



AEROSPACE STANDARD

AS6091™

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JAUS Unmanned Ground Vehicle Service Set

RATIONALE

This document, the JAUS Unmanned Ground Vehicle Service Set (AS6091), defines a message-passing interface for services commonly found in unmanned ground vehicle systems. These services represent the platform-independent capabilities common across multiple ground vehicle types. Inherited capabilities are specified in the JAUS Core Service Set (AS5710) and are frequently referenced herein.

AS6091 has been reaffirmed to comply with the SAE Five-Year Review policy.

INTRODUCTION

The primary goal of the JAUS Unmanned Ground Vehicle 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 [[AS5669](#)], is used in conjunction with this specification.

Each service in the JAUS Unmanned Ground Vehicle Set can be 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 Unmanned Ground Vehicle Service Set contains both a text based and XML based representation for each service.

At time of publication, there have not been multiple independent implementations of this standard. As such, adopters should consider this standard “experimental” as errata to the document are discovered during initial implementation and testing.

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 Unmanned Ground Vehicle 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 Unmanned Ground Vehicle Services represent the platform-specific capabilities commonly found in UGVs, and augment the Mobility Service Set [AS6009] which is platform-agnostic. At present ten (10) services are defined in this document. These services are categorized as:

Platform Description Services - This service provides information about the vehicle platform, including mobility limits and geometric properties:

- Platform Specification Service

UGV Driver Services - These services provide low-level platform mobility for the two most common UGV steering approaches, providing a service in support of each:

- Ackermann Driver Service
- Skid Steer Driver Service

Powerplant and Drivetrain Services - These services provide command and status interface to the vehicle powertrain. The Powerplant Service provides support for several classes of vehicle powerplant; the Drivetrain Service provides control of transmissions and transfer cases. The services in this category are listed as follows:

- Powerplant Service
- Drivetrain Service

Platform Stabilization Services - Presently, only one Platform Stabilization Service is defined, in support of Flipper/Articulator style anti-pitch mechanisms. Support for anti-roll stabilization ("outriggers") and stabilizers based on CG shifting may be added in a future revision.

- Stabilizer Service

Auxiliary Devices Services - These services provide interface to auxiliary devices, including lighting devices, annunciation devices (horns, sirens, synthesized speech, et al) and other discrete auxiliary devices such as parking brakes.

- Illumination Service
- Annunciation Service
- Parking Brake Driver
- Odometry Service

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 (AS5710). 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 Unmanned Ground Vehicle 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. It is important to note that implementations are considered compliant to individual Service Definitions within this Specification; it is not necessary that a single entity realize each Service to be considered compliant.

1.4 Document Organization

The layout of this document is as follows. [Section 3](#) specifies common conventions and definitions. [Section 4](#) specifies the JAUS Service Definition for each of the services, with particular emphasis on the description, assumptions, message definition, and protocol behavior. Finally, [Appendix A](#) contains the complete JSIDL representation for each service and their associated message set.

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 724-776-4970 (outside USA), www.sae.org.

AS5669	JAUS / SDP Transport Specification
AS5684	JAUS Service Interface Definition Language
AS5710	JAUS Core Service Set
AS6009	JAUS Mobility Service Set

2.1.2 JAUS Technical References

RA33P1	JAUS Reference Architecture Specification, Volume II, Part 1, Architecture Framework, Version 3.3, June 22, 2007
RA33P2	JAUS Reference Architecture Specification, Volume II, Part 2, Message Definition, Version 3.3, June 22, 2007
RA33P3	JAUS Reference Architecture Specification, Volume II, Part 3, Message Set, Version 3.3, June 22, 2007

2.1.3 Other Publications

Barry N. Taylor. The International System of Units (SI), National Institute of Standards and Technology Special Publication 330, 1991 Edition. [<http://physics.nist.gov/Document/sp330.pdf>]

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

2.2 List of Acronyms

ANSI	American National Standards Institute
AWD	All Wheel Drive
ID	Identifier
API	Application Programming Interface
ASCII	American Standard Code for Information Interchange
BLOB	Binary Large Object
DOM	Document Object Model
DOF	Degree of Freedom
FWD	Front Wheel Drive
IEEE	Institute of Electrical and Electronics Engineers
JAUS	Joint Architecture for Unmanned Systems
JSD	JAUS Service Definition
JSIDL	JAUS Service (Interface) Definition Language
NIST	National Institute of Standards and Technology
RA	(JAUS) Reference Architecture
SMC	State Machine Compiler
UML	Unified Modeling Language
URL	Uniform Resource Locator
URN	Uniform Resource Name
URI	Uniform Resource Identifier
UUID	Universally Unique Identifier
XML	Extensible Markup Language

3. COMMON CONVENTIONS

3.1 Constant Values

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

3.2 Vehicle Coordinate System

This coordinate system is defined as attached to the vehicle frame. The X-axis points in the forward direction and the Z-axis points downward. The Y-axis is defined so as to have a right-handed coordinate system, i.e. $\mathbf{i} \times \mathbf{j} = \mathbf{k}$ where $\mathbf{i}$, $\mathbf{j}$, and $\mathbf{k}$ are unit vectors along the X, Y, and Z coordinate axes. The origin of the vehicle frame must lie within a three-dimensional bounding box of the vehicle dimensions; however, it is not necessarily tied to the vehicle's center of gravity or its geometric center.

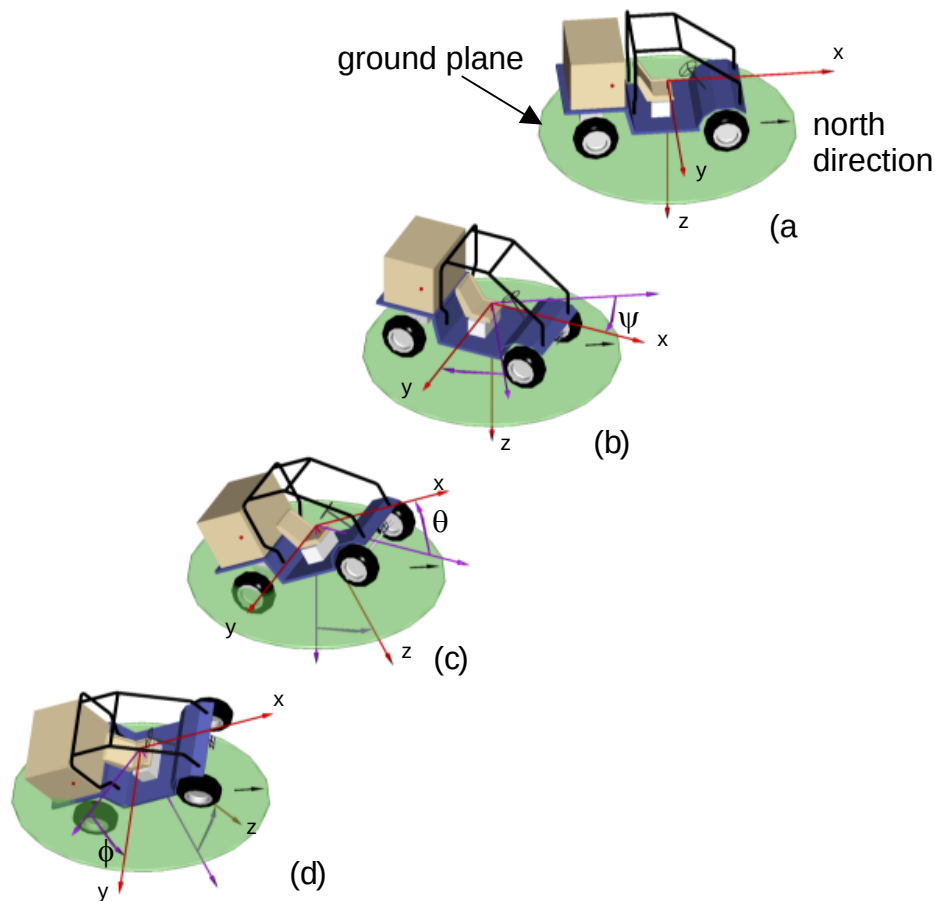


FIGURE 1 - DEFINITION OF PLATFORM ORIENTATION

3.3 Percent Effort

Throughout this document, as well as [AS6009], driver services intended to cause motion may use “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.

