Interoperability Challenge 2010

Challenge Rules & Scoring

Standards and Best Practices

In an effort to promote the use of sound engineering methodologies by student teams competing in the AUVSI competitions, our sponsors have established the Interoperability Challenge for the International Ground Vehicle Competition, the International Ariel Robotics Competition, the Autonomous Surface Competition and the Autonomous Underwater Competition.

This year the Interoperability Challenge introduces a graduated scoring approach and three (3) prize categories. Prize amounts will be based on the sponsorship contributions and the number of competing teams.

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Executive Summary

The Association of Unmanned Vehicle Systems International (AUVSI) has sponsored student robotic competitions in all mobility domains. Some of these competitions have been held for over 19 years with increasing complexity and participation. As the unmanned systems market matures it has become apparent that the use of standards for communications is imperative. Further, communications both on-board and off-board are necessary in the "net-centric" systems of today's world.

The Joint Architecture for Unmanned Systems (JAUS) is the premiere interoperability standard for unmanned systems. This standard was originally developed by the Department of Defense in 1998 and since has been adopted and matured as a set of Society of Automotive Engineers Aerospace Standards. Use of the standard is required in major Department of Defense programs and it is used in a variety of commercial and industrial applications worldwide.

The Interoperability Challenge for 2010 will include a series of JAUS based interactions with the Common Operating Picture (COP), a control and monitoring interface that will be employed by the Interoperability Challenge judging staff. The Interoperability Challenge requires that each team perform the following tasks using SAE JAUS messages. Each task is described further in later sections of this document.

1. Transport Discovery
2. Capabilities Discovery
3. System Management
4. Velocity State Report
5. Position & Orientation Report
6. Waypoint Navigation

Scoring is based on the complexity of the specific JAUS interface for each task as determined by the competition organizers. Not all tasks are applicable to each competition; for example, the Waypoint Navigation only applies to the Ground and Surface vehicle competitions. Prizes will be determined based on the top scores for each competition.

The remainder of this document describes the specific protocols and messaging to be employed by the student teams during their respective competitions. The descriptions are broken out by tasks as described above. Task complexity increases from task 1 to 5 and teams should expect the protocols from earlier tasks to be required by the higher tasks. All interaction will be between the Team's entry and the COP. No other communications will be allowed with the exception of competition specific safety equipment.

Technical Overview

Each entry will interface with the Judge's COP providing information as specified below. The general approach to the JAUS interface will be to respond to a periodic status and position requests from the COP. This requires the support of the JAUS Transport Specification (AS5669A) and the JAUS Core Service Set (AS5710). The JAUS Transport Specification supports several communication protocols, the competition will use only the Ethernet based JUDP. The Core services required for the competition include the discovery, access control, and management services. The JAUS Mobility Service Set (AS6009) or JSS-Mobility defines the messaging to be used for position communications and waypoint based navigation.

The Common Operating Picture (COP)

The COP will provide a high level view of the systems in operation that successfully implement the JAUS protocol as described above. This software is a simple validation, reporting and recording tool for the Judges to use while verifying student implementations of the JAUS standard. It provides a graphical display of the operational area in relative coordinates. Primitive graphics are loaded in the display of the COP to add perspective. Each reported status is displayed on the COP user interface and recorded for future reference. For competitions and systems reporting positional data, a 2-D map on the COP display is annotated with the updated position as well as track marks showing the previous position of the system for the current task.

Communications Protocols

The teams will implement a wireless 802.11b/g or hardwired Ethernet (RJ-45) data link. The interface can be implemented at any point in the student team's system including the control station or mobility platform.

The Internet Protocol (IP) address to be used will be provided at the competition. For planning purposes, this address will be in the range of 192.168.1.100 to 192.168.1.200. The Judge's COP will have both hard-wire and 802.11b/g capabilities where the IP address of the COP will be 192.168.1.42. All teams will be provided an IP address to be used during the competition. The last octet of the IP address is significant, as it will also be used as the subsystem identifier in the team's JAUS ID. The port number for all JAUS traffic shall be 3794.

JAUS Specific Data

The JAUS ID mentioned above is a critical piece of data used by a JAUS node to route messages to the correct process or attached device. As indicated above each team will be provided an IP address in which the last octet will be used in their respective JAUS ID. A JAUS ID consists of three elements, a Subsystem ID, a Node ID and a Component ID. The Subsystem ID uniquely identifies a major element that is an unmanned system, an unmanned system controller or some other entity on a network with unmanned systems. A Node ID is unique within a subsystem and identifies a processing element on

which JAUS Components can be found. A Component ID is unique within a Node represents an end-point to and from which JAUS messages are sent and received.

