



BSI Standards Publication

Autonomous system and fleet management system interoperability

National foreword

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Standard**

ISO 23725

**Autonomous system and
fleet management system
interoperability**

*Interopérabilité du système autonome et du système de gestion de
la flotte*

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 82, *Mining*, SC 8, *Advanced automated mining systems*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

A strategic objective for the global mining industry is to develop standards to support holistic, integrated and interoperable mine operating automation that will improve mining operations efficiency. Interoperability enables many benefits; optimal interaction of mine operating equipment and processes, integration of upstream process information (e.g. exploration, resource modelling and planning), minerals extraction and downstream processes (e.g. refining, smelting and transportation) to increase levels of operational efficiency. This document progresses interoperability in the global mining industry.

The purpose of this document is to define a reproducible integration of an autonomous haulage system (AHS) and a fleet management system (FMS) to avoid customized implementations at every site. It allows a supplier with a narrow product coverage but highly valuable core mining competencies to participate and deliver open-autonomy components in the overall autonomy technology stack.

This document defines a software API, an open-autonomy interface, that allows independent vendors to supply an FMS to dispatch an AHS autonomous fleet. The API allows for future innovations and a wide variety of implementations without requiring a modification to the protocol.

This document interface aims to create an API that will deliver:

- system wide source of truth digital map and machine positions on this map
- dispatch functionality of autonomous trucks to support material movement, fuelling, and parking.
- generate autonomous equipment production monitoring.

The scope for viable interoperability between the AHS and FMS is the API and that is the focus of this document.

Autonomous system and fleet management system interoperability

1 Scope

This document defines the interfaces required between the fleet management (FMS) and autonomous haulage (AHS) systems for dispatch of haul trucks and coordination of production information, including communication protocols, message structures, telemetry signals, map sharing and task assignments.

This document applies to surface mining. It specifies requirements and recommendations to achieve the following:

- realtime computer system communication;
- message definition and semantic;
- mine map sharing;
- truck dispatching;
- truck production monitoring.

This document does not address computer system authentication, authorization and cyber security. These methods and technologies are already covered by best practice IT deployments.

The specific requirements for safe operation of machines, including execution of task assignments issued by the FMS to the AHS rely on additional information that is agreed between the FMS and AHS supplier which is outside the scope of this document.

2 Normative references

The following documents are referred in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, on the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 8601 (all parts), *Date and time — Representations for information interchange*

ISO 11992-2, *Road vehicles — Interchange of digital information on electrical connections between towing and towed vehicles — Part 2: Application layer for brakes and running gear*

3 Terms, definitions and abbreviations

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1 Terms and definitions

3.1.1

all-stop function

function that brings all autonomous machines under the operator's supervision to a halted state when initiated

[SOURCE: ISO 17757:2019, 3.1.18, modified — The word "system" was replaced by "function".]

3.1.2

actor

software involved in communication over a connection, either providing a service or using a service

3.1.3

attribute

<JSON object> term attribute referencing to a key as opposed to an "object"

3.1.4

operator

person having control and responsibility for operating a machine or the autonomous haulage system

3.1.5

manual mode

mode of operation in which a machine is controlled by an *operator* ([3.1.4](#)) who is responsible for monitoring the surroundings and for safe operation of all machine controls

[SOURCE: ISO 17757:2019, 3.1.13]

3.1.6

pose

machine position and orientation (heading)

Note 1 to entry: The pose needs a standard frame of reference {0,0,0} for each machine so they are properly placed in space for any coordinate systems.

3.1.7

tray

<dumper body> that portion of a dumper which carries material

3.1.8

risk assessment

overall process comprising a risk analysis and a risk evaluation

[SOURCE: ISO 12100:2010, 3.17]

3.2 Abbreviations

AOZ	autonomous operating zone
API	application program interface
AHS	Autonomous Haulage System
FMS	fleet management system
GNSS	global navigation satellite system
GUID	globally unique identifier
IANA	Internet Assigned Numbers Authority

JSON	Java Script Object Notation
LV	light vehicle
UID	unique identification
TLS	transport layer security
SOP	Standard Operating Procedure
SSL	secure socket layer. Synonymous with TLS. TLS is the newer version of SSL
TUM	time usage model
wss://	web socket secure

4 Computer communication

The goals of the protocol design shall be

- a) event based (no polling),
- b) bi-directional,
- c) cloud friendly (leverage web technologies),
- d) rapid disconnection detection, and
- e) events are sent immediately,

Standard IT infrastructure is not the primary focus of this document. This document does not specify:

- security,
- authentication,
- redundancy,
- scaling,
- encryption, and
- certificates.

These functions should be implemented to support the demand of each specific deployment. See [Annex B](#) for more details.

4.1 Session and transport layer

The client system shall use a TCP/IP websocket secure (wss://) to connect to services defined in this document.

