



AEROSPACE STANDARD

AS6009™**REV. A**

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Superseding AS6009

J AUS Mobility Service Set

RATIONALE

The rationale for this revision was that the notion of Mobility needed to be extended to include maritime vehicles and it needed to be synchronized with changes in the JAUS Core Service Set. The List manager Service was promoted to the Core; consequently, it was deleted from this document. Global and Local Pose have been updated to support additional altitude types. Depth has been added to several services to support unmanned undersea vehicles (UUVs). The following services have been added: Navigation State Service, Global Loiter Driver Service, Local Loiter Driver Service, Global Operating Zone Service, Local Operating Zone Service, GPS Fix Service, and an Inertial Sensor Control Service.

AS6009A has been reaffirmed to comply with the SAE Five-Year Review policy.

INTRODUCTION

The primary goal of the JAUS Mobility Service Set is logical interoperability between communicating elements in an unmanned system. To this end, each service defines the messages (vocabulary) and protocol (rules) for data exchange. This logical interoperability is independent of the physical transport, and it is expected that a Transport Standard, such as the JAUS Transport Specification [AS5669A], is used in conjunction with this specification.

Each service in the JAUS Mobility Service Set is described using the JAUS Service Interface Definition Language [JSIDL]. JSIDL creates a formal schema based on Relax NG Compact [rng] that allows for validation of each service definition described herein. Although knowledge of JSIDL is not required to understand or implement this Specification, it is highly recommended for supporting context. For convenience, the JAUS Mobility Service Set contains both a text based and XML based representation for each service.

This document uses a number of conventions to simplify the text. All names are given in Camel Case. Names start with upper case, while reference names start with a lower case.

The tables and diagrams in this document are hand-transcribed from the JSIDL XML specification in the Appendixes. In case of transcription errors, the XML specification should be considered correct.

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1. SCOPE

This document defines a set of standard application layer interfaces called *JAUS Mobility Services*. JAUS Services provide the means for software entities in an unmanned system or system of unmanned systems to communicate and coordinate their activities. The Mobility Services represent the vehicle platform-independent capabilities commonly found across all domains and types of unmanned systems (referred to as UxVs). At present, over 15 services are defined in this document many of which were updated in this revision to support Unmanned Underwater Vehicles (UUVs). Some examples include:

- Pose Sensors: Determine the instantaneous position and orientation of a platform in global or local coordinates
- Velocity State Sensor: Determines the instantaneous velocity of a platform
- Acceleration State Sensor: Determines the instantaneous acceleration of a platform
- Primitive Driver: Performs basic mobility for a platform based on force/torque efforts
- Vector Drivers: Perform closed loop mobility for straight line travel
- Velocity State Driver: Similar to vector drivers, but with additional degrees of freedom
- Waypoint Drivers: Perform closed loop mobility to a location specified
- Waypoint List Drivers: Performs closed loop mobility using a series of locations
- Path Segment Drivers: Performs closed loop mobility along a specified path
- Navigation State: Provides a consolidated and synchronized report of the position, orientation, velocity and acceleration of the vehicle
- Operating Zone Services: Enables setting the vehicle operating areas and keep-out areas in global or local coordinates
- Loiter Drivers: Performs closed-loop traversal of a definable loiter pattern centered on either a global or local coordinate
- GPS Fix: Monitors the status of the GPS signal and controls the acquisition of a GPS position fix
- Inertial Sensor Control: Controls and reports the operational state of the vehicle's inertial sensor unit

Each service is described by a JAUS Service Definition (JSD) which specifies the message set and protocol required for compliance. Each JSD is fully compliant with the JAUS Service Interface Definition Language [[JSIDL](#)].

1.1 Purpose

The purpose of this document is to facilitate interoperation of unmanned vehicle systems, subsystems, and payloads by standardization of the message set and associated protocol.

1.2 JAUS Core Service Set

The JAUS Service Definitions defined herein make use of the inheritance functionality provided by JSIDL to incorporate capabilities as specified by the JAUS Core Service Set (AS5710A). These documents must be used together to define a complete service. It is important to note that details related to 'Message Serialization' and 'Understanding Protocol Descriptions' can be found in the JAUS Core Service Set document, and are not repeated here.

1.3 Compliance

The JAUS Mobility Service Set must support compliance assessment. To do so, this specification must be sufficiently precise to enable the “compliant”/“not compliant” distinction to be made independently of the underlying transport mechanism. An implementation is considered compliant to a Service Definition if it provides the complete vocabulary and protocol as defined within this Specification; it is not necessary that a single entity realize every Service to be considered compliant.

1.4 Document Organization

The layout of this document is as follows. [Section 2](#) lists external references used throughout the specification. [Section 3](#) specifies common conventions and definitions. [Section 4](#) specifies the JAUS Service Definition for each of the mobility services, with particular emphasis on the description, assumptions, message set, and protocol behavior. [Section 5](#) describes the message encoding for each message set. Finally, [Appendix A](#) and [Appendix B](#) contain the complete JSIDL representation for each service and their associated message set.

The tables and diagrams in this document are hand-transcribed from the JSIDL XML specification in the Appendices. In case of transcription errors, the XML specification should be considered correct.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AIR5665 Architecture Framework for Unmanned Systems,

AS5669 JAUS/SDP Transport Specification

AS5684 JAUS Service Interface Definition Language

AS5710 JAUS Core Service Set

2.1.2 Other Publications

[att] Decimal Expansion of PI [<http://www.research.att.com/~njas/sequences/A000796>]

[rng] Relax NG: [<http://www.oasis-open.org/committees/relax-ng/spec-20011203.html>] Standard lightweight XML schema language.

[nasa] Gracey, William (1980), "Measurement of Aircraft Speed and Altitude", NASA Reference Publication 1046.

[ngdc] Magnetic Field Calculator [<http://www.ngdc.noaa.gov/geomagmodels/IGRFWMM.jsp>]

POSIX.1-2008 POSIX.1-2008 is simultaneously IEEE Std 1003.1™-2008 and The Open Group Technical Standard Base Specifications, Issue 7

[st] Ball, Robert Stawell (1876), "The Theory of Screws: A Study in the Dynamics of a Rigid Body,"Hodges, Foster & Co., Dublin.

2.2 List of Acronyms

AGL Above Ground Level

ASF Above Sea Floor

Ext Extended

ID Identifier

IEEE Institute of Electrical and Electronics Engineers

IMU Inertial Measurement Unit

INU Inertial Navigation Unit

JAUS Joint Architecture for Unmanned Systems

JSD	J AUS Service Definition
JSIDL	J AUS Service (Interface) Definition Language
MSL	Mean Sea Level
OP	Operating
POSIX	Portable Operating System Interface
SOG	Speed Over Ground
SRM	Speed Relative to Medium (air, water, surface, ground)
UID	Unique Identifier
URN	Uniform Resource Name
UxV	Unmanned (Undersea, Surface, Ground, Aerial) Vehicle
WGS84	World Geodetic System 1984
XML	Extensible Markup Language
UTC	Coordinated Universal Time

2.3 Definitions

Altitude AGL: Altitude above ground level or above instantaneous sea level.

Altitude ASF: Altitude above the sea floor.

Altitude MSL: Altitude above mean sea level in accordance with WGS84.

Absolute Speed: The velocity of the platform relative to the global earth fixed coordinate system.

Clockwise: Right hand sense about a down vector (when referring to movement within a coordinate system).

Course: The horizontal direction, clockwise from north, in which the platform's velocity vector is pointing.

Deprecated: Deprecated messages are slated for deletion in a future revision. They are being maintained for an unspecified period of time to provide backwards compatibility and to enable existing systems to transition to the new messages. Each deprecated message is being replaced with a new message indicated by appending "Ext" to the message name. Note that server-side implementations must support all messages, including deprecated and extended, defined by the service, but it is recommended that client systems that use these revised services use only the new (Extended) messages.

Depth: Depth beneath the sea surface, increasing depth is an increasing positive number.

Heading: The horizontal direction, clockwise from north, in which the platform's forward axis is pointing.

Indicated Speed: Raw indication of an uncorrected speed indicator with no presumption as to whether it is Relative to Medium or Over Ground [nasa]

Speed Over Ground: Synonym for Absolute Speed.

Speed Relative to Medium: Velocity of the platform relative to the medium in which it is traveling. E.g., air, water, surface, or ground.

UTC POSIX-style time: Like POSIX, this is a 32-bit integer that represents the time in seconds since the “epoch” (1 January 1970; however, it differs from POSIX in that (a) it does not require or presume that POSIX is literally used and (b) it is an unsigned int, making all 32 bits available to represent time since the epoch. The motivation for this is to extend the usable lifetime of the representation from 2038 to 2106.

UxV: Unmanned Vehicle without regard to a specific domain of operation, where x could represent air, ground, maritime surface or maritime undersea.

Yaw¹: Synonym for Heading.

ZPOSITION: An indexed Field that allows the semantics of the value of the Z-axis data to be one of the following: Altitude AGL, Altitude ASF, Altitude MSL, Depth, or Z in the Local coordinate system.

¹ The term ‘yaw’ is also used in nautical domains to indicate deviation from a desired heading. Here the term ‘yaw’ is borrowed from aeronautical conventions to mean rotation about the vertical axis.

3. COMMON CONVENTIONS

3.1 Platform orientation

In the following Service Definitions, the parameters Ψ (yaw), θ (pitch), and ϕ (roll) define the orientation of the mobile platform. The term 'yaw' is also used in nautical domains to indicate deviation from a desired heading. Here the term 'yaw' is borrowed from aeronautical conventions to mean rotation about the vertical axis.

This definition is illustrated in Figure 1 where an XYZ coordinate system has been attached to the vehicle with its X axis pointed forward and its Z axis downward.

Global platform orientation is defined by initially aligning the X axis of the platform in a (true) northerly direction and the Z axis along the gravity vector as shown in Figure 1 (a) and following this exact yaw, pitch, roll sequence. The platform is first rotated by an yaw angle Ψ in a right-handed sense about the Z axis as shown in Figure 1 (b). Subsequently the platform is rotated by an pitch angle θ about the new Y axis as shown in Figure 1 (c) followed by a roll rotation of ϕ about the new X axis as shown in Figure 1 (d). Local platform orientation is defined in a similar manner by initially aligning the platform coordinate system with the local coordinate system and then rotating it in the same sequence as defined for the global platform orientation.

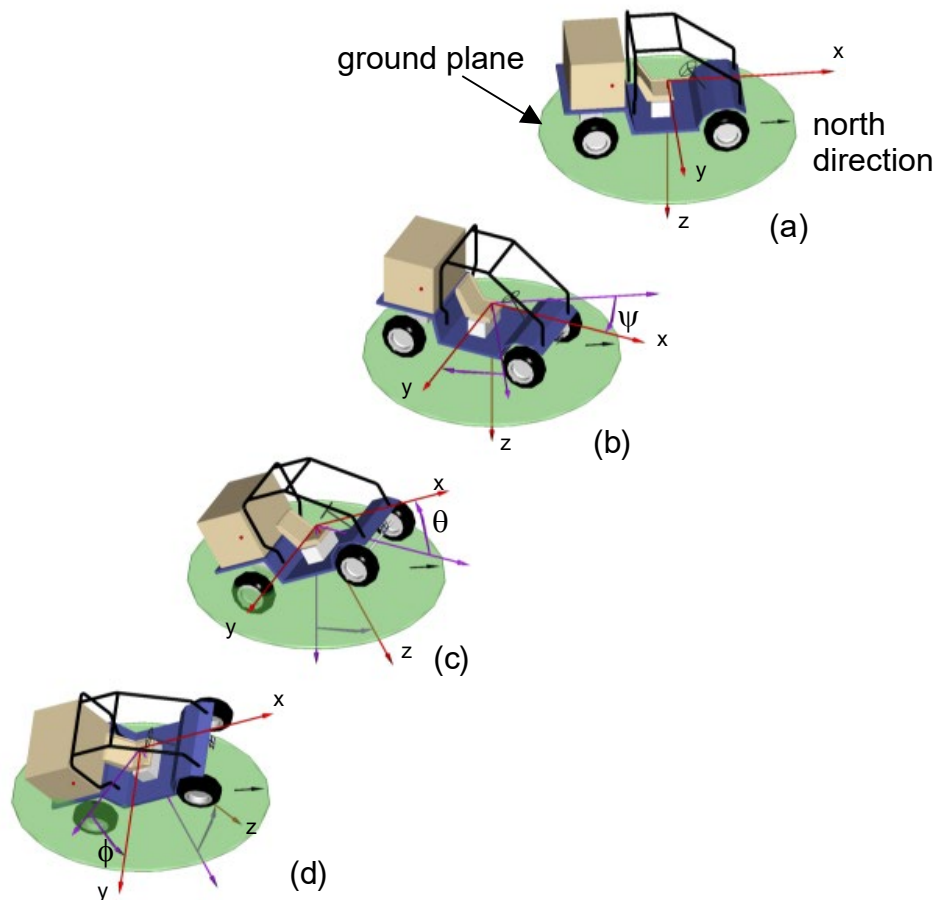


Figure 1 - Definition of platform orientation

3.2 Waypoint Tolerance

A waypoint is a position measured with respect to a known frame of reference. The waypoint has zero size, implying that the measurement is infinitely accurate. It is impossible for any physical system to know its location with such an unlimited degree of precision.

The concept of waypoint tolerance, or “close enough” distance, is used to denote the level of precision required for an unmanned system to be considered coincident with a specified waypoint. When the position of the unmanned system is within a sphere centered on the waypoint with a radius equal to the tolerance, the waypoint can be considered “satisfied” or “achieved.” Small tolerances will improve absolute positioning of the system, but may induce unnecessary “hunting” as the unmanned system makes progressively smaller or circular motions in an attempt to satisfy the tolerance.

Note that the resolution of the requested waypoint tolerance may not be attainable. For example, if an unmanned system uses a positioning system that is only accurate to within a few meters, a sub-meter waypoint tolerance is unachievable.

3.3 Path Tolerance (Travel Corridor)

Path error is defined as the smallest distance between the current position of an unmanned system and its desired path. Path tolerance defines the maximum amount of error permitted before the system enters a failure state, and can be used to describe a permitted travel corridor for the unmanned system.

