services Committee, in its report (H.Rept. 111-166 of June 18, 2009) on H.R. 2647, recommends approving the administration's request for $1,859.5 million for the Aegis BMD program, including $1,690.8 million in research and development funding for the program (page 214, line 083) and $168.7 million in procurement funds for the SM-3 interceptor missile

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

(page 116, line 036). The report also recommends approving the administration's request for $174.6 million in funding for SBX (page 215, line 092).

The committee's report states:

> *Theater missile defense*
>
> The committee has been concerned for several years that the missile defense program has been too focused on the threat from long-range ballistic missiles at the expense of providing combatant commanders with sufficient theater missile defense capabilities. The threat from short- and medium-range ballistic missiles represents the overwhelming ballistic missile threat to U.S. interests, deployed forces, and friends and allies around the world. According to estimates from the U.S. intelligence community, the total number of ballistic missiles other than from the United States, the North Atlantic Treaty Organization nations, the Russian Federation, and the People's Republic of China is over 5,900. Of that number, short- and medium-range ballistic missiles represent 99 percent of the total inventory.
>
> The Joint Capabilities Mix Study II, conducted by the Joint Staff in 2007 to examine theater missile defense inventory requirements, concluded that combatant commanders required nearly double the 96 Terminal High Altitude Area Defense (THAAD) interceptors and the 133 Standard Missile-3 (SM–3) interceptors than originally planned to address the short- and medium-range ballistic missile threat. The committee notes its support for the Department's decision to increase funding for the THAAD and Aegis Ballistic Missile Defense programs by $900.0 million in fiscal year 2010. Under the revised program plan, the SM–3 interceptor inventory will grow from 133 to 329, and the THAAD interceptor inventory will grow from 96 to 287 over the Future Years Defense Program.
>
> This decision represents an important milestone in providing the warfighter with the capabilities necessary to defend against the threats to U.S. interests, its deployed forces, and friends and allies around the world. The committee also supports the Department's decision to initiate the development of a land-based version of the SM–3 interceptor. Deployment of such a capability has the potential to expand missile defense coverage for U.S. deployed forces and friends and allies around the world. (Page 237)

The report also states:

> *Missile defense inventory and force structure analysis*
>
> The committee has long been concerned about how the Department of Defense has developed missile defense force structure and inventory requirements. In the committee report (H. Rept. 110–652) accompanying the Duncan Hunter National Defense Authorization Act for Fiscal Year 2009, the committee directed the Secretary of Defense to develop a process and methodology for determining overall missile defense force structure and inventory requirements. The Department recently notified the committee that it has begun an initial review of requirements and plans to address the committee's direction as part of the missile defense policy and strategy review required by section 229 of the Duncan Hunter National Defense Authorization Act for Fiscal Year 2009 (Public Law 110–417). The committee supports this decision.
>
> The committee expects that once the requirements review is complete, the Department will provide the results of the review to the committee, similar to the manner in which the Department provided the Joint Capabilities Mix II study results.

> The committee believes that missile defense should be placed within a stronger defense planning framework to identify the nation's longer-term missile defense requirements to defend the United States, its deployed forces, and friends and allies against the full range of ballistic missile threats. Without such a framework, the committee is concerned that program decisions and tradeoffs may be made without a comprehensive understanding of the end-to-end requirements of the entire ballistic missile defense system. The committee believes that it is important for the Department's review to include participation of key stakeholders such as the Office of the Secretary of Defense, the Joint Staff, the combatant commands, and the relevant defense agencies. Furthermore, the committee believes that the analysis supporting the review should ensure that missile defense force structure and inventory requirements are clearly linked to threat assessments and warfighter requirements, such as operational effectiveness, suitability, maintainability, and survivability. (Page 232)

The report also states:

> *Kinetic Energy Interceptor and Multiple Kill Vehicle technology applications*
>
> The committee recognizes that the Kinetic Energy Interceptor (KEI) program and the Multiple Kill Vehicle (MKV) program have completed research and development of certain technologies that could be beneficial to other defense programs. The committee directs the Secretary of Defense to provide a report to the congressional defense committees not later than March 31, 2010, on the feasibility of completing development of certain technologies that were in the process of being developed through the KEI and MKV programs and could have additional useful defense applications.
>
> *Missile defense and military operational requirements*
>
> One of the key themes resident in the three missile defense programs that the Secretary of Defense has recommended for termination in the fiscal year 2010 budget request (the second Airborne Laser aircraft, the Multiple Kill Vehicle program, and the Kinetic Energy Interceptor (KEI) program) is that each program has not been linked to clear military operational requirements. The committee believes that this is a direct result of the Department's decision in 2002 to remove the Missile Defense Agency (MDA) from the normal Department of Defense requirements process, and from oversight by the Joint Requirements Oversight Council. For example, the KEI program was originally presented to Congress as a sea-based, mobile missile defense interceptor. However, the current KEI interceptor is too large to fit into any existing Navy surface combatant without significant and costly modifications.
>
> The need to effectively link missile defense programs with the Department's overall requirements process is essential if the United States is to deploy operationally effective, suitable, and survivable systems. While a number of steps to improve MDA's integration with the rest of the Department of Defense have recently occurred, such as the establishment of the Warfighter Involvement Program and the Missile Defense Executive Board, the committee believes that additional effort is required in this area. As the Department conducts the missile defense policy and strategy review required by section 234 of the Duncan Hunter National Defense Authorization Act for Fiscal Year 2009 (Public Law 110–417), the committee encourages the Department to take the necessary actions to ensure that missile defense programs are closely linked to the military operational requirements process. (Page 231)

Senate

Division D of S. 1390 as reported by the Senate Armed Services Committee (S.Rept. 111-35 of July 2, 2009) presents the detailed line-item funding tables that in previous years have been included in the Senate Armed Services Committee's report on the defense authorization bill. Division D recommends reducing by $30 million the administration's request for $1,690.8 million in research and development funding for the Aegis BMD program, stating that the $30 million is "excess to execution" (page 697, line 083 of the printed bill). The report recommends approving the administration's request for $168.7 million in procurement funds for the SM-3 interceptor missile (page 640, line 036) and the administration's request for $174.6 million in funding for SBX (page 697, line 092).

The committee's report states:

> **Aegis ballistic missile defense**
>
> The budget request included $1.7 billion in PE 63892C for research and development of the Aegis Ballistic Missile Defense (BMD) program and its Standard Missile–3 (SM–3) interceptor.
>
> The committee notes with satisfaction that the budget request would increase substantially the planned inventory of SM–3 interceptors, from a previously planned inventory of 147 to 329, and would increase by six the number of Aegis BMD ship conversions. As indicated by Secretary of Defense Robert Gates, this increase in planned capability represents a fundamental shift in focus of the ballistic missile defense program to capabilities for protecting our forward-deployed forces, allies, and other friendly nations against the large number of existing short- and medium-range theater missile threats.
>
> This shift is consistent with the guidance provided by Congress over the last few years and with the findings of the Joint Capabilities Mix studies conducted by the Joint Staff over the last 3 years. Those studies concluded that the Department of Defense was planning to procure fewer than half of the minimum inventory of SM–3 and Terminal High Altitude Area Defense (THAAD) interceptors that would be needed to meet the operational requirements of the regional combatant commanders against existing and expected short- and medium-range missile threats.
>
> In the report to accompany the National Defense Authorization Act for Fiscal Year 2009 (Public Law 110–417), the committee stated the following: ''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.''
>
> The committee welcomes the shift in focus toward providing effective near-term capabilities against existing regional missile threats, and commends the Department of Defense for this shift.

