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Navy Aegis Ballistic Missile Defense (BMD) Program: Background and Issues for Congress

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Summary

The Aegis ballistic missile defense (BMD) program, which is carried out by the Missile Defense Agency (MDA) and the Navy, gives Navy Aegis cruisers and destroyers a capability for conducting BMD operations. Under the FY2019 budget submission, the number of BMD-capable Aegis ships is scheduled to be 41 at the end of FY2019 and 57 at the end of FY2023.

Two Japan-homeported Navy BMD-capable Aegis destroyers included in the above figures—the *Fitzgerald* (DDG-62) and the *John S McCain* (DDG-56)—were seriously damaged in collisions with merchant ships in waters off the coasts of Japan and Singapore in June 2017 and August 2017, respectively, and are currently being repaired. The temporary loss of these two BMD-capable ships reinforced, at the margin, concerns among some observers about required numbers of BMD-capable Aegis ships versus available numbers of BMD-capable Aegis ships, particularly for performing BMD operations in the Western Pacific.

Under the European Phased Adaptive Approach (EPAA) for European BMD operations, BMD-capable Aegis ships are operating in European waters to defend Europe from potential ballistic missile attacks from countries such as Iran. BMD-capable Aegis ships also operate in the Western Pacific and the Persian Gulf to provide regional defense against potential ballistic missile attacks from countries such as North Korea and Iran.

The Aegis BMD program is funded mostly through MDA's budget. The Navy's budget provides additional funding for BMD-related efforts. MDA's proposed FY2019 budget requests a total of $1,711.8 million in procurement and research and development funding for Aegis BMD efforts, including funding for two Aegis Ashore sites in Poland and Romania that are to be part of the EPAA. MDA's budget also includes operations and maintenance (O&M) and military construction (MilCon) funding for the Aegis BMD program.

Issues for Congress regarding the Aegis BMD program include the following:

- whether to approve, reject, or modify MDA's FY2019 funding procurement and research and development funding requests for the program;
- required numbers of BMD-capable Aegis ships versus available numbers of BMD-capable Aegis ships;
- the burden that BMD operations may be placing on the Navy's fleet of Aegis ships, and whether there are alternative ways to perform BMD missions now performed by U.S. Navy Aegis ships, such as establishing more Aegis Ashore sites;
- burden sharing—how European naval contributions to European BMD capabilities and operations compare to U.S. naval contributions to European BMD capabilities and operations;
- the potential for ship-based lasers, electromagnetic railguns (EMRGs), and hypervelocity projectiles (HVPs) to contribute in coming years to Navy terminal-phase BMD operations and the impact this might eventually have on required numbers of ship-based BMD interceptor missiles; and
- technical risk and test and evaluation issues in the Aegis BMD program.

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Introduction

This report provides background information and issues for Congress on the Aegis ballistic missile defense (BMD) program, which is carried out by the Missile Defense Agency (MDA) and the Navy, and gives Navy Aegis cruisers and destroyers a capability for conducting BMD operations. The issue for Congress is whether to approve, reject, or modify Department of Defense (DOD) acquisition strategies and proposed funding levels for the Aegis BMD program. Congress's decisions on the Aegis BMD program could significantly affect U.S. BMD capabilities and funding requirements, and the BMD-related industrial base.

For an overview of the strategic and budgetary context in which the Aegis BMD program may be considered, see CRS Report RL32665, *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress*, by Ronald O'Rourke.

Background

Aegis Ships

The Navy's cruisers and destroyers are called Aegis ships because they are equipped with the Aegis ship combat system—an integrated collection of sensors, computers, software, displays, weapon launchers, and weapons named for the mythological shield that defended Zeus. The Aegis system was originally developed in the 1970s for defending ships against aircraft, anti-ship cruise missiles (ASCMs), surface threats, and subsurface threats. The system was first deployed by the Navy in 1983, and it has been updated many times since. The Navy's Aegis ships include Ticonderoga (CG-47) class cruisers and Arleigh Burke (DDG-51) class destroyers.

Ticonderoga (CG-47) Class Aegis Cruisers

Overview

A total of 27 CG-47s (CGs 47 through 73) were procured for the Navy between FY1978 and FY1988; the ships entered service between 1983 and 1994. The first five ships in the class (CGs 47 through 51), which were built to an earlier technical standard in certain respects, were judged by the Navy to be too expensive to modernize and were removed from service in 2004-2005, leaving 22 ships in operation (CGs 52 through 73).

"2-4-6" Program for Modernizing 11 Existing Aegis Cruisers

Congress has directed the Navy to implement the so-called "2-4-6" program for modernizing the 11 youngest Aegis cruisers. Under the 2-4-6 program, no more than two of the cruisers are to enter the modernization program each year, none of the cruisers is to remain in reduced status for modernization for more than four years, and no more than six of the cruisers are to be in the program at any given time. Among the 11 Aegis cruisers that are to be modernized under this program are four that are BMD-capable—CG-67 (*Shiloh*), CG-70 (*Lake Erie*), CG-72 (*Vella Gulf*), and CG-73 (*Port Royal*).

Arleigh Burke (DDG-51) Class Aegis Destroyers[1]

Flight I/II and Flight IIA DDG-51s Procured in FY1985-FY2005

A total of 62 DDG-51s were procured for the Navy between FY1985 and FY2005; the first entered service in 1991 and the 62nd entered service in FY2012. The first 28 ships are known as Flight I/II DDG-51s. The next 34 ships, known as Flight IIA DDG-51s, incorporate some design changes.

No DDG-51s Procured in FY2006-FY2009

No DDG-51s were procured in FY2006-FY2009. The Navy during this period instead procured three Zumwalt (DDG-1000) class destroyers. The Navy does not plan to procure any additional DDG-1000s. The DDG-1000 design does not use the Aegis system and does not include a capability for conducting BMD operations. Navy plans do not call for modifying the three DDG-1000s to make them BMD-capable.

Procurement of DDG-51s Resumed in FY2010

Procurement of DDG-51s resumed in FY2010, following procurement of the three DDG-1000s. A total of 17 DDG-51s were procured in FY2010-FY2018.[2]

Transition to Flight III DDG-51 Design in FY2017

DDG-51s procured in FY2017 and subsequent years are being built to a new version of the DDG-51 design called the Flight III version. The Flight III version is to be equipped with a new radar, called the Air and Missile Defense Radar (AMDR) or the SPY-6 radar, that is more capable than the SPY-1 radar installed on all previous Aegis cruisers and destroyers.

Aegis Ships in Allied Navies

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, South Korea, Australia, Spain, and Norway.[3]

Aegis BMD System[4]

Aegis ships are given a capability for conducting BMD operations by incorporating changes to the Aegis system's computers and software, and by arming the ships with BMD interceptor missiles. In-service Aegis ships can be modified to become BMD-capable ships, and DDG-51s procured in FY2010 and subsequent years are being built from the start with a BMD capability.

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[1] For more on the DDG-51 program, see CRS Report RL32109, *Navy DDG-51 and DDG-1000 Destroyer Programs: Background and Issues for Congress*, by Ronald O'Rourke.

[2] The 15 DDG-51s procured in FY2010-FY2017 include one in FY2010, two in FY2011, one in FY2012, three in FY2013, one in FY2014, two in FY2015, three in FY2016, two in FY2017, and two in FY2018.

[3] The Norwegian ships 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.

[4] Unless stated otherwise, information in this section is taken from MDA briefings on the Aegis BMD program given to CRS and CBO analysts on the MDA's FY2019 and prior-year budget submissions.

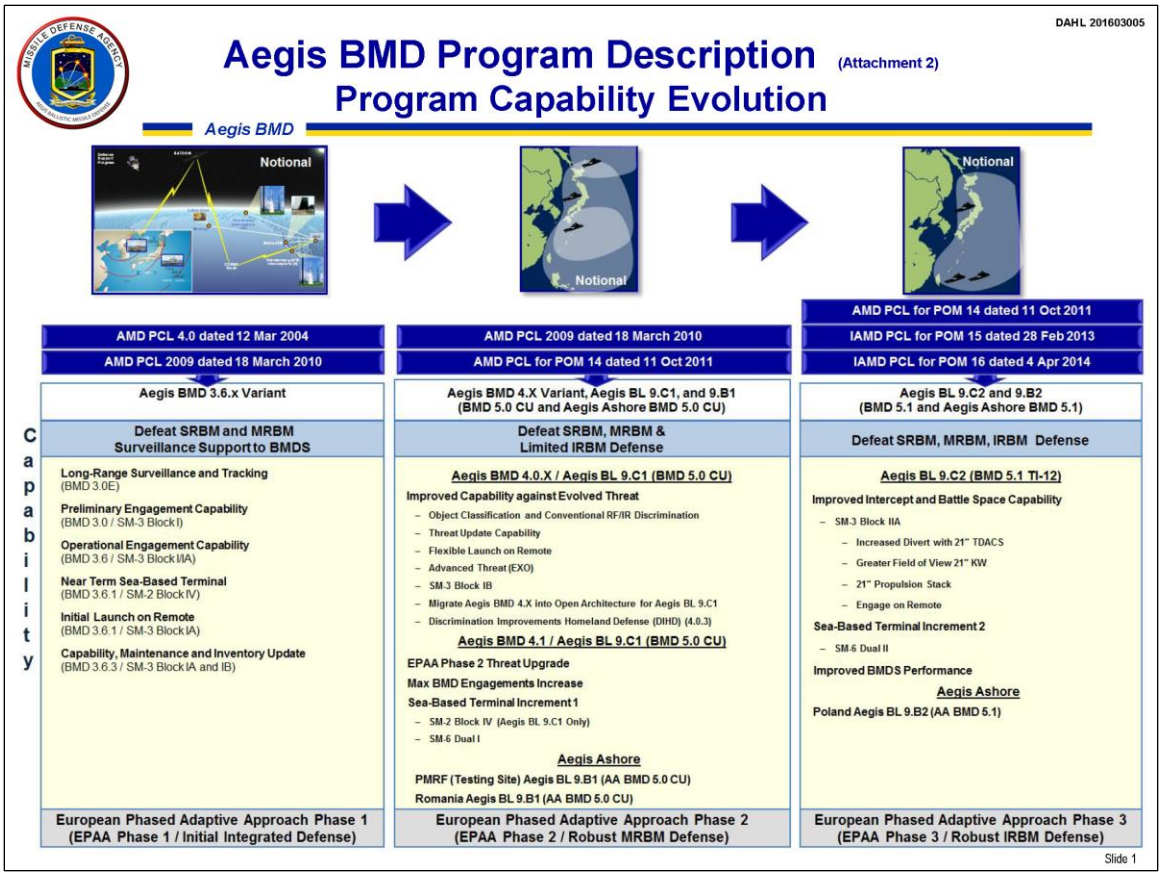
Versions and Capabilities of Aegis BMD System

The Aegis BMD system exists in several variants. Listed in order of increasing capability, these are the 3.6.X variant, the 4.0.3 variant, the 4.1 variant, the 5.0 CU (Capability Upgrade) variant (also known as the Baseline [BL] 9.C1 variant), the 5.1 variant (also known as the BL 9.C2 variant), and the 6.X variant (also known as the BL 10 variant).

Figure 1 summarizes the capabilities of most of these variants and correlates them with the phases of the European Phased Adaptive Approach (or EPAA; see below) for European BMD operations. As shown in **Figure 1**, the Aegis BMD system is designed to intercept theater-range ballistic missiles, meaning short-, medium-, and intermediate-range ballistic missiles (SRBMs, MRBMs, and IRBMs, respectively). The Aegis BMD system is not designed, at least at present, to intercept longer-ranged intercontinental ballistic missiles (ICBMs). Detection and tracking data collected by the Aegis BMD system's radar, however, might be passed to other U.S. BMD systems that are designed to intercept ICBMs, which might support intercepts of ICBMs that are conducted by those other U.S. BMD systems. See also "Reported Cooperative Development of New Radar Technology" in the section below entitled "Allied Participation and Interest in Aegis BMD Program."

Figure 1. Aegis BMD System Variants

(Summary of capabilities)



Source: MDA briefing slide provided to CRS on March 25, 2016.

Aegis BMD Interceptor Missiles

The BMD interceptor missiles used by Aegis ships are the Standard Missile-3 (SM-3), the SM-2 Block IV, and the SM-6.

SM-3 Midcourse Interceptor

The SM-3 is designed to intercept ballistic missiles above the atmosphere (i.e., exo-atmospheric intercept), in the midcourse phase of an enemy ballistic missile's flight. It is equipped with a "hit-to-kill" warhead, called a kinetic vehicle, that is designed to destroy a ballistic missile's warhead by colliding with it. MDA and Navy plans call for fielding increasingly capable versions of the SM-3 in coming years. The current versions, called the SM-3 Block IA and SM-3 Block IB, are to be supplemented in coming years by SM-3 Block IIA.

Compared to the Block IA version, the Block IB version has an improved (two-color) target seeker, an advanced signal processor, and an improved divert/attitude control system for adjusting its course. Compared to the Block IA and 1B versions, which have a 21-inch-diameter booster stage at the bottom but are 13.5 inches in diameter along the remainder of their lengths, the Block IIA version has a 21-inch diameter along its entire length. The increase in diameter to a uniform 21 inches provides more room for rocket fuel, permitting the Block IIA version to have a burnout velocity (a maximum velocity, reached at the time the propulsion stack burns out) that is greater than that of the Block IA and IB versions,[5] as well as a larger-diameter kinetic warhead. The United States and Japan have cooperated in developing certain technologies for the Block IIA version, with Japan funding a significant share of the effort.[6]

A March 26, 2018, press report states the following:

> [MDA] Director Lt. Gen. Sam Greaves said MDA "is evaluating the technical feasibility of the capability of the SM-3 Block IIA missile, currently under development, against an ICBM-class target."
>
> "If proven to be effective against an ICBM, this missile could add a layer of protection, augmenting the currently deployed GMD system," Greaves said in written testimony submitted March 22 to the Senate Armed Services strategic forces subcommittee. [Greaves] said MDA will conduct a demonstration of the SM-3 Block IIA against an ICBM-like target by the end of 2020....

[5] Some press reports and journal articles, all of which are now more than a decade old, report unconfirmed figures on the burnout velocities of various SM-3 missile configurations (some of which were proposed but ultimately not pursued). See, for example, J. D. Williams, *The Future Of Aegis Ballistic Missile Defense*, point paper dated October 15, 2004, accessed online at http://marshall.org/wp-content/uploads/2013/08/Williams-The-Future-of-Aegis-Ballistic-Missile-Defense.pdf; "STANDARD Missile-3 Destroys a Ballistic Missile Target in Test of Sea-based Missile Defense System," Raytheon news release circa January 26, 2002; Gopal Ratnam, "U.S. Navy To Play Larger Role In Missile Defense, *Defense News*, January 21-27, 2002: 10; Hans Mark, "A White Paper on the Defense Against Ballistic Missiles," *The Bridge*, Summer 2001, pp. 17-26, accessed online at https://www.nae.edu/File.aspx?id=7315; Michael C. Sirak, "White House Decision May Move Sea-Based NMD Into Spotlight," *Inside Missile Defense*, September 6, 2000: 1; Henry F. Cooper and J.D. Williams, "The Earliest Deployment Option—Sea-Based Defenses," *Inside Missile Defense*, September 6, 2000 (guest perspective; including graphic on page 21); Robert Holzer, "DoD Weighs Navy Interceptor Options, *Defense News*, July 24, 2000: 1, 60 (graphic on page 1); and Robert Holzer, "U.S. Navy Gathers Strength, Allies in NMD Showdown," *Defense News*, March 15, 1999: 1, 42 (graphic on page 1).

[6] The cooperative research effort has been carried out under a U.S.-Japan memorandum of agreement signed in 1999. The effort 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. 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 has sometimes been called the Block II/IIA development effort. The Block II missile is not planned as a fielded capability.

> [The FY2018 national defense authorization act] called on MDA to "conduct a test to evaluate and demonstrate, if technologically feasible, the capability to defeat a simple intercontinental ballistic missile threat using the Standard Missile-3 Block IIA missile interceptor."[7]

MDA and Navy plans at one point called for the SM-3 Block IIA to be succeeded by a still-more-capable interceptor called the SM-3 Block IIB. The effort to develop that missile, however, was ended, and MDA reportedly is not pursuing any follow-on capabilities to the SM-3 Block IIA.[8]

SM-2 and SM-6 Terminal Interceptors

The SM-2 Block IV is designed to intercept ballistic missiles inside the atmosphere (i.e., endo-atmospheric intercept), during the terminal phase of an enemy ballistic missile's flight. It is equipped with a blast fragmentation warhead. The existing inventory of SM-2 Block IVs—72 as of February 2012—was created by modifying SM-2s that were originally built to intercept aircraft and ASCMs. A total of 75 SM-2 Block IVs were modified, and at least 3 were used in BMD flight tests.

MDA and the Navy are now procuring a more capable terminal-phase (endo-atmospheric intercept) BMD interceptor based on the SM-6 air defense missile (the successor to the SM-2 air defense missile). The SM-6 is a dual-capability missile that can be used for either air defense (i.e., countering aircraft and anti-ship cruise missiles) or ballistic missile defense.

A July 23, 2018, press report states:

> The Defense Department has launched a prototype project that aims to dramatically increase the speed and range of the Navy's Standard Missile-6 by adding a larger rocket motor to the ship-launched weapon, a move that aims to improve both the offensive and defensive reach of the Raytheon-built system.
>
> On Jan. 17, the Navy approved plans to develop a Dual Thrust Rocket Motor with a 21-inch diameter for the SM-6, which is currently fielded with a 13.5-inch propulsion package. The new rocket motor would sit atop the current 21-inch booster, producing a new variant of the missile: the SM-6 Block IB.[9]

European Phased Adaptive Approach (EPAA) for European BMD

On September 17, 2009, the Obama Administration announced a new approach for regional BMD operations called the Phased Adaptive Approach (PAA). The first application of the approach is in Europe, and is called the European PAA (EPAA). EPAA calls for using BMD-capable Aegis ships, a land-based radar in Europe, and two Aegis Ashore sites in Romania and Poland to defend Europe against ballistic missile threats from countries such as Iran.

Phase I of EPAA involved deploying Aegis BMD ships and a land-based radar in Europe by the end of 2011. Phase II involved establishing the Aegis Ashore site in Romania with SM-3 IB interceptors in 2016.[10] Phase 3 involves establishing the Aegis Ashore site in Poland with SM-3

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[7] Jason Sherman, "MDA Exploring Potential of SM-3 Block IIA Against ICBM Threat," *Inside the Navy*, March 26, 2018.

[8] See, for example, Justin Doubleday, "Missile Defense Agency Not Pursuing Follow-On to SM-3 Block IIA Interceptor," *Inside the Navy*, October 24, 2016.

[9] Jason Sherman, "Navy Looking to Increase Range, Speed of SM-6 with Larger Rocket Motor," *Inside the Navy*, July 23, 2018.

[10] The Aegis Ashore site in Romania was operationally certified on May 12, 2016. (See "Aegis Ashore Missile Defense

IIA interceptors by perhaps FY2020. The completion of construction of the Poland site has been delayed by at least a year, MDA says, due to contractor performance issues.[11] Each Aegis Ashore site in the EPAA is to include a structure housing an Aegis system similar to the deckhouse on an Aegis ship and 24 SM-3 missiles launched from a re-locatable Vertical Launch System (VLS) based on the VLS that is installed in Navy Aegis ships.[12]

Although BMD-capable Aegis ships were deployed to European waters before 2011, the first BMD-capable Aegis ship officially deployed to European waters as part of the EPAA departed its home port of Norfolk, VA, on March 7, 2011, for a deployment to the Mediterranean that lasted several months.[13]

Numbers of BMD-Capable Aegis Ships and SM-3 Interceptors

Table 1 shows numbers of BMD-capable Aegis ships and SM-3 interceptor deliveries under DOD's FY2019 budget submission. Two Japan-homeported BMD-capable Aegis destroyers included in the figures shown in **Table 1**—the *Fitzgerald* (DDG-62) and the *John S McCain* (DDG-56)—were seriously damaged in collisions with merchant ships in waters off the coasts of Japan and Singapore in June 2017 and August 2017, respectively, and are now being repaired. Of the 35 BMD-capable ships in operation as of February 2018, 19 were homeported in the Pacific fleet, and 16 in the Atlantic fleet. The inventories of SM-3 interceptors are lower than the delivery figures shown in the table due to the use of SM-3s in tests.

Homeporting of BMD-Capable DDG-51s in Spain

On October 5, 2011, the United States, Spain, and NATO jointly announced that, as part of the EPAA, four BMD-capable Aegis ships were to be forward-homeported (i.e., based) at the naval base at Rota, Spain.[14] The four ships are the destroyers *Ross* (DDG-71) and *Donald Cook* (DDG-75), which moved to Rota in FY2014, and the destroyers *Carney* (DDG-64) and *Porter* (DDG-78), which moved to Rota in FY2015. The moves involved an estimated 1,239 military billets (including 1,204 crew members for the four ships and 35 shore-based support personnel),[15] and about 2,100 family members.[16] The Navy estimated the up-front costs of transferring the four

System-Romania Operationally Certified, *Navy News Service*, May 12, 2016; Sam LaGrone, "Aegis Ashore Site in Romania Declared Operational," *USNI News*, May 12, 2016.)

[11] See, for example, Jen Judson, "Construction Issues Still Plague Polish Aegis Ashore Site," *Defense News*, August 14, 2018.

[12] For additional discussion of the Aegis Ashore sites, see Edward Lundquist, "Aegis Ashore Adapts Sea-Based Missile Defense System to Protect Europe," *National Defense*, September 2016.

[13] Karen Parrish, "Milestone nears for European Missile Defense Plan," *American Forces Press Service*, March 2, 2011 (http://archive.defense.gov/news/newsarticle.aspx?id=62997); Untitled "Eye On The Fleet" news item, *Navy News Service*, March 7, 2011 (accessed online at http://www.navy.mil/view_single.asp?id=98184); "Warship With Radar Going To Mediterranean," *Washington Post*, March 2, 2011; Brock Vergakis, "US Warship Deploys to Mediterranean to Protect Europe Form Ballistic Missiles, *Canadian Press*, March 7, 2011.

[14] "Announcement on missile defence cooperation by NATO Secretary General Anders Fogh Rasmussen, the Prime Minister of Spain, Jose Luis Rodriguez Zapatero and US Defense Secretary Leon Panetta," October 5, 2011, accessed October 6, 2011, at http://www.nato.int/cps/en/SID-107ADE55-FF83A6B8/natolive/opinions_78838.htm. See also "SECDEF Announces Stationing of Aegis Ships at Rota, Spain," accessed October 6, 2011, at http://www.navy.mil/search/display.asp?story_id=63109.

[15] Source: Navy information paper dated March 8, 2012, provided by Navy Office of Legislative Affairs to CRS on March 9, 2012.

[16] Source: Navy briefing slides dated February 27, 2012, provided by the Navy to CRS on March 9, 2012.

ships at $92 million in FY2013, and the recurring costs of basing the four ships in Spain rather than in the United States at roughly $100 million per year.[17]

Table 1. Numbers of BMD-Capable Aegis Ships and SM-3 Missiles Under FY2019 Budget Submission

	FY17	FY18	FY19 (req.)	FY20 (proj.)	FY21 (proj.)	FY22 proj.)	FY23 (proj.)
BMD-capable Aegis ships							
3.6 version	17	15	10	6	5	4	4
4.0.X version	9	2	0	0	0	0	0
4.1 version	1	9	16	20	21	22	22
BL 9C.1 version	8	10	7	4	1	0	0
BL 9.C2 version	0	2	8	16	22	29	31
Total	**35**	**38**	**41**	**46**	**49**	**55**	**57**
Aegis Ashore sites	**1**	**1**	**2**	**2**	**2**	**2**	**2**
SM-3 missile cumulative deliveries							
Block I/IA	150	150	150	150	150	150	150
Block IB	147	182	218	253	287	324	362
Block IIA	0	4	15	17	27	42	48
TOTAL	**297**	**336**	**383**	**420**	**464**	**516**	**560**

Source: FY2019 MDA budget submission. The FY2019 quantity of 2 for Aegis Ashore sites in FY2019 may on reflect the delay in the construction of the second (Poland) site to FY2020.

Rota is on the southwestern Atlantic coast of Spain, a few miles northwest of Cadiz, and about 65 miles northwest of the Strait of Gibraltar leading into the Mediterranean. U.S. Navy ships have been homeported at Rota at various points in the past, most recently (prior to the current arrangement) in 1979.[18] For additional background information on the Navy's plan to homeport four BMD-capable Aegis destroyers at Rota, Spain, see **Appendix B.**

Aegis BMD Flight Tests

Since January 2002, the Aegis BMD system has achieved 32 successful exo-atmospheric intercepts in 41 attempts using the SM-3 missile (including 4 successful intercepts in 5 attempts by Japanese Aegis ships, and one successful intercept in two attempts attempt using the Aegis Ashore system), and 7 successful endo-atmospheric intercepts in 7 attempts using the SM-2

[17] Source: Navy briefing slides dated February 27, 2012, provided by the Navy to CRS on March 9, 2012. The briefing slides state that the estimated up-front cost of $92 million includes $13.5 million for constructing a new weapon magazine, $0.8 million for constructing a pier laydown area, $3.4 million for constructing a warehouse, $5.0 million for repairing an existing facility that is to be used as an administrative/operations space, and $69.3 million for conducting maintenance work on the four ships in the United States prior to moving them to Rota. The briefing states that the estimated recurring cost of $100 million per year includes costs for base operating support, annual PCS (personnel change of station) costs, a pay and allowances delta, annual mobile training team costs, ship maintenance work, the operation of a Ship Support Activity, and higher fuel costs associated with a higher operating tempo that is maintained by ships that are homeported in foreign countries.

[18] Source: Sam Fellman, "U.S. To Base Anti-Missile Ships in Spain," *Defense News*, October 10, 2011: 76.

Block IV and SM-6 missiles, making for a combined total of 39 successful intercepts in 48 attempts.

In addition, on February 20, 2008, a BMD-capable Aegis cruiser operating northwest of Hawaii used a modified version of the Aegis BMD system with the SM-3 missile to shoot down an inoperable U.S. surveillance satellite that was in a deteriorating orbit.[19] Including this intercept in the count increases the totals to 33 successful exo-atmospheric intercepts in 42 attempts using the SM-3 missile, and 40 successful exo- and endo-atmospheric intercepts in 49 attempts using SM-3, SM-2 Block IV, and SM-6 missiles.

The Aegis BMD development effort, including Aegis BMD flight tests, is often described as following a development philosophy long held within the Aegis program office of "build a little, test a little, learn a lot," meaning that development is done in manageable steps, then tested and validated before moving on to the next step.[20]

For further background information on Aegis BMD flight tests, see **Appendix A**.

Allied Participation and Interest in Aegis BMD Program

Japan[21]

Overview

Japan's interest in BMD, and in cooperating with the United States on BMD matters, was heightened in August 1998, when North Korea test-fired a Taepo Dong-1 ballistic missile that

[19] 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. (For additional information, see the MDA discussion available online at http://www.mda.mil/system/aegis_one_time_mission.html, and also 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.)

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." (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.)

[20] See, for example, "Aegis BMD: "Build a Little, Test a Little, Learn a Lot"," USNI blog, March 15, 2010, accessed September 11, 2013, at http://blog.usni.org/2010/03/15/aegis-bmd-build-a-little-test-a-little-learn-a-lot, and "Aegis Ballistic Missile Defense, Aegis Ballistic Missile Defense Overview for the George C. Marshall Institute, RADM Alan B. Hicks, USN, Aegis BMD Program Director, August 3, 2009, slide 16 of 20, entitled "Some of our Philosophies In a Nutshell (1 of 2)," accessed September 11, 2011, at http://www.marshall.org/pdf/materials/743.pdf.

