DARPA Software Testbed to test space warfare startegies integrated with air, cyber, land, and maritime environments

There has been exponential growth of space objects, including orbital debris that has increased the in-orbit collision risk. NASA estimates there are 21,000 objects orbiting Earth that are larger than 10 cm, 500,000 between 1 and 10 cm, and more than 100 million that are less than 1 cm. Orbital debris of even 1cm size, travelling at an average speed of about 11 km/sec can cause partial or complete destruction of satellite. Space agencies in the US and Russia track thousands of pieces of space junk larger than 10cm but estimate there could be trillions of smaller pieces.

Space is also becoming another domain of conflict due to enhanced militarization and weaponization of space. China continues to develop a variety of capabilities designed to limit or prevent the use of spacebased assets by adversaries during a crisis or conflict, including the development of directed-energy weapons and satellite jammers. “As China’s developmental counterspace capabilities become operational, China will be able to hold at risk U.S. national security satellites in every orbital regime,” says 2015 Report to Congress.

“The Department of Defense (DoD) has developed superior capabilities over decades in the physical domains of land, sea, air, and space. Space is increasingly important as a domain of strategic interest; however, nations and geo-political entities are developing the ability to exploit

potential vulnerabilities and threaten U.S. freedom of action in space", writes DARPA.

DARPA is seeking to develop a testbed for measuring, understanding, and integrating the complete spectrum of systems and capabilities to ensure stability, security, and operational dominance in space.

US DOD's space Situational Awareness goals

As the space domain has become more congested, the potential for intentional and unintentional threats to space system assets has increased. To mitigate these threats, the Department of Defense (DOD) has undertaken a variety of initiatives to enhance its network of sensors and systems to provide space situational awareness (SSA)—the current and predictive knowledge and characterization of space objects and the operational environment upon which space operations depend, according to Budgets Information Presented to the Senate Armed Services Committee.

The Air Force is investing in the Space Fence program to provide surveillance of small objects and satellites, allowing early detection of threats. Investment in additional ground-based sensors like the Space Surveillance Telescope and radars, as well as space-based sensors, will provide the necessary indications and warning of adversary actions on-orbit.

DARPA's "OrbitalOutlook" (O2) program was launched in 2014 to improve the United States Space Surveillance Network (SSN) by adding more data more often from more diverse sources to increase space situational awareness to determine when satellites are at risk from colliding with space junk. SSN is

a worldwide network of 29 space surveillance sensors (radar and optical telescopes) that observes and catalogs space objects, including 1,200 operational satellites and over 500,000 pieces of man-made space debris orbiting Earth at 17,000 miles per hour.

DARPA recently reported its O2 network now comprises more than 100 sensors around the world, making it the largest space situational network ever assembled. O2 can also completely change how the U.S. military and the global space-debris-monitoring community collect and use space situational awareness data.

O2 consists of three elements: the inclusion of new telescopes and radar from diverse locations providing diverse data types; a central database for this newly extended network of telescopes and radar and a validation process to ensure the data is accurate. O2 also seeks to demonstrate the ability to rapidly include new instruments to alert for indications and warnings of space events.

DARPA to develop space command and control testbed

DARPA launched the Hallmark project in 2016 to support military efforts to hone space war-fighting skills.

“Military commanders responsible for situational awareness and command and control of assets in space know all too well the challenge that comes from the vast size of the space domain,” DARPA said in a statement. “The volume of Earth’s operational space domain is hundreds of thousands times larger than the Earth’s oceans. It contains thousands of objects hurtling at tens of thousands of miles per hour. The scales and speeds in this extreme environment are difficult enough to grasp conceptually, let alone operationally.”

Current space awareness tools and technologies were developed when there were fewer objects in space. Only a few nations could even place satellites in orbit, and those orbits were easily predictable. “That situation has changed dramatically in the past decade with a developing space industry flooding once lonely orbits with volleys of satellite constellations,” noted DARPA. Against this backdrop, “commanders with responsibility for space domain awareness often rely on outdated tools and processes – and incomplete information – as they plan, assess, and execute operations in space.”