> The budget request would also begin the development of a land-based variant of the SM–3 missile. The committee believes such a capability could provide a significant enhancement to U.S. missile defense capabilities in a number of circumstances. It is being developed, in part, as a relatively low-risk and near-term option as a component of an Israeli upper tier missile defense system, as a risk mitigation path for the possibility that the development of the Arrow–3 interceptor will take longer than planned, or might not achieve technical success. A land-based SM–3 could also provide regional defense capability in Europe and Asia, and could be a crucial element of the ascent-phase/early intercept capability initiative included in the budget request. In this regard, a land-based SM–3 has the potential, if deployed in the European theater, to defend Europe and the United States from a potential future long-range Iranian ballistic missile threat. The committee commends the Department for initiating this land-based SM–3 development effort. The committee sees this program as a high priority, and considers it an item of special interest to the committee.
>
> The budget request of $1.7 billion in PE 63892C for the Aegis BMD system is nearly $600.0 million more than the level of funding provided in fiscal year 2009, a 34 percent increase. Although the committee strongly supports the Aegis BMD program, and the Department's shift in focus toward meeting the current needs of the regional combatant commanders against the thousands of existing short- and medium-range ballistic missiles, the committee believes that the proposed level of increased funding will be too high to execute. The committee therefore recommends, without prejudice, a reduction of $30.0 million to PE 63892C for the Aegis BMD program. (Pages 92-93)

The report also states:

> **Ballistic missile defense overview**
>
> The budget request included $7.8 billion for Missile Defense Agency (MDA) missile defense programs, including research, development, test and evaluation, procurement, and military construction funds. The committee notes a number of positive developments with the ballistic missile defense program of MDA included in the budget request.
>
> The budget request includes a shift in focus on increasing capabilities needed by regional combatant commanders to defend our forward deployed forces, allies, and other friendly nations against the many existing short- and medium-range threats. As announced by Secretary of Defense Robert Gates, the budget would increase funding by $900.0 million to increase the inventory of Terminal High Altitude Area Defense (THAAD) and Standard Missile–3 (SM–3) interceptors, and to convert an additional six Aegis Ballistic Missile Defense (BMD) ships for deployment in the Atlantic Fleet. In accordance with the budget request, the Department of Defense would plan to increase the SM–3 interceptor inventory from 147 to 329, and increase the THAAD interceptor inventory from 96 to 289. These numbers are consistent with the level of THAAD and SM–3 interceptors recommended by the Joint Capabilities Mix (JCM) studies conducted by the Joint Staff, and are consistent with the guidance of the committee and Congress....
>
> The budget request includes an initiative to develop a new capability for ascent-phase (or early) intercepts, relying on improved use of existing and new sensors and interceptors such as the SM–3, whether on ships or on land. According to senior Department officials, such a capability would allow U.S. forces to engage threat missiles early in their flight, including long-range missiles, thus providing multiple opportunities to destroy the missiles in flight. In the case of long-range threat missiles, such a capability could also permit destruction of the threat missile before the GMD system would be needed to defend the Nation. If the initiative proves successful, such a capability could, if deployed in the European theater, provide defense of Europe and the United States against a potential future long-range missile threat from Iran. The committee supports this initiative, and commends the Department for

> conceiving of the concept for a cost-effective and operationally effective system that relies, to a large extent, on existing or near-term technologies.
>
> The committee notes that Secretary of Defense Gates decided to terminate a number of long-term research and development programs for missile defense that had technical, conceptual, cost, or operational problems. These decisions include the termination of the Multiple Kill Vehicle program, the Kinetic Energy Interceptor program, and cancelation of the second Airborne Laser (ABL) aircraft, and shifting the ABL program to a research and development effort. The Director of MDA testified that he recommended these changes, and Secretary Gates' decision was supported by the Joint Chiefs of Staff and the combatant commanders. The committee supports the Secretary's decision. (Pages 96-98)

The report also states:

> **Israeli upper tier missile defense**
>
> The budget request included $119.7 million in PE 63913C for cooperative U.S.-Israeli missile defense programs, including $37.5 million for joint development of an upper tier interceptor to replace the Arrow–2 interceptor, known as the Arrow–3. The committee supports the joint U.S.-Israeli development of the Arrow–3 interceptor, but is concerned that the program has risks that may take significantly longer to resolve than the timeline envisioned, and not in time to meet Israel's required schedule.
>
> According to the testimony of Lieutenant General Patrick O'Reilly, Director of the Missile Defense Agency, the Arrow–3 development program is ''deemed to have very high schedule and technical risk.'' The Missile Defense Agency is currently negotiating an Upper Tier Project Agreement that is intended to ensure that the Arrow–3 program is managed according to sound acquisition and management principles, including a requirement for accomplishing technology knowledge points according to a schedule.
>
> According to Lieutenant General O'Reilly, to ''mitigate the Arrow–3 development schedule risk, we are ensuring that the development of a land-based variant of the proven Aegis SM–3 missile is available to meet Israel's upper tier requirements.'' The committee agrees with this management and risk mitigation approach, and commends the Department for ensuring there will be a relatively low-risk and near-term upper tier option, based on the operationally effective SM–3, to meet Israel's upper tier missile defense needs in a timely manner. The committee requests that the Missile Defense Agency keep the congressional defense committees apprised of developments in the Israeli upper tier missile defense program, including both the Arrow–3 and land-based SM–3 development programs. (Page 98-99)

The report also states:

> **Mobile maritime sensor development**
>
> The budget request included $190.0 million in PE 64501N for development efforts in support of a next-generation cruiser, CG(X). CG(X) is planned to be the replacement for the CG–47 class cruiser, with primary missions including air and missile defense. The Navy's last long-range shipbuilding plan proposed to procure the first ship of the CG(X) program in 2011. That schedule was clearly too optimistic.
>
> Part of the delay came from questions about the CG(X) Analysis of Alternatives (AoA), called the Maritime Air and Missile Defense of Joint Forces (MAMDJF) AoA. One problem has been that demanding threat requirements have led to very demanding sensor requirements, some of which could only be fit on a cruiser-size vessel by achieving major

technology breakthroughs. Another cause of the delay was that, as the committee understands it, the Secretary of the Navy was asking questions about potential contributions of off-board, networked sensors and why the MAMDJF vessel had to be self-sufficient for target acquisition and tracking.

The committee recognizes that there are at least two other platforms within DOD inventories that could provide the basis for developing a more robust off-board sensor augmentation. Such an incremental development approach might not require that the Navy make such heroic technology improvements in surface combatant radar technology. These are the Navy's own programs to develop a Cobra Judy replacement vessel, and the Missile Defense Agency's Sea-Based X-Band radar.

A mobile maritime sensor could improve upon the performance of either of these radars by making more modest technology improvements that could provide requisite capability for radars that would be less risky, cheaper to acquire and operate, and potentially available sooner than sensors that must provide equivalent performance from within the relatively constrained confines of a surface combatant. (Page 67)

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.[60] One to four Navy ships operating in the Sea of Japan, for example, could attempt to defend most or all of Japan against theater-range ballistic missiles (TBMs)[61] fired from North Korea.

[60] 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.

[61] 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 (continued...)

- 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 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

(...continued)

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.

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.[62]
- **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.

[62] 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, Mary Beth Nikitin, and Paul K. Kerr. 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 Flight Tests

From January 2002 through November 2008, the Aegis BMD system has achieved 14 successful exo-atmospheric intercepts in 18 attempts. This total includes one successful intercept and one unsuccessful intercept by Japanese Aegis ships in two Japanese test flights. The Aegis BMD system has also achieved 2 successful endo-atmospheric intercepts in 2 attempts, for a combined total of 16 successful exo- and endo-atmospheric intercepts in 20 attempts.[63] This appendix provides details on these flight tests.

Summary Table

Table C-1 summarizes Aegis BMD exo- and endo-atmospheric flight tests since January 2002.

