Unattended ground sensors standards working group

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ABSTRACT

The Department of Defense (DoD) has established an Unattended Ground Sensor (UGS) Standards Working Group to address the interoperability of UGS, promote competition, provide enhanced capabilities, and support UGS missions.

Keywords: UGS, interoperability, Sensor Web Enablement, standardization, plug-and-play

1. INTRODUCTION

The Deputy Under Secretary of Defense (DUSD) for Technical Collection and Analysis (TC&A) has emphasized the critical importance of standards to unattended ground sensors (UGS) by establishing an UGS Standards Working Group[1]. This working group will identify and define interface standards for present and future UGS systems for the Department of Defense and encourage their use in other Federal agencies. It will also help the Defense Intelligence Agency (DIA) develop a robust set of UGS standards and interfaces tailored to user requirements. This clearly defined set of standards and interfaces will improve UGS interoperability, manufacturability, and reproducibility. These improvements will subsequently enhance competition, benefiting both the government and commercial vendors.

UGS standardization offers several key benefits. For example, standardization enables interoperability across sensors, aids sensor discovery, eases sensor development, provides a consistent baseline for data quality comparisons, and optimizes sharing of data products.

The most critical standards are interface standards, which lay the foundation for a plug-and-play capability. Plug-and-play facilitates automated discovery of UGS in a region of interest as sensors are sequentially emplaced[2]. Without this automated discovery, emplaced sensors cannot exchange data in a timely manner, if at all.

An UGS controller with plug-and-play capability depends upon well-defined internal data standards. However, defined standards must apply in layered fashion to the controller, the UGS themselves, and the network external to the UGS. Only then can UGS standardization ensure backwards compatibility with previously fielded variants. Supporting previously fielded variants as standalone systems quickly becomes cumbersome and expensive.

Robust UGS internal and external standards that apply to legacy, current, and future UGS systems span time. However, these standards must also span sensor phenomenologies, such as magnetic, acoustic, radio frequency (RF), visible, and infrared (IR). In addition, they must take into account various emplacement concepts, which help determine the different ruggedized connectors needed to ensure persistent surveillance at a specific location. Finally, robust UGS standards must allow for a broad spectrum of interface technologies. For example, a variety of UGS power sources can drive interface standards in battery applications, direct connects, RF energy harvesting, and photovoltaic solar cells.

2. OPERATIONAL REQUIREMENTS

2.1 Joint Operations

Applying advanced technologies on today's battlefield highlights the need for the military services and our coalition partners to perform their missions synergistically. Effective joint operations require that each entity share information to ensure mission success and prevent mission failure. Our forces increasingly depend upon UGS technology to achieve, improve, and share battlefield situational awareness. If our UGS systems are not interoperable, they cannot effectively discern and report situational awareness over a broad area. With incomplete information and limited situational awareness, the probability of joint mission success quickly diminishes.

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2.2 Mission Dynamics

Remote and direct control. UGS systems increasingly provide persistent surveillance of an area of interest. During sensor emplacement, the operator may not have adequate time to calibrate various sensor types and ensure proper installation and setup. The dynamic nature of the emplacement process thus calls for unique performance features, which in turn define specific interface requirements. By standardizing these interfaces, the operators can train on one system and more quickly adapt to other variants or systems. Again with sensor emplacement in mind, an operator needs direct connectivity between an UGS controller and sensor during installation to verify the health and status of the sensor. This direct interface could entail Bluetooth®, USB, or other serial connection protocols. The data provided over this standardized interface must be available in both direct connect and remote control operations.

Mission duration, emplacement, and configurability. As environmental conditions and mission requirements change, power requirements will vary accordingly. An operator may configure an UGS system using commercial power, battery power, or solar cells. Modifying operational concepts may extend the operational life of the sensor by using different power-cycling options. For example, chaining battery cells, including a sleep mode, or timing out power-intensive operations could extend battery life, sensor operation, and mission duration. However, these power-cycling options depend upon the ability to connect the power system to the UGS via standardized connector interfaces.

3. INTEROPERABILITY

3.1 Data Content and Quality

Standard formats. A common complaint within the UGS user community concerns the incompatibility among systems developed by different vendors[3]. In fact, no controlling authority dictates that different generations of sensors from the same vendor be fully compatible. To date, the defense acquisition community has not standardized the data products from any class of unattended ground sensors. Such standardization would help ensure that subsequent generations of sensor class variants provide backwards compatibility. With standardization in mind, any UGS controlling authority must consider the life cycle of the sensors, the ground controllers, and the analytic tools used to exploit the sensor data. Only then can data collected and shared across multiple systems effectively contribute to successful operations in a multi-force environment. Today's joint operating environment in which devices are heterogeneous and increasingly superseded requires standardized data formats that are both interoperable and extensible.

Ideally, a user would process data from one acoustic sensor. He or she would then use this information cooperatively with acoustic data potentially collected by another vendor's system. Different variants of acoustic sensors may perform differently, but the data formats must be standardized to permit this cooperative information exchange.

