



United States Government Accountability Office
Washington, DC 20548

February 11, 2013

The Honorable Michael R. Turner
House of Representatives

Subject: *Standard Missile-3 Block IIB Analysis of Alternatives*

This letter formally transmits the briefing we provided on January 29, 2013 to the House Armed Services Subcommittee on Strategic Forces. This is the first report we are issuing in response to your September 4, 2012, request that we examine several issues related to the European Phased Adaptive Approach (EPAA), which is a policy announced by the President in September 2009 for missile defense of Europe and the United States that is planned to provide increased defense capability over time.¹ This briefing covers one part of the request, how alternatives were evaluated for the Standard Missile-3 (SM-3) Block IIB, a planned missile for that effort. The remaining topics you requested will be addressed in future GAO work. The SM-3 Block IIB's planned primary mission is to help defend the United States by providing an added layer of defense to that already provided by ground based interceptors in California and Alaska. It is planned to have significantly greater capabilities than prior versions of the SM-3, which defend against different threats. It is also expected to contribute to regional defense against medium- and intermediate-range ballistic missiles. The SM-3 Block IIB program began in June 2010. The SM-3 Block IIB is planned to be fielded by 2022 at the earliest as part of the fourth phase of U.S. missile defense in Europe.

Our specific objectives were: (1) To what extent was an analysis of alternatives (AoA) or AoA-like analysis conducted for the SM-3 Block IIB? and (2) Has there been subsequent analysis that affects the factors underlying the original decision to pursue the SM-3 Block IIB?

To conduct this work, we reviewed documentation of Missile Defense Agency (MDA) and Department of Defense (DOD) reviews that program management officials considered similar to an AoA, and compared this documentation to acquisition best practices for AoAs² and DOD acquisition guidance. Finally, we interviewed MDA and DOD officials about any reviews conducted that were relevant to an AoA.³ We conducted this performance audit from November 2012 to February 2013 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

¹ This report was prepared in response to a September 2012 request from Representative Michael R. Turner—then Chairman, House Armed Services Subcommittee on Strategic Forces—to review the extent to which an analysis of alternatives was conducted prior to initiating development of the SM-3 Block IIB.

² GAO, *Defense Acquisitions: Many Analyses of Alternatives Have Not Provided a Robust Assessment of Weapon System Options*, [GAO-09-665](#), (Washington, D.C.: September 2009).

³ We did not assess the reviews beyond whether they included information relevant for an AoA.

Summary

We have previously reported that the SM-3 Block IIB program did not conduct a formal analysis of alternatives (AoA) prior to beginning technology development. AoAs provide insight into the technical feasibility and costs of alternatives by determining if a concept can be developed and produced within existing resources. Although MDA is not required to do an AoA for its programs because of its acquisition flexibilities, we have previously reported that an AoA can be a key step to ensure that new programs have a sound acquisition basis.

While program management officials identified two reviews that they consider similar to an AoA, the reviews were not intended to be AoAs, and they did not address all of the key questions that would normally be included as part of an AoA. For example, the reviews did not consider the life-cycle costs for each alternative or the programmatic risks of the alternatives. Further, while the reviews did consider alternatives that could provide validated capabilities, the range of alternatives considered did not include other (non-Aegis) missile options that could provide an additional layer of defense to the United States. This narrow range of alternatives is particularly problematic because it limits the quality of the answers that can be provided for other key questions.

As the program has progressed, additional analysis has led to changes in the initial program assumptions and results that suggest additional development and investment will be needed by the program to defend the United States. MDA initially assumed that SM-3 Block IIB interceptors would be based on land at host nation facilities in Romania and Poland.⁴ However, subsequent MDA analyses demonstrated:

1. The Romania site was not a good location from a flight path standpoint for defending the United States with the SM-3 Block IIB.
2. The Poland site may require the development of the ability to launch the interceptor earlier—during the boost phase of the threat missile—to be useful for defense of the United States.⁵
3. A ship-based SM-3 Block IIB in the North Sea is a better location for defense of the United States and it does not require launch during boost capabilities.⁶

While MDA's initial assumption was the missile was to be land-based, the program is now requiring the SM-3 Block IIB to be ship and land compatible. However, if the SM-3 Block IIB is sea based and uses a liquid propellant, there are significant safety risks and unknown but likely significant cost implications. Navy has stated that the program may develop concepts with liquid propellants, but it has not made a final decision regarding whether it will overturn its 1988 ban on liquid propellants on ships and allow a sea-based SM-3 Block IIB to use liquid propellants.

