Advanced Explosive Ordnance Disposal Robotic System (AEODRS): A Common Architecture Revolution

Mark A. Hinton, Michael J. Zeher, Matthew V. Kozlowski, and Matthew S. Johannes

*T*he Advanced Explosive Ordnance Disposal Robotic System (AEODRS) is a Navy-sponsored acquisition program developing a new generation of open, modular robotic systems. This article describes a common architecture for a family of explosive ordnance disposal robotic systems, including the rationale for and development of the architecture, as well as decomposition of the architecture into common physical, electrical, and logical interfaces. The article further describes the role of an open standard for the interchange of information within unmanned ground vehicle systems. The Joint Architecture for Unmanned Systems (JAUS) has enabled the development of the architecture's standards-based interfaces, both at the extra-vehicle controller-interface level and for the interface and integration of vehicle payloads and subsystems. Finally, the article explores the contribution of the architecture's common topology, protocols, services, and infrastructure to the development of common controllers, payloads, and subsystems. Additionally, the effects of the achieved commonality are discussed in terms of reduced field logistics footprint, increased mission flexibility, reduced deployment time for fielding new capabilities, and extended useful design life.

INTRODUCTION

The military services have successfully used ground robots in the fight against terror over the past decade. In addition, U.S. and international law enforcement agencies have experienced the benefit of these systems in conducting dangerous and life-threatening tasks. The use of ground robots is saving lives throughout the world. However, APL and the military have been concerned that the lack of interoperability between unmanned ground vehicle (UGV) systems imposes limitations on development and deployment, complicating the integration of advanced technologies and control schemes. The Advanced Explosive Ordnance Disposal Robotic System (AEODRS) is a Joint Service Explosive Ordnance Disposal (JSEOD) program executed through

the Naval Explosive Ordnance Disposal Technology Division (NAVEODTECHDIV) via the Navy Program Management Office for Explosive Ordnance Disposal/Counter Remote Controlled Improvised Explosive Device Electronic Warfare (PMS 408). The primary goal of the AEODRS program is to develop a new generation of modular open explosive ordnance disposal (EOD) robotic systems that will provide the desired interoperability. The AEODRS approach to achieving interoperability hinges on the definition of a common architecture that partitions the system into modules possessing common physical, electrical, and logical interfaces. This enables the creation of a family of UGV systems providing interoperability and interchangeability at the module level. In turn, the high degree of module-level interoperability and interchangeability enables rapid incremental integration of new technologies and approaches into the AEODRS system.

HISTORICAL BACKGROUND

Past UGV systems have been provided as complete systems developed and supplied by a single vendor. Each vendor has integrated internally developed or off-the-shelf subsystems under their own proprietary architectures, typically using proprietary communication link protocols and messages. Interoperability has been difficult to achieve because each platform, each controller, and each sensor module has used the vendors' proprietary interfaces. The result is a lack of interoperability between the elements of similar systems and concomitant failure to realize interchangeability; this failure increases the logistics footprint of fielded systems and increases the difficulty of adding new capabilities. Figure 1 illustrates the problem.

The use of dissimilar physical interfaces complicates physical integration of a new device or capability with the platform; the use of dissimilar electrical interfaces complicates providing power and data interfaces for that capability; and the use of dissimilar messaging generally requires modification or enhancement of the vendor's proprietary system software in order to integrate that new device or capability.

AEODRS PATH FORWARD

Engineers at APL, in association with a government team and industry experts, have defined a set of EOD robotic platforms constituting a family of systems (FoS) and have partitioned these systems into a set of capability modules (CMs), each of which serves a specific function within the vehicle architecture. Careful partitioning results in CMs that are task and function specific and can be used in each of the platforms defined in the FoS. By careful partitioning of the systems into modules, and clear specification of the interfaces between those modules, the architecture enables development of capability-specific modules that perform specific functions within an overarching system, rather than shrouding capabilities within a proprietary monolith. Good partitioning and well-defined interfaces also ease integration of future technological developments as well as integration of legacy systems within the framework of the UGV. As the next generation of platforms embraces this modular open systems model, it will enable the integration of advanced CMs at lower cost and more rapidly than is currently possible. This modular approach promises a richer assortment of capabilities readily configured into a fielded system, increasing the effectiveness of the system in operational scenarios; the approach also reduces system downtime because the modular design
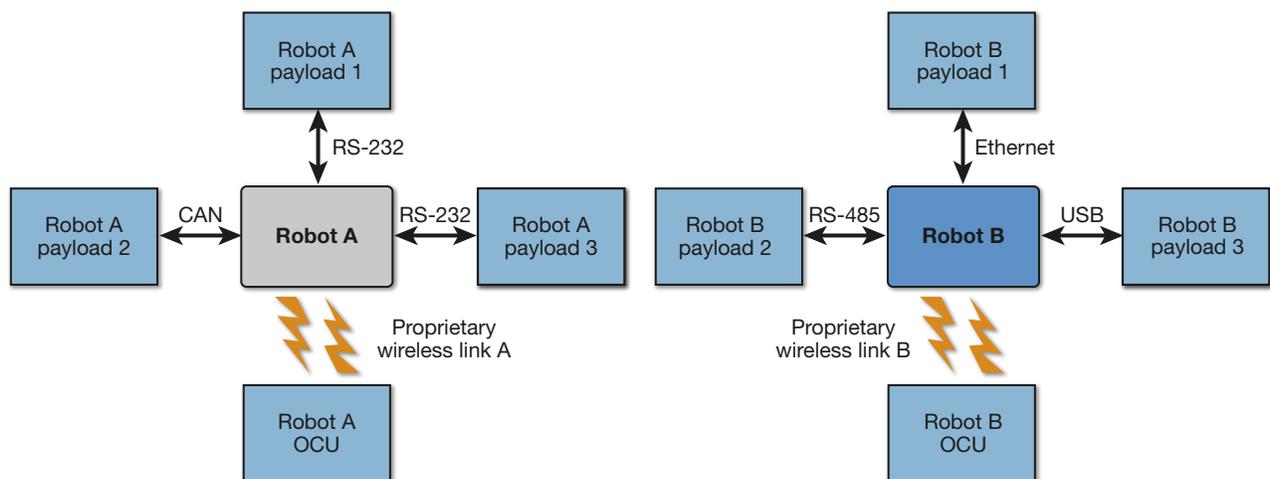

