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ROBOTICS AND AUTONOMOUS SYSTEMS – GROUND (RAS-G) INTEROPERABILITY PROFILE (IOP): OVERARCHING PROFILE

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NATO LETTER OF PROMULGATION

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1. The enclosed Allied Engineering Publication AEP-4818 Vol. I, Edition A, Version 1 ROBOTICS AND AUTONOMOUS SYSTEMS – GROUND (RAS-G) INTEROPERABILITY PROFILE (IOP): OVERARCHING PROFILE, which has been approved by the nations in the NATO ARMY ARMAMENTS GROUP (AC/225 NAAG), is promulgated herewith. The agreement of nations to use this publication is recorded in STANREC 4818.

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CHAPTER 1 SCOPE

1.1 PURPOSE

This initiative is to identify and define interoperability standards to be organized and maintained within a Robotics and Autonomous Systems – Ground (RAS-G) Interoperability Profile (IOP). This IOP will be employed by Unmanned Ground Vehicle (UGV) acquisition managers in the acquisition of future Programs of Record, the upgrade of fielded systems, and the evaluation/acquisition of Commercial-Off-The-Shelf (COTS) products. Throughout this document, the terms RAS-G and UGV are used interchangeably.

A primary goal of this initiative is to leverage existing and emerging standards within the Unmanned Vehicle (UxV) community such as the Society of Automotive Engineers (SAE) AS-4 Joint Architecture for Unmanned Systems (JAUS) standard and the Army Unmanned Aircraft Systems (UAS) Project Office IOPs. The end goals of this effort are:

– Facilitating interoperability among new UGV initiatives and legacy systems;
– Facilitating interoperability between controllers and UxV robotic system(s);
– Facilitating collaboration between UGV and UAS systems;
– Providing a path forward to standardized interoperable technology solutions
– Promoting payload and on-board subsystem modularity and commonality across the portfolio of UGV systems.

1.2 DOCUMENT STRUCTURE & OVERVIEW

This document provides the base concepts, architecture, requirements, and overview for the RAS-G IOP; and specifically addresses platform, payload, mobility, on-vehicle network, communication, and logical interoperability messaging requirements. Additionally, this document introduces and presents the conformance and validation approach to be employed within the IOP. The complete set of documents that comprise the RAS-G IOP and their intended usage is presented below.

RAS-G IOP – Overarching Profile
This document provides the overall goals and usage of the RAS-G IOP.

– RAS-G IOP – SAE JAUS Profiling Rules
Specifies the manner in which the SAE AS-4 JAUS standards have been profiled, to include clarification or additional content to define interoperability between controllers and UGVs as well as intra-UGV (platform/subsystem) interoperability.

– RAS-G IOP – Custom Services, Messages and Transports
Specifies additional, custom SAE AS-4 JAUS messages and transport protocols required to support the scope of the RAS-G IOP. Although titled "custom", these messages are published and standardized within the RAS-G IOP community with the end goal of transitioning to the SAE AS-4 JAUS standard(s) or other standards bodies for official adoption.

RAS-G IOP – Control Profile
This document specifies the Operator Control Unit (OCU) logical architecture, standards, Human-Machine Interface (HMI) requirements, and conformance approach to include host application user interface requirements, such as mission planning and command and control. Although OCU concepts and high level architecture are touched upon in the Overarching Profile, the Control Profile provides the more detailed requirements to specify how interoperability is to be achieved for conformant controllers.

RAS-G IOP – Payloads Profile
This document specifies the payload classification, standards, requirements, and conformance approach. Although these concepts are touched upon in the Overarching Profile, the Payloads Profile provides the more detailed requirements to specify the interoperability requirements for payloads with respect to the UGV platform.

RAS-G IOP – Communications Profile
This document specifies the communications standards, requirements, and conformance approach. Although these concepts are touched upon in the Overarching Profile, the Communications Profile provides the more detailed requirements to specify interoperability requirements for communications between and among controllers and UGVs.

RAS-G IOP - Applique Profile
This document specifies the appliqué systems classification, standards, requirements, and conformance approach. Although these concepts are touched upon in the Overarching Profile, the Applique Profile provides the more detailed requirements to specify the interoperability requirements for appliqué systems with respect to the unmanned ground systems, controllers, and base manned vehicle systems.

1.3 DISCUSSION OF TECHNICAL TOPICS

1.3.1 Interoperability Attributes

The RAS-G IOP has been designed to support interoperability on a variety of missions and objectives, vehicle classes/types, controller classes/types, payload classes/types, physical/software architectures, and interaction with external systems (e.g., networks, C2). Since every interoperability requirement will not be applicable to every system, the IOP provides a mechanism to independently specify these requirements in a composable, hierarchical manner, using Interoperability Attributes. In this way, Interoperability

Attributes applicable to the specification and design of a system can be identified and subsequently utilized to filter applicable requirements from the RAS-G IOP, supporting system design, development, conformance and validation testing, initial operational test and evaluation, and fielding.

Throughout the RAS-G IOP, the term "Interoperability Attributes" has been designated to identify these composable, hierarchical capabilities, which may be specified in the application of the RAS-G IOP to a system acquisition activity. System requirements specified in the RAS-G IOP are tagged, accordingly, with Interoperability Attribute designations. The manner in which the attribute is to be interpreted is also specified within the RAS-G IOP. It is acknowledged that UGV requirements will vary based upon capability, mission, and other acquisition requirements. For this reason, the Interoperability Attributes defined within this IOP specify the robotic system capabilities in a granular fashion, from the most simple to the most complex.

The Project Management (PM) office has the responsibility for identifying the Interoperability Attributes applicable to each acquisition program. The prime systems developer has the responsibility for implementing the RAS-G IOP in accordance with the specified Interoperability Attributes, and the conformance and validation tester has the responsibility for developing and executing conformance tests, based on those Interoperability Attributes.

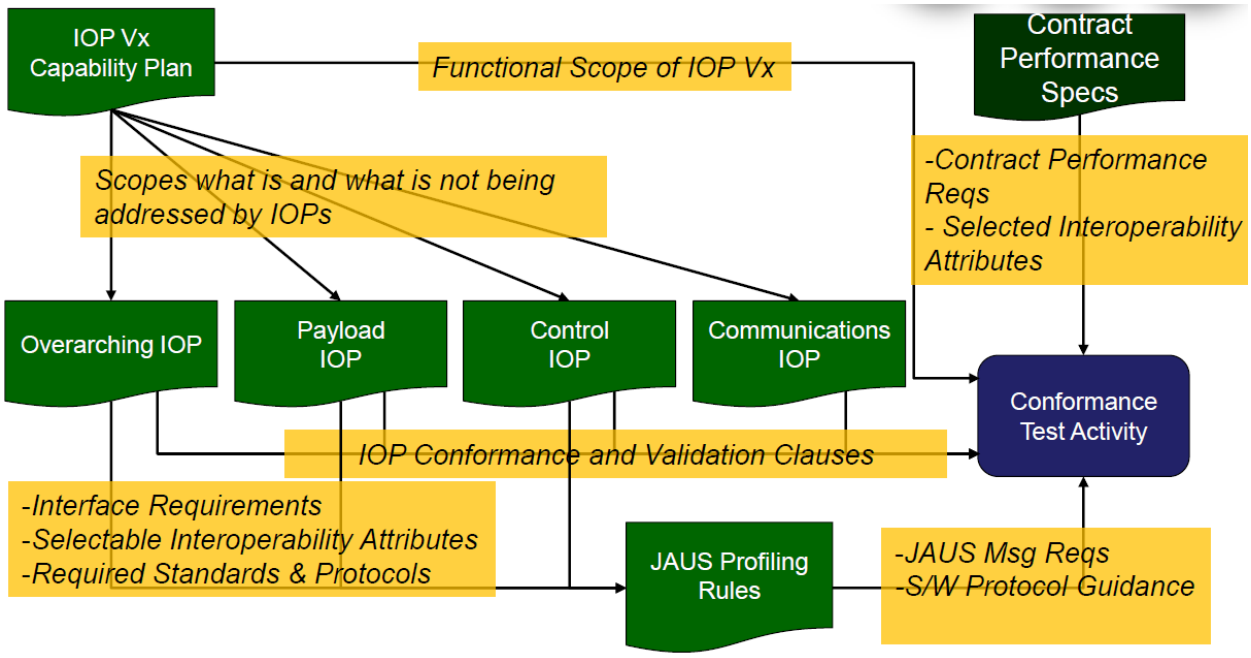

Figure 1: Mission/RAS-G IOP Flowdown

As shown in Figure 1: Mission/RAS-G IOP Flowdown above, the RAS-G Vx Capability Plan document identifies specific capabilities and functionality that are within scope of the current Version level of the IOP effort. These requirements flow directly or indirectly to individual IOPs where additional levels of detail are derived to support the IOP objectives.

These are then further decomposed within the JAUS Profiling Rules document to define specific interface requirements (e.g., synchronous message rates) and behavior required to implement the defined Capability Plan requirement(s). Requirements from all of these levels, in addition to requirements cited within the contract performance specification, are flowed to the conformance and test activity to support a given system/subsystem test and validation activity. For each individual acquisition program, the Project Manager (PM) representatives will review the IOP package and select which Interoperability Attribute values will apply, based on system requirements. The requirements associated with those Interoperability Attributes will then become part of the contractual requirements for that program.

1.3.1.1 Interoperability Attribute Reference Groups

Many of the capabilities defined by these attributes are further refined or extended using related groups of more specialized attributes, referred to as attribute reference groups. These groups may be optional or required, and are either selectable independently, as a group, or in a mutually exclusively manner. The following table lists the different combinations and the related implications for each grouping type:

Optional	Selection Type	Description
True	All	Either all attributes or no attributes from the attribute reference group MUST be selected. These attributes are linked together.
False	All	All attributes from the attribute reference group MUST be selected. These are mandatory attributes.
True	Any	As many of the attributes as desired (including none) from the attribute reference group may be selected. These are optional attributes.
False	Any	At least one of the attributes from the attribute reference group MUST be selected. These attributes are each optional, as long as one is selected.
True	One	No more than one attribute from the attribute reference group can be selected. These are mutually exclusive, though not required, attributes.
False	One	One and ONLY one attribute from the attribute reference group MUST be selected. These are mutually exclusive attributes where a choice is required.

Table 1: Attribute Reference Group Selection Types

The following example comes from the Transport Attribute, which is the capability that defines the transport layer used for delivering IOP-specified JAUS messages. Since any number of transports can be used in a system, but at least one must be implemented, the group is mandatory and the members of the group are independently selectable.

At least one of the following attributes must be chosen.

Attribute	Description
JUDP Attribute	Specifies that messages shall be transported using the JAUS over UDP as defined in AS5669A JAUS/SDP Transport Specification. JUDP defines JAUS over User Datagram Protocol, which is a simple connectionless protocol with lower latency than TCP but without guaranteed delivery.
JTCP Attribute	Specifies that messages shall be transported using the JAUS over TCP as defined in AS5669A JAUS/SDP Transport Specification. JTCP defines JAUS over Transmission Control Protocol, which is a connection oriented protocol that provides reliable delivery, but with higher latency than UDP.
Custom Transport Attribute	Specifies that a custom transport defined in the Custom Services, Messages, and Transports IOP document shall be used.

Table 2: Mandatory, Select = any

1.3.2 RAS-G Classes of Vehicles

The RAS-G IOP is targeted toward a limited set of UGV classes. These class definitions were defined by the Joint Ground Robotics Integration Team (JGRIT). In the future, the JGRIT may define additional categories (e.g., small, micro, nano), with each category having multiple variants with roles defined by modular mission payloads mounted on a common platform. The current classification is as follows:

RAS-G Class of Vehicles (CoV). Army RAS-G CoV are categorized according to transportability within the four following classes:

- **Warfighter Transportable CoV** is the UGV class small enough for Warfighters to carry for extended periods. Within this class are the Single Warfighter and Crew Served Robotic systems.
- **Vehicle Transportable CoV** is larger than Warfighter Transportable CoV and must be transported by another system, such as in a truck, on a trailer, or towed to its mission location.
- **Self Transportable CoV** is the UGV class large enough to transport itself and required payloads for extended periods.
- **Appliqué System** is an add-on standard robotics conversion appliqué kit, that will enable a manned vehicle to operated unmanned at the commander's discretion. The appliqué system equipped vehicle is a scalable UGV with controls from manual operation to fully autonomous while maintaining its transportability as an unmanned vehicle the same as it did as a manned vehicle.

Given that RAS-G classes will impact the usage and application of the RAS-G IOP, "UGV Class" has been adopted as an Interoperability Attribute. The applicability of this attribute will be defined within relevant sections of the RAS-G IOP as it is employed. Currently there are no specific requirements for any one CoV except for appliqué systems.

1.3.3 Implementation of Standards

The RAS-G IOP defines standards as well as guidance with respect to implementation in order to promote interoperability as required by the acquisition program managers. Standards requirements are identified in a variety of areas, including electrical, mechanical, video, audio, communications, and messaging. However, due to the broad scope and expected operational usage of UGVs, not all standards will be applicable to every system.

Acquisition programs requiring conformance to this IOP will specify their interoperability requirements such that system developers can identify and conform to the applicable sections of the IOP.

System developers shall adhere to the standards and guidance as mandated within their procurement contracts relating to this IOP. Robotic system end items shall be tested and validated in accordance with the conformance and validation clauses contained within this overarching profile, as well as those contained in applicable companion IOP documents.

1.3.4 Control and Status Messages & JAUS Profiling

To the degree possible, the RAS-G IOP utilizes the SAE AS-4 JAUS standards to define the interfaces between the OCU and the UGV as well as among on-board UGV subsystems. The *RAS-G IOP SAE AS-4 JAUS Profiling Rules* document provides guidance with respect to the profiling of the JAUS standard, in order to define the manner in which interfaces are applied/interpreted as a means of limiting ambiguity and maximizing interoperability among disparate vendors.

1.3.5 Custom Services, Messages, and Transports

A set of "custom" RAS-G IOP services has been defined to provide mission capabilities scoped within the RAS-G IOP domain that are either not currently available in the SAE JAUS standards or require SAE JAUS extension by the SAE AS-4 Committee. These messages are documented in the *RAS-G IOP Custom Services, Messages, and Transports document*. To the extent possible, Custom Services, Messages, and Transports will be avoided, and when deemed necessary will be taken to the SAE JAUS committee for consideration of inclusion in a future public release. If/when Custom Services, Messages, and Transports have been accepted and published within the applicable SAE AS-4 JAUS standards, they will be removed from the *RAS-G IOP Custom Services, Messages, and Transports* document.

1.3.6 Latency

Latency requirements govern the overall system performance and can be defined at various levels. For example, the control of a UGV manipulator can be measured from input on the OCU to the commanded movement of the manipulator or at various points along the thread to include OCU to comms link transmission, comms link transmission to comms link reception, comms link reception to manipulator. In general latency will be a factor of the operational mission/mission parameters and will not necessarily be applicable to every UGV system in the same regard. For this reason, latency requirements will be identified within specific Program of Record (POR) acquisition documentation.

1.3.7 Conformance Validation

The Ground Vehicle System Center (GVSC) has developed an IOP Conformance Validation Lab. Vendors shall provide system overview, functional breakdown and detailed/component description of their UGV. The government will generate a test plan that will identify the IOP attributes to be tested. The IOP attributes define features or are combined together to identify features. Features may be described as distinguishing characteristics of a software component or system. The test plan will be provided to the contractor for concurrence or modifications if needed. GVSC will generate a conformance report within one month of the end of conformance lab validation.

1.3.7.1 Software Conformance Validation

While conformance validation of a program's software attempts to locate and correct any problems in that software, it is not economically feasible or practical to plan to test until all defects have been revealed. This is a goal that we can never be sure we have reached. Because of budgets, scheduling, and customer deadlines, specific conditions must be outlined to allow managers to decide when Conformance Validation is considered to be complete.

Software reliability testing includes feature testing, load testing, and regression testing.

1.3.7.1.1 Feature Testing

Feature testing checks the features identified in the test plan and shall be executed using the Conformance Validation Tool (CVT) in the following steps:

- Each IOP Attribute that is needed to define a feature is executed once with the result recorded.
- Each Attribute and Feature is checked for its proper execution.
- Upon successful Feature testing, the CVT will be setup to rerun the Feature tests a minimum of five (5) times with all data recorded. This can be setup to run overnight.
- In addition, ordering of specific Feature tests will be changed, where applicable. A minimum of five different order sets of Feature tests will be run with all data recorded. This can be setup to run overnight.

- Any unexpected results will be identified and the code fixed if applicable.
- Repaired code will then go through regression testing.

1.3.7.1.2 Load Testing

Load Testing shall follow Feature Testing and is conducted to check the performance of the software under different work load conditions.

- The CVT will be setup to rerun the Feature tests a minimum of five (5) times with all data recorded. During each test run additional random data will be sent along the transport mechanism. This can be setup to run overnight.
- Any unexpected results will be identified and the code fixed if applicable.
- Repaired code will then go through regression testing.

1.3.7.1.3 Regression Testing

Regression testing is used to check if any new bugs have been introduced through previous bug fixes. Regression testing shall be conducted after every change or update in the software features. This testing is periodic, depending on the length and features of the software. Any suspected potential impacts to code shall then go back to feature testing at least for that section of the code.

1.3.7.2 Power Conformance Validation

Power conformance validation can be done per subsystem and is based on system performance needs. Validation will consist of peak testing for 2.5 seconds and sustained testing for 5.0 seconds. The examples below are not intended to be specific recommendations as each system will be unique. Rather they are intended to represent relevant examples.

The mobility system shall not have a sustained current higher than 0.25 A (calculated as RMS current over 5.0 s sliding window) at 24 VDC.
This means that the mobility system cannot draw more than 6 watts measured as RMS (Root Mean Square) over 5 seconds.

The mobility system shall not have a peak current higher than 1 A maintained for more than 2.5 s at 24 VDC.
This means that the mobility system cannot draw more than 24 watts measured as RMS (Root Mean Square) over 2.5 seconds

CHAPTER 2 SOURCE DOCUMENTS

The following documents are referenced within this IOP and shall be used to implement the requirements contained within the IOP.

2.1 GOVERNMENT DOCUMENTS

ID	Version	Document
1011-I-2.0	2.0	NIST Special Publication, Autonomy Levels for Unmanned Systems (ALFUS) Framework Volume I: Terminology, Version 2.0, October 2008.

