NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

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April 30, 2012

Representative Michael R. Turner
Chairman, Strategic Forces Subcommittee
House Armed Services Committee

Representative Loretta Sanchez
Ranking Member
House Armed Services Committee

Dear Mr. Turner and Ms. Sanchez:

We are pleased to provide the following responses to the twelve (12) questions you raised to us in your April 20 letter.

Before doing so, however, it is appropriate to make clear that our responses are unclassified as you requested (i.e., some specific details have been omitted to avoid making this letter classified). Furthermore, our responses are based on the briefing we provided to your subcommittee on April 18, as well as the work of a National Research Council (NRC) committee[1] which we co-chaired and helped prepare the NRC report entitled *Making Sense of Ballistic Missile Defense: An Assessment of Concepts and Systems for U.S. Boost-Phase Missile Defense in Comparison to Other Alternatives* which is undergoing final security classification review by the Missile Defense Agency (MDA).

It is also appropriate to make clear that the committee examined ballistic missile defense (BMD) for the following limited missions for defense against attacks that could plausibly be mounted by "rogue states" in the next decade or so: (1) protection of the U.S. homeland against limited nuclear, other weapons of mass destruction (WMD), or conventional ballistic missile attacks; (2) protection of U.S. forces and bases (to include forward based sensors important to homeland defense) located in theaters of operations against ballistic missile attacks armed with WMD or conventional munitions; and (3) protection of U.S. allies, partners, and host nations against ballistic-missile-delivered WMD and conventional weapons. The committee explicitly did not treat defense against Russian or Chinese strategic forces as a BMD mission. Moreover, since some level of defense against accidental or unauthorized launch from any source is an inherent capability of any defense system, it is not treated as an independent mission.

Our responses here are presented in summary form. The detailed explanations and analysis underlying them are set forth in the full report.

(1) Ref. "Please state the study panel's key observations and recommendations concerning Phases I-III of the Phased Adaptive Approach."

Phases I-III—that is Aegis, Terminal High-Altitude Area Defense (THAAD), and Patriot (PAC-3) with launch- and engage-on-remote together—provide an effective combined defense for allies and deployed U.S. forces, limited only by inventory, against short to intermediate range ballistic missile attack—in

[1]Pursuant to Section 232 of the Duncan Hunter National Defense Authorization Act for Fiscal Year 2009 (Public Law 110-417), the NRC established the Committee on An Assessment of Concepts and Systems for U.S. Boost-Phase Missile Defense in Comparison to Other Alternatives.

Europe, the Middle East, and in the Western Pacific. This will require 3 to 4 sites in Europe, including sea-based.

This conclusion depends on the assumption that Phase III will provide an interceptor with a velocity greater than 4 km/sec., i.e., sufficiently great to achieve shoot-look-shoot coverage with 3 to 4 sites against the full spectrum of attack trajectories of concern from the point of view of theater defense. We believe that velocity can be obtained within the volume and weight constraints of the existing 21-inch diameter Aegis launcher. In our judgment, an interceptor with a fly-out velocity greater than 4 km/sec is desirable not only for European defense but also is adequate for all other Aegis missions and we suggest that the Standard Missile (SM)-3-Block IIB competitive definition be focused on this objective, only at a substantially lower acquisition cost. This combination of defense systems can also provide an effective combined defense, limited only by inventory, as the BMD component of a comprehensive effort for protection against the anti-access threat to the fleet in Western Pacific operations and for defense of forward bases in Guam and Okinawa. It can also provide protection of Hawaii without the need for dedicated Ground-Based Midcourse Defense (GMD) coverage, if a "stacked" AN/TPY2 radar—described below—is deployed with THAAD and Aegis ashore at Kauai, Hawaii.

(2) Ref. "Please state the study panel's key observations and recommendations concerning Phase IV of the Phase Adaptive Approach."

In summary, Phase IV as currently defined is not necessary for theater defense and is at best less than optimal for homeland defense.

If Phases I-III are fully implemented, the additional interceptor capability of Phase IV is not required for European (or other theater) defense.