The last octet of the assigned IP address will be used as the team's JAUS Subsystem ID. So for the team assigned the IP address of 192.168.1.155, the completed JAUS ID of the position-reporting component might be 155-1-1 where the node and component are both assigned the IDs of 1. This is shown in Figure 1 below. The Node ID and Component ID are discussed further in the JAUS Service Interface Definition Language standard (AS5684). The COP software will be programmed with the assumption that all services required by the specific competition are implemented on a single component.

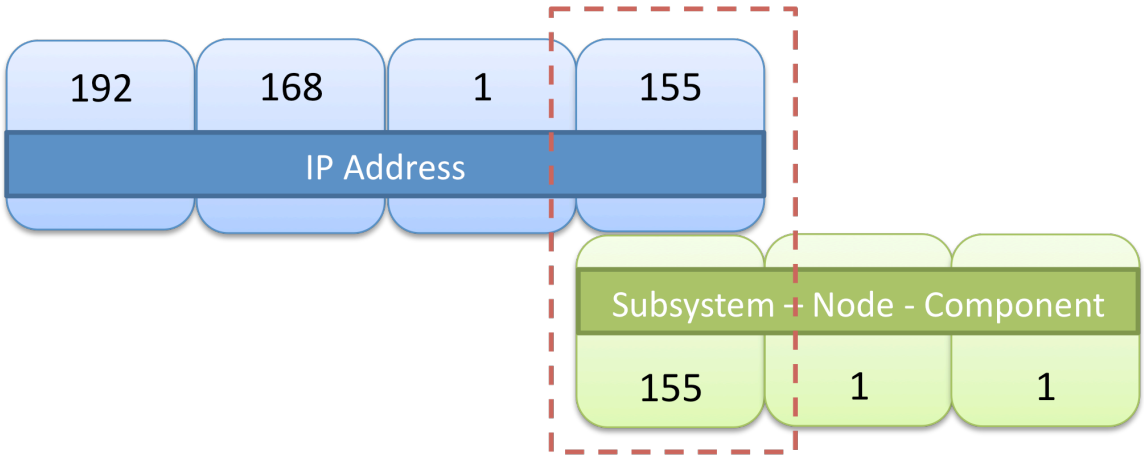

Figure 1, IP and JAUS ID Assignment

In summary, each team will be assigned an IP address by the judges. The last octet of that IP address will be the team's subsystem identifier. The COP will be a subsystem as will each team's entry in the competition. The COP will have a JAUS ID of 42:1:1 and an IP address of 192.168.1.42. The port number shall be 3794.

Competition Task Descriptions

Messages passed between the COP and the team entries will include data as described in the task descriptions below. The COP will initiate all requests subsequent to the discovery process described as Task 1. A system management component is required of all teams. This interface will implement several of the messages defined by the Management Service defined in the JSS-Core. This service inherits the Access Control, Events and Transport services also defined by the JSS-Core document. The implementation of the Access Control interfaces will be necessary to meet the JAUS Challenge requirements; however no messages from the Events service will be exercised. The sequence diagram in Figure 2 shows the required transactions for

discovery including the access control setup and system control protocol. This interaction is required for every task.

The judges will evaluate each team's ability to meet the Interoperability Challenge for the tasks described below in accordance with the scoring chart.

Task	IGVC	IARC	ASV	AUV	Value
(1) Transport Discovery	✓	✓	✓	✓	10
(2) Capabilities Discovery	✓	✓	✓	✓	10
(3) System Management	✓	✓	✓	✓	10
(4) Velocity State Report	✓	✓	✓	✓	10
(5) Position & Orientation Report	✓	✓	✓	✓	10
(6) Waypoint Navigation	✓		✓		10
Max Attainable Score	60	50	60	50	60

Table 1, Scoring Chart

Transport Discovery

For any two elements in the system to communicate meaningful data there must first be a handshake to ensure both sides use the same protocols and are willing participants in the interaction. For the sake of simplicity, the team's entry shall initiate the discovery protocol with the Judge's COP, and the IP address and JAUS ID of the COP shall be fixed. The IP address and JAUS ID of the Judge's COP are defined as:

COP IP ADDRESS: 192.168.1.42:3794

COP JAUS ID: 42-1-1 (Subsystem-Node-Component)

For the competitions, the discovery process, shown in Figure 2, will occur at the application layer. The student team's JAUS element will send a request for identification to the COP once every 5 seconds. The COP will respond with the appropriate informative message and request identification in return from the team's JAUS interface. After the identification report from the COP, the team entry will stop repeating the request. This transaction will serve as the basic discovery between the two elements.

The COP software will be programmed with the assumption that all services required by the specific competition are provided at the single JAUS ID. Furthermore, as per the AS5669A Specification, the team's entry shall receive JUDP traffic at the same IP address and port number that initiated the discovery protocol. Teams should note that this is different from common UDP programming approaches in which the outbound port for sent messages is not bound.

