BMDS/SSA Integrated Sensing Demonstration (BISD)

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ABSTRACT

This demonstration is intended to provide a near-term prototype, leave-behind capability for integrating Ballistic Missile Defense System (BMDS) ground sensors for use in the Space Situational Awareness (SSA) mission. Closed-loop tasking and cueing capability will be implemented, and a demonstration of net-centric space data dissemination using the BMDS sensors will be undertaken using various SSA mission threads. The demonstration is designed to highlight the implications of modifying software and/or hardware at the BMDS command and control node so that cost, risk, and schedule for an operational implementation can be fully understood. Additionally, this demonstration is intended to assess the impacts to both mission areas as a multi-mission, non-traditional sensor capability is integrated into the SSA mission. A successful demonstration will have many leave-behind capabilities and first-of-it's-kind achievements to include: a) an extensible SSA operational prototype configuration for BMDS X-Band radars such as AN/TPY-2 and Sea-Based X-Band (SBX) b) a prototype SSA tasking and cueing capability between the Joint Functional Component Command for Space (JFCC Space) Joint Space Operations Center (JSpOC) and the Command, Control, Battle Management, and Communications (C2BMC) Experimental Laboratory (X-Lab), extensible to the Combatant Commands (COCOMS), and out to BMDS sensors c) a capability for a two-way, net-centric, interface for JSpOC space operations, to include translation from net-centric communications to legacy systems and d) processing of BMDS X-Band Radar tracks in the Space Defense Operations Center (SPADOC).

BACKGROUND

In August of 2009 the Commander of Air Force Space Command (AFSPC/CC) directed a 100-Day Assessment of the potential for leveraging Ballistic Missile Defense System (BMDS) assets to support the SSA mission. The results and recommendations of this assessment were briefed to the AFSPC/CC in December 2009. The assessment focused on the Space Situational Awareness (SSA) mission utility of certain BMDS ground-based radars and concluded that while there were no heavy lifters, there was potential for niche contributions in the areas of space launch custody and space object characterization [1]. The assessment team also concluded that these niche/tactical contributions did not offset any of the planned and programmed AFSPC radars such as the Space Fence. Following the 100-Day Assessment, AFSPC developed an Action Plan in 2010 outlining all the Doctrine, Organization, Training, Materiel, Leadership, Personnel, Facilities (DOTMLPF) tasks required if the government were to fully integrate SSA capabilities within the BMDS domain. One of the near-term tasks in this plan is to do a technical demonstration of the viability of integrating a BMDS radar with the SSA force structure. This demonstration, now called the BMDS/SSA Integrated Sensing Demonstration (BISD), was funded by AFSPC in Fiscal Year (FY) 2011 and is planned for execution in October 2011.

The objectives of the BISD are to: a) conduct SSA operations using a TPY-2 radar on a non-interference basis to it's primary mission b) develop and demonstrate prototype machine-to-machine sensor tasking and cueing capability for non-traditional sensor contributions to the SSA mission c) create a deployable prototype space edge processor with logic for creating SSA data products from ingested raw sensor data d) demonstrate net-centric data exposure of space products with translation for backward compatibility with legacy systems and e) develop an SSA operations configuration for TPY-2 using integrated mission profiles while doing no harm to the primary mission [2]. This demonstration will allow AFSPC and Missile Defense Agency (MDA) to gain a deeper understanding of the feasibility of integrating an operational SSA capability for TPY-2 and, as an extension, other BMDS ground-based X-Band radars. The themes of this demonstration also touch on goals as directed by Department of Defense (DoD) senior leadership. These goals include the creation of multi-mission operations capabilities within both sensors and command and control (C2) assets for different mission domains – in this case SSA and BMDS. Another SSA strategic goal is to leverage the use of non-traditional sensors - those sensors not originally designed and fielded to conduct SSA operations. Preparation and execution of this demonstration will take approximately twelve months, with October 2011 as the target demonstration date.

DEMONSTRATION PREPARATION

Sensor

The TPY-2 radar was designed for support of the missile defense mission, not SSA. Therefore, the radar allocation of radio frequency (RF) energy and beam formation must be tailored to accommodate the space mission. For the purpose of the BISD, Raytheon has modified some of the existing mission profiles to allow for SSA waveforms. These mission profiles are tested within the TPY-2 Hardware-in-the-Loop (HWIL) at the development facility prior to being employed by the radar at the BISD site. The final demonstration will show how the mission profile's capability can support both the primary mission and the subordinate SSA mission on a non-interference basis.