Figure 1. Impact of incompatible interfaces on interoperability. CAN, Controller Area Network; OCU, operator control unit; USB, Universal Serial Bus.

enables simpler identification and replacement of inoperable or malfunctioning modules.

THE AEODRS FoS

The AEODRS FoS will consist of three UGVs and two OCUs; these are determined by three classes of EOD missions.

The first AEODRS system to be fielded is the Dismounted Operations System. This system is intended to focus on reconnaissance tasks but is also capable of supporting the placement of counter-charges to disrupt a device. The Dismounted Operations System must be fully backpackable, which places a premium on size and weight. The system includes a compact, lightweight UGV and a lightweight handheld controller (OCU).

The second AEODRS system is referred to as the Tactical Operations System. The primary mission focus of this variant is on in-depth reconnaissance and wide-range item prosecution. The Tactical Operations System is a medium-sized system that must be able to be transported in a vehicle and be capable of being carried by two technicians over a moderate distance. This system includes a larger, portable OCU that fully supports the increased functionality of the Tactical Operations System and the third AEODRS system, referred to as the Base/Infrastructure System. In addition, the basic functionality of the Tactical Operations UGV can be controlled by the handheld OCU of the Dismounted Operations System.

The third AEODRS system, the Base/Infrastructure System, is the largest variant and requires transportation via a large response vehicle/trailer. The primary mission focus of this variant is on providing maximum load/lift capabilities and the widest range of neutralization, render-safe, and other special capabilities. This system uses the larger portable OCU mentioned above. In addition, the basic functionality of the Base/Infrastructure System can be controlled by the handheld OCU of the Dismounted Operations System.

The three vehicle classifications effectively address the needs of the EOD technicians in a variety of frequently encountered operational scenarios. Use of the common architecture enables use of some CMs across platforms of all three system variants. Other CMs can be developed in an incremental fashion that builds upon the foundations of units developed for earlier increments.

ARCHITECTURE GOALS AND MOTIVATIONS

The EOD community desires to reduce the logistics footprint and to reduce the personnel and training footprint associated with field deployment of their robotics systems. The past environment of stovepiped proprietary systems results in an inability to share capabilities—even modular capabilities—between systems. The AEODRS

program seeks, by adopting shared module definitions and standard module interfaces, to increase module commonality between members of the FoS, thereby reducing the spares and stocking requirements for the maintenance and configuration of fielded systems. Further, increasing module commonality also reduces the number of functionally similar (but noninterchangeable) modules that maintenance personnel must be trained to support. The use of common OCUs presents operators with consistent user interface appearance and behavior across the family, which reduces operator-training requirements. Specific commonality goals for AEODRS include the following:

- Reduce the overall logistical footprint of the FoS

- Develop and adopt a common controller module to be used across the FoS

- Segregate and develop mission-specific payloads

- Increase mission flexibility through the adoption of new CMs as part of a continual technical development cycle

In other words, a system architecture that provides shared module definitions and standard module interfaces results in increased commonality of modules; this results in a system that exhibits the following:

- **Modularity:** The ability to provide control system capabilities tailored to a given EOD application without requiring modification of control system hardware or software. At its core, modularity provides the ability to configure rather than develop an AEODRS system for a given EOD application.

- **Scalability:** The ability to add new capabilities or provide higher performance (scaling up) according to mission requirements or to remove capabilities or reduce performance (scaling down) to achieve weight, power consumption, or footprint savings as required by the mission environment.

- **Upgradeability**: The ability to introduce new capabilities or improvements in performance or to avoid system obsolescence without requiring extensive reengineering.

But achieving commonality and reaching these goals depends on achieving both interoperability and interchangeability of modules.

The AEODRS FoS is characterized by the interoperability of its CMs (subsystems) via government-defined and -controlled logical, electrical, and physical interfaces and the commonality of its OCU. The FoS is also characterized by the interchangeability of its CMs with future CMs that can be integrated in a plug-and-play fashion without proprietary issues. More formal definitions of interoperability and interchangeability are as follows:[1]
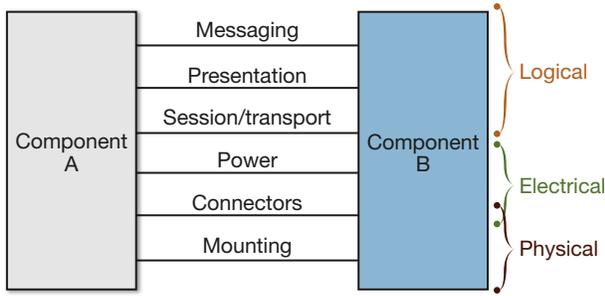
Figure 2. Physical, electrical, and logical architecture layers.