For the path segment driver services described in 4.12 and 4.13, the desired path of the unmanned system is explicit. For the various waypoint drivers, however, only the start and end points are defined. In these cases, the desired path is taken to be the straight line connecting the start and end points. This results in a permitted travel corridor that is “pill shaped”, or a cylinder with a semi-sphere cap on each end as shown in [Figure 2](#). The radius of the cylinder and semi-spheres is equal to the path tolerance.

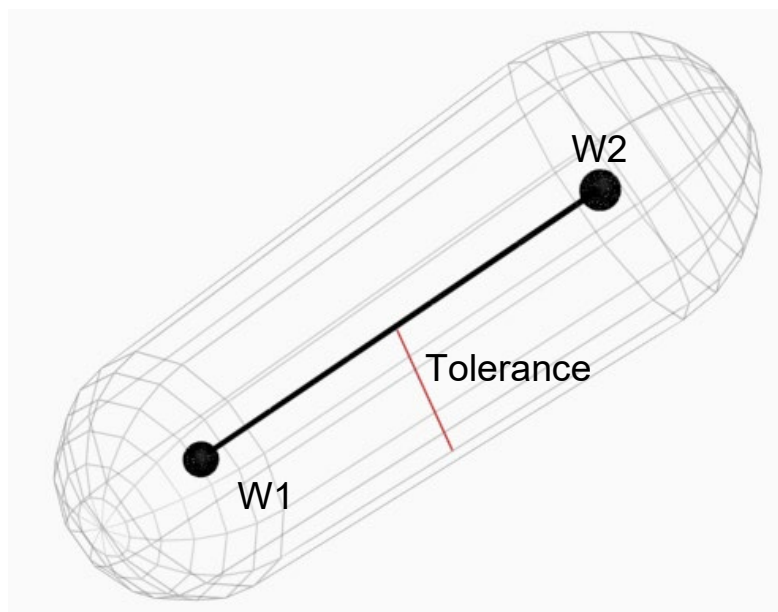


Figure 2 - Permitted travel corridor between waypoints

3.4 Constant values

In the context of this Standard, PI is defined as 3.14159265358979323846 [att].

3.5 Safe Motion on Exit from Ready State

All of the driver services contained herein inherit from the Management Service published in AS5710A and define an exit action when leaving the Controlled::Ready state. As commanded motion of the platform is only allowed in the Ready state, this transition represents an exception from a normal operating state and requires the platform to transition to safe motion. However, the actual behavior of the safe motion condition is not defined within the document, as it may be highly dependent on the domain, the vehicle capabilities, and the mission. For example, the behavior for a small ground vehicle may simply be to stop motion, while a larger ground vehicle may require both stopping and applying the parking brake. On the other hand, a surface or air vehicle capable of hovering might actively apply thruster or engines to actively maintain a fixed global position while combating effects of current and wind. Fixed wing aircraft might loiter in a circle around a global position where the transition occurred. These examples are notional only and intended for clarity; the exact behavior of any particular implementation is not defined by the Standard.

4. SERVICE DEFINITIONS

The following subsections provide a textual definition for each Service Definition in the JAUS Mobility Service Set. Corresponding JSIDL definitions are offered in the Appendix A. Additional information on interpreting the service definition elements may be found in [\[JSIDL\]](#).

4.1 Global Pose Sensor Service

name=GlobalPoseSensor
version=1.1
id= urn:jaus:jss:mobility:GlobalPoseSensor

Inherits-from AccessControl
name=accessControl
id= urn:jaus:jss:core: AccessControl
version=1.1

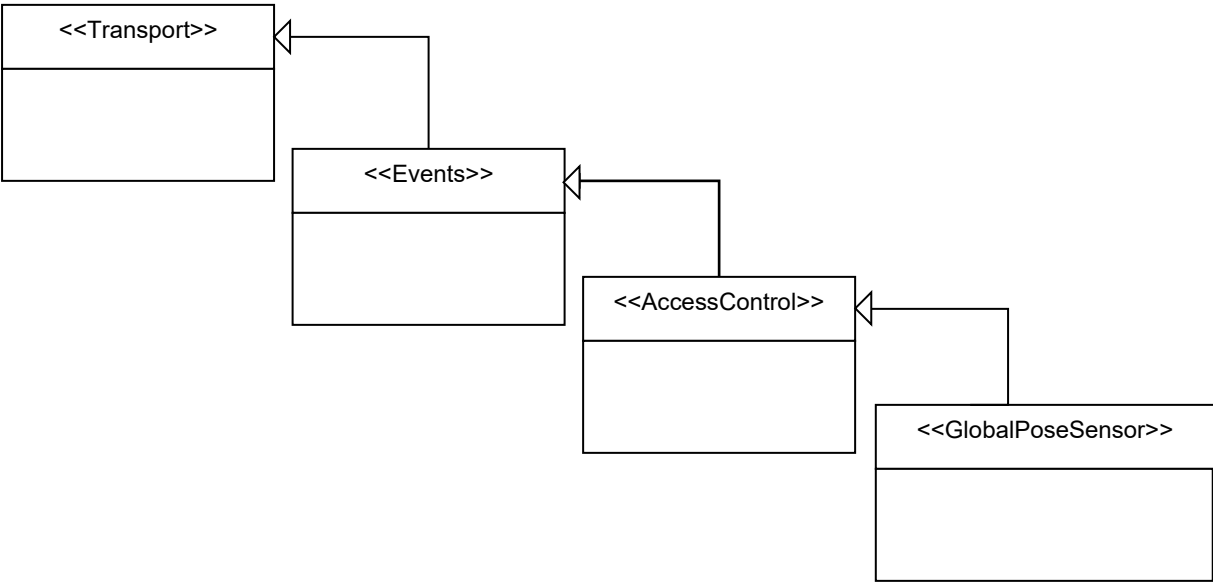


Figure 3 - Global pose sensor service

Description

The function of the Global Pose Sensor is to report the global position and orientation of the platform. The Report Global Pose message provides the position and orientation of the platform. The Set Global Pose message provides the ability for clients to initialize/update the current vehicle position for systems that only have a dead reckoning capability. The position of the platform is given in latitude, longitude, and potentially altitude and/or depth. Platform orientation is as defined in Section 3 of this document.

Assumptions

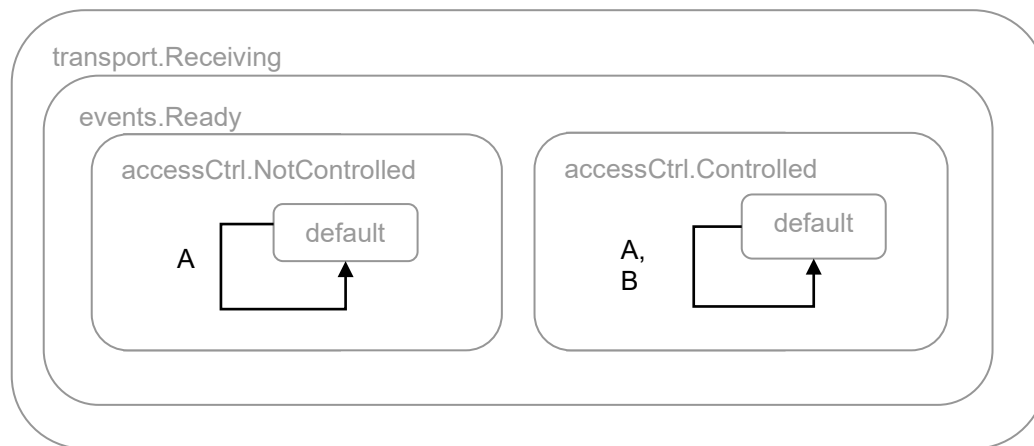
Messages may be delayed, lost or reordered.

Vocabulary

The table below lists the vocabulary of the Global Pose Sensor Service.

Table 1 - Global pose sensor service vocabulary

Message Id (hex)	Name	isCommand?
Input Set		
0402	SetGlobalPose (Deprecated)	True
04A2	SetGlobalPoseExt	True
0412	SetGeomagneticProperty	True
2402	QueryGlobalPose(Deprecated)	False
24A2	QueryGlobalPoseExt	False
2412	QueryGeomagneticProperty	False
Output Set		
4402	ReportGlobalPose(Deprecated)	False
44A2	ReportGlobalPoseExt	False
4412	ReportGeomagneticProperty	False

Protocol Behavior**Figure 4 - Global pose sensor protocol behavior****Table 2 - Global pose sensor service state transition table**

Label	Trigger	Guard	Actions
A	QueryGlobalPose		sendReportGlobalPose
	QueryGlobalPoseExt		sendReportGlobalPoseExt
	QueryGeomagneticProperty		sendReportGeomagneticProperty
B	SetGlobalPose	<i>isControllingClient</i>	<i>updateGlobalPose</i>
	SetGlobalPoseExt	<i>isControllingClient</i>	<i>updateGlobalPoseExt</i>
	SetGeomagneticProperty	<i>isControllingClient</i>	<i>updateGeomagneticProperty</i>

Table 3 - Global pose sensor service state conditions table

Condition	Interpretation
<i>isControllingClient</i>	True if the message that triggered the transition is received from the client that is in control of this service.

Table 4 - Global pose sensor service transition actions

Action	Interpretation
sendReportGlobalPose	Send Report Global Pose message to the component that sent the query
sendReportGlobalPoseExt	Send Report Global PoseExt message to the component that sent the query
sendReportGeomagneticProperty	Send Report Geomagnetic Property message to the component that sent the query
<i>updateGlobalPose</i>	Update the global pose for the component
<i>updateGlobalPoseExt</i>	Update the global poseExt for the component
<i>updateGeomagneticProperty</i>	Update the location specific magnetic variation for adjusting GPS heading

4.2 Local Pose Sensor Service

name=LocalPoseSensor

version=1.1

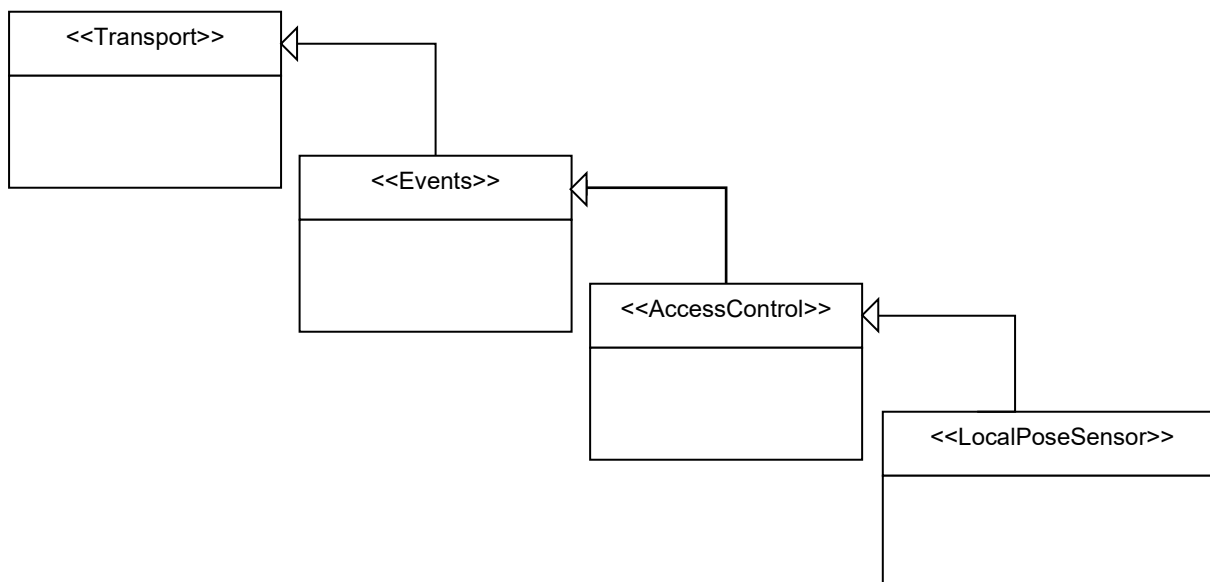
id= urn:jaus:jss:mobility:LocalPoseSensor

Inherits-from AccessControl

name=accessControl

id= urn:jaus:jss:core:AccessControl

version=1.1

**Figure 5 - Local pose sensor service**

Description

The function of the Local Pose Sensor is to report the local position and orientation of the platform. The Report Local Pose message provides the position and orientation of the platform relative to a local reference frame. A new origin of the local reference frame may be commanded using the Set Local Pose message, which sets the current position and orientation of the platform to the specified values. Platform orientation is defined in Section 3 of this document.

Assumptions

Messages may be delayed, lost or reordered.

Vocabulary

The table below lists the vocabulary of the Local Pose Sensor Service.

Table 5 - Local pose sensor service vocabulary

Message Id (hex)	Name	isCommand?
Input Set		
0403	SetLocalPose(Deprecated)	True
04A3	SetLocalPoseExt	True
2403	QueryLocalPose(Deprecated)	False
24A3	QueryLocalPoseExt	False
Output Set		
4403	ReportLocalPose(Deprecated)	False
44A3	ReportLocalPoseExt	False

Protocol Behavior

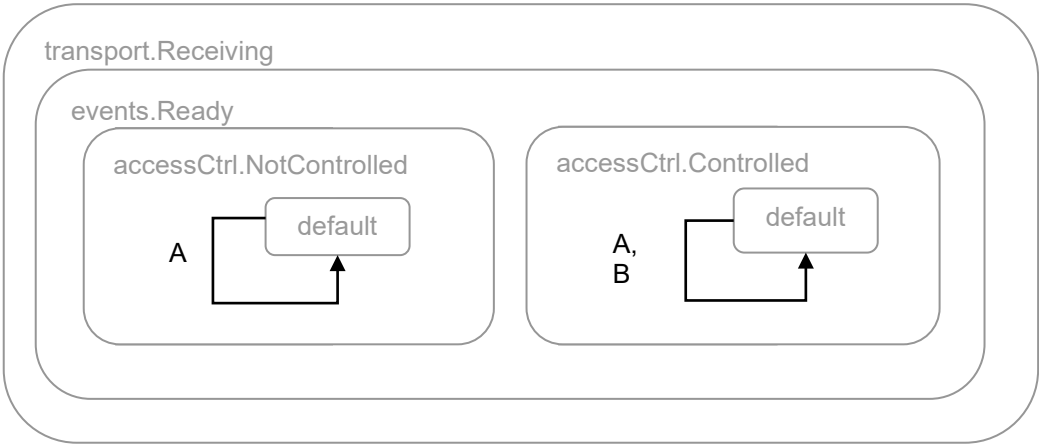


Figure 6 - Local pose sensor service protocol behavior

Table 6 - Local pose sensor service state transition table

Label	Trigger	Guard	Actions
A	QueryLocalPose		sendReportLocalPose
	QueryLocalPoseExt		sendReportLocalPoseExt
B	SetLocalPose	<i>isControllingClient</i>	<i>updateLocalPose</i>
	SetLocalPoseExt	<i>isControllingClient</i>	<i>updateLocalPoseExt</i>

Table 7 - Local pose sensor service state conditions table

Condition	Interpretation
<i>isControllingClient</i>	True if the message that triggered the transition is received from the client that is in control of this service.