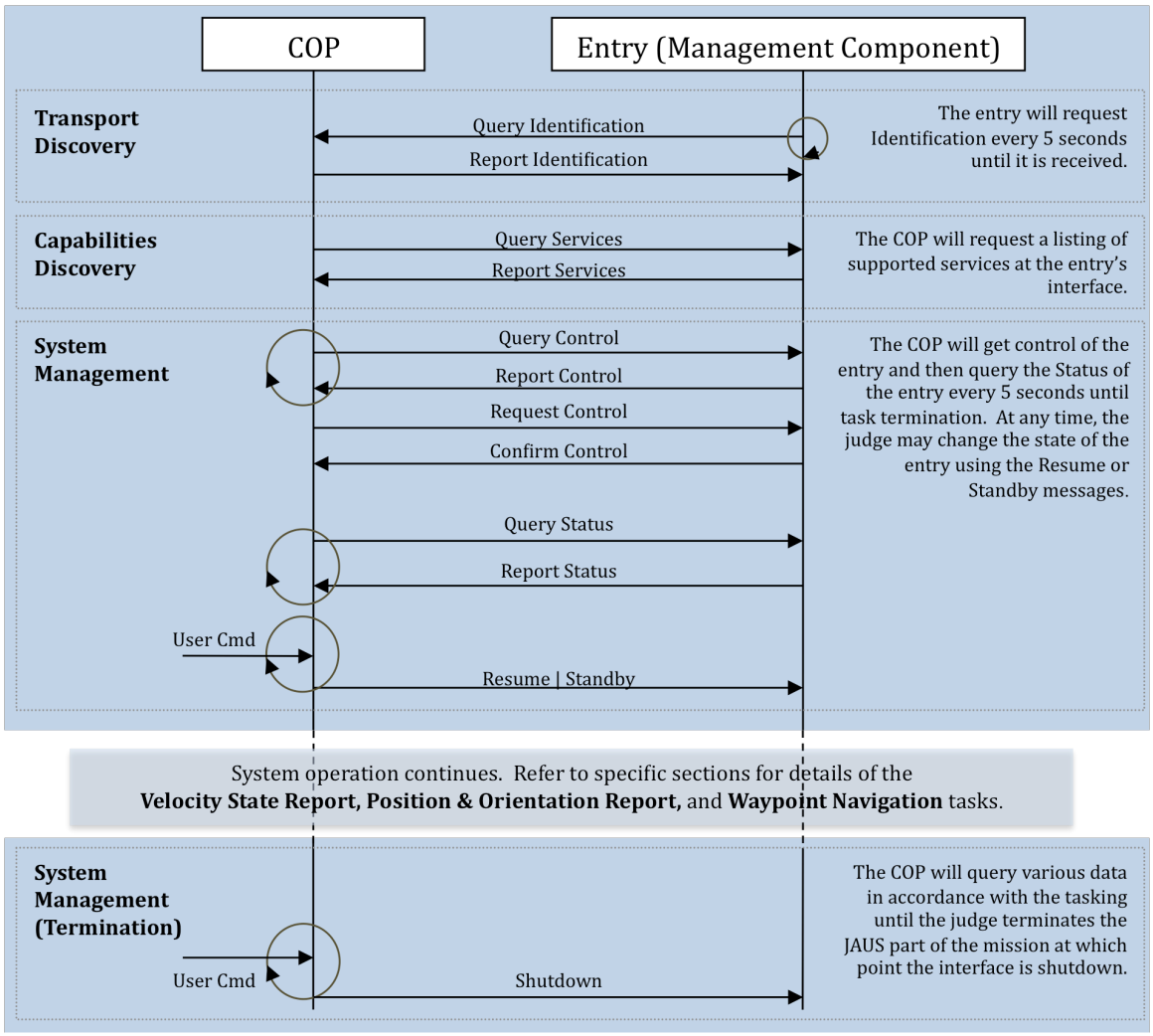

Figure 2, Discovery and System Management

The following table shows the messages sent from the COP to the team's entry, along with the expected response and minimal required fields to be set using the presence vector (PV) if applicable, required to complete this portion of the challenge:

Input Messages	Expected Response	Required Fields (PV)
Query Identification	Report Identification	N/A

Capabilities Discovery

Following the completion of the Transport Discovery handshake the COP will query the entry for its capabilities. The Query Services message and Report Services message are defined in the AS5710 document and require the inheritance of the Transport service. The COP will send a Query Services message to a student team entry. Upon receipt of

the message the student team entry shall respond with a properly formed Report Services message.