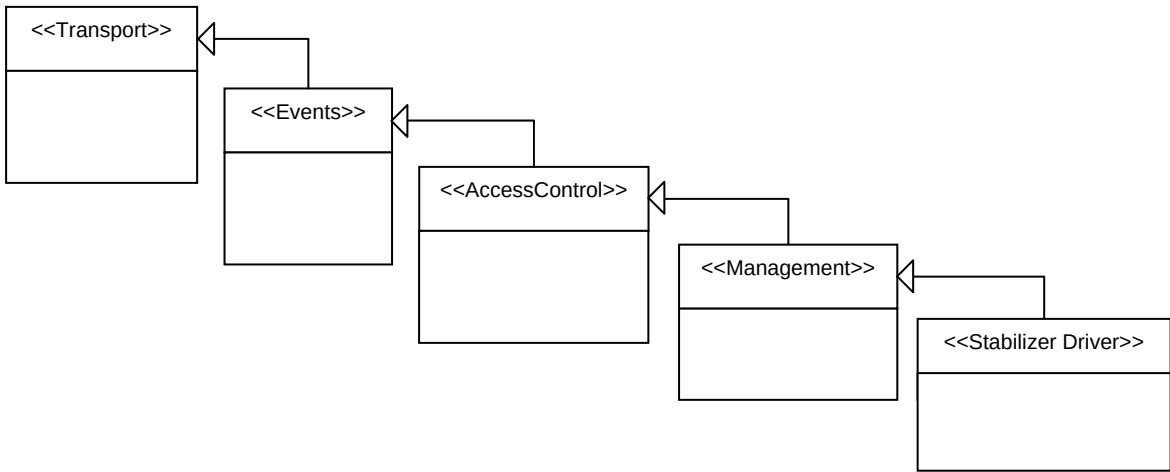
4. SERVICE DEFINITIONS

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

4.1 Stabilizer Driver

name=StabilizerDriver
version=1.0
id=urn:jaus:jss:ugv:StabilizerDriver

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



4.1.1 Description

The StabilizerDriver provides the means to control platform stabilizers, such as flippers.

4.1.2 Assumptions

Messages may be delayed, lost or reordered.

4.1.3 Vocabulary

TABLE 1 - STABILIZER DRIVER SERVICE MESSAGE VOCABULARY

Message ID (hex)	Name	Command
Input Set		
2505	QueryStabilizerCapabilities	false
0503	SetStabilizerEffort	true
2503	QueryStabilizerEffort	false
0504	SetStabilizerPosition	true
2504	QueryStabilizerPosition	false
Output Set		
4505	ReportStabilizerCapabilities	false
4503	ReportStabilizerEffort	false
4504	ReportStabilizerPosition	false

4.1.4 Encoding

4.1.4.1 Input Set

4.1.4.1.1 ID 2505: QueryStabilizerCapabilities

This message requests the vehicle stabilizer configuration.

TABLE 2 - QUERYSTABILIZERCAPABILITIES MESSAGE ENCODING

body └ (empty)
Empty message body

4.1.4.1.2 ID 0503: SetStabilizerEffort

This message sets actuator effort to move one or more stabilizers as a percentage of maximum.

TABLE 3 - SETSTABILIZEREFFORT MESSAGE ENCODING

body

└ list name = stabilizerEffort

└ (count_field = unsigned byte)

└ record name = stabilizerEffortRec

Record Name = stabilizerEffortRec

Field #	Name	Type	Units	Optional	Interpretation
1	<fixed_field> StabilizerID	unsigned byte	one	false	
2	<fixed_field> Effort	unsigned short integer	one	false	As a percent of maximum. Positive effort moves the stabilizer upward. (scaled range = [-100.0,100.0], round)

4.1.4.1.3 ID 2503: QueryStabilizerEffort

This message requests the currently commanded effort for one or more stabilizers.

TABLE 4 - QUERYSTABILIZEREFFORT MESSAGE ENCODING

body └ list name = stabilizerID (count_field = unsigned byte) └ record name = queryStabilizerRec					
Record Name = queryStabilizerRec					
Field #	Name	Type	Units	Optional	Interpretation
1	<fixed_field> StabilizerID	unsigned byte	one	false	

4.1.4.1.4 ID 0504: SetStabilizerPosition

This message requests motion of one or more stabilizers to given positions.

TABLE 5 - SETSTABILIZERPOSITION MESSAGE ENCODING

body └ list name = stabilizerPosition └ (count_field = unsigned byte) └ record name = stabilizerPositionRec					
Record Name = stabilizerPositionRec					
Field #	Name	Type	Units	Optional	Interpretation
1	<fixed_field> StabilizerID	unsigned byte	one	false	
2	<fixed_field> Position	unsigned short integer	radian	false	(scaled range = [-3.14159,3.14159], round)

4.1.4.1.5 ID 2504: QueryStabilizerPosition

This message requests the current position for one or more stabilizers.

TABLE 6 - QUERYSTABILIZERPOSITION MESSAGE ENCODING

body └ list name = stabilizerID └ (count_field = unsigned byte) └ record name = queryStabilizerRec					
Record Name = queryStabilizerRec					
Field #	Name	Type	Units	Optional	Interpretation
1	<fixed_field> StabilizerID	unsigned byte	one	false	

4.1.4.2 Output Set

4.1.4.2.1 ID 4505: ReportStabilizerCapabilities

This message reports vehicle stabilizer configuration for the platform. Each stabilizer is defined by a locally unique ID, and specified by its maximum range of angular motion and a list of points representing the geometric bounding box. The bounding box is defined over the entire range of motion for the stabilizer.

TABLE 7 - REPORTSTABILIZERCAPABILITIES MESSAGE ENCODING

body - list name = stabilizerCapabilities (count_field = unsigned byte) - sequence name = stabilizerCapabilitiesSeq - record name = stabilizerCapabilitiesRec - list name = stabilizerDimensionsList (count_field = unsigned byte) - record name = points					
Record Name = stabilizerCapabilitiesRec					
Field #	Name	Type	Units	Optional	Interpretation
1	<fixed_field> StabilizerID	unsigned byte	one	false	
2	<fixed_field> MaximumUpAngle	unsigned short integer	radian	false	(scaled range = [0.0,3.14159], round)
3	<fixed_field> MaximumDownAngle	unsigned short integer	radian	false	(scaled range = [-3.14158,0.0], round)
Record Name = points					
Field #	Name	Type	Units	Optional	Interpretation
1	<fixed_field> PointX	unsigned short integer	Meter	false	Measured from the vehicle coordinate frame (scaled range = [-32.768,32.767], round)
2	<fixed_field> PointY	unsigned short integer	Meter	false	Measured from the vehicle coordinate frame (scaled range = [-32.768,32.767], round)
2	<fixed_field> PointZ	unsigned short integer	Meter	false	Measured from the vehicle coordinate frame (scaled range = [-32.768,32.767], round)

4.1.4.2.2 ID 4503: ReportStabilizerEffort

This message reports the currently commanded effort for the stabilizers specified in the associated Query message.