Table 8 - Local pose sensor service transition actions

Action	Interpretation
sendReportLocalPose	Send Report Local Pose message to the component that sent the query
sendReportLocalPoseExt	Send Report Local PoseExt message to the component that sent the query
<i>updateLocalPose</i>	Update the local pose for the component
<i>updateLocalPoseExt</i>	Update the local poseExt for the component

4.3 Velocity State Sensor Service

name=VelocityStateSensor

version=1.1

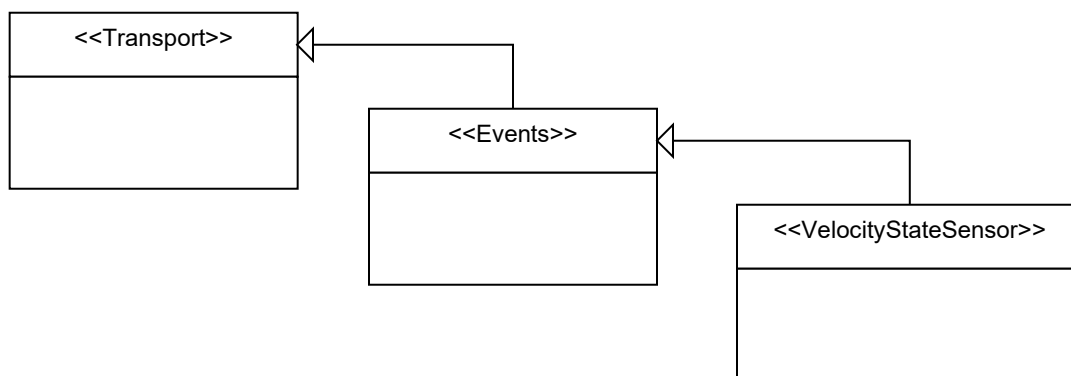
id= urn:jaus:jss:mobility:VelocityStateSensor

Inherits-from Events

name=events

id= urn:jaus:jss:core:Events

version=1.1

**Figure 7 - Velocity state sensor service**

Description

The Velocity State Sensor has the responsibility of reporting the instantaneous velocity of the platform. The velocity state of a rigid body is defined as the set of parameters that are necessary to calculate the velocity of any point in that rigid body. Six parameters are required to specify a velocity state of a rigid body in terms of some fixed reference coordinate system. The first three parameters represent the instantaneous linear velocity components of a point in the rigid body that is coincident with the origin of the fixed reference. The second three components represent the instantaneous angular velocity components. It is possible to represent the six velocity state parameters as a screw, about which the rigid body is rotating and translating along at that instant [st].

The reference frame for the velocity state sensor component is selected as a fixed coordinate system that at this instant is co-located with and aligned with the vehicle or system coordinate system. Thus the message data ‘velocity x’, ‘velocity y’, and ‘velocity z’ represents the current velocity of the subsystem’s control point at this instant. For example if ‘velocity x’ has a value of 3 m/sec and ‘velocity y’ and ‘velocity z’ are zero, then the vehicle is moving in the forward direction at a velocity of 3 m/sec. The message data ‘omega x’, ‘omega y’, and ‘omega z’ represent the actual rate of change of orientation or angular velocity of the vehicle about its coordinate axes.

Assumptions

Messages may be delayed, lost or reordered.

Vocabulary

The table below lists the vocabulary of the Velocity State Sensor Service.

Table 9 - Velocity state sensor service vocabulary

Message Id (hex)	Name	isCommand?
Input Set		
2404	QueryVelocityState(Deprecated)	False
24A4	QueryVelocityStateExt	False
Output Set		
4404	ReportVelocityState(Deprecated)	False
44A4	ReportVelocityStateExt	False

Protocol Behavior

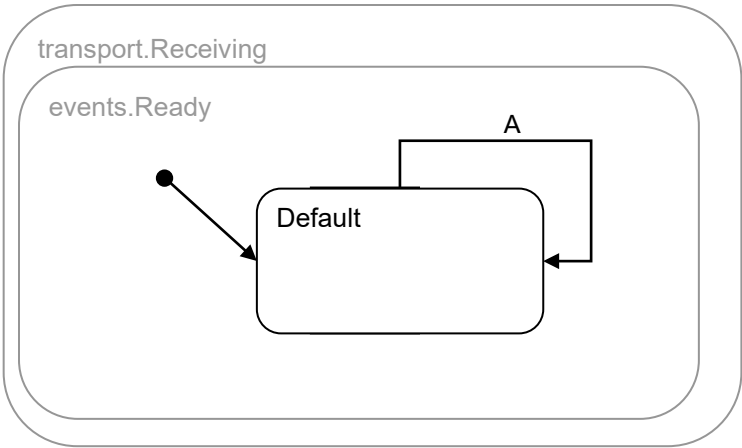


Figure 8 - Velocity state sensor service protocol behavior

Table 10 - Velocity state sensor service state transition table

Label	Trigger	Guard	Actions
A	QueryVelocityState		sendReportVelocityState
	QueryVelocityStateExt		sendReportVelocityStateExt

Table 11 - Velocity state sensor service transition actions

Action	Interpretation
sendReportVelocityState	Send Report Velocity State message to the component that sent the query
sendReportVelocityStateExt	Send Report Velocity StateExt message to the component that sent the query

4.4 Acceleration State Sensor Service

name=AccelerationStateSensor

version=1.1

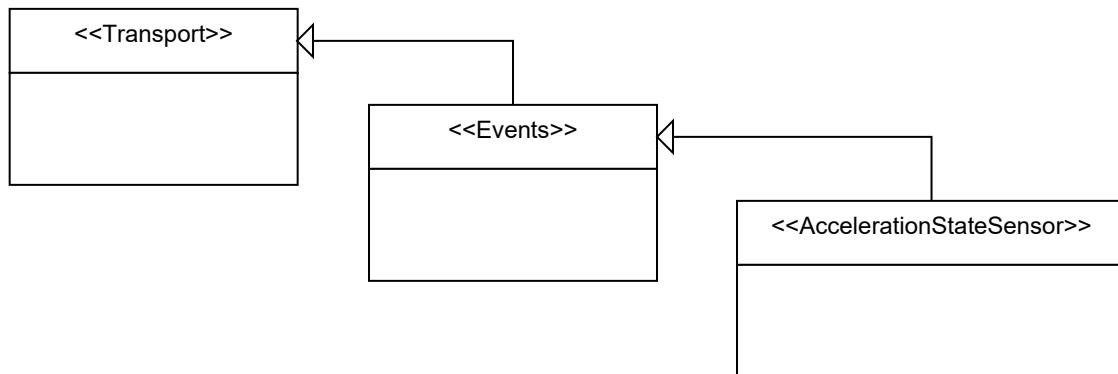
id= urn:jaus:jss:mobility:AccelerationStateSensor

Inherits-from Events

name=events

id= urn:jaus:jss:core:Events

version=1.1

**Figure 9 - Acceleration state sensor service**

Description

This service reports the acceleration state of the unmanned platform. The Acceleration State Sensor reports the acceleration state that is the first derivative (the rate of change) of the velocity state reported by the Velocity State Sensor. Refer to the description on Velocity State Sensor for coordinate details.

Assumptions

Messages may be delayed, lost or reordered.

Vocabulary

The table below lists the vocabulary of the Acceleration State Sensor Service.

Table 12 - Acceleration state sensor service vocabulary

Message Id (hex)	Name	isCommand?
Input Set		
2417	QueryAccelerationState(Deprecated)	False
24B7	QueryAccelerationStateExt	False
Output Set		
4417	ReportAccelerationState(Deprecated)	False
44B7	ReportAccelerationStateExt	False

Protocol Behavior

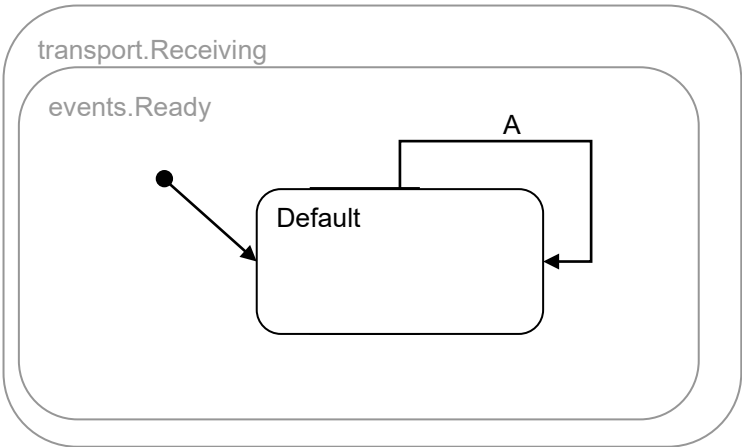


Figure 10 - Acceleration state sensor service protocol behavior

Table 13 - Acceleration state sensor service state transition table

Label	Trigger	Guard	Actions
A	QueryAccelerationState		sendReportAccelerationState
	QueryAccelerationStateExt		sendReportAccelerationStateExt

Table 14 - Acceleration state sensor service transition actions

Action	Interpretation
sendReportAccelerationState	Send Report Acceleration State message to the component that sent the query
sendReportAccelerationStateExt	Send Report Acceleration StateExt message to the component that sent the query

4.5 Primitive Driver Service

name=PrimitiveDriver
version=1.1
id= urn:jaus:jss:mobility:PrimitiveDriver

Inherits-from Management
name=management
id= urn:jaus:jss:core:Management
version=1.1

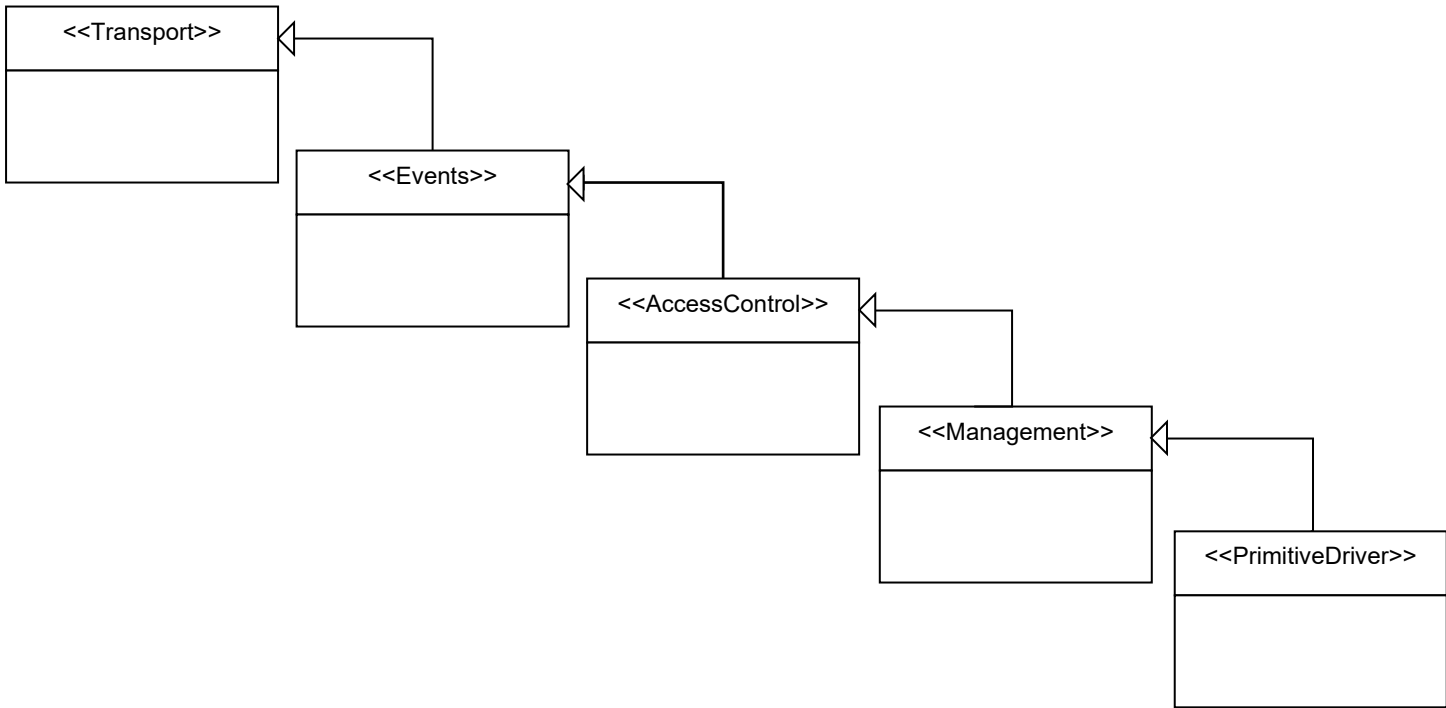


Figure 11 - Primitive driver service

Description

The Primitive Driver allows for basic platform mobility. This service does not imply any particular platform type such as tracked or wheeled, but describes mobility in six degrees of freedom using a percent of available effort in each direction. Additionally, no power plant (gasoline, diesel, or battery) is implied and the service functions strictly in an open loop manner, i.e., a velocity is not commanded or held since that requires a speed sensor. The service definition makes no assertion about the preventative actions that must be taken to avoid unintended consequences, such as rolling on an incline when given a zero propulsive and zero resistive effort. Note that the specific actuator commands are not defined by JAUS.