Table 3: Government Documents

2.2 NON GOVERNMENT DOCUMENTS

ID	Version	Document
AIR5665A	Rev A	AE Aerospace Information Report, Architecture Framework for Unmanned Systems (AFUS)
ARP6012	1.0	SAE Aerospace Recommended Practice, JAUS Compliance and Interoperability Policy
AS5669A	Rev A	SAE Aerospace Standard, JAUS/SDP Transport Specification
AS5684B	Rev B	SAE Aerospace Standard, JAUS Service Interface Definition Language
AS5710A	Rev A	SAE Aerospace Standard, JAUS Core Service Set
AS6009	1.0	SAE Aerospace Standard, JAUS Mobility Service Set
AS6057A	Rev A	SAE Aerospace Standard, JAUS Manipulator Service Set
AS6040	1.0	SAE Aerospace Standard, JAUS HMI Service Set
AS6060	1.0	SAE Aerospace Standard, JAUS Environment Sensing Service Set
AS6091	1.0	SAE Aerospace Standard, JAUS UGV Service Set
AS8024	1.0	SAE Aerospace Standard, JAUS Autonomous Behaviors Service Set
IEEE802.3-2008	1.0	Standards for Ethernet based LANs

Table 4: Non Government Documents

CHAPTER 3 ARCHITECTURE

3.1 SYSTEM CONTEXT

From a system perspective, the RAS-G IOP is defined to address interoperability at multiple levels within varying systems configurations. The context diagram, presented in Figure 2: RAS-G IOP Context below, depicts this concept by showing the UGV and a controller interfacing to external UxV and external command & control (C2)/battle command systems. This concept can be instantiated in a number of ways from a basic OCU/UGV configuration to more complex configurations (i.e., an OCU controlling multiple UGVs with UAV feeds and/or a communication relay/extension). Interoperability can be applied to various aspects of these configurations as required by the system product manager, to include:

– OCU/UxV(s) – radio/data interfaces
– Intra-OCU – between and among OCU hardware and software elements
– Intra-UGV – between and among UGV subsystems/payloads and platform
– OCU/UGV to External C2 Systems – exchange of command and control, battlespace, and audio/video information.

For the purposes of IOP V4, only the circled portion of this architecture is within scope. This includes the hardware and software interfaces to define interoperability and modularity between a platform and an OCU, between a platform and its payloads, between a radio and a platform or OCU, and between an OCU and its human operator.

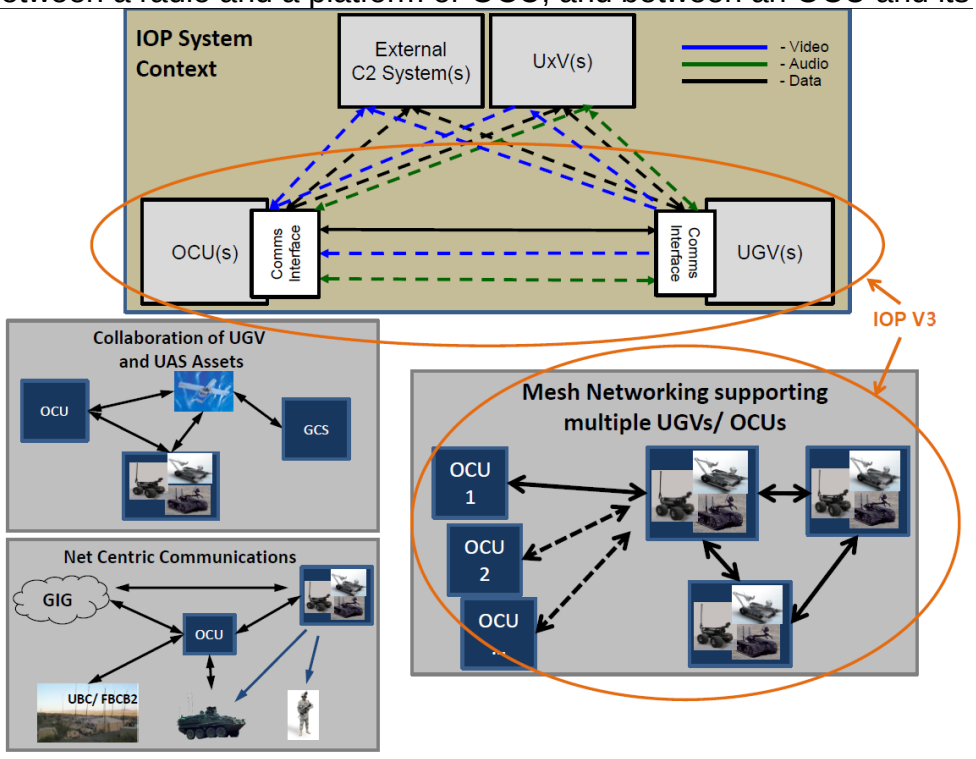

Figure 2: RAS-G IOP Context

3.2 REFERENCE ARCHITECTURE

The architecture presented in Figure 3: RAS-G IOP Reference Architecture below builds upon the system context and defines key integrated elements of the UGV and OCU along with internal and external interfaces. These elements are defined in this IOP in a generic (abstract) manner and may be realized within a system in a variety of ways. For example, although all UGVs will have a conceptual platform controller to provide platform and mobility processing, the platform controller may be realized as a single computer, a single line replaceable unit (LRU) with multiple computers or a set of LRUs with distributed processing and internal interfaces. The terms defined and presented in the architecture diagram are defined to provide a consistent terminology and point of reference for utilization throughout this IOP.

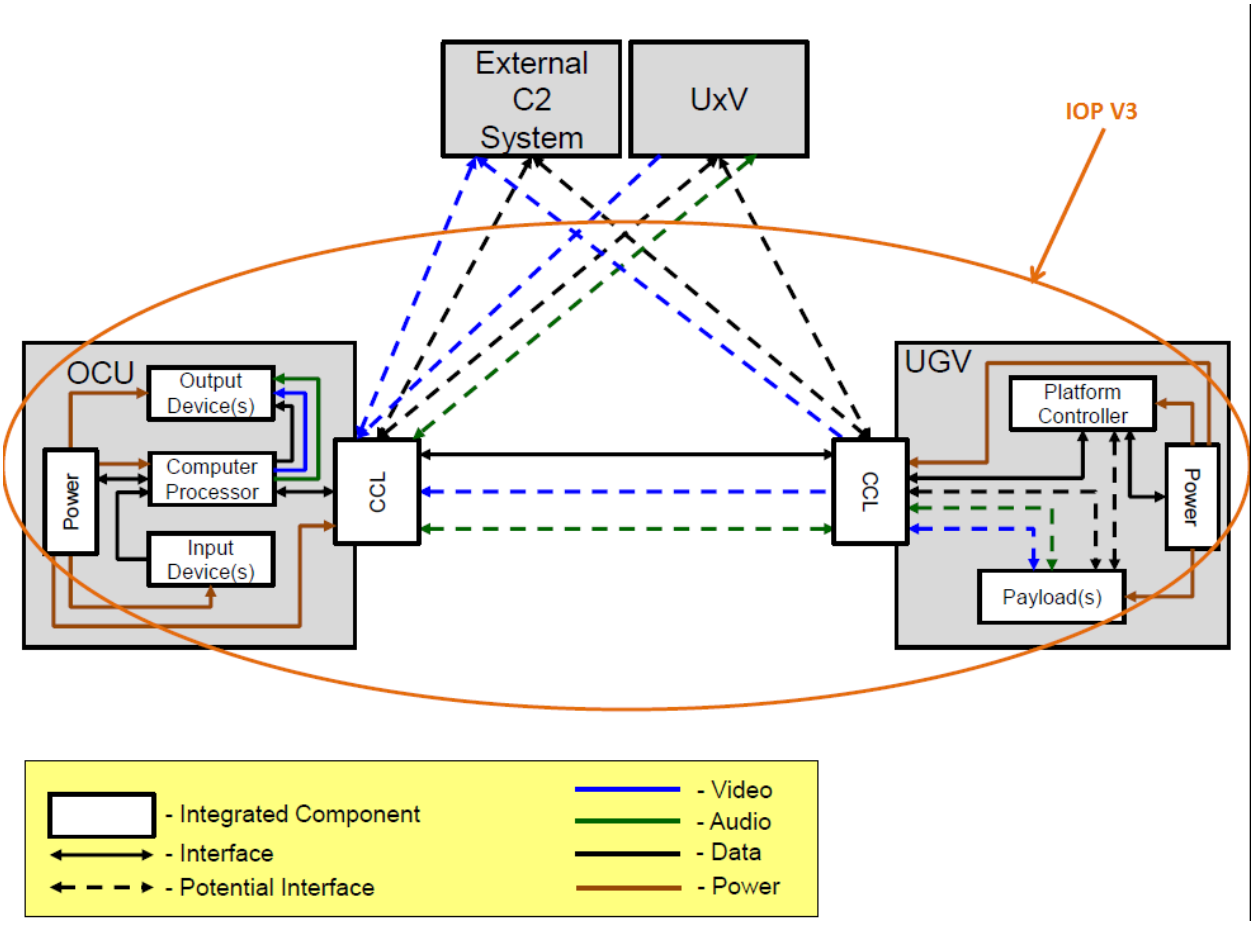

Figure 3: RAS-G IOP Reference Architecture

As depicted in the figure, systems within the reference architecture are comprised of integrated elements, interfaces, and potential interfaces. An integrated element is an element that will exist (at least conceptually) within the specified system; an interface defines an inter or intra system linkage between integrated elements; and a potential interface is an interface that may or may not exist depending upon the required functionality as specified by a system's Interoperability Attributes.

3.2.1 Operator Control Unit (OCU)

The OCU system of the reference architecture provides the human operator a capability to issue commands to and receive input back from one or more UGVs. Specific OCU-level requirements are included within the Control IOP.

The Input and Output Device element(s) are generic and could be adapted to describe a traditional controller implemented with joysticks, keyboard, mechanical switches, and a display, or other types of controllers such as those implemented with a glove, video game controller, monocle, voice, smart phone, or tactile belt.

3.2.2 Common Communications Link (CCL)

The Common Communications Link (CCL) element is an abstraction of the networking and/or point-to-point communications solution required for command and control of UGVs. It provides the OCU with the ability to transmit and receive data to/from a UGV, external C2 System, and/or another UxV.

While it is not within the scope of IOP to define all CCL requirements, it does represent the "core" set of requirements necessary to define interoperable behaviors for near-term UGV radios. A future Version of the IOP will include enhanced definition of how the CCL must operate in the long term.

3.2.3 Unmanned Ground Vehicle (UGV)

The UGV system of the reference architecture consists of a Platform Controller element integrated with zero or more Payload elements, and interfaced externally to an OCU and/or UxV and External C2 Systems via a CCL element. The Platform Controller element is conceptually responsible for providing platform management (e.g., system diagnostic monitoring, system safety, BIT/FIT) and mobility. The Platform Controller element receives data and provides status through the CCL element. The Payload element(s), if present, may be communicated with external consumers via an external connection through the CCL or may be integrated directly to the Platform Controller element. An example of a Payload element with a direct connection to the CCL might be an SAE AS-4 JAUS compliant payload that can be discovered and communicated to directly by an OCU. An example of a Payload element with a connection to the Platform Controller element might be a payload with an SAE AS-4 JAUS interface resident on the Platform Controller where commands to the SAE AS-4 JAUS interface are translated to the payload in a non-SAE AS-4 JAUS format. In addition, an SAE AS-4 JAUS compliant payload capable of interfacing directly to an OCU may still have an interface to the Platform Controller in order to provide subsystem status and to register for platform data (e.g., navigation, state/mode). The Power element provides power to all UGV integrated components.

3.2.4 External Command & Control (C2)

While outside the scope of IOP V4, the External C2 system of the reference architecture provides for the interfacing of an OCU and/or UGV with an external system, such as a battle command system. Sharing of payload data into external ground or air based systems or networks will be addressed in a future version of this IOP.

3.2.5 Other Unmanned Vehicles (UxVs)

While not explicitly within the scope of IOP, the UxV system of the reference architecture provides for the coordinated interaction of an UxV system with the OCU and/or UGV. UxV in this context represents a generic unmanned system to include another UGV, a UAV, or an unattended sensor. While many UGV/UxV capabilities can be achieved by utilizing a combination of IOP requirements and requirements of existing UxV standards, explicit interface requirements for communicating with UxVs outside of the ground domain will be addressed in a future version of this IOP. Some possible specific capabilities to be addressed in future near-term IOP versions are provided in Figure 4: Example Possible Capabilities with other UxV for Future IOP Versions below in order to generate feedback and encourage IOP contributors to begin thinking through the various interface considerations.

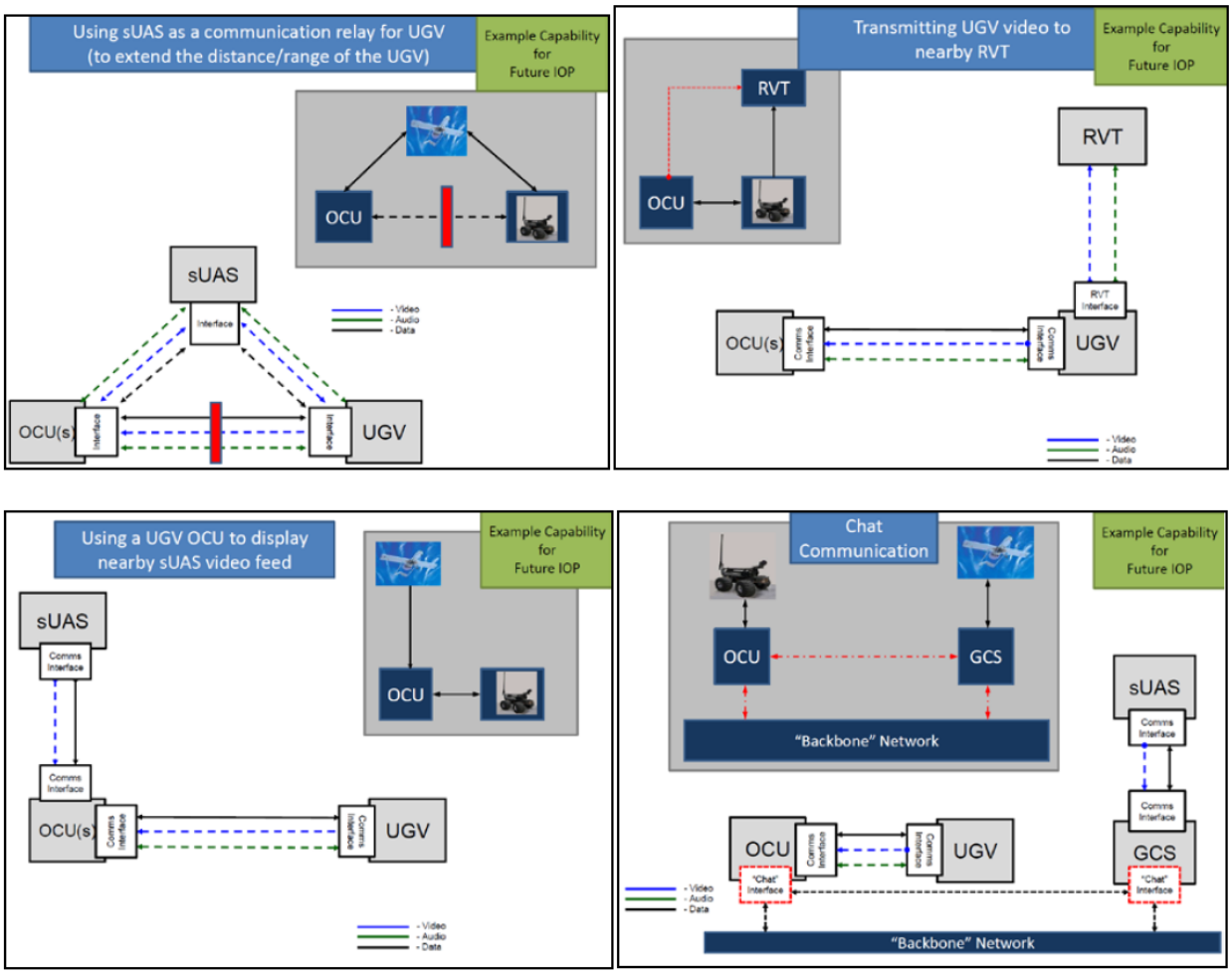

Figure 4: Example Possible Capabilities with other UxV for Future IOP Versions

3.3 UGV LOGICAL INTERNAL ARCHITECTURE

In addition to the reference and system architecture, the RAS-G IOP applies to the logical internal architectures for both the OCU and the UGV, specifying the general hardware and software interfaces relevant to interoperability within the OCU and UGV systems. The term logical refers to the fact that these elements may be implemented in varying physical configurations and that the physical configuration is not specifically relevant to the manner in which these elements interface with one another within the system. An example UGV logical internal architecture is presented in Figure 5: Example UGV Logical Internal Architecture below.

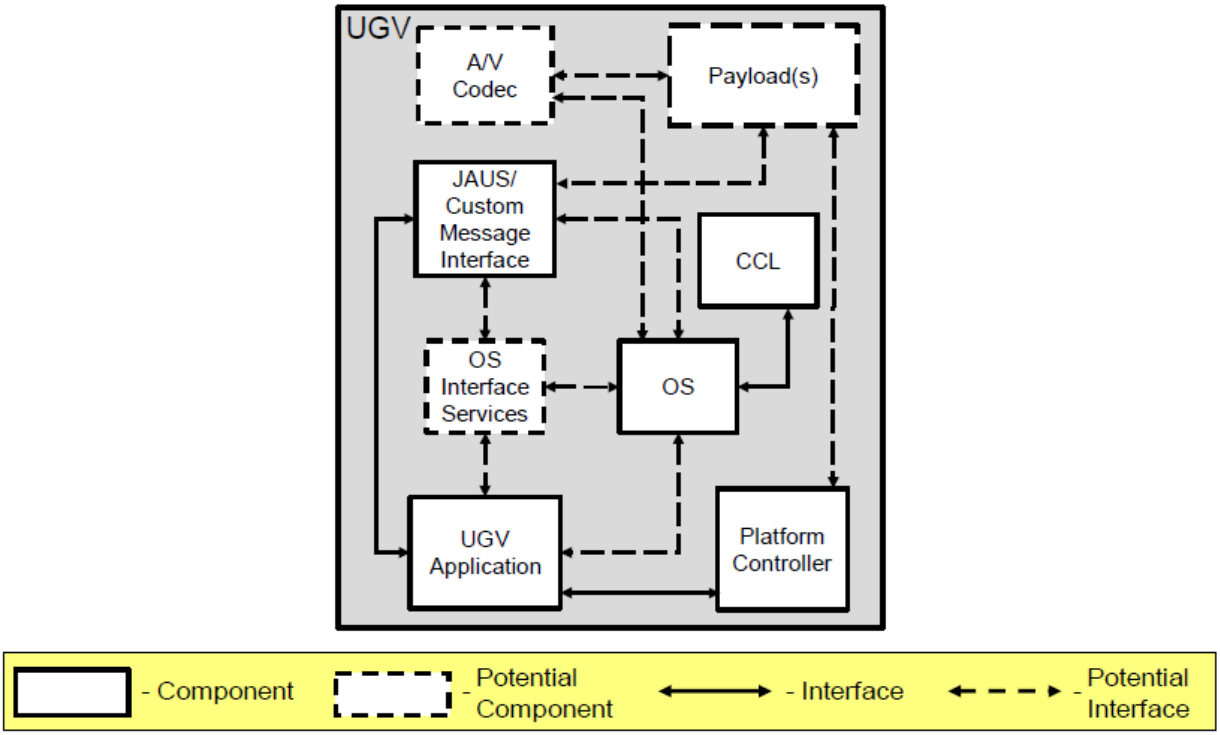

Figure 5: Example UGV Logical Internal Architecture

The solid elements depicted in the figure represent elements that are always present within the UGV system. The dashed elements represent potential elements that may be present within the UGV system. Similarly the solid lines between elements represent defined element interfaces while dashed lines represent potential element interfaces. Within the RAS-G IOP, potential element/interface requirements are subset via Interoperability Attributes to provide for the specification of a basic UGV configuration that can be augmented to accommodate specific interoperability requirements related to the interface with external system(s). A brief description of the controller elements is presented in the following paragraphs.