With regard to Phase IV's potential contribution to homeland defense, a significantly faster interceptor than needed for theater defense would be needed to avoid a forward-located homeland defense being overflown. Moreover, "early" intercept, even if achievable from a forward based interceptor system, cannot obviate the need for midcourse discrimination, because countermeasures and payload deployment can be achieved very rapidly (as historical experience shows) after threat booster burnout.

As a consequence, both a European "3rd site" for forward deployment of faster interceptors geared to homeland defense and Phase IV—understood to mean a significantly faster interceptor for deployment in the Aegis system—are poor substitutes for correcting GMD shortcomings by the measures described in Answer (6) below.

It should be noted that an effective theater defense is important to the homeland defense mission, because it protects forward deployed sensors essential to homeland defense and provides a "fence" against depressed trajectory attacks that would otherwise stress a U.S.-based homeland defense.

(3) Ref. "Please state the study panel's key observations and recommendations concerning the Precision Tracking Space Systems (PTSS). Please describe the study panel's confidence in its estimate of the expected cost of the system, and why it is different than the MDA estimate. Please also elaborate on concerns with the PTSS program of record as developed by MDA for the homeland defense mission. Please also respond to concerns raised by the Director of the Missile Defense Agency regarding the completeness of the study panel's analysis of the PTSS program of record."

The committee finds no valid justification for pursuing PTSS, and recommends terminating all effort on it.

While PTSS could provide extended tracking of threat objects, it is too far away from the threat to provide useful discrimination data, does not avoid the need for overhead persistent infrared (OPIR) cueing, and is very expensive.

We recognize the utility of precision tracking but our cost estimates show that PTSS would cost 2 to 3 times as much as MDA estimates, and that equivalent tracking and far greater discrimination capability can be achieved at a fourth to a third the expense of PTSS, by the sensor approach described in Answer (4) below that would provide extended threat tracking as well as communications and key discrimination support for engagements. We believe this conclusion holds across the full range of mission areas to which MDA has referred in disputing our analysis.

We believe these conclusions to be independent of any claimed potential for unconventional discrimination methodologies.

Our cost estimates were based on expert analysis employing experience with a range of other defense systems, and we have confidence in them. Important reasons for the cost difference between our recommended sensor configuration and PTSS include the need to replace PTSS satellites over the lifetime of the system and the learning curve savings from deploying more of the already operational AN/TPY2 radar arrays rather than embarking on a new development. However, we would welcome an independent review of PTSS costs, conducted by an organization entirely independent of MDA.

(4) Ref. "Please describe the recommendations for a more effective, less expensive sensor system as a substitute for the PTSS program of record."

A more effective, lower cost, sensor solution in all scenarios (including those referred to by MDA in its response to our analysis) is the acquisition and deployment of a forward-based X-band radar suite. That suite includes a ground based X-band radar—a "stacked" AN/TPY2 radar with two of the current AN/TPY2 radar arrays installed one above the other, on a turntable mounting similar to sea-based X-band radar (SBX), with associated electronics, power and cooling equipment. These GBX radars would be deployed at each of the five (5) existing forward-based upgraded early warning radar (UEWR) sites and possibly in Hawaii. They would provide double the power and aperture of single-array AN/TPY2s, taking advantage of economies of scale and experience in procurement, and the consolidation of security and support already in place at the recommended sites. As with PTSS, this radar suite would be cued by existing and programmed OPIR assets, e.g., Defense Support Program (DSP), Spaced Based Infrared Systems (SBIRS).

In addition, the existing SBX radar would be permanently located at Adak, Alaska, to support both testing and operations.

These radars would be integrated for discrimination with the optical sensors on the kill vehicle of the new homeland defense interceptor that we recommend to replace the existing, inadequate, ground-based interceptor (GBI) described in Answer (6) below. This combination would provide extended threat tracking as well as communications and key discrimination support to engagements.

(5) Ref. "Please describe the study panel's views on the role and utility of the Sea-based X-band radar."