This service uses “effort” as a relative measure of the amount of drive power. This measure is intentionally kept agnostic of the underlying control system for portability across hardware types. As a result, the implementation of an “effort” driver may map the request to a percent of maximum current of an electric motor, fluid pressure of a hydraulic system, duty-cycle of a pulse-width modulated controller, or position of a control lever. These examples are meant to be illustrative; the actual mapping is not restricted by JAUS, so long as it can be expressed as a percent of some maximum.

Assumptions

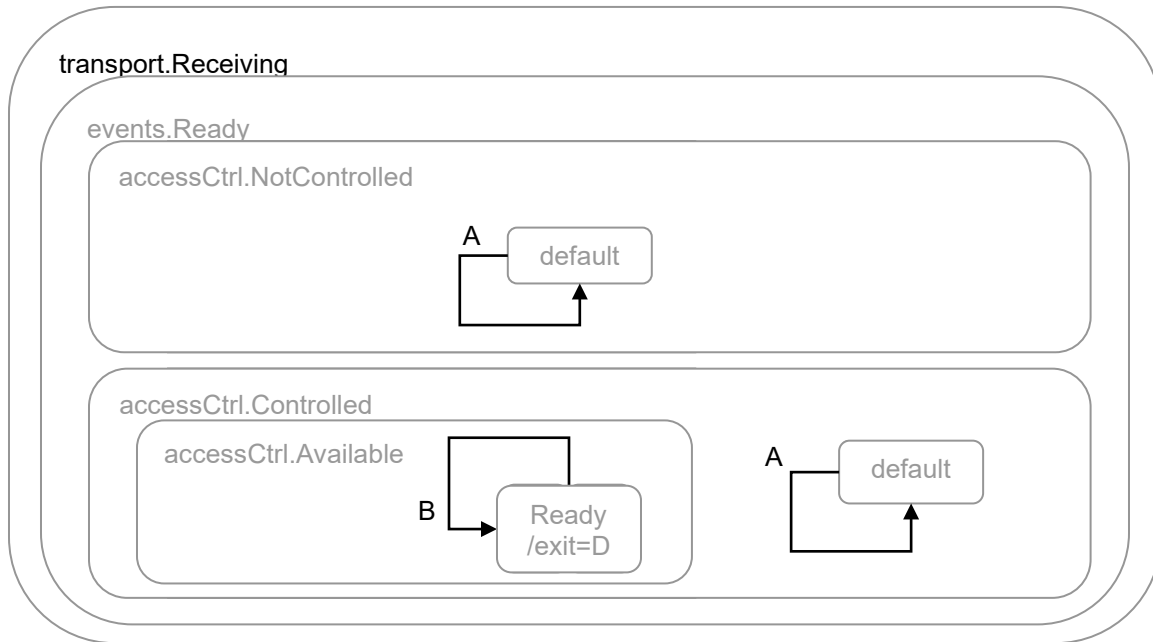
Messages may be delayed, lost or reordered.

Vocabulary

The table below lists the vocabulary of the Primitive Driver Service.

Table 15 - Primitive driver service vocabulary

Message Id (hex)	Name	isCommand?
Input Set		
0405	SetWrenchEffort	True
2405	QueryWrenchEffort	False
Output Set		
4405	ReportWrenchEffort	False

Protocol Behavior**Figure 12 - Primitive driver service protocol behavior****Table 16 - Primitive driver service entry/exit action table**

Label	State	Type	Guard	Actions
D	management.Ready	exit		<i>resetTravelSpeed</i>

Table 17 - Primitive driver service transition table

Label	Trigger	Guard	Actions
A	QueryWrenchEffort		sendReportWrenchEffort
B	SetWrenchEffort	<i>isControllingClient</i>	<i>setWrenchEffort</i>

Table 18 - Primitive driver service state conditions table

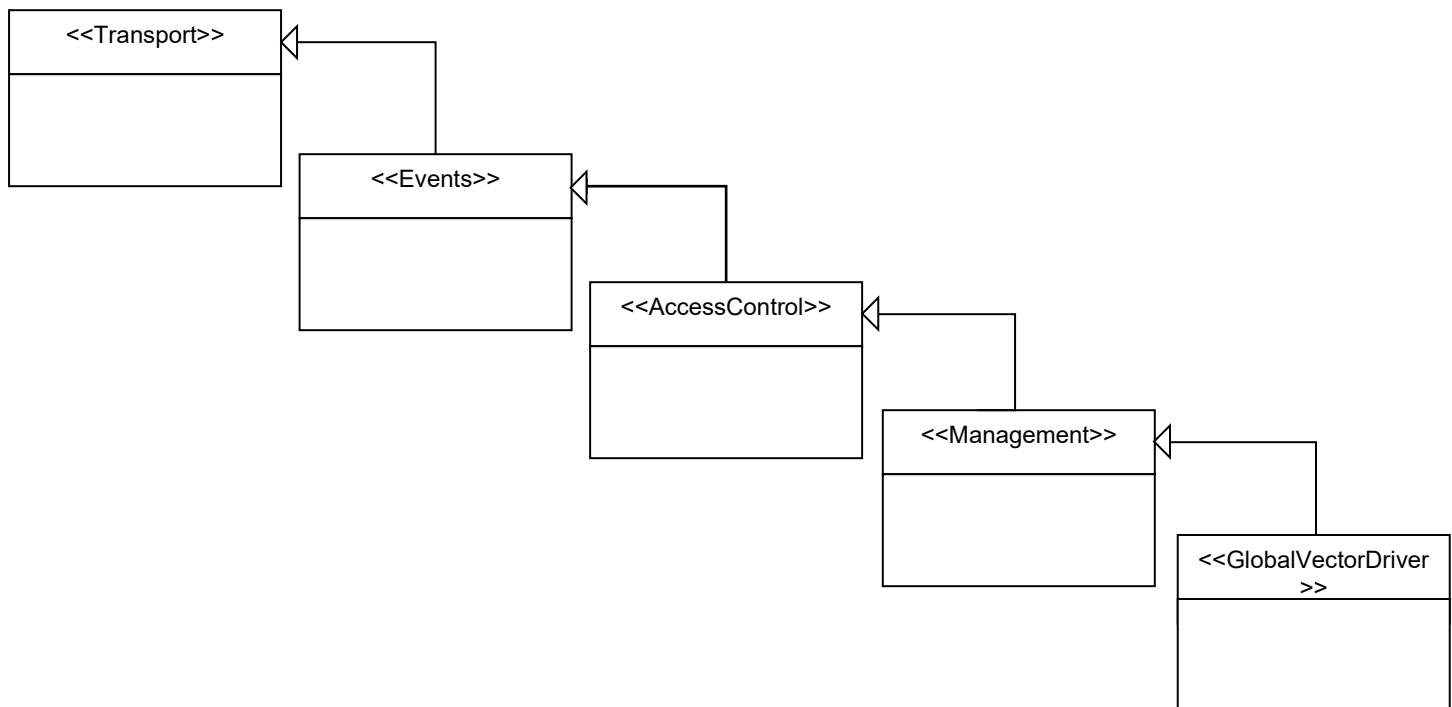
Condition	Interpretation
<i>isControllingClient</i>	True if the message that triggered the transition is received from the client that is in control of this service.

Table 19 - Primitive driver service transition actions

Action	Interpretation
<i>setWrenchEffort</i>	Set the wrench effort for the platform.
<i>sendReportWrenchEffort</i>	Send a Report Wrench Effort message
<i>resetTravelSpeed</i>	Safe motion of the platform, as described in 3.5

4.6 Global Vector Driver Service

name=GlobalVectorDriver
 version=1.1
 id= urn:jaus:jss:mobility:GlobalVectorDriver
 Inherits-from Management
 name=management
 id= urn:jaus:jss:core:Management
 version=1.1

**Figure 13 - Global vector driver service**

Description

The function of the Global Vector Driver is to perform closed loop control of the desired global yaw, roll, pitch, altitude or depth, and the speed of a mobile platform. The Global Vector Driver takes the desired heading (yaw) of the platform as measured with respect to the global coordinate system and the desired speed of the platform. Note that the new Ext messages support different values for course and heading (yaw) for holonomic systems that allow such configurations. The desired Altitude, measured in accordance with the WGS 84 standard, provides a means through which systems capable of flight can be controlled. Vehicles also may be controlled by specifying the desired altitude with respect to Mean Sea Level. Submersible vehicles may be controlled by specifying the desired Depth or Altitude ASF. For ground-based systems, the Altitude field is optional. The speed of the vehicle can be expressed as either Speed over Ground or Speed Relative to Medium.

Assumptions

Messages may be delayed, lost or reordered.

Vocabulary

The table below lists the vocabulary of the Global Vector Driver Service.

Table 20 - Global vector driver service vocabulary

Message Id (hex)	Name	isCommand?
Input Set		
0407	Set GlobalVector(Deprecated)	True
04A7	SetGlobalVectorExt	True
2407	Query GlobalVector(Deprecated)	False
24A7	QueryGlobalVectorExt	False
Output Set		
4407	Report GlobalVector(Deprecated)	False
44A7	ReportGlobalVectorExt	False

Protocol Behavior

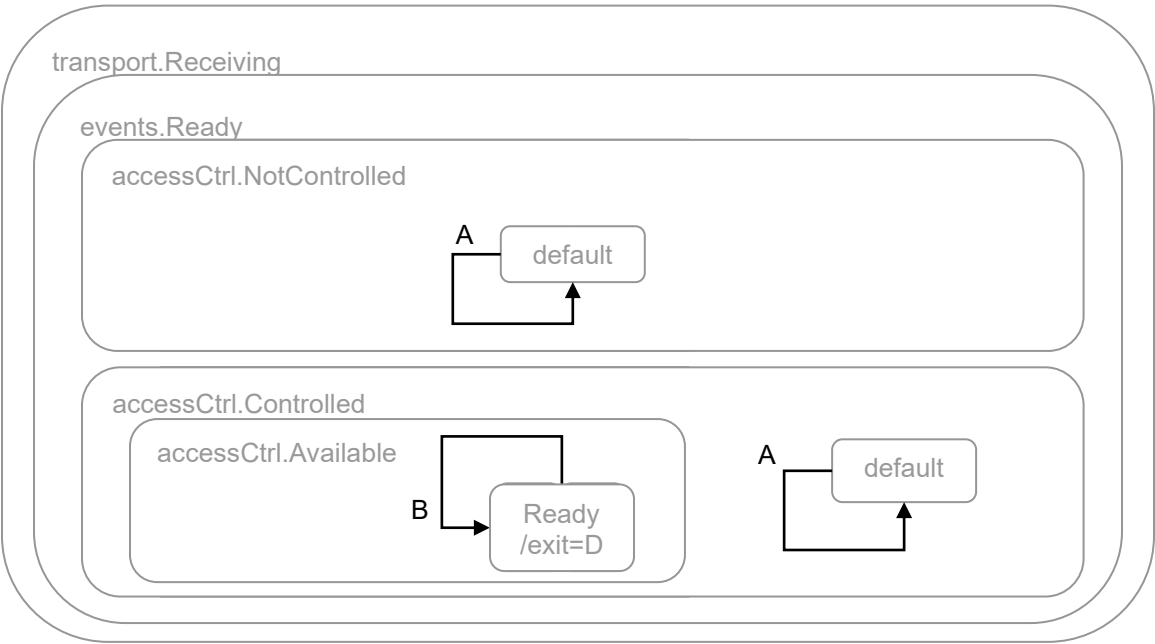


Figure 14 - Global vector driver service protocol behavior

Table 21 - Global vector driver service entry/exit action table

Label	State	Type	Guard	Actions
D	management.Ready	exit		<i>resetTravelSpeed</i>

Table 22 - Global vector driver service transition table

Label	Trigger	Guard	Actions
A	QueryGlobalVector		sendReportGlobalVector
	QueryGlobalVectorExt		sendReportGlobalVectorExt
B	SetGlobalVector	<i>isControllingClient</i>	<i>setGlobalVector</i>
	SetGlobalVectorExt	<i>isControllingClient</i>	<i>setGlobalVectorExt</i>

Table 23 - Global vector driver service state conditions table

Condition	Interpretation
<i>isControllingClient</i>	True if the message that triggered the transition is received from the client that is in control of this service.