Table C-1. Aegis BMD Flight Tests Since January 2002

Date	Country	Successful?	Cumulative successes	Cumulative attempts
		Exo-atmospheric (using SM-3 missile)		
1/22/02	US	Yes	1	1
6/13/02	US	Yes	2	2
11/21/02	US	Yes	3	3
6/18/03	US	**No**	3	4
12/11/03	US	Yes	4	5
2/24/05	US	Yes	5	6
11/17/05	US	Yes	6	7
6/22/06	US	Yes	7	8
12/7/06	US	**No**	7	9
4/26/07	US	Yes	8	10
6/22/07	US	Yes	9	11
8/31/07	US	Yes	10	12
11/6/07	US	Yes	11	13
		Yes	12	14

[63] 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.)

Date	Country	Successful?	Cumulative successes	Cumulative attempts
12/17/07	Japan	Yes	13	15
11/1/08	US	Yes	14	16
		No	14	17
11/19/08	Japan	**No**	14	18
		Endo-atmospheric (using SM-2 missile)		
5/24/06	US	Yes	1	1
6/5/08	US	Yes	2	2
3/24-26/09	US	Yes	3	3
		Combined total for exo- and endo-atmospheric tests		
n/a	US and Japan	n/a	17	21

Source: Prepared by CRS based on DOD data.

Details On Selected Exo-Atmospheric Flight Tests

June 22, 2006 Test. This was the first test to use the Aegis 3.6 computer program.[64]

December 7, 2006 Test. This 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. 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.[65]

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....

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

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

> 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.
>
> 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.[66]

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.[67]

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.

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

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

> "Difficulties such as those that delayed the latest flight intercept attempt illustrate the complexity of the system, and how everything must be carefully orchestrated to achieve success," Coyle added. "Nevertheless, this particular setback won't take the Navy long to correct."[68]

April 26, 2007 Test. MDA states that this 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.[69]

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.[70]

June 22, 2007 Test. MDA states that this 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.
>
> 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.[71]

August 31, 2007, Test. MDA has publicly noted the occurrence of this test and the fact that it resulted in a successful intercept,[72] but states that the details about the test are classified.[73] MDA

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[68] Zachary M. Peterson, "Sea-Based Missile Defense Test Fails Due To 'Incorrect Configuration,'" *Inside the Navy*, December 11, 2006.

[69] Missile Defense Agency, "Successful Sea-Based Missile Defense 'Hit to Kill' Intercept," April 26, 2007 (07-NEWS-0032).

[70] Audrey McAvoy, "Aegis Missile Test Successful," *NavyTimes.com*, April 27, 2007.

[71] Missile Defense Agency, "Sea-Based Missile Defense 'Hit to Kill' Intercept Achieved," June 22, 2007 (07-NEWS-0037).

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.[74]

November 6, 2007 Test. MDA states that this test involved:

> 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 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.[75]

December 17, 2007 Test. In this flight test, 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.[76]

November 1, 2008 Test. This flight test was reportedly the first U.S. Navy Aegis BMD flight test conducted by the Navy, without oversight by MDA. The test involved two Aegis ships, each attempting to intercept a ballistic missile. The SM-3 fired by the first Aegis ship successfully

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(...continued)

[72] 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.

[73] 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."

[74] MDA's website, when accessed on June 30, 2008, did not show a news release issued on of soon after August 31, 2007, that discusses this test.

[75] Missile Defense Agency, "Sea-Based Missile Defense "Hit to Kill" Intercept Achieved," November 6, 2007 (07-NEWS-0051).