The committee recommends that, as part of the homeland defense system outlined in Answer (6), the existing SBX radar be permanently located at Adak. That radar provides important support to intercepts of Pacific threats from the Fort Greely Alaska site.

(6) Ref. "Please describe the recommended path forward for a more effective, less expensive, homeland missile defense."

Because boost-phase intercept is not feasible except in very limited cases, a properly configured midcourse defense is the most effective means of protecting North America at reasonable cost against limited ballistic missile attack. There is no effective ballistic missile area defense that does not require dealing with midcourse discrimination (or shooting at all potential threat objects!) In particular, "early" post-boost intercept, even if achievable, cannot assure defeat of the threat before payload deployment and the emergence of both deliberate and "incidental" non-threat objects. So any effective area defense must confront the midcourse discrimination challenge.

The key to discrimination of real threat objects that must be engaged, in the face of countermeasures that are likely in the next decade, is exploiting the long observation time available for concurrent radar viewing by radars and the optical viewing by the interceptor sensor while it is closing on the threat. Accordingly, it is the committee's conclusion that the highest likelihood of successfully defeating countermeasures is based on effective use of today's surface-based X-band radars and the interceptor kill vehicle optical sensor that, while closing on the target, is gathering data highly useful for discrimination, and on enabling the integrated exploitation of these data sources by providing the necessary communications support.

Such a system can take advantage of the longer look and decision times that are available with midcourse defense, to employ a firing doctrine that uses a larger battle space, and integrated sensor support, for shoot-look-shoot capability. Such a capability, in contrast to salvo firing, not only saves costly and limited interceptor inventory; it uses information from initial shots to enhance the probability of the success of later shots.

The current GMD system has serious shortcomings, and provides at best a limited, initial defense against a relatively primitive threat. However, it can be fixed. The elements the committee recommends for doing that are:

- A smaller, faster (6 km/sec) two-stage interceptor with a short (70 sec) total boost time, derived from 1st and 2nd stage booster rocket motor development work done on the terminated Kinetic Energy Interceptor (KEI) program, with a new, more capable kill vehicle.
- Deploying this interceptor initially at a third site in the northeastern part of the U.S., to provide the battle space necessary for shoot-look-shoot of the entire country, followed by retrofit at Fort Greely (100 total interceptors).
- A sensor suite comprised of the two AN/TPY2 radars currently in Turkey and Japan, the existing SBX radar permanently located at Adak, and 5 new ground based X-band radars (2 AN/TPY2 arrays "stacked" on top of each other) at each of the existing UEWR sites (Fylingdales, United Kingdom; Cape Cod, Massachusetts; Thule, Greenland; Grand Forks, North Dakota; and Clear, Alaska).
- Limit procurement of the existing GBIs to the quantity needed to support the 30 now planned for Fort Greely and Vandenberg Air Force Base, California, and to conduct flight testing. As the Fort Greely GBIs are replaced, divert the GBIs to serve as test targets.
- Terminate PAA Phase IV (but ensure that PAA Phase III meets velocity goals by refocusing the effort), PTSS, and boost-phase defense other than for the limited potentially feasible uses described in Answer (10).

(7) Ref. "Please describe the recommendations regarding an East Coast site, including an interceptor for that site."

As explained in Answer (6), our recommended homeland defense system would include an interceptor base in the northeastern part of the United States. That site would receive the first installments of the new homeland defense interceptor described in Answer (6).

(8) Ref. "Please state the study panel's key observations and findings concerning procurement of additional ground-based interceptors of the current design and specification."

As explained in Answer (6), the committee recommends that procurement of the current GBIs be limited to that needed to support the 30 now planned for Fort Greely and Vandenberg, and to conduct flight testing.

(9) Ref. "Please state the study panel's key observations and findings about airborne directed energy for missile defense and other applications."

For the reasons explained in Answer (10), airborne directed energy boost-phase defense is range limited by the attenuation of the beam as it passes through the atmosphere. While long-term research on laser technology should be continued, that limitation is likely to persist for the foreseeable future.

