BMD: The world's largest defense electronics market

Even before North Korea's own "declaration of independence" on July 4 of this year, ballistic missile defense (BMD) was a huge defense electronics program in the U.S., as sensors and C4I (command, control, communications, computers, and intelligence) are the most crucial aspects of most programs. New interceptors (missiles) have also been developed, but the process of locating, tracking, and destroying opposing missiles is largely controlled by sophisticated electronics rather than brute force. Now, with threats of even longer range ballistic missiles from China as well as North Korea, BMD can be expected to remain the world's most important defense electronics market.

The mission of the Missile Defense Agency (MDA) is to develop a ballistic missile defense system (BMDS) for defending the U.S. and its deployed forces, friends, and allies from ballistic missiles. The MDA's overall approach to developing and fielding a BMDS is to create an integrated, layered defense against threats of all ranges, in all phases of flight, that will ensure the defense is not vulnerable to any particular threat. BMDS will likely provide the greatest funding of any defense electronics program over the next decade, with radar sensors and complex C4I systems earning the bulk.

There are currently two Pave Paws upgraded early warning radar sites in the U.S.

Midcourse defense

The BMD midcourse defense segment phase of flight offers, for the time being, the most significant leverage to engage the threat. It aims to engage and destroy ballistic missiles in their boost or midcourse phases of trajectory. From a time perspective, the midcourse phase is comparatively long, allowing defenses extended sensor viewing time and multiple engagement opportunities. It is the first line of defense.

Perhaps surprisingly, space-based and airborne electrooptical and infrared sensors and C4I will receive relatively minor funding compared to terrestrial radars, worth between $500 million and $900 million per year for the next decade. But although only a small slice of BMD funding, these will be among the most valuable electrooptical programs in the world, and are also vital to the MDA's layered BMDS approach.

The DSP (Defense Support Program) satellite constellation has been in service, with constant updates, for more than 30 years, with the last of 25 DSP satellites just launched. Aerojet General and Northrop Grumman have supplied the primary sensor—short-wave infrared—with Lockheed Martin prime contractor for the associated Joint Tactical Ground Station.

The Space Based Infrared System (SBIRS)-High program, the largest and most vital of the next-generation space-based elements of the BMDS, has seen repeated cost growth and schedule delays. This has led some to suggest elimination of one of the satellite's sensors as a way to cut costs. In recent years, SBIRS-High's program cost has increased by more than $3.5 billion, raising the total to almost $10 billion.

The four SBIRS-High geosynchronous Earth orbit satellites are designed to carry two sensors each, an IR scanning sensor to search the entire Earth rapidly for major IR events (missile launches), and an IR staring sensor that is then cued to view a particular area, looking for much briefer IR events such as the quick burn of short- or theater-range missiles. The staring sensor will be able to monitor several areas on Earth, with revisit times significantly shorter than those of the DSP satellites. These GEO spacecraft will interact with SBIRS-High IR scanning sensors on two satellites in highly elliptical orbit, which will eventually replace the DSP satellites. Northrop Grumman is prime contractor for all these sensors.

The other next-generation system, the STSS or Space Tracking and Surveillance System (formerly SBIRS-Low), will provide data to close the fire control loop with BMDS interceptors, allowing earlier and, if necessary, additional shots. STSS will focus on midcourse detection and tracking, after the target has separated from its hot booster (where SBIRS-H sensors excel). This phase is particularly difficult, with a cold target against the cold backdrop of space.

The two Block 2006 R&D STSS satellites will have a short-wave IR acquisition sensor with a scanning refractive telescope and a narrow field-of-view tracking sensor with an "agile" telescope, all developed by Raytheon. Sensors will cover bands from visible light to long-wave IR. Production Block 2012 sensors—to be a major program—are still in competition between Raytheon and Northrop Grumman.

