MDA Discrimination

JSR-10-620

August 3, 2010

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Abstract

This JASON study reports on discrimination techniques, both present and planned, for US ballistic missile defense in the mid-course flight phase of ICBMs and regional missiles. The mid-course phase encompasses ballistic flight through the airless exoatmosphere of an offensive threat cloud with lethal re-entry vehicles (RVs), launch-associated objects such as rocket fuel tanks and booster stages, and deliberate countermeasures including decoys. Discrimination is necessary both to distinguish RVs from deliberate countermeasures, such as decoys, as well as to distinguish the RVs from launch-associated objects. Discrimination assets reviewed include radars and other sensors connected with the Ground-Based Interceptors (GBIs) and their warheads, the Exoatmospheric Kill Vehicles (EKVs), as well as the Aegis defense system of ship-based Standard Missiles used with the SPY-1 radar. Defenses against shorter-range missiles by the THAAD and Patriot systems were not considered. The study was done for the Missile Defense Agency, at the request of Congress.

Executive Summary

This is an unclassified executive summary of a classified report, called for in the 2010 National Defense Authorization Act, on the discrimination capabilities of the US ballistic missile defense systems. The JASON study was supported by the Missile Defense Agency (MDA), which gave us full access to the information we needed. We thank them for their generous cooperation. The Act required that:

> ...JASON shall carry out a study on the discrimination capabilities and limitations of the ballistic missile defense system of the United States, including such discrimination capabilities that exist or are planned as of the date of the study.

Our report covers two areas of the mid-course phase, or layer, of missile defense.[1] The first is the Ground Missile Defense (GMD) system that employs Ground-Based Interceptors (GBIs) whose defensive warheads, the Exoatmospheric Kill Vehicles (EKVs), attempt to destroy the lethal threat objects (re-entry vehicles, or RVs) by impact (hit-to-kill). The second, also hit-to-kill, is the Aegis system now mounted on special cruisers and destroyers. Under the MDA Phased Adaptive Approach, Aegis hardware, including missiles and the supporting radar, are to be used on land (Aegis Ashore) where they will be integrated with powerful ground-based radars. Both GMD and Aegis engage RVs in mid-course flight at very high altitudes in the airless exoatmosphere, where the RVs and accompanying objects, possibly including countermeasures such as decoys, are assumed to be in ballistic flight.

[1] We did not consider defense in boost, ascent, and terminal phases, where discrimination is less important. In particular, we do not deal with THAAD and Patriot missile defense systems.

We begin with some general remarks on discrimination issues, followed by a brief history of MDA's accomplishments and shortcomings, and then give our unclassified findings and recommendations. In a number of cases the evidence for our findings is available only in the classified report, whose findings and recommendations give more detail than we can give here.

1 Discrimination challenges

In the context of missile defense, to discriminate is to distinguish among lethal RVs in mid-course flight that should be targeted by defensive kill vehicles, and non-lethal accompanying objects, whether deliberate countermeasures such as decoys or objects that usually accompany a missile launch, such as booster stage and rocket fuel tanks. Even in the absence of coutermeasures, discrimination is still necessary to distinguish RVs from these launch-associated objects. Sensor assets, such as radars, that can be used for discrimination are also essential to track all the objects in a threat cloud. The kill vehicles carry optical sensors to track and home on the RV.

Discrimination of countermeasures is a stringent challenge, because given a reasonable amount of time, money, initiative, and expertise, the offense can (in principle) field countermeasures that the defense cannot handle at any reasonable marginal cost. Aside from the actual missile defense itself, a main defensive objective must be to make the offense's use of countermeasures difficult, costly, and uncertain—if possible—always with the objective of *deterring* the missile attacks themselves or dissuading the offense from using the most effective countermeasures.

The classic countermeasure is a decoy that causes the defensive kill

vehicle to think a decoy is an RV, or that the RV is a decoy, so that the kill vehicle misses its true target. But countermeasures need not be just decoys; they can include RVs that maneuver in mid-course out of the way of the kill vehicle (violating the assumption of ballistic flight), or maneuver aerodynamically at re-entry into the atmosphere[2] and, technically simplest of all, the raid or salvo threat: Launching of enough offensive missiles at one time and one place, so that the defense is overwhelmed.

2 A brief history

The Missile Defense Agency (before 2002, the Ballistic Missile Defense Organization) has the mission to design and deploy a layered missile defense system for the US and its allies. In past years a recognition of the rapidly-growing proliferation and sophistication of the threat of both nuclear and non-nuclear missiles led to MDA's being given special exemptions from some of DoD's usual acquisition and test evaluation requirements. The result was that flight tests were schedule-driven, and if a flight test failed it was not easy to re-schedule it; there was a substantial number of flight-test target failures.