(10) Ref. "Please state the study panel's key observations and findings on boost-phase defense and whether additional development of testing can change the findings, and what the exceptions are to the NAS's findings on boost-phase defense."

Boost-phase defense, while possible in principle with either kinetic or directed energy, is not practical technically, militarily, or affordably because the defense cannot be based close enough to the threat during its boost-phase to kill it, even with the most optimistic assumptions about technical performance. Kinetic kill mechanisms are range limited by the limited time of boosted flight of threat missiles. Moreover, even though directed energy kill mechanisms operate at the speed of light, they are also range limited by attenuation of the beam. These range limits (coupled with the impracticality of stationing aircraft over most third country airspace or in places subject to hostile air defense) mean that, in a very broad spectrum of scenarios, a boost-phase interceptor cannot be located close enough to effect intercept during boost-phase.

Leaving aside the dominating problem of range limits, there are easily implemented countermeasures against boost-phase intercept, including salvoing and short burn times. These obstacles are not subject to being overcome by further testing or development in the foreseeable future. Nor are the geographical constraints on where boost-phase interceptors can be stationed likely to change. In particular, while long term research should continue, the prospect is not high for fundamental breakthroughs in laser technology that might significantly ease the limitations on directed energy boost-phase intercept.

There are a few limited cases in which boost-phase defense would be feasible—all have the common feature that the threat scenarios are such that the interceptors safely can be in position. These include:

- Engagement of a North Korean intercontinental ballistic missile launched against Hawaii, which could be defended against by an SM-3 Block IIA equipped Aegis ship in the East Sea, provided weapon release authority had been delegated.
- Engagement of theater ballistic missiles launched from hostile ships off the coasts of the U.S. or allies, provided the hostile ships had been identified and an Aegis ship or tactical aircraft equipped were stationed within a few tens of kilometers.
- In conflict situations in which the U.S. had air supremacy, so that tactical aircraft could safely operate close to or over enemy basing areas.

In general, for these sort of scenarios where proximity to the target is not an issue, no new interceptor types would be needed because existing interceptors based on tactical aircraft or ships could be used.

(11) Ref. "Please state the study panel's key observations and recommendations concerning the feasibility and cost of space-based interceptors of specific constellation sizes, including the cost comparison to other missile defense programs, over similar periods of time."

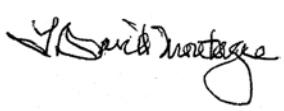
Space basing theoretically solves the range and stationing problem, but is prohibitively expensive because of the need to have literally hundreds, if not thousands, of interceptor satellites in orbit at all times to assure having one in a location such that it can intercept an attack—the timing of which is in the control of the enemy. Because of the costs to launch, maintain, operate, and replenish such a constellation, even a limited system geared to longer-burning liquid fueled threats would cost about $200 billion to acquire and have a $300 billion 20-year life cycle cost—at least ten times any other defense approach.

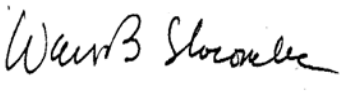
(12) Ref. "Please state the study panel's key observations about the prior administrations European Third Site Approach."

The committee did not analyze the prior administrations plan to deploy an additional interceptor site in Poland as such. However, since the interceptor proposed for that site would have been a derivative of the existing GBI, it would presumably have been subject to the same limitations that made the committee recommend replacing the existing GBI with a different interceptor. In addition, it is the committee's view, for the reasons stated in Answer (2), that it is preferable for homeland defense to put an additional interceptor site in the northeastern part of the U.S., and that the successful implementation of PAA Phase III would provide a sufficient defense of Europe.

We hope these responses to your questions are helpful and we would be pleased to answer any additional questions that you might have.

Sincerely yours,





L. David Montague, Committee Co-Chair Walter B. Slocombe, Committee Co-Chair
NRC Committee on an Assessment of Concepts and Systems for U.S. Boost-Phase Missile Defense in Comparison to Other Alternatives

cc: LTG Patrick O'Reilly, USA, Director, MDA
Mr. James F. Hinchman, Deputy Executive Officer, NRC