The Space Congress® Proceedings

1998 (35th) Horizons Unlimited

Apr 29th, 8:00 AM

Paper Session II-C - Warfighter-1: User Utility Activities

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Warfighter-1: User Utility Activities

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Abstract

The Air Force Research Laboratory Integrated Space Technology Demonstrations (ISTD) program office has partnered with Orbital Science Corporation to complement the commercial OrbView satellite's high-resolution panchromatic imaging and Multispectral imaging (MSI) systems with a high resolution hyperspectral imaging (HSI) spectrometer camera. The program is an advanced technology demonstration utilizing a commercially based space capability with unique functionality in a remote sensing technology. This leveraging of commercial industry to perform the Warfighter-1 contract utilizes the precepts of acquisition reform [1]. By exploiting the latest commercial technology and using streamlined acquisition practices in concert with traditional American know-how, the Air Force is acquiring the finest space systems for our warfighters with the best value for the United States.

The HSI system will be able to detect targets from the spectral signature measured by the HSI camera. The Warfighter-1 program will also demonstrate the utility of the spectral information to theater military commanders and intelligence analysts by transmitting HSI data directly to a mobile ground station that receives and processes the data. This paper presents the details of the Warfighter-1 User Utility activities to demonstrate both the technology of HSI and the real-time tasking capabilities of the system.

Mission Area Deficiencies

In a speech given Nov 97 by General Estes, commander of US Space Command, titled *National Security — the Space Dimension*, he states "We must devote more Air Force science and technology dollars to key space enabling technologies…We need to develop a real-time, space-based earth surveillance system to provide the dominant battlefield awareness."[2] The design and execution of the Warfighter-1 program moves the Air Force toward these goals and the goals of the Joint Vision 2010. The User Utility segment of the Warfighter-1 program, which is targeting the exploitation of new technologies to achieve dominant battlefield awareness, continues to have a high level of interest and support.

Warfighter-1 is a user-focused demonstration of emerging technologies to impact deficiencies identified by the Air Force covering Reconnaissance and Surveillance. Of the top 20 deficiencies, Warfighter-1 addresses nine and impacts an additional three.

User Utility Emphasis

Since the beginning of the Warfighter-1 program, the emphasis has been to support the user of the data, the warfighter in the theater. Because of this emphasis, a User Utility (UU) Integrated Product Team (IPT) has been formed to support the insertion of the Warfighter-1 into specific User Utility Demonstrations (UUDs). The UU-IPT has representation across the DOD with members coming from research to operational organizations including: Army Space and Missile Defense Command, Army Battle Command/Battle Labs, Air Force Space Warfare Center, Air Force Space Command, Air Force Space and Missile Systems Center, Air Force Re-

search Lab, Navy Space Command, and US Space Command (J2 and J5).

The UU-IPT has prioritized its goals into three levels to include primary, secondary and tertiary objectives. The primary objectives include:

1. Demonstrate tactical military utility of a moderate resolution spaceborne hyperspectral imaging system for near-real-time target detection and discrimination. This will be accomplished by providing a comparative analysis of panchromatic versus hyperspectral imagery, multispectral versus hyperspectral imagery, and panchromatic versus combined panchromatic and hyperspectral imagery. The analysis will include such factors as timeliness and accuracy (probability of detection & probability of false alarm) of target detections.
2. Demonstrate tactical military utility of a moderate resolution spaceborne hyperspectral imaging system for near-real-time terrain classification.
3. Understand the utility, operational impact and cost effectiveness of a employing commercially leveraged remote earth sensing systems for tactical use.

The secondary objectives of the UU-IPT are to:

1. Evaluate operations concepts associated with a field taskable, direct downlink imagery system. This includes assessing the impact of such a system on the field commander's decision cycle timelines and understanding system level trades associated with the use of such architecture.
2. Compare in-theater control of space imagery asset with centralized control and assess the effectiveness of operations concepts for both types of system.

And the tertiary objectives of the UU-IPT are to:

1. Evaluate utility of the system to perform target classification and material, functional, and unit identification.
2. Evaluate ability of the system to perform trafficability assessments and its utility as a mapping and charting information source.
3. Evaluate the capability of the system as a battle damage assessment tool.
4. Assess the utility of the system for intelligence preparation of the battlefield.