The satellite tracking data that is collected by the BMDS radar must be interoperable with the SSA mission processing accomplished at the JSpOC. The SSA data formation will be accomplished by a Massachusetts Institute of Technology Lincoln Laboratory (MIT/LL)- developed prototype edge processor. The edge processor will produce SSA interoperable positional/metric data on satellite targets as well as Space Object Identification (SOI) data on selected satellites of interest. This forward-deployable edge processor development leverages the original Extended Space Sensors Architecture Advanced Concepts Technology Demonstration (ESSA ACTD) from 2009 and tailors it to the latest TPY-2 hardware and software configuration baseline with an added goal of reducing the power and physical space footprint when mated with the radar thereby creating a tactical configuration for the space mission. Early testing of the edge processor and its interface with the radar takes place at Vandenberg Air Force Base (VAFB) and the Pacific Missile Range Facility (PMRF) prior to the final demonstration scheduled for October 2011.

Command and Control (C2)

Space tasking and requests for space track collection support is initiated by the JSpOC for the SSA mission. However, the TPY-2 radar is not designed to receive and or process these type of requests. The TPY-2 radar must receive cues from a C2BMC element. Therefore, the C2BMC X-Lab integrates space tasking translation logic that converts JSpOC tasking to standard B- or C-series cue messages and allows for transmission and access to the radar in a timely fashion. This translation logic has been prototyped by Raytheon and will be tested early in a pair wise test using the HWIL and X-Lab. The C2BMC element must also deconflict the radar activities prior to sending any timely cues, select mission profiles, and propagate satellite ephemeris to validate access. AFSPC astrodynamic algorithms will be integrated to improve interoperability and performance. Once cues are sent to the radar, acknowledgement messages will be sent to the correlation element at MIT/LL to ensure collections are on the expected targets.

The JSpOC will utilize the operational auto-tasker capability to initiate space tasking requests for the TPY-2 radar. This requires an addition of the radar location and performance parameters to the tasking database. The auto-tasker will check sensor visibility as compared to a small set of candidate satellites and initiate TPY-2 tasking message dissemination for the C2BMC X-Lab. In addition, the JSpOC can provide an element set service which posts the relevant positional data in Two-Line Element (TLE) set format for the tasked satellites. Once the radar collections are complete and processed by the edge processor, the SSA data products (Metric and SOI) can be disseminated back to the JSpOC for mission processing. This will require utilization of the SAFB Mod 10 interface for non-traditional sensors. The JSpOC SPADOC system will be able to process the metric data utilizing automated and manual differential corrections (DCs) to integrate the satellite observations into the United States Strategic Command (USSTRATCOM) Space Catalog. Numerical validation of the radar observations will be accomplished by AFSPC early to ensure interoperability and quality control for the Space Catalog.

Net-Centric Environment
The Secret Internet Protocol Router Network (SIPRNet) will serve as the transportation layer for data exposure and traffic flow. SSA data products will be published via Net-Centric Enterprise Services (NCES) messaging on the SIPRNet, making them available for import to the JSpOC and the National Air and Space Intelligence Center (NASIC). MIT/LL has developed eXtensible Markup Language (XML) schemas for the data product messages as well as the tasking message conversion from the SPADOC surrogate sidecar. These schemas aid in harmonizing data objects within the SSA mission domain. Harmonization improves the consistency and comparability of data across information systems. They also aid in ensuring better interoperability through a common approach to representing data.

The JSpOC Mission System (JMS) Element Set service will be leveraged for this demonstration. This initial JMS release provides a Service Oriented Architecture (SOA) approach to dissemination of space catalog positional data such as element sets. Element sets will be posted which correspond to the tasking requests the JSpOC transmits to the C2BMC X-Lab for TPY-2 satellite collection support.