To some extent, this progression has been driven by the early decision to narrow solutions to an Aegis-based missile without the benefit of a robust analysis of other alternatives. While this does not mean the SM-3 Block IIB is not a viable choice, we have previously reported that without fully exploring alternatives, programs may not achieve an optimal concept for the war fighter, are at risk for cost increases, and can face schedule delays or technology maturity challenges.

⁴ These locations are planned to provide both regional and U.S. homeland defense. We did not assess these locations for regional defense purposes.

⁵ With launch during boost, the missile launches during the boost phase of the threat missile. It intercepts the threat after the boost phase.

⁶ According to DOD, additional operational analysis of this location would be needed.

In commenting on a draft of the briefing, the Department of Defense provided technical comments which were incorporated into the briefing as appropriate.

We are sending copies of this report to the appropriate congressional committees. We are also sending copies to the Secretary of Defense, the Under Secretaries of Defense for Policy and for Acquisition, Technology and Logistics; and the Director of the Missile Defense Agency. This report will also be available at no charge on our website at <http://www.gao.gov>. Should you or your staff have questions concerning this report, please contact me at (202) 512-4841 or at chaplainc@gao.gov.

Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. Key contributors to this report were David B. Best, Assistant Director, Ann Rivlin, Analyst-in-Charge, Brian Tittle, Karen Richey, Bob Swierczek and Alyssa Weir.

A handwritten signature in black ink, appearing to read 'Cristina Chaplain', with a long horizontal line extending to the right.

Cristina Chaplain, Director
Acquisition and Sourcing Management

Enclosure

Standard Missile-3 Block IIB Analysis of Alternatives

**Briefing Prepared for
House Armed Services Subcommittee
on Strategic Forces
January 29, 2013**



Briefing Overview

- Introduction and Objectives
- Scope and Methodology
- Background
- Objective 1: Extent of analysis of alternatives
- Objective 2: Subsequent MDA analysis
- Conclusions
- DOD Comments

Introduction and Objectives

- The Chairman, House Armed Services Committee, Subcommittee on Strategic Forces, asked GAO to examine several issues related to the European Phased Adaptive Approach (EPAA), which is a policy announced by the President in September 2009 for European and U.S. homeland missile defense that is planned to provide increased defense capability over time.
- This briefing covers one part of the request, how alternatives were evaluated for the Standard Missile-3 (SM-3) Block IIB, a planned missile that is to be included in the EPAA. The remaining topics in the request letter will be addressed in future GAO products.
 - Our specific objectives were:
 1. To what extent was an analysis of alternatives (AoA) or AoA-like analysis conducted for the SM-3 Block IIB?
 2. Has there been subsequent analysis that affects the factors underlying the original decision to pursue the SM-3 Block IIB?

Scope and Methodology

- We reviewed documentation of MDA and DOD reviews that program management officials considered similar to an AoA, and compared this documentation to acquisition best practices¹ and DOD acquisition guidance. Finally, we interviewed MDA and DOD officials about any reviews conducted that were relevant to an AoA.²
- We conducted this performance audit from November 2012 to January 2013, in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

1. GAO, Defense Acquisitions: Many Analyses of Alternatives Have Not Provided a Robust Assessment of Weapon System Options, GAO-09-665, (Washington, D.C.: September 2009).

2. We did not assess the reviews beyond whether they included information relevant for an AoA.

Background: U.S. Homeland Defense

- The U.S. homeland is currently defended by existing large, ground-based interceptors based in Alaska and California.
- DOD has sought to provide an additional layer of U.S. homeland defense, which includes the capability to shoot a missile, look at the results of the shot, and shoot again if needed.
 - This defense could be provided through missiles that intercept a threat early in its flight, during midcourse flight, or in the terminal stages of flight.
- A missile system's physical location affects its ability to defend against certain threat flight paths as well as the overall capabilities and technologies that must be developed for that missile.
- Prior to 2009, the plan for a layered U.S. homeland defense relied on deploying ground-based interceptors in Europe for midcourse defense.
- In 2009, this plan changed with the announcement of the EPAA. This approach is designed to provide both near term regional defense of Europe and develop longer-term layered defense for the U.S. homeland. It involves different locations and missiles than the prior plan.

