Terra Harvest: Intelligence, surveillance, and reconnaissance force multiplier

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ABSTRACT

The Defense Intelligence Agency's Terra Harvest program, launched in 2009, is developing an open, integrated battlefield unattended ground sensors (UGS) architecture that ensures interoperability among disparate UGS components and systems. Having successfully demonstrated a Terra Harvest-compliant UGS controller at Empire Challenge 2010, the program has since developed a Terra Harvest open architecture specification and developer's guide; created a web-based forum for architecture evolution and industry collaboration; and developed an array of *asset plug-ins*. These software plug-ins send data to or acquire it from an asset, and then convert it into a viable payload capable of supporting intelligence-driven operations. Building on this foundation, commercial vendors are developing field-ready implementations for Trident Spectre 2012. Once fully matured, Terra Harvest will streamline acquisition processes, reduce deployment timelines, and serve users as an intelligence, surveillance, and reconnaissance (ISR) force multiplier.

Keywords: acquisition, activity-based intelligence, Army Research Laboratory, assets, communications, Defense Intelligence Agency, flexibility, interoperability, ISR, plug-ins, software component architecture, Terra Harvest, Trident Spectre, unattended ground sensor, user interfaces, wired/wireless interfaces

1. INTRODUCTION

In theater, military operators and analysts use sensing systems and peripheral devices to monitor activities in defined areas and infer intent. These systems are equipped with cameras, seismic sensors, microphones, infrared detectors, and other assets. Such key system components must be able to communicate with one another in near real time despite having been built by different vendors. Primary sensor controllers and their asset suites, each manufactured by different companies, have tended to use incompatible interfaces, software, and resources. This lack of interoperability wreaks havoc on the warfighter, who must carry dissimilar equipment to and from sites, replace parts, and service systems that cannot be adapted in real time. Poor component interoperability leads to reduced operational flexibility and performance from the sensor systems. Reduced flexibility and poor performance leads to incomplete missions and missed ISR opportunities.

Given the growing emphasis on *activity-based intelligence*—"the activity and transactions associated with an entity, population, or area of interest"[1]—operational flexibility and interoperable sensor system components are more important than ever to realizing mission outcomes. With this emphasis in mind, a target-based focus on stationary sites is giving way to a focus on individuals, their relationships, and their activities in context, with the aim of "mapping the human geography and anticipating what may happen"[2].

For many years, vendors have developed proprietary unattended ground sensors, and these sensors are still used in the field. Thus, the ability to combine these sensors and optimize deployed configurations for a wide variety of operational missions has degraded. In this vein, users have repeatedly voiced concerns about:

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- Stovepiped architectures, with each system having its own specific internal and external interfaces, training, communications, mission planning/deployment tools, and graphical user interface (GUI) workstations
- Being locked into one vendor so that any follow-on integration, technology insertion, or reconfiguration requires going back to the original vendor
- Integration time exceeding operational mission timelines, complicating integration efforts when multiple vendors have to work together in near real time
- Inflexible systems that do not permit field adjustments, quick integration, or reconfiguration

With the above concerns in mind, operators require a flexible, vendor-agnostic UGS system architecture that lets them collect necessary raw intelligence more effectively. Acting as a force multiplier, this adaptable UGS system architecture would address changing mission needs, incorporate plug-and-play sensor components, employ common training procedures, and minimize deployment time.

System architecture engineering, development, and acquisition levels must enhance UGS operational flexibility and increase sensor performance to deliver the above capabilities to operators in the field. To that end, industry needs specifications to which all vendors can build so that commercial development takes place in an effective manner. Such specifications include a common lexicon; a well-defined software architecture; and common communications and user interfaces. Similarly, government users need a shorter, more predictable acquisition cycle that enables cost reductions and timely deployment in dynamic mission environments.

The Defense Intelligence Agency (DIA) is developing Terra Harvest as an ISR force multiplier. The Terra Harvest team, led by DIA and the Army Research Laboratory (ARL), has developed an open, standards-based battlefield UGS architecture for adaptable, modular sensor components. Addressing industry, acquisition, and field-specific requirements, Terra Harvest uses an open architecture approach and well-defined interfaces that make the most of industry investment. Architecture development efforts have yielded testable reference implementations. One implementation is slated for immediate deployment to theater. Other such implementations will be demonstrated and assessed at Trident Spectre 2012.