The goal of Hallmark Software Testbed is a comprehensive and effective set of space command and control (C2) capability technologies that can be spiraled into the Joint Space Operations Center and/or the Joint Inter-Agency Combined Space Operations Center.

When called upon, the U.S. military must have superior capabilities to rapidly plan, assess, and execute space operations in support of the full spectrum of military actions. Because the space domain enables and supports military operations in the land, sea, and air domains, space operations must also be integrated with existing and future military and intelligence operations in those domains.

“We envision a system that would fuse information from diverse sources and vastly reduce the overall time required to make and execute decisions and observe results,” said Brad Tousley, director of DARPA’s Tactical Technology Office, which oversees Hallmark.

It is anticipated that the architecture will need to support modeling and simulation of current and future SSA, space C2 tools, capabilities, subsystems and systems, as well as external capabilities and interfaces to support air, cyber, land, and maritime environments.

BAE Systems wins DARPA contract to develop 3D space warfare lab

The Defense Advanced Research Projects Agency awarded BAE Systems a contract worth up to $12.8 million to develop a digital lab to help U.S. military commanders prepare for combat in outer space, the company announced Nov. 14, 2017. The task is to create a virtual space-battle zone so U.S. military leaders can better understand the space environment and the potential threats.

“Military commanders must have superior space domain awareness in order to quickly assess, plan and execute operations in this increasingly complex environment,” said Mike Penzo, director of ground resiliency and analytics at BAE Systems, in Reston, Virginia.

The technology will help the military “quickly evaluate and integrate technologies for space command and control,” Penzo said in a news release. In a virtual space war setting, commanders would learn how to gain “situational awareness” – a tough challenge when the action is happening hundreds or thousands of miles above Earth. Awareness in the space domain means tracking and managing many thousands of objects that are moving at extreme velocities.

The testbed also would allow leaders to practice “multi-domain” operations so data collected in space, on land, in the air, at sea or in cyberspace can be combined and analyzed to support simultaneous space and terrestrial missions. DARPA describes it as a “flexible, scalable, and secure enterprise software architecture that would become the backbone of technology development and experimentation.”

The first phase of the Hallmark project focuses on space situational awareness and command-and-control technologies. Later DARPA wants to add new features to the system for “realistic, scenario-based exercises for testing space

command-and-control technologies against sophisticated emerging threats.”

BAE will host exercises to collect metrics for Hallmark’s cognitive evaluation team, and to identify technologies for future use by the Defense Department’s Joint Space Operations Center and the National Space Defense Center.

DARPA expects this technology will give commanders “unprecedented awareness” so they can shorten the timeline required to make decisions and take action.

The next phase of the project is a “Hallmark space evaluation and analysis capability” to be located in Northern Virginia. The analysis center would be used for development, integration, modeling, simulation and realistic testing of space command-and-control software and processes.

Hallmark Software Testbed

While existing technology can provide elements of situational awareness, indications and warnings, command, control and communications, there is currently no satisfactory capability to evaluate new technologies for their impact on space command and control capabilities. Using a testbed approach (including playback and simulation capabilities), research and development activities, experiments, explorations, and exercises can occur without detrimental impact to operational space domain systems.”

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The objective of the Software Testbed portion of the Hallmark program (Hallmark-ST) is to design, develop, and maintain a state-of-the-art enterprise software architecture for the integration of multiple tools and capabilities for supporting space enterprise command and control. The architecture shall be based on scalable and flexible service- oriented enterprise architecture. It is anticipated that tools and capabilities to be integrated will include those in the areas of space situational awareness, indications and warning, modeling and simulation, course of action generation, decision/action determination, and damage assessment.

Further, Hallmark-ST personnel will be integral to the actual integration of external space C2 tools, capabilities, and data as well as execution of a number of anticipated tests and scenario-based exercises.