TABLE 8 - REPORTSTABILIZEREFFORT MESSAGE ENCODING

body └─ list name = stabilizerEffort └─ (count_field = unsigned byte) └─ record name = stabilizerEffortRec					
Record Name = stabilizerEffortRec					
Field #	Name	Type	Units	Optional	Interpretation
1	<fixed_field> StabilizerID	unsigned byte	one	false	
2	<fixed_field> Effort	unsigned short integer	one	false	As a percent of maximum. Positive effort moves the stabilizer upward. (scaled range = [-100.0,100.0], round)

4.1.4.2.3 ID 4504: ReportStabilizerPosition

This message reports the commanded and actual positions for the stabilizer specified in the associated Query message.

TABLE 9 - REPORTSTABILIZERPOSITION MESSAGE ENCODING

body └─ list name = stabilizerPosition └─ (count_field = unsigned byte) └─ record name = stabilizerPositionRec					
Record Name = stabilizerPositionRec					
Field #	Name	Type	Units	Optional	Interpretation
1	<fixed_field> StabilizerID	unsigned byte	one	false	
2	<fixed_field> CommandedPosition	unsigned short integer	radian	false	(scaled range = [-3.14159,3.14159], round)
3	<fixed_field> ActualPosition	unsigned short integer	radian	false	(scaled range = [-3.14159,3.14159], round)

4.1.5 Protocol Behavior

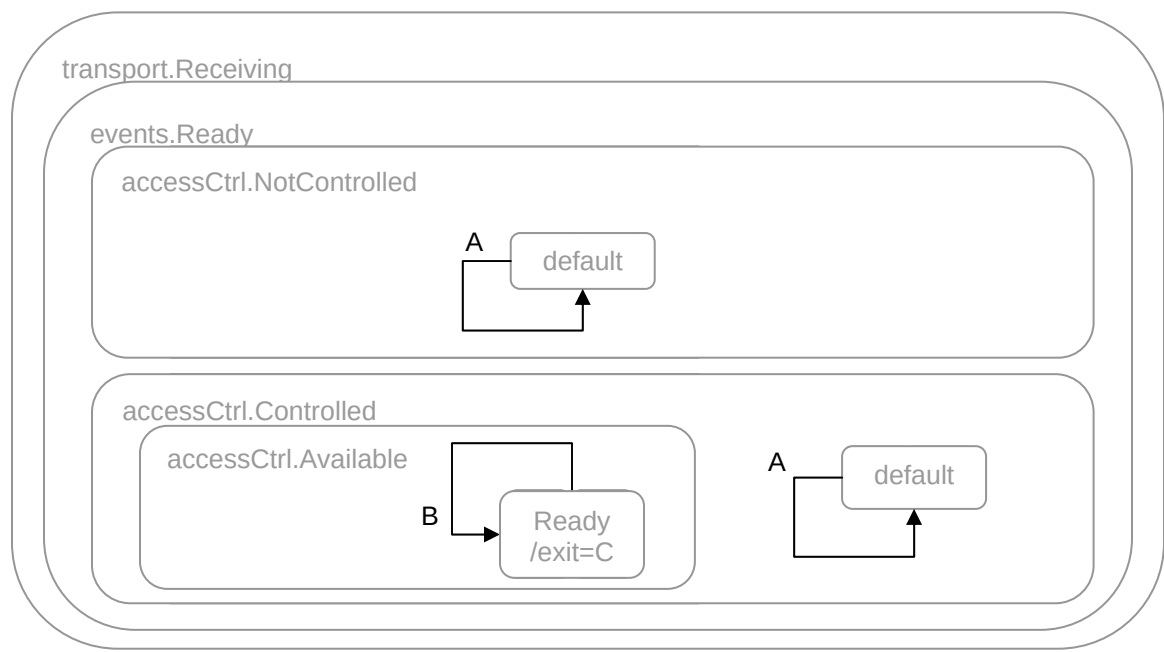


FIGURE 2 - STABILIZER DRIVER SERVICE PROTOCOL BEHAVIOR

TABLE 10 - STABILIZER DRIVER SERVICE ENTRY/EXIT ACTION TABLE

Label	State	Type	Guard	Actions
C	management.Ready	exit		stopMotion

TABLE 11 - STABILIZER DRIVER SERVICE TRANSITION TABLE

Label	Trigger	Guard	Actions
A	QueryStabilizerCapabilities		sendReportStabilizerCapabilities
	QueryStabilizerEffort		sendReportStabilizerEffort
	QueryStabilizerPosition		sendReportStabilizerPosition
B	SetStabilizerEffort	isControllingClient AND stabilizersExist	setStabilizerEffort
	SetStabilizerPosition	isControllingClient AND stabilizersExist AND areReachable	setStabilizerPosition

TABLE 12 - STABILIZER DRIVER SERVICE 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.
stabilizersExist	True if the message contains only valid stabilizer IDs.
areReachable	True if the positions specified in the message are within each stabilizers reachable workspace.

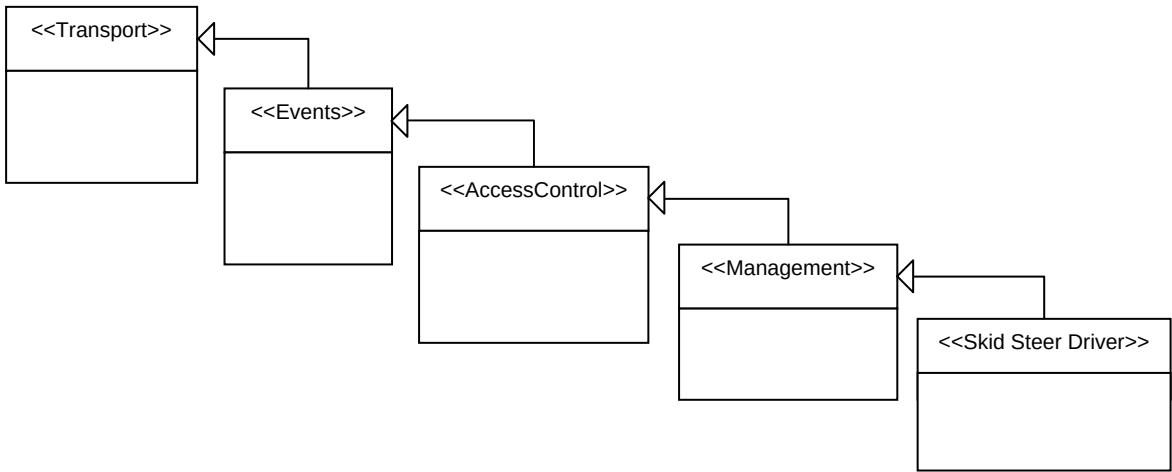
TABLE 13 - STABILIZER DRIVER SERVICE TRANSITIONS ACTIONS TABLE

Action	Interpretation
<i>setStabilizerEffort</i>	Set the actuator effort levels for the specified stabilizers.
<i>setStabilizerPosition</i>	Set the position for the specified stabilizers.
<i>sendReportStabilizerCapabilities</i>	Send a Report Stabilizer Configuration message
<i>sendReportStabilizerEffort</i>	Send a Report Stabilizer Effort message
<i>sendReportStabilizerPosition</i>	Send a Report Stabilizer Position message
<i>stopMotion</i>	Stop motion on all stabilizers.

4.2 SkidSteerDriver

name=SkidSteerDriver
version=1.0
id=urn:jaus:jss:ugv: SkidSteerDriver

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



4.2.1 Description

The SkidSteer Driver provides the means to control skid steer vehicles. A skid steer vehicle is defined as generating differential velocity by independently energizing wheels or tracks on opposite sides of the vehicle.