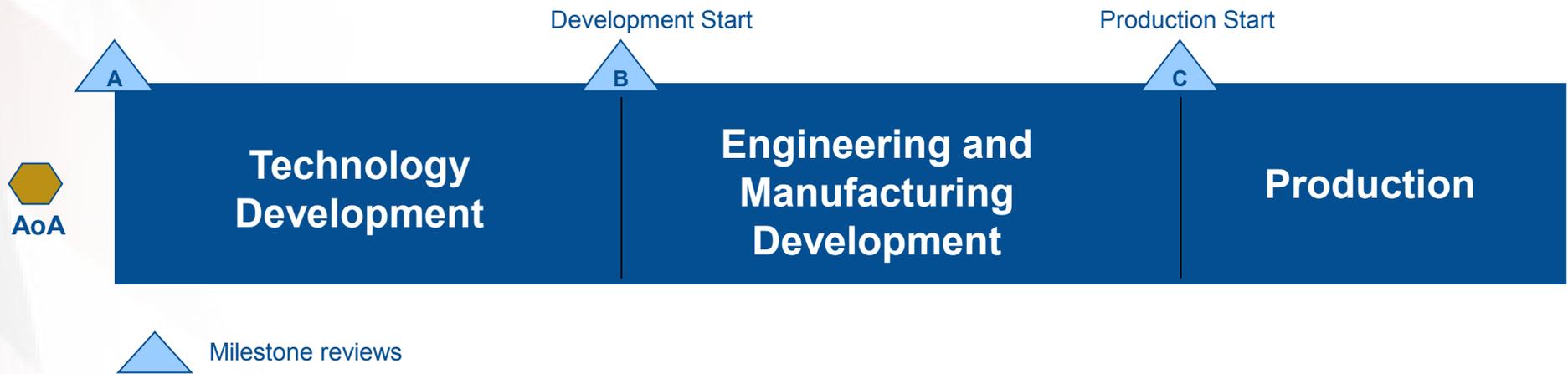
Background: EPAA Overview

- EPAA relies on the Aegis Ballistic Missile Defense (BMD) system, which includes shipboard radars and SM-3 missiles. Aegis BMD is being developed in increments to track and defend against threats of all ranges. EPAA also includes multiple other systems, including land- and space- based sensors and an integrated command and control network. EPAA assets are planned to be deployed as the various capabilities mature and the threat develops.
- Increasingly capable SM-3 missiles are associated with each EPAA phase.
 - Phase 1 (deployed in 2011) defends against short and medium range threats to Europe, using SM-3 Block IA missiles.
 - Phases 2 and 3 are to expand the defense of Europe using sea- and land-based missiles.
 - Phase 2 (deploys in the 2015 timeframe) will use SM-3 Block IB missiles, now in flight tests, against short- and medium-range threats.
 - Phase 3 (deploys in the 2018 timeframe) will use SM-3 Block IIA missiles, now in development, to add intermediate-range threats.
 - Phase 4 (deploys in the 2020 timeframe) will use SM-3 Block IIB missiles as part of a layered defense against some ICBM threats to the United States.

Background: SM-3 Block IIB Overview

- Given its primary mission of defending the United States against some ICBM threats, the SM-3 Block IIB is planned to have significantly greater capabilities than earlier SM-3 variants, which defend against different threats.
 - According to current plans, the SM-3 Block IIB will entail significant development beyond that required for the SM-3 Block IIA; for example, one option the program is exploring is to have a 27 inch diameter missile as opposed to the planned 21 inch diameter for the SM-3 Block IIA missile.
 - The SM-3 Block IIB missile is also planned to contribute to regional defense against medium and intermediate range threats.
- However, the amount of commonality among the SM-3 Block IIB and prior SM-3s will not be known until a contract is awarded for development of the missile.
- The program began in June 2010 and is currently in a concept definition phase. Three contractors are developing possible missile configurations and evaluating potential missile performance and technology risk. For example, one consideration is if the propellant for the missile should be liquid or solid.

Background: AoAs in DOD acquisition process



Source: GAO analysis of DOD acquisition policy

- Department of Defense (DOD) acquisition programs are generally required by law and/or regulation to complete an AoA prior to entering the technology development phase of the DOD acquisition cycle.
- An AoA is an analytical study that compares the operational effectiveness, cost, and risks of alternative potential solutions to address valid needs and shortfalls in operational capability.