“For example, an intuitive user interface incorporating 3-D visualization technology would present complex information in novel ways and provide commanders with unprecedented awareness and comprehension,” Tousley said. Such a testbed “would significantly facilitate research and development activities, experiments and exercises to evaluate new technologies for their impact on space command and control capabilities,” he added.

The architecture must possess, as a minimum, the following qualities:

- **Flexibility** – the ability to quickly and easily change attributes to accommodate varying user and mission requirements.
- **Expandability** – the ability to add new features and functions without system redesign.
- **Scalability** – the ability to increase or decrease the system capabilities to accommodate bigger or smaller

requirements. The system should support scalability of data to hundreds of thousands of space objects

- **Modular Composability** – the ability to initialize and change the systems attributes by changing modules (hardware and/or software).
- **Multiple classification levels** – the ability to deal with data and data sources that exist at multiple classification levels and integrate that data with computational processes that will generate additional data at multiple classification levels. The architecture needs to operate using multiple levels of data classification, from Unclassified to Top Secret/Special Compartmented Information/Special Access Program with the possibility of evaluations and exercises operating at different security levels and compartments.

DARPA TTO office is also interested in:

1. Technologies and concepts of operations that enable twenty-four hours/seven days a week (24/7) space situational awareness, from search/detect/track to initial/in-depth object characterization, in all orbital regimes using multiple or new/novel phenomenologies.
2. Development of advanced space situational awareness data fusion algorithms, enhancing the nation’s ability to effectively respond to threats to our space capabilities.
3. Development and validation of real-time space domain awareness architectures and technologies.

The JSpOC Mission System upgrade

The Air Force has made an initial investment in building the Joint Interagency Combined Space Operations Center (JICSpOC)

which is designed to ensure the national security space enterprise meets and outpaces advances in space threats. To act on information provided by SSA architecture, JICSpOC will provide resilient, responsive, and interoperable C2 capabilities to
provide the ability to respond once a threat is known.

Additionally, the Air Force is investing in C2 tools such as Joint Space Operations Center (JSpOC) Mission System (JMS), which will provide modernized hardware and software solutions to better synthesize the increased volume of SSA data. Improved SSA data coupled with a mission-ready JICSpOC ensures future implementation of Space Enterprise Vision (SEV) principles to their greatest degree of survivability in a war that extends into space, ultimately supporting joint warfighters across land, air and sea to maintain the operational advantage.

The Joint Space Operations Center (JSPOC), which is responsible for space surveillance, collision avoidance and launch support, is undergoing a three-phased hardware and software upgrade, under a program known as the JSpOC Mission System with an eye toward providing more precise and timely orbital information, among other goals. Strategic Command's Joint Space Operations Center (JSpOC), receives data from the Space Surveillance Network, a combination of terrestrial and space-based sensors, both optical and radar. The Air Force has been undergoing a broad modernization of the Joint Space Operations Center (JSpOC), the processing center of U.S. military space operations headquartered at Vandenberg Air Force Base, California.

JMS Program is a Space Command and Control (C2) capability for the Commander, Joint Functional Component Commander for Space (JFCC SPACE). The JMS program is predominately a software effort that will produce an integrated, net-centric Service Oriented Architecture (SOA) and the necessary software applications to accomplish required missions. Analysis

workloads increasing with added JMS capabilities and are expected to continue increasing as more objects are cataloged and tracked.

The program will provide a collaborative environment that will enhance and modernize space situational awareness (SSA) capabilities; create decision-relevant views of the space environment; rapidly detect, track and characterize objects of interest; identify / exploit traditional and non-traditional sources; perform space threat analysis; and enable efficient distribution of data across the Space Surveillance Network (SSN).

References and resources also include:

http://www.chinatopix.com/articles/94070/20160630/darpa-space-junk-surveillance-program-complete.htm

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http://spacenews.com/bae-systems-wins-darpa-contract-to-develop-3d-space-warfare-lab/