The Airborne IR Surveillance (AIRS) program allows for the acquisition and tracking of BMD targets from horizon to horizon through aircraft zenith. The AIRS program is a proof of concept for employing optical sensors as an operational ele-


The SBX radar, seen here on a mobile oil rig, is 27 stories high.

ment of the BMDS. AIRS sensors have been developed and integrated by L-3 Communications' Aeromet Division.

Another major component of midcourse defense is the legacy BMD upgraded early warning radars (UEWRs), comprised of large ground-based, fixed-site, phased-array radar complexes originally developed for detection and early warning of Soviet strategic submarine-launched ballistic missile attacks against the U.S. There are currently two Pave Paws UEWR sites in the U.S. (on perimeter coastlines at Cape Cod and at Beale, Calif.), and three BMEWS (Ballistic Missile Early Warning System) UEWR sites, in Alaska (Clear), Greenland (Thule), and the U.K. (Fylingdales). Upgrades to these radars will be worth about a quarter-billion dollars per year for the next decade.

For BMDS use, the UEWRs detect, track, and count individual targets early in their trajectory, and also cue the higher resolution X-band radars to the location and trajectory of incoming targets. Pave Paws and BMEWS radars have all been upgraded to Pave Paws standard and will be a major component of any future BMD system. Planned future upgrades will provide precise tracking early enough to significantly expand the battlespace for ground-based interceptors.

In November 2000 Taiwan requested a possible sale of two Pave Paws radars, though by August 2001 the plan had changed to one modified AN/FPS-115 Pave Paws. In March 2004, the DOD finally okayed the sale, now planned as one initial radar, to be followed by a second when Taiwan's finances allow. In June 2005, Taiwan contracted for the first radar, worth $752 million.

Raytheon is the developer and prime contractor for upgrades to UEWR radars, though several other companies have won large support contracts to maintain and manage these fixed-site systems in extremely cold, harsh environments.

The final, and most valuable, component of the BMD Midcourse Defense Segment (aside from the already in-service Aegis system) is a series of large ground- or sea-based X-band radars, either fixed site or relocatable. Systems and programs include the GBR-P (ground-based radar-prototype) on Kwajalein Atoll, the SBX (sea-based X-band) and IFICS (in-flight interceptor communications system) data terminal (IDT) and GCN (GMD communications network), the FBX-T (forward based X-band radar-transportable), TPS-X radar and X-band dish radars, Cobra Dane radar on Shemya Island in Alaska, CJR (Cobra Judy Replacement) radar, and, finally, GFC/C (GMD fire control and communications) system.

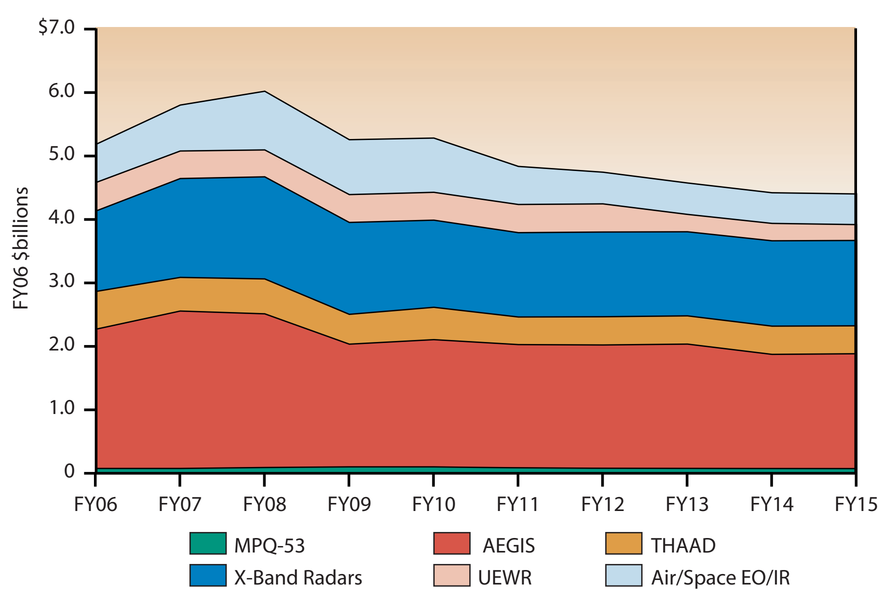
Many of these next-generation programs are classified, but we estimate they will be worth about $1.5 billion per year for at least the next several years.