2. THE KEYS TO INTEROPERABILITY

DIA and ARL designed Terra Harvest to address dynamic mission requirements and operational issues such as stovepiped architectures, proprietary components, and limited interoperability. Terra Harvest has resolved these issues via an open architecture approach built around software *plug-ins*: Java files that allow an internal component (e.g., a motion detector) or an external sensor asset (e.g., a camera) to be exercised by the sensor system via a set of common interfaces. The following types of plug-ins are defined within the Terra Harvest standard and reside within the controller:

- **Asset plug-in.** Sends data to or acquires data from an asset, using the communication service assigned by the end-user. After acquiring data from an asset, the plug-in transforms the raw data into a payload that conforms to a common lexicon.
- **Persistent store plug-in.** Caches the payload into the persistent store. The persistent store acts as a repository for data local to the asset. It also serves as a repository for payloads that are available for other plug-ins to refine, process, or disseminate.
- **Refine/process plug-in.** A vendor- or domain-provided plug-in that pulls asset-specific or multi-asset data from the persistent store for one or more assets. It then either refines or processes the payload.
- **Dissemination plug-in.** This plug-in exfiltrates designated payloads from the controller using the communication service assigned by the end-user[3].

This approach built around plug-ins results in less hardware, a significant benefit for operating budgets and personnel on the ground. The vendor- and platform-agnostic architecture enhances operational flexibility and reduces the amount of equipment operators must procure and carry into the field[4].

Java-based, the Terra Harvest architecture incorporates the Open Services Gateway initiative (OSGi) framework. The OSGi architecture simplifies building, maintaining, and deploying applications. Thus, OSGi makes it possible to add a given device or asset in near real time, without requiring a restart. To minimize and manage component couplings, OSGi "enables these components to dynamically discover each other for collaboration" via standard interfaces for common functions. These functions include Hypertext Transfer Protocol (HTTP) servers, configuration, logging, security, user administration, eXtensible Markup Language (XML), and others[5].

The Terra Harvest controller provides management, monitoring, and control functions; acquires data from a sensor asset; and disseminates data to another controller or to a domain-specific software component. *Assets* are system components that can be tasked or reconfigured to produce a payload (data, information, knowledge, command) for processing and dissemination[6]. Data is disseminated via an industry-standard communication service or a vendor-provided, domain-specific communication service that is registered within the Terra Harvest framework (e.g., Broadband Global Area Network [BGAN], Common Sensor Radio, Iridium, Microhard, and Security Equipment Integration Working Group [SEIWG] radio).

3. DEMONSTRATING OPERATIONAL UTILITY AT TRIDENT SPECTRE 2012

Trident Spectre, a joint training exercise performed annually since 2004, is an invitation-only venue for special operations, intelligence, interagency, and law enforcement personnel. This exercise allows operators to demonstrate and evaluate emerging technologies under controlled conditions in an operationally representative environment. Asset requirements, sensor configurations, and mission types vary according to operational vignettes. Trident Spectre brings developers and users together to assess deployable government and commercial technologies deemed useful to the warfighter. By wringing out these technologies in an operational scenario, the exercise gives analysts, tactical operators, and collectors a chance to try out new intelligence exploitation tools and techniques.

At the May 2012 event, which will take place in Ft. Story, Virginia, DIA and ARL will demonstrate and assess the capabilities and performance of Terra Harvest-compliant systems, assets, and communications in an operational setting. In particular, DIA and ARL will demonstrate the ability to deploy operational UGS systems and components built by multiple vendors. They will determine the ease or difficulty of reconfiguring compliant components in near real time (i.e., within hours rather than days) and enabling command and control of UGS within Trident Spectre's operational domain.

Terra Harvest elements that will be tested at Trident Spectre include ground-based, airborne, and mobile components. A wide range of Terra Harvest-compliant assets will also be tested. As a cross section, components under scrutiny at Trident Spectre will include:

- Digital Force Technologies: Muskrat controller
- Honeywell: controller and T-Hawk unattended airborne system (UAS)
- Adaptive Flight: Hornet UAS
- McQ Inc: Omnisense UGS
- Northrop Grumman: Scorpion II imagers
- SpotterRF: Micro Surveillance Radar

DIA and ARL chose relevant Trident Spectre test assets based on the value they add to the Terra Harvest architecture and their ability to exchange information with compliant assets from multiple vendors. Their technology readiness level, operations legacy, and performance level were additional factors[7].