Sensor status information. No controlling authority today compels vendors to develop non-unique data formats for different UGS systems, thus allowing multiple unique data formats for health and status information. However, commercial vendors could feasibly develop common data formats that are standard, yet flexible enough to meet health and status reporting needs. A user could then interface/read data from multiple sensors without loading unique software with each upgrade of the sensor network. This flexibility would allow an UGS controller to discover network sensors in an ad hoc fashion, greatly improving operational utility and overall mission effectiveness.

3.2 Technology Transition

Plan for the next generation. A long view of the UGS life cycle merits special consideration. For instance, if an operator could use standard interfaces to upgrade an UGS without replacing numerous chassis, power, and communications components, then he or she could improve sensor performance while minimizing cost and schedule impacts. Thus, standardized plug-and-play hardware and software interfaces would allow an operator to increase performance as detector technologies improve. Further, these standard interfaces could speed sensor platform reconfiguration to satisfy unique missions in hostile environments, simultaneously improving UGS utility to the warfighter while minimizing operator exposure.

4. INTERFACE TECHNOLOGIES

UGS system interfaces form three basic groups: hardware, software, and communications. Only coherent standardization within each of these groups will enable seamless interoperability among different sensor systems.

4.1 Hardware

The hardware interfaces cover the mechanical and electrical connections between components of an UGS and any external devices. Harsh environmental conditions, anti-tamper features, and concealment goals often drive UGS requirements, complexity, and costs.

Mechanical requirements. Environmental operating conditions largely determine mechanical interface designs. For example, severe emplacement methodologies, such as aircraft egress, underground burial, or littoral deployment, can govern sturdier, and more expensive, mechanical interfaces. Hostile desert environments of blowing sand, ineffective software tools, and limited time drive interface costs while making the UGS physical set-up and connection processes demanding and unforgiving. Common, standard mechanical interfaces can satisfy mechanical requirements, operate in harsh conditions, and reduce design costs.

Electrical requirements. Without clear standards, vendors can design UGS system components to unique requirements without uniform power, test, or control interfaces. Standardized electrical interfaces improve manufacturability, shrink the logistics tail, lighten field employment burdens, and reduce costs. Further, standard keyed connectors enhance system safety and UGS operability by preventing operators from inadvertently stripping out connectors.

4.2 Software

Control and health. Automated discovery of UGS systems in a local network only occurs with standardization of recognize-and-respond messages that a system processes. The scientific and engineering test instruments community uses a similar approach with its IEEE-488 protocols, illustrating the benefits of standardization[4]. In like manner, by using standard protocols, a robust UGS controller suite could handle multiple sensors and still keep pace as new systems and new users come online. Establishing the standard protocols by which UGS systems are developed constitutes the critical first step.

Data. Merging data products from disparate sensors dramatically improves the effectiveness of tactical UGS systems[5]. Using innovative data fusion techniques to correlate dissimilar data saves time and money when compared to stovepiped data exploitation systems. Smartly abstracting dissimilar data in the processing chain can aid the data fusion target ID system by hiding the data implementation details[6]. Data abstraction works best, however, with clearly defined, standard data types.

Security and encryption. An astute enemy can intercept unencrypted communication as video information is transmitted[7]. Passing information in an open format encompasses several advantages, such as commercial exploitation software and reduced processing requirements. With deployed UGS numbers increasing, however, maintaining this open format may eventually compromise operational security and data integrity[8]. These two critical concerns argue for encryption of the UGS data. Developing or leveraging a common encryption format would help prevent a proliferation of numerous encryption standards from multiple vendors.

4.3 Communications

Direct connect. During UGS emplacement, an operator must ensure proper operation prior to departure. Using a test port, the operator can arm the system, check for power and health, and configure the UGS for any unique local factors, such as field of view, positional information, and operating mode. Standardizing this test connection would release the operator from unique hardware requirements for each type of emplaced sensor, save time, and reduce personnel risks.

RF link. An alternate solution could incorporate an RF communications link for health and status checks. The direct connection may offer the benefit of no radiated signature, but a low-power RF link could enable remote UGS maintenance checks.. Like Bluetooth®, for example, this communications scheme calls for clearly defined, well-developed standards.

5. DOD DIRECTION

The DUSD(TC&A) in 2009 tasked the Director, Defense Intelligence Agency, to lead an effort to develop standards for the UGS user and acquisition communities[9]. This guidance helps minimize duplication of capabilities while encouraging UGS system flexibility for joint operations. In addition, it addresses mission needs while reducing costs by allowing competition between vendors without constraining innovation.

5.1 Flexibility

Acquisition competition. Current UGS developers can use proprietary designs that may impact the warfighter's logistics chain and slow sensor upgrades that would increase capabilities[10]. In contrast, establishing interface standards that preserve contractors' Intellectual Property rights while defining common protocols could speed sensor upgrades and encourage increased vendor participation. Common standards enable sensor developers to participate in addition to UGS system integration prime contractors, increasing competition and the potential for new capabilities.

Mission dynamics. Multiple services and intelligence agencies must coordinate and consolidate their UGS resources in a budget-constrained environment. Battlefield dynamics, however, may drive commanders to tailor their assets toward specific missions. Focusing current and future UGS development on integrated operation without proprietary designs can satisfy both objectives by increasing UGS interoperability and flexibility.