These X-band radars, also with huge AESA (active electronically scanned array) antennas, are more sensitive for long-range target discrimination than in-service S-band (AN/SPY-1 Aegis) or G-band (AN/MPQ-53 Patriot) radars. They enable better detection of slow-flying cruise missiles and of larger, faster ballistic missiles, and also provide better discrimination against background clutter at low altitudes.

Raytheon essentially has a monopoly on large X-band radars, and nearly all these very expensive systems have Raytheon as both prime contractor and radar developer. Northrop Grumman is developing some of the C4I systems (GFC/C and IDT).

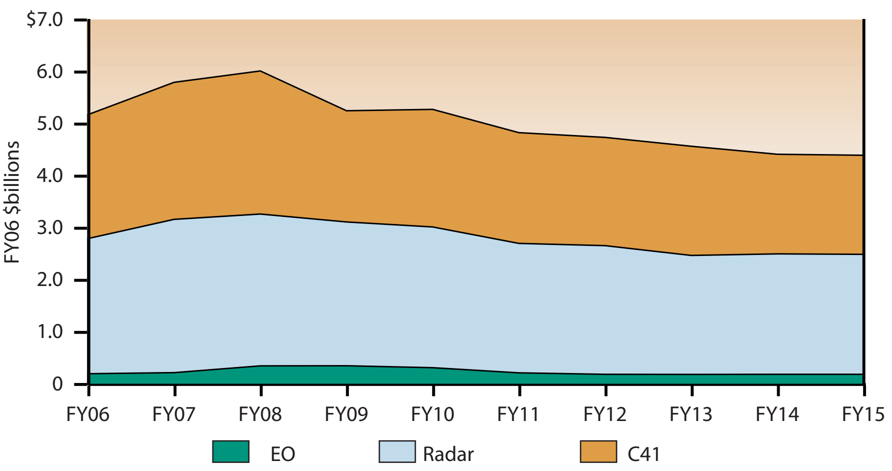
BMD FUNDING FORECAST

RDT&E+procurement available to the U.S.



BMD FUNDING SHARE

RDT&E+procurement available to the U.S.



Aegis BMD

The second primary element of the BMD Midcourse Defense Segment is Aegis BMD (including both sensors and C4I), which comprises the backbone of today's BMDS capability. Aegis BMD will be worth about $2 billion per year through our forecast period.

At the heart of Aegis BMD is Lockheed Martin's SPY-1 3D phased-array air search radar, the basis for the weapon system. The SPY-1 antenna system comprises four 12 ft×12 ft octagonal faces mounted flush with the ship's superstructure, each with 140 array modules containing at least 32 radiating elements and phase shifters driven by eight transmitters. Raytheon supplies major components of the SPY-1 system (its transmitter and the Mk 99 fire control system), and the list of subcontractors to Lockheed Martin is almost too long to count.

The Aegis system is used aboard Navy CG-47 (Ticonderoga)-class cruisers and DDG-51 (Arleigh Burke)-class destroyers, Japanese Kongo-class destroyers, and Spanish F-100 frigates. It is currently in production for the Arleigh Burkes, more Kongos, and South Korean KDX-III destroyers. Production of the smaller SPY-1F is under way for five Norwegian Fridtjof Nansen-class frigates, and Australia selected Aegis in July 2005 for its future Air Warfare Destroyers, to enter service from 2013. In all, Aegis is currently deployed on more than 75 ships around the world, with about 30 more ships planned or contracted, and many more than this in our forecast. Even Taiwan will likely eventually get the Aegis ships it has long requested.