OS (Element) – The OS represents the controller operating system. In general, requirements related to the operating system will not be addressed within this IOP and will instead be defined via acquisition requirements or design decisions.

OS Interface Services (Potential Element) – The OS interface services specify inter-process communication (IPC) mechanisms required to implement interoperability interfaces between software (application) elements. This could be an interface between the controller application and an external system(s), the controller application and a vendor plug-in, and/or an interface utilized by the JAUS system to provide an underlying transport.

A/V Codec (Potential Element) – The A/V Codec represents the element within the system that decodes/encodes digital audio and video data streams. The codec formats required within the system will largely be dependent upon the requirements associated with specific payloads and/or the communications data link.

JAUS/Custom Message Interface (Element) – The JAUS/Custom message interface represents the element responsible for interfacing with the application to encode, marshal, transmit and receive, unmarshal, and decode JAUS messages between the controller and the robotic system(s). This element may be incorporated with or separate from the application software component.

UGV Application (Element) – The UGV application specifies the element responsible for the logical execution of the UGV system. In general requirements related to the application will not be addressed within this IOP and will instead be defined via acquisition requirements or design decisions.

Platform Controller (Element) – The platform controller specifies the element responsible for hosting and execution of the UGV application. This element may be realized in a variety of ways from a small micro-controller up to a multi-LRU configuration in accordance with the platform size and mission capabilities/requirement(s). In general internal requirements related to the platform controller will not be addressed within this IOP and will instead be defined via acquisition requirements or design decisions. External and interfacing requirements associated with the platform controller will be defined and presented within this IOP.

CCL (Element) – The CCL represents the communications data link between the controller and the robotic system. The requirements governing this interface are specified within the *RAS-G IOP Communications Profile.*

Payload(s) (Potential Element) – The Payload element specifies the element responsible for conducting mission specific functions/capabilities alone or in concert with other payloads and/or the UGV platform. This element may be realized in a variety of ways and configurations in accordance with the platform size and mission capabilities/requirement(s). Internal requirements related payloads will not be addressed within this IOP and will instead be defined via acquisition requirements or design decisions. Payload interfaces to/from the platform (e.g., electrical, mechanical), as well as interfaces between the payload and external systems (e.g., data formats, message protocols) are defined within the *RAS-G IOP Payload Profile.*

CHAPTER 4 IOP USAGE GUIDE

4.1 OVERVIEW OF IOP USAGE PROCESS

This set of IOPs will be used by both the Project Manager (PM) community and the vendor community. For convenience, individuals within the Materiel Developer (the PM) will be referred to as "MATDEV". Private industry (or academia) developers of systems, payloads, radios, technologies, or systems engineering/integration expertise will be referred to as "vendors". For a given UGV acquisition program, the process begins with the MATDEV reviewing the operational requirements as articulated by the User community.

The MATDEV will then use systems engineering processes to transform these operational requirements into performance requirements. During this process, the MATDEV will conduct a formal review of the IOP documentation and select the attributes defined within the set of IOPs corresponding to the capabilities of the system. Many Interoperability Attributes will have one or more associated requirements, which will be inserted into the PM's contractual requirements for the program's Request for Proposal (RFP). Selection of the appropriate Interoperability Attributes will often require the MATDEV to conduct formal trade studies to inform the decision. There are also a number of Mandatory Interoperability Attributes across all of the IOP documents, whose requirements will be imposed on all systems. These Mandatory Interoperability Attributes are further described within this document, the *JAUS Profiling Rules document, and the Communications, Control, and Payloads IOP documents.*

The vendors within the competition space will then implement the requirements that have been selected based on the Interoperability Attributes, in accordance with the IOPs, and particularly in accordance with the *JAUS Profiling Rules IOP* and the *Custom Services, Messages & Transports* document.

An example of this process would be that the MATDEV receives a new requirement for a system that has Leader / Follower capabilities, as well as requirements for sensing Chemical, Biological, Radiological, Nuclear (CBRN) threats. In this case, the MATDEV will know that in addition to specifying the Mobility Interoperability Attribute with its associated "Core Mobility", "Drive Timeout", and "Emergency Stop Safety" requirements, they will also know that they must select, at a minimum, the Leader/Follower Interoperability Attribute. Similarly, the MATDEV will also know that it must also specify the CBRN Sensor Attribute, in addition to other common payload requirements. The requirements associated with each of these attributes would then become requirements imposed on the vendor to be compliant with the performance and/or product specifications.

4.2 IOP USAGE

For the MATDEV, the IOPs will be used as part of the requirements decomposition & allocation process prior to release of RFPs. It should be noted that the interface requirements in the IOPs represent a "product level specification", as opposed to the typical "performance level specification" that PMs are typically responsible for. This has been done intentionally in order to provide sustained interoperability and modularity of systems throughout their full lifecycles. MATDEVs will build program-specific interoperability requirements into their RFPs prior to being released, based on this IOP. For the MATDEV, the Overarching IOP, Payloads IOP, Communications IOP, and Control IOP are of primary interest, since those contain definitions of the Interoperability Attributes, and the applicable requirements for each.

For vendors who are marketing products, this IOP should be used as a guide for what to expect in future RFPs. This package of documents describes the hardware and software interfaces that the DoD would like to see in products that vendors may be developing. For vendors who are awarded RFPs in future programs, these documents represent the technical requirements that will be imposed to promote interoperability. For industry, the JAUS Profiling Rules document is of primary interest, as it contains the product level specifications that can be implemented to build interoperable systems.

4.2.1 Usage of Overarching IOP

The Overarching IOP will support the MATDEV and industry to serve as a description of the intent of the full IOP package, to describe its usage, to define overarching requirements for all systems, to point to applicable sections in the other IOPs, and to define Interoperability Attributes that may be selected by the MATDEV to impose interoperability requirements into acquisition contracts.

4.2.2 Usage of Communications IOP

The Communications IOP will be used by the MATDEV and industry to define communications and radio related requirements for a CCL, to point to applicable sections in the other IOPs, and to define communications related Interoperability Attributes that may be selected by the MATDEV to impose interoperability requirements into acquisition contracts.

V1.OVA-1	*UGV platforms shall implement the communications data link interface in accordance with the RAS-G IOP Communications Profile and any required (specified) Interoperability Attributes.*

4.2.3 Usage of Payloads IOP

The *Payloads IOP* will be used by the MATDEV and industry to define payload related requirements for both payloads themselves and UGV platforms, to point to applicable

sections in the other IOPs, and to define payload related Interoperability Attributes that may be selected by the MATDEV to impose interoperability requirements into acquisition contracts.

V1.OVA-2	*Payloads shall be implemented in accordance with the RAS-G IOP Payloads Profile and any required (specified) Interoperability Attributes.*

4.2.4 Usage of Appliqué IOP

The *Appliqué IOP* will be used by the MATDEV and industry to define appliqué related requirements for unmanned appliqué kits.

V1.OVA-3	*Appliqué shall be implemented in accordance with the RAS-G IOP Appliqué Profile and any required (specified) Interoperability Attributes.*

4.2.5 Usage of Control IOP

The Control IOP will be used by the MATDEV and industry to define desired common qualities of controllers. It is acknowledged that there are a variety of types of controllers that make sense for different missions, and the technology related to controllers is evolving rapidly, particularly based on advancements being made in the mobile/smart-phone and gaming markets. The current Control IOP V4 contains desired guidelines for user interfaces for conventional controllers, but does not mandate explicit requirements. Controllers must be capable of communicating JAUS-based messages as defined in this IOP package, and must interface with the CCL as defined in the Communications IOP. The primary intent of the Control IOP is to promote an interoperable Human Machine Interface (HMI), which means that the relationship between the controller and the human operator must be modular based on minimized training for operation among different systems. If controllers can support the JAUS-based messages described in this IOP package, then interoperable messages will become the interface between the controller and the UGV platform.

For example, if a controller operator presses a keypad arrow to turn right, then an interpretable message command will be received and understood by the UGV platform. If another controller utilizes a joystick to turn right, then the UGV platform should receive a message similar as that sent from the first controller. User input to turn right on a smartphone type accelerometer device, a speech-based device, a motion-recognition device, or other innovative controller technology should all result in a similar functionality, interpretable JAUS-based message being received by the UGV platform.

V1.OVA-4	*Controller requirements shall be implemented in accordance with the RAS-G IOP Control Profile.*
V1.OVA-5	*All IOP compliant controllers will be capable of communicating with platforms using the JAUS-based message set contained within the other IOP documents. The Control IOP serves to provide additional guidance as to the design of controllers.*

4.2.6 Usage of JAUS Profiling Rules IOP

The JAUS Profiling Rules IOP will be used primarily by industry to define the services needed for complying with the requirements defined within the other IOPs. It provides the product-level JAUS-based message implementation guidance, and reference to the appropriate SAE AS-4 JAUS documents. Additionally, the JAUS Profiling Rules IOP will be used by the MATDEV in developing System Integration Labs (SILs) for verifying that the IOPs achieve the desired outcomes, as well as assessing the compliance of vendor products to the IOPs.

V1.OVA-6 *JAUS Profiling Rules shall be implemented in accordance with the RAS-G IOP JAUS Profile and any required (specified) Interoperability Attributes.*

4.2.7 Usage of Custom Services, Messages & Transports IOP

The Custom Services, Messages & Transports document will be used to define JAUS-based services that are not currently defined in any existing SAE AS-4 JAUS approved document. Currently in V1, the Custom Services, Messages & Transports document contains JAUS-based guidance for the following Custom Services:

Service	**IOP V1**
Acoustic Sensor	Introduced
Channel Status	Introduced
Comms Lost Policy Manager	Introduced
Communicator	Introduced
Component Physical Properties	Introduced
Convoy	Introduced
CostMap2D	Introduced
Data Logging	Introduced
Debris Blower	Introduced
Digital Audio	Introduced
Digital Audio Annunciator	Introduced
Digital Audio Sensor	Introduced
Digital Resource Discovery	Introduced
Digital Video	Introduced
Engagement Detection	Introduced
Enhanced Access Control	Introduced
Enhanced Waypoint Navigation (Global)	Introduced
Enhanced Waypoint Navigation (Local)	Introduced
Extended Primitive Manipulator	Introduced
Extended Primitive Pan/Tilt	Introduced
Filter Mapper	Introduced
Follower Status	Introduced
Force Torque Sensor	Introduced
Frame of Reference	Introduced

General Sensor	Introduced
Global Contact Tracking	Introduced
Guarded Teleoperation Policy Manager	Introduced
H264 Video Encoding	Introduced
Handoff Controller	Introduced
Health Monitor Service	Introduced
Health Reporter	Introduced
Intelligent Vehicle Policy Manager	Introduced
Leader Follower Driver	Introduced
Leader Management	Introduced
Loading Specifications	Introduced
Magnetic Sensor	Introduced
Manipulator End-Effector Force/Torque Sensor	Introduced
Military Illumination	Introduced
Mount Site Properties	Introduced
NodeID Allocator	Introduced
Pass-through Message	Introduced
Path Reporter	Introduced
Physical Specification	Introduced
Platform Door	Introduced
Platform Mode	Introduced
Platform State	Introduced
Preset Pose	Introduced
Render Useless	Introduced
Retrotraverse	Introduced
Seismic Sensor	Introduced
Self-Collision Avoidance Policy Manager	Introduced
Software Version Reporting	Introduced
Stability Control	Introduced
SubsystemID Allocator	Introduced
Surrogate UAV Driver	Introduced
Tamper Detection	Introduced
Tether Spooler Driver	Introduced
Tire Pressure	Introduced
Uninterruptible Power Supply	Introduced
Unsolicited Broadcast Control Available	Introduced
Unsolicited Heartbeat	Introduced
Video Illuminator	Introduced
Wiper	Introduced

Table 5: Summary of IOP Custom Services

Currently there are no defined custom transports in this document.

Whenever possible, it is the intent of the DoD for each of the custom services, messages, and transports defined in this package to be recommended for adoption by the SAE AS-4 JAUS Committee, and published in an approved SAE document. Once the services, messages, or transports are approved in a published SAE document, this IOP package will be modified to reference the new published document instead of the Custom Services, Messages & Transports document (and they will be removed from the subject document as well).

Custom (or "private") messages provide a mechanism to specify necessary command, control, and status messages that have not been defined within the specified SAE AS-4 JAUS standards. For the RAS-G IOP, all custom messages approved for use are defined within the RAS-G IOP Custom Services, Messages and Transports. Custom messages are controlled within the RAS-G IOP activity and it is the intent of the DoD to seek standardization of these custom messages within the applicable SAE AS-4 JAUS committees and seek wide adoption within the Army robotic ground vehicle community.

The RAS-G IOP will specify the use of SAE AS-4 JAUS messages to achieve interoperability and only employ custom messages when no JAUS message will suffice.

Custom messages will be published and distributed to the stakeholder community without proprietary markings.

V1.OVA-7	*Custom command, control and status messages shall be implemented in accordance with the RAS-G IOP Custom Services, Messages and Transports.*

4.3 NON-COMPLIANCE

In the event that a program of record specifies the incorporation of a technology that currently does not meet one or more of the physical, electrical, or logical requirements specified within the IOP profiles for the capabilities/attributes it utilizes, it will be deemed "non-compliant". Methods of dealing with non-compliance (when specifically allowed for a given program) are intended to allow non-compliant technology to operate with the IOP Profiles and consist of the following options:

1. "Adoption" of a new physical, electrical or logical interface into the appropriate IOP profiles(s), and subsequent creation of new IOP attributes to profile the interface.
2. "Wrapping" or "Adapting" the physical, electrical or software interfaces. Examples include:
    a. A physical adaptor such as a bracket that could bridge between the physical hardware requirements of the IOP and a new technology
    b. A 7 to 5 pin converter (adaptor)
    c. A software wrapper that would act as a "bridge software component" between two differing message sets (i.e., STANAG 4586 to JAUS)

Although non-compliance should be avoided, it is recognizes that the constraints of an individual program may require a temporary non-compliant step (this may be considered on a case-by-case basis). In all cases, over time, non-compliant technology should migrate to full compliance through system upgrades or this technology, if viable, should be added to future versions of the IOP.

Note that certain capabilities within the IOP may not work well with a mixture of compliant and non-compliant elements within the robotic sub-system. One such example is the Render Useless capability. Should a solution use non-compliant technology that does not expose its own logical interface for the compliant side of the system to bridge to, then the mission security and IA needs may not be fully achievable. The POR should review such solutions on a case-by-case basis.

4.4 DEPRECATION

As standards evolve it will become necessary to remove and/or replace certain paragraphs, messages or attributes. In order to provide backward compatibility and give developers who have used a specific feature enough time to evolve their code into compliance, key features will be deprecated instead of immediately removed. The following procedures will be used when deprecating a paragraph, message or attribute:

1. Identify the item to be deprecated.
2. In the document, clearly mark the item (paragraph, message, attribute) as "DEPRECATED" and provide the rationale as to why the item is being deprecated, as well as the known/anticipated version when the item will be removed.
3. Remove the deprecated item from the appropriate version, when that version is released.

4.5 INTEGRATION WITH OTHER STANDARDS EFFORTS

4.5.1 ROS-M

The primary goal of the IOP is to define the physical, electrical, and logical interfaces between platforms, payloads, and devices for unmanned ground systems. This promotes interoperability between such devices, without prescribing any internal implementation. This allows vendors and suppliers to use whatever tools, intellectual property, or proprietary implementations they wish. The IOP does not encourage one solution over another, so long as the interfaces are compliant.

As a result, the IOP can be seen as agnostic of, or compatible with, common software tool efforts such as the Robotic Operating System - Military (ROS-M). ROS-M is an on-going effort to promote ROS, maintained independently by the Open Source Robotics Foundation (OSRF), by developing and fostering an ecosystem of stabilized, validated, and approved ROS 2.0 packages. The goal is to promote rapid development through shared implementation of common robotic behaviors freely accessible as open source software.

Since the IOP emphasizes interfaces while ROS-M focuses on implementations, the two can be used together or entirely independently of one another. If both are used within an implementation, it will be necessary to convert or bridge between the IOP/JAUS messages used by the interface and the ROS/DDS topics used by the internals. Future versions of the IOP may provide additional guidance on this subject.

4.5.2 Logistics and SA

The IOP enables interoperability between robotic platforms, controllers, and payloads. While intended for use in a wide variety of configurations, the most commonly fielded systems to date generally involve a single human using a single controller to remotely operate a single platform. However, multiple experiments and projects demonstrate the applicability of IOP for coordination of multiple platforms with emphasis on supervisory control of autonomous and automated behaviors.

As robotic and autonomous ground systems grow in capability, they are more likely to be integrated in larger scale Situational Awareness (SA); Command and Control (C2); and Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) systems. These systems often define interface standards of their own, likely with little overlap of those from the IOP. However, it is expected that these interfaces can be used simultaneously: that is, a controller, platform, or payload may be compliant to an IOP instantiation in addition to any other interface standards required by the project or program. Note that such compliance may require additional radios, physical interfaces, and logical communications. Future versions of the IOP may provide additional guidance on this subject.