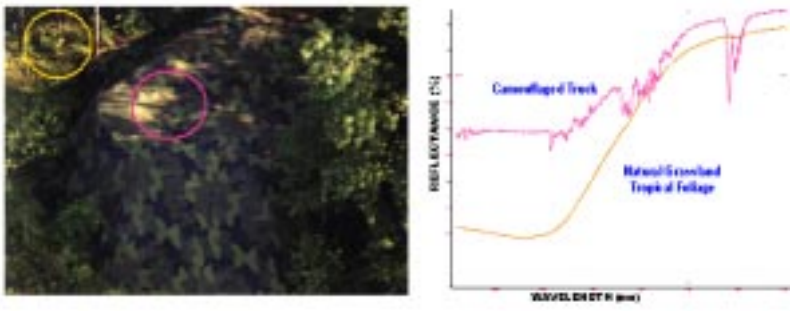

Figure 1: Forest Camouflage (pink circle) in a forest background (tan circle) with spectral signatures of a camouflaged truck and natural vegetation in visible-near IR spectral region.

Focus Areas of IPT

The UU-IPT has five focus areas: Target Detection vs multiple backgrounds; Terrain Categorization on multiple terrains; Concept of Operations (CONOPS); Commercial Leveraging; and Specific Applications. These areas have been identified as critically important to the end user and require a full assessment and 'lessons learned' from the Warfighter-1 system.

Detecting a target against myriad backgrounds has proven to be a challenging task for panchromatic and multispectral imaging systems and will not be trivial for even an HSI system. Figure 1 illustrates an example scene of forest camouflage netting in a forested area. The only camouflage material that will match in all hyperspectral bands is the background itself. Plastics, nylon and other synthetics do not match and cut foliage works for less than two hours before it will be detectable.

Terrain categorization on multiple terrains has been performed using airborne data [3, 4, 5] with success dependent upon the type of terrain. Simple hyperspectral data cubes, which consist of large homogeneous areas of relatively distinct spectral features, have been categorized with much success [6]. However, urban areas have proven to be very difficult to apply robust terrain categorization algorithms on because of the great diversity in both spectral reflectance features and scale size of the objects in the scene [7]. All backgrounds will be investigated for user support of terrain categorization. Further usage of overhead hyperspectral imagery ranges from determining static “prewar” physical terrain characteristics through helping establish highly dynamic situational awareness of the battlespace. The former are generally time insensitive requirements which are the focus of the terrain categorization, but they become critical in real-world situations with limited available data of a new “hot spot.” The latter are generally very time sensitive. Relevant terrain categorization information contained in spectral imagery falls into two categories: a) that which may be perceived with minimal analysis, or derived by reasonably quick (under 3 hours) automated algorithms (contributing to combat information), and b) that which must be coupled with other information sources, or requires lengthy automated processing, to build a more complete assessment of the battlefield situation (finished intelligence). The above considerations suggest grouping HSI terrain characterization objectives into four categories, whose prioritization will depend on the assigned mission: Category 1 - Generic Surface Classification; Category 2 - Specific Surface Type Classification; Category 3 - Anomalous Militarily Relevant Features; and Category 4 - Characteristics Requiring Tailored/Enhanced Analysis. The Warfighter-1 payload and ground stations should be able to generate many features in the first three categories, and should provide input to the tailored analyses inherent in category 4.

The CONOPS for using a satellite as a theater level asset has been explored with the Eagle Vision and NASA Clark Mobile Ground Station (CMGS). One of the lessons from the Desert Storm engagement was that broad area search capabilities were needed with delivery timelines measured in minutes or hours and not days. The Warfighter-1 Mobile Ground Station (WMGS) will provide the capability to task the WF-OV satellite and receive the direct downlink into the WMGS for processing and dissemination. Figure 2 diagrams the communication concept of operations for the WMGS in conjunction with the ground and space components.

Specific applications of the Warfighter-1 data can also be exploited for other missions such as intelligence gathering and environmental studies. These other missions are evolving as cooperative agreements are being established to provide data to ongoing test and research programs. It must be remembered that the Warfighter-1 is not a panacea that will answer all of the outstanding questions for the HSI, and battlespace awareness.

Figure 2: CONOPS for Warfighter-1 Mobile Ground Station

Conclusions

The Air Force Research Lab ISTD Program Office has partnered with Orbital Sciences Corporation to complement the commercial OrbView satellite's high-resolution panchromatic and MSI systems with an HSI spectrometer camera. By exploiting the latest commercial technology and using a streamlined acquisition approach, the Air Force is acquiring the finest space systems for our warfighters with the best value for the United States.

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