Major Aegis upgrades are ongoing to support BMD developments, with continuing "baseline" improvements for new builds and ship retrofit. Baseline 7 was approved for deployment in September 2005, including the first complete COTS computing architecture. Lockheed Martin is continuing to develop commercial system software for the Navy's Aegis Open Architecture program, which will lower Aegis costs, boost capabilities, and extend service life by allowing the Navy to exploit commercial computing technology.

Today, Navy ships are certified only for contingency BMD capability, as part of the Navy's emergency Aegis BMD program, with the Aegis 3.0 tactical program and SM-3 Block 1 missile. This basic capability is available on only about 10 ships, with two engagement cruisers and only 11 missiles available for emergency deployment in Hawaii as of early this year.

In July 2005, Japan also contracted with Lockheed Martin (through FMS) to upgrade one existing Kongo-class Aegis destroyer to an Aegis BMD Block 2004 capability. This $124-million contract, with work to be performed largely in the U.S., is just the first of many as Japan becomes a full member in the U.S. BMDS program. They are also participating in FBX-T X-band radar development and deployment.

Terminal defense

The final layer of the BMDS is the Terminal Defense Segment, which provides the final opportunity to engage short- to medium-range ballistic missiles not engaged or destroyed in the boost or midcourse phases of trajectory. Patriot, THAAD, and Aegis BMD provide today's only capability to defend deployed U.S. forces from short- to medium-range ballistic missiles, and to protect broadly dispersed assets and population centers or selected U.S. sites. Mobile ground-based programs will be worth more than a half-billion dollars per year for the next decade.

Raytheon's AN/MPQ-53 is the primary engagement radar of the Patriot ground-based mobile medium- to long-range air defense missile system. Patriot has been in service for more than a decade—it had some success downing Iraqi Scud missiles in Operation Desert Storm in 1990-1991—but antimissile system development continues under Lockheed Martin's PAC-3, or Patriot ATM (anti-tactical ballistic missile) Capability-3, program, which adds the PAC-3/ERINT kinetic-energy hit-to-kill missile. Army procurement funding for Patriot ended in 1992, but was revived when PAC-3 came on line.

MPQ-53 upgrade funding for BMD will continue at a moderate level for the U.S. military, with about 104 radars procured, though this funding will be minimal compared to larger BMD sensors, at less than $100 million per year. Perhaps more rewarding will be sales for international customers. The Patriot offers a proven missile defense capability, it is affordable, and it is releasable to many U.S. allies. Japan and Germany have been involved in license production of earlier versions of the system, and it has been sold to the Netherlands, Germany, Italy, Israel, Turkey, and Saudi Arabia. Interest in ballistic missile defenses, especially in Asia, indicates a large potential market for PAC-3 systems and the MPQ-53 radar.

THAAD (Terminal High Altitude Area Defense) is a hypervelocity, antitactical ballistic missile system designed to defend large areas by defeating tactical ballistic missiles in the upper atmosphere. It will provide area defense in contingency operations, and will complement the shorter-ranged Patriot PAC-3 system. THAAD is transportable via C-5 and C-17 sorties.

Raytheon's THAAD radar is an X-band phased-array system using 25,344 solid-state transmit/receive modules. It

BMEWS has three locations—in Alaska, Greenland, and the U.K.

provides the fire unit with initial surveillance data, missile uplink features, and continual missile and target tracking. Data provided by the THAAD radar are used to perform target classification, target ID, impact point prediction, attack assessment, and kill assessment. The radar is reported to have a nominal detection range in excess of 1,000 km, although the missile has a range of only 200 km with a ceiling of 150 km. Versions of THAAD are also being developed into several other X-band BMDS radars.