4.5.3 SAE

The IOP, and particularly the logical interface definitions, makes extensive use of the JAUS services publish by the SAE AS-4 standards body. Where necessary, the IOP extends published JAUS services by providing additional profiling rules and custom services to support a wider variety of projects and programs. In some cases, these custom services are being provided back to the AS-4 committee for possible adoption. The IOP is expected to maintain this close relationship with the AS-4 JAUS body going forward.

Furthermore, the Unmanned Systems Control Segment (UCS) Architecture has been brought under the AS-4 group. UCS uses a Model Driven Architecture (MDA) approach to define a Platform Independent Model (PIM) of the data being exchanged. While some examples and projects have been created to define a Platform-Specific Model (PSM) to demonstrate plug-and-play interoperability, this is not currently the main emphasis of the effort. Ultimately, AS-4 looks to align JAUS and UCS such that JAUS could be considered a specific PSM for an extended UCS architecture. This is likely a long term process, and it is not expected that this alignment will have significant impact on the IOP.

ANNEX A ACRONYMS AND ABBREVIATIONS

AEODRS	Advanced Explosive Ordnance Disposal Robotic System
AFUS	Architecture for Unmanned Systems
ALFUS	Architecture Levels for Unmanned Systems
BIT	Built in Test
CCL	Common Communications Link
DISR	DoD Information Technology Standards Registry
DoD	Department of Defense
FIT	Fault Isolation and Test
IA	Information Assurance
IP	Internet Protocol
JAUS	Joint Architecture for Unmanned Systems
JGRIT	Joint Ground Robotics Integration Team
LRU	Line Replaceable Unit
OCU	Operator Control Unit
QoS	Quality of Service
RAS-G	Robotics and Autonomous Systems - Ground
SA	Situational Awareness
SAE	Society of Automotive Engineers
SWB	Software Blocking
TCP	Transmission Control Protocol
UAS	Army Unmanned Aircraft Systems
UDP	User Datagram Protocol
UGV	Unmanned Ground Vehicle
UxV	Unmanned Vehicle

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ANNEX B DEFINITIONS

Actuator: An actuator is a mechanical device that can change shape in response to a signal. An actuator can be a simple device that has linear movement (prismatic) or rotational movement (revolute), or it can be an articulated manipulator arm with many joints and links. The classic manipulator is an "arm" of a robotic system used to position an end-effector. Another common manipulator is a pan-tilt unit often used to position a directional sensor or emitter. At this time, all unpowered devices attached to a robot will also be classified as an actuator. (Examples include rakes, extensions, and bumpers.)

Analysis: Analysis is an element of verification that uses established technical or mathematical models or simulations, algorithms, charts, graphs, circuit diagrams, or other scientific principles and procedures to provide evidence that stated requirements were met.

Capability: A capability is a single operationally relevant function - for example, teleoperation would be a capability that provides the function of allowing a user to drive a vehicle non-line of sight using a camera.

Complex Payload: A complex payload is a payload that aggregates multiple capabilities either logically or physically. A complex payload shall always be represented by a JAUS node.

Demonstration: Demonstration is an element of verification that involves the actual operation of an item to provide evidence that the required functions were accomplished under specific scenarios. The items may be instrumented and performance monitored.

Emitter: An emitter is a device that can discharge a substance or energy into the environment. Examples include radio, RADAR, LASER, loudspeaker, liquid jet or disruptor or sprayer, ballistic weapons, and launchers for various self-propelled devices. An emitter can be a hardware device that generates some form of oscillating electromagnetic fields, which is intended to convey information (via modulation) to a receiver (i.e. radios). An emitter can be a device that creates acoustic pressure waves to convey audible information, or to incapacitate those in hearing range with very high energy acoustic waves. An emitter can also be a device that discharges a solid object on a ballistic trajectory; drops objects by way of gravity (special case of ballistics); shoots a jet or water or other liquid, a disruptor; etc. Most weapons fall into the class of emitters.

Examination: Examination is an element of verification that is generally nondestructive and typically includes the use of sight, hearing, smell, touch, and taste; simple physical manipulation; and mechanical and electrical gauging and measurement.

Interoperability Attribute: This concept is defined in Section 1.3.1.

JAUS Component: A JAUS component is a logical grouping of services. Each JAUS component aggregates services to provide a single operationally relevant capability. The JAUS component offers a service interface to other consuming components to use. For example, teleoperation could be a JAUS component that aggregates a primitive driver service and some sensor services to provide teleoperation capabilities to a robotic controller.

JAUS Node: JAUS nodes are a logical grouping of JAUS components within a JAUS subsystem. Within this IOP, JAUS nodes are specified to aggregate related capabilities. This aggregation may be either logical (i.e. any capability that affects platform motion is aggregated under the Mobility JAUS node) or physical (i.e. a manipulator payload with two cameras and a sensor on it are considered a JAUS node).

JAUS Service: JAUS services represent the lowest level of the JAUS topology. For the purposes of this IOP, JAUS services provide an abstraction to hardware or software algorithms that reside on the platform. JAUS services may by internalized within a JAUS component or may be provided via an interface that is consumed by other JAUS components.

JAUS Subsystem : A JAUS subsystem is an independent and distinct unit within a JAUS system. JAUS subsystems include robotic controllers, robotic platforms, and video terminals connected and communicating via a specified set of Interoperability Attributes. A JAUS subsystem contains one or more JAUS nodes.

JAUS System: The top level element within the JAUS topology and can encompass all interoperable elements (robotic controllers and robotic platforms). The JAUS system contains multiple JAUS subsystems.

Payload: A robot payload is a physical device that interfaces to the robot using interoperable physical, power, and / or data interfaces, and is replaceable (modular) based on mission needs. A payload can be similar in nature to other devices that are integrated on a robotic vehicle, but a payload is not required for native UGV capabilities.

Retro-Traverse: A robotic operation where the robot reverses the path that was driven based on stored data, or otherwise safely navigates back to an originating position. The retro-traverse feature can be initiated by the operator, a loss of communications condition or an operator timeout condition. The operator (assuming he has an active comms signal with the robot) will have the capability of stopping the retro-traverse at any point in time.

Sensor: Sensors codify information from the environment and can be used to reason about the environment. Typical sensor types include, but are not limited to, tactile, proprioceptive, seismic, acoustic, meteorological, chemical, biological, radiological, nuclear, visual, and range finding. All sensors fall into two categories, either passive or active. Passive sensors perform their detection without effecting or altering the environment (i.e. thermometer). Active sensors use some form of emission to detect the reflection or other effect that emission has on the environment (i.e. radar).

Test: Test is an element of verification in which scientific principles and procedures

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ANNEX C IOP ATTRIBUTES AND REFERENCE GROUPS

Interoperability Attributes are the primary organizational structure of the RAS-G IOP, where each Interoperability Attribute represents a composable, hierarchical capability. It is acknowledged that UGV requirements will vary based upon capability, mission, and other acquisition requirements. For this reason and to support system acquisition activity, the Interoperability Attributes defined within this IOP specify the robotic system capabilities in a granular fashion, from the most simple to the most complex. In addition to the relationship between Interoperability Attributes created by the attribute hierarchy, Interoperability Attributes may additionally have one or more groups of related capabilities, called attribute reference groups. Each group of referenced attributes has a selection modifier that specifies whether all, any, or exactly one attribute from that group must be selected when the original Interoperability Attribute is included in a program's instantiation.

This appendix lists all of the Interoperability Attributes in the IOP and, for each one, displays its name, its parent Interoperability Attribute, a summary of its capability, and any referenced capability groups. While referenced capability groups in each IOP Document are tailored to an established viewpoint with stakeholders from that domain in mind, the following listing of Interoperability Attributes seeks to facilitate a cross-domain view by indicating to which IOP domain(s) each referenced Interoperability Attribute belongs.

C.1 IOP USAGE

Attribute Summary: *Root attribute defining how to use the IOP documents*

C.1.1 Hardware Attribute

Parent Attribute: *IOP Usage Attribute*

Attribute Summary: *Root attribute of all hardware capabilities*

Any number of the following attributes can be chosen.

Attribute	Domain(s)	Description
OCU Hardware Attribute	Controls	Allows for specification of OCU hardware.
Platform Hardware Attribute	Payloads	Allows for specification of platform hardware.
Communications Hardware Attribute	Comms	Allows for specification of communications related hardware.

Table 1: - Optional Select = any

C.1.1.1 Platform Hardware Attribute

Parent Attribute: *Hardware Attribute*

Attribute Summary: *Allows for specification of platform hardware.*

Any number of the following attributes can be chosen.

Attribute	Domain(s)	Description
Mounting Attribute	Payloads	Mounting of a payload.
Physical and Electrical Interfaces Attribute	Payloads	Physical And Electrical Interface to a platform
Uninterrupted Power Supply Attribute	Payloads	In cases of sudden loss of power, the UPS capability affords the system the ability to shut down without loss of data, or causing damage to any part of the system.
NATO Slave Receptacle Attribute	Payloads	NATO Slave Receptacle
Payload Physical Specifications Attribute	Payloads	Provides various physical specifications of a payload

Table 2: - Optional Select = any

C.1.1.1.1 Mounting Attribute

Parent Attribute: *Platform Hardware Attribute*

Attribute Summary: *Mounting of a payload.*

At least one of the following attributes must be chosen.

Attribute	Domain(s)	Description
Physical Mounting Attribute	Payloads, Appliqué	Physical mounting of a payload
Vehicle Manufacturer-Specified Mounting Attribute	Appliqué	Physical mounting specified by vehicle manufacturer.

Table 3: - Mandatory Select = any

C.1.1.1.1.1 Physical Mounting Attribute

Parent Attribute: *Mounting Attribute*

Attribute Summary: *Physical mounting of a payload*

Any number of the following attributes can be chosen.

Attribute	Domain(s)	Description
Picatinny Rail Attribute	Payloads	Mounting rail(s) of varying length
Optical Bench Attribute	Payloads	A series of threaded holes placed in a rectangular grid of varying size

Table 4: - Optional Select = any

C.1.1.1.1.1.1 Picatinny Rail Attribute

Parent Attribute: *Physical Mounting Attribute*

Attribute Summary: *Mounting rail(s) of varying length*

C.1.1.1.1.1.2 Optical Bench Attribute

Parent Attribute: *Physical Mounting Attribute*

Attribute Summary: *A series of threaded holes placed in a rectangular grid of varying size*

C.1.1.1.1.2 Vehicle Manufacturer-Specified Mounting Attribute

Parent Attribute: *Mounting Attribute*

Attribute Summary: *Physical mounting specified by vehicle manufacturer.*

C.1.1.1.2 Physical and Electrical Interfaces Attribute

Parent Attribute: *Platform Hardware Attribute*

Attribute Summary: *Physical And Electrical Interface to a platform*

The following attributes are mandatory.

Attribute	Domain(s)	Description
Electrical Power Attribute	Payloads, Appliqué	This attribute provides baseline electrical power requirements that are intended to be used in conjunction with a chosen class of connectors.

Table 5: - Mandatory Select = all

At least one of the following attributes must be chosen.

Attribute	Domain(s)	Description
Power-Only Connector Attribute	Payloads	Provides the capability to include connectors that only transmit power.
Data Connector Attribute	Payloads	Provides the capability to have connectors that transmit data.

Table 6: - Mandatory Select = any

Any number of the following attributes can be chosen.

Attribute	Domain(s)	Description
Tethered Communications Attribute	Payloads	Utilizes a tether for communication.

Table 7: - Optional Select = any

C.1.1.1.2.1 Electrical Power Attribute

Parent Attribute: *Physical and Electrical Interfaces Attribute*

Attribute Summary: *This attribute provides baseline electrical power requirements that are intended to be used in conjunction with a chosen class of connectors.*

Any number of the following attributes can be chosen.

Attribute	Domain(s)	Description
Clean Power Attribute	Appliqué	This attribute provides "clean" electrical power as defined in MIL-STD-704.
Base Vehicle Power Attribute	Appliqué	Base Vehicle Power Attribute This attribute provides standard military ground vehicle 28V electrical power as defined in MIL-STD-1275.

Table 8: - Optional Select = any

The following attributes are mutually exclusive, exactly one must be chosen.

Attribute	Domain(s)	Description
Power Interface 12V Attribute	Payloads	This attribute provides the capability to use the 12V electrical power interface.
Power Interface 24V Attribute	Payloads	This attribute provides the capability to use the 24V electrical power interface.
Power Interface 48V Attribute	Payloads	This attribute provides the capability to use the 48V electrical power interface.

Table 9: - Mandatory Select = one

C.1.1.1.2.1.1 Power Interface 12V Attribute

Parent Attribute: *Electrical Power Attribute*

Attribute Summary: *This attribute provides the capability to use the 12V electrical power interface.*

C.1.1.1.2.1.2 Power Interface 24V Attribute

Parent Attribute: *Electrical Power Attribute*

Attribute Summary: *This attribute provides the capability to use the 24V electrical power interface.*

C.1.1.1.2.1.2.1 Clean Power Attribute

Parent Attribute: *Power Interface 24V Attribute*

Attribute Summary: *This attribute provides "clean" electrical power as defined in MIL-STD-704.*

C.1.1.1.2.1.2.2 Base Vehicle Power Attribute

Parent Attribute: *Power Interface 24V Attribute*

Attribute Summary: *Base Vehicle Power Attribute This attribute provides standard military ground vehicle 28V electrical power as defined in MIL-STD-1275.*

C.1.1.1.2.1.3 Power Interface 48V Attribute

Parent Attribute: *Electrical Power Attribute*

Attribute Summary: *This attribute provides the capability to use the 48V electrical power interface.*

C.1.1.1.2.2 Power-Only Connector Attribute

Parent Attribute: *Physical and Electrical Interfaces Attribute*

Attribute Summary: *Provides the capability to include connectors that only transmit power.*

The following attributes are mutually exclusive, exactly one must be chosen.

Attribute	Domain(s)	Description
Power-Only Connector Interface A	Payloads	This interface uses a DIN (Deutsches Institut für Normung) VG95234 Connector, shell size 22 with insert 22-22 (Also referred to as 22-22 Contact Arrangement), consisting of 4 contacts.
Power-Only Connector Interface B	Payloads	This interface uses a DIN (Deutsches Institut für Normung) VG95234 Connector, shell size 24 with insert 24-28 (Also referred to as 24-28 Contact Arrangement), consisting of 24 contacts.

Table 10: - Mandatory Select = one

C.1.1.1.2.2.1 Power-Only Connector Interface A

Parent Attribute: *Power-Only Connector Attribute*

Attribute Summary: *This interface uses a DIN (Deutsches Institut für Normung) VG95234 Connector, shell size 22 with insert 22-22 (Also referred to as 22-22 Contact Arrangement), consisting of 4 contacts.*

C.1.1.1.2.2.2 Power-Only Connector Interface B

Parent Attribute: *Power-Only Connector Attribute*

Attribute Summary: *This interface uses a DIN (Deutsches Institut für Normung) VG95234 Connector, shell size 24 with insert 24-28 (Also referred to as 24-28 Contact Arrangement), consisting of 24 contacts.*

C.1.1.1.2.3 Data Connector Attribute

Parent Attribute: *Physical and Electrical Interfaces Attribute*

Attribute Summary: *Provides the capability to have connectors that transmit data.*

The following attributes are mutually exclusive, exactly one must be chosen.

Attribute	Domain(s)	Description
MIL-DTL-38999 Series III Connector Attribute	Payloads	This is a class of connectors that are military grade and come with a variety of shell types, pin counts, environmental ratings, and other properties. Series III is a replacement for Series II specified by previous version of the IOP.
Mini38999 Connector Attribute	Payloads	At least two companies have developed compatible connectors designed to be comparable to MIL-DTL-

		38999 series connectors, but with significant weight and size savings. These variants are currently offered by companies Glenair and Amphenol, and may be offered by other entities in the future.
MIL-DTL-38999 Series II Connector Attribute (Deprecated)	Payloads	This is a class of connectors that are military grade and come with a variety of shell types, pin counts, environmental ratings, and other properties. Series II is now deprecated in favor of Series III.

Table 11: - Mandatory Select = one

C.1.1.1.2.3.1 MIL-DTL-38999 Series III Connector Attribute

Parent Attribute: *Data Connector Attribute*

Attribute Summary: *This is a class of connectors that are military grade and come with a variety of shell types, pin counts, environmental ratings, and other properties. Series III is a replacement for Series II specified by previous version of the IOP.*

At least one of the following attributes must be chosen.

Attribute	Domain(s)	Description
Connector Interface A Attribute	Payloads	This interface uses a MIL-STD-38999 Series III connector with 13 pins and a B35 (11-35) insert.
Connector Interface B Attribute	Payloads	This interface uses a MIL-STD-38999 Series III connector with 22 pins and a C35 (13-35) insert.
Connector Interface B - Configuration Lines Attribute	Payloads	This interface uses a MIL-STD-38999 Series III connector with 22 pins and a C35 (13-35) insert. This connector provides configuration lines on the same pins as the AEODRS connector, but is NOT compatible with the actual similar connector defined in the AEODRS documentation.

Table 12: - Mandatory Select = any

C.1.1.1.2.3.1.1 Connector Interface A Attribute

Parent Attribute: *MIL-DTL-38999 Series III Connector Attribute*

Attribute Summary: *This interface uses a MIL-STD-38999 Series III connector with 13 pins and a B35 (11-35) insert.*

C.1.1.1.2.3.1.2 Connector Interface B Attribute

Parent Attribute: *MIL-DTL-38999 Series III Connector Attribute*

Attribute Summary: *This interface uses a MIL-STD-38999 Series III connector with 22 pins and a C35 (13-35) insert.*

C.1.1.1.2.3.1.3 Connector Interface B - Configuration Lines Attribute

Parent Attribute: *MIL-DTL-38999 Series III Connector Attribute*

Attribute Summary: *This interface uses a MIL-STD-38999 Series III connector with 22 pins and a C35 (13-35) insert. This connector provides configuration lines on the same pins as the AEODRS connector, but is NOT compatible with the actual similar connector defined in the AEODRS documentation.*

C.1.1.1.2.3.2 MIL-DTL-38999 Series II Connector Attribute (Deprecated)

Parent Attribute: *Data Connector Attribute*

Attribute Summary: *This is a class of connectors that are military grade and come with a variety of shell types, pin counts, environmental ratings, and other properties. Series II is now deprecated in favor of Series III.*

At least one of the following attributes must be chosen.