[21] For a research paper providing additional background information U.S.-Japan cooperation in ballistic missile defense, see Rachel Hoff, "U.S.-Japan Missile Defense Cooperation: Increasing Security and Cutting Costs," American

flew over Japan before falling into the Pacific.[22] Japan's interest has been periodically reinforced since then by subsequent North Korean ballistic missile test flights.

BMD-Capable Aegis Destroyers

Japan is modifying all six of its Aegis destroyers to include the Aegis BMD capability. As of August 2017, four of the six ships reportedly had been modified, and Japan planned to modify a fifth by March 2018, or perhaps sooner than that.[23] In November 2013, Japan announced plans to procure two additional Aegis destroyers and equip them as well with the Aegis BMD capablity, which will produce an eventual Japanese force of eight BMD-capable Aegis destroyers. As of 2016, the two additional ships were expected to enter service in 2020 and 2021. Japanese BMD-capable Aegis ships have participated in some of the flight tests of the Aegis BMD system using the SM-3 interceptor (see **Table A-1** in **Appendix A**).

Cooperative Development of SM-3 Block IIA Missile

Japan has cooperated with the United States on development the SM-3 Block IIA missile. Japan developed certain technologies for the missile, and paid for the development of those technologies, reducing the missile's development costs for the United States.

Aegis Ashore Sites

In May 2017, it was reported that Japan was considering purchasing an Aegis Ashore capability to further bolster Japan's BMD capabilities for defending against North Korean ballistic missiles.[24] In August 2017, it was reported that the Japanese government planned to deploy an Aegis Ashore system and would seek funding in the budget for Japan's next fiscal year to cover Aegis Ashore system design costs.[25] In October 2017, it was reported that Japan was interested in purchasing SM-6 interceptors for its desired Aegis Ashore sites, so that the sites would employ both SM-3 midcourse-interceptors and SM-6 terminal-phase interceptors.[26]

In November 2017, it was reported that the United States was providing Japan initial pricing and technical data for both the existing Aegis Ashore system and a version equipped with the AMDR. The report stated that Japan was interested in purchasing two Aegis Ashore systems, and that the systems, if purchased, would go into operation by 2023.[27] It was also reported in November 2017 that the two Aegis Ashore systems might be located at Ground Self-Defense Force (GSDF) facilities in Akita Prefecture in eastern Japan and Yamaguchi Prefecture in western Japan, and

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Action Forum, December 2, 2015.

[22] 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.

[23] Richard Abott, "Japan Plans To Expand Missile Defense Systems, Includes Aegis Ashore," *Defense Daily*, August 21, 2017: 7-9.

[24] Sam LaGrone, "Defense Minister: Japan Considering Purchasing Aegis Ashore Following North Korean ICBM Test," *USNI News*, May 16, 2017.

[25] Richard Abott, "Japan Plans To Expand Missile Defense Systems, Includes Aegis Ashore," *Defense Daily*, August 21, 2017: 7-9.

[26] Richard Tomkins, "Report: Japan Eyeing SM-6 Missiles for Defense Program," *United Press International*, October 20, 2017.

[27] Anthony Capaccio, "Japan in Talks With U.S. on Buying Aegis Missile Defense," *Bloomberg*, November 7, 2017.

would be operated mainly by the GSDF (i.e., Japan's army).[28] In December 2017, it was reported that that the Japanese cabinet had approved the purchase of two Aegis Ashore systems.[29] In July 2018, it was reported that Japan had decided to equip its two Aegis Ashore systems with a new Lockheed-made radar called the Long Range Discrimination Radar (LRDR) rather than the Raytheon-made SPY-6 AMDR that is being installed on U.S. Navy Flight III DDG-51s.[30]

Reported Cooperative Development of New Radar Technology

A July 6, 2018, press report states:

> The U.S. and Japan are looking to jointly develop next-generation radar technology that would use Japanese semiconductors to more than double the detection range of the Aegis missile defense system….
>
> Japanese vessels equipped with the system currently employ Lockheed Martin's SPY-1 radar. The U.S. Navy plans to upgrade its ships with Raytheon's SPY-6, which can detect missiles more than 1,000 kilometers away, or more than twice as far as the SPY-1.
>
> The U.S. and Japan now aim to develop an even longer-range system that is also more compact, letting ships stationed in the Sea of Japan watch for missiles across all of the Korean Peninsula and part of eastern China.
>
> Washington apparently broached the topic of collaborating on this next-generation system at high-level military talks in June. It hopes to incorporate technologies from companies such as Mitsubishi Electric that use gallium nitride chips, which make radar systems much more powerful at little additional energy cost. While American contractors have similar technology, Japan is thought to be the leader in the field.
>
> The countries are expected to agree on the joint project as early as this year. Studies would come first, preparing for mass production five or 10 years down the road. Japan plans to begin budgeting research expenses for the project as early as in fiscal 2019.[31]

Other Countries

Other countries that MDA views as potential naval BMD operators (using either the Aegis BMD system or some other system of their own design) include the United Kingdom, the Netherlands, Spain, Germany, Denmark, South Korea, and Australia. Spain, South Korea, and Australia 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

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[28] Yomiuri Shimbun, "Akita, Yamaguchi to Get Aegis Ashore/GSDF Involvement Expected to Strengthen Missile Defense," *The Japan News*, November 11, 2017. See also Kyodo, "Japan Mulling News Missile Interceptor Deployment to Guard Against North Korea," *South China Morning Post*, November 11, 2017.

[29] "Japan to Expand Ballistic Missile Defense with Ground-Based Aegis Batteries," *Reuters*, December 18, 2017; Daisuke Kikuchi, "Japan Approves Introduction of Aegis Ashore Missile Defense System amid North Korea Threat," *Japan Times*, December 19, 2017; Mari Yamaguchi, "Japan to Buy Aegis Ashore Missile Defense Systems," *Defense News*, December 19, 2017; Megan Eckstein, "Japan Cabinet Approves Aegis Ashore Buy to Supplement DDGs In Ballistic Missile Defense," *USNI News*, December 22, 2017.

[30] Nobuhiro Kubo, "Japan Picks Lockheed Martin Radar for Missile Defence System: Ministry Official," *Reuters*, July 2, 2018; Reuters Staff, "Japan Picks $1.2 Billion Lockheed Radar for Aegis Ashore Batteries," *Reuters*, July 30, 2018; Ben Werner, "Japan Selects Lockheed Martin to Supply Radar for Aegis Ashore System," *USNI News*, July 30, 2018; Dan Leaf, "Japan's Risky Aegis Ashore Radar Choice," *Japan Times*, July 30, 2018; Rich Abott, "Japan Chooses Lockheed Martin For Aegis Ashore Radar," *Defense Daily*: July 31, 2018: 1-2.

[31] Nikkei staff writers, "US Taps Japan Radar Tech to Double Missile Defense Range," *Nikkei Asian Review*, July 6, 2018.

operations. For additional background information on allied participation and interest in the Aegis BMD program for countries other than Japan, see **Appendix C**.

FY2019 MDA Funding Request

The Aegis BMD program is funded mostly through MDA's budget. The Navy's budget provides additional funding for BMD-related efforts. **Table 2** shows MDA procurement and research and development funding for the Aegis BMD program.

Table 2. MDA Funding for Aegis BMD Efforts, FY2019-FY2023

(In millions of dollars, rounded to nearest tenth; totals may not add due to rounding)

	FY19 (req.)	FY20 (proj.)	FY21 (proj.)	FY22 (proj.)	FY23 (proj.)
Procurement					
Aegis BMD (line 29)	593.5	576.2	538.6	565.7	767.0
Aegis BMD Advance Procurement (line 30)	115.2	97.0	44.9	17.5	0
Aegis Ashore Phase III (line 34)	15.0	0	0	0	0
Aegis BMD hardware and software (line 36)	97.1	125.8	60.4	87.2	85.0
SUBTOTAL Procurement	**820.8**	**799.0**	**643.9**	**670.4**	**852.0**
Research and development					
Aegis BMD (PE 0603892C) (line 78)	767.5	780.1	707.9	693.3	562.7
Aegis BMD Test (PE 0604878C) (line 107)	95.8	80.7	94.1	146.9	136.6
Land-based SM-3 (PE 0604880C) (line 109)	27.7	29.3	28.4	27.2	28.2
Aegis SM-3 IIA (PE 0604881C) (line 110)	0	0	0	0	0
SUBTOTAL RDT&E	**891.0**	**890.1**	**830.4**	**867.4**	**727.5**
TOTAL	**1,711.8**	**1,689.1**	**1,474.3**	**1,537.8**	**1,579.5**

Source: Table prepared by CRS based on FY2019 MDA budget submission.

As shown in **Table 2**, which shows MDA funding only, MDA's proposed FY2019 budget requests a total of $1,711.8 million in procurement and research and development funding for Aegis BMD efforts, including funding for the two Aegis Ashore sites that are part of the EPAA, which are referred to in the table as funding for the land-based SM-3. MDA's budget also includes additional funding not shown in the table for operations and maintenance (O&M) and military construction (MilCon) for the Aegis BMD program.

Issues for Congress

FY19 Funding Request

One issue for Congress is whether to approve, reject, or modify MDA's FY2019 procurement and research and development funding requests for the program. In considering this issue, Congress may consider various factors, including whether the work that MDA is proposing to fund for FY2019 is properly scheduled for FY2019, and whether this work is accurately priced.

Required vs. Available Numbers of BMD-Capable Aegis Ships

Overview

Another potential issue for Congress concerns required numbers of BMD-capable Aegis ships versus available numbers of BMD-capable Aegis ships. Some observers are concerned about the potential operational implications of a shortfall in the available number of BMD-capable relative to the required number. Regarding the required number of BMD-capable Aegis ships, an August 15, 2018, Navy information paper states the following:

> The [Navy's] 2016 Force Structure Assessment [FSA][32] sets the requirement [for BMD-capable ships] at 54 BMD-capable ships, as part of the 104 large surface combatant requirement, to meet Navy unique requirements to support defense of the sea base and limited expeditionary land base sites….
>
> The minimum requirement for 54 BMD ships is based on the Navy unique requirement as follows. It accepts risk in the sourcing of combatant commander (CCDR) requests for defense of land.
>
> - 30 to meet CVN escort demand for rotational deployment of the carrier strike groups
>
> - 11 INCONUS for independent BMD deployment demand
>
> - 9 in forward deployed naval forces (FDNF) Japan to meet operational timelines in USINDOPACOM
>
> - 4 in FDNF Europe for rotational deployment in EUCOM[33]

BMD-Capable Destroyers *Fitzgerald* and *John S McCain* Seriously Damaged

Two Japan-homeported Navy BMD-capable Aegis destroyers—*Fitzgerald* (DDG-62) and *John S McCain* (DDG-56)—were seriously damaged in collisions with merchant ships in waters off the coasts of Japan and Singapore in June 2017 and August 2017, respectively, and are curerntly being repaired. Reportedly, *Fitzgerald* will remain nonoperational for more than a year, and *John S McCain* for at least several months, while repairs on the two ships are completed.[34] The temporary loss of these two BMD-capable ships reinforced, at the margin, concerns among some observers about required numbers of BMD-capable Aegis ships versus available numbers of BMD-capable Aegis ships, particularly for performing BMD operations in the Western Pacific.[35]

An October 12, 2017, press report states the following:

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[32] The FSA is the Navy's analysis, performed every few years, that establishes the Navy's ship force structure requirements. For further discussion, see CRS Report RL32665, *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress*, by Ronald O'Rourke.

[33] Navy information paper dated August 15, 2018, entitled "Ballistic Missile Defense (BMD) Capable Ships requirement," provided by Navy Office of Legislative Affairs to CBO and CRS on August 15, 2018. The information paper was requested by CBO.

[34] Sam LaGrone, "USS Fitzgerald Repair Will Take More Than a Year; USS John S. McCain Fix Could Be Shorter," *USNI News*, September 2017.

[35] See, for example, Chandan Prasad, "USS John McCain: Destroyer Collision Opens Gap In Missile Defense Against North Korea," *International Business Times*, August 21, 2107; Kristen Doerer, "Do U.S. Navy Collisions Weaken Our Defense Against A North Korean Missile Attack?" *PBS NewsHour*, August 22, 2017; Aaron Barruga, "The USS McCain Tragedy Has A Dire Impact On US Missile Defenses," *Task and Purpose*, August 24, 2017; Saadia M. Pekkanen, "To Contend With North Korea, Can Japan Rely On The U.S.?" *Forbes*, August 29, 2017; Mike Fabey "North Korean Missiles Are Testing A Stressed U.S. Defense Net," *Space News*, August 31, 2017.

> The Navy is surging a guided-missile destroyer and altering the deployment of a guided-missile destroyer to cover gaps left by two ballistic missile defense-capable destroyers that were damaged in collisions with merchant ships, USNI News has learned.
>
> The Norfolk-based cruiser USS Monterey (CG-61) and Pearl Harbor-based destroyer USS O'Kane (DDG-77) will be deployed to assist in BMD missions, two Navy officials confirmed to USNI News....
>
> O'Kane was scheduled for an independent patrol to an unspecified location before it was tasked to U.S. 7th Fleet for BMD operations in the Western Pacific, a Navy official confirmed to USNI News.
>
> Monterey will conduct an independent BMD deployment in the U.S. 6th and 5th Fleet areas of operation in Europe and the Middle East to ease to overall BMD burden for the service, a Navy official told USNI News.
>
> Both deployments will last about six months.
>
> Monterey's surge deployment follows a seven-month Middle East deployment as part of the Eisenhower Carrier Strike Group, which ended in late December.
>
> Both ships will share the U.S. BMD burden left after collisions with merchant ships sidelined guided-missile destroyers USS Fitzgerald (DDG-62) and USS John S. McCain (DDG-56).[36]

Burden of BMD Mission on U.S. Navy Aegis Ships

A related potential issue for Congress is the burden that BMD operations may be placing on the Navy's fleet of Aegis ships, and whether there are alternative ways to perform BMD missions now performed by U.S. Navy Aegis ships, such as establishing more Aegis Ashore sites. A June 16, 2018, press report states

> The U.S. Navy's top officer wants to end standing ballistic missile defense patrols and transfer the mission to shore-based assets.
>
> Chief of Naval Operations Adm. John Richardson said in no uncertain terms on June 12 that he wants the Navy off the tether of ballistic missile defense patrols, a mission that has put a growing strain on the Navy's hard-worn surface combatants, and the duty shifted towards more shore-based infrastructure.
>
> "Right now, as we speak, I have six multi-mission, very sophisticated, dynamic cruisers and destroyers—six of them are on ballistic missile defense duty at sea," Richardson said during his address at the U.S. Naval War College's Current Strategy Forum. "And if you know a little bit about this business you know that geometry is a tyrant.
>
> "You have to be in a tiny little box to have a chance at intercepting that incoming missile. So, we have six ships that could go anywhere in the world, at flank speed, in a tiny little box, defending land."
>
> Richardson continued, saying the Navy could be used in emergencies but that in the long term the problem demands a different solution.
>
> "It's a pretty good capability and if there is an emergent need to provide ballistic missile defense, we're there," he said. "But 10 years down the road, it's time to build something

[36] Sam LaGrone, "Navy to Surge USS Monterey, Deploy USS O'Kane for BMD Operations to Cover Ships Sidelined in Collisions," *USNI News*, October 12, 2017. See also Mark D. Faram, "Navy to Send Destroyer to Far East to Boost Ballistic Missile Defense," *Navy Times*, October 12, 2017.

on land to defend the land. Whether that's AEGIS ashore or whatever, I want to get out of the long-term missile defense business and move to dynamic missile defense."

The unusually direct comments from the CNO come amid growing frustration among the surface warfare community that the mission, which requires ships to stay in a steaming box doing figure-eights for weeks on end, is eating up assets and operational availability that could be better used confronting growing high-end threats from China and Russia.

The BMD mission was also a factor in degraded readiness in the surface fleet. Amid the nuclear threat from North Korea, the BMD mission began eating more and more of the readiness generated in the Japan-based U.S. 7th Fleet, which created a pressurized situation that caused leaders in the Pacific to cut corners and sacrifice training time for their crews, an environment described in the Navy's comprehensive review into the two collisions that claimed the lives of 17 sailors in the disastrous summer of 2017.

Richardson said that as potential enemies double down on anti-access technologies designed to keep the U.S. Navy at bay, the Navy needed to focus on missile defense for its own assets.

"We're going to need missile defense at sea as we kind of fight our way now into the battle spaces we need to get into," he said. "And so restoring dynamic maneuver has something to do with missile defense.[37]

A June 23, 2018 press report states

The threats from a resurgent Russia and rising China—which is cranking out ships like it's preparing for war—have put enormous pressure on the now-aging [U.S. Navy Aegis destroyer] fleet. Standing requirements for BMD patrols have put increasing strain on the U.S. Navy's surface ships.

The Navy now stands at a crossroads. BMD, while a burden, has also been a cash cow that has pushed the capabilities of the fleet exponentially forward over the past decade. The game-changing SPY-6 air and missile defense radar destined for DDG Flight III, for example, is a direct response to the need for more advanced BMD shooters. But a smaller fleet, needed for everything from anti-submarine patrols to freedom-of-navigation missions in the South China Sea, routinely has a large chunk tethered to BMD missions.

"Right now, as we speak, I have six multimission, very sophisticated, dynamic cruisers and destroyers—six of them are on ballistic missile defense duty at sea," Chief of Naval Operations Adm. John Richardson said during an address at the recent U.S. Naval War College's Current Strategy Forum. "You have to be in a tiny little box to have a chance at intercepting that incoming missile. So we have six ships that could go anywhere in the world, at flank speed, in a tiny little box, defending land."

And for every six ships the Navy has deployed in a standing mission, it means 18 ships are in various stages of the deployment cycle preparing to relieve them.

The Pentagon, led by Defense Secretary Jim Mattis, wants the Navy to be more flexible and less predictable—"dynamic" is the buzzword of moment in Navy circles. What Richardson is proposing is moving standing requirements for BMD patrols away from ships underway and all the associated costs that incurs, and toward fixed, shore-based sites, and also surging the Navy's at-sea BMD capabilities when there is an active threat....

In a follow-up response to questions posed on the CNO's comments, Navy spokesman Cmdr. William Speaks said the Navy's position is that BMD is an integral part of the service's mission, but where long-term threats exist, the Navy should "consider a more persistent, land-based solution as an option."

[37] David B. Larter, "The US Navy Is Fed Up with Ballistic Missile Defense Patrols," *Defense News*, June 16, 2018.

"This idea is not about the nation's or the Navy's commitment to BMD for the U.S. and our allies and partners—the Navy's commitment to ballistic missile defense is rock-solid," Speaks said. "In fact, the Navy will grow the number of BMD-capable ships from 38 to 60 by 2023, in response to the growing demand for this capability.

"The idea is about how to best meet that commitment. In alignment with our national strategic documents, we have shifted our focus in an era of great power competition—this calls us to think innovatively about how best to meet the demands of this mission and optimize the power of the joint force."...

While the idea of saving money by having fixed BMD sites and freeing up multimission ships is sensible, it may have unintended consequences, said Bryan McGrath, a retired destroyer skipper and owner of the defense consultancy The FerryBridge Group.

"The BMD mission is part of what creates the force structure requirement for large surface combatants," McGrath said on Twitter after Defense News reported the CNO's comments. "Absent it, the number of CG's and DDG's would necessarily decline. This may in fact be desirable, depending on the emerging fleet architecture and the roles and missions debate underway. Perhaps we need more smaller, multi-mission ships than larger, more expensive ones.

"But it cannot be forgotten that while the mission is somewhat wasteful of a capable, multi-mission ship, the fact that we have built the ships that (among other things) do this mission is an incredibly good thing. If there is a penalty to be paid in peacetime sub-optimization in order to have wartime capacity--should this not be considered a positive thing?"

McGrath went on to say that the suite of combat systems that have been built into Aegis have been in response to the BMD threat. And indeed, the crown jewels of the surface fleet—Aegis Baseline 9 software, which allows a ship to do both air defense and BMD simultaneously; the Aegis common-source library; the forthcoming SPY-6; cooperative engagement—have come about either in part or entirely driven by the BMD mission....

A Navy official who spoke on condition of anonymity, to discuss the Navy's shifting language on BMD, acknowledged the tone had shifted since the 2000s when the Navy latched onto the mission. But the official added that the situation more than a decade later has dramatically shifted.

"The strategic environment has changed significantly since the early 2000s—particularly in the western Pacific. We have never before faced multiple peer rivals in a world as interconnected and interdependent as we do today," the official said. "Nor have we ever seen technologies that could alter the character of war as dramatically as those we see emerging around us. China and Russia have observed our way of war and are on the move to reshape the environment to their favor."

In response to the threat and Defense Secretary Jim Mattis' desire to use the force more dynamically, the Navy is looking at its options, the official said. "This includes taking a look at how we employ BMD ships through the lens of great power competition to compete, deter and win against those who threaten us."[38]

Burden Sharing: U.S. vs. European Naval Contributions to European BMD

Another related potential issue for Congress concerns burden sharing—how European naval contributions to European BMD capabilities and operations compare to U.S. naval contributions

[38] David B. Larter, "As Threats Mount, US Navy Grapples with Costly Ballistic Missile Defense Mission," *Defense News*, June 23, 2018.

to European BMD capabilities and operations, particularly in light of constraints on U.S. defense spending, worldwide operational demands for U.S. Navy Aegis ships, and calls by some U.S. and European observers for increased defense efforts by NATO countries in Europe. Potential oversight issues for Congress include the following:

- How does the total value of European naval contributions to European BMD capabilities and operations compare to the total value of the U.S. naval contributions (including the Aegis Ashore sites) to European BMD capabilities and operations?
- Given constraints on U.S. defense spending, worldwide operational demands for U.S. Navy Aegis ships,[39] and calls by some U.S. and European observers for increased defense efforts by NATO countries in Europe—as well as the potential for European countries to purchase or build BMD-capable Aegis ships, upgrade existing ships with BMD capabilities, or purchase Aegis ashore systems—should the United States seek increased investment by European countries in their regional BMD capabilities so as to reduce the need for assigning BMD-capable U.S. Navy Aegis ships to the EPAA? Why should European countries not pay a greater share of the cost of the EPAA, since the primary purpose of the EPAA is to defend Europe against theater-range missiles?

Potential Future BMD Contribution from Lasers, Railguns, and Gun-Launched Guided Projectiles

Another potential issue for Congress concerns the potential for ship-based lasers, electromagnetic railguns (EMRGs), and gun-launched guided projectiles (GLGPs, previously known as hypervelocity projectiles [HVPs]) to contribute in coming years to Navy terminal-phase BMD operations and the impact this might eventually have on required numbers of ship-based BMD interceptor missiles. Another CRS report discusses the potential value of ship-lasers, EMRGs, and GLGPs for performing various missions, including, potentially, terminal-phase BMD operations.[40]

Technical Risk and Test and Evaluation Issues

Another potential oversight issue for Congress is technical risk and test and evaluation issues in the Aegis BMD program.

January 2018 DOT&E Report

A January 2018 report from DOD's Director, Operational Test and Evaluation (DOT&E)—DOT&E's annual report for FY2017—stated the following in its section on the Aegis BMD program:

> **Assessment**
>
> • With one exception, the MDA completed its planned flight testing with the SM-3 Block IB TU [Threat Update] missile as documented in the Integrated Master Test Plan. The lone exception is FTM-24, a planned engagement against a complex MRBM target that the

[39] See, for example, Lance M. Bacon, "Missile Defense Ships Face Arms Race, High Op Tempo," *Navy Times*, January 31, 2015.

[40] See CRS Report R44175, *Navy Lasers, Railgun, and Gun-Launched Guided Projectile: Background and Issues for Congress*, by Ronald O'Rourke.

MDA delayed until FY20. The legacy SM-3 Block IB missile (i.e., without the TU) completed its flight testing in November 2014.

• DOT&E has lower confidence in SM-3 missile reliability due to recent in-flight failures, coupled with MDA shortfalls in simulating the in-flight environment in its SM-3 ground test program, addressing failures and anomalies identified during flight testing; and implementing a rigorous configuration management and control process for SM-3 production.

• The MDA missile ground test program may not adequately simulate the in-flight environment:

- Contractors introduced a software design flaw into the SM-3 Block IB that was not present in the SM-3 Block IA. The MDA did not discover this flaw during ground testing, but instead discovered this flaw during a failed SM CTV [Controlled Test Vehicle]-01 launch in 2016 and subsequent investigation after the EPAA Phase 2 capability declaration.

- During the course of routine production testing, Raytheon discovered a rare condition that could cause the SM-3 Block IB Kinetic Warhead Guidance Unit Guidance Unit to fail. The MDA halted deliveries of SM-3 Block IB missiles for approximately 5 months while it identified a root cause. The MDA corrected the problem with Block IB software build 6.404, released in August 2016.

- The SM-3 Block IB electromagnetic interference test and subsequent ground tests have not been compliant with Military Standard 461F, did not evaluate the self-compatibility of SM-3 Block IB electrical and software systems, and did not reflect in-flight electrical grounding, including electrical isolation and grounding shifts due to stage separations.

• The MDA did not thoroughly address, prior to flight testing, the software flaws that were present during recent flight testing:

- The MDA did not correct the software design flaw that led to the SM CTV-01 failure before conducting the test. The MDA did not correct this problem before retesting the SM-3 during SM CTV-01a, but rather employed patches in a non-tactical software build to conduct the test.

- Another software design flaw that caused kinetic warhead guidance units to be unresponsive was observed during contractor acceptance testing, but was not addressed prior to conducting five subsequent flight tests. Although the flaw did not adversely affect the flight tests, it represented an unmitigated risk to SM-3 reliability. The root cause of this flaw appears to be the MDA configuration and control process for SM-3, discussed below.

• The SM-3 program may need to improve configuration management and control:

- The software design flaw that caused the failed SM CTV-01 launch was associated with a change to the software boot-up processes and not related to capability upgrades. The MDA's continuing efforts to improve the SM-3 Block IB could introduce other unintended consequences.

- The MDA discovered the software design flaw associated with kinetic warhead guidance units (also discussed above) when it observed a performance difference in one of the circuit cards in 2016. This performance difference resulted from an approved manufacturing tooling change made in 2011. The MDA did not evaluate the potential for software performance problems caused by the tooling change until it conducted the SM CTV-01 failure investigation 5 years later.

- The MDA did not discover an unapproved manufacturing process change in 2014 associated with wiring harnesses until one failed a hardware inspection over a year later. Failures associated with this change had the potential to prevent stage separation during SM-3 Block IB missile operational use.

• Results from flight testing, high-fidelity M&S [modeling and simulation], and HWIL [hardware in the loop] and distributed ground testing demonstrate that Aegis BMD 4.0 and Baseline 9.1 firing assets can engage and intercept non-separating, simple-separating, and complex-separating ballistic missiles in the midcourse phase with SM-3 Block IB and Block IB TU guided missiles. However, flight testing and M&S are not yet sufficient to assess the full range of expected threat types, ground ranges, and raid sizes.

• The SM-3 Block IIA guided missile has flown in two developmental intercept flight tests, the first achieving a successful intercept. The second attempt, during SFTM-02, was unsuccessful because a sailor onboard the firing ship inadvertently pushed a button that caused the Aegis Weapon System to break engagement and initiate a message commanding the SM-3 Block IIA missile to destruct, destroying the missile in flight. DOT&E attributes this flight test failure to a design deficiency that allows an operator to break a ballistic missile engagement with the push of a button, without having to confirm the action. After conducting a Failure Review Board (FRB), the MDA provided a number of recommendations to the Navy that, if implemented, would preclude this type of failure from reoccurring.