The MDA plans to field the first fire unit in 2009 and the second in 2010. These systems will likely be EMD (engineering and manufacturing development) systems, even if everything stays on schedule, which is unlikely. A genuine procurement decision is very unlikely before FY10. By the middle of this year, total costs for THAAD since 1992 had probably reached $8 billion. By 2011, costs will reach $12.3 billion, according to the Government Accountability Office. We forecast about a half-billion dollars per year for the next decade.

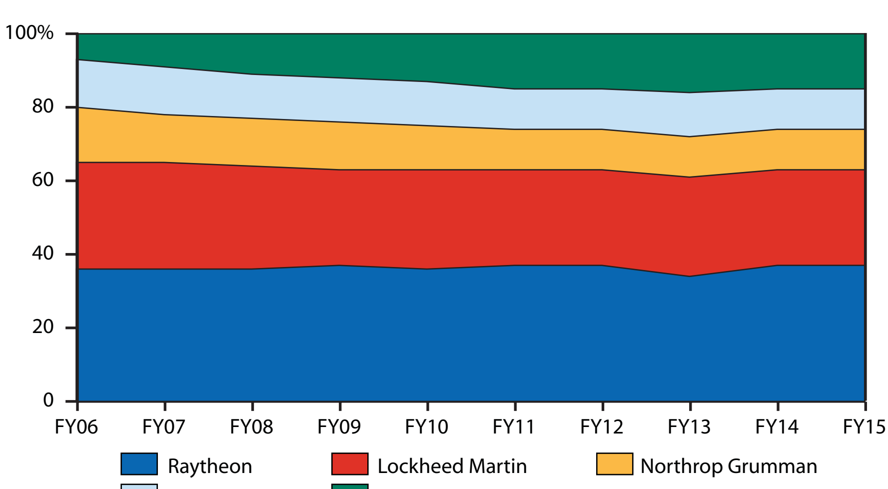
Winners and losers

BMD funding will decline after a peak of $6 billion per year in FY08. However, even with very few individual programs, BMD will remain one of the largest segments of the defense electronics market. It will exceed the total electrooptical (EO) market every year for the next decade, and will nearly match the entire radar market. The largest world radar programs are for BMD. The only segment of the radar market that will approach BMD funding will be airborne fighter radars, with $21.1 billion forecast from FY06 to FY15, versus $25.8 billion for BMD radars.

Because networking sensors are so important for ballistic missile detection in multiple layers across the globe, BMD C4I will receive nearly as much funding as the sensors themselves ($22.3 billion from FY06 to FY15), probably the one defense sensor market where this will be the case. EO sensors, once the primary detectors of ballistic missile launch, will become a relatively small portion of the total ($2.5 billion), although not really a small market at all.

BMD MARKET SHARE

RDT&E+procurement available to the U.S.



Aegis is currently deployed on 75 ships around the world.

Who will reap the windfall of all this funding ($50.5 billion over the next 10 years)? As might be expected, the "big three" defense sensor manufacturers will gain the lion's share, though a large portion allocated to Raytheon, Lockheed Martin, and Northrop Grumman will in fact be subcontracted to other defense and commercial electronics firms, especially for C4I. Other funding for major contracts will go to companies besides the big three, and there is also "available" (meaning still uncontracted) funding that could go to anyone—including, for example, Raytheon or Northrop Grumman, currently competing for the billion-dollar Block 2012 STSS sensor contract.

Raytheon will lead the overall BMD sensor and C4I market ($18.3 billion from FY06 to FY15) largely because of its total dominance of numerous large X-band radar programs. Lockheed Martin ($13.7 billion) will be equally dominant with Aegis—this single huge program should provide the majority of their BMD funding. Northrop Grumman will bring up the rear ($6.2 billion), never quite achieving the status of heavyweights Raytheon and Lockheed Martin. Though Northrop will actually be number two to Lockheed Martin in C4I, and will lead the EO market with their SBIRS-High sensor, they will have a very small part in BMD radar programs and consequently will lack the power to control, or steer, any segment of the BMD market.

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