Background: AoAs in DOD acquisition process, continued

- The AoA is generally updated during the technology development phase and reviewed and updated as necessary prior to the start of product development to reaffirm the cost-effectiveness of the program.
- In 2002, MDA was given the flexibility to defer the application of the defense acquisition cycle to specific elements of the ballistic missile defense system, such as the SM-3 Block IIB, until late in the DOD acquisition cycle when a decision is made to transfer a BMDS capability to a military service for production, operation, and sustainment.
- MDA can therefore develop the SM-3 Block IIB without the application of certain laws and regulations, including those that require AoAs early in the DOD acquisition cycle.

Background: AoA contributes to a sound basis for investment in programs

- In prior reports, we have stressed the importance of a program having a sound basis before committing resources.
 - A key first step in the acquisition process is the AoA.
 - We previously have reported that an AoA should address each alternative's advantages, disadvantages, associated risks, and uncertainties, how any uncertainties might influence the comparison, and try to identify the most promising conceptual alternative.³
- We previously also have found most programs that conducted a limited assessment of alternatives before the start of product development tended to have poorer outcomes than those that conducted more robust analyses.

3. GAO-09-665; *Defense Acquisitions: Realistic Business Cases Needed to Execute Navy Shipbuilding Programs*, GAO-07-943T, (Washington, D.C., July 24, 2007); and *GAO Cost Estimating and Assessment Guide*, GAO-09-3SP, (Washington, D.C., March 2009).

Background: GAO previously reported the SM-3 Block IIB lacked an AoA

- In April 2012, we reported the SM-3 Block IIB program office did not conduct a formal AoA.⁴
- The program did assess some missile concepts for early intercept capability in a system concept review.
 - It plans to conduct engineering and trade studies during the technology development phase that will include cost information.
 - While these studies will provide important information, they are occurring later than an AoA would generally occur for programs following the DOD acquisition cycle.

4. GAO, *Missile Defense: Opportunity Exists to Strengthen Acquisitions by Reducing Concurrency*, GAO-12-486, (Washington, D.C.: April 2012).

Objective One: Extent of AoA conducted for SM-3 Block IIB program

Overall Finding

- MDA is not required to conduct an AoA, and a formal AoA was not conducted for the SM-3 Block IIB program.
- Program management officials identified two reviews that they consider similar to an AoA for the SM-3 Block IIB.⁵
- These reviews did not assess all key areas that would have been addressed by an AoA, and there were key gaps in some of the areas they did assess.

5. We did not assess the reviews beyond whether they included information relevant for an AoA.

Objective One: Two reviews cited by MDA

1. The Ballistic Missile Defense Review (BMDR), the product of a comprehensive DOD ballistic missile strategy and policy review, was published in February 2010.
 - The review compared three policy alternatives—(1) the prior administration’s plan of large, ground-based interceptors in Poland and a radar in the Czech Republic, (2) a modified version of that plan with alternate locations, and (3) a phased, adaptive approach that adjusts as threats emerge.
 - The third alternative—the EPAA—was selected for several reasons, but largely because of its flexibility to address threats as they emerge.
 - The analysis that resulted in the BMDR compared potential policy alternatives, not assets to be included in each EPAA phase. It was not intended to develop specific architectures for each phase or be an AoA.
 - The SM-3 Block IIB was not specifically compared to other alternatives, including the interceptor used in the prior administration’s plan.

Objective One: Two reviews cited by MDA, continued

- Program management officials stated they took the BMDR analysis as a tasking to develop an Aegis missile that could defend against some intercontinental ballistic missiles.
2. Following the BMDR, MDA conducted an August 2010 system concept review (SCR) that compared a set of possible Aegis missiles to be based in Romania and Poland.
- According to program management officials, between 15 and 20 Aegis missile concepts were evaluated for the SCR, which focused on technical and performance measures.
- While SM-3 Block IIB program management officials stated these two reviews included information that make them similar to AoAs, the reviews are not formal AoAs, nor were they intended to be.

Objective One: GAO has reported an AoA should answer several key questions

- These include:
 1. Did an AoA occur at an appropriate time?
 2. What alternatives provided validated capabilities?
 3. Are the alternatives operationally suitable and effective?
 4. Can the alternatives be supported?
 5. What are the technical, operational, and programmatic risks for each alternative?
 6. What are the life cycle costs for each alternative?
 7. How do the alternatives compare to one another?