Table 24 - Global vector driver service transition actions

Action	Interpretation
<i>setGlobalVector</i>	Set the global vector values for the platform.
<i>setGlobalVectorExt</i>	Set the global vectorExt values for the platform.
sendReportGlobalVector	Send a Report Global Vector message
sendReportGlobalVectorExt	Send a Report Global VectorExt message
<i>resetTravelSpeed</i>	Safe motion of the platform, as described in 3.5

4.7 Local Vector Driver Service

name=LocalVectorDriver

version=1.1

id= urn:jaus:jss:mobility:LocalVectorDriver

Inherits-from Management

name=management

id= urn:jaus:jss:core:Management

version=1.1

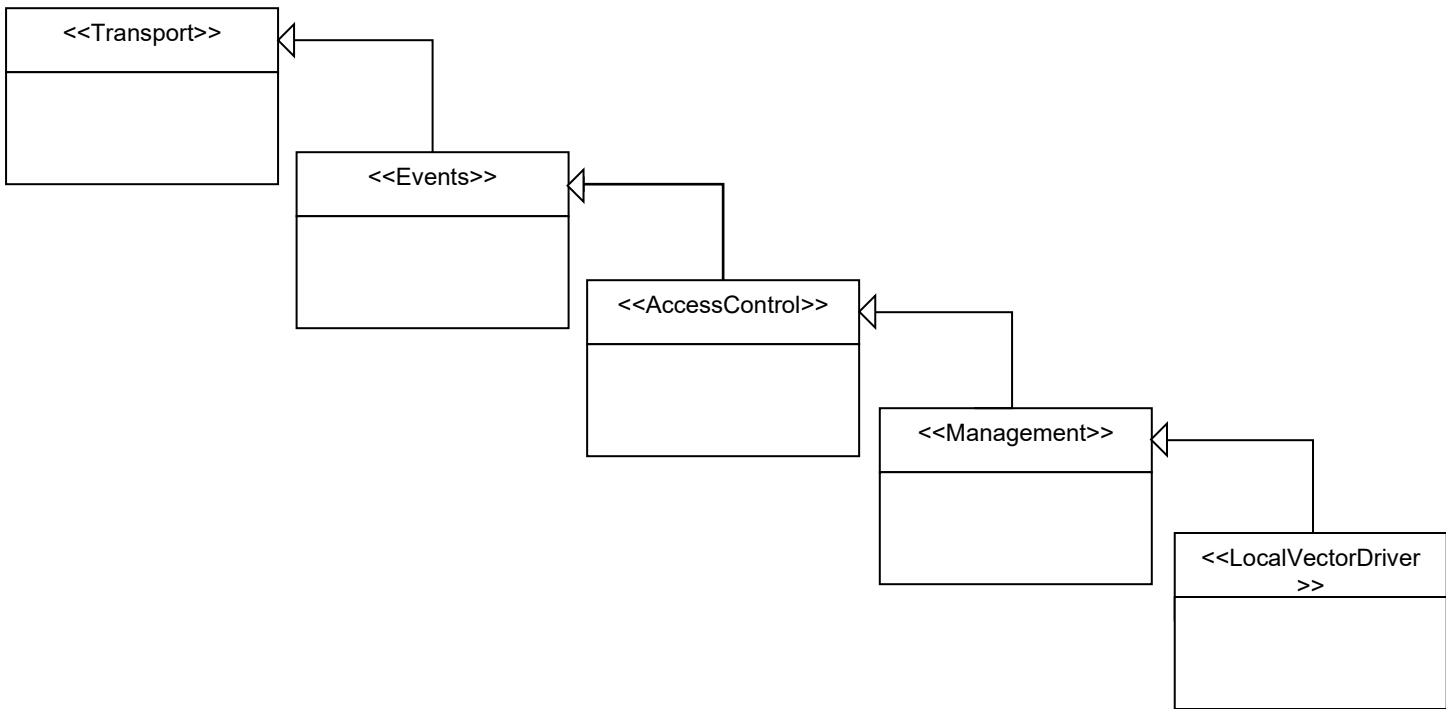


Figure 15 - Local vector driver service

Description

The Local Vector Driver performs closed loop control of the desired local heading (yaw), pitch, roll, altitude or depth, and speed of a mobile platform. The Local Vector Driver is very similar in function to the Global Vector Driver, the difference being that the desired yaw is defined in terms of a local coordinate system as opposed to the global coordinate system. Note that the new Ext messages support different values for course and heading (yaw) for holonomic systems that allow such configurations. Vehicles may be controlled by specifying the desired altitude with respect to the ground or Mean Sea Level. Submersible vehicles may be controlled by specifying the desired Depth or Altitude ASF. For ground-based systems, the Altitude field is optional. The speed of the vehicle can be expressed as either Speed over Ground or Speed Relative to Medium.

Assumptions

Messages may be delayed, lost or reordered.

Vocabulary

The table below lists the vocabulary of the Local Vector Driver Service.

Table 25 - Local vector driver service vocabulary

Message Id (hex)	Name	isCommand?
Input Set		
0408	Set LocalVector(Deprecated)	True
04A8	SetLocalVectorExt	True
2408	Query LocalVector(Deprecated)	False
24A8	QueryLocalVectorExt	False
Output Set		
4408	Report LocalVector(Deprecated)	False
44A8	QueryLocalVectorExt	False

Protocol Behavior

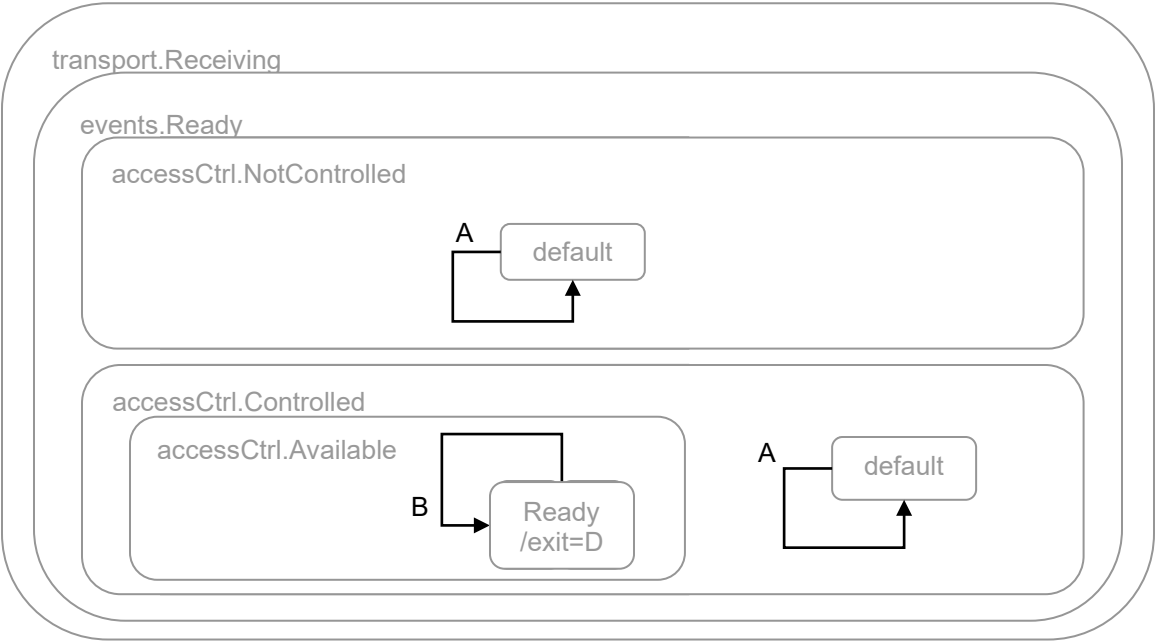


Figure 16 - Local vector driver service protocol behavior

Table 26 - Local vector driver service entry/exit action table

Label	State	Type	Guard	Actions
D	management.Ready	exit		resetTravelSpeed

Table 27 - Local vector driver service transition table

Label	Trigger	Guard	Actions
A	QueryLocalVector		sendReportLocalVector
	QueryLocalVectorExt		sendReportLocalVectorExt
B	SetLocalVector	isControllingClient	setLocalVector
	SetLocalVectorExt	isControllingClient	setLocalVectorExt

Table 28 - Local vector driver service state conditions table

Condition	Interpretation
isControllingClient	True if the message that triggered the transition is received from the client that is in control of this service.

Table 29 - Local vector driver service transition actions

Action	Interpretation
<i>setLocalVector</i>	Set the local vector values for the platform.
<i>setLocalVectorExt</i>	Set the local vectorExt values for the platform.
<i>sendReportLocalVector</i>	Send a Report Local Vector message
<i>sendReportLocalVectorExt</i>	Send a Report Local VectorExt message
<i>resetTravelSpeed</i>	Safe motion of the platform, as described in 3.5

4.8 Global Waypoint Driver Service

name=GlobalWaypointDriver

version=1.1

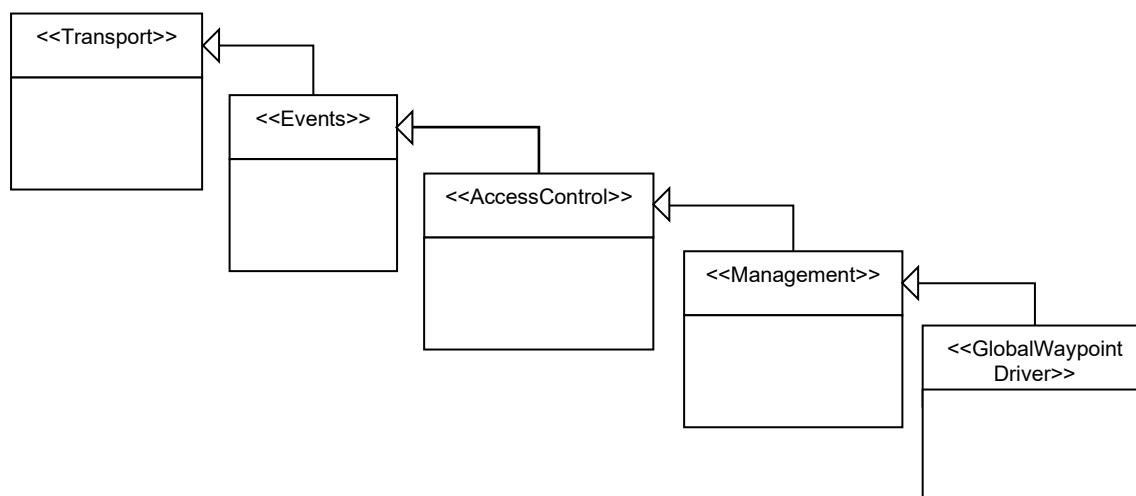
id= urn:jaus:jss:mobility:GlobalWaypointDriver

Inherits-from Management

name=management

id= urn:jaus:jss:core:Management

version=1.1

**Figure 17 - Global waypoint driver service**

Description

The function of the Global Waypoint Driver is to move the platform given a single target waypoint and desired travel speed. A single waypoint is provided via the Set Global Waypoint message. The waypoint remains unchanged until a new Set Global Waypoint message is received. A waypoint consists of the desired position and orientation of the platform. Another commanded input consists of the desired travel speed. The desired travel speed remains unchanged unless a new Set Travel Speed Message is received. The travel speed may then be changed at any time during waypoint navigation.

Assumptions

Messages may be delayed, lost or reordered.

Vocabulary

The table below lists the vocabulary of the Global Waypoint Driver Service.

Table 30 - Global waypoint driver service vocabulary

Message Id (hex)	Name	isCommand?
Input Set		
040A	SetTravelSpeed (Deprecated)	True
04AA	SetTravelSpeedExt	True
040C	Set Global Waypoint(Deprecated)	True
04AC	SetGlobalWaypointExt	True
240A	QueryTravelSpeed (Deprecated)	False
24AA	QueryTravelSpeedExt	False
240C	QueryGlobalWaypoint(Deprecated)	False
24AC	QueryGlobalWaypointExt	False
Output Set		
440A	ReportTravelSpeed(Deprecated)	False
44AA	ReportTravelSpeedExt	False
440C	ReportGlobalWaypoint(Deprecated)	False
44AC	ReportGlobalWaypointExt	False

Protocol Behavior

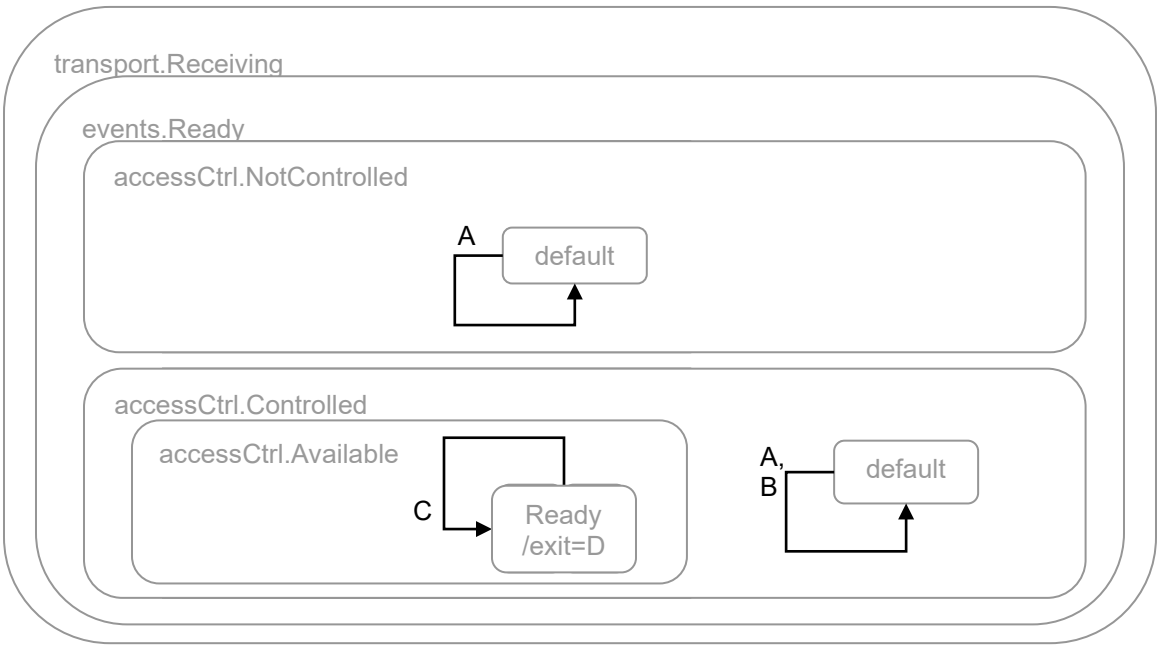


Figure 18 - Global waypoint driver service protocol behavior

Table 31 - Global waypoint driver service entry/exit action table

Label	State	Type	Guard	Actions
D	management.Ready	exit		<i>resetTravelSpeed</i>

Table 32 - Global waypoint driver service transition table

Label	Trigger	Guard	Actions
A	QueryTravelSpeed		sendReportTravelSpeed
	QueryTravelSpeedExt		sendReportTravelSpeedExt
	QueryGlobalWaypoint	<i>waypointExists</i>	sendReportGlobalWaypoint
	QueryGlobalWaypointExt	<i>waypointExists</i>	sendReportGlobalWaypointExt
B	SetGlobalWaypoint	<i>isControllingClient</i>	<i>setWaypoint</i>
	SetGlobalWaypointExt	<i>isControllingClient</i>	<i>setWaypointExt</i>
C	SetTravelSpeed	<i>isControllingClient</i> AND <i>waypointExists</i>	<i>setTravelSpeed</i>
	SetTravelSpeedExt	<i>isControllingClient</i> AND <i>waypointExists</i>	<i>setTravelSpeedExt</i>

Table 33 - Global waypoint driver service state conditions table

Condition	Interpretation
<i>isControllingClient</i>	True if the message that triggered the transition is received from the client that is in control of this service.
<i>waypointExists</i>	True if a valid waypoint has been received.

