

REPORT OF THE DEFENSE SCIENCE BOARD

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TASK FORCE ON  
Defense Strategies for Advanced Ballistic and  
Cruise Missile Threats

January 2017



Office of the Under Secretary of Defense  
for Acquisition, Technology, and Logistics  
Washington, D.C. 20301-3140

This report is a product of the Defense Science Board (DSB).

The DSB is a Federal Advisory Committee established to provide independent advice to the Secretary of Defense. Statements, opinions, conclusions, and recommendations in this report do not necessarily represent the official position of the Department of Defense (DoD). The Defense Science Board Task Force on Defense Strategies for Advanced Ballistic and Cruise Missile Threats completed its information-gathering in February 2016. The report was cleared for open publication by the DoD Office of Security Review on 09 January 2017.

This report is unclassified and cleared for public release.



DEFENSE SCIENCE  
BOARD

OFFICE OF THE SECRETARY OF DEFENSE  
3140 DEFENSE PENTAGON  
WASHINGTON, DC 20301-3140

January 2017

MEMORANDUM FOR UNDER SECRETARY OF DEFENSE FOR ACQUISITION,  
TECHNOLOGY & LOGISTICS

SUBJECT: Final Report of the Defense Science Board (DSB) Task Force on  
Defense Strategies for Advanced Ballistic and Cruise Missile Threats

I am pleased to forward the final report of the DSB Task Force on Defense  
Strategies for Advanced Ballistic and Cruise Missile Threats.

The study reviewed current and future ballistic and cruise missile threats and assessed the implications of those threats to the survivability of U.S. forward based critical assets. The study found that the survivability of those assets could be very problematic given recent increases in potential adversary ballistic and cruise missile inventories and capabilities, in combination with a continued U.S. trend to make its regional offense capabilities increasingly dependent on fewer and fewer forward based assets. The final report recommends a three-pronged strategy to mitigate this problem based on a combination of passive defense enhancements, active defense enhancements, and some offensive capabilities not easily targetable by regional cruise and ballistic missiles. Implementing that strategy entails an ongoing annual investment of about \$2.5 billion.

The study also recommended that the Department of Defense enhance its ability to perform the kinds of broad, cross-Service and cross-modality cost effectiveness analyses that were highlighted by this investigation. Lastly, a recommendation is made for the Department to re-invigorate the process whereby critical warfighting assets are assessed for vulnerabilities and mitigation measures are prioritized.

I fully endorse all of the recommendations contained in this report and urge their careful consideration and soonest adoption.

A handwritten signature in blue ink, appearing to read "Craig Fields".

Dr. Craig Fields  
Chairman

## Executive Summary

The Defense Science Board task force on Defense Strategies for Advanced Ballistic and Cruise Missile Threats held its first meeting in January 2015 and its last in February 2016. Its membership included experts with broad experience in cruise and ballistic missile defense, cyber offense and defense, and in dealing with the challenges associated with military operations dependent on forward based critical assets. It also included government advisors from the Missile Defense Agency, Defense Intelligence Agency, and an Executive Secretary from the Office of the Secretary of Defense.

The terms of reference for the study directed the members to review current and future ballistic and cruise missile threats and assess the implications of those threats to the survivability of U.S. critical assets. That assessment was to be based on a review of current capabilities as well as the countermeasures a potential adversary might take to defeat or mitigate those capabilities. In response to whatever shortfalls might be uncovered by that review, the task force was asked to propose and prioritize both short and long-term potential responses, being particularly mindful of the relative cost effectiveness of the proposed recommendations. Lastly, it urged the study to look broadly at the problem and to include in its thinking not only improved missile defenses but also options for long range strike, improved surveillance sensing, autonomous systems, and alternate ways to accomplish missions with lower vulnerability to adversary missile attack.

Although the terms of reference left open the question of which critical assets should be the focus of the study, the task force decided early in its investigation to concentrate its attention on forward-based assets critical to U.S. military operations and attacks by missiles with non-nuclear warheads. This decision was based on the task force's belief that both nuclear attack and attacks on the U.S. homeland fundamentally change the nature of the problem to one of strategic deterrence and that the spirit of the terms of reference was more tactically focused, albeit both warfighting and deterrent capabilities have an important role to play.

The task force held meetings, received briefings, and participated in discussions with a wide range of organizations in the Office of the Secretary of Defense, including the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics, the Office of the Under Secretary of Defense for Policy, the Strategic Capabilities Office, Cost Assessment and Program Evaluation, and the Defense Advanced Research Projects Agency. Discussions were also held throughout the study with the Joint Staff, the Missile Defense Agency, and the Joint Integrated Air & Missile Defense Organization.

The task force received a number of briefings from members of the intelligence community and the Combatant Commands, including U.S. Pacific Command, U.S. European Command, and U.S. Strategic Command, as well as the U.S. Cyber Command. Several organizations in the U.S. Army, Navy, and Air Force also supported the study and provided briefings.