Objective One: Did an AoA occur at the appropriate time?

- We have previously reported that an AoA can be conducted too late to inform effective trade-off discussions before development. DOD acquisition regulations state that such an analysis should occur before initiating a program at Milestone A.
- Although not intended to be AoAs, the two reviews cited by MDA did occur at the appropriate time to allow them to serve as AoAs.
 - Both reviews predate the July 2011 entrance into MDA's technology development phase.

Objective One: What alternatives provided validated capabilities?

- We have previously reported that programs that considered a broad range of alternatives had better cost and schedule outcomes than those that looked at a narrow scope.
- However, in both reviews identified by MDA, a narrow range of alternatives was considered.
 - The BMDR considered three broad policy alternatives and did not specifically analyze the SM-3 Block IIB.
 - The SCR alternatives were too narrow in terms of an AoA. It did not include options that could provide additional U.S. homeland defense, such as non-Aegis missiles and different basing modes for all of the options.
 - The alternatives were limited to analyzing an Aegis missile that is land-based, compatible with a third generation Aegis Weapon System, and based in certain locations.

Objective One: Are the alternatives operationally effective and suitable?

- Operationally effective: AoAs typically determine whether alternatives can meet a needed capability, include consideration of the threat to be addressed, and evaluate how the alternatives address that threat.
- For the two reviews, there was some consideration of the operational effectiveness of a limited set of alternatives.
 - The BMDR did compare the operational effectiveness of the prior administration's plan and the EPAA, but did not specifically address the effectiveness of individual EPAA components, such as the SM-3 Block IIB.
 - The SCR did assess some level of operational effectiveness, such as the probability of engagement success against certain threat missile trajectories.
- Operationally suitable: AoAs typically assess how well a system can be used and sustained in the field.
 - Neither the BMDR nor the SCR considered the operational suitability of the limited range of alternatives.

Objective One: Can the alternatives be supported?

- AoAs require understanding of the concepts of operations—the details of the peacetime, contingency, and wartime employment of the alternatives—and support—the plans and resources for training, maintenance, and other logistics support—for the alternatives.
- There is limited evidence that support for the alternatives was included in the reviews.
 - The BMDR contains no evidence that system training, maintenance or logistics support was considered in the analysis. However, it considered concerns about foreign basing related to a fixed land site.
 - The SCR does not include a discussion of whether the alternatives can be supported. However, MDA officials stated that some of the constraints used in the SCR were designed to ensure the SM-3 Block IIB alternatives considered could be supported.

Objective One: What are the risks for each alternative?

- There may be technical, programmatic or operational risks associated with alternatives that should be considered in an AoA when determining which is the best weapon system. Comparing risks across alternatives is critical for new development programs, which often rely on breakthrough technologies and assume that technology will be achieved as planned.
- The two reviews partially considered technical and operational risks, but not programmatic risks such as schedule risks.
 - The BMDR analysis did not include a breakdown of the SM-3 Block IIB risks compared to alternatives, or fully discuss them for the alternatives it did consider. Some technical and operational risks were considered by evaluating the technology maturity levels and the ability to respond to future threats.
 - The SCR did not address programmatic risk, but did include some analysis of the technical and operational risks shared by all the SM-3 Block IIB alternatives it considered.
 - This analysis did not compare the limited set of alternatives in terms of these risks, but it did highlight common issues, such as the risks of modifying a launch system for a 27 inch interceptor.

Objective One: What are the life cycle costs for each alternative?

- An AoA should include the estimates of the total life-cycle cost (or ownership cost) of each alternative, which should also be combined with the operational effectiveness analysis to portray cost-effectiveness comparisons.
- No evidence suggests that the life-cycle cost of the alternatives was considered or cost-effectiveness comparisons made.
 - No evidence suggests that the BMDR analysis developed a life-cycle cost estimate or made a cost-effectiveness comparison for the SM-3 Block IIB. We have previously reported that life cycle costs were not developed for the EPAA during the BMDR.
 - The SCR includes no information on life cycle costs and did not make cost-effectiveness comparisons.

Objective One: How do the alternatives compare to each other?

- An AoA should compare the alternatives on the factors discussed above.
- No evidence exists that alternatives were compared on all the AoA factors by the BMDR and SCR.⁶ The ability to make this comparison is limited given the issues previously identified.
 - The BMDR did not compare the SM-3 Block IIB to other alternatives.
 - The SCR did some comparison of different alternatives, but did not provide a conclusion about which to pursue. It also did not compare the alternatives in key areas, such as programmatic risks and cost effectiveness.