Table 34 - Global waypoint driver service transition action

Action	Interpretation
<i>setTravelSpeed</i>	Set the travel speed for the platform.
<i>setTravelSpeedExt</i>	Set the travel speedExt for the platform.
<i>setWaypoint</i>	Set the target destination of the platform.
<i>setWaypointExt</i>	Set the target WaypointExt destination of the platform.
sendReportGlobalWaypoint	Send a Report Global Waypoint message
sendReportGlobalWaypointExt	Send a Report Global WaypointExt message
sendReportTravelSpeed	Send a Report Travel Speed message
sendReportTravelSpeedExt	Send a Report Travel SpeedExt message
<i>resetTravelSpeed</i>	Safe motion of the platform, as described in 3.5

4.9 Local Waypoint Driver Service

name=LocalWaypointDriver

version=1.1

id= urn:jaus:jss:mobility:LocalWaypointDriver

Inherits-from Management

name=management

id= urn:jaus:jss:core:Management

version=1.1

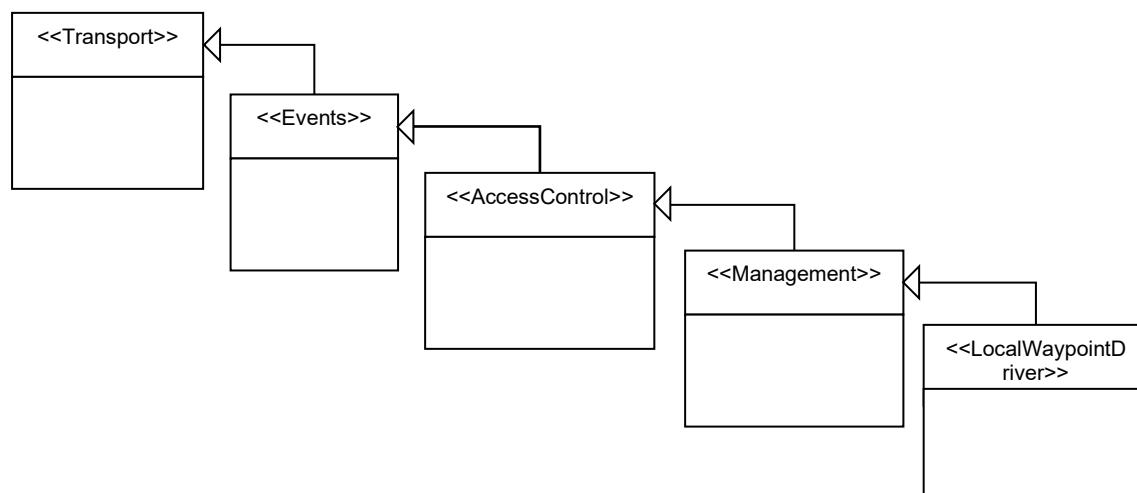


Figure 19 - Local waypoint driver service

Description

The function of the Local Waypoint Driver is to move the platform given a single target waypoint and desired travel speed. A single waypoint is provided via the Set Local Waypoint message. The waypoint remains unchanged until a new Set Local Waypoint message is received. A waypoint consists of the desired position and orientation of the platform. Another commanded input consists of the desired travel speed. The desired travel speed remains unchanged unless a new Set Travel Speed Message is received. The travel speed may then be changed at any time during waypoint navigation.

Assumptions

Messages may be delayed, lost or reordered.

Vocabulary

The table below lists the vocabulary of the Local Waypoint Driver Service.

Table 35 - Local waypoint driver service vocabulary

Message Id (hex)	Name	isCommand?
Input Set		
040A	SetTravelSpeed (Deprecated)	True
04AA	SetTravelSpeedExt	True
040D	SetLocalWaypoint(Deprecated)	True
04AD	SetLocalWaypointExt	True
240A	QueryTravelSpeed(Deprecated)	False
24AA	QueryTravelSpeedExt	False
240D	QueryLocalWaypoint(Deprecated)	False
24AD	QueryLocalWaypointExt	False
Output Set		
440A	ReportTravelSpeed(Deprecated)	False
44AA	ReportTravelSpeedExt	False
440D	ReportLocalWaypoint(Deprecated)	False
44AD	ReportLocalWaypointExt	False

Protocol Behavior

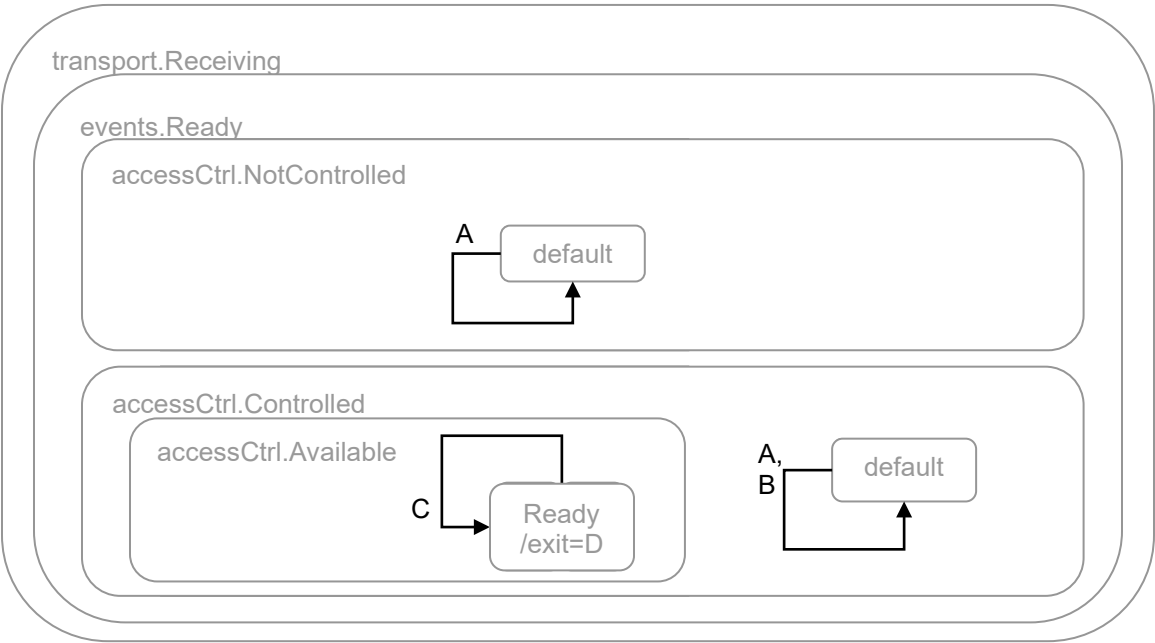


Figure 20 - Local waypoint driver service protocol behavior

Table 36 - Local waypoint driver service entry/exit action table

Label	State	Type	Guard	Actions
D	management.Ready	exit		resetTravelSpeed

Table 37 - Local waypoint driver service transition table

Label	Trigger	Guard	Actions
A	QueryTravelSpeed		sendReportTravelSpeed
	QueryTravelSpeedExt		sendReportTravelSpeedExt
	QueryLocalWaypoint	waypointExists	sendReportLocalWaypoint
	QueryLocalWaypointExt	waypointExists	sendReportLocalWaypointExt
B	SetLocalWaypoint	isControllingClient	setWaypoint
	SetLocalWaypointExt	isControllingClient	setWaypointExt
C	SetTravelSpeed	isControllingClient AND waypointExists	setTravelSpeed
	SetTravelSpeedExt	isControllingClient AND waypointExists	setTravelSpeedExt

Table 38 - Local waypoint driver service state conditions table

Condition	Interpretation
<i>isControllingClient</i>	True if the message that triggered the transition is received from the client that is in control of this service.
<i>waypointExists</i>	True if a valid waypoint has been received.

Table 39 - Local waypoint driver service transition actions

Action	Interpretation
<i>setTravelSpeed</i>	Set the travel speed for the platform.
<i>setTravelSpeedExt</i>	Set the travel speedExt for the platform.
<i>setWaypoint</i>	Set the target destination of the platform.
<i>setWaypointExt</i>	Set the target destination WaypointExt of the platform.
<i>sendReportLocalWaypoint</i>	Send a Report Local Waypoint message
<i>sendReportLocalWaypointExt</i>	Send a Report Local WaypointExt message
<i>sendReportTravelSpeed</i>	Send a Report Travel Speed message
<i>sendReportTravelSpeedExt</i>	Send a Report Travel SpeedExt message
<i>resetTravelSpeed</i>	Safe motion of the platform, as described in 3.5

4.10 Global Waypoint List Driver Service

name=GlobalWaypointListDriver

version=1.1

id= urn:jaus:jss:mobility:GlobalWaypointListDriver

Inherits-from ListManager

name= listManager

id= urn:jaus:jss:core:ListManager

version=1.1

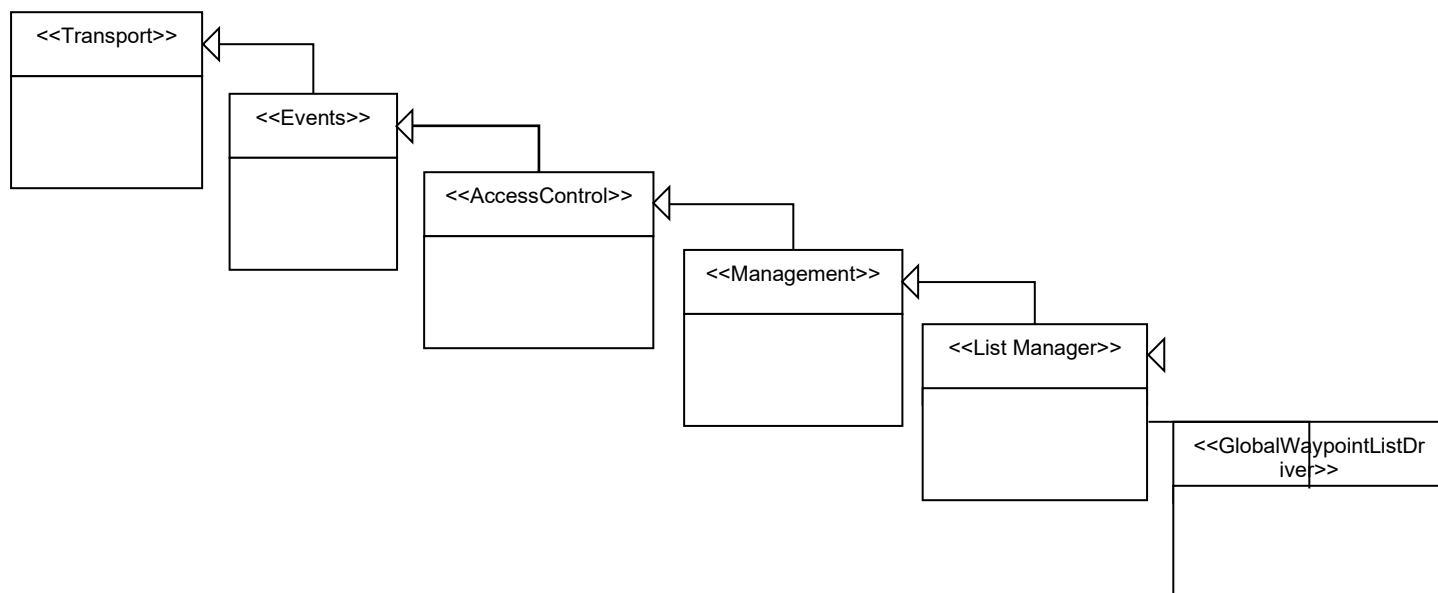


Figure 21 - Global waypoint list driver service

Description

The function of the Global Waypoint List Driver is to move the platform given a series of target waypoints and desired travel speed. The sequence of waypoints is specified by one or more SetElement messages. A waypoint consists of the desired position and orientation of the platform. Another commanded input consists of the desired travel speed and an optional starting element. The desired travel speed remains unchanged unless a new ExecuteList command is received. The travel speed may then be changed at any time during waypoint navigation.

Assumptions

Messages may be delayed, lost or reordered.

Vocabulary

The table below lists the vocabulary of the Global Waypoint List Driver Service.