The task force hosted several companies heavily involved in missile defense, providing the task force with each company's views on future capabilities that might help deal with the problem. These companies included BAE, Boeing, Lockheed Martin, Northrop Grumman, and Raytheon. Finally, a number of subject matter experts from advisory organizations provided their assessments.

A foundation of the U.S. security strategy is to maintain the ability to conduct military operations any place in the world at any time it might become necessary. Doing so is dependent on the survival of a relatively small number of forward-based and forward-deployed assets, such as airfields, ammunition supply points, ports of debarkation, fuel distribution facilities, aircraft carriers, and so on.

Recent potential adversary investments in regional, precision attack cruise and ballistic threaten that foundation, investments that have dramatically increased both quantity and quality. The task force determined that a single solution was not adequate to solve this growing problem. Rather, a three-pronged strategy was recommended based on a combination of passive defense enhancements, active defense enhancements and some offensive capabilities not easily targetable by regional cruise and ballistic missiles. In addition, two more issues were uncovered: the definition of which assets are critical, assessment of their vulnerability and the prioritization of mitigation measures; and serious weaknesses in the the Department's ability to conduct meaningful, unbiased, cross-Service, cross-modality, cost-effectiveness analyses of the type required to guide investment strategies on difficult problems such as the subject of this study. Recommendations on how to improve the situation were provided on both issues.

Progress toward improving the functional and physical survivability of critical forward-based warfighting assets against ballistic and cruise missile threats will not be inexpensive (the study estimated an ongoing investment of about \$2.5 billion annually) and will thus require the continued attention and direction by senior DoD leadership. Unfortunately, no less than that will be sufficient for the U.S. to successfully carry out a national security strategy based in part on the ability to project force and military presence anywhere in the world at any time of its choosing.

To access a copy of the full report, please contact the Defense Science Board office.

## Terms of Reference



ACQUISITION,  
TECHNOLOGY  
AND LOGISTICS

### THE UNDER SECRETARY OF DEFENSE

3010 DEFENSE PENTAGON  
WASHINGTON, DC 20301-3010

MAY 16 2014

MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Terms of Reference – Defense Science Board Study on Defense Strategies for Advanced Ballistic and Cruise Missile Threats

Current and next generation foreign ballistic and cruise missiles are increasingly threatening the survivability of high-value U.S. air vehicles, sea-based combatants, land bases, and ground forces. The proliferation of advanced technology, including precise guidance, stealth technology, electronic warfare systems, multimode missile seekers, and improved deception and countermeasures, has reduced the defense capabilities of U.S. systems. A wide range of possible U.S. responses exists, but a broad review of the specific active and passive defense enhancements, strike options, and deterrence opportunities would strengthen the U.S. preparation for countering these missile threats and improving system survivability.

The purpose of this Defense Science Board (DSB) Task Force is to review current and future ballistic and cruise missile threats, assess the implications of those systems to the survivability of U.S. critical assets, review current U.S. responses to those threats and counter-measures that might nullify those responses, and investigate and prioritize a proposed short- and long-term U.S. response. A key Task Force concern should be the cost-effectiveness of any proposed recommendations.

A key component of developing a U.S. response is an analysis of the current missile threats and a projection of their future capabilities. Ballistic missile technology has proliferated to potential adversaries, and missile accuracy, range, maneuver, lethality, and countermeasure improvements will become increasingly challenging to long-range active defense sensors and interceptors. Cruise missile technology has also proliferated, and missile accuracy, speed, radar cross section, flight altitude, and maneuver improvements will become increasingly challenging to the survival of our high value assets. In addition to these missile advances, threat electronic and cyber warfare advancements can further reduce the survivability of our high-value assets by directly attacking our active defense systems, as well as the supporting command and control networks, communication links, and intelligence, surveillance, and reconnaissance (ISR) systems.

The United States should respond early to threats that have lower development costs and higher potential impacts. The Task Force should prioritize the most critical survivability concerns for near-term response, extrapolate the current missile threat, and prioritize the threat capabilities that should drive U.S. defense system and technology investment. Additionally, the Task Force should investigate the effects chains for the highest priority missile threats and highlight areas of potential vulnerability. These vulnerabilities may be exploited through a range of measures, to include: reducing threat sensor performance through electronic or cyber-attacks; hardening; adding target decoys; increasing background clutter; or using other deceptive

techniques. Improvements to our active defense system may also include enhancement of long-range sensor and interceptor performance through new target discrimination or combat identification techniques. Based on the threat effects, chain vulnerabilities, and the effectiveness of possible defense measures, the Task Force should review all current counter missile efforts and prioritize the defense system and technology needs for near and far-term investment. The Task Force should also look more broadly at possible responses, including improvements to our passive defenses, possibilities for pre-missile launch strike, disruption of the threat missile supply chains, and approaches for improved deterrence. Alternative, more resilient defense architectures should be investigated, including architectures with larger stand-off distances enabled by long-range strike missiles, improved ISR sensing, and autonomous air, land, and sea systems. Finally, in some instances, the United States may be fielding systems that are in effect lucrative targets that cannot be economically defended. In these instances, the Task Force should consider the possibility of employing alternate military systems to accomplish the required military objectives and missions with substantially reduced vulnerability.