• Two intercept flight tests in previous fiscal years and accredited high-fidelity M&S demonstrated that the Aegis Baseline 9.C1 system's SBT capability can successfully engage select SRBMs with SM-6 Dual I and SM-2 Block IV missiles. The SBT flight tests in FY17 demonstrated the ability to engage select MRBMs in the terminal phase of flight with SM-6 Dual I missiles, but the MDA has not yet performed M&S analyses with accredited models. The MDA plans to conduct M&S studies for select MRBM threats in FY19 and COMOPTEVFOR plans to accredit the M&S in the same timeframe.

• SM CTV-03 in October 2017 demonstrated the capability of the Aegis BMD 4.1 upgrade to fire an SM-6 Dual I missile. The BMD 4.1 build incorporates Baseline 9.C1 capabilities into the BMD 4.0 baseline.

• SM-6 Dual I and SM-2 Block IV missiles have been reliable in SBT flight tests. Missile reliability estimates for these missiles meet the specification, but not with statistical confidence due to the limited number of firings. To date, the MDA and Navy have conducted nine firings of the SM-6 Dual I or SM-6 Processor Replacement Program missile, and five firings of the SM-2 Block IV missile after modification for the SBT mission.

• Reliability, maintainability, availability, and supportability (RMA&S) data that the MDA collected during Aegis Baseline 9.1 BMD-related testing through FY17 show that the system's availability is less than desired due to large repair and logistics delay times. However, the DOT&E estimate of availability is consistent with the specification.

• The MDA demonstrated the Aegis Baseline 9.C1 system IAMD capabilities to a limited degree in flight testing. IAMD flight test engagements to date have included at most two cruise missile surrogates and a single ballistic missile target.

• MDA ground test events routinely demonstrated that inter-element coordination and interoperability need improvement to increase situational awareness. The tests also highlighted an Aegis BMD problem related to track management when it operates with other elements of the BMDS.

• The FS-17 fleet exercise demonstrated the ability of Aegis BMD 4.0.3 to interoperate with NATO partners over operational communication architectures during cruise missile and ballistic missile engagements, and to use remote data provided by NATO partners to prosecute remote engagements.

Recommendations

• Status of Previous Recommendations. The MDA:

1. Partially addressed the second recommendation from FY13 to conduct operationally realistic testing that exercises Aegis BMD 4.0's improved engagement coordination with Terminal High-Altitude Area Defense (THAAD) and Patriot, when it conducted Flight Test Operational-02 (FTO-02) Event 2a (FY16) using an Aegis Baseline 9.C1 destroyer and THAAD firing assets. This flight test did not include Patriot. The MDA plans to include Patriot in FTO-03 Event 2 in FY18.

2. Partially addressed the third recommendation from FY14 to ensure that the Aegis Baseline 9.C1 system conducts sufficient flight testing to allow for verification, validation, and accreditation (VV&A) of the M&S suite to cover the full design to Aegis BMD battlespace. The MDA has collected sufficient flight test data to allow the BMDS Operational Test Agency (OTA) to accredit the high fidelity M&S suite over a portion of the engagement battlespace for Aegis Baseline 9.B1. The MDA and the BMDS OTA plan to conduct VV&A over the remaining battlespace for Baseline 9.C1 in FY18.

3. Has not addressed the second recommendation from FY15 to conduct stressing simultaneous air and ballistic missile defense engagements with the Aegis Baseline 9.C1 system operating in IAMD radar priority mode, with simultaneous engagement of multiple ballistic missile and anti-ship cruise missile threats.

4. Has not addressed the first recommendation from FY16 to conduct high-fidelity M&S runs-for-the-record for Aegis Baseline 9.B2 and 9.C2 to assess performance across the expected engagement battlespace in all Combatant Command areas of responsibility and develop an appropriate M&S VV&A plan to support that effort. The MDA developed a VV&A plan, but it will not perform Aegis Baseline 9.2 runs-for-the-record until FY20.

5. Has not addressed the second recommendation from FY16 to conduct a live-flight test demonstration of a fully remote engagement. The MDA plans to conduct this type of engagement in FY18 during FTM-29.

6. Partially addressed the third recommendation from FY16 to include BMDS OTA RMA&S data collectors in all flight test missions to improve the accuracy and statistical confidence of future suitability assessments. COMOPTEVFOR [Commander, Operational Test and Evaluation Force] works with the program to have data collectors present at each flight test event. However, the MDA has not always funded data collectors for follow-on system-level flight tests like FTO-02 Event 1a and FTO-02 Event 2a.

• FY17 Recommendations. The MDA should:

1. Conduct an in-depth review of SM-3 missile reliability to ensure ground testing is adequately simulating the in-flight environment as observed during recent test failures.

2. Implement processes to fix failures and anomalies identified during SM-3 ground testing prior to flight testing.

3. Ensure that SM-3 production configuration management, manufacturing control processes, and reporting requirements are adequate.

4. Conduct high-fidelity M&S analysis of the performance of an Aegis Baseline 9 variant ship operating in IAMD radar priority mode when simultaneously engaging multiple ballistic missile and AAW threats.

5. Work with the Navy to implement recommendations from the SFTM-02 FRB report, including the implementation of fail-safe software designs, to preclude future inadvertent operator actions from breaking engagements against hostile ballistic missile tracks.[41]

Regarding the SM-6 missile, the January 2018 DOT&E report also stated the following:

[41] Department of Defense, Director, Operational Test & Evaluation, *FY2017 Annual Report*, January 2018, pp. 293-295.

Assessment

• As reported in DOT&E's memorandum, "Post Initial Operational Test and Evaluation Observations and Assessment of Standard Missile-6 Block I Suitability," dated December 2016, DOT&E considers the previously reported uplink/downlink antenna shroud reliability deficiency resolved.

• The Navy developed specific software improvements to SM-6 BLK I to mitigate the classified performance deficiency discovered during IOT&E and in DOT&E's classified IOT&E report. VCD FOT&E events conducted by the Navy demonstrated that the software improvements work as intended and lessen the severity of the deficiency, but the improvements did not resolve the deficiency in all instances. The testing identified two concerns that contributed to the deficiency not being fully resolved.

- Testing revealed a classified concern with the missile's Target Detection Device.

- Testing revealed a classified concern with the missile's active seeker.

• NIFC-CA FTS event LFT-5 further demonstrates the NIFC-CA FTS capability, but – as with previous NIFC-CA FTS tests – the Navy did not conduct the test under operationally realistic conditions. Moreover, the Navy's test scenarios are not sufficiently challenging to demonstrate the NIFC-CA FTS requirements defined in the Navy's September 2012 NIFC-CA FTS Testing Capability Definition Letter. Nevertheless, the Navy has deployed the NIFC-CA FTS capability as a tactical option in fleet air defense. DOT&E reported on NIFC-CA FTS in the classified "Aegis Weapon System Baseline 9A Early Fielding Report" issued in July 2015, and will continue to report on NIFC-CA FTS in future Aegis Weapon System assessments.

• During SM-6 BLK 1A event GTV-3a, the SM-6 BLK IA experienced an inflight failure that prevented the target from intercepting its intended target. The failure delayed the start of SM-6 BLK IA operational testing.

• The Launch Availability Key Performance Parameter was unresolved in SM-6 BLK I IOT&E. During SM-6 BLK I FOT&E, the Navy fired, without failure, seven missiles that met the required storage requirements. While these results were not sufficient to state that BLK I meets its required Launch Availability with high statistical confidence, the results were sufficient to indicate no significant problem exists with storage reliability.

Recommendations

• Status of Previous Recommendations.

- The Navy is addressing the previous recommendations from FY14 to 1) complete corrective actions of the classified performance deficiency discovered during IOT&E and 2) develop a flight test program to test those corrective actions.

- The Navy has not addressed the FY15 recommendation to provide DOT&E an operational test concept and operational test plan for NIFC-CA FTS Increment 2; DOT&E rescinded this recommendation as the Navy integrated NIFC-CA FTS as a tactical option in fleet air defense. DOT&E removed the NIFC-CA FTS program from T&E oversight and it will be tested as a normal tactic in future Aegis/SM-6 testing.

• FY17 Recommendation.

1. The Navy should continue investigating the classified performance deficiency discovered during IOT&E, perform corrective actions, and verify corrective actions with

flight tests. This includes correcting the two new problems encountered during FY17 SM-6 BLK I VCD tests.[42]

May 2017 GAO Report

An May 2017 Government Accountability Office (GAO) report on missile defense programs stated the following for the Aegis BMD program:

> The Aegis BMD program supported the European Phased Adaptive Approach (EPAA) Phase 2 delivery in December 2015 with the delivery of AWS 5.0CU. However, another spiral that was part of the original concept was delayed. EPAA Phase 2 capability was supported, in part, by two BMDS level operational flight tests called Flight Test Operational (FTO)-2 Event 1a and FTO-02 Event 2a. While MDA experienced challenges in fiscal year 2015 with the initial attempts at both tests, once conducted, they demonstrated AWS capabilities, allowing EPAA Phase 2 declared delivered. Specifically:
>
> • MDA successfully conducted FTO-02 Event 1a in December 2015. In the test, the Aegis Ashore test installation in Hawaii engaged an air-launched medium range target with the upgraded Aegis BMD Standard Missile (SM)-3 Block IB interceptor using data from the collocated off board radar. The initial test attempt in June 2015—FT0-02 Event 1—failed after a new intermediate-range target malfunctioned. As we previously reported, the delay between the initial test and the retest reduced the time available to assess all aspects of performance prior to the Romania site delivery. In addition, although the system intercepted the target, the Aegis Ashore installation was not equipped with operational version of the planned software known as AWS Baseline 9.B1, which reduced the extent the test reflected the operational architecture.
>
> • MDA conducted FTO-02 Event 2a, in November 2015. The test was designed to demonstrate a layered BMDS with Aegis BMD and Terminal High-Altitude Area Defense (THAAD) sharing common defended areas and shot opportunities against two threat-representative ballistic missile targets. The primary Aegis BMD test objective was to conduct a ballistic missile engagement in the presence of debris generated by a THAAD intercept, while simultaneously conducting anti-air warfare against an anti-ship cruise missile target. Although the Aegis ship successfully engaged the cruise missile, the Aegis BMD SM-3 Block IB failed in flight, preventing an intercept of the ballistic missile target. Moreover, according to the Director, Operational Test and Evaluation, the scenario with two Aegis targets was less stressing than prior test of similar capabilities. However, despite the Aegis BMD SM-3 Block IB failure, THAAD intercepted the target, MDA was able to collect important data on AWS tracking and engagement processing performance. For further details on the Aegis BMD SM-3 Block IB and THAAD programs, see appendix IV and IX.
>
> Both upgraded software packages— Baseline 9.B1 and 9.C1— offer advanced defense capabilities and integration capability with other systems external to the Aegis ships. However, according to MDA officials both versions required updates, after the EPAA Phase 2 delivery, which were certified July 2016. Additionally, according to DOT&E, testing of Baseline 9.B1 indicated that the weapons system has software issues, which lowers its reliability and availability.
>
> In fiscal year 2016, Aegis BMD continued to assess options for developing AWS 4.1, which was initially planned to provide ballistic missile defense capabilities for additional ships. Specifically, the upgrade was initially planned to be retrofitted on ships, especially those planned for EPAA Phase 2 as ships equipped with Baseline 9.C1 were slated for other regions. However, the effort was put on hold last year, following development

[42] Department of Defense, Director, Operational Test & Evaluation, *FY2017 Annual Report*, January 2018, pp. 220-221.

> challenges and program funding issues. For example, as we reported in May 2015, technical assessments revealed challenges with matching Baseline 9.C1 performance characteristics on ships which utilize older hardware. This year however, MDA continued to explore options to deliver this capability, but not in support of EPAA Phase 2. Rather, current plans indicate full delivery in December 2020.
>
> Aegis BMD also participated in two key BMD system-level assessments for the delivery of discrimination upgrades for Homeland Defense. The tests, called Ground Test Integrated -06 Part 2 and Ground Test Distributed -06 Part 2, employed models and simulations to assess upgraded AWS software— including AWS 4.0.3 and AWS 3.6.3. The new software is designed to provide upgrades for discrimination and interoperability with other BMDS elements. According to MDA, the tests successfully demonstrated the upgrades but analysis delayed the delivery of the associated capability planned for March 2017.
>
> Aegis BMD made progress in development of AWS 5.1 for Aegis ships (Baseline 9.C2) and Aegis Ashore (Baseline 9.B2). AWS 5.1 improves AWS 5.0CU capability against longer range and more complex threats in the middle and terminal phases of flight. It also extends defended areas by engaging threats based on tracks from forward-based sensors. These AWS versions, expected to be delivered in December 2018, are slated to support EPAA Phase 3 and defend against intermediate range ballistic missile attacks.
>
> However, the program schedule to meet EPAA Phase 3 lacks margins and has risk. For example, the deliveries of AWS Baseline 9.C2 and 9.B2 are now planned at the beginning of EPAA Phase 3 integration activities, leaving no time to rectify challenges that could still arise during development. Moreover, communication upgrades for this AWS version, are now behind schedule. Program documentation indicates that the lag in development could result in compatibility issues between these upgrades with the rest of the weapons system. This, in turn, could require retrofits and reduce performance. In addition, C2BMC delays deferred completion of Aegis BMD's capability to intercept threats based on tracks from forward-based sensors until fiscal year 2021.[43]

Regarding Aegis Ashore systems, the report stated:

> MDA delivered the Aegis Ashore facility in Romania to support the European Phased Adaptive Approach Phase 2 declaration in December 2015, after demonstrating performance with only one intercept test. As we have previously reported, insufficient testing while fielding assets increases the risk of performance shortfalls and increased costs if issues are discovered as a result of flight testing. In December 2015, MDA conducted a BMDS level flight test—FTO-02 Event 1a—intended to demonstrate the operational capability of EPAA Phase 2 and Aegis Ashore's ability to defend Europe against medium-range ballistic threats. In the test, the Aegis Ashore Missile Defense test facility successfully engaged an air-launched medium-range target with an upgraded Aegis BMD SM-3 Block IB interceptor.
>
> FT0-02 Event 1a was Aegis Ashore's first and only intercept test prior to declaring the site operational. Moreover, since 2013, Aegis Ashore has reduced the number of planned intercept tests prior to EPAA Phase 3 from four to two. According to program officials, they are leveraging data from sea-based Aegis BMD tests, however, conditions at sea are different than on land, as are the system configurations. While MDA delivered Aegis Ashore in Romania, incomplete test data delayed the evaluation of Aegis Ashore's performance against all expected engagement scenarios to determine its capabilities and limitations. This analysis is not expected to be completed until at least fiscal year 2018.
>
> Construction of the Aegis Ashore site in Poland, the schedule for which has already been compressed, has been further complicated due to delays in completing work at the site in

[43] Government Accountability Office, *Missile Defense[:] Some Progress Delivering Capabilities, but Challenges with Testing Transparency and Requirements Development Need to Be Addressed*, GAO-17-381, May 2017, pp. 81-83.

> Romania. The Romanian site's late finish and the Poland site's slow start has resulted in the Aegis Ashore program concurrently working on both sites, leading to the increased risk of schedule delays or reduced testing. Aegis Ashore program documentation indicated that all work on the Aegis Ashore site in Romania was to be complete by December 2015; however work will be ongoing until at least fiscal year 2017 due to, among other things, the necessity to resolve power system issues required to complete system verification and validation. Overseeing work at two sites simultaneously has placed additional burdens on the program and the contractor's managers. According to program documentation, these issues place the program at risk of not being able to meet its testing and delivery milestones.
>
> MDA has taken some steps to mitigate the project's schedule risks. According to Aegis Ashore officials; they believe "lessons learned" from the construction of the Romania site can be utilized in Poland to offset some schedule compression. Specifically, to reduce schedule risks, the program plans to add additional personnel and is working with the contractor to prevent the delays from further impacting the project schedule. Consequently, according to program documentation, the program expects to complete the installation and delivery of Aegis Ashore Poland on schedule in 2018 and meet the EPAA Phase 3 deadline. However, further delays could result in either delaying the planned delivery or not having sufficient time to conduct all planned testing limiting the warfighter's understanding of the system's capabilities and limitations.[44]

Regarding the SM-3 Block IB interceptor, the report stated:

> MDA successfully tested and delivered the Standard Missile-3 Block IB for operational use in fiscal year 2016, but the program still faces several technical issues, some of which have implications for performance or reliability. According to the Department of Operational Test and Evaluation, these reliability issues could negatively affect the interceptor's operational effectiveness due to the chance of the missile failing in flight. MDA assessed the interceptor's reliability as being within its requirements, but is taking steps to address the risks. These steps include redesigning certain components and working with Raytheon to address quality and production issues that have been discovered during recent reviews.
>
> Addressing reliability concerns discovered during testing introduced delays and additional costs. The SM-3 Block IB program experienced two separate test failures in fiscal year 2016 that required convening a Failure Review Board to identify root causes for the failure and implement corrective actions. As a result of the failures, MDA suspended deliveries of additional interceptors, and as a result MDA missed its target for interceptor delivery. The program has identified the components responsible for the failures and will incorporate fixes during the recertification process.
>
> In part in response to one of our prior recommendations, MDA postponed putting into production a significant design change to the interceptor's third-stage rocket motor until properly tested. MDA further delayed its decision to enter full production, from the 2nd quarter of fiscal year 2016 to the 2nd quarter of fiscal year 2017 while attempting to address issues identified in the most recent test failure. MDA has delayed full production multiple times over the life of the SM-3 Block IB, which was initially scheduled for fourth quarter, fiscal year 2012.
>
> MDA successfully tested the new third-stage rocket motor design with two non-intercept flight tests– Standard Missile Controlled Test Vehicle (SM CTV)-01a and SM CTV-02. The redesign is intended to increase interceptor reliability, and was necessitated by a test failure in October 2013. The program initially planned to execute the tests in February 2016, but delayed the tests after the SM-3 Block IB failed a diagnostic test before the initial attempt. The tests were successfully completed in May 2016 and the redesign was approved

[44] Government Accountability Office, *Missile Defense[:] Some Progress Delivering Capabilities, but Challenges with Testing Transparency and Requirements Development Need to Be Addressed*, GAO-17-381, May 2017, pp. 85-86.

> for production in July 2016. The first missiles with the redesigned rocket motor are expected for delivery in the second quarter of fiscal year 2017. MDA plans to retrofit existing SM-3 Block IB interceptors during the periodic recertification process. The cost to fix each interceptor is expected to be about $545 thousand per interceptor.[45]

Regarding the SM-3 Block IIA interceptor, the report stated:

> The Aegis BMD SM-3 Block IIA conducted one test in fiscal year 2016, which revealed some technical challenges. Although delayed due to developmental challenges with the guidance system, the SM-3 Block IIA program conducted a non-intercept test named Standard Missile-3 Cooperative Development Controlled Test Vehicle (SCD CTV)-01 in June 2015, as well as the second non-intercept test–SCD CTV-02–in December 2015. Both tests demonstrated key capabilities including the ability to control the interceptor through the final rocket stage, separation of the kinetic warhead, and operation of the warhead after separation. The tests were successful by these measures, but still exposed some technical problems that could affect its schedule and result in further cost overruns. These challenges include design issues with missile guidance systems, which steer the interceptor to the target, and missile communication with sensors.
>
> In order to assess these issues and incorporate lessons learned, the next test, which was also the first intercept test – Standard Missile-3 Block IIA Flight Test Mission (SFTM)-01 – was delayed from the end of fiscal year 2016 to February, 2017. MDA previously stated that any further delay in SFTM-01 could impact the schedule for SFTM-02, and with it, MDA's initial production decision scheduled for the fourth quarter of fiscal year 2017. Program documentation also stated that additional schedule delays could affect future planned testing and increase overall program cost. Despite these risks, MDA does not believe these issues will impact the schedule for EPAA Phase 3.
>
> The development of the SM-3 Block IIA continues to deal with cost growth, in addition to schedule problems and technical issues, all of which threaten the ability to deliver an effective interceptor on time and within budget. The Missile Defense Agency reports that the contractor's estimated cost at program completion increased by around $61 million. While the program has implemented some mitigation measures, according to program documentation, additional growth threatens to result in funding shortfalls.
>
> The program has also experienced a delay in awarding the contract for the materials needed to build interceptor test rounds, which has had further impact on the program schedule. In particular, the procurement delay has required adjustments to Flight Test Mission (FTM) - 29, the first flight test designed to fire the interceptor against an intermediate-range target while relying on remote sensor data. While the program is taking steps to mitigate the delay, risk remains that the test will be delayed which could affect the scheduled EPAA Phase 3 declaration date.[46]

Legislative Activity for FY2019

Summary of Action on FY2019 MDA Funding Request

Table 3 summarizes congressional action on the FY2018 request for MDA procurement and research and development funding for the Aegis BMD program.

[45] Government Accountability Office, *Missile Defense[:] Some Progress Delivering Capabilities, but Challenges with Testing Transparency and Requirements Development Need to Be Addressed*, GAO-17-381, May 2017, pp. 88-89.

[46] Government Accountability Office, *Missile Defense[:] Some Progress Delivering Capabilities, but Challenges with Testing Transparency and Requirements Development Need to Be Addressed*, GAO-17-381, May 2017, pp. 91-92.

Table 3. Summary of Congressional Action on FY2019 Request for MDA Procurement and RDT&E Funding for Aegis BMD Program

(In millions of dollars, rounded to nearest tenth; totals may not add due to rounding)

		Authorization			Appropriation		
	Request	HASC	SASC	Conf.	HAC	SAC	Conf.
Procurement							
Aegis BMD (line 29)	593.5	593.5	593.5	593.5	679.6	708.7	700.5
Aegis BMD advance procurement (line 30)	115.2	115.2	115.2	115.2	0	0	0
Aegis Ashore Phase III (line 34)	15.0	15.0	15.0	15.0	15.0	35.0	15.0
Aegis BMD hardware and software (line 36)	97.1	97.1	97.1	97.1	97.1	97.1	97.1
Subtotal Procurement	**820.8**	**820.8**	**820.8**	**820.8**	**791.7**	**840.8**	**812.6**
Research, development, test, and evaluation (RDT&E)							
Aegis BMD (PE 0603892C) (line 78)	767.5	767.5	767.5	767.5	726.1	773.5	741.1
Aegis BMD test (PE 0604878C) (line 107)	95.8	95.8	95.8	95.8	95.8	95.8	95.8
Land-based SM-3 (PE 0604880C) (line 109)	27.7	27.8	27.7	27.7	27.7	27.7	27.7
Aegis SM-3 IIA (PE 0604881C) (line 110)	0	0	0	0	0	0	0
Subtotal RDT&E	**891.0**	**891.1**	**891.0**	**891.0**	**849.6**	**897.0**	**864.6**
TOTAL	**1,711.8**	**1,711.9**	**1,711.8**	**1,711.8**	**1,641.3**	**1,737.8**	**1,677.2**

Source: Table prepared by CRS based on DOD's original FY2019 budget submission, committee and conference reports, and explanatory statements on FY2018 National Defense Authorization Act and FY2019 DOD Appropriations Act.

Notes: HASC is House Armed Services Committee; **SASC** is Senate Armed Services Committee; **HAC** is House Appropriations Committee; **SAC** is Senate Appropriations Committee; **Conf.** is conference agreement.

National Defense Authorization Act for Fiscal Year 2019/John S. McCain National Defense Authorization Act for Fiscal Year 2019 (H.R. 5515/S. 2987/P.L. 115-232)

House

The House Armed Services Committee, in its report (H.Rept. 115-676 of May 15, 2018) on H.R. 5515, recommended the funding levels for the Aegis BMD program shown in the HASC column of **Table 3**. The recommended increase of $150,000 [i.e., $0.15 million] for line 109 is for "Retain Poland CHUs." (Page 418)

Section 125 of H.R. 5515 as reported by the committee states the following:

> SEC. 125. Multiyear procurement authority for standard missile–6.
>
> (a) Authority for multiyear procurement.—Subject to section 2306b of title 10, United States Code, the Secretary of the Navy may enter into one or more multiyear contracts, beginning with the fiscal year 2019 program year, for the procurement of up to 625 standard missile–6 missiles at a rate of not more than 125 missiles per year during the covered period.

(b) Condition for out-year contract payments.—A contract entered into under subsection (a) shall provide that any obligation of the United States to make a payment under the contract for a fiscal year after fiscal year 2019 is subject to the availability of appropriations or funds for that purpose for such later fiscal year.

(c) Covered period defined.—In this section, the term "covered period" means the 5-year period beginning with the fiscal year 2019 program year and ending with the fiscal year 2023 program year.

Section 1255 of H.R. 5515 as reported by the committee states the following (emphasis added):

SEC. 1255. Missile defense exercises in the Indo-Pacific region with United States regional allies and partners.

(a) Findings.—Congress finds the following:

(1) The Democratic People's Republic of Korea (North Korea) continues to develop, test, and threaten the use of intercontinental ballistic missiles and nuclear weapons that threaten the United States and United States allies and partners.

(2) The People's Republic of China and the Russian Federation continue to develop and deploy advanced counter-intervention technologies, including fielding and testing highly maneuverable reentry vehicles and warheads (such as hypersonic weapons), and cruise missiles and small-unmanned aircraft systems (UAS) that challenge United States strategic, operational, and tactical freedom of movement and maneuver.

(b) Sense of Congress.—It is the sense of Congress that the United States should—

(1) continue to develop and deploy a robust missile defense in the Indo-Pacific region;

(2) increase the capacity of interceptors, sensors, and operational concepts in the region;

(3) continue bilateral and multilateral operationally realistic missile defense exercises in the region;

(4) increase coordination with United States regional allies and partners, including Japan, South Korea, Australia, India, and other countries, as appropriate;

(5) begin planning for military exercises in 2020 with United States regional allies and partners that is specifically focused on interoperability;

(6) integrate radar information from United States and allied Patriot, Terminal High Altitude Area Defense, **Aegis**, and other systems for region-wide command and control capabilities;

(7) increase the capacity of United States allies and partners through foreign military sales;

(8) seek increased areas of co-production for components of missile defense systems; and

(9) develop new capabilities to address threats to the region.

(c) Missile defense exercises in the Indo-Pacific region.—The Secretary of Defense may conduct missile defense exercises in the Indo-Pacific region with United States regional allies and partners to improve interoperability.

(d) Briefing.—Not later than 120 days after the date of the enactment of this Act, the Secretary of Defense shall provide to the appropriate congressional committees a briefing on plans for missile defense exercises as described in subsection (c).

(e) Appropriate congressional committees defined.—In this section, the term "appropriate congressional committees" means—

(1) the congressional defense committees; and

(2) the Committee on Foreign Relations of the Senate and the Committee on Foreign Affairs of the House of Representatives.

Section 1666 of H.R. 5515 as reported by the committee states the following:

SEC. 1666. Requirements for ballistic missile defense capable ships.

(a) Force structure assessment.—The Secretary of the Navy, in consultation with the Director of the Missile Defense Agency, shall include in the first force structure assessment conducted following the date of the enactment of this Act the following:

(1) An assessment of the requirements for ballistic missile defense capable ships.

(2) The force structure requirements associated with advanced ballistic missile defense capabilities.

(b) Force structure assessment defined.—The term "force structure assessment" has the meaning given the term in Chief of Naval Operations Instruction 3050.27.

Section 1667 of H.R. 5515 as reported states the following:

SEC. 1667. Multiyear procurement authority for standard missile–3 block IB missiles.

(a) Authority for multiyear procurement.—Subject to section 2306b of title 10, United States Code, the Director of the Missile Defense Agency may enter into one or more multiyear contracts, beginning with the 2019 program year, for the procurement of standard missile–3 block IB missiles.

(b) Condition for out-year contract payments.—A contract entered into under subsection (a) shall provide that any obligation of the United States to make a payment under the contract for a fiscal year after fiscal year 2019 is subject to the availability of appropriations or funds for that purpose for such later fiscal year.