6. We did not assess these reviews beyond whether they included information relevant for an AoA.

Objective Two: Subsequent analysis may affect original basis for SM-3 Block IIB decision

Overall Finding

- Subsequent analysis by MDA suggests that, in terms of U.S. homeland defense, modifications are needed to the concept of operations and basing plan. Specifically:
 - As presented in the SCR, the SM-3 Block IIB was to be based in both Romania and Poland.
 - According to MDA technical analysis, basing in Poland retains some feasibility for U.S. homeland defense, but may require a new operational concept and additional investment.
 - Further, a location in the North Sea is a better location than either Romania or Poland for defense of the U.S. homeland, although this option, if liquid propellants are used, has significant safety risks and unknown, but likely substantial, cost implications.

Objective Two: Program faces challenges related to basing location

- According to defense acquisition guidance, the AoA should be updated during the technology development phase and reviewed prior to the start of product development to reaffirm, among other things, the cost-effectiveness of the program.
- The 2010 SCR assumed SM-3 Block IIB interceptors would be based on land at host nation facilities in Romania and Poland.⁷
- Subsequent MDA analyses demonstrated:
 - the Romania site was not a good location from a flight path standpoint for defending the U.S. homeland with the SM-3 Block IIB.
 - the Poland site may require the development of the ability to launch the interceptor earlier—during the boost phase of the threat missile—to be useful for U.S. homeland defense.

7. These locations are planned to provide both regional and U.S. homeland defense. We did not assess these locations for regional defense purposes.

Objective Two: Launch during boost requires additional investment

- The 2010 SCR included information that launch during boost was not a desirable capability because it reduces the effective range for the missile.⁸
- Program management officials stated that their modeling of launch during boost and understanding of this capability has increased since the SCR, and they now believe it is a potential option.
- MDA completed an assessment of launch during boost capabilities during summer 2012 that found this capability was feasible.
 - MDA currently estimates launch during boost capabilities will cost \$130 million.
 - Adding this capability will require additional development or modifications of the SM-3 Block IIB, the command and control system used for missile defense, and existing space-based sensors that detect threat missile launches.

8. With launch during boost, the missile launches during the boost phase of the threat missile. It intercepts the threat after the boost phase.



Objective Two: Sea-based location has different costs and risks

- MDA technical analysis in 2012 concluded that a ship-based SM-3 Block IIB in the North Sea is a better location for U.S. homeland defense and it does not require launch during boost capabilities.⁹
- While during the SCR analysis the missile was to be land-based, the program is now requiring the SM-3 Block IIB to be ship and land compatible.
- One option currently under consideration for the SM-3 Block IIB is to use a liquid propellant for certain components.
- Liquid propellants offer performance advantages, such as a faster missile, but pose significant safety risks and costs for ships.
 - Navy banned the use of liquid propellants on ships in 1988 because of significant safety and cost reasons, including fire hazards and the costs of new systems to combat fires caused by these propellants on ships.
 - While Navy is open to MDA pursuing an interceptor with liquid propellant during the program's concept definition phase, it has identified this option as requiring significant efforts to reduce the safety risk and fleet wide changes.¹⁰

9. According to DOD, additional operational analysis of this location would be needed.

10. According to DOD, Navy has not made a final decision on whether it would accept liquid propellants in the SM-3 Block IIB if a decision is made to further develop the missile.

Conclusions

- Neither review conducted considered the full range of AoA questions.
 - Both reviews considered too narrow a range of alternatives which limits their ability to fully address the other key questions. Key analyses, such as the programmatic risks and cost effectiveness of alternatives, did not occur. However, MDA is not required to conduct an AoA for its programs.
- While this does not mean the SM-3 Block IIB is not a viable choice, we have previously reported that without fully exploring alternatives, programs may not achieve an optimal concept for the war fighter, are at risk for cost increases, and can face schedule delays or technology maturity challenges.
- As the program has progressed into the technology development phase, additional analysis has led to changes in the initial program assumptions that suggest additional development and investment will be needed by the program. To some extent, this progression has been driven by the early decision to narrow solutions to an Aegis-based missile without the benefit of a robust analysis of other alternatives.

DOD Comments

- DOD provided technical comments, which were incorporated as appropriate.

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