4.2.2 Assumptions

Messages may be delayed, lost or reordered.

4.2.3 Vocabulary

TABLE 14 - SKIDSTEER DRIVER SERVICE MESSAGE VOCABULARY

Message ID (hex)	Name	Command
Input Set		
0501	SetSkidSteerEffort	true
2501	QuerySkidSteerEffort	false
Output Set		
4501	ReportSkidSteerEffort	false

4.2.4 Encoding

4.2.4.1 Input Set

4.2.4.1.1 ID 0501: SetSkidSteerEffort

This message sets the level of effort for each side of a skid steer vehicle.

TABLE 15.- SET SKID STEER EFFORT MESSAGE ENCODING

body └ record name = skidSteerData					
Record Name = skidSteerData					
Field #	Name	Type	Units	Optional	Interpretation
1	<fixed_field> LeftSidePropulsiveEffort	unsigned short integer	one	false	As a percent of maximum. Positive results in forward thrust, while negative results in backward thrust. (scaled range = [-100.0,100.0], round)
2	<fixed_field> RightSidePropulsiveEffort	unsigned short integer	one	false	As a percent of maximum. Positive results in forward thrust, while negative results in backward thrust. (scaled range = [-100.0,100.0], round)

4.2.4.1.2 ID 2501: QuerySkidSteerEffort

This message queries the skid steer driver for current commanded effort.

TABLE 16 - QUERY SKID STEER EFFORT MESSAGE ENCODING

body └ (empty)
Empty message body

4.2.4.2 Output Set

4.2.4.2.1 ID 4501: ReportSkidSteerEffort

This message reports the commanded level of effort for each side of a skid steer vehicle.

TABLE 17 - REPORT SKID STEER EFFORT MESSAGE ENCODING

body └ record name = skidSteerData					
Record Name = skidSteerData					
Field #	Name	Type	Units	Optional	Interpretation
1	<fixed_field> LeftSidePropulsiveEffort	unsigned short integer	one	false	As a percent of maximum. Positive implies forward thrust, while negative results in backward thrust. (scaled range = [-100.0,100.0], round)
2	<fixed_field> RightSidePropulsiveEffort	unsigned short integer	one	false	As a percent of maximum. Positive implies forward thrust, while negative results in backward thrust. (scaled range = [-100.0,100.0], round)

4.2.5 Protocol Behavior

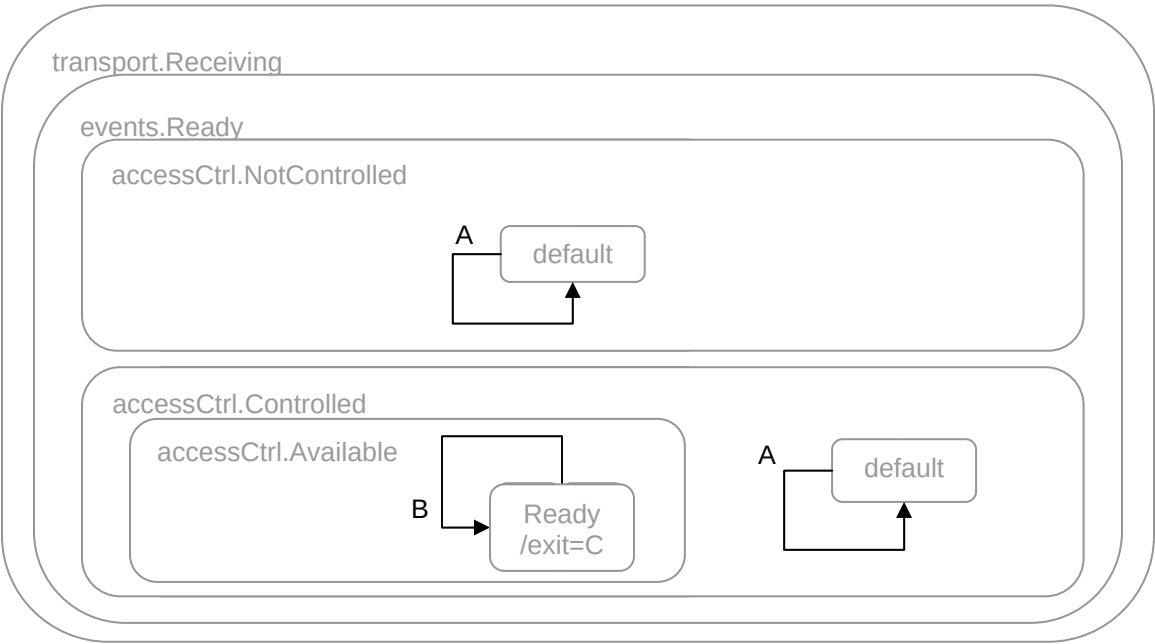


FIGURE 3 - SKID STEER DRIVER SERVICE PROTOCOL BEHAVIOR

TABLE 18 - SKID STEER DRIVER SERVICE ENTRY/EXIT ACTION TABLE

Label	State	Type	Guard	Actions
C	management.Ready	exit		stopMotion

TABLE 19 - SKID STEER DRIVER SERVICE TRANSITION TABLE

Label	Trigger	Guard	Actions
A	QuerySkidSteerEffort		sendReportSkidSteerEffort
B	SetSkidSteerEffort	isControllingClient	setSkidSteerEffort

TABLE 20 - SKID STEER DRIVER SERVICE 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.

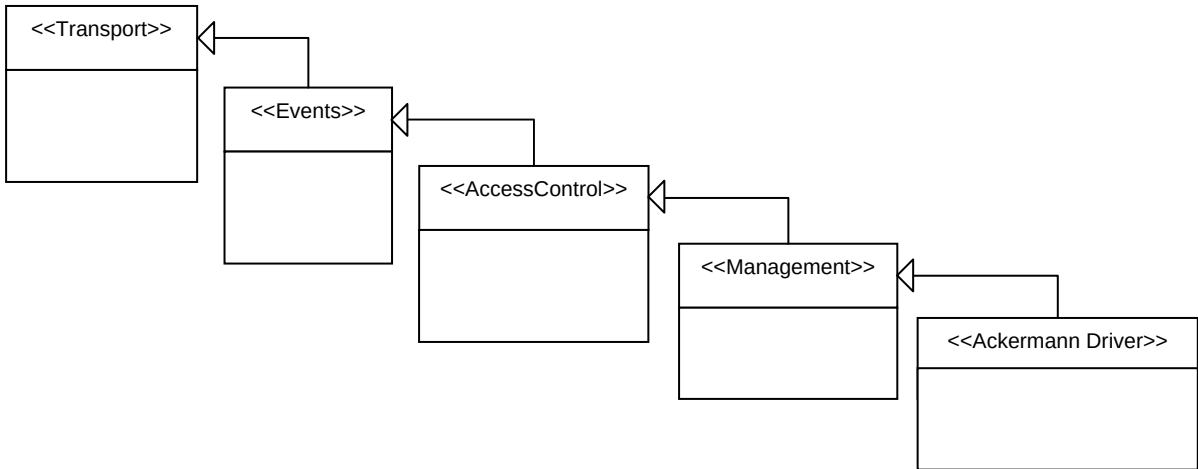
TABLE 21 - SKID STEER DRIVER SERVICE TRANSITIONS ACTIONS TABLE

Action	Interpretation
setSkidSteerEffort	Set the actuator effort levels for each side of the vehicle.
sendReportSkidSteerEffort	Send a Report Skid Steer Effort message
stopMotion	Stop motion on both sides.