H.Rept. 115-676 states the following:

Surface Fleet Live Fire Training

The committee recognizes the Navy's desire to increase fleet readiness training and exercise ship systems before deployment by including live-firing of missiles in pre-deployment training exercises. The committee also notes the Navy's Standard Missile-3 Block IA inventory is approaching the end of service life. Furthermore, the committee is aware that in lieu of demilitarization, the Navy intends to assess repurposing these missiles to conduct live-fire readiness training using shipboard ballistic missile defense systems. The committee encourages this initiative and directs the Secretary of the Navy to provide a briefing to the House Committee on Armed Services not later than November 5, 2018, on the Navy's progress in making SM–3 Block IA missiles approaching the end of their service life available for live-fire readiness training for ships and crews. (Page 91)

H.Rept. 115-676 also states the following:

Options To Supplement Missile Defense of Hawaii

The committee notes that Hawaii is currently defended against missile threats from North Korea by the deployed ground-based interceptors located at Fort Greely, Alaska, and Vandenberg Air Force Base, California. Mindful of potential costs and untested capability of Standard Missile–3 (SM–3) interceptors against long-range missile threats, the committee directs the Secretary of the Navy, in consultation with the Director of the Missile Defense Agency, to provide a briefing to the Committee on Armed Services of the House of Representatives, not later than September 15, 2018, on the potential to supplement this defense by assigning a permanent Aegis ship patrol to increase a layered ballistic missile defense of Hawaii, with the assumption that SM–3 missiles might be effective against long-

range threats. The briefing should address the technical capability, feasibility, benefits, risks, cost, and tradeoffs of this option for the purpose of defending Hawaii.

In addition, mindful of the high demand for Terminal High Altitude Area Defense (THAAD) batteries and the untested capability of the THAAD weapon system against long-range threats, the committee also directs the Director of the Missile Defense Agency, in coordination with the Secretary of the Army, to provide a briefing to the Committee on Armed Services of the House of Representatives, not later than September 15, 2018, on the feasibility of stationing a permanent THAAD battery in Hawaii, and the technical capability, costs, benefits, and risks of testing a THAAD interceptor against an intercontinental ballistic missile. (Page 233)

H.Rept. 115-676 also states the following:

Protection of Ballistic Missile Defense System Components

The committee notes an increase to land-based ballistic missile defense system (BMDS) components with the development and delivery of the Long Range Discriminating Radar, Homeland Defense Radar-Hawaii, Pacific Radar, and completion of the Aegis Ashore site in Poland. These new sites are in addition to already deployed terrestrial weapon system sites and radars. Responsibility for protection of these sites against threats such as cruise missiles, unmanned aerial vehicles, and electronic warfare falls under the combatant commander for which they are located.

The committee directs the Secretary of Defense, in coordination with the Commander, U.S. Strategic Command, and appropriate regional combatant commands, to provide a briefing to the congressional defense committees by November 30, 2018, detailing the current protections of deployed BMDS assets from cruise missile, unmanned aerial vehicle, and electronic warfare threats. The briefing should also include the requirements for protection of the future assets that are in the program of record, as well as any plans to increase protection of current and future assets, including costs and any mitigating measures in the event that a system is degraded or unavailable. (Page 234)

H.Rept. 115-676 also states the following:

Standard Missile–3 Testing and Reliability

The committee is aware of the role and importance of the Standard Missile–3 (SM–3) interceptors in providing missile defense capability to the warfighter. The committee notes that failures of the SM–3 IB and SM–3 IIA revealed issues that may have been avoided with additional system engineering focus, and these recent challenges could have impacts on reliability assessments of these interceptors by the Director, Operational Test and Evaluation.

The committee also notes that section 1680 of the National Defense Authorization Act for Fiscal Year 2018 (Public Law 115–91) included a requirement to test the SM–3 IIA capability against a longer range threat. The committee directs the Director of the Missile Defense Agency to provide a briefing to the Committees on Armed Services of the House of Representatives and the Senate, not later than August 1, 2018, on how the recent SM–3 IIA test failure affects the planned test of this missile against an intercontinental ballistic missile-range target. This briefing should include implications such as changes to timeline of planned tests, requirements for additional tests, and changes in funding requirements.

The committee also directs the Director of the Missile Defense Agency, in coordination with the Director of the Office of Test and Evaluation, to provide a briefing to the Committees on Armed Services of the Senate and the House of Representatives, not later than December 15, 2018, detailing how the Missile Defense Agency will ensure the contractor's systems engineering and ground testing procedures are adequate to support production of SM–3 IB and SM–3 IIA interceptors. The briefing should describe how

> ground test data from production interceptors supports SM–3 reliability estimates from the Missile Defense Agency and the Office of Test and Evaluation. (Pages 234-235)

H.Rept. 115-676 also states the following:

> Aegis Ashore Poland Austere Housing
>
> The committee notes that the U.S. Navy has made the decision to maintain austere housing accommodations for the Aegis Ashore site in Redzikowo, Republic of Poland. This decision was made despite the committee's concerns about the impact that these conditions could have on the quality of life for the sailors manning the site.
>
> Aegis Ashore Poland will provide critical missile defense capability to defend our deployed forces, allies, partners, and friends from missile defense threats. The site will be manned 24/7 by sailors on rotating, unaccompanied tours. The Commander of Naval Installations Command determined that the Aegis Ashore site located in Redzikowo, Poland, warranted ''austere'' housing, and the Chief of Naval Operations approved this determination. Under this determination, the housing accommodation guidelines will place up to 4 persons in each berthing room.
>
> The committee is concerned that the austere housing may have a negative impact on quality of life for the sailors manning the site as they execute a critical missile defense mission. Therefore, the committee directs the Secretary of the Navy to provide a briefing to the House Committee on Armed Services by November 30, 2018, on options to improve housing standards for sailors at the Aegis Ashore Poland site, including estimated costs and schedule for completing the possible improvements. (Pages 267-268)

Senate

The Senate Armed Services Committee, in its report (S.Rept. 115-262 of June 5, 2018) on S. 2987, recommended the funding levels for the Aegis BMD program shown in the SASC column of **Table 3**.

Section 125 of S. 2987 as reported states:

> SEC. 125. Multiyear procurement authority for Standard Missile-6.
>
> (a) Authority for multiyear procurement.—Subject to section 2306b of title 10, United States Code, the Secretary of the Navy may enter into one or more multiyear contracts, beginning with the fiscal year 2019 program year, for the procurement of up to 625 Standard Missile–6 guided missiles.
>
> (b) Authority for advance procurement and economic order quantity.—The Secretary may enter into one or more contracts for advance procurement associated with the missiles (including economic order quantity) for which authorization to enter into a multiyear procurement contract is provided under subsection (a).
>
> (c) Cost analysis requirement.—The Secretary may not exercise the authority provided under subsection (a) or (b) until the Secretary of Defense submits to the congressional defense committees the report and confirmation required under subparagraphs (A) and (B), respectively, of section 2306b(i)(2) of title 10, United States Code.
>
> (d) Condition for out-year contract payments.—A contract entered into under subsection (a) shall provide that any obligation of the United States to make a payment under the contract for a fiscal year after fiscal year 2019 is subject to the availability of appropriations for that purpose for such later fiscal year.

Section 1652 of S. 2987 as reported states:

> SEC. 1652. Multiyear procurement authority for Standard Missile–3 IB guided missiles.

(a) Authority for multiyear procurement.—Subject to section 2306b of title 10, United States Code, the Secretary of Defense may enter into one or more multiyear contracts, beginning with the fiscal year 2019 program year, for the procurement of Standard Missile–3 Block IB guided missiles.

(b) Authority for advance procurement.—The Secretary may enter into one or more contracts for advance procurement associated with the missiles for which authorization to enter into a multiyear procurement contract is provided under subsection (a).

(c) Cost analysis requirement.—The Secretary may not exercise the authority provided under subsection (a) or (b) until the Secretary submits to the congressional defense committees the report and confirmation required under subparagraphs (A) and (B), respectively, of section 2306b(i)(2) of title 10, United States Code.

(d) Condition for out-year contract payments.—A contract entered into under subsection (a) shall provide that any obligation of the United States to make a payment under the contract for a fiscal year after fiscal year 2019 is subject to the availability of appropriations for that purpose for such later fiscal year.

Regarding Section 1652, S.Rept. 115-262 states:

Multiyear procurement authority for Standard Missile–3 IB guided missiles (sec. 1652)

The committee recommends a provision that would provide authority for the Secretary of Defense to enter into a multiyear contract for the procurement of up to 204 Standard Missile–3 (SM–3) Block IB guided missiles for fiscal year 2019 through fiscal year 2023 program years, with advance procurement for economic order quantities also beginning in fiscal year 2019 pending the Director of Cost Assessment and Program Evaluation confirmation of the Secretary of the Navy's preliminary findings as required in subsection a of section 2306b of title 10, United States Code.

The SM–3 Block IB program is a core element of the Aegis Ballistic Missile Defense program and is approved through the current future years defense program. This provision would provide the following benefits: (1) Generate cost savings compared to annual procurement cost estimates; (2) Provide stable production of SM–3 Block IBs; (3) Provide a long-term commitment to the low-density aerospace industrial base that stabilizes aerospace employment levels; (4) Provide an incentive for industry capital investment for productivity improvements that would benefit several Department of Defense missile programs; and (5) Reduce disruptions in vendor delivery schedules. (Page 344)

Conference

The conference report (H.Rept. 115-874 of July 25, 2018) on H.R. 5515/P.L. 115-232 of August 13, 2018, recommends the funding levels shown in the authorization conference column of **Table 3**.

Section 124 of H.R. 5515 states:

SEC. 124. MULTIYEAR PROCUREMENT AUTHORITY FOR STANDARD MISSILE–6.

(a) AUTHORITY FOR MULTIYEAR PROCUREMENT.—Subject to section 2306b of title 10, United States Code, the Secretary of the Navy may enter into one or more multiyear contracts, beginning with the fiscal year 2019 program year, for the procurement of up to 625 standard missile–6 missiles at a rate of not more than 125 missiles per year during the covered period.

(b) AUTHORITY FOR ADVANCE PROCUREMENT AND ECONOMIC ORDER QUANTITY.—The Secretary may enter into one or more contracts for advance

procurement associated with the missiles (including economic order quantity) for which authorization to enter into a multiyear procurement contract is provided under subsection (a).

(c) CONDITION FOR OUT-YEAR CONTRACT PAYMENTS.—A contract entered into under subsection (a) shall provide that any obligation of the United States to make a payment under the contract for a fiscal year after fiscal year 2019 is subject to the availability of appropriations or funds for that purpose for such later fiscal year.

(d) COVERED PERIOD DEFINED.—In this section, the term ''covered period'' means the 5-year period beginning with the fiscal year 2019 program year and ending with the fiscal year 2023 program year.

Section 1684 of H.R. 5515 states:

SEC. 1684. REQUIREMENTS FOR BALLISTIC MISSILE DEFENSE CAPABLE SHIPS.

(a) FORCE STRUCTURE ASSESSMENT.—The Secretary of the Navy, in consultation with the Director of the Missile Defense Agency, shall include in the first force structure assessment conducted following the date of the enactment of this Act the following:

(1) An assessment of the requirements for ballistic missile defense capable ships.

(2) The force structure requirements associated with advanced ballistic missile defense capabilities.

(b) FORCE STRUCTURE ASSESSMENT DEFINED.—The term ''force structure assessment'' has the meaning given the term in Chief of Naval Operations Instruction 3050.27.

Section 1685 of H.R. 5515 states:

SEC. 1685. MULTIYEAR PROCUREMENT AUTHORITY FOR STANDARD MISSILE–3 IB GUIDED MISSILES.

(a) AUTHORITY FOR MULTIYEAR PROCUREMENT.—Subject to section 2306b of title 10, United States Code, the Secretary of Defense may enter into one or more multiyear contracts, beginning with the fiscal year 2019 program year, for the procurement of standard missile–3 block IB guided missiles.

(b) AUTHORITY FOR ADVANCE PROCUREMENT.—The Secretary may enter into one or more contracts for advance procurement associated with the missiles for which authorization to enter into a multiyear procurement contract is provided under subsection (a).

(c) CONDITION FOR OUT-YEAR CONTRACT PAYMENTS.—A contract entered into under subsection (a) shall provide that any obligation of the United States to make a payment under the contract for a fiscal year after fiscal year 2019 is subject to the availability of appropriations for that purpose for such later fiscal year.

FY2019 DOD Appropriations Act (H.R. 6157/S. 3159/Division A of H.R. 6157/P.L. 115-245)

House

The House Appropriations Committee, in its report (H.Rept. 115-769 of June 20, 2018) on H.R. 6157, recommended the funding levels for the Aegis BMD program shown in the HAC column of **Table 3**.

The recommended net increase of $86.151 million for line 29 includes a recommended reduction of $4.925 million for "Spares excess growth," a recommended reduction of $5.946 million for "SM-3 IIA unit cost growth," a recommended reduction of $2.258 million for "SM-3 IIA obsolescence early to need," and a recommended increase of $99.28 million for "SM-3 IIA production—transfer from line 30." The recommended reduction of $115.206 million (the entire requested amount) for line 30 is for "Excess to need" ($15.926 million) and "Lack of justification—transfer to line 29 for SM-3 IIA production ($99.28 million). (Page 208)

The recommended net reduction of $41.463 million for line 78 includes a recommended reduction of $30.463 million for "Weapon system capability insertion early to need," a recommended reduction of $15.0 million for "Aegis BMD SM-3 development unjustified growth," and a recommended increase of $4.0 million for "Program increase—improved discrimination capabilities." (Page 283)

H.Rept. 115-769 states

> AEGIS ASHORE POLAND
>
> The Committee recognizes that the Aegis Ashore in Redzikowo, Poland will provide critical missile defense capability to defend deployed forces, allies, and partners from ballistic missile threats. The site will be manned and operated by sailors on rotating, unaccompanied tours. The Committee provides for the use of up to $150,000 of Operation and Maintenance, Navy funding to maintain the current containerized handling units on site in Poland for housing.
>
> The Committee directs the Secretary of the Navy to provide a report to the congressional defense committees not later than 60 days after the enactment of this Act on options to improve long-term housing for sailors at the Aegis Ashore Poland site, including estimated costs and schedule for completing the possible improvements. (Pages 71-72)

Senate

The Senate Appropriations Committee, in its report (S.Rept. 115-290 of June 28, 2018) on S. 3159, recommended the funding levels for the Aegis BMD program shown in the SAC column of **Table 3**.

The recommended increase of $115.206 million for line 29 is for "Transfer: Transfer from line 30 for additional SM–3 Block IIA interceptors." The recommended reduction of $115.206 million (the entire requested amount) for line 30 is for "Restoring acquisition accountability: Lack of justification—transfer to line 29 for additional SM–3 Block IIA interceptors." The recommended increase of $20.0 million for line 34 is for "Program increase: AEGIS Ashore Poland." (Page 142)

The recommended increase of $5.981 million for line 78 is for "Program increase: Discrimination capabilities" ($4.0 million) and "Program increase: Facilities, sustainment, restoration and modernization" ($1.981 million). (Page 197)

S.Rept. 115-290 states

> *Aegis Ashore Poland*.—The Committee understands that completion of the Aegis Ashore site in Poland will slip by at least 1 year, delaying installation of the weapon system and transition of the capability to U.S. European Command. The Committee is concerned with this delay and recommends an additional $20,000,000 to continue combat system and combat structure adaptation, integration, installation, and testing. The Committee directs the Director, MDA, to submit to the congressional defense committees, with the fiscal year 2020 President's budget request, an updated program baseline for Aegis Ashore Poland, to include revised cost estimates. The Director, CAPE, is directed to provide, with the fiscal

> year 2020 President's budget request, an Independent Cost Estimate for Aegis Ashore Poland. (Page 10)

S.Rept. 115-290 also states

> *AEGIS Modernization*.—The fiscal year 2019 President's budget request includes $396,403,000 to develop modifications to the AEGIS Weapon system and integrate combat capabilities developed by the Navy and the Missile Defense Agency into the AEGIS Combat System, an increase of $44,874,000 over amounts appropriated in fiscal year 2018. The Committee notes the improved joint briefing materials provided by the Navy and the Missile Defense Agency in support of the budget request and directs the Program Executive Officer, Integrated Warfare Systems, and the Director, Missile Defense Agency to continue to provide these materials, as subsequently modified per congressional request, in future budget briefings. (Page 176)

Conference

In final action, the FY2019 DOD Appropriations Act became Division A of the Department of Defense and Labor, Health and Human Services, and Education Appropriations Act, 2019, and Continuing Appropriations Act, 2019 (H.R. 6157/P.L. 115-245 of September 28, 2018).

The joint explanatory statement for H.R. 6157/P.L. 115-245 specified the funding levels shown in the appropriations conference column of **Table 3**. The net increase of $107.0 million for Line 29 includes a reduction of $5.946 million for "SM-3 IIA unit cost growth," a reduction of $2.258 million for "SM-3 IIA obsolescence early to need," and an increase of $115.206 million for "SM-3 IIA additional interceptors - transfer from line 30." (PDF page 229 of 559) The reduction of $115.206 million (the entire requested amount) for Line 30 is for "Lack of justification - transfer to line 29 for SM-3 IIA additional interceptors." (PDF page 229 of 559) The net reduction of $26.463 million for Line 78 includes a reduction of $30.463 million for "Weapon system capability insertion early to need," and an increase of $4.0 million for "Program increase - improved discrimination capabilities." (PDF page 321 of 559)

Appendix A. Aegis BMD Flight Tests

This appendix presents additional background information on Aegis BMD flight tests.

Summary of Test Flights

Table A-1 presents a summary of Aegis BMD flight tests since January 2002. As shown in the table, since January 2002, the Aegis BMD system has achieved 32 successful exo-atmospheric intercepts in 41 attempts using the SM-3 missile (including 4 successful intercepts in 5 attempts by Japanese Aegis ships, and one successful intercept in two attempts attempt using the Aegis Ashore system), and 7 successful endo-atmospheric intercepts in 7 attempts using the SM-2 Block IV and SM-6 missiles, making for a combined total of 39 successful intercepts in 48 attempts.

In addition, on February 20, 2008, a BMD-capable Aegis cruiser operating northwest of Hawaii used a modified version of the Aegis BMD system with the SM-3 missile to shoot down an inoperable U.S. surveillance satellite that was in a deteriorating orbit.[47] Including this intercept in the count increases the totals to 33 successful exo-atmospheric intercepts in 42 attempts using the SM-3 missile, and 40 successful exo- and endo-atmospheric intercepts in 49 attempts using SM-3, SM-2 Block IV, and SM-6 missiles.

[47] 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. (For additional information, see the MDA discussion available online at http://www.mda.mil/system/aegis_one_time_mission.html, and also 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.)

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." (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.)

Table A-1. Aegis BMD Flight Tests From January 2002 to the Present

Date	Country	Name of flight test of exercise	Ballistic Missile Target	Successful?	Cumulative successes	Cumulative attempts
Exo-atmospheric (using SM-3 missile)						
1/25/02	US	FM-2	Unitary short-range (TTV)	Yes	1	1
6/13/02	US	FM-3	Unitary short-range (TTV)	Yes	2	2
11/21/02	US	FM-4	Unitary short-range (TTV)	Yes	3	3
6/18/03	US	FM-5	Unitary short-range (TTV)	**No**	3	4
12/11/03	US	FM-6	Unitary short-range (TTV)	Yes	4	5
2/24/05	US	FTM 04-1 (FM-7)	Unitary short-range (TTV)	Yes	5	6
11/17/05	US	FTM 04-2 (FM-8)	Separating short-range (MRT)	Yes	6	7
6/22/06	US	FTM 10	Separating short-range (TTV)	Yes	7	8
12/7/06	US	FTM 11	Unitary short-range (TTV)	**No**	7	9
4/26/07	US	FTM 11 Event 4	Unitary short-range (ARAV-A)	Yes	8	10
6/22/07	US	FTM 12	Separating short-range (MRT)	Yes	9	11
8/31/07	US	FTM-11a	Classified	Yes	10	12
11/6/07	US	FTM 13	Unitary short-range (ARAV-A)	Yes	11	13
			Unitary short-range (ARAV-A)	Yes	12	14
12/17/07	Japan	JFTM-1	Separating short-range (MRT)	Yes	13	15
11/1/08	US	Pacific Blitz	Unitary short-range (ARAV-A)	Yes	14	16
			Unitary short-range (ARAV-A)	**No**	14	17
11/19/08	Japan	JFTM-2	Separating short-range (MRT)	**No**	14	18
7/30/09	US	FTM-17	Unitary short-range (ARAV-A)	Yes	15	19
10/27/09	Japan	JFTM-3	Separating short-range (MRT)	Yes	16	20
10/28/10	Japan	JFTM-4	Separating short-range (MRT)	Yes	17	21
4/14/11	US	FTM-15	Separating intermediate range (LV-2)	Yes	18	22
9/1/11	US	FTM-16 E2	Separating short-range (ARAV-B)	**No**	18	23

Date	Country	Name of flight test of exercise	Ballistic Missile Target	Successful?	Cumulative successes	Cumulative attempts
5/9/12	US	FTM-16 E2a	Unitary short-range (ARAV-A)	Yes	19	24
6/26/12	US	FTM-18	Separating short-range (MRT)	Yes	20	25
10/25/12	US	FTI-01	Separating short-range (ARAV-B)	**No**	20	26
2/12/13	US	FTM-20	Separating medium-range (MRBM-T3)	Yes	21	27
5/15/13	US	FTM-19	Separating short-range (ARAV-C)	Yes	22	28
9/10/13	US	FTO-01	Separating medium-range (eMRBM-T1)	Yes	23	29
9/18/13	US	FTM-21	Separating short-range (ARAV-C++)	Yes	24	30
10/3/13	US	FTM-22	Separating medium-range (ARAV-TTO-E)	Yes	25	31
11/6/14	US	FTM-25	Separating short-range (ARAV-B)	Yes	26	32
6/25/15	US	FTO-02 E1	Separating medium-range (IRBM T1)	n/a[a]	26	32
10/4/15	US	FTO-02 E2	Separating medium-range (eMRBM)	n/a[b]	26	32
10/20/15	US	ASD-15 E2	Separating short-range (Terrier Orion)	Yes	27	33
11/1/15	US	FTO-02 E2a	Separating medium-range (eMRBM)	No	27	34
12/10/15	US (Aegis Ashore)	FTO02 E1a	Separating medium-range (IRBM T1)	Yes	28	35
2/3/17	US-Japan	SFTM-01	Separating medium-range (MRT)	Yes	29	36
6/21/17	US-Japan	SFTM-02	Medium-range	**No**	29	37
10/15/17	US	FS17	Medium-range target	Yes	30	38
1/31/18	US (Aegis Ashore)	FTM-29	Intermediate-range target	**No**	30	39
9/11/18	Japan	JFTM-05	Simple separating target	Yes	31	40
10/26/18	US	FTM-45	Medium range	Yes	32	41
Endo-atmospheric (using SM-2 missile Block IV missile and [for MMW Event 1] SM-6 Dual 1 missile)						
5/24/06	US	Pacific Phoenix	Unitary short-range target (Lance)	Yes	1	1
6/5/08	US	FTM-14	Unitary short-range target (FMA)	Yes	2	2

Date	Country	Name of flight test of exercise	Ballistic Missile Target	Successful?	Cumulative successes	Cumulative attempts
3/26/09	US	Stellar Daggers	Unitary short-range target (Lance)	Yes	3	3
7/28/15	US	MMW E1	Unitary short-range target (Lance)	Yes	4	4
7/29/15	US	MMW E2	Unitary short-range target (Lance)	Yes	5	5
12/14/16	US	FTM-27	Unitary short-range target (Lance)	Yes	6	6
8/29/17	US	FTM-27 E2	Medium-range target (MRBM)	Yes	7	7
Combined total for exo- and endo-atmospheric above tests					39	48

Sources: Table presented in MDA fact sheet, "Aegis Ballistic Missile Defense Testing," February 2017, accessed on October 16, 2017, at https://www.mda.mil/global/documents/pdf/aegis_tests.pdf, and (for flight tests subsequent to February 2017) MDA news releases.

Notes: TTV is target test vehicle; **ARAV** is Aegis Readiness Assessment Vehicle. In addition to the flight tests shown above, there was a successful use of an SM-3 on February 20, 2008, to intercept an inoperative U.S. satellite—an operation called Burnt Frost. Including this intercept in the count increases the totals to 31 successful exo-atmospheric intercepts in 40 attempts using the SM-3 missile, and 38 successful exo- and endo-atmospheric intercepts in 47 attempts using SM-3, SM-2 Block IV, and SM-6 missiles.

a. MDA's table shows this as a test that did not result in the launch of an SM-3. MDA as of August 3, 2015, had not issued a news release discussing this event. MDA's count of 31 successful intercepts in 37 launches through July 29, 2015, does not appear to include this test, suggesting that this was considered a "no test" event—a test in which there was a failure that was not related to the Aegis BMD system or the SM-3 interceptor. News reports state that the test was aborted due to a failure of the target missile. (Andrea Shalal, "U.S. Skips Aegis Ashore Missile Test After Target Malfunction," *Reuters*, June 26, 2015.) MDA's table similarly shows the test of December 7, 2006, as a test that did not result in the launch of an SM-3. MDA issued a news release on this test, which stated that an SM-3 was not launched "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 [SM-3] 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." MDA counts the test of December 7, 2006, as an unsuccessful intercept in its count of 31 successful intercepts in 37 launches through July 29, 2015.

b. MDA's table shows this as a test that did not result in the launch of an SM-3. MDA as of November 10, 2015, had not issued a news release discussing this event. MDA's count of 32 successful intercepts in 39 launches through November 1, 2015, does not appear to include this test, suggesting that this was considered a "no test" event—a test in which there was a failure that was not related to the Aegis BMD system or the SM-3 interceptor.

May 2010 Criticism of Claimed Successes in Flight Tests

In a May 2010 magazine article and supplementary white paper, two professors with scientific backgrounds—George Lewis and Theodore Postol—criticized DOD claims of successes in Aegis (and other DOD) BMD flight tests, arguing that

> the Defense Department's own test data show that, in combat, the vast majority of "successful" SM-3 experiments would have failed to destroy attacking warheads. The data also show potential adversaries how to defeat both the SM-3 and the GMD [ground-based

> missile defense] systems, which share the same serious flaws that can be readily exploited by adversaries.[48]

The criticisms made by Lewis and Postol were reported in a May 18, 2010, *New York Times* article.[49] In response to the criticisms and the *New York Times* article, MDA issued a press release and other information defending the flight tests and arguing that the criticisms are based on inaccurate or incomplete information.[50]

Details on Selected Exo-Atmospheric (SM-3) Flight Tests Since June 2006

June 22, 2006, Test. This was the first test to use the 3.6 version of the Aegis BMD system.[51]

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.[52]

A news article about the ninth test stated the following:

> "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....

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[48] George N. Lewis and Theodore A. Postol, "A Flawed and Dangerous U.S. Missile Defense Plan," *Arms Control Today*, May 2010: 24-32. The quoted passage appears on p. 26. The associated white paper is George N. Lewis and Theodore A. Postol, *A Technically Detailed Description of Flaws in the SM-3 and GMD Missile Defense Systems Revealed by the Defense Department's Ballistic Missile Test Data*, May 3, 2010, 13 pp.

[49] William J. Broad and David E. Sanger, "Review Cites Flaws In U.S. Antimissile Program," *New York Times*, May 18, 2010: 1.

[50] Missile Defense Agency, "Missile Defense Agency Responds to New York Times Article," May 18, 2010 (10-NEWS-0005); Missile Defense Agency, *Missile Defense Agency Response to Request for Information, Standard Missile – 3 Interceptor Testing*, May 18, 2010, 2 pp.; Missile Defense Agency, *Missile Defense Agency Response to Request for Information, Response to New York Times May 18, 2010, Article Regarding SM-3 Testing*, May 18, 2010, 3 pp.; Richard Lehner, "Missile Defense Agerncy Responds to New York Times Article*," DOD Live* (http://www.dodlive.mil), May 18, 2010; Transcript of Department of Defense Bloggers Roundtable With Richard Lehner, Spokesman, Missile Defense Agency (MDA), Subject: Standard Missile 3 Test Program, May 18, 2010.