The following table shows the messages sent from the COP to the team's entry, along with the expected response and minimal required fields to be set using the presence vector (PV) if applicable, required to complete this portion of the challenge:

Input Messages	Expected Response	Required Fields (PV)
Query Services	Report Services	N/A

System Management

All competitions require the implementation of the status report. This interoperability task, like the discovery tasks above, is also a prerequisite for all other tasks. The task begins with the discovery handshake as described above and continues for an indeterminate period of time. The protocol is given in Figure 2.

The following table shows the messages sent from the COP to the team's entry, along with the expected response and minimal required fields to be set using the presence vector (PV) if applicable, required to complete this portion of the challenge:

Input Messages	Expected Response	Required Fields (PV)
Query Control	Report Control	N/A
Request Control	Confirm Control	N/A
Query Status	Report Status	N/A
Resume	<none>	N/A
Standby	<none>	N/A
Shutdown	<none>	N/A

Velocity State Report

In the Velocity State Report task the COP will query the entry for its current velocity state. The COP will send a Query Velocity State message to a student team entry. Upon receipt of the message the student team entry shall respond with a properly formed Report Velocity State message.

The following table shows the messages sent from the COP to the team's entry, along with the expected response and minimal required fields to be set using the presence vector (PV) if applicable, required to complete this portion of the challenge:

Input Messages	Expected Response	Required Fields (PV)
Query Velocity State	Report Velocity State	Velocity X, Yaw Rate & Time Stamp [320 Decimal, 0140h]

Position & Orientation Report

For those systems performing the task Position & Orientation Report for their respective competition, the discovery and status protocols described above are also required. In addition to the COP queries for status, the vehicle systems will also be required to respond correctly to local position queries. The reports will be validated for relative position and with respect to a relative time offset to ensure the time contained within each position report is valid with respect to some timer within the entry's system. In other words, the position reports must show that the travel occurred at a reasonable speed and not instantaneously. Additional variation in the position reporting using the available presence vectors is allowed. Minimally, IGVC and ASV entries must report X, Y and Time Stamp, while IARC and AUV entries must report Yaw and the Time Stamp.

The following table shows the messages sent from the COP to the team's entry, along with the expected response and minimal required fields to be set using the presence vector (PV) if applicable, required to complete this portion of the challenge:

Input Messages	Expected Response	Required Fields (PV)
Set Local Pose	<none>	X, Y & Yaw [67 Decimal, 0043h]
Query Local Pose	Report Local Pose	X, Y & Time Stamp (IGVC, ASV) [259 Decimal, 0103h] Yaw & Time Stamp (IARC, AUV) [320 Decimal, 0140h]

Waypoint Navigation

The team entry shall implement the Local Waypoint List Driver service from the JAUS Mobility Service Set (AS6009). From a starting point in the JAUS challenge test area the student entry will be commanded to traverse, in order, a series of 4 waypoints. Time will be kept and will start at the moment that the student entry exits the designated start box. Upon leaving the start box the student entry will proceed to the first waypoint in the list. Upon satisfactorily achieving each waypoint the team will be credited with 2.5 points. Time is kept for each waypoint achieved. The shortest overall time taken to achieve this task will determine the winner in the event of a tie.

The following table shows the messages sent from the COP to the team's entry, along with the expected response and minimal required fields to be set using the presence vector (PV) if applicable, required to complete this portion of the challenge:

Input Messages	Expected Response	Required Fields (PV)
Set Element	Confirm Element Request	N/A
Query Element List	Report Element List	N/A
Query Element Count	Report Element Count	N/A
Execute List	<none>	Speed (value of 1)
Query Active Element	Report Active Element	N/A
Query Travel Speed	Report Travel Speed	N/A
Query Local Waypoint	Report Local Waypoint	X & Y (value of 3)

Document Summary

The requirements put forth in this document specify only the communications protocol for student team vehicles to provide position and status information to the Judge's monitoring station. Additionally, the required use of the JAUS standards is intentionally limited due to the time and budget constraints on the student teams. However, successful implementation of the requirements herein will provide an excellent background for application of the standard.

The messaging protocols described above are intended to provide a Common Operating Picture (COP) on a Judge's monitor station that depicts each Entry's tracks as it moves through the competition area. Successful implementation of the JAUS element of the competition is the correct and accurate reporting of position and status described.

AUVSI Student Competition JAUS Requirements Document History			
Version	1.0	**Date**	November 2, 2009
Change Notes	Initial release of 2010 update. Changes from 2009 document include graduated scoring approach, clarification on which competitions require specific services and the inclusion of services discovery. Other changes are the result of modifying the scoring approach and introducing message tables with variable field descriptions.		
Version		**Date**	
Version		**Date**	
Version		**Date**	

References
SAE AS5710 SAE AS5669A SAE AS6009