Table 40 - Global waypoint list driver service vocabulary

Message Id (hex)	Name	isCommand?
Input Set		
041E	Execute List(Deprecated)	True
04AE	ExecuteListExt	True
240A	QueryTravelSpeed(Deprecated)	False
24AA	QueryTravelSpeedExt	False
240C	QueryGlobalWaypoint(Deprecated)	False
24AC	QueryGlobalWaypointExt	False
241E	QueryActiveElement	False
Output Set		
440A	ReportTravelSpeed(Deprecated)	False
44AA	ReportTravelSpeedExt	False
440C	ReportGlobalWaypoint(Deprecated)	False
44AC	ReportGlobalWaypointExt	False
441E	ReportActiveElement	False

Protocol Behavior

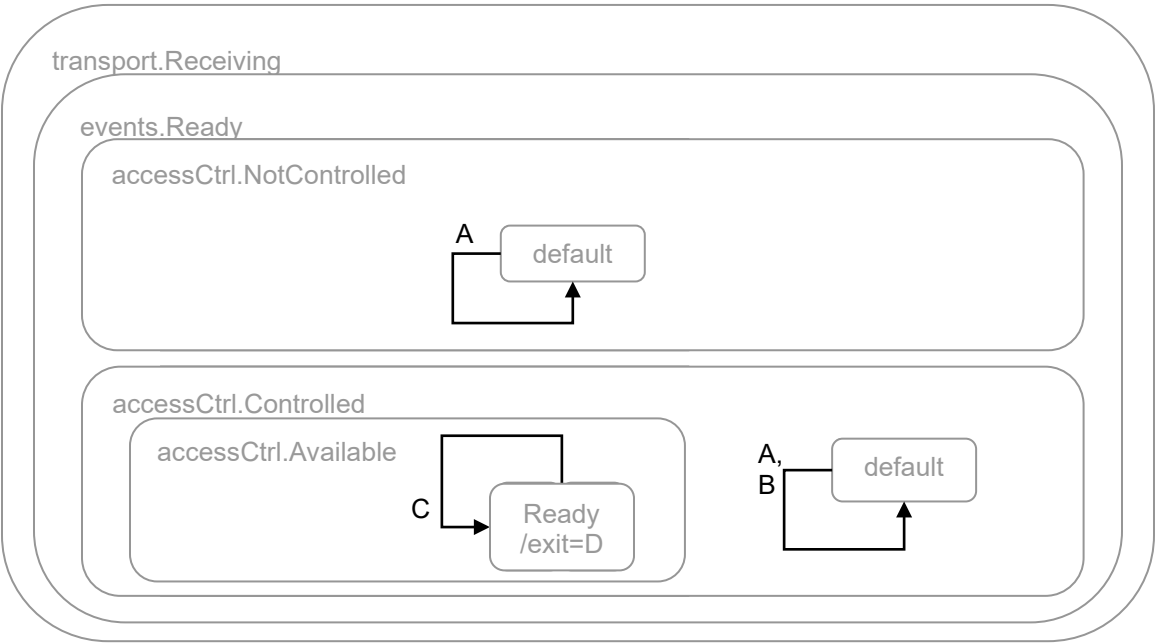


Figure 22 - Global waypoint driver list service protocol behavior

Table 41 - Global waypoint list driver service entry/exit action table

Label	State	Type	Guard	Actions
D	management.Ready	exit		resetTravelSpeed

Table 42 - Global waypoint list driver service transition table

Label	Trigger	Guard	Actions
A	QueryTravelSpeed		sendReportTravelSpeed
	QueryTravelSpeedExt		sendReportTravelSpeedExt
	QueryGlobalWaypoint	<i>waypointExists</i>	sendReportGlobalWaypoint
	QueryGlobalWaypointExt	<i>waypointExists</i>	sendReportGlobalWaypointExt
	QueryActiveElement		sendReportActiveElement
B	SetElement	<i>isControllingClient AND isValidElementRequest AND isElementSupported</i>	<i>setElement</i> sendConfirmElementRequest
	SetElement	<i>isControllingClient AND !isValidElementRequest</i>	sendRejectElementRequest
	SetElement	<i>isControllingClient AND !isElementSupported</i>	sendRejectElementRequest
C	ExecuteList	<i>isControllingClient AND elementExists</i>	<i>executeWaypointList</i>
	ExecuteList	<i>isControllingClient AND !elementSpecified</i>	<i>modifyTravelSpeed</i>
	ExecuteListExt	<i>isControllingClient AND elementExists</i>	<i>executeWaypointList</i>
	ExecuteListExt	<i>isControllingClient AND !elementSpecified</i>	<i>modifyTravelSpeed</i>

Table 43 - Global waypoint list driver service state conditions table

Condition	Interpretation
<i>isControllingClient</i>	True if the message that triggered the transition is received from the client that is in control of this service.
<i>waypointExists</i>	True if a valid waypoint has been received.
<i>elementExists</i>	True if the Element UID specified in the message that triggered the transition exists in the list.
<i>isValidElementRequest</i>	True if the resulting list will not be invalid as defined by the List Manager Service description and the receiving entity has sufficient memory to store the element(s).
<i>isElementSupported</i>	True if the message that triggered the transition contains payload(s) of valid serialized Set Global Waypoint message(s).
<i>elementSpecified</i>	True if the ExecuteList message that triggered the transition contains an Element UID.

Table 44 - Global waypoint list driver service transition actions

Action	Interpretation
<i>setElement</i>	Store the given waypoint(s) in the waypoint list with sequence specified by the previous and next element UIDs. If this action represents an insert or append into an existing list, the service should modify the NextUID of the previous element and/or the PreviousUID of the next element to reflect the updated sequence
<i>executeWaypointList</i>	Begin sequential execution of the waypoint list starting at the specified element, at the specified speed.
sendReportGlobalWaypoint	Send a Report Global Waypoint message
sendReportGlobalWaypointExt	Send a Report Global WaypointExt message
sendReportTravelSpeed	Send a Report Travel Speed message
sendReportTravelSpeedExt	Send a Report Travel SpeedExt message
sendReportActiveElement	Send a Report Active Element message
sendConfirmElementRequest	Send a Confirm Element Request message
sendRejectElementRequest	Send a Reject Element Request message
<i>resetTravelSpeed</i>	Safe motion of the platform, as described in 3.5
<i>modifyTravelSpeed</i>	Set the travel speed to the specified value.

4.11 Local Waypoint List Driver Service

name=LocalWaypointListDriver

version=1.1

id= urn:jaus:jss:mobility:LocalWaypointListDriver

Inherits-from ListManager

name=listManager

id= urn:jaus:jss:core:ListManager

version=1.1

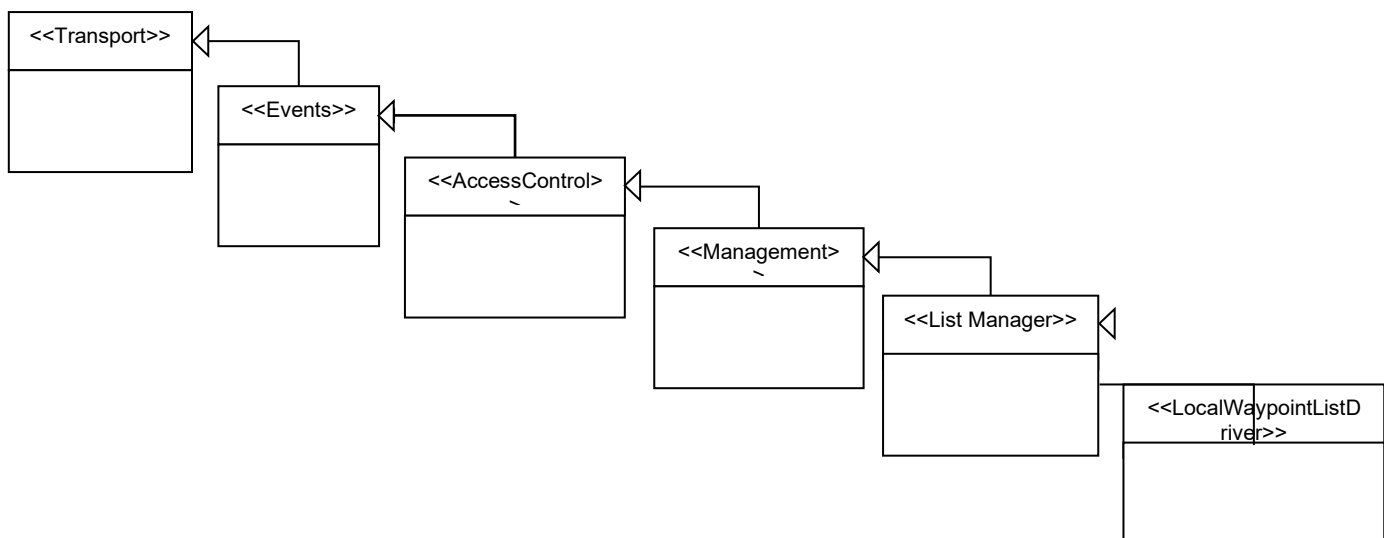


Figure 23 - Local waypoint list driver service

Description

The function of the Local Waypoint List Driver is to move the platform given a series of target waypoints and desired travel speed. The sequence of waypoints is specified by one or more SetElement messages. A waypoint consists of the desired position and orientation of the platform. Another commanded input consists of the desired travel speed and an optional starting element. The desired travel speed remains unchanged unless a new ExecuteList is received. The travel speed may then be changed at any time during waypoint navigation.

Assumptions

Messages may be delayed, lost or reordered.

Vocabulary

The table below lists the vocabulary of the Local Waypoint List Driver Service.

Table 45 - Local waypoint list driver service vocabulary

Message Id (hex)	Name	isCommand?
Input Set		
041E	ExecuteList(Deprecated)	True
04AE	ExecuteListExt	True
240A	QueryTravelSpeed(Deprecated)	False
24AA	QueryTravelSpeedExt	False
240D	QueryLocalWaypoint(Deprecated)	False
24AD	QueryLocalWaypointExt	False
241E	QueryActiveElement	False
Output Set		
440A	ReportTravelSpeed(Deprecated)	False
44AA	ReportTravelSpeedExt	False
440D	ReportLocalWaypoint(Deprecated)	False
44AD	ReportLocalWaypointExt	False
441E	ReportActiveElement	False

Protocol Behavior

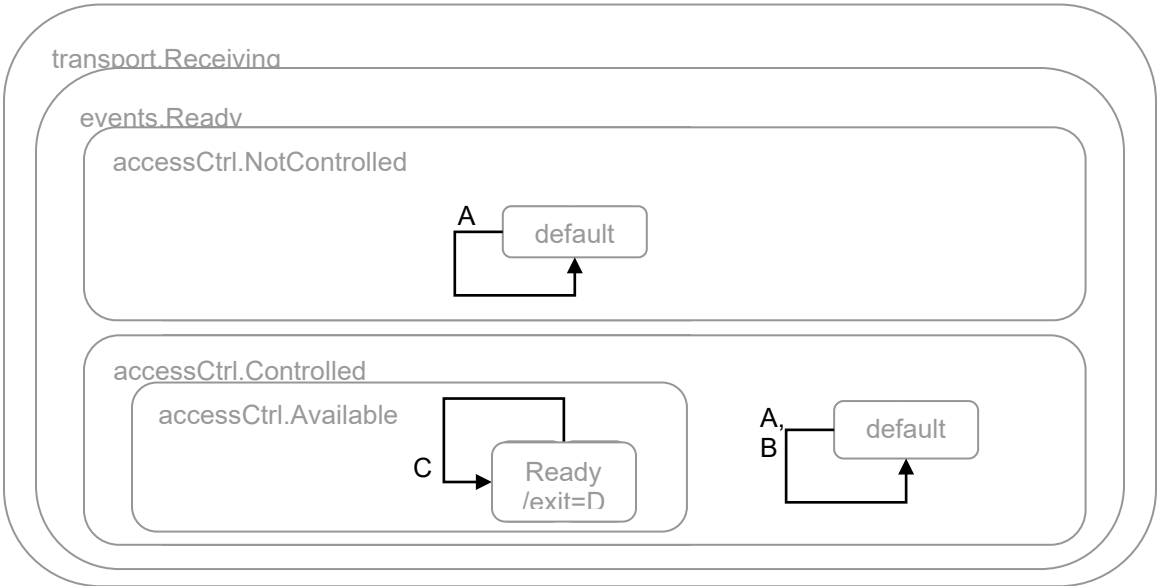


Figure 24 - Local waypoint list driver service protocol behavior

Table 46 - Local waypoint list driver service entry/exit action table

Label	State	Type	Guard	Actions
D	management.Ready	exit		<i>resetTravelSpeed</i>

Table 47 - Local waypoint list driver service transition table

Label	Trigger	Guard	Actions
A	QueryTravelSpeed		sendReportTravelSpeed
	QueryTravelSpeedExt		sendReportTravelSpeedExt
	QueryLocalWaypoint	<i>waypointExists</i>	sendReportLocalWaypoint
	QueryLocalWaypointExt	<i>waypointExists</i>	sendReportLocalWaypointExt
	QueryActiveElement		sendReportActiveElement
B	SetElement	<i>isControllingClient AND isValidElementRequest AND isElementSupported</i>	<i>setElement</i> sendConfirmElementRequest
	SetElement	<i>isControllingClient AND !isValidElementRequest</i>	sendRejectElementRequest
	SetElement	<i>isControllingClient AND !isElementSupported</i>	sendRejectElementRequest
C	ExecuteList	<i>isControllingClient AND elementExists</i>	<i>executeWaypointList</i>
	ExecuteList	<i>isControllingClient AND !elementSpecified</i>	<i>modifyTravelSpeed</i>
	ExecuteListExt	<i>isControllingClient AND elementExists</i>	<i>executeWaypointList</i>
	ExecuteListExt	<i>isControllingClient AND !elementSpecified</i>	<i>modifyTravelSpeed</i>

Table 48 - Local waypoint list driver service state conditions table

Condition	Interpretation
<i>isControllingClient</i>	True if the message that triggered the transition is received from the client that is in control of this service.
<i>waypointExists</i>	True if a valid waypoint has been received.
<i>elementExists</i>	True if the Element UID specified in the message that triggered the transition exists in the list.
<i>isValidElementRequest</i>	True if the resulting list will not be invalid as defined by the List Manager Service description and the receiving entity has sufficient memory to store the element(s).
<i>isElementSupported</i>	True if the message that triggered the transition contains payload(s) of valid serialized Set Local Waypoint message(s).
<i>elementSpecified</i>	True if the ExecuteList message that triggered the transition contains an Element UID.



Table 49 - Local waypoint list driver service transition actions

Action	Interpretation
<i>setElement</i>	Store the given waypoint(s) in the waypoint list with sequence specified by the previous and next element UIDs. If this action represents an insert or append into an existing list, the service should modify the NextUID of the previous element and/or the PreviousUID of the next element to reflect the updated sequence
<i>executeWaypointList</i>	Begin sequential execution of the waypoint list starting at the specified element, at the specified speed.
sendReportLocalWaypoint	Send a Report Local Waypoint message
sendReportLocalWaypointAGS	Send a Report Local WaypointExt message
sendReportTravelSpeed	Send a Report Travel Speed message
sendReportTravelSpeedExt	Send a Report Travel SpeedExt message
sendReportActiveElement	Send a Report Active Element message
sendConfirmElementRequest	Send a Confirm Element Request message
sendRejectElementRequest	Send a Reject Element Request message
<i>resetTravelSpeed</i>	Safe motion of the platform, as described in 3.5
<i>modifyTravelSpeed</i>	Set the travel speed to the specified value.