Attribute	Domain(s)	Description
MIL-DTL-38999 Series II Connector Interface A Attribute (Deprecated)	Payloads	This interface uses a MIL-STD-38999 Series II connector with a 13 pin 10-35 insert.
MIL-DTL-38999 Series II Connector Interface B Attribute (Deprecated)	Payloads	This interface uses a MIL-STD-38999 Series II connector with a 22 pin 12-35 insert.
MIL-DTL-38999 Series II Connector Interface B - Configuration Lines Attribute (Deprecated)	Payloads	This interface uses a MIL-STD-38999 Series II connector with a 22 pin 12-35 insert. This connector provides configuration lines on the same pins as the AEODRS connector, but is NOT compatible with the actual similar connector defined in the AEODRS documentation.

Table 1: - Mandatory Select = any

C.1.1.1.2.3.2.1 MIL-DTL-38999 Series II Connector Interface A Attribute (Deprecated)

Parent Attribute: *MIL-DTL-38999 Series II Connector Attribute (Deprecated)*

Attribute Summary: *This interface uses a MIL-STD-38999 Series II connector with a 13 pin 10-35 insert.*

C.1.1.1.2.3.2.2 MIL-DTL-38999 Series II Connector Interface B Attribute (Deprecated)

Parent Attribute: *MIL-DTL-38999 Series II Connector Attribute (Deprecated)*

Attribute Summary: *This interface uses a MIL-STD-38999 Series II connector with a 22 pin 12-35 insert.*

C.1.1.1.2.3.2.3 MIL-DTL-38999 Series II Connector Interface B - Configuration Lines Attribute (Deprecated)

Parent Attribute: *MIL-DTL-38999 Series II Connector Attribute (Deprecated)*

Attribute Summary: *This interface uses a MIL-STD-38999 Series II connector with a 22 pin 12-35 insert. This connector provides configuration lines on the same pins as the AEODRS connector, but is NOT compatible with the actual similar connector defined in the AEODRS documentation.*

C.1.1.1.2.3.3 Mini38999 Connector Attribute

Parent Attribute: *Data Connector Attribute*

Attribute Summary: *At least two companies have developed compatible connectors designed to be comparable to MIL-DTL-38999 series connectors, but with significant weight and size savings. These variants are currently offered by companies Glenair and Amphenol, and may be offered by other entities in the future.*

C.1.1.1.3 NATO Slave Receptacle Attribute

Parent Attribute: *Platform Hardware Attribute*

Attribute Summary: *NATO Slave Receptacle*

C.1.1.1.4 Payload Physical Specifications Attribute

Parent Attribute: *Platform Hardware Attribute*

Attribute Summary: *Provides various physical specifications of a payload*

C.1.1.2 Communications Hardware Attribute

Parent Attribute: *Hardware Attribute*

Attribute Summary: *Allows for specification of communications related hardware.*

Any number of the following attributes can be chosen.

Attribute	Domain(s)	Description
Tethered Communications Attribute	Comms	Utilizes a tether for communication.
Antenna Attribute	Comms	Using an antenna for communications.

Table 14: - Optional Select = any

C.1.1.2.1 Tethered Communications Attribute

Parent Attribute: *Communications Hardware Attribute*

Attribute Summary: *Utilizes a tether for communication.*

Any number of the following attributes can be chosen.

Attribute	Domain(s)	Description
Tether Spooler Attribute	Payloads	Adds support for controlling and obtaining status from a tether's spooling mechanism

Table 15: - Optional Select = any

C.1.1.2.2 Antenna Attribute

Parent Attribute: *Communications Hardware Attribute*

Attribute Summary: *Using an antenna for communications.*

C.1.1.3 OCU Hardware Attribute

Parent Attribute: *Hardware Attribute*

Attribute Summary: *Allows for specification of OCU hardware.*

The following attributes are mandatory.

Attribute	Domain(s)	Description
OCU Physical and Electrical Interface	Controls	Physical Mounting on an OCU.
OCU Size Categories	Controls	Size of OCU hardware.

Table 16: - Mandatory Select = all

C.1.1.3.1 OCU Physical and Electrical Interface

Parent Attribute: *OCU Hardware Attribute*

Attribute Summary: *Physical Mounting on an OCU.*

C.1.1.3.2 OCU Size Categories

Parent Attribute: *OCU Hardware Attribute*

Attribute Summary: *Size of OCU hardware.*

C.1.2 Core Software and Logical Attribute

Parent Attribute: *IOP Usage Attribute*

Attribute Summary: *Root capability of all software and logical functions*

The following attributes are mandatory.

Attribute	Domain(s)	Description
Core JAUS Attribute	JAUS	Mandatory attribute that must be selected for every system that defines requirements using Interoperability Attributes.
JAUS Hierarchy Rules Attribute	JAUS	Defines the rules for translating attribute requirements from this IOP into a JAUS Subsystem, Node, Component hierarchy.

Table 17: - Mandatory Select = all

Any number of the following attributes can be chosen.

Attribute	Domain(s)	Description
Core OCU Software Attribute	Controls	Common capabilities and requirements for systems that employ an OCU.
Global Attribute	JAUS, Controls	Global Interoperability Attributes do not tightly fit into a single attribute group or are likely to be used in conjunction with many different Interoperability Attributes
Platform Attribute	JAUS, Controls	Platform-centric attributes that provide platform level capabilities such as discovery, engine status information, health information, etc.
Mobility Attribute	JAUS, Controls	The Mobility Interoperability Attribute defines attributes related to platform mobility, such as driving.
Sensor Attribute	JAUS, Controls	UGVs have payloads which can collect data from the surrounding environment. In addition UGVs have sensors that collect data from the robot in order to report back to the operator health and other status information.
Emitter Attribute	JAUS, Controls	UGVs have payloads which can affect their surrounding environment at a distance. These include Lights, Speakers, Laser Target Designators, and Weapons.
Actuator Attribute	JAUS, Controls	Actuator payloads provide mechanical means of manipulation.

Table 18: - Optional Select = any

C.1.2.1 JAUS Hierarchy Rules Attribute

Parent Attribute: *Core Software and Logical Attribute*

Attribute Summary: *Defines the rules for translating attribute requirements from this IOP into a JAUS Subsystem, Node, Component hierarchy.*

C.1.2.2 Core OCU Software Attribute

Parent Attribute: *Core Software and Logical Attribute*

Attribute Summary: *Common capabilities and requirements for systems that employ an OCU.*

C.1.2.3 Core JAUS Attribute

Parent Attribute: *Core Software and Logical Attribute*

Attribute Summary: *Mandatory attribute that must be selected for every system that defines requirements using Interoperability Attributes.*

The following attributes are mandatory.

Attribute	Domain(s)	Description
Access Control Attribute	JAUS	Specifies how authority is used to control access to services that accept commands, like mobility and manipulator services.
Management Attribute	JAUS	Capability to protect a system from taking certain actions if a system is in an emergency, failure, or other state that precludes the use of that functionality. Instructive uses of this capability are E-Stop and managing a dead man switch.
Component Liveness Attribute	JAUS	Specifies that a Liveness service shall be provided by each component (allows liveness/connectivity checks to be performed).
ID Assignment and Propagation Attribute	JAUS	Defines basic concepts used in assignment of JAUS Subsystems (Platform / OCU) and Nodes (payloads). Parent of all Subsystem and Node ID Assignment and Propagation attributes.
Transport Attribute	JAUS	Specifies the type of transport layer(s) used to transport JAUS messages.

Table 19: - Mandatory Select = all

C.1.2.3.1 Transport Attribute

Parent Attribute: *Core JAUS Attribute*

Attribute Summary: *Specifies the type of transport layer(s) used to transport JAUS messages.*

At least one of the following attributes must be chosen.

Attribute	Domain(s)	Description
JUDP Attribute	JAUS	Specifies that messages shall be transported using the JAUS over UDP as defined in AS5669A JAUS/SDP Transport Specification. JUDP defines JAUS over User Datagram Protocol, which is a simple connectionless protocol with lower latency than TCP but without guaranteed delivery.

JTCP Attribute	JAUS	Specifies that messages shall be transported using the JAUS over TCP as defined in AS5669A JAUS/SDP Transport Specification. JTCP defines JAUS over Transmission Control Protocol, which is a connection oriented protocol that provides reliable delivery, but with higher latency than UDP.
Custom Transport Attribute	JAUS	Specifies that a custom transport defined in the Custom Services, Messages, and Transports IOP document shall be used.

Table 20: - Mandatory Select = any

Any number of the following attributes can be chosen.

Attribute	Domain(s)	Description
Off-Board Communications Attribute	JAUS, Comms	The Off-Board Communications Interoperability Attributes define capabilities to deal with communications off-board the platform.

Table 21: - Optional Select = any

C.1.2.3.1.1 JUDP Attribute

Parent Attribute: *Transport Attribute*

Attribute Summary: *Specifies that messages shall be transported using the JAUS over UDP as defined in AS5669A JAUS/SDP Transport Specification. JUDP defines JAUS over User Datagram Protocol, which is a simple connectionless protocol with lower latency than TCP but without guaranteed delivery.*

C.1.2.3.1.2 JTCP Attribute

Parent Attribute: *Transport Attribute*

Attribute Summary: *Specifies that messages shall be transported using the JAUS over TCP as defined in AS5669A JAUS/SDP Transport Specification. JTCP defines JAUS over Transmission Control Protocol, which is a connection oriented protocol that provides reliable delivery, but with higher latency than UDP.*

C.1.2.3.1.3 Custom Transport Attribute

Parent Attribute: *Transport Attribute*

Attribute Summary: *Specifies that a custom transport defined in the Custom Services, Messages, and Transports IOP document shall be used.*

C.1.2.3.1.4 Off-Board Communications Attribute

Parent Attribute: *Transport Attribute*

Attribute Summary: *The Off-Board Communications Interoperability Attributes define capabilities to deal with communications off-board the platform.*

The following attributes are mandatory.

Attribute	Domain(s)	Description
Communicator Attribute	JAUS, Controls, Comms	Defines a capability to interact with a communications device, such as a radio, including configuring it.

Table 22: - Mandatory Select = all

At least one of the following attributes must be chosen.

Attribute	Domain(s)	Description
Meshed Networks Attribute	Comms	Utilize mesh networking
Non-meshed Networks Attribute	Comms	Utilizes non-mesh or point-to-point networking
Cloud Network Attribute	Comms	Cloud networks allow OCUs and platforms to be part of a larger network without dedicated channels and are not within the scope of IOP V4.

Table 23: - Mandatory Select = any

C.1.2.3.1.4.1 Communicator Attribute

Parent Attribute: *Off-Board Communications Attribute*

Attribute Summary: *Defines a capability to interact with a communications device, such as a radio, including configuring it.*

C.1.2.3.1.4.2 Non-meshed Networks Attribute

Parent Attribute: *Off-Board Communications Attribute*

Attribute Summary: *Utilizes non-mesh or point-to-point networking*

C.1.2.3.1.4.3 Meshed Networks Attribute

Parent Attribute: *Off-Board Communications Attribute*

Attribute Summary: *Utilize mesh networking*

C.1.2.3.1.4.4 Cloud Network Attribute

Parent Attribute: *Off-Board Communications Attribute*

Attribute Summary: *Cloud networks allow OCUs and platforms to be part of a larger network without dedicated channels and are not within the scope of IOP V4.*

C.1.2.3.2 Access Control Attribute

Parent Attribute: *Core JAUS Attribute*

Attribute Summary: *Specifies how authority is used to control access to services that accept commands, like mobility and manipulator services.*

Any number of the following attributes can be chosen.

Attribute	Domain(s)	Description
Unsolicited Broadcast Control Available Attribute	JAUS, Controls	Provides the capability to alert potential clients within the system that control has been made available.

Table 24: - Optional Select = any

C.1.2.3.2.1 Unsolicited Broadcast Control Available Attribute

Parent Attribute: *Access Control Attribute*

Attribute Summary: *Provides the capability to alert potential clients within the system that control has been made available.*

C.1.2.3.3 Management Attribute

Parent Attribute: *Core JAUS Attribute*

Attribute Summary: *Capability to protect a system from taking certain actions if a system is in an emergency, failure, or other state that precludes the use of that functionality. Instructive uses of this capability are E-Stop and managing a dead man switch.*

Any number of the following attributes can be chosen.

Attribute	Domain(s)	Description
Motion Inhibit Attribute	Controls	Provides a means of locking out all motion commands to a platform and its payloads. This will inhibit unintended movement for safety purposes, for example when a human operator is acting in close proximity to the platform.

Table 25: - Optional Select = any

C.1.2.3.3.1 Motion Inhibit Attribute

Parent Attribute: *Management Attribute*

Attribute Summary: *Provides a means of locking out all motion commands to a platform and its payloads. This will inhibit unintended movement for safety purposes, for example when a human operator is acting in close proximity to the platform.*

C.1.2.3.4 Component Liveness Attribute

Parent Attribute: *Core JAUS Attribute*

Attribute Summary: *Specifies that a Liveness service shall be provided by each component (allows liveness/connectivity checks to be performed).*

C.1.2.3.5 ID Assignment and Propagation Attribute

Parent Attribute: *Core JAUS Attribute*

Attribute Summary: *Defines basic concepts used in assignment of JAUS Subsystems (Platform / OCU) and Nodes (payloads). Parent of all Subsystem and Node ID Assignment and Propagation attributes.*

The following attributes are mandatory.

Attribute	Domain(s)	Description
Subsystem ID Assignment Attribute	JAUS	Specifies how JAUS Subsystems within a JAUS system are assigned a subsystem ID.
Node ID Assignment Attribute	JAUS	Specifies how JAUS Nodes within a JAUS subsystem are assigned a node ID.

Table 26: - Mandatory Select = all

Any number of the following attributes can be chosen.

Attribute	Domain(s)	Description
Subsystem ID Propagation Attribute		Defines a dynamic method for propagating the Subsystem ID from a Platform to its payloads and other attached JAUS Nodes. This attribute is mandatory when centralized subsystem ID assignment is performed because the JAUS Subsystem ID is not known a-priori.

Table 27: - Optional Select = any

C.1.2.3.5.1 Subsystem ID Assignment Attribute

Parent Attribute: *ID Assignment and Propagation Attribute*

Attribute Summary: *Specifies how JAUS Subsystems within a JAUS system are assigned a subsystem ID.*

The following attributes are mutually exclusive, exactly one must be chosen.

Attribute	Domain(s)	Description
Static Subsystem Assignment Attribute	JAUS	Defines static assignment of JAUS Subsystem IDs. Static assignment implies a predetermined set of JAUS Subsystem IDs are assigned for each JAUS Subsystem.
Centralized Subsystem Assignment Attribute	JAUS	Defines a centralized approach to acquiring JAUS Subsystem IDs. In this approach, a central server provides unique IDs to all JAUS Subsystems that submit a request for an ID.

Table 28: - Mandatory Select = one

C.1.2.3.5.1.1 Static Subsystem Assignment Attribute

Parent Attribute: *Subsystem ID Assignment Attribute*

Attribute Summary: *Defines static assignment of JAUS Subsystem IDs. Static assignment implies a predetermined set of JAUS Subsystem IDs are assigned for each JAUS Subsystem.*

C.1.2.3.5.1.2 Centralized Subsystem Assignment Attribute

Parent Attribute: *Subsystem ID Assignment Attribute*

Attribute Summary: *Defines a centralized approach to acquiring JAUS Subsystem IDs. In this approach, a central server provides unique IDs to all JAUS Subsystems that submit a request for an ID.*

The following attributes are mandatory.

Attribute	Domain(s)	Description
Subsystem ID Propagation Attribute	JAUS	Defines a dynamic method for propagating the Subsystem ID from a Platform to its payloads and other attached JAUS Nodes. This attribute is mandatory when centralized subsystem ID assignment is performed because the JAUS Subsystem ID is not known a-priori.

Table 29: - Mandatory Select = all

C.1.2.3.5.2 Subsystem ID Propagation Attribute

Parent Attribute: *ID Assignment and Propagation Attribute*

Attribute Summary: *Defines a dynamic method for propagating the Subsystem ID from a Platform to its payloads and other attached JAUS Nodes. This attribute is mandatory when centralized subsystem ID assignment is performed because the JAUS Subsystem ID is not known a-priori.*

C.1.2.3.5.3 Node ID Assignment Attribute

Parent Attribute: *ID Assignment and Propagation Attribute*

Attribute Summary: *Specifies how JAUS Nodes within a JAUS subsystem are assigned a node ID.*

The following attributes are mutually exclusive, exactly one must be chosen.

Attribute	Domain(s)	Description
Static Node ID Assignment Attribute	JAUS	Defines static assignment of JAUS Node IDs, done at setup / configuration time.
Dynamic Node ID Assignment Attribute	JAUS	Defines dynamic assignment of JAUS Node IDs, done at run-time.

Table 30: - Mandatory Select = one

C.1.2.3.5.3.1 Static Node ID Assignment Attribute

Parent Attribute: *Node ID Assignment Attribute*

Attribute Summary: *Defines static assignment of JAUS Node IDs, done at setup / configuration time.*

C.1.2.3.5.3.2 Dynamic Node ID Assignment Attribute

Parent Attribute: *Node ID Assignment Attribute*

Attribute Summary: *Defines dynamic assignment of JAUS Node IDs, done at run-time.*

C.1.2.4 Global Attribute

Parent Attribute: *Core Software and Logical Attribute*

Attribute Summary: *Global Interoperability Attributes do not tightly fit into a single attribute group or are likely to be used in conjunction with many different Interoperability Attributes*

Any number of the following attributes can be chosen.

Attribute	Domain(s)	Description
Pose And Attitude Attribute	JAUS, Controls	Adds ability to view/ report the pose and attitude of a platform. Many other capabilities are built upon this information.
Power Plant Management Attribute	JAUS, Controls	Provides the ability to get information from and manage a power plant, which may be batteries, a gasoline engine, a diesel engine, or a hydraulic/pneumatic system.
Preset Pose Attribute	JAUS, Controls	Provides the ability to get information on available preset poses that a platform or payload has, and to command that platform or payload to go to one of those preset poses (i.e. a "Stow" pose for storing a system).
Render Useless Attribute	JAUS, Controls	Defines the capability to render a platform, payload, or other device useless.
Tamper Detection Attribute	JAUS, Controls	Defines the capability to report on when tampering has occurred.
Odometry Attribute	JAUS	Defines on distance travelled and provides the ability to set trip meters.
Health Attribute	JAUS	Provides for summary reports and detailed reports of JAUS subsystem, node, and component health,

		providing reporting to the level of service health to the level of sensors and actuators.
Obstacle Reporting Attribute	JAUS, Controls	Provides a way to report obstacles and hazardous terrain using an overhead 2D cost map.
Physical Specification Attribute	JAUS	Provides a mechanism for describing the physical characteristics of a node, and any associated mounting sites for child nodes.
Data Logging Attribute	JAUS, Controls	Provides the ability to control and receive feedback from one or more loggers.
Software Version Reporting Attribute	JAUS, Controls	Provides the ability for a JAUS component to describe the software packages, shared libraries, scripts, etc. installed on it.
Uninterrupted Power Supply Attribute	JAUS, Controls	In cases of sudden loss of power, the UPS capability affords the system the ability to shut down without loss of data, or causing damage to any part of the system.