4.3 AckermannDriver

name= AckermannDriver
version=1.0
id=urn:jaus:jss:ugv:AckermannDriver

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



4.3.1 Description

The AckermannDriver provides the means to control Ackermann steered vehicles. An Ackermann vehicle uses steering linkages in which the inside and outside wheels are turned at different angles to compensate for the different radii each wheel traces through a turn.

4.3.2 Assumptions

Messages may be delayed, lost or reordered.

4.3.3 Vocabulary

TABLE 22 - ACKERMANN DRIVER SERVICE MESSAGE VOCABULARY

Message ID (hex)	Name	Command
Input Set		
0500	SetAckermannConfiguration	true
2500	QueryAckermannConfiguration	false
Output Set		
4500	ReportAckermannConfiguration	false

4.3.4 Encoding

4.3.4.1 Input Set

4.3.4.1.1 ID 0500: SetAckermannConfiguration

This message sets the Ackermann driver parameters for the vehicle.

TABLE 23 - SETACKERMANNCONFIGURATION MESSAGE ENCODING

body └ record name = ackermanData					
Record Name = ackermannData					
Field #	Name	Type	Units	Optional	Interpretation
1	<presence_vector>	Unsigned byte	One	False	
2	<fixed_field> SteeringAngle	unsigned short integer	radian	False	The desired effective steering angle of the vehicle, as measured by a virtual wheel at the center of the front axle. Negative values cause the platform to turn left; positive values cause the vehicle to turn right. Control systems that attach directly to the steering wheel/column may need to convert this value to a steering wheel position that achieves the desired steering angle. (scaled range = $[-\pi/2, \pi/2]$, round)
3	<fixed_field> ThrottleEffort	unsigned short integer	one	False	As a percent of maximum. (scaled range = $[0.0, 100.0]$, round)
4	<fixed_field> BrakeEffort	unsigned short integer	one	False	As a percent of maximum. (scaled range = $[0.0, 100.0]$, round)
5	<fixed_field> MaxSteeringRate	Unsigned short integer	Radian per second	true	The absolute value of the maximum rate of change in the steering angle. Lower values result in more gradual steering changes. (scaled_range = $[0, 32.767]$, round)
6	<fixed_field> MaxSteeringTorque	Unsigned short integer	Newton meter	true	The absolute value of the maximum torque allowed to effect a change in steering angle, as experienced at the steering wheel. Lower values allow a human operator to override remote commands. (scaled_range = $[0, 500]$, round)

4.3.4.1.2 ID 2500: QueryAckermannConfiguration

This message queries the current Ackermann driver parameters for the vehicle.

TABLE 24 - QUERYACKERMANNCONFIGURATION MESSAGE ENCODING

body └ (empty)
Empty message body

4.3.4.2 Output Set

4.3.4.2.1 ID 4500: ReportAckermannConfiguration

This message reports the current Ackermann driver parameters for the vehicle.

TABLE 25 - REPORTACKERMANNCONFIGURATION MESSAGE ENCODING

body └ record name = ackermanDataRec					
Record Name = ackermannDataRec					
Field #	Name	Type	Units	Optional	Interpretation
1	<presence_vector>	Unsigned byte	One	False	
2	<fixed_field> SteeringAngle	unsigned short integer	radian	false	The desired effective steering angle of the vehicle, as measured by a virtual wheel at the center of the front axle. Negative values cause the platform to turn left; positive values cause the vehicle to turn right. Control systems that attach directly to the steering wheel/column may need to convert this value to a steering wheel position that achieves the desired steering angle. (scaled range = $[-\pi/2, \pi/2]$, round)
3	<fixed_field> ThrottleEffort	unsigned short integer	one	false	As a percent of maximum. (scaled range = $[0.0, 100.0]$, round)
4	<fixed_field> BrakeEffort	unsigned short integer	one	false	As a percent of maximum. (scaled range = $[0.0, 100.0]$, round)
5	<fixed_field> SteeringRate	Unsigned short integer	Radian per second	true	The current rate of change in the steering angle. Negative values indicate the vehicle is trying to turn left. (scaled_range = $[-32.768, 32.767]$, round)
6	<fixed_field> SteeringTorque	Unsigned short integer	Newton meter	true	The current torque allowed to effect a change in steering angle, as experienced at the steering wheel. Negative values indicate the vehicle is trying to turn left. (scaled_range = $[-500, 500]$, round)

4.3.5 Protocol Behavior

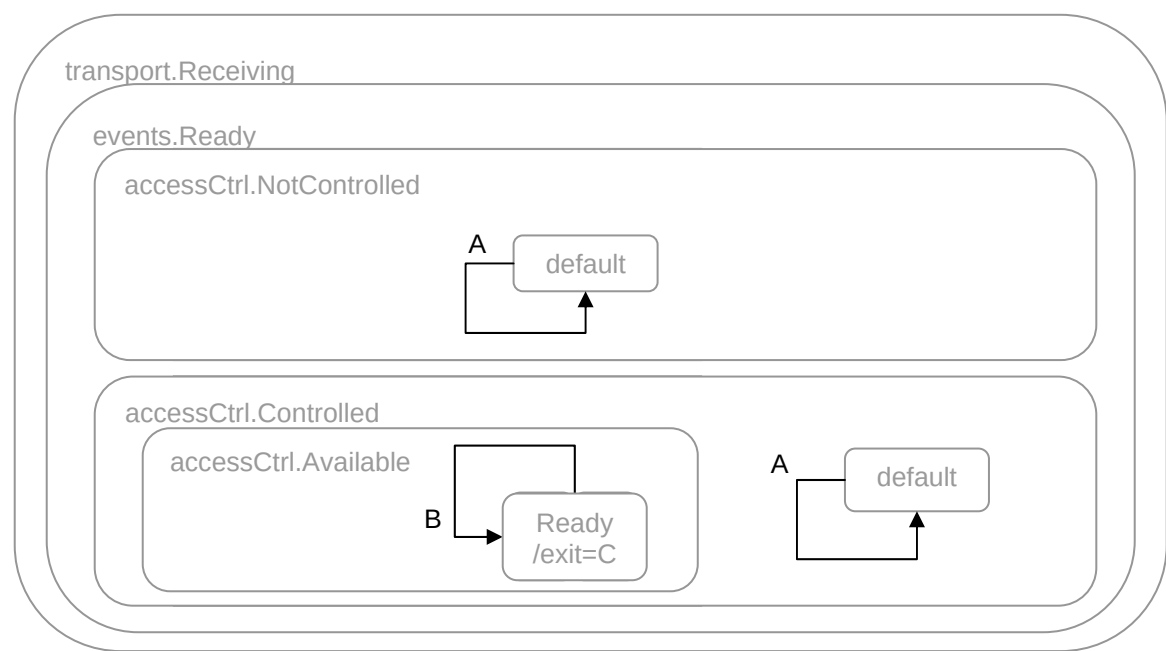


FIGURE 4 - ACKERMANN DRIVER SERVICE PROTOCOL BEHAVIOR

TABLE 26 - ACKERMANN DRIVER SERVICE ENTRY/EXIT ACTION TABLE

Label	State	Type	Guard	Actions
C	management.Ready	exit		stopMotion

TABLE 27 - ACKERMANN DRIVER SERVICE TRANSITION TABLE

Label	Trigger	Guard	Actions
A	QueryAckermannConfiguration		sendReportAckermannConfiguration
B	SetAckermannConfiguration	isControllingClient	setAckermannConfiguration

TABLE 28 - ACKERMANN DRIVER SERVICE 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.