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

[52] 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.[53]

A subsequent news article stated the following:

> 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.[54]

Another article stated the following:

> Philip Coyle, a former head of the Pentagon's testing directorate, gives the Navy credit for "discipline and successes so far" in its sea-based ballistic missile defense testing program. Coyle is now a senior adviser at the Center for Defense Information.
>
> "The U.S. Navy has an enviable track record of successful flight intercept tests, and is making the most of its current, limited Aegis missile defense capabilities in these tests," Coyle told [*Inside the Navy*] Dec. 7.
>
> "Difficulties such as those that delayed the latest flight intercept attempt illustrate the complexity of the system, and how everything must be carefully orchestrated to achieve success," Coyle added. "Nevertheless, this particular setback won't take the Navy long to correct."[55]

April 26, 2007, Test. MDA states that this test:

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

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

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

> 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.[56]

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.[57]

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.[58]

August 31, 2007, Test. MDA has publicly noted the occurrence of this test and the fact that it resulted in a successful intercept,[59] but states that the details about the test are classified.[60] MDA does not appear to have issued a news release about this flight test following the completion of the test, as it has for other Aegis BMD flight tests.[61]

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

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

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

[59] 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.

[60] 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."

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

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.[62]

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.[63]

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 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

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

[63] 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.

> nominal trajectory, however intercept was not achieved. Extensive analysis of the flight mission will be used to improve the deployed Aegis BMD system.[64]

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.[65]

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.

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[64] 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.

[65] Missile Defense Agency, "Japan/U.S. Missile Defense Flight Test Completed," November 19, 2008 (08-NEWS-0087).

> 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.[66]

July 30, 2009, Test. MDA states that

> In conjunction with the Missile Defense Agency (MDA), U.S. Pacific Fleet ships and crews successfully conducted the latest Aegis Ballistic Missile Defense (BMD) at-sea firing event on July 30. During this event, entitled Stellar Avenger, the Aegis BMD-equipped ship, USS Hopper (DDG 70), detected, tracked, fired and guided a Standard Missile -3 (SM-3) Block (Blk) IA to intercept a sub-scale short range ballistic missile. The target was launched from the Kauai Test Facility, co-located on the Pacific Missile Range Facility (PMRF), Barking Sands, Kauai. It was the 19th successful intercept in 23 at-sea firings, for the Aegis BMD Program, including the February 2008 destruction of the malfunctioning satellite above the earth's atmosphere. Stellar Avenger was part of the continual evaluation of the certified and fielded Aegis BMD system at-sea today.
>
> At approximately 5:40 pm (HST), 11:40 pm (EDT), a target was launched from PMRF. Three U.S. Navy Aegis BMD-equipped ships, the cruiser, USS Lake Erie (CG 70) and

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

> destroyers USS Hopper (DDG 70) and USS O'Kane (DDG 77) detected and tracked the target with their SPY radars. Each developed fire control solutions. At 5:42 pm (HST), 11:42 pm (EDT) the crew of USS Hopper fired one SM-3 Blk IA missile. The USS Hopper's Aegis BMD Weapon System successfully guided the SM-3 to a direct body to body hit, approximately two minutes after leaving the ship. The intercept occurred about 100 miles above the Pacific Ocean. USS O'Kane conducted a simulated engagement of the target. USS Lake Erie, with its recently installed upgraded Aegis BMD 4.0.1 Weapons System, detected and tracked the same target.[67]

A July 31, 2009, press report states the following:

> The test was the first Aegis BMD exercise to feature two versions of the software in a single event, according to Lisa Callahan, Lockheed's vice president for ballistic missile defense programs.
>
> A goal of the exercises was to test the Aegis system's ability to discern all the different parts and pieces of a ballistic missile, Nick Bucci, Lockheed's director for Aegis BMD development programs, told reporters July 29 during a pre-exercise conference call.
>
> Three more flight tests this fall will further test the system's discrimination capabilities, Bucci added, with each test becoming more complex. The last test will "be against a pretty darn complex target," he said.
>
> The July 30 tests also validated fixes put in place after a BMD test last November involving a missile launched from the Aegis BMD Japanese destroyer Chokai failed to intercept its target, according to MDA spokesman Chris Taylor. The improvements—which were successful in the most recent test—involved fixes to the Solid Divert Attitude Control System.
>
> The Chokai is the second of four Japanese Aegis ships being upgraded with BMD capability. A third ship, the Myoko, is scheduled to carry out a BMD test this fall.[68]

An August 3, 2009, press report states the following:

> This test was added to the schedule to evaluate changes made after last year's failed attempt to intercept a target with an SM-3 Block IA launched by a Japanese Aegis-equipped ship .... After the Nov. 19 test, MDA officials said, "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."
>
> A root cause has not been identified, and an MDA spokesman did not say whether fixes have been made to hardware or operational procedures resulting from the failure review. It is also unclear why a subscale target was used in the July 30 trial.[69]

An August 4, 2009, press report states the following:

> [Rear Admiral Alan "Brad" Hicks, Aegis/SM-3 program manager for MDA], said that a November [2008] failure of an SM-3 Block IA... during a flight-test was attributable to poor adherence to processes on Raytheon's assembly line in Tucson, Ariz.
>
> This was isolated to that missile, and it was the result of perturbations to the build process encountered when shifting from development to production operations.

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[67] Missile Defense Agency, "Aegis Ballistic Missile Defense Test Successful," July 31, 2009 (09-News-0015).

[68] Christopher P. Cavas, "Aegis BMD Test Successful," *DefenseNews.com*, July 31, 2009.

[69] Amy Butler, "SM-3 Scores Hit After Fixes Implemented," *Aerospace Daily & Defense Report*, August 3, 2009: 5.

> During the November test, a Japanese Aegis-equipped ship fired the interceptor and it flew "perfectly," Hicks said. In the endgame, a failure of the divert and attitude control system on the unitary kill vehicle led to a miss.
>
> The July 30 demonstration using a U.S. ship "restored confidence" for the Japanese that the miss last fall was an isolated incident, he says.[70]

October 27, 2009, Test. This was the third Japanese flight test, and it involved a single ballistic missile target. MDA states that

> The Japan Maritime Self-Defense Force (JMSDF) and the United States Missile Defense Agency (MDA) announced the successful completion of an Aegis Ballistic Missile Defense (BMD) intercept flight test, in cooperation with the U.S. Navy, off the coast of Kauai in Hawaii. The event, designated Japan Flight Test Mission 3 (JFTM-3), marked the third time that a JMSDF ship has successfully engaged a ballistic missile target, including two successful intercepts, with the sea-based midcourse engagement capability provided by Aegis BMD.
>
> The JFTM-3 test event verified the newest engagement capability of the Japan Aegis BMD configuration of the recently upgraded Japanese destroyer, JS MYOKO (DDG-175). At approximately 6:00pm (HST), 1:00 pm Tokyo time on Oct 28, a separating, medium-range ballistic missile target was launched from the Pacific Missile Range Facility, Barking Sands, Kauai, Hawaii. JS MYOKO crew members detected and tracked the target. The Aegis Weapon System then developed a fire control solution and, at approximately 6:04pm (HST), 1:04 pm Tokyo time a Standard Missile-3 (SM-3) Block IA interceptor missile was launched. Approximately 3 minutes later, the SM-3 successfully intercepted the target approximately 100 miles above the Pacific Ocean. JFTM-3 is a significant milestone in the growing cooperation between Japan and the U.S. in the area of missile defense.
>
> Also participating in the test, were the Pearl Harbor-based USS Lake Erie (CG 70) and USS Paul Hamilton (DDG 60) which detected and tracked the target and conducted a simulated engagement.[71]

October 28, 2010, Test. This was the fourth Japanese flight test, and it involved a single ballistic missile target. MDA states that

> The Japan Maritime Self-Defense Force (JMSDF) and the United States Missile Defense Agency (MDA) announced the successful completion of an Aegis Ballistic Missile Defense (BMD) intercept flight test, in cooperation with the U.S. Navy, off the coast of Kauai in Hawaii.
>
> The event marked the fourth time that a JMSDF ship has engaged a ballistic missile target, including three successful intercepts, with the sea-based midcourse engagement capability provided by Aegis BMD.
>
> The JFTM-4 test event verified the newest engagement capability of the Japan Aegis BMD configuration of the recently upgraded Japanese destroyer, JS KIRISHIMA. At approximately 5:06 p.m. (HST), 12:06 p.m. Tokyo time on Oct. 29, 2010, a separating

[70] Amy Butler, "SM-3 Upgrade Program Cost Increases," *Aerospace Daily & Defense Report*, August 4, 2009: 1-2. See also Dan Taylor, "Navy Conducts Aegis BMD Test, New Baseline System Participates," *Inside the Navy*, August 3, 2009; Daniel Wasserbly, "US Aegis BMD System Achieves Trial Success," *Jane's Defence Weekly*, August 5, 2009: 8.

[71] Missile Defense Agency, "Japan/U.S. Missile Defense Flight Test Successful," October 28, 2009 (09-News-0021). See also Christopher P. Cavas, "Japanese Destroyer Conducts Successful BMD Test," *NavyTimes.com*, October 28, 2009; and Amy Butler and Michael Bruno, "SM-3 Scores Hit In Japanese Test," *Aerospace Daily & Defense Report*," October 29, 2009: 3.

> 1,000 km class ballistic missile target was launched from the Pacific Missile Range Facility at Barking Sands, Kauai, Hawaii.
>
> JS KIRISHIMA crew members detected and tracked the target. The Aegis Weapon System then developed a fire control solution and launched a Standard Missile -3 (SM-3) Block IA missile. Approximately three minutes later, the SM-3 successfully intercepted the target approximately 100 miles above the Pacific Ocean. JFTM-4 is a significant milestone in the growing cooperation between Japan and the U.S. in the area of missile defense.
>
> Also participating in the test was USS LAKE ERIE and USS RUSSELL, Aegis ships which cooperated to detect, track and conduct a simulated intercept engagement against the same target.[72]

April 15, 2011, Test. MDA states that this flight test "was the most challenging test to date, as it was the first Aegis BMD version 3.6.1 intercept against an intermediate-range target (range 1,864 to 3,418 [statute] miles) and the first Aegis BMD 3.6.1 engagement relying on remote tracking data." MDA states that

> The Missile Defense Agency (MDA), U.S. Navy sailors aboard the Aegis destroyer USS O'KANE (DDG 77), and Soldiers from the 94th Army Air and Missile Defense Command operating from the 613th Air and Space Operations Center at Hickam Air Force Base, Hawaii, successfully conducted a flight test of the Aegis Ballistic Missile Defense (BMD) element of the nation's Ballistic Missile Defense System, resulting in the intercept of a separating ballistic missile target over the Pacific Ocean. This successful test demonstrated the capability of the first phase of the European Phased Adaptive Approach (EPAA) announced by the President in September, 2009.
>
> At 2:52 a.m. EDT (6:52 p.m. April 15 Marshall Island Time), an intermediate-range ballistic missile target was launched from the Reagan Test Site, located on Kwajalein Atoll in the Republic of the Marshall Islands, approximately 2,300 miles southwest of Hawaii. The target flew in a northeasterly direction towards a broad ocean area in the Pacific Ocean. Following target launch, a forward-based AN/TPY-2 X-band transportable radar, located on Wake Island, detected and tracked the threat missile. The radar sent trajectory information to the Command, Control, Battle Management, and Communications (C2BMC) system, which processed and transmitted remote target data to the USS O'KANE. The destroyer, located to the west of Hawaii, used the data to develop a fire control solution and launch the SM-3 Block IA missile approximately 11 minutes after the target was launched.
>
> As the IRBM target continued along its trajectory, the firing ship's AN/SPY-1 radar detected and acquired the ballistic missile target. The firing ship's Aegis BMD weapon system uplinked target track information to the SM-3 Block IA missile. The SM-3 maneuvered to a point in space as designated by the fire control solution and released its kinetic warhead. The kinetic warhead acquired the target, diverted into its path, and, using only force of a direct impact, destroyed the threat in a "hit-to-kill" intercept.
>
> During the test the C2BMC system, operated by Soldiers from the 94th Army Air and Missile Defense Command, received data from all assets and provided situational awareness of the engagement to U.S. Pacific Command, U.S. Northern Command and U.S. Strategic Command.
>
> The two demonstration Space Tracking and Surveillance Satellites (STSS), launched by MDA in 2009, successfully acquired the target missile, providing stereo "birth to death" tracking of the target.

[72] Missile Defense Agency, "Joint Japan-U.S. Missile Defense Flight Test Successful," October 29, 2010 (10-News-0016). See also Marina Malenic, "Japanese Aegis Destroyer Successfully Completes Missile-Intercept Test," *Defense Daily*, November 1, 2010: 6.

> Today's event, designated Flight Test Standard Missile-15 (FTM-15), was the most challenging test to date, as it was the first Aegis BMD version 3.6.1 intercept against an intermediate-range target (range 1,864 to 3,418 [statute] miles) and the first Aegis BMD 3.6.1 engagement relying on remote tracking data. The ability to use remote radar data to engage a threat ballistic missile greatly increases the battle space and defended area of the SM-3 missile.
>
> Initial indications are that all components performed as designed. Program officials will spend the next several months conducting an extensive assessment and evaluation of system performance based upon telemetry and other data obtained during the test.[73]

September 1, 2011, Test. This flight test, which did not result in an intercept, was the first flight test of the SM-3 Block IB interceptor. MDA states that it

> was unable to achieve the planned intercept of a ballistic missile target during a test over the Pacific Ocean exercising the sea-based element of the Ballistic Missile Defense System (BMDS).
>
> At approximately 3:53 a.m. Hawaii Standard Time (9:53 a.m. EDT) a short-range ballistic missile target was launched from the U.S. Navy's Pacific Missile Range Facility on Kauai, Hawaii. Approximately 90 seconds later, a Standard Missile 3 (SM-3) Block 1B interceptor missile was launched from the cruiser USS LAKE ERIE (CG-70) but an intercept of the target was not achieved.
>
> This was the first flight test of the advanced SM-3 Block 1B interceptor missile. Program officials will conduct an extensive investigation to determine the cause of the failure to intercept.[74]

May 9, 2012, Test. MDA states that this flight test "was the first successful live fire intercept test of the SM-3 Block IB interceptor and the second-generation Aegis BMD 4.0.1 weapon system." MDA states that

> The Missile Defense Agency (MDA) and U.S. Navy sailors aboard the USS LAKE ERIE (CG 70) successfully conducted a flight test of the Aegis Ballistic Missile Defense (BMD) system, resulting in the first intercept of a short-range ballistic missile target over the Pacific Ocean by the Navy's newest Missile Defense interceptor, the Standard Missile – 3 (SM-3) Block IB.
>
> At 8:18 p.m. Hawaiian Standard Time (2:18 a.m. EDT May 10) the target missile was launched from the Pacific Missile Range Facility, located on Kauai, Hawaii. The target flew on a northwesterly trajectory towards a broad ocean area of the Pacific Ocean. Following target launch, the USS LAKE ERIE detected and tracked the missile with its onboard AN/SPY-1 radar. The ship, equipped with the second-generation Aegis BMD 4.0.1 weapon system, developed a fire control solution and launched the Standard Missile-3 (SM-3) Block IB interceptor.
>
> The USS LAKE ERIE continued to track the target and sent trajectory information to the SM-3 Block IB interceptor in-flight. The SM-3 maneuvered to a point in space, as designated by the fire control solution, and released its kinetic warhead. The kinetic warhead acquired the target, diverted into its path, and, using only the force of a direct impact, engaged and destroyed the threat in a hit-to-kill intercept.

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[73] Missile Defense Agency, "Sea-based Missile Defense Flight Test Results in Successful Intercept," April 15, 2011 (11-News-0007).

[74] Missile Defense Agency, "Sea-Based Missile Defense Test Conducted," September 1, 2011 (11-News-0016). See also Amy Butler, "Upgraded Ballistic Missile Killer Fizzles In First Flight Test," *Aerospace Daily & Defense Report*, September 2, 2011: 3; and Mike McCarthy, "Sea-Based Missile Defense Test Fails," *Defense Daily*, September 2, 2011: 2-3.

> Today's event, designated Flight Test Standard Missile-16 (FTM-16) Event 2a, was the first successful live fire intercept test of the SM-3 Block IB interceptor and the second-generation Aegis BMD 4.0.1 weapon system. Previous successful intercepts were conducted with the Aegis BMD 3.6.1 weapon system and the SM-3 Block IA interceptor, which are currently operational on U.S. Navy ships deployed across the globe....
>
> Initial indications are that all components performed as designed. Program officials will conduct an extensive assessment and evaluation of system performance based upon telemetry and other data obtained during the test.[75]

June 26, 2012, Test. MDA states that this flight test "was the second consecutive successful intercept test of the SM-3 Block IB missile and the second-generation Aegis BMD 4.0.1 weapon system." MDA states that

> The Missile Defense Agency (MDA) and U.S. Navy sailors in the USS LAKE ERIE (CG 70) successfully conducted a flight test of the Aegis Ballistic Missile Defense (BMD) system, resulting in the intercept of a separating ballistic missile target over the Pacific Ocean by the Navy's newest missile defense interceptor missile, the Standard Missile-3 (SM-3) Block IB.
>
> At 11:15 pm Hawaii Standard Time, June 26 (5:15 am EDT June 27), the target missile was launched from the Pacific Missile Range Facility, located on Kauai, Hawaii. The target flew on a northwesterly trajectory towards a broad ocean area of the Pacific Ocean. Following target launch, the USS LAKE ERIE detected and tracked the missile with its onboard AN/SPY-1 radar. The ship, equipped with the second-generation Aegis BMD 4.0.1 weapon system, developed a fire control solution and launched the SM-3 Block IB missile.
>
> The USS LAKE ERIE continued to track the target and sent trajectory information to the SM-3 Block IB missile in-flight. The SM-3 maneuvered to a point in space, as designated by the fire control solution, and released its kinetic warhead. The kinetic warhead acquired the target, diverted into its path, and, using only the force of a direct impact, engaged and destroyed the threat in a hit-to-kill intercept.
>
> Today's test event was the second consecutive successful intercept test of the SM-3 Block IB missile and the second-generation Aegis BMD 4.0.1 weapon system. The first successful SM-3 Block IB intercept occurred on May 9, 2012. Today's intercept is a critical accomplishment for the second phase of the President's European Phased Adaptive Approach consisting of the SM-3 Block IB interceptor employed in an Aegis Ashore system in Romania in 2015.
>
> Initial indications are that all components performed as designed resulting in a very accurate intercept.[76]

October 25, 2012, Test. MDA states that in this flight test,

> The Missile Defense Agency (MDA), U.S. Army soldiers from the 94th and 32nd Army Air and Missile Defense Command (AAMDC); U.S. Navy sailors aboard the USS FITZGERALD (DDG 62); and airmen from the 613th Air and Space Operations Center successfully conducted the largest, most complex missile defense flight test ever attempted resulting in the simultaneous engagement of five ballistic missile and cruise missile targets.

[75] Missile Defense Agency, "Second-Generation Aegis Ballistic Missile Defense System Completes Successful Intercept Flight Test," May 9, 2012 (12-News-0007).

[76] Missile Defense Agency, "Second-Generation Aegis Ballistic Missile Defense System Completes Second Successful Intercept Flight Test," June 27, 2012 (12-News-0008).

> An integrated air and ballistic missile defense architecture used multiple sensors and missile defense systems to engage multiple targets at the same time....
>
> The USS FITZGERALD successfully engaged a low flying cruise missile over water. The Aegis system also tracked and launched an SM-3 Block 1A interceptor against a Short-Range Ballistic Missile. However, despite indication of a nominal flight of the SM-3 Block 1A interceptor, there was no indication of an intercept of the SRBM.[77]

February 12, 2013, Test. MDA states that in this flight test,

> The Missile Defense Agency (MDA) and U.S. Navy sailors aboard the USS LAKE ERIE (CG 70) successfully conducted a flight test of the Aegis Ballistic Missile Defense (BMD) system, resulting in the intercept of a medium-range ballistic missile target over the Pacific Ocean by a Standard Missile-3 (SM-3) Block IA guided missile.
>
> At 11:10 p.m. HST (4:10 a.m. EST) a unitary medium-range ballistic missile target was launched from the Pacific Missile Range Facility, on Kauai, Hawaii. The target flew northwest towards a broad ocean area of the Pacific Ocean.
>
> The in-orbit Space Tracking and Surveillance System-Demonstrators (STSS-D) detected and tracked the target, and forwarded track data to the USS LAKE ERIE. The ship, equipped with the second-generation Aegis BMD weapon system, used Launch on Remote doctrine to engage the target.
>
> The ship developed a fire control solution from the STSS-D track and launched the SM-3 Block IA guided missile approximately five minutes after target launch. The SM-3 maneuvered to a point in space and released its kinetic warhead. The kinetic warhead acquired the target reentry vehicle, diverted into its path, and, using only the force of a direct impact, engaged and destroyed the target.
>
> Initial indications are that all components performed as designed. Program officials will assess and evaluate system performance based upon telemetry and other data obtained during the test.
>
> Today's event, designated Flight Test Standard Missile-20 (FTM-20), was a demonstration of the ability of space-based assets to provide mid-course fire control quality data to an Aegis BMD ship, extending the battlespace, providing the ability for longer range intercepts and defense of larger areas.[78]

May 16, 2013, Test. MDA states that in this flight test,

> The Missile Defense Agency (MDA) and U.S. Navy sailors aboard the USS LAKE ERIE (CG-70) successfully conducted a flight test today of the Aegis Ballistic Missile Defense (BMD) system, resulting in the intercept of a separating ballistic missile target over the Pacific Ocean by the Aegis BMD 4.0 Weapon System and a Standard Missile-3 (SM-3) Block IB missile.
>
> At 5:25 p.m. (Hawaii Time, 11:25 p.m. EDT), May 15, a separating short-range ballistic missile target was launched from the Pacific Missile Range Facility, on Kauai, Hawaii. The target flew northwest towards a broad ocean area of the Pacific Ocean. Following target launch, the USS LAKE ERIE (CG-70) detected and tracked the missile with its onboard AN/SPY-1 radar. The ship, equipped with the second-generation Aegis BMD weapon system, developed a fire control solution and launched the SM-3 Block IB missile. The SM-3 maneuvered to a point in space based on guidance from Aegis BMD Weapons

[77] Missile Defense Agency, "Ballistic Missile Defense System Engages Five Targets Simultaneously During Largest Missile Defense Flight Test in History," October 25, 2012 (12-News-0011).

[78] Missile Defense Agency, "Aegis Ballistic Missile Defense Intercepts Target Using Space Tracking and Surveillance System-Demonstrators (STSS-D) Data," February 13, 2013 (13-News-0002). See also Troy Clarke, "Space-Based Sensors Star in "Stellar Eyes" Missile Defense Test," *Navy News Service*, February 13, 2013.

> Systems and released its kinetic warhead. The kinetic warhead acquired the target reentry vehicle, diverted into its path, and, using only the force of a direct impact, engaged and destroyed the target.
>
> Initial indications are that all components performed as designed. Program officials will assess and evaluate system performance based upon telemetry and other data obtained during the test.
>
> This test exercised the latest version of the second-generation Aegis BMD Weapon System and Standard Missile, providing capability for engagement of longer-range and more sophisticated ballistic missiles.
>
> Last night's event, designated Flight Test Standard Missile-19 (FTM-19), was the third consecutive successful intercept test of the Aegis BMD 4.0 Weapon System and the SM-3 Block IB guided missile. Previous successful ABMD 4.0 SM-3 Block IB intercepts occurred on May 9, 2012 and June 26, 2012. Other Aegis BMD intercepts have employed the ABMD 3.6 and 4.0 with the SM-3 Block IA missile, which is currently operational on U.S. Navy ships deployed across the globe.[79]

September 10, 2013, Test. MDA states that in this flight test,

> The Missile Defense Agency (MDA), Ballistic Missile Defense System (BMDS) Operational Test Agency, Joint Functional Component Command for Integrated Missile Defense, and U.S. Pacific Command, in conjunction with U.S. Army soldiers from the Alpha Battery, 2nd Air Defense Artillery Regiment, U.S. Navy sailors aboard the guided missile destroyer USS Decatur (DDG-73), and U.S. Air Force airmen from the 613th Air and Operations Center successfully conducted a complex missile defense flight test, resulting in the intercept of two medium-range ballistic missile targets. The flight test was planned more than a year ago, and is not in any way connected to events in the Middle East.
>
> The test was conducted in the vicinity of the U.S. Army Kwajalein Atoll/Reagan Test Site and surrounding areas in the western Pacific. The test stressed the ability of the Aegis Ballistic Missile Defense (BMD) and Terminal High Altitude Area Defense (THAAD) weapon systems to function in a layered defense architecture and defeat a raid of two near-simultaneous ballistic missile targets.
>
> The two medium-range ballistic missile targets were launched on operationally realistic trajectories towards a defended area near Kwajalein. Along with overhead space assets providing launch alerts, an Army-Navy/Transportable Radar Surveillance and Control (AN/TPY-2) radar in Forward Based Mode detected the targets and relayed track information to the Command, Control, Battle Management, and Communications (C2BMC) system for further transmission to defending BMDS assets.
>
> The USS Decatur with its Aegis Weapon System detected and tracked the first target with its onboard AN/SPY-1 radar. The Aegis BMD weapon system developed a fire control solution, launched a Standard Missile-3 (SM-3) Block IA missile, and successfully intercepted the target.
>
> In a demonstration of BMDS layered defense capabilities, a second AN/TPY-2 radar in Terminal Mode, located with the THAAD weapon system, acquired and tracked the target missiles. THAAD developed a fire control solution, launched a THAAD interceptor missile, and successfully intercepted the second medium-range ballistic missile target. THAAD was operated by soldiers from the Alpha Battery, 2nd Air Defense Artillery

[79] Missile Defense Agency, "Aegis Ballistic Missile Defense System Completes Successful Intercept Flight Test," May 16, 2013 (13-News-0005). See also Mike McCarthy, "Aegis Missile Intercept Successful," *Defense Daily*, May 17, 2013: 7-8; and Amy Butler, "MDA Conducts Two Successful Flight Tests," *Aerospace Daily & Defense Report*, May 17, 2013: 3.

Regiment. As a planned demonstration of THAAD's layered defense capabilities, a second THAAD interceptor was launched at the target destroyed by Aegis as a contingency in the event the SM-3 did not achieve an intercept.

Initial indications are that all components performed as designed. MDA officials will extensively assess and evaluate system performance based upon telemetry and other data obtained during the test.

The event, a designated Flight Test Operational-01 (FTO-01), demonstrated integrated, layered, regional missile defense capabilities to defeat a raid of two threat-representative medium-range ballistic missiles in a combined live-fire operational test. Soldiers, sailors, and airmen from multiple combatant commands operated the systems, and were provided a unique opportunity to refine operational doctrine and tactics while increasing confidence in the execution of integrated air and missile defense plans.[80]

September 18, 2013, Test. MDA states that in this flight test,

The Missile Defense Agency (MDA), U.S. Pacific Command, and U.S. Navy sailors aboard the USS Lake Erie (CG 70) successfully conducted a flight test today of the Aegis Ballistic Missile Defense (BMD) system, resulting in the intercept of a complex separating short-range ballistic missile target over the Pacific Ocean by the Aegis BMD 4.0 Weapon System and a Standard Missile-3 (SM-3) Block IB guided missile.