I will sponsor the study. Mr. Bob Stein and Mr. Jim Carlini will serve as Co-chairmen of the study. Mr. James Macstravic will serve as Executive Secretary. Captain James CoBell, U.S. Navy, will serve as the DSB Secretariat Representative.

The study will operate in accordance with the provisions of Public Law 92-463, the "Federal Advisory Committee Act" and Department of Defense (DoD) Directive 5105.04, the DoD Federal Advisory Committee Management Program." It is not anticipated that this study will need to go into any "particular matters" within the meaning of title 18, U.S.C., section 208, nor will it cause any member to be placed in the position of action as a procurement official.



Frank Kendall

## Task Force Membership

### Chairmen

Mr. Robert Stein  
Mr. James Carlini

Private Consultant  
Private Consultant

### Executive Secretary

Mr. Edward Wolski

Office of the Under Secretary of Defense for Acquisition,  
Technology, and Logistics

### Members

LtGen Thomas Conant (Ret.)  
Mr. Roy Evans  
Dr. Aryeh Feder  
Mr. James Gosler  
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Dr. Joseph Markowitz  
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### Government Advisors

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Mr. David Burns  
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Missile Defense Agency  
Missile Defense Agency  
Defense Intelligence Agency

### Defense Science Board

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Executive Director  
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### Support Staff

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## **Briefings to the Study**

### **Office of the Secretary of Defense**

LCDR Rob Betts, Office of the Under Secretary of Defense for Acquisition, Technology & Logistics  
Mr. Tim Booher, Defense Advanced Research Projects Agency (DARPA)  
Dr. Yisroel Brumer, Cost Assessment and Program Evaluation  
Mr. Jeff Grobman, Cost Assessment and Program Evaluation  
Mr. Jacob Heim, Office of the Under Secretary of Defense for Policy  
Col Jason Hinds, Office of the Under Secretary of Defense for Policy  
Mr. Michael Olmstead, RDA Task Force  
Dr. Will Roper, Strategic Capabilities Office  
Mr. Chris Skaluba, Office of the Under Secretary of Defense for Policy  
Dr. Brad Tousley, Defense Advanced Research Projects Agency (DARPA)

### **Missile Defense Agency (MDA) and Joint Integrated Air & Missile Defense Organization (JIAMDO)**

Ms. Kari Anderson  
Mr. Keith Englander  
Mr. Richard Glitz  
Mr. Rich Matlock  
LtCol J.P. McDonough

### **Defense Intelligence Agency (DIA) and National Air & Space Intelligence Center (NASIC)**

Briefings on Russia, China, Iran, and North Korea

### **Joint Staff**

COL Steven Carozza, U.S. Army  
Mr. David Johnson  
Col Robert Manion, U.S. Marine Corps

### **Combatant Commands**

Dr. George Ka'iliwai, U.S. Pacific Command  
COL Robert J. Quigg, U.S. Strategic Command  
Mr. Peter Woodmansee, U.S. European Command  
Representatives from U.S. Cyber Command

### **U.S. Army**

LTG David Mann, Army Space and Missile Defense Command  
Mr. Kip Kendrick, Space and Missile Defense Command  
Mr. Mike Hammons, U.S. Army Engineering Research and Development Center

### **U.S. Air Force**

Mr. Jorge Beraun, Air Force Research Laboratory  
Mr. Greg Hulcher, HQE for SAF/AQ, Headquarters U.S. Air Force  
Dr. Carl Rehberg, Pacific Air Forces (PACAF)  
Mr. Joseph Shaw, Integrated Air and Missile Defense

### **U.S. Navy**

Mr. Bill Bray, Naval Sea Systems Command  
CDR Vincent Chernesky, Naval Sea Systems Command  
RDML Jon Hill, Naval Sea Systems Command  
VADM Thomas Rowden, Naval Surface Forces  
CAPT Andrew Stewart, Navy Cyber Warfare Development Group  
Mr. David Yoshihara, U.S. Pacific Fleet

### **Industry briefings**

Boeing Company  
BAE Systems  
Lockheed Martin  
Northrop Grumman  
Raytheon Company

### **Senior Advisors**

Dr. Anne Adamczyk, MIT Lincoln Laboratory  
Dr. Glenn Mitzel, Air Force Scientific Advisory Board  
Mr. Robert Tripp, RAND Corporation  
Mr. Linton Wells, MITRE Corporation