Table 31: - Optional Select = any

C.1.2.4.1 Pose And Attitude Attribute

Parent Attribute: *Global Attribute*

Attribute Summary: *Adds ability to view/ report the pose and attitude of a platform. Many other capabilities are built upon this information.*

At least one of the following attributes must be chosen.

Attribute	Domain(s)	Description
Basic Global Position and Attitude Attribute	JAUS	Defines the capability to report Basic Global Position and Attitude.
Basic Local Position and Attitude Attribute	JAUS	Defines the capability to report Basic Local Position and Attitude.
Path Reporting Attribute	JAUS	Defines the capability to access the historical (previous) local and global positions of the platform.

Table 32: - Mandatory Select = any

C.1.2.4.1.1 Path Reporting Attribute

Parent Attribute: *Pose And Attitude Attribute*
Attribute Summary: *Defines the capability to access the historical (previous) local and global positions of the platform.*

At least one of the following attributes must be chosen.

Attribute	Domain(s)	Description
Local Path Reporting Attribute	JAUS	Defines the capability to access the historical (previous) local positions of the platform.
Global Path Reporting Attribute	JAUS	Defines the capability to access the historical (previous) global positions of the platform.

Table 33: - Mandatory Select = any

C.1.2.4.1.1.1 Local Path Reporting Attribute

Parent Attribute: *Path Reporting Attribute*

Attribute Summary: *Defines the capability to access the historical (previous) local positions of the platform.*

C.1.2.4.1.1.2 Global Path Reporting Attribute

Parent Attribute: *Path Reporting Attribute*

Attribute Summary: *Defines the capability to access the historical (previous) global positions of the platform.*

C.1.2.4.1.2 Basic Global Position and Attitude Attribute

Parent Attribute: *Pose And Attitude Attribute*

Attribute Summary: *Defines the capability to report Basic Global Position and Attitude.*

C.1.2.4.1.3 Basic Local Position and Attitude Attribute

Parent Attribute: *Pose And Attitude Attribute*

Attribute Summary: *Defines the capability to report Basic Local Position and Attitude.*

C.1.2.4.2 Power Plant Management Attribute

Parent Attribute: *Global Attribute*

Attribute Summary: *Provides the ability to get information from and manage a power plant, which may be batteries, a gasoline engine, a diesel engine, or a hydraulic/pneumatic system.*

C.1.2.4.3 Preset Pose Attribute

Parent Attribute: *Global Attribute*

Attribute Summary: *Provides the ability to get information on available preset poses that a platform or payload has, and to command that platform or payload to go to one of those preset poses (i.e. a "Stow" pose for storing a system).*

C.1.2.4.4 Render Useless Attribute

Parent Attribute: *Global Attribute*

Attribute Summary: *Defines the capability to render a platform, payload, or other device useless.*

C.1.2.4.5 Tamper Detection Attribute

Parent Attribute: *Global Attribute*

Attribute Summary: *Defines the capability to report on when tampering has occurred.*

C.1.2.4.6 Odometry Attribute

Parent Attribute: *Global Attribute*

Attribute Summary: *Defines on distance travelled and provides the ability to set trip meters.*

C.1.2.4.7 Health Attribute

Parent Attribute: *Global Attribute*

Attribute Summary: *Provides for summary reports and detailed reports of JAUS subsystem, node, and component health, providing reporting to the level of service health to the level of sensors and actuators.*

Any number of the following attributes can be chosen.

Attribute	Domain(s)	Description
Health Reporter Attribute	JAUS	Adds low level health reporting capabilities, tied into built in tests (BIT).

Table 34: - Optional Select = any

C.1.2.4.7.1 Health Reporter Attribute

Parent Attribute: *Health Attribute*
Attribute Summary: *Adds low level health reporting capabilities, tied into built in tests (BIT).*

C.1.2.4.8 Message Filter Attribute

Parent Attribute: *Global Attribute*

Attribute Summary: *Provides a way to pass actions such as commands through a filter before they reach their final destination.*

C.1.2.4.9 Obstacle Reporting Attribute

Parent Attribute: *Global Attribute*

Attribute Summary: *Provides a way to report obstacles and hazardous terrain using an overhead 2D cost map.*

C.1.2.4.10 Physical Specification Attribute

Parent Attribute: *Global Attribute*

Attribute Summary: *Provides a mechanism for describing the physical characteristics of a node, and any associated mounting sites for child nodes.*

C.1.2.4.11 Data Logging Attribute

Parent Attribute: *Global Attribute*

Attribute Summary: *Provides the ability to control and receive feedback from one or more loggers.*

C.1.2.4.12 Software Version Reporting Attribute

Parent Attribute: *Global Attribute*

Attribute Summary: *Provides the ability for a JAUS component to describe the software packages, shared libraries, scripts, etc. installed on it.*

C.1.2.4.13 Uninterrupted Power Supply Attribute

Parent Attribute: *Global Attribute*
Attribute Summary: *In cases of sudden loss of power, the UPS capability affords the system the ability to shut down without loss of data, or causing damage to any part of the system.*

C.1.2.5 Platform Attribute

Parent Attribute: *Core Software and Logical Attribute*

Attribute Summary: *Platform-centric attributes that provide platform level capabilities such as discovery, engine status information, health information, etc.*

The following attributes are mutually exclusive, exactly one must be chosen.

Attribute	Domain(s)	Description
Platform Management Attribute	JAUS, Controls	The system provides platform management functionality.
No Platform Manager Attribute	JAUS, Controls	Implies that there is no Platform Manager JAUS node or component and that discovery is not provided.

Table 35: - Mandatory Select = one

Any number of the following attributes can be chosen.

Attribute	Domain(s)	Description
Enhanced Access Control Attribute	JAUS, Controls	Adds enhanced access control capability to all components that provide the standard access control. Enhanced access control gives the ability to perform graceful handoff of control from a current controller to one with equal or less authority.
Stability Control Attribute	JAUS	Provides a way to discover and activate driver-assist capabilities of the vehicle.
Terrain Limits Attribute	JAUS, Controls	Provides a capability to detect when the platform has encountered impassable terrain.
Loading Specifications Attribute	JAUS	Describes the physical characteristics of a load (such as a trailer) attached to a platform.

Table 36: - Optional Select = any

The following attributes are mutually exclusive, exactly one must be chosen.

Attribute	Domain(s)	Description
No Automated Behaviors Attribute	JAUS, Controls	Specifies that the platform offers no dedicated services for automated behaviors, and leaves that support to the OCU.
Basic Automated Behaviors Attribute	JAUS, Controls	Adds support for accomplishing automated behaviors by issuing predefined sequences of JAUS messages.
Advanced Automated Behaviors Attribute	JAUS, Controls	Placeholder for future enhanced automated behaviors that extend the basic capabilities.

Table 37: - Mandatory Select = one

C.1.2.5.1 Platform Management Attribute

Parent Attribute: *Platform Attribute*

Attribute Summary: *The system provides platform management functionality.*

Any number of the following attributes can be chosen.

Attribute	Domain(s)	Description
Advanced Platform Management Attribute	JAUS	The Advanced Platform Management Interoperability Attribute is reserved for providing future capabilities such as calibration, software updates, etc.
Mission Configuration Attribute	Controls	Defines the capability to control of a subset of a platform's capabilities that allow an operator to achieve mission-specific, platform-level behaviors
Maintenance Attribute	Controls	Provides the capability to monitor and perform maintenance.
Platform Mode Attribute	JAUS	Provides the capability to query and change the mode of a platform, for example, from operational to maintenance.
Platform State Attribute	JAUS	Provide the capability query and change the state of a platform. The state is the overall platform state, and changing the state of the platform may change the state of various entities on that platform.

Table 38: - Optional Select = any

The following attributes are mandatory.

Attribute	Domain(s)	Description
Digital Resource Discovery Attribute	JAUS	Digital resource discovery attribute specifies how digital resources like digital video and audio streams are registered to be discovered by clients like an OCU.

Table 39: - Mandatory Select = all

C.1.2.5.1.1 Platform Mode Attribute

Parent Attribute: *Platform Management Attribute*

Attribute Summary: *Provides the capability to query and change the mode of a platform, for example, from operational to maintenance.*

C.1.2.5.1.2 Platform State Attribute

Parent Attribute: *Platform Management Attribute*

Attribute Summary: *Provide the capability query and change the state of a platform. The state is the overall platform state, and changing the state of the platform may change the state of various entities on that platform.*

C.1.2.5.1.3 Advanced Platform Management Attribute

Parent Attribute: *Platform Management Attribute*

Attribute Summary: *The Advanced Platform Management Interoperability Attribute is reserved for providing future capabilities such as calibration, software updates, etc.*

C.1.2.5.1.4 Mission Configuration Attribute

Parent Attribute: *Platform Management Attribute*

Attribute Summary: *Defines the capability to control of a subset of a platform's capabilities that allow an operator to achieve mission-specific, platform-level behaviors*

C.1.2.5.1.5 Maintenance Attribute

Parent Attribute: *Platform Management Attribute*

Attribute Summary: *Provides the capability to monitor and perform maintenance.*

C.1.2.5.2 No Platform Manager Attribute

Parent Attribute: *Platform Attribute*

Attribute Summary: *Implies that there is no Platform Manager JAUS node or component and that discovery is not provided.*

C.1.2.5.3 Enhanced Access Control Attribute

Parent Attribute: *Platform Attribute*

Attribute Summary: *Adds enhanced access control capability to all components that provide the standard access control. Enhanced access control gives the ability to perform graceful handoff of control from a current controller to one with equal or less authority.*

C.1.2.5.4 Stability Control Attribute

Parent Attribute: *Platform Attribute*

Attribute Summary: *Provides a way to discover and activate driver-assist capabilities of the vehicle.*

C.1.2.5.5 Terrain Limits Attribute

Parent Attribute: *Platform Attribute*

Attribute Summary: *Provides a capability to detect when the platform has encountered impassable terrain.*

Any number of the following attributes can be chosen.

Attribute	Domain(s)	Description
Obstacle Avoidance Attribute	JAUS, Controls	Provides a capability to stop or deviate around obstacles encountered when the platform is moving.
Obstacle Reporting Attribute	JAUS, Controls	Provides a way to report obstacles and hazardous terrain using an overhead 2D cost map.

Table 40: - Optional Select = any

C.1.2.5.6 Loading Specifications Attribute

Parent Attribute: *Platform Attribute*

Attribute Summary: *Describes the physical characteristics of a load (such as a trailer) attached to a platform.*

C.1.2.5.7 Digital Resource Discovery Attribute

Parent Attribute: *Platform Attribute*

Attribute Summary: *Digital resource discovery attribute specifies how digital resources like digital video and audio streams are registered to be discovered by clients like an OCU.*

C.1.2.5.8 No Automated Behaviors Attribute

Parent Attribute: *Platform Attribute*

Attribute Summary: *Specifies that the platform offers no dedicated services for automated behaviors, and leaves that support to the OCU.*

C.1.2.5.9 Basic Automated Behaviors Attribute

Parent Attribute: *Platform Attribute*

Attribute Summary: *Adds support for accomplishing automated behaviors by issuing predefined sequences of JAUS messages.*

C.1.2.5.9.1 Advanced Automated Behaviors Attribute

Parent Attribute: *Basic Automated Behaviors Attribute*

Attribute Summary: *Placeholder for future enhanced automated behaviors that extend the basic capabilities.*

C.1.2.6 Mobility Attribute

Parent Attribute: *Core Software and Logical Attribute*

Attribute Summary: *The Mobility Interoperability Attribute defines attributes related to platform mobility, such as driving.*

Any number of the following attributes can be chosen.

Attribute	Domain(s)	Description
Platform Specification Attribute	JAUS	Report the Platform Specification inherent to the platform such as limits for speed and acceleration (not based on the mobility type).
Gear Attribute	JAUS	Provides the ability to control the gears of a platform.
Parking Brake Driver Attribute	JAUS	Provides the ability to control the parking brake on a platform.
Stabilizer Attribute	JAUS, Controls	Provides the ability to control a platform stabilizer (i.e. flippers).
Remote Control Attribute	JAUS	Provides services for performing basic, open loop, line of sight remote control of a vehicle.
Teleoperation Attribute	JAUS	Provides the services for performing teleoperation control of a platform. Teleoperation is the non-line of sight equivalent to remote control, and requires the addition of a drive video source.
Autonomy and Behaviors Attribute	JAUS, Controls	Provide higher level navigation capabilities and support for other behaviors that take place absent complete operator control.

Table 41: - Optional Select = any

C.1.2.6.1 Platform Specification Attribute

Parent Attribute: *Mobility Attribute*

Attribute Summary: *Report the Platform Specification inherent to the platform such as limits for speed and acceleration (not based on the mobility type).*

C.1.2.6.2 Teleoperation Attribute

Parent Attribute: *Mobility Attribute*

Attribute Summary: *Provides the services for performing teleoperation control of a platform. Teleoperation is the non-line of sight equivalent to remote control, and requires the addition of a drive video source.*

The following attributes are mandatory.

Attribute	Domain(s)	Description
Remote Control Attribute	JAUS	Provides services for performing basic, open loop, line of sight remote control of a vehicle.
Video Attribute	JAUS	Provides a method for interacting with a video source, such as a digital or analog camera or video from another source.

Table 42: - Mandatory Select = all

C.1.2.6.3 Remote Control Attribute

Parent Attribute: *Mobility Attribute*

Attribute Summary: *Provides services for performing basic, open loop, line of sight remote control of a vehicle.*

Any number of the following attributes can be chosen.

Attribute	Domain(s)	Description
Effort Driving Attribute	JAUS	Provides the ability to engage in open-loop, effort-based driving.
Velocity State Driver Attribute	JAUS	Provides the ability to control the vehicle using closed loop velocity commands.
Vector Driver Attribute	JAUS	Provides the ability to perform closed loop control of the desired heading, altitude, and speed of a mobile platform.
Ackermann Steering Attribute	JAUS	Provides the ability to control Ackermann steered vehicles.
Skid Steer Attribute	JAUS	Provides the ability to control skid steer vehicles.

Table 2: - Optional Select = any

C.1.2.6.3.1 Velocity State Driver Attribute

Parent Attribute: *Remote Control Attribute*

Attribute Summary: *Provides the ability to control the vehicle using closed loop velocity commands.*

C.1.2.6.3.2 Vector Driver Attribute

Parent Attribute: *Remote Control Attribute*

Attribute Summary: *Provides the ability to perform closed loop control of the desired heading, altitude, and speed of a mobile platform.*

At least one of the following attributes must be chosen.

Attribute	Domain(s)	Description
Local Vector Driver Attribute	JAUS	Provides the ability to perform closed loop control of the desired local heading, altitude, and speed of a mobile platform using local (non-GPS) coordinates.
Global Vector Driver Attribute	JAUS	Provides the ability to perform closed loop control of the desired global heading, altitude, and speed of a mobile platform using global (GPS) coordinates.

Table 44: - Mandatory Select = any

C.1.2.6.3.2.1 Local Vector Driver Attribute

Parent Attribute: *Vector Driver Attribute*

Attribute Summary: *Provides the ability to perform closed loop control of the desired local heading, altitude, and speed of a mobile platform using local (non-GPS) coordinates.*

C.1.2.6.3.2.2 Global Vector Driver Attribute

Parent Attribute: *Vector Driver Attribute*

Attribute Summary: *Provides the ability to perform closed loop control of the desired global heading, altitude, and speed of a mobile platform using global (GPS) coordinates.*

C.1.2.6.3.3 Ackermann Steering Attribute

Parent Attribute: *Remote Control Attribute*

Attribute Summary: *Provides the ability to control Ackermann steered vehicles.*

C.1.2.6.3.4 Skid Steer Attribute

Parent Attribute: *Remote Control Attribute*

Attribute Summary: *Provides the ability to control skid steer vehicles.*

C.1.2.6.3.5 Effort Driving Attribute

Parent Attribute: *Remote Control Attribute*

Attribute Summary: *Provides the ability to engage in open-loop, effort-based driving.*

C.1.2.6.4 Gear Attribute

Parent Attribute: *Mobility Attribute*

Attribute Summary: *Provides the ability to control the gears of a platform.*

C.1.2.6.5 Parking Brake Driver Attribute

Parent Attribute: *Mobility Attribute*

Attribute Summary: *Provides the ability to control the parking brake on a platform.*

C.1.2.6.6 Autonomy and Behaviors Attribute

Parent Attribute: *Mobility Attribute*

Attribute Summary: *Provide higher level navigation capabilities and support for other behaviors that take place absent complete operator control.*

Any number of the following attributes can be chosen.

Attribute	Domain(s)	Description
Waypoint Navigation Attribute	JAUS, Controls	Provides the capability for navigation using waypoint path following.
Leader/Follower Attribute	JAUS, Controls	Provides the capability for navigation using a leader/follower configuration, such as in a convoy.
Retrotraverse Attribute	JAUS	Provides the capability to perform retrotraverse actions. A retrotraverse action causes a vehicle to move back along a path that it previously has travelled.
Guarded Teleop Attribute	JAUS	Provides the capability to define a guarded teleoperation policy that will be used for a platform.

Obstacle Avoidance Attribute	JAUS, Controls	Provides a capability to stop or deviate around obstacles encountered when the platform is moving.
Driver Assist Attribute	JAUS, Controls	Provides the capability to enable common driver assist/driver warning functionality.
Lost Comms Management Attribute	JAUS	Provides the capability to define a policy for when communications are lost between the platform and its controller.
Path Segment Driver Attribute	JAUS	Provides the ability to perform closed loop control of position and velocity along a path
Self-Righting Attribute	JAUS, Controls	Provides a mechanism for controlling and obtaining status of a self-righting behavior.

Table 45: - Optional Select = any

C.1.2.6.6.1 Waypoint Navigation Attribute

Parent Attribute: *Autonomy and Behaviors Attribute*

Attribute Summary: *Provides the capability for navigation using waypoint path following.*

At least one of the following attributes must be chosen.