- **Interoperability:** The ability of systems to provide data, information, materiel, and services and accept the same from other systems, and to use the data, information, materiel, and services so exchanged to enable them to operate effectively together.

- **Interchangeability**: A condition that exists when two or more items possessing such functional and physical characteristics as to be equivalent in performance and durability are capable of being exchanged one for the other without alteration of the items themselves or of adjoining items, except for adjustment, and without selection for fit and performance.

In summary, all interfacing elements between two functional components on an electric-drive UGV system can be defined in terms of their physical, electrical, and logical interfaces. UGV systems can be implemented as a networked system in which subsystem elements (components) are able to communicate with each other. The physical, electrical, and logical interface layers are illustrated in Fig. 2. Interoperability can be achieved through the specification and standardization of these interfaces.

AEODRS COMMON ARCHITECTURE

Key capabilities identified by the EOD community as important for AEODRS UGVs can be decomposed into a few crude categories as follows:

- **Mobility** of the platform

- **Manipulation:** The ability to reach and manipulate or grasp objects in the UGV's environment

- **Vision:** The ability to see the UGV's surroundings and to see objects to be manipulated

- **Auditory:** The ability to hear and project sound

- **Power:** A power system adequate to enable the activities and capabilities of the UGV

Adopting these categories as identifiers of basic UGV capabilities leads to a crude identification of potential CMs for the AEODRS system, which are identified in Fig. 3. Figure 3 also illustrates interfaces required
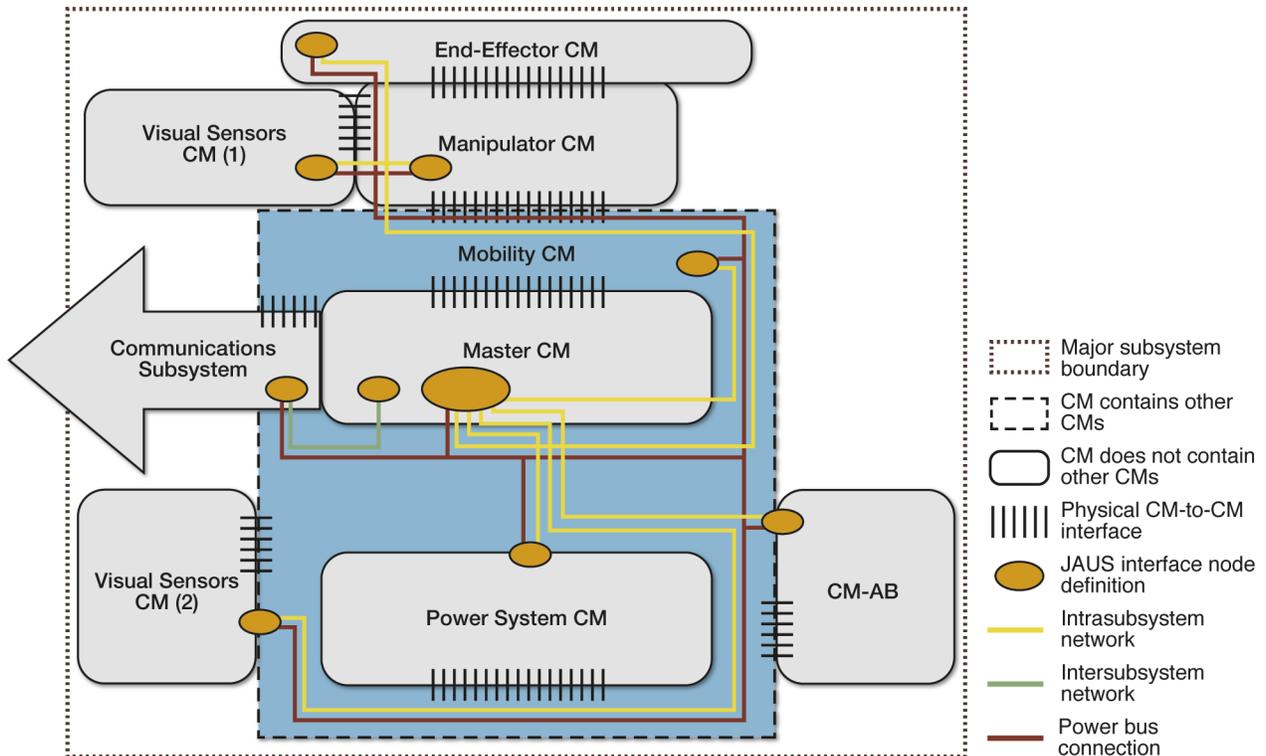

Figure 3. Notional UGV block diagram.

between the modules in order to construct a functioning system. The CMs identified are:

- **Mobility CM**: This module provides the propulsion system for the UGV and includes the UGV chassis/body.

- **Power System CM:** The Power System CM provides electrical power for all other UGV modules.