[76] 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.

intercepted its target, but the SM-3 fired by the second Aegis ship did not intercept its target. A press release from the U.S. Third Fleet (the Navy's fleet for the Eastern Pacific) states that:

> Vice Adm. Samuel J. Locklear, Commander, U.S. Third Fleet announced today the successful Navy intercept of a ballistic missile target over the Pacific Ocean during Fleet Exercise Pacific Blitz. This was the first Fleet operational firing to employ the Standard Missile-3 (SM-3) against a ballistic missile target. Command and control of this mission resided with Commander, U.S. Third Fleet, based in San Diego, Calif.
>
> Pearl Harbor-based Aegis destroyers, USS Paul Hamilton (DDG 60) and USS Hopper (DDG 70), which have been upgraded to engage ballistic missiles, fired SM-3 missiles at separate targets. During this event, a short-range ballistic missile target was launched from the Pacific Missile Range Facility (PMRF), Barking Sands, Kauai, Hawaii. Upon detecting and tracking the target, USS Paul Hamilton, launched a SM-3 missile, resulting in a direct-hit intercept. Following USS Paul Hamilton's engagement, PMRF launched another target. USS Hopper successfully detected, tracked and engaged the target. The SM-3 followed a nominal trajectory, however intercept was not achieved. Extensive analysis of the flight mission will be used to improve the deployed Aegis BMD system.[77]

November 19, 2008 Test. This was the second Japanese flight test, and involved a single ballistic missile target. The test did not result in a successful intercept. MDA states that:

> Rear Admiral Tomohisa Takei, Director General of Operations and Plans, for the Japanese Maritime Staff Office (MSO), Japan Maritime Self Defense Force (JMSDF), and Lt. General Henry "Trey" Obering, United States Missile Defense Agency director, announced the completion today of a cooperative sea-based Aegis Ballistic Missile Defense intercept flight test off the coast of Kauai in Hawaii. The event, designated Japan Flight Test Mission 2 (JFTM-2), marked the second attempt by an Allied naval ship to intercept a ballistic missile target with the sea-based midcourse engagement capability provided by Aegis Ballistic Missile Defense. Target performance, interceptor missile launch and flyout, and operation of the Aegis Weapon System by the crew were successful, but an intercept was not achieved.
>
> The JFTM-2 was a test of the newest engagement capability of the Aegis Ballistic Missile Defense configuration of the recently upgraded Japanese destroyer, JS CHOKAI (DDG-176). At approximately 4:21 pm (HST), 11:21 am (Tokyo time) a ballistic missile target was launched from the Pacific Missile Range Facility, Barking Sands, Kauai, Hawaii. JS CHOKAI crew members detected and tracked the target using an advanced on-board radar. The Aegis Weapon System then developed a fire control solution, and at approximately 4:24 pm (HST), 11:24 am (Tokyo time) on Nov 20, a single Standard Missile -3 (SM-3) Block IA was launched. Approximately two minutes later, the SM-3 failed to intercept the target. There is no immediate explanation for the failed intercept attempt. More information will be available after a thorough investigation. The JS CHOKAI crew performance was excellent in executing the mission. JFTM-2 was the second time that a Japanese ship was designated to launch the interceptor missile, a major milestone in the growing cooperation between Japan and the U.S.[78]

[77] Commander, U.S. Third Fleet, Public Affairs Office, press release 23-08, dated November 1, 2008, entitled "Navy Intercepts Ballistic Missile Target in Fleet Exercise Pacific Blitz." See also Dave Ahearn, "One of Two Missiles Hit In Aegis Test; Navy For First Time Runs Test Instead of MDA," *Defense Daily*, November 4, 2008: 1-2.

[78] Missile Defense Agency press release 08-News-0087, dated November 19, 2008, entitled "Japan/U.S. Missile Defense Flight Test Completed."

A November 21, 2008 press report states that:

> An Aegis ballistic missile defense (BMD) test by the Japanese destroyer Chokai (DDG-176) ended in failure when the Standard Missile-3 Block 1A interceptor lost track of the target missile in the final seconds before a planned hit-to-kill.
>
> The Chokai and its crew performed well throughout the test, and the SM-3 also performed flawlessly through its first three stages, according to Rear Adm. Brad Hicks, the U.S. Navy Aegis ballistic missile defense program director. He spoke with several reporters in a teleconference around midnight ET Wednesday-Thursday, after the test in the area of the Pacific Missile Range Facility, Barking Sands, Kauai, Hawaii.
>
> This was the second Aegis BMD test failure in less than a month....