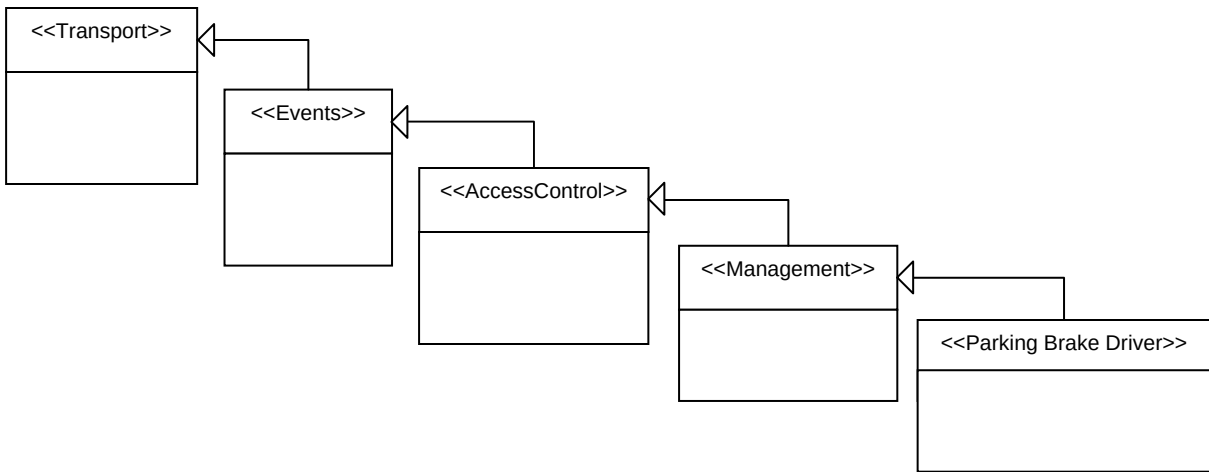
TABLE 29 - ACKERMANN DRIVER SERVICE TRANSITIONS ACTIONS TABLE

Action	Interpretation
setAckermannConfiguration	Set the throttle, brake and steering parameters for the vehicle.
sendReportAckermannConfiguration	Send a Report Ackermann parameters message
stopMotion	Stop motion on all tracks.

4.4 ParkingBrakeDriver

name= ParkingBrakeDriver
version=1.0
id=urn:jaus:jss:ugv:ParkingBrakeDriver

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



4.4.1 Description

The Parking Brake Driver provides the means to control parking brakes. A parking brake is defined as a latching brake intended to keep the vehicle stationary.

4.4.2 Assumptions

Messages may be delayed, lost or reordered.

4.4.3 Vocabulary

TABLE 30 - PARKING BRAKE DRIVER SERVICE MESSAGE VOCABULARY

Message ID (hex)	Name	Command
Input Set		
0512	SetParkingBrake	true
2512	QueryParkingBrake	false
Output Set		
4512	ReportParkingBrake	false

4.4.4 Encoding

4.4.4.1 Input Set

4.4.4.1.1 ID 0512: SetParkingBrake

This message sets parking brake to the specified level of engagement.

TABLE 31 - SETPARKINGBRAKE MESSAGE ENCODING

body └─ record name = parkingBrakeRec					
Record Name = parkingBrakeRec					
Field #	Name	Type	Units	Optional	Interpretation
1	<fixed_field> parkingBrake	unsigned byte	one	false	Percentage of application. Zero means off, while 100% mean fully engaged. (scale_range = [0, 100], rounded)

4.4.4.1.2 ID 2512: QueryParkingBrake

This message queries current parking brake level of engagement.

TABLE 32 - QUERY PARKINGBRAKE MESSAGE ENCODING

body └─ (empty)					
Empty message body					

4.4.4.2 Output Set

4.4.4.2.1 ID 4512: ReportParkingBrake

This message reports commanded and current parking brake level of engagement.

TABLE 33 - REPORTPARKINGBRAKE MESSAGE ENCODING

body └─ record name = parkingBrakeRec					
Record Name = parkingBrakeRec					
Field #	Name	Type	Units	Optional	Interpretation
1	<fixed_field> commandedParkingBrake	unsigned byte	one	false	Percentage of application. Zero means off, while 100% mean fully engaged. (scale_range = [0, 100], rounded)
2	<fixed_field> actualParkingBrake	unsigned byte	one	false	Percentage of application. Zero means off, while 100% mean fully engaged. (scale_range = [0, 100], rounded)

4.4.5 Protocol Behavior

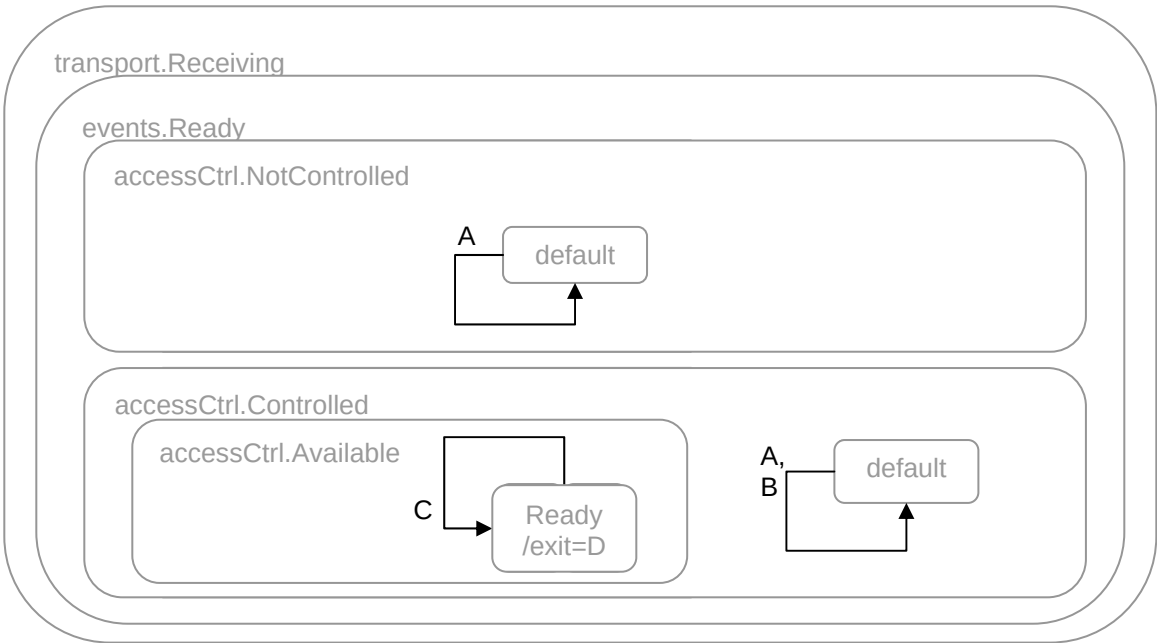


FIGURE 5 - PARKING BRAKE DRIVER SERVICE PROTOCOL BEHAVIOR

TABLE 34 - PARKING BRAKE DRIVER SERVICE ENTRY/EXIT ACTION TABLE

Label	State	Type	Guard	Actions
D	management.Ready	exit		engageBrake

TABLE 35 - PARKING BRAKE DRIVER SERVICE TRANSITION TABLE

Label	Trigger	Guard	Actions
A	QueryParkingBrake		sendReportParkingBrake
B	SetParkingBrake	isControllingClient && isEngage	setBrakeLevel
C	SetParkingBrake	isControllingClient	setBrakeLevel

TABLE 36 - PARKING BRAKE DRIVER SERVICE 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.
isEngage	True if the message that triggered the transition is a request to engage the brake to a level greater than the current setting (more braking)