5.2 Logistics and Maintainability

Use commercial standards. Using commercial standards could ease the adoption of UGS guidelines in the acquisition and development communities. These uniform guidelines could sharply focus the acquisition community on the logistics and maintainability aspects of UGS. For example, using flexible, reconfigurable power supplies might limit multiple power supply variations, subsequently reducing logistics and maintenance costs. Standard connections, cases, and other mechanical features also reduce training costs and increase system re-use.

Minimize unique, vendor proprietary solutions. Unique, vendor proprietary design features decrease flexibility, degrade maintainability over time, and accelerate system obsolescence. Standard design features that can adapt as industry changes would equally benefit vendors and the government. In a similar vein, inputs from the vendor community that help shape standards in the UGS development process increase stakeholder participation and minimize unique solutions.

5.3 Cost

Minimize duplication. Each organization involved in UGS development determines specific performance requirements based upon relevant mission needs. These mission needs, however, may not fully take into account the force mix inherent in joint warfare. Joint UGS development efforts, though well intended, may fail if stakeholders do not modify unique capability needs that defeat design commonality. Accepted common designs enable interoperable UGS systems while minimizing expensive, overlapping capabilities.

Improve commonality of components. Focusing on common UGS components as the building blocks of UGS systems facilitates the development of low-cost, standard, reusable interfaces. This approach could permit an increased emphasis on improving detectors by not using scarce funds to reinvent interconnections with each new generation of UGS systems.

Accelerate development and acquisition. Combat or exercise operations highlight an enemy that can rapidly adapt to our advanced technology systems[11]. With this adaptability in mind, legacy acquisition processes allow too much time between concept development and capabilities fielded. Standardized interfaces and protocols reduce costs, shorten the acquisition cycle, speed delivery of capabilities to the user, and keep the warfighter ahead of the adversary.

6. STANDARDIZATION

6.1 Interfaces

Interface standards constitute minimum hardware and software requirements. UGS vendors should not view standards as an overarching constraint on development. Rather, standards define the minimum common features of interfaces, thus allowing multiple systems to share these interfaces.

Mission requirements drive interoperability. Dynamic field operations determine mission requirements, and these requirements drive interoperability. Non-interoperability restricts data flow, multiplies technology risks, and degrades military applications[12]. These three factors work together to minimize chances for mission success. Therefore, standards-based UGS interoperability increases the likelihood of operational success.

Plug-and-play success depends upon early specification in the acquisition cycle. An UGS controller with plug-and-play interfaces depends upon well-defined data standards. These clearly specified data standards start with the UGS program offices involving the vendor community early in the acquisition process. The Sensor Web Enablement (SWE) initiative within the Open Geospatial Consortium, Inc.® (OGC) serves as an exemplar for early standards development interaction between users and vendors. The SWE initiative focuses on developing standards that enable sensor discovery, tasking, and observations[13]. This effort may serve as a useful paradigm to develop plug-and-play interfaces for UGS controllers.

6.2 Membership

DIA action to lead. In 2009, the DUSD(TC&A) directed the DIA to form and lead a working group that will establish standards for current and future UGS systems. Accordingly, DIA is reaching out to DoD and other Federal agencies involved with UGS development to participate in the UGS Standards Working Group (SWG). DIA will not reinvent or usurp existing standards, but instead will address the needs and gaps. For example, the OGC is pioneering standards in the areas of multiple-sensor discovery and sensor tasking. The SWG will expand upon OGC's work by filling in UGS-relevant standards gaps. It will then study these standards to determine whether they should be incorporated into the SWG.

Army, Air Force, USMC, OGC, NIST, and NASIC. Along with DIA, key members of the UGS SWG include the United States Army (USA), the Army Research Lab (ARL), OGC, the National Institute of Standards and Technology (NIST), the National Air and Space Intelligence Center (NASIC), and the United States Marine Corps (USMC). The SWG will meet regularly throughout the year with the UGS acquisition community to develop standards that enable interoperable systems. Subsequently, the SWG will organize any technical working groups needed to study and recommend standards for adoption.

7. CONCLUSION

Standards working group. The UGS Standards Working Group will meet with key stakeholders several times during 2010 to begin defining key interfaces. The SWG will work with UGS acquisition program offices to highlight gaps in the interface standards and focus the working group on necessary refinements or modifications.

Open architecture's significant payoffs. Current remote ground control systems must quickly exchange critical event and control data with each other. This dynamic information exchange can degrade or collapse a stovepipe communications architecture. In contrast, a robust, open architecture easily exchanges control and event data[15]. An integrated UGS network thus argues for an open controller architecture.€

Terra Harvest, the future of common, standards-driven UGS for DIA. DIA is researching an open, integrated battlefield UGS architecture that will employ multiple, flexible sensors via standards-based development. The Terra Harvest program breaks apart the UGS system into its fundamental components and standardizes the internal and external interfaces to increase interoperability. Following this example, other programs can join this effort, meet their particular mission requirements, and take advantage of Terra Harvest resources. Terra Harvest can help synergize the UGS community, reduce costs, and provide a technology insertion path for next generation sensors.

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