At approximately 2:30 p.m. Hawaii Standard Time (8:30 p.m. EDT), a complex separating short-range ballistic missile target was launched from the Pacific Missile Range Facility on Kauai, Hawaii. The target flew northwest towards a broad ocean area of the Pacific Ocean. Following target launch, the USS Lake Erie detected and tracked the missile with its onboard AN/SPY-1 radar. The ship, equipped with the second-generation Aegis BMD weapon system, developed a fire control solution and launched two SM-3 Block IB guided missiles to engage the target. The first SM-3 that was launched successfully intercepted the target warhead. This was the first salvo mission of two SM-3 Block IB guided missiles launched against a single separating target.

Program officials will assess and evaluate system performance based upon telemetry and other data obtained during the test.

This test exercised the latest version of the second-generation Aegis BMD Weapon System, capable of engaging longer range and more sophisticated ballistic missiles. This was an operationally realistic test, in which the target's launch time and bearing are not known in advance, and the target complex was the most difficult target engaged to date.[81]

October 3, 2013, Test. MDA states that in this flight test,

The Missile Defense Agency (MDA), U.S. Pacific Command, and U.S. Navy sailors aboard the USS Lake Erie (CG 70) successfully conducted an operational flight test of the Aegis Ballistic Missile Defense (BMD) system, resulting in the intercept of a medium-range ballistic missile target over the Pacific Ocean by the Aegis BMD 4.0 Weapon System and a Standard Missile-3 (SM-3) Block IB guided missile.

[80] Missile Defense Agency, "Successful Missile Defense Test Against Multiple Targets," September 10, 2013 (13-News-0007). See also Megan Eckstein, "Aegis BMDS, THAAD Successful In Complex MDA Flight Test," *Defense Daily*, September 11, 2013: 1; and Amy Butler, "MDA Goes Two For Two In Operational Test," *Aerospace Daily & Defense Report*, September 11, 2013: 4.

[81] Missile Defense Agency, "Aegis Ballistic Missile Defense System Completes Successful Intercept Flight Test," September 18, 2013 (13-News-0008). See also Mike McCarthy, "Pentagon Succeeds At Sea-Based Missile Defense Test," *Defense Daily*, September 20, 2013: 1; Amy Butler, "Aegis Intercepts In First-Ever Salvo Test," *Aerospace Daily & Defense Report*, September 20, 2013: 3; and Jason Sherman and John Liang, "Missile Defense Agency's SM-3 Block IB Intercepts Target In Salvo Fire," *Inside the Navy*, September 23, 2013.

> At approximately 7:33 p.m. Hawaii Standard Time, Oct. 3 (1:33 a.m. EDT, Oct.4), a medium-range ballistic missile target was launched from the Pacific Missile Range Facility on Kauai, Hawaii. The target flew northwest towards a broad ocean area of the Pacific Ocean. Following target launch, the USS Lake Erie detected and tracked the missile with its onboard AN/SPY-1 radar. The ship, equipped with the second-generation Aegis BMD weapon system, developed a fire control solution and launched the SM-3 Block IB guided missile to engage the target. The SM-3 maneuvered to a point in space and released its kinetic warhead. The kinetic warhead acquired the target reentry vehicle, diverted into its path, and, using only the force of a direct impact, engaged and destroyed the target.
>
> Program officials will assess and evaluate system performance based upon telemetry and other data obtained during the test.
>
> This test exercised the latest version of the second-generation Aegis BMD Weapon System, capable of engaging longer range and more sophisticated ballistic missiles.[82]

November 6, 2014, Test. MDA states that in this flight test,

> The Missile Defense Agency, U.S. Pacific Command, and U.S. Navy Sailors aboard the USS John Paul Jones (DDG 53) successfully conducted a flight test today of the Aegis Ballistic Missile Defense (BMD) system, resulting in three successful near-simultaneous target engagements over the Pacific Ocean by the Aegis Baseline (BL) 9.C1 (BMD 5.0 Capability Upgrade) Weapon System configured ship. One short-range ballistic missile target was intercepted by a Standard Missile-3 (SM-3) Block IB guided missile, while two low-flying cruise missile targets were engaged by Standard Missile-2 (SM-2) Block IIIA guided missiles near-simultaneously.
>
> At approximately 12:03 p.m. (Hawaii Standard Time, 5:03 p.m. Eastern Standard Time) one short-range ballistic missile target and two cruise missile targets were launched from the Pacific Missile Range Facility (PMRF) on Kauai, Hawaii. Following the target launches, the USS John Paul Jones, in Integrated Air and Missile Defense (IAMD) Radar Priority Mode, detected and tracked the missiles with its onboard AN/SPY-1 radar.
>
> The ship, equipped with the Aegis BMD weapon system, developed a fire control solution and launched one SM-3 Block IB guided missile to engage the ballistic missile target. The SM-3 missile maneuvered to a point in space and released its kinetic warhead. The kinetic warhead acquired the target's reentry vehicle, diverted into its path, and destroyed the target with the sheer energy and force of direct impact. The ship also launched two SM-2 Block IIIA guided missiles to successfully engage the cruise missile targets.
>
> Program officials will evaluate system performance based upon telemetry and other data obtained during the test.
>
> This test, designated Flight Test Standard Missile-25 (FTM-25), was the first live-fire event of the Aegis Weapon System in IAMD Radar Priority Mode, engaging a ballistic missile target and a raid of cruise missile targets.[83]

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[82] Missile Defense Agency, "Aegis Ballistic Missile Defense System Completes Successful Intercept Flight Test," October 4, 2013 (13-News-0009). See also Michael Fabey, "Aegis Completes Another Intercept Test," *Aerospace Daily & Defense Report*, October 7, 2013: 2; Jason Sherman, "SM-3 Block IB Completes IOT&E With A Bang, Full-Rate Production Review," *Inside the Navy*, October 7, 2013; Mike McCarthy, "Aegis Missile Defense Test Scores Hit," *Defense Daily*, October 7, 2013: 4.

[83] Missile Defense Agency, "Aegis Ballistic Missile Defense System Completes Successful Intercept Flight Test," November 6, 2014 (14-News-0012). See also Andrea Shalal, "U.S. Aegis System Zaps Cruise, Ballistic Missile Targets in Test," *Reuters (www.reuters.com)*, November 6, 2014; Mike McCarthy, "Aegis BMD Hits Three Targets In Simultaneous Test," *Defense Daily*, November 10, 2014.

June 25, 2015, Test. MDA's summary table of Aegis BMD flight tests[84] shows this as a test that did not result in the launch of an SM-3. MDA as of August 3, 2015, had not issued a news release discussing this event. MDA's count of 31 successful intercepts in 37 launches through July 29, 2015, does not appear to include this test, suggesting that this was considered a "no test" event—a test in which there was a failure that was not related to the Aegis BMD system or the SM-3 interceptor. A June 26, 2015, news report states the following:

> The U.S. Missile Defense Agency on Friday said a target malfunction caused it to abort a key intercept test of the Aegis Ashore missile defense system, built by Lockheed Martin Corp, that is due to be installed in Romania this year.
>
> "Due to a target malfunction, the test wasn't conducted and an interceptor wasn't launched," said Rick Lehner, a spokesman for the U.S. Defense Department agency....
>
> It was not immediately clear what caused the target to malfunction, or when the test would be rescheduled.[85]

October 4, 2015, Test. MDA as of November 10, 2015, had not issued a news release discussing this event. MDA's count of 32 successful intercepts in 39 launches through November 1, 2015, does not appear to include this test, suggesting that this was considered a "no test" event—a test in which there was a failure that was not related to the Aegis BMD system or the SM-3 interceptor.

October 20, 2015, Test. Regarding this test, the Navy states the following:

> USS Ross (DDG 71) successfully intercepted a ballistic missile in the North Atlantic Ocean during the Maritime Theater Missile Defense (MTMD) Forum's At Sea Demonstration (ASD) Oct. 20, 2015.
>
> This is first time a Standard Missile-3 (SM-3) Block IA guided interceptor was fired on a non-U.S. range and the first intercept of a ballistic missile threat in the European theater.
>
> For the scenario, a short-range Terrier Orion ballistic missile target was launched from Hebrides Range and was inflight simultaneously with two anti-ship cruise missiles fired at the coalition task group. Ross fired a SM-3 and successfully engaged the ballistic missile target in space. In its air defense role, USS The Sullivans (DDG 68) fired a SM-2, which is the first time a SM-2 was fired on the Hebrides Range....
>
> "ASD-15 shows that with communication, collaboration and commitment nations can come together and flawlessly defend against a complex threat scenario." [said] Vice Adm. James Foggo, Commander, U.S. 6th Fleet....
>
> ASD-15 is a U.K.-hosted, U.S.-facilitated, multi-national demonstration of coalition Integrated Air and Missile Defense capability....
>
> There are a number of firsts associated with this event including:
>
> — First intercept of a ballistic missile target in the European theater
>
> — First SM-3 fired on a non-U.S. range
>
> — The first firing of an SM-2 and SM-3 on the Hebrides Range, United Kingdom

[84] "Aegis Ballistic Missile Defense Test Firing Record," accessed August 3, 2015, at http://www.mda.mil/global/documents/pdf/aegis_tests.pdf. [The URL now begins with https://.]

[85] Andrea Shalal, "U.S. Skips Aegis Aegis Ashore Missile Test After Target Malfunction," *Reuters*, June 26, 2015. See also "First Aegis Ashore Intercept Test Aborted. Does this Raise Issues for Planned 2015 Deployment Date for the Romanian Aegis Ashore Site?" *Mostly Missile Defense*, June 27, 2015.

— First use of multi-national beyond line of sight link architecture for IAMD purposes in the European theater

— First international ship (Netherlands and Spain) transmissions of BMD cues to a U.S. BMD guided missile destroyer

— First time coalition IAMD used in a scenario with simultaneous attack from anti-ship cruise and ballistic missiles.

This test demonstrates the commitment of the United States to the defense of Europe through our four Aegis ships forward deployed to Rota, Spain, and shore station in Romania.

The 10 MTMD Forum member nations are: Australia, Canada, France, Germany, Italy, The Netherlands, Norway, Spain, United Kingdom, and the United States.

Eight nations provided ships and aircraft for ASD-15 including Canada, France, Italy, The Netherlands, Norway, Spain, United Kingdom, and the United States with Germany providing personnel to augment the Forum's multi-national Combined Task Group staff.

The tactical data link used in ASD-15 covers over 5.7 million square miles.

USS Mount Whitney (LCC-20), flag ship for U.S. 6th Fleet, served as the viewing platform for officials representing participating coalition nations during ASD-15; delegates from seven MTMD Forum nations, Denmark, and Japan watched the missile intercept on a live video feed aboard the ship.

The Maritime Theater Missile Defense forum was established in 1999 as a co-operative body for participating navies to develop improved cooperation and promote interoperability in sea-based missile defense.[86]

November 1, 2015, Test. Regarding this test, MDA states the following:

The U.S. Missile Defense Agency (MDA), Ballistic Missile Defense System (BMDS) Operational Test Agency, Joint Functional Component Command for Integrated Missile Defense, U.S. European Command, and U.S. Pacific Command conducted a complex operational flight test of the BMDS demonstrating a layered defense architecture.

The test, designated Flight Test Operational-02 Event 2a, was conducted in the vicinity of Wake Island and surrounding areas of the western Pacific Ocean. The test stressed the ability of Aegis Ballistic Missile Defense (BMD) and Terminal High Altitude Area Defense (THAAD) weapon systems to negate two ballistic missile threats while Aegis BMD simultaneously conducted an anti-air warfare operation.

This was a highly complex operational test of the BMDS which required all elements to work together in an integrated layered defense design to detect, track, discriminate, engage, and negate the ballistic missile threats.

BMDS assets included: a THAAD battery consisting of a THAAD Fire Control and Communications (TFCC) unit, THAAD launcher, and an Army Navy/Transportable Radar Surveillance and Control Model 2 (AN/TPY-2) radar in terminal mode; a second AN/TPY-2 radar in forward-based mode; Command, Control, Battle Management and Communications (C2BMC); and the USS JOHN PAUL JONES (DDG-53) Aegis BMD-configured ship with its onboard AN/SPY-1 radar.

At approximately 11:05 pm EDT (October 31), a Short Range Air Launch Target (SRALT) was launched by a U.S. Air Force C-17 aircraft southeast of Wake Island. The THAAD AN/TPY-2 radar in terminal mode detected the target and relayed track information to the

[86] U.S. Naval Forces Europe-Africa/U.S. 6th Fleet Public Affairs, "USS Ross Successfully Intercepts Ballistic Missile Target During Coalition Test," *Navy News*, October 20, 2015.

TFCC to develop a fire control solution and provide track information for use by other defending BMDS assets. The THAAD weapon system developed a fire control solution, launched a THAAD interceptor missile, and successfully intercepted the SRALT target.

While THAAD was engaging the SRALT, an extended Medium Range Ballistic Missile (eMRBM) was air-launched by another Air Force C-17. The eMRBM target was detected and tracked by multiple BMDS assets including the AN/TPY-2 in forward-based mode, and the USS JOHN PAUL JONES with its AN/SPY-1 radar. Shortly after eMRBM launch, a BQM-74E air-breathing target was also launched and tracked by the USS JOHN PAUL JONES.

As a demonstration of layered defense capabilities, both Aegis BMD and THAAD launched interceptors to engage the eMRBM. The USS JOHN PAUL JONES successfully launched a Standard Missile-3 (SM-3) Block IB Threat Upgrade guided missile, but an anomaly early in its flight prevented a midcourse intercept. However, the THAAD interceptor, in its terminal defense role, acquired and successfully intercepted the target. Concurrently, Aegis BMD successfully engaged the BQM-74E air-breathing target with a Standard Missile-2 Block IIIA guided missile. A failure review is currently underway to investigate the SM-3 anomaly.

Several other missile defense assets observed the launches and gathered data for future analysis. Participants included the Command, Control, Battle Management, and Communications (C2BMC) Experimental Lab (X-Lab), C2BMC Enterprise Sensors Laboratory (ESL), and the Space Tracking and Surveillance System-Demonstrators (STSS-D).

The MDA will use test results to improve and enhance the BMDS.[87]

December 10, 2015, Test. Regarding this test, MDA states the following:

The Missile Defense Agency (MDA) and the Ballistic Missile Defense System (BMDS) Operational Test Agency, in conjunction with U.S. Pacific Command, U.S. European Command, and Joint Functional Component Command for Integrated Missile Defense, successfully conducted the first intercept flight test today (December 9, Hawaii Standard Time) of a land-based Aegis Ballistic Missile Defense (BMD) weapon system and Standard Missile (SM)-3 Block IB Threat Upgrade guided missile, launched from the Aegis Ashore Missile Defense Test Complex at the Pacific Missile Range Facility (PMRF), Kauai, Hawaii.

During the test, a target representing a medium-range ballistic missile was air-launched from a U.S. Air Force C-17 aircraft over the broad ocean area southwest of Hawaii. An AN/TPY-2 radar in Forward Based Mode, located at PMRF, detected the target and relayed target track information to the Command, Control, Battle Management, and Communication (C2BMC) system. The Aegis Weapon System at the Aegis Ashore site received track data from C2BMC and used its component AN/SPY-1 radar to acquire, track, and develop a fire control solution to engage the target. The Aegis Weapon System then launched the SM-3 Block IB Threat Upgrade guided missile from its Vertical Launch System. The SM-3's kinetic warhead acquired the target reentry vehicle, diverted into its path, and destroyed the target using the kinetic force of a direct impact.

The primary purpose of the test, designated Flight Test Operational-02 Event 1a, was to assess the operational effectiveness of the Aegis Ashore capability as part of a larger BMDS architecture. Aegis Ashore uses a nearly identical configuration of the Vertical Launch System, fire control system, and SPY-1 radar currently in use aboard Aegis BMD cruisers and destroyers deployed at sea around the world.

[87] Missile Defense Agency, "Ballistic Missile Defense System Demonstrates Layered Defense While Conducting Multiple Engagements in Operational Test," November 1, 2015 (15-NEWS-0008).

> Vice Admiral James D. Syring, MDA Director, said, "Today's test demonstrated that the same Aegis Ballistic Missile Defense capability that has been fielded at sea and operational for years, will soon be operational ashore as part of the European Phased Adaptive Approach (EPAA) Phase 2 capability in Romania. I am very proud of the tremendous effort by the entire government/industry team in executing this vitally important mission for our Nation and our allies."[88]

February 3, 2017, Test. Regarding the intercept of February 3, 2017, MDA states the following:

> The U.S. Missile Defense Agency (MDA), the Japan Ministry of Defense (MoD), and U.S. Navy sailors aboard USS John Paul Jones (DDG 53) successfully conducted a flight test Feb. 3 (Hawaii Standard Time), resulting in the first intercept of a ballistic missile target using the Standard Missile-3 (SM-3) Block IIA off the west coast of Hawaii....
>
> At approximately 10:30 p.m., Hawaii Standard Time, Feb. 3 (3:30 a.m. Eastern Daylight Time, Feb. 4) a medium-range ballistic missile target was launched from the Pacific Missile Range Facility at Kauai, Hawaii. John Paul Jones detected and tracked the target missile with its onboard AN/SPY-1D(V) radar using the Aegis Baseline 9.C2 weapon system. Upon acquiring and tracking the target, the ship launched an SM-3 Block IIA guided missile which intercepted the target.
>
> "Today's test demonstrates a critical milestone in the cooperative development of the SM-3 Block IIA missile," said MDA Director Vice Adm. Jim Syring. "The missile, developed jointly by a Japanese and U.S. government and industry team, is vitally important to both our nations and will ultimately improve our ability to defend against increasing ballistic missile threats around the world."
>
> Based on preliminary data the test met its primary objective. Program officials will continue to evaluate system performance based upon telemetry and other data obtained during the test.
>
> The flight test, designated SM-3 Block IIA Cooperative Development (SCD) Project Flight Test, Standard Missile (SFTM)-01, was the third flight test of the SM-3 Block IIA guided missile, and the first intercept test. This test also marks the first time an SM-3IIA was launched from an Aegis ship and the first intercept engagement using the Aegis Baseline 9.C2 (BMD 5.1) weapon system.[89]

June 21, 2017, Test. Regarding the intercept test of June 21, 2017, MDA states the following:

> The U.S. Missile Defense Agency and the Japan Ministry of Defense conducted a development flight test today of a new Standard Missile-3 (SM-3) BLock IIA missile off the coast of Hawaii.
>
> A planned intercept was not achieved....
>
> At approximately 7:20 p.m., Hawaii Standard Time, June 21 (1:20 am Eastern Daylight Time, June 22), a medium-range ballistic target missile was launched from the Pacific Missile Range Facility at Kauai, Hawaii. The USS John Paul Jones (DDG 53) detected and tracked the target missile with its onboard AN/SPY-1 radar using the Aegis Baseline 9.C2 weapon system. Upon acquiring and tracking the target, the ship launched an SM-3 Block IIA guided missile, but the missile did not intercept the target.

[88] Missile Defense Agency, "Standard Missile Completes First Intercept Test from Aegis Ashore Test Site," December 10, 2015 (15-NEWS-0011).

[89] Missile Defense Agency, "U.S., Japan Successfully Conduct First SM-3 Block IIA Intercept Test," February 3, 2017 (17-NEWS-0002).

> Program officials will conduct an extensive analysis of the test data. Until that review is complete, no additional details will be available.[90]

A July 24, 2017, press report stated the following:

> A U.S. Missile Defense Agency review of a failed ballistic missile intercept test showed that a mistaken input into the combat system by a sailor on the destroyer John Paul Jones caused the missile to self-destruct before reaching the target.
>
> A tactical datalink controller, in charge of maintaining encrypted data exchanges between ships and aircraft, accidentally identified the incoming ballistic missile target as a friendly in the system, causing the SM-3 missile to self-destruct in flight, according to a source familiar with the test.
>
> The head of MDA did not comment on the sailor error, but said in a statement that the ongoing review confirmed it wasn't an issue with the SM-3 Block IIA missile or the Navy's Aegis combat system.
>
> "Though the review is still in process, the SM-3 IIA interceptor and Aegis Combat System have been eliminated as the potential root cause," of the failure, said Air Force Lt. Gen. Sam Greaves, the director of MDA.
>
> "We are conducting an extensive review as part of our standard engineering and test processes, and it would be inappropriate to comment further until we complete the investigation."[91]

October 15, 2017, Test. Regarding the intercept test of October 15, 2017, MDA states the following:

> Ships from Canada, France, Germany, Italy, the Netherlands, Spain, the United Kingdom, and the United States participated in a live-fire integrated air and missile defense (IAMD) scenario, defending against a ballistic missile target as well as three anti-ship cruise missiles Oct. 15 as part of exercise Formidable Shield 2017 (FS17). Naval Striking and Support Forces NATO (STRIKFORNATO) is conducting Formidable Shield on behalf of the U.S. 6th Fleet. The U.S. Missile Defense Agency is also a major participant in this exercise.
>
> During the collective self-defense scenario, the Arleigh Burke-class guided-missile destroyer USS Donald Cook (DDG 75) successfully detected, tracked and intercepted a medium-range ballistic missile target with a Standard Missile-3 Block IB guided missile. Simultaneously, the Spanish frigate SPS Alvaro de Bazan (F101) fired an Evolved SeaSparrow Missile (ESSM) against an incoming anti-ship cruise missile while the Netherlands frigate HNLMS Tromp (F803) fired ESSMs against a pair of incoming anti-ship cruise missiles. This was the first time NATO's smart defense concept was demonstrated with ships serving as air defense units protecting naval ballistic missile defense units.
>
> Following that event, the U.S. Missile Defense Agency and U.S. Navy sailors aboard USS McFaul (DDG 74) successfully test fired a Standard Missile-6 (SM-6). That flight test, designated Standard Missile Controlled Test Vehicle (SM CTV)-03, demonstrated the successful performance of an SM-6 launched from an Aegis Ballistic Missile Defense capable DDG and was conducted as part of the system's flight certification process. The SM-6 test was not part of the Formidable Shield exercise, but was conducted in coordination with that event to leverage the available range assets....

[90] Missile Defense Agency, "Aegis Missile Defense Test Conducted," June 21, 2017 (17-NEWS-0006).

[91] David B. Larter, "Sailor Error Led to Failed US Navy Ballistic Missile Intercept Test," *Defense News*, July 24, 2017.

> Formidable Shield is designed to improve allied interoperability in an IAMD environment, using NATO command-and-control reporting structures and datalink architecture. FS17 is the inaugural iteration of this exercise....
>
> More than 14 ships, 10 aircraft, and approximately 3,300 personnel from Belgium, Canada, Denmark, France, Germany, Italy, the Netherlands, Spain, the U.K., and the U.S., are participating in FS17 on the U.K. Ministry of Defense's Hebrides Range located on the Western Isles of Scotland....
>
> U.S. ships participating in Formidable Shield include the Arleigh Burke-class guided-missile destroyers Donald Cook, USS Mitscher (DDG 57), USS Winston S. Churchill (DDG 81), and the Louis and Clark-class dry cargo ship USNS Medger Evers (T-AKE 13).
>
> Formidable Shield 2017 began Sept. 24, and is scheduled to conclude Oct. 18, 2017. This exercise is planned to be a recurring, biennial event, and is designed to assure allies, deter adversaries, and demonstrate our commitment to collective defense of the NATO alliance. Formidable Shield and exercise Joint Warrior 17-2, a U.K.-led, multinational exercise in a maritime training environment for allies to improve interoperability and prepare forces for combined operations, are occurring concurrently.[92]

January 31, 2018, Test. Regarding the intercept test of January 31, 2018, MDA states the following:

> The Missile Defense Agency and U.S. Navy sailors manning the Aegis Ashore Missile Defense Test Complex (AAMDTC) conducted a live-fire missile flight test Jan. 31 using a Standard-Missile (SM)-3 Block IIA missile launched from the Pacific Missile Range Facility, Kauai, Hawaii. This was a developmental and operational test of a new capability and utilized a missile variant not yet in production. The primary objective of the test, to intercept an air-launched intermediate-range ballistic missile target with an SM-3 Block IIA missile, was not achieved. However, much was still learned that demonstrated an increase in the effective range of the overall ballistic missile defense system.
>
> Several firsts were accomplished as a result of this mission, which included using both ground and space-based sensors to remotely cue the launch of the interceptor by the Aegis weapon system. This was also the first time an SM-3 Block IIA missile was launched from land using the Aegis Ashore test complex. The test also demonstrated a highly complex multi-domain command, control, battle management and communications system, which was used by operational crews to execute the mission.
>
> "We always make progress every time we conduct a test," said MDA Director Lt. Gen. Sam Greaves. "While we are disappointed that we did not demonstrate a successful intercept, we did demonstrate significant advances in capability and collected valuable test data that will allow us to further improve our capability and capacity of the ballistic missile defense system. We are committed to protecting and defending our nation, its warfighters, friends and allies against all ranges of ballistic missiles in all phases of flight."
>
> MDA will conduct an extensive investigation to determine the cause or causes of any anomalies that may have prevented a successful intercept.[93]

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[92] Missile Defense Agency, "Formidable Shield 2017: Ship Engages BMD Target During NATO Exercise, MDA and Navy Conduct SM-6 Test Launch," October 15, 2017 (17-NEWS-0010).

[93] Missile Defense Agency, "Test Conducted From Aegis Ashore Missile Defense Test Complex," January 31, 2018 (18-NEWS-0001). See also David B. Larter, "Another US Navy Ballistic Missile Intercept Reportedly Fails in hawaii," *Defense News*, January 31, 2018; Richard Abott, "SM-3 IIA Missile Defense Test In Hawaii Reportedly Fails, Defense Tester Report Finds Lower Confidence," *Defense Daily*, February 1, 2018: 4-6; David B. Larter, "Reality Check: Failures Happen, Even in Missile Defense Testing," *Defense News*, February 1, 2018; Ben Werner, "Pentagon Confirms SM-3 Block IIA Missile Missed its Target in Test This Week," *USNI News*, February 1, 2018; Jason

September 11, 2018, Test. Regarding the intercept test of September 11, 2018, MDA states the following:

> The Japan Maritime Self-Defense Force (JMSDF) and the United States Missile Defense Agency (MDA) announce the successful completion of an Aegis Ballistic Missile Defense (BMD) intercept flight test, in cooperation with the U.S. Navy, off the coast of Kauai in Hawaii. The event, designated Japan Flight Test Mission-05 (JFTM-05), was conducted in order to demonstrate a successful engagement of a target missile from the JS ATAGO using the sea-based midcourse engagement capability provided by Aegis BMD.
>
> The JFTM-05 test event verified the newest BMD engagement capability of the Japan (J6) Aegis BMD configuration of the recently upgraded Japan destroyer, JS ATAGO (DDG-177). At approximately 10:37pm HST on September 11, 2018 a simple separating, ballistic missile target was launched from the Pacific Missile Range Facility at Barking Sands, Kauai, Hawaii. JS ATAGO crew members detected and tracked the target. The Aegis Weapon System then developed a fire control solution and a Standard Missile -3 Block IB Threat Upgrade (SM-3 Blk IB TU) missile was launched. The SM-3 successfully intercepted the target above the Pacific Ocean. JFTM-05 is a significant milestone in the growing cooperation between Japan and the U.S. in the area of missile defense.
>
> "This successful test is a major milestone verifying the capabilities of an upgraded Aegis BMD configuration for Japan's destroyers," said MDA Director Lt. Gen. Sam Greaves. "This success provides confidence in the future capability for Japan to defeat the developing threats in the region. My congratulations to the Japan Maritime Self-Defense Force, our MDA team, and our industry partners. We are committed to assisting the Government of Japan in upgrading its national missile defense capability against emerging threats."[94]

October 26, 2018, Test. Regarding the intercept test of October 26, 2018, MDA states the following:

> The U.S. Missile Defense Agency (MDA), and U.S. Navy sailors aboard USS John Finn (DDG-113) successfully conducted an intercept of a medium-range ballistic missile target with a Standard Missile-3 (SM-3) Block IIA missile during a flight test off the west coast of Hawaii….
>
> On October 26, 2018, the target missile was launched from the Pacific Missile Range Facility at Kauai, Hawaii. The USS John Finn (DDG-113) detected and tracked the target missile with its onboard AN/SPY-1 radar using the Aegis Baseline 9.C2 weapon system. Upon acquiring and tracking the target, the ship launched an SM-3 Block IIA guided missile which intercepted the target.
>
> "This was a superb accomplishment and key milestone for the SM-3 Block IIA return to flight," said MDA Director Lt. Gen. Sam Greaves. "My congratulations to the entire team, including our sailors, industry partners, and allies who helped achieve this milestone."