Attribute	Domain(s)	Description
Global Basic Navigation Attribute	JAUS	Defines the capability for navigation using waypoint path following with globally referenced waypoints.
Local Basic Navigation Attribute	JAUS	Defines the capability for navigation using waypoint path following with locally referenced waypoints.

Table 46: - Mandatory Select = any

Any number of the following attributes can be chosen.

Attribute	Domain(s)	Description
Enhanced Waypoint Navigation Attribute	JAUS, Controls	Augments Waypoint Navigation by adding more detailed waypoint information and execution status.

Table 47: - Optional Select = any

C.1.2.6.6.1.1 Global Basic Navigation Attribute

Parent Attribute: *Waypoint Navigation Attribute*

Attribute Summary: *Defines the capability for navigation using waypoint path following with globally referenced waypoints.*

C.1.2.6.6.1.2 Local Basic Navigation Attribute

Parent Attribute: *Waypoint Navigation Attribute*

Attribute Summary: *Defines the capability for navigation using waypoint path following with locally referenced waypoints.*

C.1.2.6.6.1.3 Enhanced Waypoint Navigation Attribute

Parent Attribute: *Waypoint Navigation Attribute*

Attribute Summary: *Augments Waypoint Navigation by adding more detailed waypoint information and execution status.*

At least one of the following attributes must be chosen.

Attribute	Domain(s)	Description
Global Enhanced Navigation Attribute	JAUS	Augments the Global Waypoint Navigation Attribute by adding more detailed waypoint information and waypoint execution status.
Local Enhanced Navigation Attribute	JAUS	Augments the Local Waypoint Navigation Attribute by adding more detailed waypoint information and waypoint execution status.

Table 48: - Mandatory Select = any

C.1.2.6.6.1.3.1 Global Enhanced Navigation Attribute

Parent Attribute: *Enhanced Waypoint Navigation Attribute*

Attribute Summary: *Augments the Global Waypoint Navigation Attribute by adding more detailed waypoint information and waypoint execution status.*

C.1.2.6.6.1.3.2 Local Enhanced Navigation Attribute

Parent Attribute: *Enhanced Waypoint Navigation Attribute*

Attribute Summary: *Augments the Local Waypoint Navigation Attribute by adding more detailed waypoint information and waypoint execution status.*

C.1.2.6.6.2 Leader/Follower Attribute

Parent Attribute: *Autonomy and Behaviors Attribute*

Attribute Summary: *Provides the capability for navigation using a leader/follower configuration, such as in a convoy.*

At least one of the following attributes must be chosen.

Attribute	Domain(s)	Description
Leader Attribute	JAUS	Provides the capability to perform the leader portion of leader follow navigation, such as in a convoy.
Follower Attribute	JAUS	Provides the capability to perform the follower portion of leader follow navigation, such as in a convoy.

Table 49: - Mandatory Select = any

C.1.2.6.6.2.1 Leader Attribute

Parent Attribute: *Leader/Follower Attribute*

Attribute Summary: *Provides the capability to perform the leader portion of leader follow navigation, such as in a convoy.*

C.1.2.6.6.2.2 Follower Attribute

Parent Attribute: *Leader/Follower Attribute*

Attribute Summary: *Provides the capability to perform the follower portion of leader follow navigation, such as in a convoy.*

C.1.2.6.6.3 Retrotraverse Attribute

Parent Attribute: *Autonomy and Behaviors Attribute*

Attribute Summary: *Provides the capability to perform retrotraverse actions. A retrotraverse action causes a vehicle to move back along a path that it previously has travelled.*

C.1.2.6.6.4 Guarded Teleop Attribute

Parent Attribute: *Autonomy and Behaviors Attribute*

Attribute Summary: *Provides the capability to define a guarded teleoperation policy that will be used for a platform.*

C.1.2.6.6.5 Obstacle Avoidance Attribute

Parent Attribute: *Autonomy and Behaviors Attribute*

Attribute Summary: *Provides a capability to stop or deviate around obstacles encountered when the platform is moving.*

C.1.2.6.6.6 Driver Assist Attribute

Parent Attribute: *Autonomy and Behaviors Attribute*

Attribute Summary: *Provides the capability to enable common driver assist/driver warning functionality.*

C.1.2.6.6.7 Lost Comms Management Attribute

Parent Attribute: *Autonomy and Behaviors Attribute*

Attribute Summary: *Provides the capability to define a policy for when communications are lost between the platform and its controller.*

C.1.2.6.6.8 Path Segment Driver Attribute

Parent Attribute: *Autonomy and Behaviors Attribute*

Attribute Summary: *Provides the ability to perform closed loop control of position and velocity along a path*

At least one of the following attributes must be chosen.

Attribute	Domain(s)	Description
Local Path Segment Driver Attribute	JAUS	Provides the ability to perform closed loop control of position and velocity along a path where the path is defined in a generic manner, using local (non-GPS) coordinates.
Global Path Segment Driver Attribute	JAUS	Provides the ability to perform closed loop control of position and velocity along a path where the path is defined in a generic manner, using global (GPS) coordinates.

Table 50: - Mandatory Select = any

C.1.2.6.6.8.1 Global Path Segment Driver Attribute

Parent Attribute: *Path Segment Driver Attribute*

Attribute Summary: *Provides the ability to perform closed loop control of position and velocity along a path where the path is defined in a generic manner, using global (GPS) coordinates.*

C.1.2.6.6.8.2 Local Path Segment Driver Attribute

Parent Attribute: *Path Segment Driver Attribute*

Attribute Summary: *Provides the ability to perform closed loop control of position and velocity along a path where the path is defined in a generic manner, using local (non-GPS) coordinates.*

C.1.2.6.6.9 Self-Righting Attribute

Parent Attribute: *Autonomy and Behaviors Attribute*

Attribute Summary: *Provides a mechanism for controlling and obtaining status of a self-righting behavior.*

C.1.2.7 Sensor Attribute

Parent Attribute: *Core Software and Logical Attribute*

Attribute Summary: *UGVs have payloads which can collect data from the surrounding environment. In addition UGVs have sensors that collect data from the robot in order to report back to the operator health and other status information.*

Any number of the following attributes can be chosen.

Attribute	Domain(s)	Description
Video Attribute	Payloads, JAUS, Controls	Provides a method for interacting with a video source, such as a digital or analog camera or video from another source.
Still Image Attribute	Payloads, JAUS	Provides the capability to configure and retrieve information from a still image source.

Range Sensor Attribute	Payloads, JAUS, Controls	Provides the capability for getting information back from a range sensor. This may be either a simple range finder (one range, like a ranging laser) or a more complex range finder (like a LIDAR unit with many returns per second over a large azimuth).
Microphone Attribute	Payloads, JAUS, Controls	Provides the capability to receive audio from a microphone device. It is assumed that the audio will be sent in a digital format. Multiple microphones may be represented using this attribute.
Chemical, Biological, Radiological, & Nuclear Sensor Attribute	Payloads, JAUS, Controls	The Chemical, Biological, Radiological, & Nuclear Sensor Attribute provides a method for interacting with a Chemical, Biological, Radiological, & Nuclear (CBRN) sensor source.
Explosive Detection Sensor Attribute	Controls	Chemical detectors identify the presence of specific chemicals in the surrounding area of the UGV asset.
Tire Pressure System Attribute	JAUS, Controls	Provides the capability to communicate, control and receive status from a tire pressure system.
Radar Sensor Attribute	Controls	Provides the capability to communicate, control and receive status from a radar.
Acceleration State Sensor Attribute	JAUS	Defines the capability to report acceleration state information.
Velocity State Sensor Attribute	JAUS	Defines the capability to report velocity state information.
Thermal Sensor Attribute	Payloads	A thermal sensor
Force/Torque Sensor Attribute	Payloads, JAUS	Provides a way to get force or torque information from one or more devices.
Acoustic Sensor Attribute	Payloads, JAUS, Controls	Provides a mechanism for controlling and obtaining data from an acoustic sensor.
Engagement Detection Attribute	Payloads, JAUS, Controls	The Engagement Detection Attribute provides a capability to identify and locate small weapons fire. The capability itself is agnostic of the underlying detection mechanism and specific sensor(s) used.

Magnetic Sensor Attribute	Payloads, JAUS, Controls	Provides a mechanism for controlling and obtaining data from an magnetic sensor.
Seismic Sensor Attribute	Payloads, JAUS, Controls	Provides a mechanism for controlling and obtaining data from a seismic sensor.
Global Contact Tracking Attribute	Payloads, JAUS, Controls	Provides a capability to identify and track objects moving in the environment. These objects may be limited to humans, vehicles, pedestrians, etc. based on the specific needs of the program. The actual method of detection and tracking, e.g. vision versus lidar or some combination, is left to the implementation

Table 51: - Optional Select = any

C.1.2.7.1 Video Attribute

Parent Attribute: *Sensor Attribute*

Attribute Summary: *Provides a method for interacting with a video source, such as a digital or analog camera or video from another source.*

At least one of the following attributes must be chosen.

Attribute	Domain(s)	Description
Digital Video Attribute	Payloads, JAUS	The Digital Video Interoperability Attribute provides a method for interacting with a digital video source, such as a digital camera or digital video from another digital source.
Analog Video Attribute	Payloads, JAUS	Provides a method for interacting with an analog video source, such as an analog camera.

Table 52: - Mandatory Select = any

Any number of the following attributes can be chosen.

Attribute	Domain(s)	Description
Pan Tilt Video Sensor Attribute	Payloads, JAUS	Provides the capability to configure, control, and find/connect to a video device (analog or digital) that has pan tilt capabilities (i.e. a PTZ camera).

Table 53: - Optional Select = any

C.1.2.7.1.1 Digital Video Attribute

Parent Attribute: *Video Attribute*

Attribute Summary: *The Digital Video Interoperability Attribute provides a method for interacting with a digital video source, such as a digital camera or digital video from another digital source.*

The following attributes are mutually exclusive, exactly one must be chosen.

Attribute	Domain(s)	Description
Digital Video Pull Attribute	JAUS	Provides a method for interacting with an digital video source using the 'Pull' configuration.
Digital Video Push Attribute	JAUS	Provides a method for interacting with an digital video source using the 'Push' configuration.

Table 54: - Mandatory Select = one

The following attributes are mandatory.

Attribute	Domain(s)	Description
H264 Video Encoding Attribute	JAUS	If H264 video encoding is used, specifies services and requirements to support H.264 video encoding.

Table 55: - Mandatory Select = all

C.1.2.7.1.1.1 Digital Video Pull Attribute

Parent Attribute: *Digital Video Attribute*

Attribute Summary: *Provides a method for interacting with an digital video source using the 'Pull' configuration.*

C.1.2.7.1.1.2 Digital Video Push Attribute

Parent Attribute: *Digital Video Attribute*

Attribute Summary: *Provides a method for interacting with an digital video source using the 'Push' configuration.*

C.1.2.7.1.1.3 H264 Video Encoding Attribute

Parent Attribute: *Digital Video Attribute*

Attribute Summary: *If H264 video encoding is used, specifies services and requirements to support H.264 video encoding.*

C.1.2.7.1.2 Analog Video Attribute

Parent Attribute: *Video Attribute*

Attribute Summary: *Provides a method for interacting with an analog video source, such as an analog camera.*

C.1.2.7.1.3 Pan Tilt Video Sensor Attribute

Parent Attribute: *Video Attribute*

Attribute Summary: *Provides the capability to configure, control, and find/connect to a video device (analog or digital) that has pan tilt capabilities (i.e. a PTZ camera).*

The following attributes are mandatory.

Attribute	Domain(s)	Description
Pan Tilt Manipulator Attribute	JAUS	Defines requirements common to all pan-tilt manipulator related services.

Table 56: - Mandatory Select = all

C.1.2.7.2 Still Image Attribute

Parent Attribute: *Sensor Attribute*

Attribute Summary: *Provides the capability to configure and retrieve information from a still image source.*

C.1.2.7.3 Range Sensor Attribute

Parent Attribute: *Sensor Attribute*

Attribute Summary: *Provides the capability for getting information back from a range sensor. This may be either a simple range finder (one range, like a ranging laser) or a more complex range finder (like a LIDAR unit with many returns per second over a large azimuth).*

Any number of the following attributes can be chosen.

Attribute	Domain(s)	Description
Ground-Penetrating Radar Attribute	Payloads	Specialized range finder using radar pulses to image the subsurface

Table 57: - Optional Select = any

C.1.2.7.3.1 Ground-Penetrating Radar Attribute

Parent Attribute: *Range Sensor Attribute*

Attribute Summary: *Specialized range finder using radar pulses to image the subsurface*

C.1.2.7.4 Microphone Attribute

Parent Attribute: *Sensor Attribute*

Attribute Summary: *Provides the capability to receive audio from a microphone device. It is assumed that the audio will be sent in a digital format. Multiple microphones may be represented using this attribute.*

At least one of the following attributes must be chosen.

Attribute	Domain(s)	Description
Microphone Pull Attribute	JAUS	Provides the capability to receive audio from a microphone device. It is assumed that the audio will be sent in a digital format. The pull method uses an RTSP endpoint to serve up a digital stream over RTP, making the client pull the stream from a registered audio endpoint.
Microphone Push Attribute	JAUS	Provides the capability to receive audio from a microphone device. It is assumed that the audio will be sent in a digital format. The push method tells the digital audio source what endpoint it should send audio to using RTP.

Table 58: - Mandatory Select = any

C.1.2.7.4.1 Microphone Pull Attribute

Parent Attribute: *Microphone Attribute*

Attribute Summary: *Provides the capability to receive audio from a microphone device. It is assumed that the audio will be sent in a digital format. The pull method uses an RTSP endpoint to serve up a digital stream over RTP, making the client pull the stream from a registered audio endpoint.*

C.1.2.7.4.2 Microphone Push Attribute

Parent Attribute: *Microphone Attribute*

Attribute Summary: *Provides the capability to receive audio from a microphone device. It is assumed that the audio will be sent in a digital format. The push method tells the digital audio source what endpoint it should send audio to using RTP.*

C.1.2.7.5 Chemical, Biological, Radiological, & Nuclear Sensor Attribute

Parent Attribute: *Sensor Attribute*

Attribute Summary: *The Chemical, Biological, Radiological, & Nuclear Sensor Attribute provides a method for interacting with a Chemical, Biological, Radiological, & Nuclear (CBRN) sensor source.*

The following attributes are mandatory.

Attribute	Domain(s)	Description
Digital Resource Discovery Attribute	JAUS	Digital resource discovery attribute specifies how digital resources like digital video and audio streams are registered to be discovered by clients like an OCU.

Table 59: - Mandatory Select = all

C.1.2.7.6 Explosive Detection Sensor Attribute

Parent Attribute: *Sensor Attribute*

Attribute Summary: *Chemical detectors identify the presence of specific chemicals in the surrounding area of the UGV asset.*

C.1.2.7.7 Tire Pressure System Attribute

Parent Attribute: *Sensor Attribute*

Attribute Summary: *Provides the capability to communicate, control and receive status from a tire pressure system.*

C.1.2.7.8 Radar Sensor Attribute

Parent Attribute: *Sensor Attribute*

Attribute Summary: *Provides the capability to communicate, control and receive status from a radar.*

C.1.2.7.9 Acceleration State Sensor Attribute

Parent Attribute: *Sensor Attribute*

Attribute Summary: *Defines the capability to report acceleration state information.*

C.1.2.7.10 Velocity State Sensor Attribute

Parent Attribute: *Sensor Attribute*

Attribute Summary: *Defines the capability to report velocity state information.*

C.1.2.7.11 Thermal Sensor Attribute

Parent Attribute: *Sensor Attribute*

Attribute Summary: *A thermal sensor*

C.1.2.7.12 Force/Torque Sensor Attribute

Parent Attribute: *Sensor Attribute*

Attribute Summary: *Provides a way to get force or torque information from one or more devices.*

C.1.2.7.13 Acoustic Sensor Attribute

Parent Attribute: *Sensor Attribute*

Attribute Summary: *Provides a mechanism for controlling and obtaining data from an acoustic sensor.*

C.1.2.7.14 Engagement Detection Attribute

Parent Attribute: *Sensor Attribute*

Attribute Summary: *The Engagement Detection Attribute provides a capability to identify and locate small weapons fire. The capability itself is agnostic of the underlying detection mechanism and specific sensor(s) used.*

C.1.2.7.15 Magnetic Sensor Attribute

Parent Attribute: *Sensor Attribute*

Attribute Summary: *Provides a mechanism for controlling and obtaining data from an magnetic sensor.*

C.1.2.7.16 Seismic Sensor Attribute

Parent Attribute: *Sensor Attribute*

Attribute Summary: *Provides a mechanism for controlling and obtaining data from a seismic sensor.*

C.1.2.7.17 Global Contact Tracking Attribute

Parent Attribute: *Sensor Attribute*

Attribute Summary: *Provides a capability to identify and track objects moving in the environment. These objects may be limited to humans, vehicles, pedestrians, etc. based on the specific needs of the program. The actual method of detection and tracking, e.g. vision versus lidar or some combination, is left to the implementation*

C.1.2.8 Emitter Attribute

Parent Attribute: *Core Software and Logical Attribute*

Attribute Summary: *UGVs have payloads which can affect their surrounding environment at a distance. These include Lights, Speakers, Laser Target Designators, and Weapons.*

Any number of the following attributes can be chosen.

Attribute	Domain(s)	Description
Illumination Attribute	Payloads, JAUS, Controls	Provides the capability to interact with lights.
Camera Lights Attribute	JAUS	Provides a method for interacting with lights associated with one or more cameras.
Speaker Attribute	Payloads, JAUS, Controls	Provides the capability to send audio that gets annunciated over a speaker. Multiple speakers may be represented using this attribute.
Debris Blower Attribute	Payloads, JAUS, Controls	Provides the capability to blow debris.
Laser Attribute	Controls	Provides the capability to use a laser target designator or laser range finder.

Table 60: - Optional Select = any

C.1.2.8.1 Illumination Attribute

Parent Attribute: *Emitter Attribute*

Attribute Summary: *Provides the capability to interact with lights.*

Any number of the following attributes can be chosen.

Attribute	Domain(s)	Description
Military Illumination Attribute	JAUS	Provides the capability to engage military style lighting such as blackout lamps (i.e. markers, head lights, tail lights, etc.).