- **Master CM:** The Master CM provides common system-level services, including support for configuration (detection, registration, publication, and subscription to services provided by the UGV modules) and communications management.

- **Communications Subsystem:** The Communications Subsystem provides a data link between the UGV and the OCU.

- **Visual Sensors CM:** Each Visual Sensors CM may support multiple sensors (for example, full-light cameras and thermal imagers) and provides for management and control of those sensors and formatting and transmission of each sensor's data.

- **Manipulator CM:** A Manipulator CM provides the UGV with means to reach to or toward objects of interest. This is typically implemented with a multi-segment jointed arm; the module provides for control and operation of the arm.

- **End-Effector CM:** This module attaches to the distal end of the Manipulator arm and provides the means to grasp or otherwise manipulate an object of interest.

- **Autonomous Behaviors CM (CM-AB):** This module implements autonomous navigation, high-level manipulation behaviors, and other autonomous and semiautonomous control behaviors.
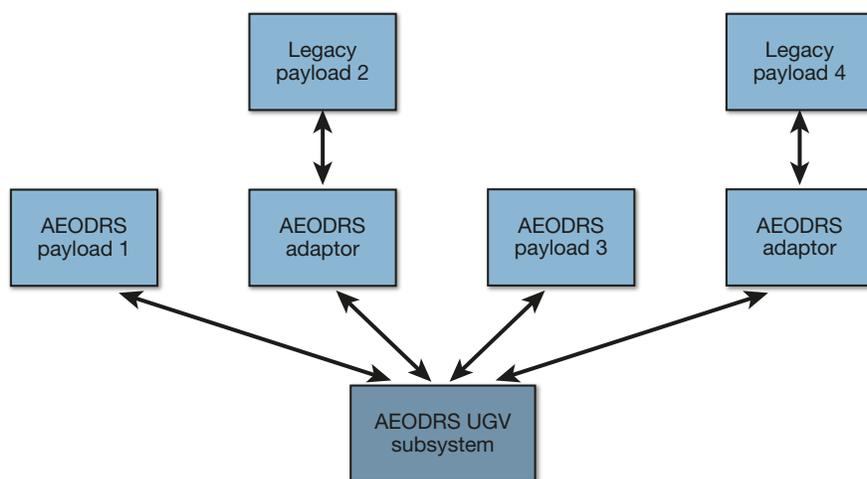
This list of potential CMs is hardly unexpected, as the decomposition is fairly common. Figure 3 also depicts several interfaces and interface types that the architecture must define:

- The electrical and physical connectivity of the subsystem to the power bus (via specified connector and connection characteristics),

- The electrical and physical connectivity of the subsystem to the communications bus (via specified connector and connection characteristics),

- The messaging, timing, and presentation of the subsystem commands to the communications bus (via logical layer protocols and messaging), and

- The mechanical attachment of the subsystem to the host or other subsystem.

The following sections describe an approach to architecture that enables more rapid development of new capabilities and a clear path to integration and support for preexisting, non-AEODRS modules.

Adaptor Paradigm for Legacy Subsystems

The problem of proprietary, noninteroperable interfaces may be resolved with the introduction of well-specified system interfaces. This is accompanied by the development of adaptors that support the system interface and provision of mapping of system-level operations to the interfaces and operations required by the supported payload, device, or subsystem. This approach isolates proprietary and dissimilar interfaces from the overall system. Figure 4 includes a notional depiction of an adaptor paradigm to encapsulate the dissimilar interfaces of several sensors and actuators, providing a standard "AEODRS interface" to the system.

This is a simplistic example but introduces a notion that will be useful for the remainder of this architecture discussion: It is not necessary for a vendor to completely redesign existing capabilities in order to integrate those capabilities into the AEODRS system, because provision of an AEODRS-compliant facade is a viable alternative approach. This important concept of providing interoperability by implementation of a standards-compliant facade is critical to understanding the intent of the AEODRS program. The definition of module boundaries and module interfaces is central to the pro-

Figure 4. AEODRS adaptor concept.

gram, but how the defined interfaces are implemented is left to a module provider's engineering judgment.

CM Concept

Refining our terminology, the term "Capability Module" is AEODRS program specific and denotes an AEODRS vehicle module consisting of the mechanical, electrical, and logical components required to achieve a set of clearly delineated system capabilities. As an example, a Manipulator CM would consist of a manipulator, means of actuation and control of and means of obtaining feedback from that manipulator, and implementation of the standard AEODRS manipulator interface. Thus, an AEODRS CM encapsulates a fundamental capability and presents a standard set of interfaces (logical, electrical, and physical) to the robot platform while preserving the native interfaces to each sensor, actuator, or other device on which it relies.

CMs and Distributed Architecture

A key characteristic for the AEODRS FoS is the interoperability of its CMs, achieved through government-defined and -controlled logical, electrical, and physical interfaces and commonality of OCUs. The AEODRS FoS is also characterized by the interchangeability of CMs between family members and extensibility of system capabilities with future CMs that can be integrated in a near-plug-and-play manner without proprietary issues.