These latest two failures come as some Democrats in Congress are poised to cut spending on missile defense programs when they convene next year to consider the Missile Defense Agency budget for the fiscal year ending Sept. 30, 2010....

> Still, in the coming money debates next year, missile defense advocates will be able to point out that even including the Hopper and Chokai failures, the record for the Aegis tests is an overwhelming 16 successful hits demolishing target missiles out of 20 attempts.
>
> Those successes included the first Japanese attempt. The Japanese destroyer Kongo (DDG-173) successfully used its SM-3 interceptor to kill a target missile. The difference in tests is that the Kongo crew was advised beforehand when the target missile would be launched, while the Chokai crew wasn't....
>
> [Hicks] said a board will be convened to examine why the latest test failed. Hicks declined to speculate on why the SM-3 interceptor missed the target. "I'm confident we'll find out the root cause" of the Chokai interceptor failure to score a hit, he said.
>
> However, he was asked by *Space & Missile Defense Report* whether the prior SM-3 successes make it unlikely the Chokai failure stems from some basic design flaw in all SM-3s, and whether it is more likely that the Chokai SM-3 failed because of some flaw or glitch in just that one interceptor.
>
> Hicks said that is likely.
>
> "Obviously, we believe this is hopefully related to this one interceptor," and doesn't reflect any basic design flaw in the SM-3 interceptors, he said.
>
> The Chokai test failure cost Japan a $55 million loss, he said, adding, "It wasn't cheap."...
>
> In the Chokai test, the target missile was launched from Barking Sands, and about three minutes later the Chokai crew had spotted the target, the Aegis system had developed a tracking and hit solution, and the SM-3 interceptor was launched.
>
> The first, second and third stages of the interceptor performed nominally, without problems, but then came the fourth stage. The nosecone components opened to expose the kill vehicle area, and somehow the program to track the target missile failed.
>
> "It lost track," Hicks said, only seconds before the hit would have been achieved.

If the kill had occurred, it would have been about 100 nautical miles (roughly 115 statute miles) above Earth, and some 250 miles away from Barking Sands, Hicks said.

It took the interceptor about two minutes flight time to reach the near miss with the target missile.

Meanwhile, the Hamilton was nearby watching the test. The Hamilton Aegis system successfully spotted and tracked the target, and developed a simulated solution and simulated interceptor launch that, if it had been real, would have resulted in a successful hit on the target, Hicks said. The Hamilton didn't cue the Chokai, however. "It was strictly Chokai's engagement," Hicks said.[79]

[79] Dave Ahearn, "Japanese Aegis Missile Defense Test Fails, But Aegis Record Is 16 Hits In 20 Tries," Defense Daily, November 21, 2008: 5-6.

Appendix D. Multiple Kill Vehicle (MKV) and Kinetic Energy Interceptor (KEI)

The Administration's proposed FY2010 budget proposes to terminate the development of two BMD programs that had potential connections to sea-based BMD—the Multiple Kill Vehicle (MKV) and the Kinetic Energy Interceptor (KEI). This appendix presents discussions of these two programs in relation to sea-based BMD as those discussions existed prior to the proposal in the FY2010 budget to terminate the two programs.

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)?

A 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 was expected by DOD to achieve initial capability in 2017.[80]

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.

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.

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

> 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.[81]

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 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:

[81] 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.

> 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.[82]

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."[83]

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 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.[84]

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[82] H.Rept. 110-434, p. 346.

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

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

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 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.[85]

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.

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

[85] 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.

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.[86]

Press Report

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

> [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,

[86] S.Rept. 110-155, p. 268.

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.[87]

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[87] Christopher P. Cavas, "U.S. May Build 25,000-Ton Cruiser, Analysis of Alternatives Sees Nuclear BMD Vessel," Defense News, July 23, 2007.