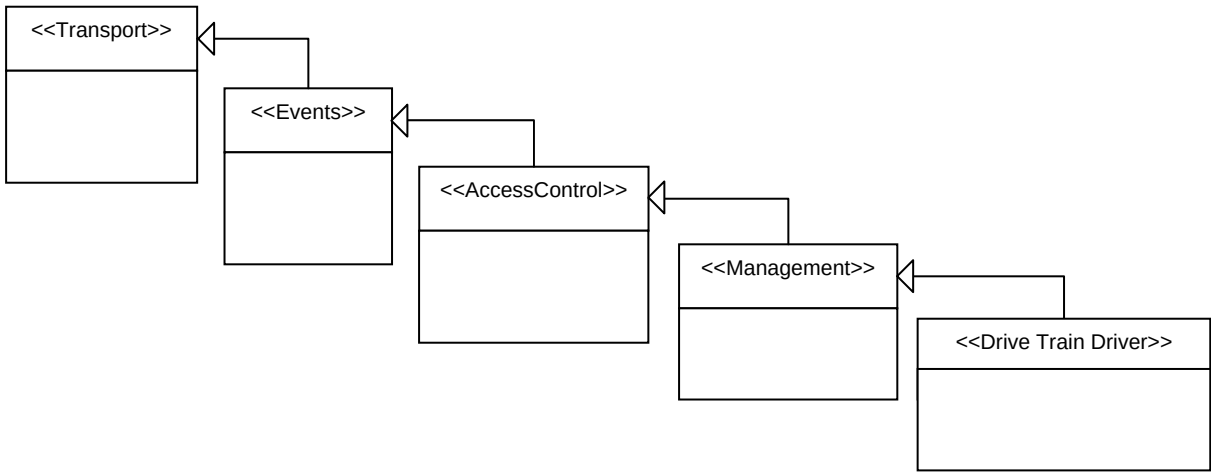
TABLE 37 - PARKING BRAKE DRIVER SERVICE TRANSITIONS ACTIONS TABLE

Action	Interpretation
sendReportParkingBrake	Send a Report Parking Brake message
setBrakeLevel	Set the parking brake to the specified level.
engageBrake	Set the parking brake to the fully engaged level

4.5 Drive Train Driver

name= DriveTrainDriver
version=1.0
id=urn:jaus:jss:ugv:DriveTrainDriver

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



4.5.1 Description

The Drive Train Driver provides the means to control transmissions.

4.5.2 Assumptions

Messages may be delayed, lost or reordered.

4.5.3 Vocabulary

TABLE 38 - DRIVETRAINDRIVER SERVICE MESSAGE VOCABULARY

Message ID (hex)	Name	Command
Input Set		
0509	SetTransmissionState	true
2509	QueryTransmissionState	false
0510	SetTransferCaseState	true
2510	QueryTransferCaseState	false
2511	QueryTransmissionCapabilities	false
Output Set		
4509	ReportTransmissionState	false
4510	ReportTransferCaseState	false
4511	ReportTransmissionCapabilities	false

4.5.4 Encoding

4.5.4.1 Input Set

4.5.4.1.1 ID 0509: SetTransmissionState

This message sets the desired transmission state.

TABLE 39 - SETTRANSMISSIONSTATE MESSAGE ENCODING

body └ record name = transmissionStateRec					
Record Name = transmissionStateRec					
Field #	Name	Type	Units	Optional	Interpretation
1	<fixed_field> TransmissionState	Unsigned byte	one	false	Value set, offset=false, ranges/enums: 0= DEFAULT 1= PARK 2= NEUTRAL 3= REVERSE 4= DRIVE 5= OVERDRIVE 6= L1 7= L2 8= L3 9= L4 10= L5 11= L6 12= L7 13= L8 14= L9 15= L10

4.5.4.1.2 ID 2509: QueryTransmissionState

This message queries for the current transmission state.

TABLE 40 - QUERYTRANSMISSIONSTATE MESSAGE ENCODING

body (empty)
Empty message body

4.5.4.1.3 ID 0510: SetTransferCaseState

This message sets the desired transfer case state for Front, Four, or All Wheel Drive vehicles.

TABLE 41 - SETTRANSFERCASESTATE MESSAGE ENCODING

body record name = transferCaseState					
Record Name = transferCaseState					
Field #	Name	Type	Units	Optional	Interpretation
1	<fixed_field> TransferCaseState	unsigned byte	one	false	Value set, offset=false, ranges/enums: 0= DEFAULT 1= FWD 2= AUTO_4WD 3= MANUAL_LOW_4WD 4= MANUAL_HIGH_4WD 5= LOW_AWD 6= HIGH_AWD 7-200= Reserved for future JAUS messages 201-255= Reserved for user defined use

4.5.4.1.4 ID 2510: QueryTransferCaseState

This message queries for the current transfer case state.

TABLE 42 - QUERYTRANSFERCASESTATE MESSAGE ENCODING

body (empty)
Empty message body

4.5.4.1.5 ID 2511: QueryTransmissionCapabilities

This message queries for a bitfield of valid gears and transfer case settings.

TABLE 43 - QUERYTRANSMISSIONCAPABILITIES MESSAGE ENCODING

body (empty)
Empty message body

4.5.4.2 Output Set

4.5.4.2.1 ID 4509: ReportTransmissionState

This message returns the current transmission state.

TABLE 44 - REPORTTRANSMISSIONSTATE MESSAGE ENCODING

body └ record name = reportTransmissionStateRec					
Record Name = reportTransmissionStateRec					
Field #	Name	Type	Units	Optional	Interpretation
1	<fixed_field> RequestedTransmissionState	Unsigned byte	one	false	Value set, offset=false, ranges/enums: 0= DEFAULT 1= PARK 2= NEUTRAL 3= REVERSE 4= DRIVE 5= OVERDRIVE 6= L1 7= L2 8= L3 9= L4 10= L5 11= L6 12= L7 13= L8 14= L9 15= L10
1	<fixed_field> ActualTransmissionState	Unsigned byte	one	false	Value set, offset=false, ranges/enums: 0= DEFAULT 1= PARK 2= NEUTRAL 3= REVERSE 4= DRIVE 5= OVERDRIVE 6= L1 7= L2 8= L3 9= L4 10= L5 11= L6 12= L7 13= L8 14= L9 15= L10

4.5.4.2.2 ID 4510: ReportTransferCaseState

This message returns the current transfer case state for Front Wheel Drive or All Wheel Drive vehicles.

TABLE 45 - REPORTTRANSFERCASESTATE MESSAGE ENCODING

body └─ record name = transferCaseState					
Record Name = transferCaseState					
Field #	Name	Type	Units	Optional	Interpretation
1	<fixed_field> TransferCaseState	Unsigned byte	one	false	Value set, offset=false, ranges/enums: 0= DEFAULT 1= FWD 2= AUTO_4WD 3= MANUAL_LOW_4WD 4= MANUAL_HIGH_4WD 5= LOW_AWD 6= HIGH_AWD 7-200= Reserved for future JAUS messages 201-255= Reserved for user defined use

4.5.4.2.3 ID 4511: ReportTransmissionCapabilities

This message returns a bitfield of valid gears and transfer case settings. Each high bit represents a gear or transfer case setting supported by the vehicle.