The desire for interoperability and interchangeability, and for system extensibility, drives the partitioning of system capabilities into implementable, intercommunicating CMs; this, in turn, strongly suggests a distributed architecture for the AEODRS. Interoperability is maintained through the use of a message-passing distributed architecture with well-specified messages and messaging interfaces. Interchangeability is facilitated through the
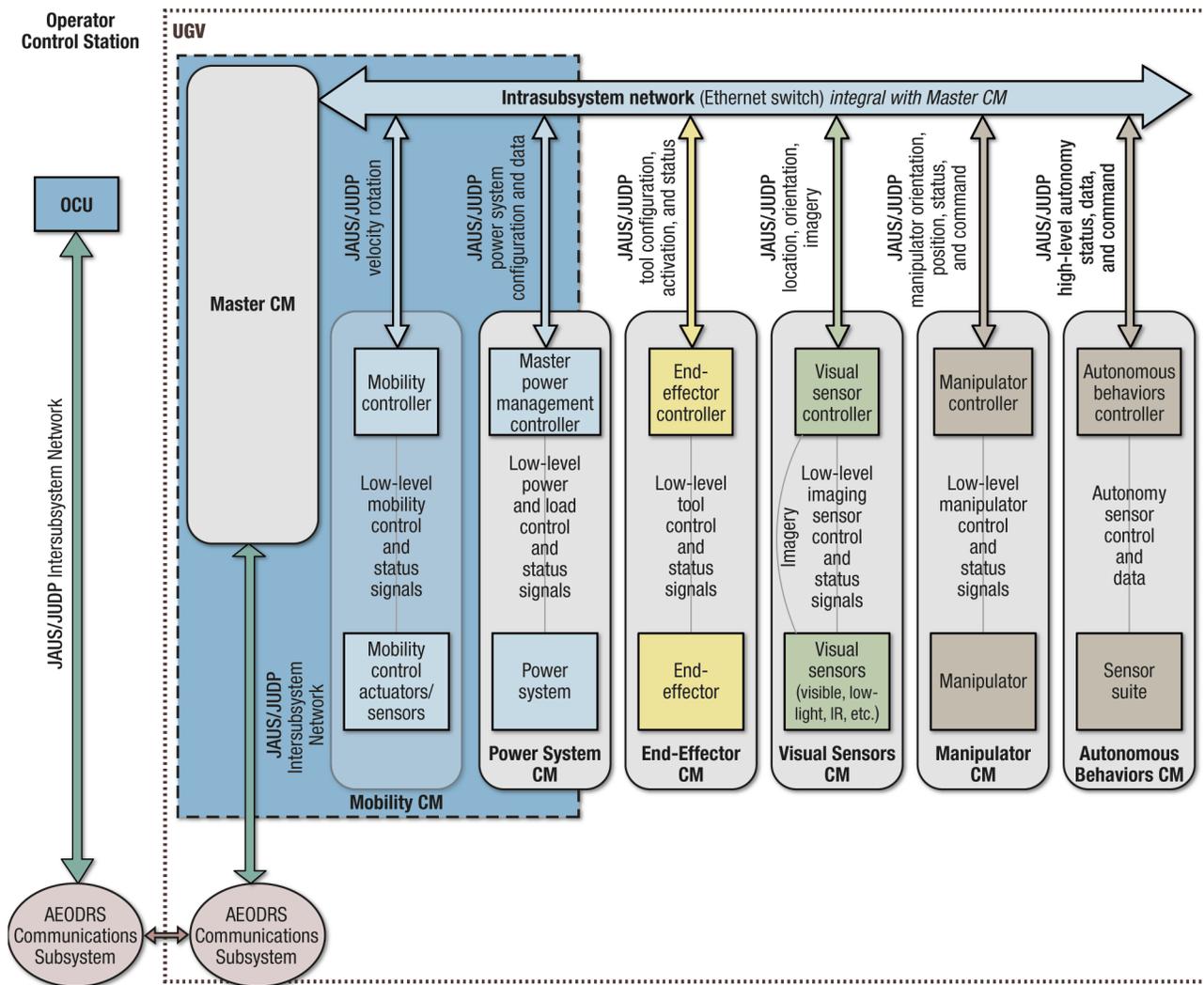

Figure 5. AEODRS distributed architecture concept and capability modules. JUDP, JAUS transport for User Datagram Protocol.

definition and use of standard electrical and physical module interfaces.

Figure 5 depicts the partitioning of a notional EOD UGV Vehicle Control System into multiple CMs and illustrates some CM boundaries and interfaces.

The mobility controller in Fig. 5 receives commands and requests for information (for example, a request for current platform linear and rotational velocities) over the standard AEODRS interface via AEODRS messages. These commands and requests are processed by the mobility controller, and the controller appropriately commands actuators and monitors sensors and possibly communicates with subordinate controls (such as a drive controller) to implement commands and respond to requests. Each AEODRS CM controller receives its commands and requests and returns responses via an Intrasubsystem Network, which serves as the intermodule communications backbone of the AEODRS vehicle's distributed control topology.

LOGICAL LAYER SYSTEM OVERVIEW

The AEODRS Common Architecture defines a system consisting of two primary subsystems: an OCU and a UGV. The UGV is itself a distributed system consisting of a set of intercommunicating CMs connected by a single network. This network, termed the Intra-subsystem Network, is separate and distinct from the Intersubsystem Network, which links the OCU subsystem and the UGV subsystem. The routing of messages between the two networks is one of the primary tasks of the Master CM (see Fig. 6).