4. TRANSITION PLANS

Terra Harvest is transitioning its architecture development and related technology to the UGS Standards Working Group (SWG). This phased transition of the maintenance and evolution of the architecture will take place in the 2013-2015 timeframe. Chartered in 2009 by the Deputy Under Secretary of Defense (DUSD) for Technical Collection and Analysis (TC&A) Office of the Secretary of Defense (OSD)[8], the UGS SWG retailored its priorities in 2011 via its signed charter. It now reflects current operational user requirements and community direction. With these new priorities in mind, the UGS SWG has subdivided its workflow among three Technology Focus Groups (TFGs). These groups concentrate on particular technical issues subsumed in the Open Architecture Standards for Unattended Sensors (OASUS), the UGS SWG unattended sensors architecture derived from Terra Harvest. More precisely, a software component architecture, a wired and wireless component architecture, and user interfaces are the focal points of the three TFGs.

Led by ARL, the Software Component Architecture TFG centers on the software framework for UGS systems controllers and component plug-ins. Wired and Wireless Interfaces is chaired by the U.S. Marine Corps, bringing its extensive UGS experience to the OASUS effort. This TFG is developing standards for wired and wireless interfaces between UGS systems components. Special Operations Command (SOCOM) leads the User Interfaces (UI) group. This group identifies or develops standards for UGS UIs, driven by data output and dissemination, command and control, and operations[9].

The Terra Harvest team chose forge.mil, a collaborative environment hosted by the Defense Information Systems Agency (DISA)[10], as its community outreach platform. The forge.mil site will host relevant documentation, source code, a common lexicon, compliance guidance, and announcements. Via DIA, access to this site is already available to members of the community of interest who have an ECA certificate or Common Access Card (CAC).

5. CONCLUSION

Terra Harvest objectives include enhanced operational flexibility, improved interoperability of UGS components, and reduced integration time and costs. With active industry involvement, DIA has developed the Terra Harvest reference architecture and several compliant implementations. Other acquisition programs can take advantage of the Terra Harvest/OASUS open architecture to meet their own challenging mission requirements for sensor integration. In the main, the Terra Harvest architecture can benefit many unattended sensor developments.

A successful Trident Spectre demonstration and subsequent operational deployment will validate the Terra Harvest model of cost-effective interoperability across unattended sensor systems and associated components. In parallel, as the UGS SWG Technology Focus Groups standardize interfaces and protocols, users and vendors will have the opportunity to participate, define standards, and deliver improved operational capability to the warfighter and to users in other operational domains.

REFERENCES

[1] Biltgen, P. "Activity-Based Intelligence. " BAE System Intelligence & Security. Available: http://www.baesystemsintel.com/inside_intelligence/activity_based_intelligence/ (1 February 2012).

[2] Biltgen, P. "Activity-Based Intelligence. " BAE System Intelligence & Security. Available: http://www.baesystemsintel.com/inside_intelligence/activity_based_intelligence/ (1 February 2012).

[3] Tokarcik, L. and Winkler, R. "Terra Harvest Open Architecture System for Unattended Sensors," Proc. SPIE 8389-20 in press (2012). Abstract available: http://spie.org/app/program/index.cfm?fuseaction=conferencedetail&conference_id=967217&event_id=957483&list=1

[4] Humeniuk, D. and Landoll, D. "Terra Harvest Software Architecture," Proc. SPIE 8389-21in press (2012). Abstract available: http://spie.org/app/program/index.cfm?fuseaction=conferencedetail&conference_id=967217&event_id=957483&list=1

[5] OSGi Alliance. "What is the OSGi technology in a nutshell?" Available: http://www.osgi.org/About/FAQ#q6.

[6] Humeniuk, D. and Landoll, D. "Terra Harvest Software Architecture," Proc. SPIE 8389-21in press (2012). Abstract available: http://spie.org/app/program/index.cfm?fuseaction=conferencedetail&conference_id=967217&event_id=957483&list=1

[7] Kolodny, M. "Terra Harvest Demonstration at Trident Spectre 2012," Proc. SPIE 8389-19 in press (2012). Abstract available: http://spie.org/app/program/index.cfm?fuseaction=conferencedetail&conference_id=967217&event_id=957483&list=1

[8] Salvatori, J. B., Deputy Under Secretary of Defense for Technical Collection and Analysis, Memorandum for See Distribution: Establishment of Unattended Ground Sensors Working Group, 5 January 2009.

[9] Heathcock, R. and Brasch, C. "Enabling open architecture standards for unattended sensors through the unattended ground sensors standards working group," Proc. SPIE 8389-8 in press (2012). Abstract available: http://spie.org/app/program/index.cfm?fuseaction=conferencedetail&conference_id=967217&event_id=957483&list=1

[10] Defense Information Systems Agency. Forge.mil. Available: http://forge.mil/.