TABLE 46 - REPORTTRANSMISSIONCAPABILITIES MESSAGE ENCODING

body └─ record name = transmissionCapabilities					
Record Name = transmissionCapabilities					
Field #	Name	Type	Units	Optional	Interpretation
1	<bit_field> transmissionBF	unsigned short integer	bit_field	false	When the bit is set high, the vehicle supports the specified mode. Otherwise, it is not supported. Bit 0: Transmission PARK Bit 1: Transmission NEUTRAL Bit 2: Transmission REVERSE Bit 3: Transmission DRIVE Bit 4: Transmission OVERDRIVE Bit 5: Transmission L1 Bit 6: Transmission L2 Bit 7: Transmission L3 Bit 8: Transmission L4 Bit 9: Transmission L5 Bit 10: Transmission L6 Bit 11: Transmission L7 Bit 12: Transmission L8 Bit 13: Transmission L9 Bit 14: Transmission L10 Bit 15: Reserved
1	<bit_field> transferCaseBF	unsigned byte	bit_field	false	When the bit is set high, the vehicle supports the specified mode. Otherwise, it is not supported. Bit 0: Transfer Case FWD Bit 1: Transfer Case AUTO_4WD Bit 2: Transfer Case MANUAL_LOW_4WD Bit 3: Transfer Case MANUAL_HIGH_4WD Bit 4: Transfer Case LOW_AWD Bit 5: Transfer Case HIGH_AWD Bit 6: Reserved for future use Bit 7: Reserved for user defined use

4.5.5 Protocol Behavior

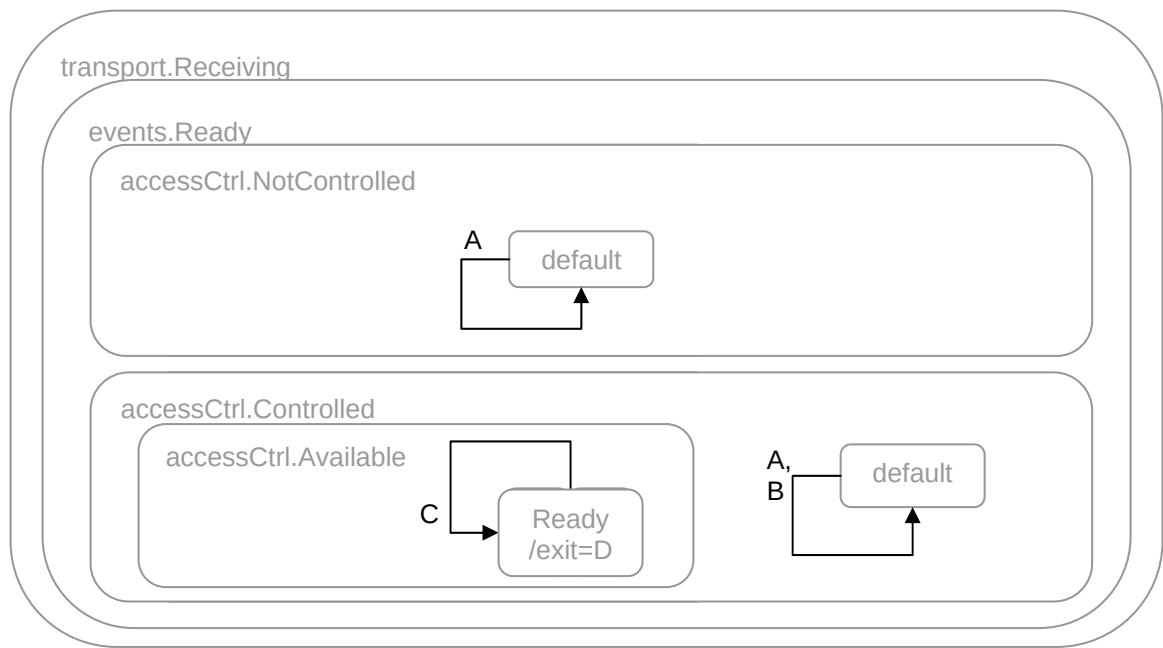


FIGURE 6 - DRIVE TRAIN DRIVER SERVICE PROTOCOL BEHAVIOR

TABLE 47 - DRIVE TRAIN DRIVER SERVICE ENTRY/EXIT ACTION TABLE

Label	State	Type	Guard	Actions
D	management.Ready	exit		shiftToPark

TABLE 48 - DRIVE TRAIN DRIVER SERVICE TRANSITION TABLE

Label	Trigger	Guard	Actions
A	QueryTransmissionState		sendReportTransmissionState
	QueryTransferCaseState		sendReportTransferCaseState
	QueryTransmissionCapabilities		sendReportTransmissionCapabilities
B	SetTransferCaseState	isControllingClient && isSupported	setTransferCaseState
	SetTransmissionState	isControllingClient && isPark	setTransmissionState
C	SetTransmissionState	isControllingClient && isSupported	setTransmissionState

TABLE 49 - DRIVE TRAIN DRIVER SERVICE 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>isSupported</i>	True if the message contains a transmission or transfer case mode that is supported by the service.
<i>isPark</i>	True if the message is a request to shift to the 'Park' state. If the vehicle does not support Park, this condition is true if the requested transmission or transfer case mode would prevent or inhibit vehicle motion.

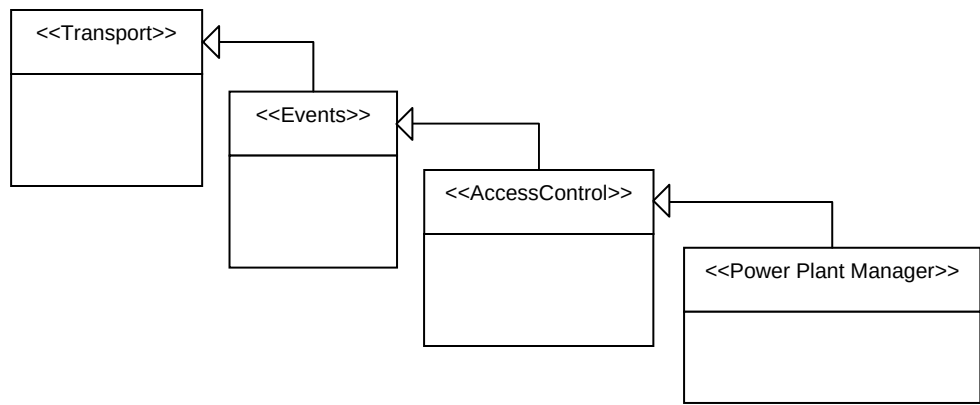
TABLE 50 - DRIVE TRAIN DRIVER SERVICE TRANSITIONS ACTIONS TABLE

Action	Interpretation
<i>sendReportTransmissionState</i>	Send a Report Transmission State message
<i>sendReportTransferCaseState</i>	Send a Report Transfer Case State message
<i>sendReportTransmissionCapabilities</i>	Send a Report Transmission Capabilities message
<i>setTransferCaseState</i>	Set the specified transfer case state.
<i>setTransmissionState</i>	Set the specified transmission state.
<i>shiftToPark</i>	When leaving the Ready state, the transmission should switch to Park once the vehicle has safely stopped. If the vehicle does not support Park, it should transition into a state that prevents or inhibits vehicle motion.

4.6 Power Plant Manager

name= PowerPlantManager
version=1.0
id=urn:jaus:jss:ugv:PowerPlantManager

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



4.6.1 Description

The Power Plant Manager provides the means to control and monitor vehicle power plants, such as gas engines or batteries.

4.6.2 Assumptions

Messages may be delayed, lost or reordered.

4.6.3 Vocabulary

TABLE 51 - POWER PLANT MANAGER SERVICE MESSAGE VOCABULARY

Message ID (hex)	Name	Command
Input Set		
0506	SetPowerPlantConfiguration	true
2506	QueryPowerPlantConfiguration	false
2507	QueryPowerPlantCapabilities	false
2508	QueryPowerPlantStatus	false
Output Set		
4506	ReportPowerPlantConfiguration	false
4507	ReportPowerPlantCapabilities	false
4508	ReportPowerPlantStatus	false