The Intrasubsystem Network is implemented as a gigabit-capable Ethernet, relying on an unmanaged, speed-sensing switch to enable the connection of CMs supporting 100BASE-T as well as 1000BASE-T interfaces. This provides adequate bandwidth to support present and future telemetry and video requirements. Thus, the Master CM would route an OCU request for manipulator information to the Manipulator CM, and the Master CM would route the Manipulator CM response to the OCU.

Protocols, Services, and Standards

The AEODRS program has adopted the Joint Architecture for Unmanned Systems (JAUS) protocols, services, and messages as the core of its intermodule communications architecture. The JAUS standard, tested in numerous demonstrations and field experiences, has reached adequate maturity to support systems architecture and design; moreover, the JAUS standard provides a comprehensive architecture element for construction of an interoperable system.
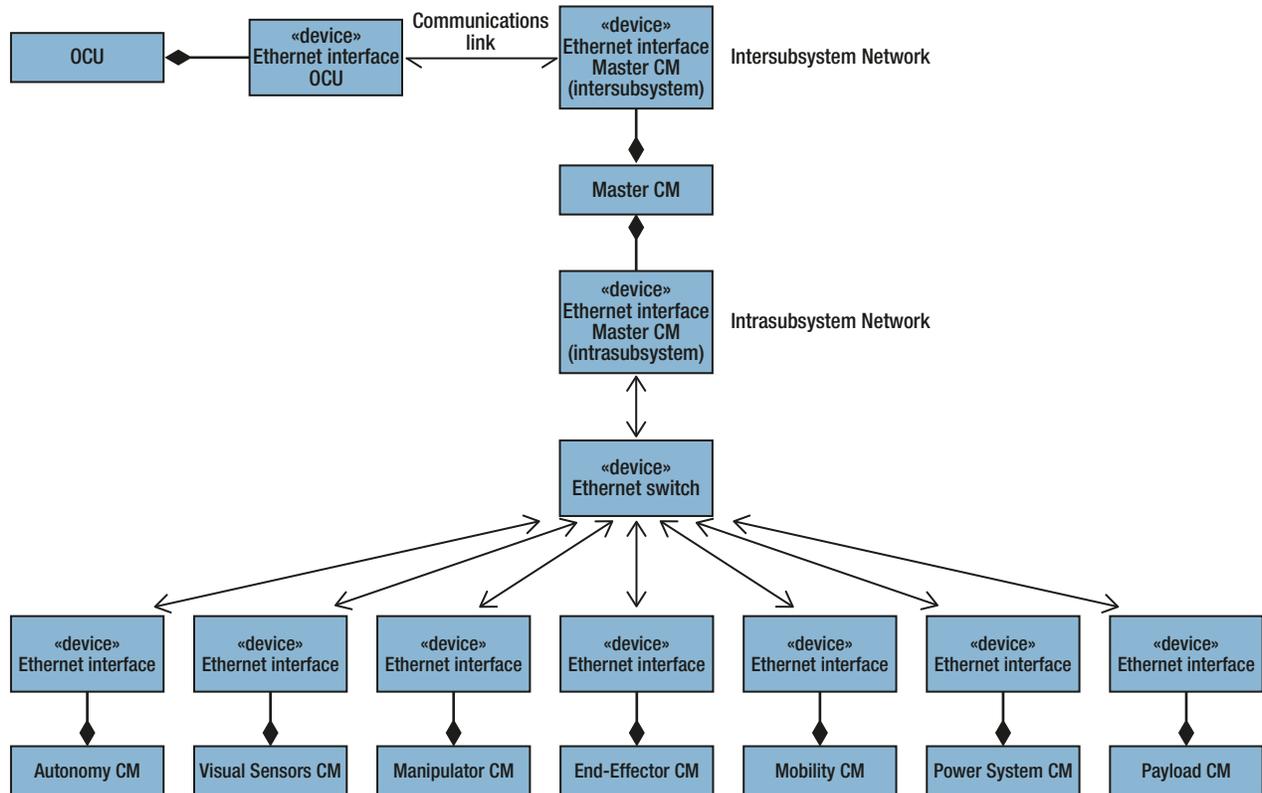

Figure 6. Logical layer system topology.

Initially envisioned as a component architecture standard for the development of unmanned ground systems, and initially called the Joint Architecture for Unmanned Ground Systems (JAUGS), the standard has evolved into a more broadly scoped, service-oriented architecture for use throughout the unmanned systems community.[2] As a message-based architecture, JAUS is well suited to the distributed, message-passing architecture envisioned for AEODRS; as a service-oriented architecture, JAUS is readily tailorable for use in ground robotics.

The migration of the JAUS standards development effort and standards publication to SAE International, an international standards body for mobility engineering, has resulted in increased availability of the JAUS standard; the resulting international availability of the standard makes it more appealing to potential AEODRS vendors with overseas operations or customers.

Core services defined in the JAUS standard include message transport services,[3] safety services (such as the heartbeat messages of the Liveness Service), event generation and handling, authority-based arbitration of component control, and a Discovery Service providing for the automatic detection, registration, and publication of services provided by components and nodes within a distributed system.[4]

Before discussing an example AEODRS system, a few pieces of JAUS terminology need to be introduced:

- A *service* is a "mechanism to enable access to one or more capabilities, where the access is provided using a prescribed interface and is exercised consistent with constraints and policies specified by the service description."[5] A JAUS service "facilitates interoperation of unmanned vehicle systems, subsystems and payloads by standardization of the message set and associated protocol."[4]

- A *service set* is a packaging of documentation of a group of related services.