In 2007 the Missile Defense Executive Board, with senior representatives from Defense, State, and the National Security Council, was formed to recommend and oversee the implementation of many MDA strategic policies and plans. With this Board's guidance the flight test program was restructured, becoming more effective at gaining understanding and techni-

[2]During the Gulf War, Iraqi SCUDs tended to break apart as they re-entered. The extra debris and wobbly flight of these SCUDs were an example of inadvertent but effective countermeasures against the Patriot missile defense system of that era.

cal skills through testing. In consequence, MDA today has a good record of intercepting test RVs, but under conditions that often do not challenge the discrimination capabilities of the missile defense system.

In 2006, following recommendations by an MDA-sponsored external review body termed the Black Team[3], the discrimination paradigm changed radically. Certain long-held assumptions were overthrown in favor of a more realistic view of the threat, the potential for effective countermeasures, and the technical means needed to discriminate effectively. To its credit, MDA embraced the findings of the Black Team and immediately embarked on new programs designed to implement them.

Unfortunately, it was not easy to change the legacy of discrimination, because so many costly hardware assets were already in place and it would be difficult to change or replace them; furthermore, contracts existing at that time supporting the legacy discrimination program could not be easily changed. At the same time the threat had not, and still has not, stopped growing and changing. As a consequence, today MDA has a vision for future discrimination whose implementation may fall behind the evolution of the threat, both in its size and its countermeasure capabilities.

3 Findings

1. In flight tests of recent years MDA has shown success in hitting a test RV, often in circumstances that do not challenge discrimination capabilities.

[3]Under MDA sponsorship the Institute for Defense Analyses organized a Red Team of non-MDA scientists with no inside knowledge of MDA technology to challenge the theoretical model of discrimination and countermeasures. Later, the Red Team was given this inside knowledge and continued its challenges, under the name of the Black Team.

2. Development of missile-defense radars such as the Sea-Based X-band (SBX) radar has been effective.

3. Much remains to be learned about the practical feasibility and effectiveness of countermeasure threats.

4. The Aegis (Ashore) current and planned programs and supporting technology are technically sound for a legacy threat, but that threat is rapidly being superseded by new and more dangerous ones, such as multimissile raids.

5. MDA is not agile and flexible, and it may have trouble responding to opponents' timelines for developing and fielding decoys and other countermeasures.

6. In certain areas, resource allocation is not aligned with rapidly evolving threats and discrimination needs.

7. Although MDA has, to its credit, established some small-scale review bodies and Red Teams in certain technical areas, it has no US peer competitor in missile defense that can independently and authoritatively review, test, and challenge MDA's technical programs. There are US government or government-sponsored laboratories as well as academic bodies that could collectively fill this role.

4 Recommendations

These findings lead to an overarching recommendation:

MDA should consider adjusting its priorities to establish alliances with US government-sponsored laboratories and academic groups. These bodies

would, within broad MDA mission guidelines, act independently of MDA; have outstanding technical expertise in MDA mission areas; have full inside knowledge of relevant MDA programs; and funding to carry out challenging reviews and simulations as well as to propose alternative concepts. When justified, and with the cooperation and support of MDA, these bodies should be involved in testing programs. Although funded by MDA they would not act as standard contractors, working to detailed and rigid proposals. Their role would be to give independent and authoritative critical reviews of MDA programs; to formulate, simulate, and validate alternative concepts and strategies; and to supply Red Team challenges to the missile defense system. We mention here three technical areas of interest, but there may be others:

1. We recommend that MDA form a countermeasures test program through an independent agency. This agency, with appropriate connections to the Critical Measurements program and other elements of MDA, would have the responsibility to challenge MDA countermeasures efforts, to design countermeasures, and to simulate their performance against the national missile defense. When it seems warranted this agency would build and test, in cooperation with MDA, these countermeasures in intercept flight tests.

2. We recommend forming stronger two-way connections between MDA and the intelligence agencies gathering and interpreting data on foreign missile threats and countermeasures, with MDA staff assigned to work with intelligence analysts in technical interpretation of the data.

3. We recommend that MDA make use of an independent technical body with statistical expertise to make a comprehensive analysis of engage-

ment optimization, including defenses against raids, that includes uncertainties in knowledge of threat properties.

There are also several technology-oriented recommendations, of which we can only give two here:

1. MDA should make it a high priority to resolve information flow bottlenecks in the integration of their BMD assets into a unified system.

2. MDA should consider, as laid out in the main report, specific sensors on forward-based UAVs, near the radars, to provide important data for fusion with the radar information.