Sherman, "MDA Acknowledges Aegis BMD Flight Test Failure," *Inside the Navy*, February 5, 2018 (which identifies the target as an "air-launched intermediate-range ballistic missile target"); "Failed Missile Test Off of Kauai Costs the US $130 Million," *Associated Press*, February 20, 2018; Daniel Cebul, "Missile Defense Failure Might Prove a Good Thing for SM-3 IIA in the Long Run, Says MDA Head," *Defense News*, March 6, 2018; Anthony Capaccio, "Blame a Spark Plug for U.S.-Japan Missile Failure, Pentagon Says," *Bloomberg*, October 1, 2018; Rich Abott, "MDA Says SM-3 IIA Test Failure Caused By Third Stage Ignition Part," *Defense Daily*, October 3, 2018: 7; Jason Sherman, "MDA Pins SM-3 Block IIA Flight Test Failure on Device Needed to Ignite Rocket," *Inside the Navy*, October 5, 2018.

[94] Missile Defense Agency, "Japan Missile Defense Flight Test Successful Through Intercept," September 12, 2018 (18-NEWS-0005). See also Jason Sherman, "Japan's Newest Destroyer Intercepts Ballistic Missile Target in Test with United States," *Inside the Navy*, September 17, 2018; Patrick Tucker, "Japan's New Ship-Based Interceptor Shoots Down a Ballistic Missile in Test," *Defense One*, September 12, 2018.

> Based on observations and initial data review, the test met its objectives. Program officials will continue to evaluate system performance.[95]

Details on Selected Endo-Atmospheric (SM-2 Block IV and SM-6) Flight Tests Since July 2015

May 24, 2006, Test. Regarding the intercept of May 24, 2006, MDA states the following:

> The U.S. Navy, in cooperation with the Missile Defense Agency, today successfully conducted a ballistic missile defense demonstration involving the intercept of a target missile in the terminal phase (the last few seconds) of flight. The test involved an Aegis cruiser modified to detect, control and engage a ballistic missile target with a modified Standard Missile - 2 (SM-2) Block IV. The Pearl Harbor-based Aegis cruiser USS Lake Erie (CG 70) conducted the mission against a short-range target missile launched from the Pacific Missile Range Facility, Barking Sands, Kauai, Hawaii. It was the first sea-based intercept of a ballistic missile in its terminal phase.
>
> The modified Aegis Weapon System and the modified SM-2 Block IV provided the firing ship the capability to guide the missile to achieve either; 1) a direct body to body hit between the interceptor and the threat or, 2) a near-direct hit where the high pressure, heat and fragments are placed on the threat by a blast fragmentation warhead. This warhead is similar in concept to that used in the deployed Israeli Arrow system. In today's test, the threat missile was completely destroyed by the combined effects of these two mechanisms.
>
> "This is another example of the ongoing cooperative spirit between the Navy and the Missile Defense Agency," said Rear Admiral Barry McCullough, Director, Surface Warfare, on the staff of the Chief of Naval Operations.
>
> "We believe it is an important step towards the desired end-state of a robust sea-based terminal ballistic missile defense capability," McCullough added, "and it begins to meet an immediate near-term concern of our Combatant Commanders." "The only terminal phase program we currently have that is operational is the Patriot Advanced Capability 3 (PAC-3)," he added, "and considerations to put those aboard ships are still under review."
>
> There is currently no sea-based terminal ballistic missile defense capability. The Navy Area Theater Ballistic Missile Defense (TBMD) Program, had been under development, but was terminated in December 2001. In ballistic missile defense, the modified Aegis Weapon System, with a modified SM-2 Block IV missile provides a near term, limited emergency capability against a very specific segment of the ballistic missile threat. The Navy and MDA consider it vital to develop a more robust capability for terminal ballistic missile defense of the joint sea base and friendly force embarkation points ashore.
>
> "There is a significant number of SM-2 Block IV missiles available, which may be modified and deployed on Navy ships modified to perform a BMD mission," said Air Force Lieutenant General Henry "Trey" Obering, Missile Defense Agency director. "While talking with the Navy and the Combatant Commanders, on how and when, we might be able to make that happen," Lieutenant General Obering added, "MDA will continue to improve its development of the midcourse Aegis sea-based ballistic missile defense

[95] Missile Defense Agency, "U.S. Successfully Conducts SM-3 Block IIA Intercept Test," October 26, 2018 (18-NEWS-0006). See also Aaron Mehta, "After Consecutive Failures, Watch US Navy Intercept Test Missile with SM-3 Weapon," *Defense News*, October 26, 2018; Jason Sherman, "SM-3 Block IIA, A $1 Billion Development Project, Hits Target in Do-Over Test," *Inside Defense (Daily News)*, October 26, 2018, which states that the test was designed FTM-45.

capability, which utilizes the Standard Missile – 3 (SM-3), and has successfully achieved 6 intercepts in 7 flight tests."[96]

June 5, 2008, Test. Regarding the intercept of June 5, 2008, MDA states the following:

> Air Force Lieutenant General Henry "Trey" Obering III, Missile Defense Agency (MDA) director, announced the successful completion of the latest flight test of the sea-based Aegis Ballistic Missile Defense (BMD) element, conducted jointly with the U.S. Navy off the coast of Kauai, Hawaii. The event, designated as Flight Test Maritime-14 (FTM-14), marked the fourteenth overall successful intercept, in sixteen attempts, for the Aegis BMD program and the second successful intercept of a terminal phase (last few seconds of flight) target by a modified Standard Missile - 2 Block IV (SM-2 Blk IV) interceptor. The mission was completed by the cruiser USS Lake Erie (CG 70), using the tactically -certified Aegis BMD shipboard weapon system, modified for a terminal capability, and the modified SM-2 Blk IV. This is the 35th successful terminal and midcourse defense intercept in 43 tests since 2001.
>
> Aegis BMD is the sea-based mid-course component of the MDA's Ballistic Missile Defense System (BMDS) and is designed to intercept and destroy short to intermediate-range ballistic missile threats. In 2006, the program's role was expanded to include a sea-based terminal defense effort, using a modified version of the SM-2 Blk IV. Unlike other missile defense technologies now deployed or in development, the SM-2 Blk IV does not use "hit to kill" technology (directly colliding with the target) to destroy the target missile. Rather, it uses a blast fragmentation device that explodes in direct proximity to the target to complete the intercept and destroy the target.
>
> At 8:13 a.m. Hawaii Standard Time (2:13 p.m. Eastern Daylight Time) a short range target was launched from a mobile launch platform 300 miles west of the Pacific Missile Range Facility (PMRF), Barking Sands, Kauai, Hawaii. Moments later, the USS Lake Erie's Aegis BMD Weapon System detected and tracked the target and developed fire control solutions.
>
> Approximately four minutes later, the USS Lake Erie's crew fired two SM-2 Blk IV missiles, and two minutes later they successfully intercepted the target inside the earth's atmosphere, about 12 miles above the Pacific Ocean and about 100 miles west-northwest of Kauai.
>
> FTM-14 test objectives included evaluation of: the BMDS ability to intercept and kill a short range ballistic missile target with the Aegis BMD, modified with the terminal mission capability; the modified SM-2 Blk IV missile using SPY-1 cue; and system-level integration of the BMDS.[97]

March 26, 2009, Test. Regarding the intercept of March 26, 2009, the Navy states the following:

> Commander, U.S. 3rd Fleet, Vice Adm. Samuel J. Locklear announced the completion of the fleet operational exercise, Stellar Daggers, March 26.

[96] Missile Defense Agency, "First at-Sea Demonstration of Sea-Based Terminal Capability Successfully Completed," May 24, 2006 (06-FYI-0079). See also 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*, June 12, 2006.

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

> The scheduled event took place March 24 and 26. Command and control of the participants in Stellar Daggers resided with U.S. 3rd Fleet based in San Diego.
>
> San Diego-based Aegis destroyer, USS Benfold (DDG 65) engaged multiple targets during this multi-event exercise with Standard Missile-2 (SM-2) Block IIIA and modified SM-2 BLK IV missiles. The overall objective of
>
> Stellar Daggers was to test the Aegis system's sea-based ability to simultaneously detect, track, engage and destroy multiple incoming air and ballistic missile threats during terminal or final phase of flight.
>
> During the event, Benfold's Aegis Weapons System successfully detected and intercepted a cruise missile target with a SM-2 BLK IIIA, while simultaneously detecting and intercepting an incoming short range ballistic missile (SRBM) target with a modified SM-2 BLK IV. This is the first time the fleet has successfully tested the Aegis system's ability to intercept both an SRBM in terminal phase and a low-altitude cruise missile target at the same time.[98]

July 28-29, 2015, Test. Regarding the intercepts of July 28 and 29, 2015, MDA states the following:

> The Missile Defense Agency (MDA), U.S. Pacific Command, and U.S. Navy Sailors aboard the USS John Paul Jones (DDG 53) successfully conducted a series of four flight test events exercising the Aegis Ballistic Missile Defense (BMD) element of the nation's Ballistic Missile Defense System (BMDS). The flight test, designated Multi-Mission Warfare (MMW) Events 1 through 4, demonstrated successful intercepts of short-range ballistic missile and cruise missile targets by the USS John Paul Jones, configured with Aegis Baseline 9.C1 (BMD 5.0 Capability Upgrade) and using Standard Missile (SM)-6 Dual I and SM-2 Block IV missiles. All flight test events were conducted at the Pacific Missile Range Facility (PMRF), Kauai, Hawaii.
>
> MDA Director Vice Adm. James D. Syring said, "This important test campaign not only demonstrated an additional terminal defense layer of the BMDS, it also proved the robustness of the multi-use SM-6 missile on-board a Navy destroyer, further reinforcing the dynamic capability of the Aegis Baseline 9 weapon system."
>
> Event 1
>
> On July 28, at approximately 10:30 p.m. Hawaii Standard Time (July 29, 4:30 a.m. Eastern Daylight Time), a short-range ballistic missile (SRBM) target was launched from PMRF in a northwesterly trajectory. The USS John Paul Jones, positioned west of Hawaii, detected, tracked, and launched a SM-6 Dual I missile, resulting in a successful target intercept.
>
> Event 2
>
> On July 29, at approximately 8:15 p.m. Hawaii Standard Time (July 30, 2:15 a.m. Eastern Daylight Time), a short-range ballistic missile (SRBM) target was launched from PMRF in a northwesterly trajectory. The USS John Paul Jones detected, tracked, and launched a SM-2 Block IV missile, resulting in a successful target intercept.
>
> Event 3
>
> On July 31, at approximately 2:30 p.m. Hawaii Standard Time, (8:30 p.m. Eastern Daylight Time) an AQM-37C cruise missile target was air-launched to replicate an air-warfare threat. The USS John Paul Jones detected, tracked, and successfully engaged the target using an SM-6 Dual I missile.

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

> Event 4
>
> On August 1, at approximately 3:45 p.m. Hawaii Standard Time, (9:45 p.m. Eastern Standard Time), a BQM-74E cruise missile target was launched from PMRF. The USS John Paul Jones detected, tracked, and successfully engaged the target using an SM-6 Dual I missile. The SM-6's proximity-fuze warhead was programmed not to detonate after reaching the lethal distance from the target, thus providing the ability to recover and reuse the BQM-74E target....
>
> MMW Event 1 was the first live fire event of the SM-6 Dual I missile.
>
> MMW Events 1 and 2 were the 30th and 31st successful ballistic missile defense intercepts in 37 flight test attempts for the Aegis BMD program since flight testing began in 2002.[99]

December 14, 2016, Test. Regarding the intercept of December 14, 2016, MDA states the following:

> The Missile Defense Agency and sailors aboard USS John Paul Jones (DDG 53), an Aegis baseline 9.C1 equipped destroyer, today successfully fired a salvo of two SM-6 Dual I missiles against a complex medium-range ballistic missile target, demonstrating the Sea Based Terminal endo-atmospheric defensive capability and meeting the test's primary objective.
>
> The test was conducted off the coast of Hawaii just after midnight on Dec. 14.
>
> "This test demonstrated the capabilities MDA and the Navy are delivering to our fleet commanders," said MDA Director Vice Adm. Jim Syring. "The SM-6 missile and the Aegis Weapon System continue to prove that they are critical components of our nation's multilayered, robust ballistic missile defense system."...
>
> Program officials will continue evaluating system performance based upon telemetry and other data obtained during the test.[100]

A December 16, 2016, press report states the following:

> The Missile Defense Agency (MDA) said its new Sea Based Terminal (SBT) system achieved its second ballistic missile intercept during a Dec. 14 test over the Pacific Ocean.
>
> During the test, the USS John Paul Jones (DDG-53)... fired a salvo of two Raytheon [RTN] Standard Misisle-6 (SM-6) interceptors in immediate succession against a medium-range ballistic missile target launched from the Pacific Missile Range Facility on Kauai, Hawaii. The first interceptor was not armed and was designed to collect test data, MDA said. The second interceptor, which carried an explosive warhead, intercepted the Lockheed Martin-built target....
>
> MDA called the target "complex" but declined to elaborate. However, according to the Missile Defense Advocacy Alliance, the target emulated China's Dong-Feng 21 (DF-21), a ballistic missile equipped with a maneuverable re-entry vehicle and designed to destroy U.S., aircraft carriers.
>
> The event, designated Flight Test Standard Missile-27 (FTM-27), was SBT's first salvo test and its second intercept in as many tries.[101]

---

[99] Missile Defense Agency, "Aegis Ballistic Missile Defense System Completes Successful Series of Intercept Flight Test Events," August 3, 2015 (15-NEWS-0007).

[100] Missile Defense Agency, "MDA Conducts SM-6 MRBM Intercept Test," December 14, 2016 (16-NEWS-0012).

[101] Marc Selinger, "Missile Defense Agency Scores Second Intercept With Sea Based Terminal System," *Defense Daily*, December 16, 2016: 3-4.

A March 15, 2017, press report quoted Mike Campisi, Raytheon's SM-6 senior director, as stating the following: "We had two missiles in the air and we wanted to make sure that we were in fact pulling in on the target and looking at target versus looking at the other missile that's in the air. Simulations all said the missile would never look at the other missile in the air however, but it's nice to prove that."[102]

August 29, 2017, Test. Regarding the intercept of August 29, 2017, MDA states the following:

> The Missile Defense Agency and U.S. Navy sailors aboard the USS John Paul Jones (DDG 53) successfully conducted a complex missile defense flight test, resulting in the intercept of a medium-range ballistic missile (MRBM) target using Standard Missile-6 (SM-6) guided missiles during a test off the coast of Hawaii today [August 29].
>
> John Paul Jones detected and tracked a target missile launched from the Pacific Missile Range Facility on Kauai, Hawaii with its onboard AN/SPY-1 radar, and onboard SM-6 missiles executed the intercept.
>
> "We are working closely with the fleet to develop this important new capability, and this was a key milestone in giving our Aegis BMD ships an enhanced capability to defeat ballistic missiles in their terminal phase," said MDA Director Lt. Gen. Sam Greaves. "We will continue developing ballistic missile defense technologies to stay ahead of the threat as it evolves."
>
> This test, designated Flight Test Standard Missile-27 Event 2 (FTM-27 E2), marks the second time that an SM-6 missile has successfully intercepted a medium-range ballistic missile target.[103]

[102] Kris Osborn, "Breakthrough - Missile Defense Agency Fires 2 SM-6 Interceptors at Once - Testing New Seeker Technology," *Scout Military*, March 15, 2017.

[103] Missile Defense Agency, "Aegis BMD System Intercepts Target Missile," August 29, 2017 (17-NEWS-0009).

Appendix B. Homeporting of U.S. Navy Aegis BMD Ships at Rota, Spain

This appendix presents additional background information on the homeporting of four BMD-capable Aegis destroyers at Rota, Spain.

As part of the October 5, 2011, U.S.-Spain joint announcement of the plan, the Prime Minister of Spain, Jose Luis Rodriguez Zapatero, stated the following, in part:

> This meeting marks a step forward on the path that we set for ourselves less than a year ago at the Lisbon Summit, aiming to make NATO an Alliance that is "more effective, engaged and efficient than ever before", in the words of [NATO] Secretary-General Rasmussen.
>
> At that historic Summit, decisions of enormous importance for the future of the Alliance were taken, such as the New Strategic Concept to face the new challenges of the 21st century, and the establishment of a new command structure that is leaner and more flexible, and improved.
>
> Besides these two important innovations, and as a consequence of them, the allies decided to develop an Anti-Missile Defence System.…
>
> As you will recall, as a consequence of this new structure launched in Lisbon, Spain obtained an installation of great importance within NATO's Command and Control Structure: the Combined Air Operations Centre (CAOC) in Torrejón de Ardoz, Spain.
>
> This Centre, together with the Centre in Uedem, Germany, will form part of the air command and control system which is to include the anti-missile defence that the Alliance is going to implement.
>
> Together with this land-based component of the new air defence system, I can inform you that Spain is also going to support, starting in 2013, an important part of the system's naval element.
>
> In recent months, the different options have been studied, and finally, it was decided that Spain should be the site for this component of the system, due to its geostrategic location and its position as gateway to the Mediterranean.
>
> Specifically, the United States is going to deploy, as its contribution to NATO's Anti-Missile Defence System, a total of four vessels equipped with the AEGIS system, to be based in Rota.
>
> This means that Rota is going to become a support centre for vessel deployment, enabling them to join multinational forces or carry out NATO missions in international waters, particularly in the Mediterranean….
>
> Moreover, this initiative will have a positive impact, in socio-economic terms, on our country, and most especially on the Bay of Cadiz.
>
> Permanently basing four vessels in Rota will require investing in the Base's infrastructure, and contracts with service providers, thus generating approximately a thousand new jobs, both directly and indirectly.
>
> For the shipyards, and for Spain's defence industry, the foreseeable impact will also be highly positive, as the USA is considering conducting the vessels' maintenance and upkeep

> at the nearby San Fernando shipyards, in the province of Cadiz. In addition, there will be significant transfer of state-of-the-art technology, from which Spain can benefit.[104]

As part of the same joint announcement, Secretary of Defense Leon Panetta stated the following, in part:

> With four Aegis ships at Rota, the alliance is significantly boosting combined naval capabilities in the Mediterranean, and enhancing our ability to ensure the security of this vital region. This relocation of assets takes place as part of the United States' ongoing effort to better position forces and defensive capabilities in coordination with our European allies and partners.
>
> This announcement should send a very strong signal that the United States is continuing to invest in this alliance, and that we are committed to our defense relationship with Europe even as we face growing budget constraints at home.…
>
> Alongside important agreements that were recently concluded with Romania, Poland, and Turkey, Spain's decision represents a critical step in implementing the European Phased Adaptive Approach, as our leaders agreed to in Lisbon.…
>
> Beyond missile defense, the Aegis destroyers will perform a variety of other important missions, including participating in the Standing NATO Maritime Groups, as well as joining in naval exercises, port visits, and maritime security cooperation activities….
>
> The agreement also enables the United States to provide rapid and responsive support to the U.S. Africa and U.S. Central Commands, as needed.[105]

An October 5, 2011, press report stated the following:

> A senior U.S. defense official said making the [ships'] base at Rota, on Spain's southwestern Atlantic coast near Cadiz, would reduce the numbers of [BMD-capable Aegis] ships needed for the [EPAA] system.
>
> "You [would] probably need 10 of these ships if they were based in the eastern U.S. to be able to ... transit across the ocean back and forth to [keep the same number on] patrol in the Med," he said.
>
> The U.S. official said the United States was committed to having at least one ship on station at all times in the eastern Mediterranean, where their anti-missile missiles would be most effective. Having them based in Rota would enable more than one to be in the eastern Mediterranean as needed.
>
> The ships also would be part of the pool of vessels available to participate in standing NATO maritime groups, which are used to counter piracy and for other missions, he said.[106]

An October 10, 2011, press report stated the following:

> "Our plan is to have the first couple [of ships] there in 2014 and the next two in about 2015," said Cmdr. Marc Boyd, spokesman for [U.S. Navy] 6th Fleet. Boyd added: "It's

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[104] "Announcement on missile defence cooperation by NATO Secretary General Anders Fogh Rasmussen, the Prime Minister of Spain, Jose Luis Rodriguez Zapatero and US Defense Secretary Leon Panetta," October 5, 2011, accessed October 6, 2011, at http://www.nato.int/cps/en/SID-107ADE55-FF83A6B8/natolive/opinions_78838.htm.

[105] "Announcement on missile defence cooperation by NATO Secretary General Anders Fogh Rasmussen, the Prime Minister of Spain, Jose Luis Rodriguez Zapatero and US Defense Secretary Leon Panetta," October 5, 2011, accessed October 6, 2011, at http://www.nato.int/cps/en/SID-107ADE55-FF83A6B8/natolive/opinions_78838.htm. See also "SECDEF Announces Stationing of Aegis Ships at Rota, Spain," accessed October 6, 2011, at http://www.navy.mil/search/display.asp?story_id=63109.

[106] David Brunnstrom and David Alexander, "Spain To Host U.S. Missile Defense Ships," *Reuters*, October 5, 2011. Ellipsis as in original.

really early in the process and we haven't selected any of the ships yet." Boyd said the shift will bring an estimated 1,300 sailors and Navy civilians and 2,100 dependents to Naval Station Rota, which would double the base's ranks. Naval Station Rota spokesman Lt. j.g. Jason Fischer said the base now has 1,067 sailors….

The three piers at the base primarily support Navy ships passing through on port calls.

Boyd said 6th Fleet is considering plans to add base infrastructure and maintenance facilities to support the ships, as well as additional housing for crews, "but the base is pretty suited as it is now."[107]

[107] Sam Fellman, "U.S. To Base Anti-Missile Ships in Spain," *Defense News*, October 10, 2011: 76.

Appendix C. Allied Participation and Interest in Aegis BMD Program

This appendix presents additional background information on allied participation and interest in the Aegis BMD program for countries other than Japan.

An October 12, 2018, press report states:

> The South Korean military has decided to buy ship-based SM-3 interceptors to thwart potential ballistic missile attacks from North Korea, a top commander of the Joint Chiefs of Staff revealed Oct. 12.
>
> "The decision was made actually during a top JCS meeting in September last year," said Maj. Gen. Kim Sun-ho, the head of Joint Chiefs of Staff's force buildup planning bureau, in response to a lawmaker's question about the SM-3 missile procurement.
>
> "The type of the ship-based anti-ballistic missile to be procured is an SM-3 class," Kim said during a parliamentary audit of the JCS. "The interceptor will be responsible for shooting down an incoming ballistic missile in the upper tier of the KAMD system."
>
> KAMD refers to the Korea Air and Missile Defense network designed to take down low-flying missiles in the terminal phase. For lower-altitude interceptions, American-built Patriot missiles and locally developed medium-range surface-to-air missiles, dubbed M-SAM, have been deployed in the field….
>
> The South Korean military believes SM-3 interceptors will be effective against an electromagnetic pulse attack originating from a high altitude.
>
> The timetable for adopting the SM-3 has not been laid out, according to the JCS. In the meantime, a preliminary study on the procurement of SM-class interceptors is underway.[108]

An October 3, 2016, press report states that MDA is examining how allied countries in Europe could be brought into the European Aegis missile defense architecture. The report states that

> MDA is studying how the Netherlands' new SMART-L long-range naval radar could be integrated into U.S. ballistic missile defense architectures, namely the Aegis Ashore system in Europe, according to Rear Adm. Johnny Wolfe, the program executive officer for Aegis BMD at MDA. He said the agency is also looking at how to loop the United Kingdom's Type 45 destroyers and Spain's Aegis destroyers—which do not have BMD capabilities of their own—into the U.S. network.[109]

A September 6, 2016, press report states:

> A trio of planned South Korean guided missile destroyers will be built with the capability to intercept ballistic missile threats, USNI News has learned.
>
> The addition of the capability will give the Republic of Korea (RoK) Navy a powerful organic BMD capability in addition to U.S. Army ground-based interceptors peppered throughout South Korea.
>
> Under the plan, the three remaining ships in the Sejong the Great-class will be able to simultaneously intercept traditional air warfare threats while adding a ballistic missile

[108] Jeff Jeong, "South Korea to Buy Ship-Based Interceptors to Counter Ballistic Missile Threats," *Defense News*, October 12, 2018.

[109] Justin Doubleday, "MDA Looking to Integrate European Allies into Missile Defense Architecture," *Inside the Navy*, October 3, 2016. See also Ellen Mitchell, "Missile Defense Agency Seeks More Aegis Integration in Europe," *Politico Pro Defense Report*, September 30, 2016.

> defense capability through a series of hardware and software upgrades over the current class of ship, several sources confirmed to USNI News.
>
> The destroyers will be fitted with the U.S. Navy's Baseline 9 version of the Aegis Combat System that combines modern computing architecture to allow the ship's AN/SPY-1D(v) radar to detect and track aircraft, cruise missiles and ballistic missiles at the same time.
>
> The capability will likely be paired with Raytheon Standard Missile 3 BMD interceptors the ships can pair with the combat system to detect and destroy medium-range ballistic missile threats. Several Korean press outlets have reported the military is seeking to install SM-3s on the three new ships.
>
> Officials with Aegis combat system developer Lockheed Martin told USNI News the new Korean ships would have an "integrated air and missile defense" (IAMD) capability installed aboard but would not elaborate on any other details of the combat system.[110]

An October 26, 2015, press report states:

> The U.S. Navy and its NATO counterparts are discussing how to make maritime ballistic missile defense (BMD) training a routine event in Europe, in the hopes that countries will grow more comfortable working with one another in this warfare area and even invest in greater capabilities, the head of American ballistic missile defense in Europe told USNI News.
>
> Last week's Maritime Theater Missile Defense (MTMD) Forum Integrated Air and Missile Defense (IAMD) At Sea Demonstration [i.e., the October 20, 2015 Aegis BMD flight test] was the first of its kind but will not be the last—the U.S. Navy is both planning a 2016 follow-up to coincide with the annual Rim of the Pacific (RIMPAC) exercise, and working with NATO to develop an ongoing maritime ballistic missile defense exercise program, Capt. Jeffrey Wolstenholme, commodore of Task Force 64, told USNI News in an interview from aboard USS Ross (DDG-71) in the U.S. 6th Fleet area of operations.
>
> Wolstenholme said BMD had for a long time been considered a land-based mission set. The U.S. Army and Air Force, as well as their counterparts in Europe, have a variety of assets across the continent to track and engage incoming missiles – including the Raytheon Patriot surface-to-air missile system and the Lockheed Martin Terminal High-Altitude Area Defense (THAAD) system.
>
> "The (MTMD) forum was started because of the emphasis that was starting to be placed on maritime ballistic missile defense," he said.
>
> "We have Patriot missile defense capabilities, THAAD missile defense capabilities that are primarily in the Army and Air Force realm. Maritime has always kind of played second fiddle to that, but with the advent of the Aegis ship and what we have brought forward with the ballistic missile defense capability within in the U.S. Navy, now maritime is really coming to the forefront.
>
> "And the other nations are starting to get involved in this warfare area as well," he continued.
>
> "We're seeing a lot of development in the Netherlands. The Spanish are showing a lot of interest, as well as the United Kingdom and the Italians. And to some degree the French, who have been watching this."
>
> Though NATO is not affiliated with the MTMD Forum, most of the 10 forum members are in NATO—Australia, Canada, France, Germany, Italy, The Netherlands, Norway,

[110] Sam LaGrone, "New South Korean Destroyers to Have Ballistic Missile Defense Capability," *USNI News*, September 6, 2016. See also Sam LaGrone, "Report: South Kore Wants BMD Capability for Guided Missile Destroyers," *USNI News*, August 15, 2016; Bradley Perrett and Kim Minseok, "Adding Interceptors, SM-3 May Join Missile Defenses in South Korea," *Aviation Week & Space Technology*, August 15-28, 2016: 49.