- A *component* is a software element in a JAUS system, encapsulating a set of services that provide or support a clearly delineated capability. A component is frequently realized as an independent executable.

Implementations built on an operating system platform that supports the classical notion of a process have generally implemented each JAUS component residing on a node as a separate process on that node. Communication between JAUS components on a given node has commonly been realized with JAUS-compliant messaging via interprocess communications mechanisms. This exposed the intercomponent communications for simplified debugging and analysis.

The AEODRS program does not prescribe or proscribe design below the defined intrasubsystem interfaces. The preceding discussion of traditional JAUS component implementations is provided for background purposes.

Some clarifications of AEODRS network naming and terminology are also in order:

- The *Intersubsystem Network* enables communications between AEODRS subsystems. Examples of AEODRS subsystems include AEODRS UGVs and AEODRS OCUs.

- The *Intrasubsystem Network* enables communications between entities within an AEODRS subsystem. Examples include communications between AEODRS CMs onboard an AEODRS UGV.

System Example: Dismounted Operations System

The Dismounted Operations System is the smallest member of the AEODRS FoS and must be small enough to be transported via a backpack. The primary mission focus of this system is on reconnaissance, but it may also be used to support counter-charge placement. This system entails the development of nine modules:

- Master CM
- Mobility CM
- Manipulator CM
- End-Effector CM
- Visual Sensors CM
- Power System CM
- Payload CM
- Communications Subsystem
- OCU Subsystem

The following paragraphs will summarize the capabilities of each of these modules, then present and briefly discuss the JAUS components and services that provide access to their capabilities.

Master CM

The Master CM interfaces to both the Intersubsystem Network and the Intrasubsystem Network. The Master CM provides vehicle subsystem management support in the form of Intrasubsystem Network address assignment for CMs, a Discovery Service to support detection, registration, and deregistration of CMs as part of the UGV subsystem, and message-routing services for communications beyond the UGV subsystem boundary. Other subsystem management services are also provided.

Mobility CM

The Mobility CM interfaces to the Intrasubsystem Network. It provides a low-level interface to mobility capabilities, including basic effort-based drive control and reporting of low-level feedback and status. The Mobility CM also provides access to and control of several platform-associated capabilities, including con-

trol of annunciators, lighting systems, and stabilization devices such as flippers or articulators.

Higher-level mobility control modes are provided by the Mobility Support Component residing on the CM-AB.

Manipulator CM

The Manipulator CM interfaces to the Intrasubsystem Network and provides joint-based control of the manipulator. The supported joint-based control modes and reporting capabilities include the following:

- Joint-position control and reporting

- Joint velocity control and reporting

- Joint force (for prismatic joints) and joint torque (for revolute joints) control and reporting

- Primitive effort-based (open-loop) joint control and commanded-effort reporting

End-Effector CM

The End-Effector CM interfaces to the Intrasubsystem Network. The End-Effector CM provides a low-level interface to control of simple gripper-type end effectors for the Dismounted member of the AEODRS FoS.

Higher-level control modes may be provided by the Manipulation Support Component residing on the CM-AB. The Intrasubsystem Network provides connectivity.

Visual Sensors CM

The Visual Sensors CM provides a well-defined message-based interface for the initialization, configuration, and control of Visual Sensors, and the configuration and control of any video stream or single-frame image requested by another AEODRS CM or subsystem.

The Visual Sensors CM interfaces to the Intrasubsystem Network.

Power System CM

The Power System CM interfaces to the Intrasubsystem Network. The Power System CM provides the AEODRS vehicle platform with a multisource, multibus power system and with management and control services supporting its utilization.

Autonomous Behaviors Capability Module

The CM-AB interfaces to the Intrasubsystem Network. CM-AB accepts and acts upon mission definitions for autonomous and semiautonomous operations and provides aids to the operator for assistive teleoperation of the platform, its manipulator, and its payloads.

CM-AB obtains position, orientation, obstacle, and other needed information through sensors integrated with CM-AB. It also provides standard service interfaces through which other AEODRS CMs and subsystems may gain access to its sensor data. The CM-AB receives high-level commands from other CMs or from the OCU.

Payload CM

The Payload CM defines a generic AEODRS interface used to configure, control, and query a variety of sensors used in the EOD mission space. The Payload CM is not required for the Dismounted Operations System.

OCU and Communications Subsystems

The OCU Subsystem for the Dismounted Operations System is a handheld device allowing a human to remotely operate the UGV, with control of its capabilities. It provides operator input devices appropriate to operation of the UGV platform, its manipulator, and payloads and provides the operator with relevant sensor information (for example, video streams from the UGV's Visual Sensors).

The OCU Subsystem communicates with the UGV by means of the Communications Subsystem, which presents standard interfaces to the OCU and the UGV. The initial Communications Subsystem will be an RF link.

ELECTRICAL LAYER SYSTEM OVERVIEW

The AEODRS Common Architecture defines an electrical layer for both the system power bus and the system communications bus. The result of trade studies on system bandwidth, power budgeting, and market analysis on available COTS systems has led to the selection of the buses as described below.