4.12 Global Path Segment Driver Service

name=GlobalPathSegmentDriver

version=1.1

id= urn:jaus:jss:mobility:GlobalPathSegmentDriver

Inherits-from ListManager

name= listManager

id= urn:jaus:jss:core:ListManager

version=1.1

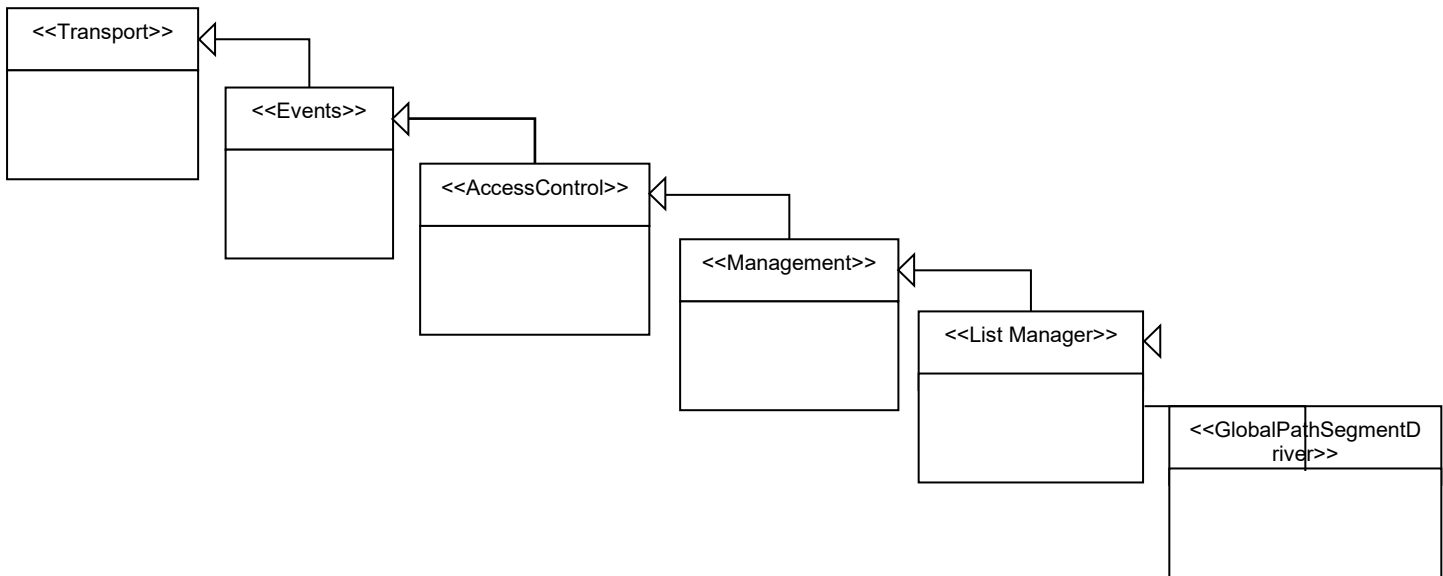


Figure 25 - Global path segment driver service

Description

The function of the Global Path Segment Driver is to perform closed loop control of position and velocity along a path where the path is defined in a generic manner. The Global Path Segment Driver differs from the Waypoint Drivers in that the exact path between “waypoints” is strictly defined. A path segment will be defined by specifying the three-dimensional coordinates of three points, $\mathbf{P}_0$, $\mathbf{P}_1$, and $\mathbf{P}_2$ together with one scalar weighting value w_1 . The equation of the path is defined as:

$$\mathbf{p}(u) = \frac{(1-u)^2 \mathbf{P}_0 + 2u(1-u)w_1 \mathbf{P}_1 + u^2 \mathbf{P}_2}{(1-u)^2 + 2u(1-u)w_1 + u^2},$$

where $\mathbf{p}$ represents some point on the path segment as u varies from 0 to 1. This equation defines a path segment as a second order polynomial (ellipse, parabola, or hyperbola) that lies in the plane defined by the three points $\mathbf{P}_0$, $\mathbf{P}_1$, and $\mathbf{P}_2$. When $u=0$, $\mathbf{p}(0) = \mathbf{P}_0$ and when $u=1$, $\mathbf{p}(1) = \mathbf{P}_2$ and thus the path segment begins at point $\mathbf{P}_0$ and ends at point $\mathbf{P}_2$. The point $\mathbf{P}_1$ is a control point that is not necessarily on the path. Figure 26 shows a path segment that is defined by $\mathbf{P}_0 = [1, 2, 0]^T$, $\mathbf{P}_1 = [3, 5, 0]^T$, $\mathbf{P}_2 = [5, 1, 0]^T$, and $w_1 = 1.5$. Figure 27 demonstrates the effect of varying the weighting factor w_1 . As can be seen in the figure, a larger value of w_1 draws the curve towards the path control point $\mathbf{P}_1$.

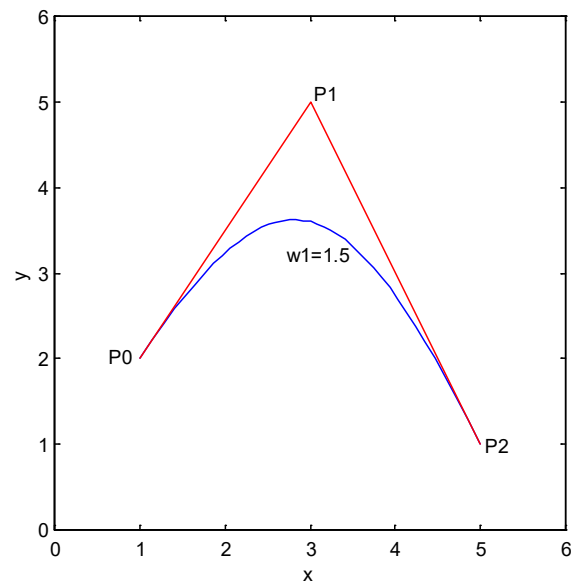


Figure 26 - Sample path segment with control points shown

One feature of this representation of a path segment is that at the start of the path, the line from P_0 to P_1 will be tangent to the curve. Similarly at the end of the path, the line from P_1 to P_2 will be tangent to the curve. This feature makes it easy to define subsequent path segments so that there will be continuity at the connection point. Figure 28 shows the path segment shown in Figure 26 connected to a second path segment defined by the points $P_2 = [5, 1, 0]^T$, $P_3 = [6, -1, 0]^T$, and $P_4 = [8, -1, 0]^T$ with a weighting factor of $w_1 = 2$. As shown in the figure, continuity of slope will occur if the line from P_1 to P_2 is collinear with the line from P_2 to P_3 .

The second input consists of the desired travel speed. The desired travel speed remains unchanged unless a new ExecuteList message is received. The travel speed may then be changed at any time during waypoint navigation.

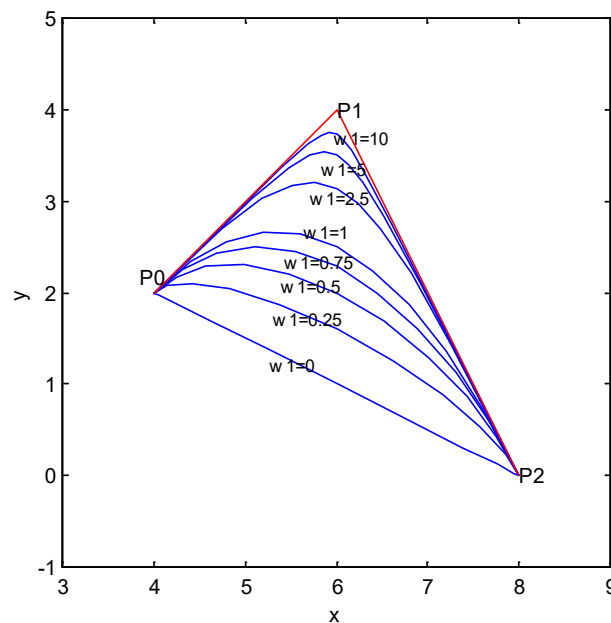


Figure 27 - Effect of weighting parameter w_1 on curve shape

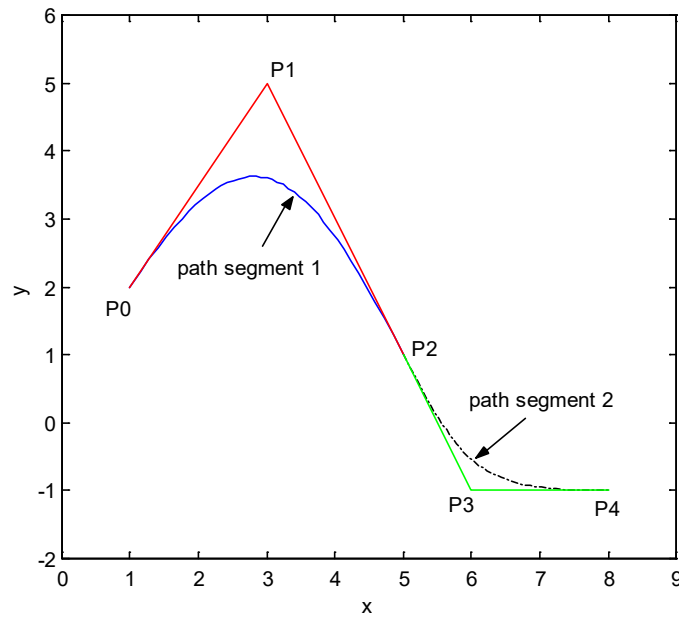


Figure 28 - Slope continuity at path segment connection point

Assumptions

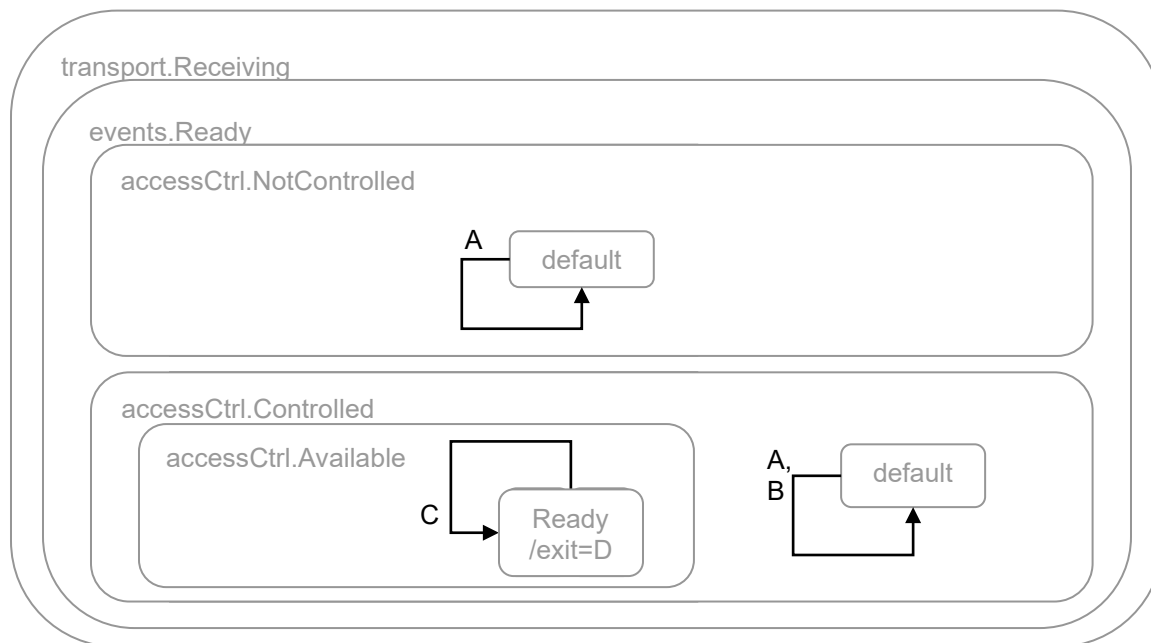
Messages may be delayed, lost or reordered.

Vocabulary

The table below lists the vocabulary of the Global Path Segment Driver Service.

Table 50 - Global path segment driver service vocabulary

Message Id (hex)	Name	isCommand?
Input Set		
041E	ExecuteList(Deprecated)	True
04AE	ExecuteListExt	True
240A	QueryTravelSpeed(Deprecated)	False
24AA	QueryTravelSpeedExt	False
240F	QueryGlobalPathSegment(Deprecated)	False
24AF	QueryGlobalPathSegmentExt	False
241E	QueryActiveElement	False
Output Set		
440A	ReportTravelSpeed(Deprecated)	False
44AA	ReportTravelSpeedExt	False
440F	ReportGlobalPathSegment(Deprecated)	False
44AF	ReportGlobalPathSegmentExt	False
441E	ReportActiveElement	False

Protocol Behavior**Figure 29 - Global path segment driver service protocol behavior****Table 51 - Global path segment driver service entry/exit action table**

Label	State	Type	Guard	Actions
D	management.Ready	exit		<i>resetTravelSpeed</i>

Table 52 - Global path segment driver service transition table

Label	Trigger	Guard	Actions
A	QueryTravelSpeed		sendReportTravelSpeed
	QueryTravelSpeedExt		sendReportTravelSpeedExt
	QueryGlobalPathSegment	<i>segmentExists</i>	sendReportGlobalPathSegment
	QueryGlobalPathSegmentExt	<i>segmentExists</i>	sendReportGlobalPathSegmentExt
	QueryActiveElement		sendReportActiveElement
B	SetElement	<i>isControllingClient AND isValidElementRequest AND isElementSupported</i>	<i>setElement</i> sendConfirmElementRequest
	SetElement	<i>isControllingClient AND !isValidElementRequest</i>	sendRejectElementRequest
	SetElement	<i>isControllingClient AND !isElementSupported</i>	sendRejectElementRequest
C	ExecuteList	<i>isControllingClient AND elementExists</i>	<i>executePathSegmentList</i>
	ExecuteList	<i>isControllingClient AND !elementSpecified</i>	<i>modifyTravelSpeed</i>
	ExecuteListExt	<i>isControllingClient AND elementExists</i>	<i>executePathSegmentList</i>
	ExecuteListExt	<i>isControllingClient AND !elementSpecified</i>	<i>modifyTravelSpeed</i>