> Spain, United Kingdom and the United States. Australia did not participate in the demo and Germany sent personnel to support the exercise but not any military platforms.
>
> NATO is in the midst of discussions about how to improve theater missile defense, Wolstenholme said, and was watching the nine-country live fire demonstration closely.
>
> "There's a lot of discussion going on throughout the NATO community. In fact, just earlier this month there was a conference in Spain … and there was a lot of discussion about where do we go next after this At-Sea Demo in developing an exercise program," he said.
>
> "And there's several proposals being discussed right now to figure out how we get this stood up and make it more mature.".....
>
> The exercise included the first launch of a Standard Missile-3 in Europe, and securing the region for the ballistic missile target launch and the SM-3 intercept was no easy undertaking—commercial air traffic in and out of Europe typically flies right over the Hebrides Range in Scotland and had to be diverted to the south, and U.S. Navy P-3s and P-8s and U.K. E-3Ds scanned the water to ensure the seas were clear of all boat traffic....
>
> Mary Keifer, Lockheed Martin's Aegis in-service and fleet readiness program director, said after the at-Sea demonstration that the company was working with NATO and MTMD Forum members to improve their ships on a budget. After working with the Spanish Navy in 2007 to demonstrate a carry-on/carry-off temporary solution to help Spain's Aegis-equipped ships track ballistic missiles, Keifer said the company again worked with Spain ahead of the demonstration to do a partial upgrade to some Aegis BMD tracking capabilities.[111]

A July 28, 2014, press report states:

> The Italian navy is working to develop the ballistic missile defense (BMD) capability of its Orizzonte-class air-defense ships and pave the way for BMD systems to be installed on a new class of ship to be launched in the early 2020s.
>
> Software engineers at the Italian navy's programming center—known as Maricenprog—near the navy's main dockyard at Taranto, have been developing tactical BMD capabilities for the ship as part of the country's participation in the wider NATO tactical BMD program. The Italian defense ministry supports the effort with the land-based TPS-77 radar system and the SAMP-T ground-based air defense system, but wants to back up these efforts at sea with the Orizzonte or Horizon-class ships.
>
> According to Gianpaolo Blasi, director of Maricenprog, the program has already completed two of what NATO describe as Ensemble Tests (ET), which pave the way for entry into the NATO BMD program. The navy is preparing for a trial due to take place in 2015 that will see the Orizzonte-class vessel ITN Doria supporting and defending another—as yet unconfirmed—BMD-capable ship that will track and potentially engage a ballistic missile target. During the trials the Doria will act as shotgun, defending the missile-tracking vessel from conventional air threats that the other ship cannot deal with as it tracks the ballistic missile.
>
> The Doria will be able to transmit details of the engagement around the fleet through a tactical data link modified to carry BMD data.[112]

A June 13, 2014, press report states:

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[111] Megan Eckstein, "NATO Hopes To Boost Collective Maritime BMD Capability Through Exercises, Investments," *USNI News*, October 26, 2015.

[112] Tony Osborne, "Italian Navy Paves Way For Ship-Based BMD Capability," *Aerospace Daily & Defense Report*, July 28, 2014: 1-2.

> Talks between the U.S. and Australia have given fresh momentum to Washington's plans to create a larger ballistic-missile defense shield for its allies in Asia.
>
> According to a U.S. statement overnight, discussions between President Barack Obama and visiting Australian Prime Minister Tony Abbott resulted in a commitment from Canberra for help in pushing forward with expanded missile-defense plans as a counter to North Korea....
>
> Washington's statement on Thursday [June 12] said the U.S. was now examining ways for Australia to participate in a bigger regional system using the country's coming fleet of missile destroyers equipped with advanced Aegis radar capability.
>
> "We are…working to explore opportunities to expand cooperation on ballistic missile defense, including working together to identify potential Australian contributions to ballistic-missile defense in the Asia-Pacific region," the U.S. statement said.
>
> Australia is building a new fleet of warships that could be equipped to shoot down hostile missiles, as part of an ambitious military buildup that includes investments in new stealth-fighter aircraft, cruise missiles, amphibious carriers and submarines. The revamp will cost close to 90 billion Australian dollars (US$85 billion) over a decade.
>
> "This might mean the Australian Defence Force could end up mounting advanced missiles on its Aegis-equipped air-warfare destroyers," said security analyst James Brown of Australia's Lowy Institute.[113]

A September 16, 2013, press report states:

> One of the UK Royal Navy's new Type 45 destroyers is conducting tests to establish whether the warships could provide British forces with theater ballistic-missile defense (TBMD) capabilities for the first time, according to the head of the Royal Navy.
>
> First Sea Lord Adm. Sir George Zambellas said during a speech to industry executives and military personnel on the opening day of the DSEi defense exhibition that the "type is on trials in the Pacific to explore the ballistic-missile defense capabilities that are ready to be exploited, bringing strategic opportunities to the vessel."
>
> The Type 45 destroyer Daring, one of six Type 45s built by BAE Systems for the Royal Navy, has been in the Pacific for several weeks, having departed its Portsmouth base this summer for a wide-ranging nine-month deploy-ment, which the Royal Navy said in May would include science and technology trials. The work is being done as part of a US Missile Defense Agency (MDA) research and development test....
>
> In May, the UK Defence Ministry confirmed it was talking to Aster 30 partners France and Italy about developing an extended-range version of a missile already used by the French and Italian armies to intercept incoming missiles While there is no program to adapt the Type 45 to include TBMD capability, the trials support the possibility of such a move once a decision whether to go down that route is made by the British government.[114]

A March 18, 2013, press report states:

> Raytheon has discussed a possible pooling arrangement with three navies in northern Europe to make its SM-3 ballistic missile inter-ceptor more affordable, according to a senior company executive.
>
> Speaking after a successful test of a new data link enabling the SM-3 to communicate with X-band radars operated by Dutch, Danish and Ger-man warships, George Mavko, director of European missile defense at Raytheon Missile Systems, said the idea of a pooling

[113] Rob Taylor, "U.S. and Australia to Cooperate on Asian Missile-Defense Plans," *Wall Street Journal* (http://online.wsj.com), June 13, 2014.

[114] Andrew Chuter, "UK Royal Navy Examines BMD Capabilities," *Defense News*, September 16, 2013: 38.

> arrangement had been raised by the company, even though none of the countries are pursuing procurement at this point....
>
> While all three European navies have expressed an interest in the capability of the SM-3 to engage ballistic missiles at ranges outside the atmosphere, none appear close to actually procuring the missiles....
>
> Instead, led by the Dutch, the initial moves appear focused on updating naval X-band radars and other systems so they can provide target data to SM-3 missiles even if they can't prosecute their own attack....
>
> Aside from the pooling idea, Raytheon also recently opened discussions with the U.S. Missile Defense Agency over co-production of SM-3 systems in Europe to sweeten any future deal, Mavko said....
>
> Small bits of the missile are already produced in Europe, although it was "too early to imply the U.S. is willing to release any major subsystems to other countries for co-production," Mavko said....
>
> Raytheon has been cooperating with the Dutch Navy for several years, exploring the potential of the SM-3 to talk to X-band radars. The Dutch have co-funded a study with the U.S. government on the feasibil-ity of a dual-band data link; the study is due to be extended into a second phase. The German government has agreed to participate this time.[115]

A March 11, 2013, press report states:

> The Eurosam SAMP/T surface-to-air missile system has destroyed a representative theater ballistic missile during a test in France.
>
> The March 6 test saw a joint Italian and French team engage an aircraft-launched target using an Aster 30 missile fired from the Biscarosse missile test center on the Bay of Biscay coast.
>
> According to French government defense procurement agency the DGA, the operational evaluation firing was jointly carried out by the Italian 4th Artillery Regiment of Mantova with the French military airborne test center (CEAM) of Mont-de-Marsan. In a change from previous interceptions, the SAMP/T used Link 16 data links to provide target information. The test also was the first to use what Eurosam calls a NATO environment in terms of command and control of the weapon, rather than simply using French sensors.
>
> The company says the firing was as "close to what would be an operational use for an anti-theater ballistic missile mission under the aegis of the alliance Active Layered Theater Ballistic Missile Defense program."
>
> The company adds, "The NATO Ballistic Missile Defense Operations Cell, located in Ramstein, Germany, was in the loop via Link 16 network."[116]

Another March 11, 2013, press report states:

> Joint US and European testing of command, control, communications and radar systems are underway to demonstrate the feasibility of integration of European radars and command and control systems into a future missile defense systems based on the planned European Phased Adaptive Approach (EPAA) utilizing the several AEGIS destroyers or cruisers to be based in Spain, land-based SM-3 interceptors to be stationed in Romania and Poland, along with SPY-2 radars sites. These assets are to be complemented by a number of European deployed radar sites.

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[115] Andrew Chuter, "Raytheon Pushes European SM-3 Missile Pool," *Defense News*, March 18, 2013: 4.

[116] Tony Osborne, "European SAMP/T Destroys Ballistic Missile In Test," *Aerospace Daily & Defense Report*, March 11, 2013: 3.

> In recent weeks tests were carried out to evaluate such integration. Last week Raytheon reported about a recent trial that showed that a radar used by Dutch, German and Danish navies could provide target information to the interceptor. The current radar installed on the Dutch frigates is incompatible with the AEGIS/SM-3 link operating over S-band. The demonstration which took place at the Den Helder military test range validated a datalink that allows the missile to receive information from the Thales sensor while retaining the ability to communicate with Aegis combat ships used by the U.S. Navy. Generally, The Dutch, German and Danish navies datalinks are operating on X bands, while Norway, Spain and the U.S. operate AEGIS frigates communicating with their interceptors over the S band. To avoid unique configurations of missiles, Raytheon has developed a dual-band datalink which enables the same missile to communicate in both bands. This dual-band datalink was first tested in 2011.[117]

A March 8, 2013, press report states:

> The British Royal Navy is exploring the possibility of outfitting its newest class of destroyers with a ballistic missile defense capability.
>
> The Defence Ministry said this week it wants to examine the potential for the Type 45 destroyers to play a role in defending the United Kingdom and allies from the threat of ballistic missiles. The ministry said it will build on its relationship with the Pentagon's Missile Defense Agency to look at the option....
>
> The joint Defence Ministry and industry-run U.K. Missile Defence Center (MDC) plans to take part in a trial that for the first time will use a Type 45 in a research and development program with their American counterparts.
>
> That will involve testing the Sampson radar, which is part of the Sea Viper missile system, in detecting and tracking ballistic missiles, the ministry said.
>
> The is no program to deploy ballistic missile defense on Type 45s but the MDC has in recent years been exploring the option for the destroyers.
>
> "It will be a step change to be able to work so closely with such a ship in an emerging area of defense," MDC head Simon Pavitt said in a statement. "Working with an operational platform will make a significant difference to our level of understanding and could contribute both financially and technically towards any future program."[118]

An October 2012 article stated:

> The Royal Netherlands Navy's (RNLN's) four De Zeven Provincien-class LCF air defence and command frigates are to receive a substantially upgraded and rearchitectured SMART-L D-band volume search radar that will give the ships a ballistic missile defence (BMD) early warning capability.
>
> Thales Nederland received a EUR116 million (USD145 million) contract from the Netherlands' Defence Materiel Organisation (DMO) in June 2012 for the new extended-range sensor known as 'SMART-L EWC'. This new variant of SMART-L, which builds oni the results of a previous Extended Long Range (ELR) capability demonstration, will push instrumented range out to 2,000 km; improve elevation coverage; introduce new wave

[117] Tamir Eshel, "Integrating European Radars with AEGIS/SM-3 Missile Defenses," *Defense Update* (http://defense-update.com), March 11, 2013, accessed March 20, 2013, at http://defense-update.com/20130311_integrating-european-radars-with-aegissm-3-missile-defenses.html.

[118] Mike McCarthy, "U.K. Examining Sea-Based Missile Defense," *Defense Daily*, March 8, 2013: 10. See also "British Destroyer to Participate in U.S. Missile Defense Trials," *Defense Update* (http://defense-update.com), March 7, 2013, accessed March 27, 2013, at http://defense-update.com/20130307_british-destroyer-to-participate-in-u-s-missile-defense-trials.html.

> forms and processing optimised for the detection and tracking of very-high-velocity ballistic missile targets at altitude; and enable estimation of trajectories, launch sites and points of impact. At the same time, all SMART-L volume air search functionality will be retained.[119]

A journal article published in the summer of 2012 states:

> Today the steady growth of Aegis-capable ships in the U.S. Navy—as well as an increasing number of world navies fielding such ships—presents new opportunities and challenges....
>
> ... the Aegis BMD capabilities present in the navies of U.S. allies and friends can now provide the Global Maritime Partnership with a means to address the "high end" of the kill chain with combined, coordinated, ballistic-missile defense: the Aegis BMD Global Enterprise.
>
> This potential is already manifest in the Asia-Pacific region in the close working relationship between the United States and Japan. Korea and Australia could well join this Aegis network soon, giving the four governments the means to address not only territorial BMD but also coordinated BMD of fleet units operating together. In Europe, plans are well along to provide robust territorial defense of European nations with ALTBMD [active layered theater BMD] and the EPAA. Together, these systems provide a nascent BMD capability today and promise an even more robust capability as the EPAA evolves over the next decade and a half.
>
> But as demonstrated in Iraq, Afghanistan, and now Libya, NATO and the nations of Europe have equities often well beyond the territorial boundaries of the European continent. Also, a European military deployed beyond Europe's borders will always have a naval component. This is therefore a propitious time to begin to link European allies more completely into an Aegis BMD Global Enterprise in much the same way the U.S. Navy is linked to its Asia-Pacific partners—Japan today, Korea soon, and thereafter Australia in the near future—in a high-end Aegis BMD Global Maritime Partnership....
>
> The diffusion of Aegis BMD capability abroad is occurring quietly. Governments that have made naval force-structure investment decisions based primarily on inwardly focused national interests have discovered that their investments also enable them to combine their resources in collective defense....
>
> This effort to create a broad BMD enterprise builds on the current participation of allied navies in the Aegis program. This global effort started with a foreign military sales relationship with Japan, subsequently expanded to relationships with Australia and Korea, and now includes a commercial connection with Spain as well as an enterprise between Norway and Spain.22 Several other states have expressed interest in acquiring the Aegis weapon system and Aegis BMD. Importantly, Australia and other countries that are acquiring the Aegis system are stipulating that the systems they buy must have the capability of adding BMD in the future....
>
> In Europe, the decision as to whether and how to connect the European NATO allies' short- and medium-range theater missile-defense systems to the U.S. long-range missile defense system will be critical to the coherence of alliance-wide BMD. A high level of commitment to international partnership on the parts of both the United States and its allies—already evinced by ALTBMD and C2BMC shared situational-awareness tests—will encourage interoperability initiatives. This interoperability will, in turn, help ensure the success of the U.S. Phased Adaptive Approach....
>
> Close cooperation in the area of Aegis BMD between the United States and Japan, possibly Korea, and potentially Australia does not in itself qualify as an "Aegis BMD Global

[119] Kate Tringham, "Warning Signs: Netherlands Evolves SMART-L Radar For Ballistic Missile Defence Mission," *Jane's International Defence Review*, October 2012: 28-29.

> Enterprise." But to include European nations in an Aegis-afloat enterprise of capabilities approaching those planned for the ALTBMD/EPAA system would....
>
> European navies are now deployed worldwide fulfilling the vision of a Global Maritime Partnership: supporting operations in Iraq and Afghanistan, fighting in Libya, conducting antipiracy patrols in the Horn of Africa and elsewhere, and supporting humanitarian assistance operations around the world. There could be no more propitious time to begin to link more completely European allies in an Aegis BMD Global Enterprise, in much the same way the U.S. Navy is now linked to its Asia-Pacific partners in a high-end Aegis BMD Global Maritime Partnership....
>
> But it is unlikely that such a venture would succeed without ongoing U.S. leadership, the same sort of leadership that is supporting sea-based Aegis BMD for territorial and fleet ballistic-missile defense today in the northeast Pacific as well as sea-based and land-based ballistic territorial missile defense in Europe. Clearly, U.S. leadership could be what accelerates the morphing of a now-nascent Aegis BMD Global Enterprise in Europe into a global Aegis BMD afloat capability....
>
> There is a growing worldwide commitment to Aegis ballistic-missile defense, a commitment with broad potential to field an international global enterprise capable of defending against the most imminent, and growing, threat to nations and navies, on land and at sea alike—the threat of ballistic missiles, particularly those armed with weapons of mass destruction.[120]

A May 7, 2012, press report states:

> The German Navy's fleet of frigates could be upgraded to deploy Raytheon's [RTN] Standard Missile-3 to participate in NATO's ballistic missile defense program if the modifications were approved by the government, Germany's top naval officer recently said.
>
> Vice Admiral Axel Schimpf, the counterpart to the U.S. Navy's chief of naval operations, said in a recently published article that the F124 frigates are capable of being upgraded to play a vital role in ballistic missile defense (BMD).
>
> "The German Navy, with the F124 Frigates in their current configuration, has a weapon system at their disposal which forms the basis for capability enhancements for (German) armed forces' participation in various roles," according to a translation of an article he penned in Marine Forum, a publication of the German Maritime Institute.
>
> One option, Schimpf said, would be to upgrade the F124s' SMART-L and Active Phased Array Radar (APAR) combat management system, along with the Mk-41 vertical launch system to accommodate the SM-3....
>
> The enhancements would be one way for Germany to participate in the Obama administration's European Phased Adaptive Approach (EPAA) embraced by NATO, and could be done in cooperation with Denmark or the Netherlands, Schimpf said....
>
> The German government has not made on decisions on whether to adapt its frigates for ballistic missile defense, and Germany's role in EPAA is the source of ongoing political discussions in Berlin ahead of NATO's May 20-21 summit in Chicago....
>
> Only a handful of NATO allies deploy the Aegis combat system on ships, and Germany is not one of them. Germany's combat system does not operate on an S-band frequency used

[120] Brad Hicks, George Galdorisi, and Scott C. Truver, "The Aegis BMD Global Enterprise," *Naval War College Review*, Summer 2012: 65-80.

> on Aegis. Raytheon, however, says it has developed a duel band data link that would allow the combat system on allied ships to talk to the SM-3 and guide it to targets.[121]

An October 3, 2011, press report stated that

> The Netherlands, which has had a longtime interest in a missile shield, is pressing ahead to build up its own capabilities. The Dutch defense ministry plans to expand the capabilities of the Thales Smart-L radar on Dutch frigates to take on BMD roles. The program's value is estimated at €100-250 million, including logistics support and spares.
>
> Other European navies using the sensor may follow the Dutch lead.
>
> Dutch Defense Minister Hans Hillen notes that the Smart-L effort would help address the BMD sensor shortage within the NATO alliance. Citing NATO's decision last year to take a more expansive approach to BMD, Hillen says Smart-L could give the ALTBMD [Active Layered Theater BMD] command-and control backbone the required long-range target-detection analysis to help identify where a threat originates.
>
> The Netherlands has already carried out a sensor trial for the expanded role in cooperation with the U.S. Navy. The move does not include the purchase of Raytheon Standard Missile SM-3 interceptors.
>
> Both hardware and software modifications to the combat management system are needed. All four [of the Dutch navy's] De Zeven Provincien-class frigates would be modified to ensure that two can be deployed, even as one is in maintenance and the fourth is being readied for operations.
>
> Thales is due to complete a series of studies to prepare for the acquisition of the upgrade in the third quarter of 2012. The goal is to have the first frigates ready for operations by 2017. All four should be upgraded by the end of that year.
>
> Although the Netherlands is leading the program, other Smart-L users, including the German navy and Denmark, have been monitoring the effort. France also has shown interest in the system, Hillen said in a letter to legislators.
>
> France also wants to upgrade its Aster 30 interceptor to give it a basic BMD capability, although a formal contract has not been awarded….
>
> Raytheon, meanwhile, is still fighting to win a foothold for its Standard Missile 3 (SM-3) in Europe. The company continues its push to persuade continental navies to embrace the SM-3 Block 1B for missile defense roles, and says it has largely validated the dual-mode data link that would be key to the concept.
>
> The data link would feature both S- and X-band capability—the former to support the Aegis radar system used by the U.S. and others, and the latter for the Smart-L/APAR (active phased array radar) combination used, for instance, by the Dutch navy.[122]

A September 2011 press report states:

> The gulf in sea-based ballistic missile defence (BMD) capability between the navies of NATO's European member states and the US Navy (USN) was brought into stark relief by the recent deployment of the Ticonderoga-class cruiser USS Monterey to the

[121] Mike McCarthy, "Raytheon's SM-3 An Option For German Role In Missile Defense, Admiral Says," *Defense Daily*, May 7, 2012: 9.

[122] Robert Wall, Amy Svitak, and Amy Butler, "Supporting Role," *Aviation Week & Space Technology*, October 3, 2011: 28-29. A shorter version of the story was published as Robert Wall, "Dutch Press Forward On Ship-Based Missile Defense Effort," *Aerospace Daily & Defense Report*, September 27, 2011: 4. See also Menno Steketee, "Dutch Frigates to Gain BMD Capability," *Jane's Navy International* (*Janes.com*), September 28, 2011. (The print version of the report appeared under the same article title in the November 2011 issue of *Jane's Navy International*, page 8.

Mediterranean and Black Sea region, as the first element of the United States' European Phased Adaptive Approach (EPAA) for missile defence....

However, this situation is about to change as European NATO nations are committing their naval assets to BMD in response to evolving alliance policy towards developing a BMD architecture to protect the continent from perceived threats emanating from the Middle East.

NATO embarked on an Active Layered Theatre Ballistic Missile Defence System (ALTBMDS) programme in September 2005, following a two-year feasibility study. Its initial focus was the protection of deployed alliance forces and high-value assets against short- and medium-range threats. At the November 2010 Lisbon Summit, political leaders from NATO states committed to expanding that remit to include the defence of the alliance's European territory.

ALTBMD is providing a C2 framework on which to build a scalable and adaptable BMD 'system of systems' architecture, integrating new national systems as they are committed to the alliance and enabling a complete lower- and upper-layer capability covering Europe to be fielded. The first of these, Capability 1, with initial operational capability planned for the 2012 timeframe, integrates C2 infrastructure, sensors and ground-based Patriot interceptors. The expansion to provide upper-layer defence is due to achieve full operational capability between 2015 and 2016.

The US contribution to this architecture is the EPAA set out by the Obama administration in September 2009....

There is evidence that the EPAA has acted as a spur for some European nations to make a more coherent contribution to the NATO BMD construct, particularly in the maritime domain, as they seek to maintain sovereignty in the development and integration of indigenous BMD systems and defence of their territories.

A number of classes of the latest generation of anti-air warfare (AAW) combatants with the potential to acquire a BMD capability are either operational or entering service in the navies of Denmark, France, Germany, Italy, the Netherlands, Norway, Spain and the UK. These offer the attributes of flexibility in deployment, mobility and sustainability inherent in naval platforms and could operate as effective sensor nodes even without an organic intercept capability.

They would be able to forward deploy close to the origin of the threat and act as force multipliers in this role by providing early warning of launches and cueing of off-board interceptor systems with the provision of timely and accurate impact point prediction and missile tracks, together with launch point prediction for counter-targeting.[123]

[123] Charles Hollosi, "European Fleets Respond to Ballistic Missile Threats," *Jane's Navy International*, September 2011: 23-24, 26-30.

Appendix D. Target for Simulating Endo-Atmospheric Flight of DF-21 ASBM

A past oversight issue for Congress concerns the lack of a target for simulating the endo-atmospheric (i.e., final) phase of flight of China's DF-21 anti-ship ballistic missile. DOD's Director, Operational Test and Evaluation (DOT&E), in a December 2011 report (DOT&E's annual report for FY2011), stated the following:

> **Anti-Ship Ballistic Missile Target**
>
> A threat representative Anti-Ship Ballistic Missile (ASBM) target for operational open-air testing has become an immediate test resource need. China is fielding the DF-21D ASBM, which threatens U.S. and allied surface warships in the Western Pacific. While the Missile Defense Agency has exo-atmospheric targets in development, no program currently exists for an endo-atmospheric target. The endo-atmospheric ASBM target is the Navy's responsibility, but it is not currently budgeted. The Missile Defense Agency estimates the non-recurring expense to develop the exo-atmospheric target was $30 million with each target costing an additional $30 million; the endo-atmospheric target will be more expensive to produce according to missile defense analysts. Numerous Navy acquisition programs will require an ASBM surrogate in the coming years, although a limited number of targets (3-5) may be sufficient to validate analytical models.[124]

A February 28, 2012, press report stated the following:

> "Numerous programs will require" a test missile to stand in for the Chinese DF-21D, "including self-defense systems used on our carriers and larger amphibious ships to counter anti-ship ballistic missiles," [Michael Gilmore, the Pentagon's director of operational test and evaluation] said in an e-mailed statement....
>
> "No Navy target program exists that adequately represents an anti-ship ballistic missile's trajectory," Gilmore said in the e-mail. The Navy "has not budgeted for any study, development, acquisition or production" of a DF-21D target, he said.
>
> Lieutenant Alana Garas, a Navy spokeswoman, said in an e-mail that the service "acknowledges this is a valid concern and is assessing options to address it. We are unable to provide additional details."...
>
> Gilmore, the testing chief, said his office first warned the Navy and Pentagon officials in 2008 about the lack of an adequate target. The warnings continued through this year, when the testing office for the first time singled out the DF-21D in its annual public report....
>
> The Navy "can test some, but not necessarily all, potential means of negating anti-ship ballistic missiles," without a test target, Gilmore said.[125]

The December 2012 report from DOT&E (i.e., DOT&E's annual report for FY2012) did not further discuss this issue; a January 21, 2013, press report stated that this is because the details of the issue are classified.[126]

A December 16, 2016, press report states the following (emphasis added):

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[124] Department of Defense, Director, Operational Test and Evaluation, *FY 2011 Annual Report*, December 2011, p. 294.

[125] Tony Capaccio, "Navy Lacks Targets To Test U.S. Defenses Against China Missile," *Bloomberg Government* (*bgov.com*), February 28, 2012.

[126] Christopher J. Castelli, "DOD Testing Chief Drops Public Discussion Of ASBM Target Shortfall," *Inside the Navy*, January 21, 2013.

> The Missile Defense Agency (MDA) said its new Sea Based Terminal (SBT) system achieved its second ballistic missile intercept during a Dec. 14 test over the Pacific Ocean.
>
> During the test, the USS John Paul Jones (DDG-53)... fired a salvo of two Raytheon [RTN] Standard Misisle-6 (SM-6) interceptors in immediate succession against a medium-range ballistic missile target launched from the Pacific Missile Range Facility on Kauai, Hawaii. The first interceptor was not armed and was designed to collect test data, MDA said. The second interceptor, which carried an explosive warhead, intercepted the Lockheed Martin-built target....
>
> **MDA called the target "complex" but declined to elaborate. However, according to the Missile Defense Advocacy Alliance, the target emulated China's Dong-Feng 21 (DF-21), a ballistic missile equipped with a maneuverable re-entry vehicle and designed to destroy U.S., aircraft carriers.**
>
> The event, designated Flight Test Standard Missile-27 (FTM-27), was SBT's first salvo test and its second intercept in as many tries.[127]

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[127] Marc Selinger, "Missile Defense Agency Scores Second Intercept With Sea Based Terminal System," *Defense Daily*, December 16, 2016: 3-4.