RISK REDUCTION

This demonstration requires the coordination of multiple government organizations (AFSPC, USSTRATCOM, MDA), engineering companies (MIT/LL, MITRE, The Aerospace Corporation, and Raytheon), as well as the development and testing of first-of-its-kind capabilities. Mitigation of risk is essential to a successful demonstration. The following are some examples of risk reduction measures prior to the final demonstration:

- Pairwise testing will be accomplished between the TPY-2 HWIL and the C2BMC element at the X-Lab. The test will run the interfaces and message traffic such as cues between the radar and C2BMC.
- The edge processor will be deployed to VAFB to participate in the MDA Field Test Exercise (FTX)-17 event. This is an opportunity to test out the mating of the edge processor and the radar as well as allow for satellite data collections using the Raytheon-modified mission profiles and SSA processing within the edge processor.
- Data collections will be accomplished at PMRF working around the Flight Test Terminal High-Altitude Area Defense (FTT)-12 schedule. This provides testing of the edge processor interface with the actual demonstration radar and provides opportunities for early satellite data collections.
- TPY-2 satellite tracking data collections will be numerically validated by AFSPC prior to being allowed to be sent to the JSpOC for mission processing during the demonstration
- A dress rehearsal will be accomplished just prior to the demonstration. This will test out the end-to-end interfaces between JSpOC, C2BMC, and TPY-2/edge processor.

EXECUTION OF DEMONSTRATION

The final demonstration is planned for October 2011. It will initiate with space tasking from the JSpOC utilizing the SPADOC and Special Perturbations (SP) tasking capability. A standard tasking message will be disseminated containing the satellite numbers, priority categories, and collection requirements via the legacy interface to MIT/LL. The JSpOC tasking message will then be transmitted to the surrogate sidecar at Lincoln Laboratory and converted to an XML message which can then be exposed net-centrically on SIPRNet. In addition to the tasking message, the associated element sets will be made available via a SOA approach leveraging an early JMS service. .

The C2BMC/X-Lab will pull the JSpOC generated space tasking and the associated element sets off the SIPRNet and translate the requests to cue messages. This translation process includes functions such as a) deconfliction of other sensor activities such as missile defense b) propagation of the element sets to current time c) creation of sensor look angles and d) selection of sensor mission profiles. The cue message will then be transmitted to the radar via dedicated BMDS networks. In addition, the X-Lab will disseminate a tasking acknowledgment message, again via dedicated BMDS networks, to the edge processor to aid in correlation.

The TPY-2 radar will receive the cue message and initiate satellite tracking. The radar will configure with the selected mission profiles which allow for the proper waveforms and allocation of RF energy to conduct SSA collections. The collected satellite data will be processed by the mated edge processor and SSA data products (observations and SOI) will be transmitted to the correlator at Lincoln Laboratory. Once the correlation confirms the SSA products match the requested targets, the data will be posted on SIPRNet. If the correlation is not confirmed, all SSA data products generated by the edge processor for that satellite will be deleted to prevent inadvertent publication.

The SSA data products will be routed back to the JSpOC utilizing the SAFB Modular 10 interface for non-traditional SSA sensors. At this point the XML data on SIPRNet will be stripped off and the standard USSTRATCOM spacetrack observation messages will be transmitted to the JSpOC via dedicated AFSPC networks. The observation messages will be processed using the SPADOC and Astrodynamic Software Workstation (ASW) systems. Differential corrections will determine the viability of the data for updates of element sets that can be incorporated into the Space Catalog.

SUMMARY

A successful demonstration will allow AFSPC, MDA, and USSTRATCOM to better determine the feasibility of integrating BMDS ground-based X-Band radars in support of the SSA mission. BISD will report on the technical challenges which must be overcome if a decision were made to operationally integrate SSA requirements within the BMDS domain. Lessons learned will address the radar and C2 hardware and software, as well as the communications paths (dedicated and net-centric) which would need to be tailored to meet SSA operational requirements. While BISD is primarily a technical demonstration, it is clearly understood that any potential operational implementation will also need to consider all the other DOTMLPF actions.

REFERENCES

1. The Aerospace Corporation, MITRE, MIT-LL, 100 Day Assessment of BMDS SSA Integration, Dec 2009, AFSPC Brief and Mod/Sim data
2. AFSPC/A5C, BMDS SSA Integrated Sensing Demonstration (BISD) Test Plan, Aug 2011