Power Bus

A negatively grounded 24-V joint payload and platform power bus has been selected for the Increment 1 system. The Increment 2 and Increment 3 systems retain the 24-V payload power bus and add a separate 48-V platform power bus. The internal platform power bus is used for high-power devices such as platform drive motors and possibly manipulation systems (on Increment 2 and 3 systems). The external platform accessibility will be minimized because of safety concerns. The secondary bus (24-V payload) primarily drives external payloads, peripherals, and sensors. This bus is more externally accessible for in-the-field interoperability and swap of field-configurable CMs. In addition to maintaining commonality, the standardization of the power bus maximizes efficiency through the avoidance of using multiple DC-to-DC converters.

Intrasubsystem Network

A Gigabit Ethernet[6] communications bus has been selected for the Intrasubsystem Network. Gigabit Ethernet is adequate for bandwidth needs of the system and allows for future expandability. Many new sensors use Ethernet communications links, and the use of a speed-sensing network switch enables integration of peripherals that do not require gigabit bandwidth interfaces.

PHYSICAL LAYER SYSTEM OVERVIEW

The AEODRS Common Architecture defines a physical layer for the connection of the CMs to the power bus and to the communications bus. Additionally, the physical layer defines the mechanical mounting of the CMs to the base platform or other CMs where required.

Power/Communications Connectivity

Because of the environmental requirements and availability of military standards as well as a precedent set forth in the UGV and other related fields, MIL-STD-38999-series connectors were selected. These connectors are used for both the power and communication buses.

Mechanical Mounting

The mechanical mounting of CMs to the host platform or to other CMs is specified through the use of a mechanical breadboard approach. The breadboard approach uses a 1 × 1 in. grid array of threaded holes for 1/4 in.-20 hardware. By sizing the requisite grid on a CM basis for the worst-case torque/force loading, a reliable and simple interface is achieved.

INTEGRATION OVERVIEW

In the current phase of the AEODRS program, the CMs will be developed by several different vendors and integrated by the lead integrator. This exercise will provide feedback and refinement for the architecture, its interface definitions, and the associated documentation.

An incremental integration strategy will be used, taking advantage of the well-defined, standards-based system interfaces of each CM. This strategy uses simulations of each of the CMs within a system test bed environment that allows replacement of each CM simulation with its corresponding CM implementation at any time during the integration phase. The use of this mixed-simulation environment for integration relaxes program dependence on a given fixed sequence of module delivery and reduces the number of unknown interactions in the initial testing of a given integrand. As a result, the lead integrator will be able to pursue incremental (stepwise) module integration, controlling each increment's scope and maintaining a controlled integration environment.

CONCLUSION

The AEODRS Common Architecture provides for successful interoperability at the system and subsystem levels. The resulting FoS will significantly reduce the logistical footprint of fielded systems and lowers the proprietary vendor interface barrier for implementation of continuous improvement programs. The well-defined open and published interfaces will lower the entry barrier for small organizations of specialized capabilities to produce AEODRS-compliant prototypes for evaluation. The well-defined interfaces and module boundaries provide a means to perform incremental integration of new capabilities and modules, reducing time and cost to integrate, evaluate, and deploy new capabilities from even small suppliers and developers.

It is the long-term vision of the AEODRS technical team that the AEODRS common architecture will revolutionize the small UGV industry, allowing innovative small firms and organizations to more effectively integrate and demonstrate novel capabilities, thereby advancing both the technology and the industry. We believe that realization of this vision will result in the provision of new tools to men and women working in an essential, life-saving mission space.

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The Authors

Mark A. Hinton is a member of APL's Senior Technical Staff and serves APL's AEODRS team as Systems Architect. He has developed embedded systems software for the control of drive systems, resistance welding applications, cutting machine computer numerical control systems, mail-processing equipment, and UGVs. Mark currently chairs SAE Technical Committee AS4-B (JAUS Network Environment Committee). His current research interest is interoperability of robotic subsystems. **Michael J. Zeher** is currently a member of the APL Senior Technical Staff and serves as the Project Manager of APL's AEODRS team. He has accumulated 23 years of experience in the fields of space exploration and national defense as a software developer, technologist, technical manager, and project manager. **Matthew V. Kozlowski** is currently the Director of Robotics Research for Contineo Robotics. He served as a senior mechanical engineer for 6 years in the National Security and Biomedicine business areas at APL and as APL's Socket and Body Attachment Team Lead and Wrist Development Team Lead on the Defense Advanced Research Projects Agency (DARPA) Revolutionizing Prosthetics program. Dr. Kozlowski's research interests include prosthetic limb design, patient–device interfaces, and high-dexterity human-integrated robotic systems. **Matthew S. Johannes** is a member of the APL Technical Staff and serves as Lead Mechanical Engineer on APL's AEODRS team. Dr. Johannes's doctoral research focused on the design, control, and automated motion of nanoscale instrumentation for the modification of materials at the nanoscale. His interests include robotic system design and integration as well as neural prosthetics. For further information on the work reported here, contact Mark Hinton. His e-mail address is mark.hinton@jhuapl.edu.

Mark A. Hinton

Michael J. Zeher

Matthew V. Kozlowski

Matthew S. Johannes

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