Table 3: - Optional Select = any

C.1.2.8.1.1 Military Illumination Attribute

Parent Attribute: *Illumination Attribute*

Attribute Summary: *Provides the capability to engage military style lighting such as blackout lamps (i.e. markers, head lights, tail lights, etc.).*

C.1.2.8.2 Camera Lights Attribute

Parent Attribute: *Emitter Attribute*

Attribute Summary: *Provides a method for interacting with lights associated with one or more cameras.*

C.1.2.8.3 Speaker Attribute

Parent Attribute: *Emitter Attribute*

Attribute Summary: *Provides the capability to send audio that gets annunciated over a speaker. Multiple speakers may be represented using this attribute.*

At least one of the following attributes must be chosen.

Attribute	Domain(s)	Description
Speaker Pull Attribute	JAUS	Provides the capability to send audio to a speaker device. It is assumed that the audio will be sent in a digital format. The pull method uses an RTSP endpoint to serve up a digital stream over RTP, making the speaker component pull the audio that it will play from a specified stream.

Speaker Push Attribute	JAUS	Provides the capability to send audio to a speaker device. It is assumed that the audio will be sent in a digital format. The push method tells the client (i.e. OCU) where it should push audio data over RTP to.

Table 62: - Mandatory Select = any

C.1.2.8.3.1 Speaker Pull Attribute

Parent Attribute: *Speaker Attribute*

Attribute Summary: *Provides the capability to send audio to a speaker device. It is assumed that the audio will be sent in a digital format. The pull method uses an RTSP endpoint to serve up a digital stream over RTP, making the speaker component pull the audio that it will play from a specified stream.*

C.1.2.8.3.2 Speaker Push Attribute

Parent Attribute: *Speaker Attribute*

Attribute Summary: *Provides the capability to send audio to a speaker device. It is assumed that the audio will be sent in a digital format. The push method tells the client (i.e. OCU) where it should push audio data over RTP to.*

C.1.2.8.4 Debris Blower Attribute

Parent Attribute: *Emitter Attribute*

Attribute Summary: *Provides the capability to blow debris.*

C.1.2.8.5 Laser Attribute

Parent Attribute: *Emitter Attribute*

Attribute Summary: *Provides the capability to use a laser target designator or laser range finder.*

C.1.2.9 Actuator Attribute

Parent Attribute: *Core Software and Logical Attribute*

Attribute Summary: *Actuator payloads provide mechanical means of manipulation.*

At least one of the following attributes must be chosen.

Attribute	Domain(s)	Description
Robotic Arm Control Attribute	Payloads, JAUS, Controls	Provides the capability to communicate, control, and receive status from a robotic arm.
Pan Tilt Manipulator Attribute	Payloads, JAUS, Controls	Defines requirements common to all pan-tilt manipulator related services.
End Effector Attribute	Payloads, JAUS, Controls	Adds support for the capability to control and/or receive status from an end-effector

Table 63: - Mandatory Select = any

Any number of the following attributes can be chosen.

Attribute	Domain(s)	Description
Self-Collision Avoidance Attribute	Payloads, JAUS, Controls	Provides the capability to communicate, control, and receive status from a self-collision avoidance system.

Table 64: - Optional Select = any

C.1.2.9.1 Robotic Arm Control Attribute

Parent Attribute: *Actuator Attribute*

Attribute Summary: *Provides the capability to communicate, control, and receive status from a robotic arm.*

Any number of the following attributes can be chosen.

Attribute	Domain(s)	Description
Basic Manipulator Attribute	Payloads, JAUS	Defines a basic manipulator controlled using open loop control.
Mast Actuator Attribute	Payloads, JAUS, Controls	Provides the capability to communicate, control, and receive status from a mast actuator.
Manipulator Joint Velocity Control Attribute	JAUS	Defines the capability to control manipulator joints using closed loop velocity control.

Manipulator Joint Position Control Attribute	JAUS	Defines the capability to control manipulator joints using closed loop position control.
Manipulator Joint Force/Torque Driver Attribute	JAUS	Provides the capability to add closed loop force (prismatic joint) or torque (revolute joint) control of a manipulator.
Fly-The-End-Effector Attribute	JAUS	Defines the capability to control the location or velocity of an end-effector through commanding the manipulator arm on which it is attached.
Manipulator Joint Motor Brake Attribute	Controls	Defines the capability to command and control a brake on the motor of a manipulator joint.
Manipulator Joint Velocity Sensor Attribute	JAUS	Defines the capability to get velocity information for manipulator joints.
Manipulator Joint Position Sensor Attribute	JAUS	Defines the capability to get position information for manipulator joints.
Manipulator Joint Force/Torque Sensor Attribute	JAUS	Provides the capability to report the values of instantaneous torques (for revolute joints) and forces (for prismatic) joints.
Manipulator End Effector Position Sensor Attribute	JAUS	Defines the capability to get information on the position of the end effector.
Manipulator End Effector Velocity State Sensor Attribute	JAUS	Defines the capability to get information on the velocity of the end effector.

Table 65: - Optional Select = any

C.1.2.9.1.1 Basic Manipulator Attribute

Parent Attribute: *Robotic Arm Control Attribute*

Attribute Summary: *Defines a basic manipulator controlled using open loop control.*

C.1.2.9.1.2 Mast Actuator Attribute

Parent Attribute: *Robotic Arm Control Attribute*

Attribute Summary: *Provides the capability to communicate, control, and receive status from a mast actuator.*

C.1.2.9.1.3 Manipulator Joint Position Control Attribute

Parent Attribute: *Robotic Arm Control Attribute*

Attribute Summary: *Defines the capability to control manipulator joints using closed loop position control.*

C.1.2.9.1.4 Manipulator Joint Velocity Control Attribute

Parent Attribute: *Robotic Arm Control Attribute*

Attribute Summary: *Defines the capability to control manipulator joints using closed loop velocity control.*

C.1.2.9.1.5 Manipulator Joint Force/Torque Driver Attribute

Parent Attribute: *Robotic Arm Control Attribute*

Attribute Summary: *Provides the capability to add closed loop force (prismatic joint) or torque (revolute joint) control of a manipulator.*

C.1.2.9.1.6 Fly-The-End-Effector Attribute

Parent Attribute: *Robotic Arm Control Attribute*

Attribute Summary: *Defines the capability to control the location or velocity of an end-effector through commanding the manipulator arm on which it is attached.*

The following attributes are mandatory.

Attribute	Domain(s)	Description
End Effector Attribute	JAUS	Adds support for the capability to control and/or receive status from an end-effector

Table 66: - Mandatory Select = all

At least one of the following attributes must be chosen.

Attribute	Domain(s)	Description
Manipulator End Effector Position Control Attribute	JAUS	Defines the capability to "fly the end effector" using closed loop position control of an end effector.
Manipulator End Effector Velocity Control Attribute	JAUS	Defines the capability to "fly the end effector" using closed loop velocity commands.

Table 67: - Mandatory Select = any

Any number of the following attributes can be chosen.

Attribute	Domain(s)	Description
Manipulator End Effector Frame of Reference Attribute	JAUS, Controls	The Frame of Reference Attribute allows a client to change the coordinate frame for end effector based services. This allows for more user-friendly options for fly-the-end-effector functionality and coordination between two or more manipulators on the same platform.

Manipulator End Effector Position Sensor Attribute	JAUS	Defines the capability to get information on the position of the end effector.
Manipulator End Effector Velocity State Sensor Attribute	JAUS	Defines the capability to get information on the velocity of the end effector.

Table 68: - Optional Select = any

C.1.2.9.1.6.1 Manipulator End Effector Position Control Attribute

Parent Attribute: *Fly-The-End-Effector Attribute*

Attribute Summary: *Defines the capability to "fly the end effector" using closed loop position control of an end effector.*

C.1.2.9.1.6.2 Manipulator End Effector Velocity Control Attribute

Parent Attribute: *Fly-The-End-Effector Attribute*

Attribute Summary: *Defines the capability to "fly the end effector" using closed loop velocity commands.*

C.1.2.9.1.7 Manipulator Joint Velocity Sensor Attribute

Parent Attribute: *Robotic Arm Control Attribute*

Attribute Summary: *Defines the capability to get velocity information for manipulator joints.*

C.1.2.9.1.8 Manipulator Joint Position Sensor Attribute

Parent Attribute: *Robotic Arm Control Attribute*

Attribute Summary: *Defines the capability to get position information for manipulator joints.*

C.1.2.9.1.9 Manipulator Joint Force/Torque Sensor Attribute

Parent Attribute: *Robotic Arm Control Attribute*

Attribute Summary: *Provides the capability to report the values of instantaneous torques (for revolute joints) and forces (for prismatic) joints.*

C.1.2.9.1.10 Manipulator Joint Motor Brake Attribute

Parent Attribute: *Robotic Arm Control Attribute*

Attribute Summary: *Defines the capability to command and control a brake on the motor of a manipulator joint.*

C.1.2.9.1.11 Manipulator End Effector Position Sensor Attribute

Parent Attribute: *Robotic Arm Control Attribute*

Attribute Summary: *Defines the capability to get information on the position of the end effector.*

C.1.2.9.1.12 Manipulator End Effector Velocity State Sensor Attribute

Parent Attribute: *Robotic Arm Control Attribute*

Attribute Summary: *Defines the capability to get information on the velocity of the end effector.*

C.1.2.9.2 Pan Tilt Manipulator Attribute

Parent Attribute: *Actuator Attribute*

Attribute Summary: *Defines requirements common to all pan-tilt manipulator related services.*

At least one of the following attributes must be chosen.

Attribute	Domain(s)	Description
Basic Pan Tilt Attribute	JAUS	Defines a basic, open-loop pan tilt manipulator capability.
Pan Tilt Manipulator Position Control Attribute	JAUS	Defines the capability to control a pan tilt manipulator using closed loop position control.
Pan Tilt Manipulator Velocity Control Attribute	JAUS	Defines the capability to control a pan tilt manipulator using closed loop velocity control.

Table 69: - Mandatory Select = any

Any number of the following attributes can be chosen.

Attribute	Domain(s)	Description
Pan Tilt Manipulator Velocity Sensor Attribute	JAUS	Defines the capability to get velocity information for a pan tilt manipulator.
Pan Tilt Manipulator Position Sensor Attribute	JAUS	Defines the capability to get position information for a pan tilt manipulator.

Table 70: - Optional Select = any

C.1.2.9.2.1 Basic Pan Tilt Attribute

Parent Attribute: *Pan Tilt Manipulator Attribute*

Attribute Summary: *Defines a basic, open-loop pan tilt manipulator capability.*

C.1.2.9.2.2 Pan Tilt Manipulator Velocity Control Attribute

Parent Attribute: *Pan Tilt Manipulator Attribute*

Attribute Summary: *Defines the capability to control a pan tilt manipulator using closed loop velocity control.*

C.1.2.9.2.3 Pan Tilt Manipulator Position Control Attribute

Parent Attribute: *Pan Tilt Manipulator Attribute*

Attribute Summary: *Defines the capability to control a pan tilt manipulator using closed loop position control.*

C.1.2.9.2.4 Pan Tilt Manipulator Velocity Sensor Attribute

Parent Attribute: *Pan Tilt Manipulator Attribute*

Attribute Summary: *Defines the capability to get velocity information for a pan tilt manipulator.*

C.1.2.9.2.5 Pan Tilt Manipulator Position Sensor Attribute

Parent Attribute: *Pan Tilt Manipulator Attribute*

Attribute Summary: *Defines the capability to get position information for a pan tilt manipulator.*

C.1.2.9.3 Self-Collision Avoidance Attribute

Parent Attribute: *Actuator Attribute*

Attribute Summary: *Provides the capability to communicate, control, and receive status from a self-collision avoidance system.*

The following attributes are mutually exclusive, exactly one must be chosen.

Attribute	Domain(s)	Description
Centralized Self-Collision Avoidance Attribute	JAUS	Provides the capability to have centralized self-collision avoidance on a system.
Distributed Self-Collision Avoidance Attribute	JAUS	Provides the capability to have distributed self-collision avoidance on a system.

Table 71: - Mandatory Select = one

C.1.2.9.3.1 Centralized Self-Collision Avoidance Attribute

Parent Attribute: *Self-Collision Avoidance Attribute*

Attribute Summary: *Provides the capability to have centralized self-collision avoidance on a system.*

The following attributes are mandatory.

Attribute	Domain(s)	Description
Message Filter Attribute	JAUS	Provides a way to pass actions such as commands through a filter before they reach their final destination.

Table 72: - Mandatory Select = all

C.1.2.9.3.2 Distributed Self-Collision Avoidance Attribute

Parent Attribute: *Self-Collision Avoidance Attribute*

Attribute Summary: *Provides the capability to have distributed self-collision avoidance on a system.*

C.1.2.9.4 End Effector Attribute

Parent Attribute: *Actuator Attribute*

Attribute Summary: *Adds support for the capability to control and/or receive status from an end-effector*

Any number of the following attributes can be chosen.

Attribute	Domain(s)	Description
Basic End Effector Attribute	Payloads, JAUS, Controls	Provides the capability to communicate, control, and receive status from an end-effector.
Manipulator End Effector Frame of Reference Attribute	JAUS, Controls	The Frame of Reference Attribute allows a client to change the coordinate frame for end effector based services. This allows for more user-friendly options for fly-the-end-effector functionality and coordination between two or more manipulators on the same platform.
Fly-The-End-Effector Attribute	JAUS	Defines the capability to control the location or velocity of an end-effector through commanding the manipulator arm on which it is attached.
Manipulator End Effector Position Control Attribute	JAUS	Defines the capability to "fly the end effector" using closed loop position control of an end effector.
Manipulator End Effector Position Sensor Attribute	JAUS	Defines the capability to get information on the position of the end effector.
Manipulator End Effector Velocity Control Attribute	JAUS	Defines the capability to "fly the end effector" using closed loop velocity commands.
Manipulator End Effector Velocity State Sensor Attribute	JAUS	Defines the capability to get information on the velocity of the end effector.
Stabilizer Attribute	JAUS, Controls	Provides the ability to control a platform stabilizer (i.e. flippers).
Complex End Effector Attribute	Payloads, JAUS	Provides the capability to define a complex end effector beyond a simple one degree of freedom.
Gripper Control Attribute	Controls	Provides the capability to communicate, control, and receive status from a gripper.
Windshield Wiper Attribute	JAUS, Controls	Provides the capability to communicate, control, and receive status from windshield wipers.
Sensor Cleaning System Attribute	Controls	Provides the capability to communicate, control, and receive status from a sensor cleaning system.

Door Lock System Attribute	JAUS, Controls	Provides the capability to communicate, control, and receive status from the door locking system on the robot.
Manipulator End Effector Force/Torque Sensor Attribute	JAUS	Provides a way to get force or torque information from a manipulator end effector.
Surrogate UAV Attribute	Payloads, JAUS, Controls	Provides a capability to identify, launch, and recover a surrogate UAV associated with the host platform.
Tether Spooler Attribute	Payloads, JAUS, Controls	Adds support for controlling and obtaining status from a tether's spooling mechanism

Table 73: - Optional Select = any

C.1.2.9.4.1 Basic End Effector Attribute

Parent Attribute: *End Effector Attribute*

Attribute Summary: *Provides the capability to communicate, control, and receive status from an end-effector.*

C.1.2.9.4.2 Manipulator End Effector Frame of Reference Attribute

Parent Attribute: *End Effector Attribute*

Attribute Summary: *The Frame of Reference Attribute allows a client to change the coordinate frame for end effector based services. This allows for more user-friendly options for fly-the-end-effector functionality and coordination between two or more manipulators on the same platform.*

C.1.2.9.4.3 Stabilizer Attribute

Parent Attribute: *End Effector Attribute*

Attribute Summary: *Provides the ability to control a platform stabilizer (i.e. flippers).*

C.1.2.9.4.4 Complex End Effector Attribute

Parent Attribute: *End Effector Attribute*

Attribute Summary: *Provides the capability to define a complex end effector beyond a simple one degree of freedom.*

The following attributes are mandatory.

Attribute	Domain(s)	Description
Basic Manipulator Attribute	Payloads, JAUS	Defines a basic manipulator controlled using open loop control.

Table 74: - Mandatory Select = all

C.1.2.9.4.5 Gripper Control Attribute

Parent Attribute: *End Effector Attribute*

Attribute Summary: *Provides the capability to communicate, control, and receive status from a gripper.*

C.1.2.9.4.6 Windshield Wiper Attribute

Parent Attribute: *End Effector Attribute*

Attribute Summary: *Provides the capability to communicate, control, and receive status from windshield wipers.*

C.1.2.9.4.7 Sensor Cleaning System Attribute

Parent Attribute: *End Effector Attribute*

Attribute Summary: *Provides the capability to communicate, control, and receive status from a sensor cleaning system.*

C.1.2.9.4.8 Door Lock System Attribute

Parent Attribute: *End Effector Attribute*

Attribute Summary: *Provides the capability to communicate, control, and receive status from the door locking system on the robot.*

C.1.2.9.4.9 Manipulator End Effector Force/Torque Sensor Attribute

Parent Attribute: *End Effector Attribute*

Attribute Summary: *Provides a way to get force or torque information from a manipulator end effector.*

C.1.2.9.4.10 Surrogate UAV Attribute

Parent Attribute: *End Effector Attribute*

Attribute Summary: *Provides a capability to identify, launch, and recover a surrogate UAV associated with the host platform.*

C.1.2.9.4.11 Tether Spooler Attribute

Parent Attribute: *End Effector Attribute*

Attribute Summary: *Adds support for controlling and obtaining status from a tether's spooling mechanism*

C.1.3 Common Payload Attribute

Parent Attribute: *IOP Usage Attribute*

Attribute Summary: *Common capability and requirements of payloads.*

Any number of the following attributes can be chosen.

Attribute	Domain(s)	Description
Sensor Attribute	Payloads	UGVs have payloads which can collect data from the surrounding environment. In addition UGVs have sensors that collect data from the robot in order to report back to the operator health and other status information.
Emitter Attribute	Payloads	UGVs have payloads which can affect their surrounding environment at a distance. These include Lights, Speakers, Laser Target Designators, and Weapons.
Actuator Attribute	Payloads	Actuator payloads provide mechanical means of manipulation.
Platform Hardware Attribute	Payloads	Allows for specification of platform hardware.
Self-Collision Avoidance Attribute	Payloads	Provides the capability to communicate, control, and receive status from a self-collision avoidance system.

Table 75: - Optional Select = any

C.1.4 Appliqué Core Attribute

Parent Attribute: *IOP Usage Attribute*

Attribute Summary: *Core capability and requirements for appliqué systems*

C.1.5 CCL Attribute

Parent Attribute: *IOP Usage Attribute*

Attribute Summary: *Communications link between IOP systems*

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