Once the connection is established, then the state of each data models shall be shared (not necessarily synchronized) between the client and the server.

Once the data models are shared, then each system shall update the other system through the wss:// connection as events and states change.

4.1.1 WebSocket client and service behaviour

The following should be behaviours of the WebSocket client and server:

- WebSocket clients should implement an automatic re-connection to the WebSocket server if the connection is lost.
- WebSocket servers (listeners) should implement a configurable Ping in accordance to RFC6455, Section 5.5.2.
- WebSocket clients may implement a configurable Ping in accordance to RFC6455, Section 5.5.2.

NOTE Some WebSocket implementations will close the connection if there is no frame transferred for a certain amount of time. RFC 6455, Section 5.5.2 provides a Ping-Pong function to prevent premature closure.

4.2 Presentation layer

The presentation layer is defined by OSI, presentation layer - ISO/IEC 7498-1 (basic model).

4.2.1 Container, serialization, and encoding

The following specifications shall apply to container, serialization, and encoding (see [Table 1](#)):

Table 1 — Container, serialization and encoding

Layer	Specifications
Container	JSON ECMA-404
Serialization	English text
Encoding	UTF-8

4.2.2 JSON container

The JSON notation shall be used in English human readable form to represent serialized object.

4.2.3 NULL attribute

If an attribute is required in a message (see [7.5](#)) but is un-instrumented on the machine (i.e., it does not exist physically) from the sender, then the attribute shall be set to 'null'.

NOTE Null has a different semantic than 0 and different from an empty array. NULL means it is absent. An empty array means that at the moment the list is empty, but the array may grow beyond empty in the future. Semantically, a zero value does not imply unknown, broken or invalid unless otherwise stated in the specification.

4.2.4 Units

The exchanged attributes shall use a common set of units for the different measurements. The following units shall be used for value transmission (see [Table 2](#)):

Table 2 — Measurement units

Measurement	Unit
UTC Date time stamp	ISO 8601 (all parts)
Time	seconds
Distance	meter
Speed	km/h
Angle	degree
Temperature	Celsius

Table 2 (continued)

Measurement	Unit
Pressure	kPa
Mass	kg
Heading	degree

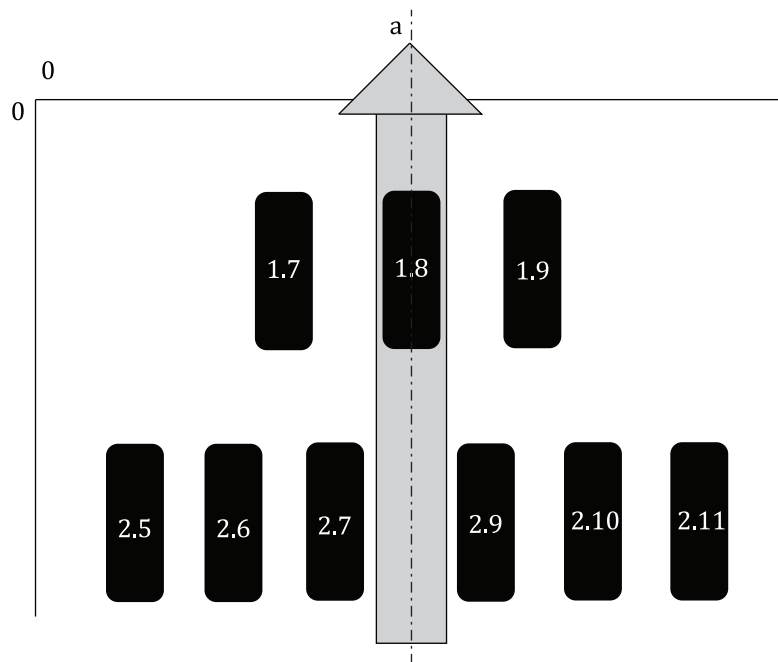
4.2.5 On machine component arrays

ISO 11992-2 shall be used to identify a particular tire/wheel and axle position. For consistency, the same numbering method shall be used to identify a particular machine component when there are multiple component instances on a machine.

Machine components shall be numbered according to their position on the machine. Represented as a 2D coordinate in the form {ROW, COLUMN}. Rows are starting from the front to the back of the machine in accordance to their position.

Row numbering shall start at 1.x, and increasing in increments of 1 (i.e. 1.x, 2.x, etc.). Objects to the left of the middle should count down from .7 and objects to the right of the middle should count up from .9. An odd cardinality of components (a middle component) shall be assigned ROW#.8 (ROW# corresponding to the specific row number).

The following examples clarify when and how to use ROW#.8 for odd and even number of items; [Figure 1](#) and [Figure 2](#) a) and b) provide examples of component numberings.



^a Forward driving direction.

Figure 1 — Example of tire number on 9-wheel rig (adapted from ISO 11992-2:2014)

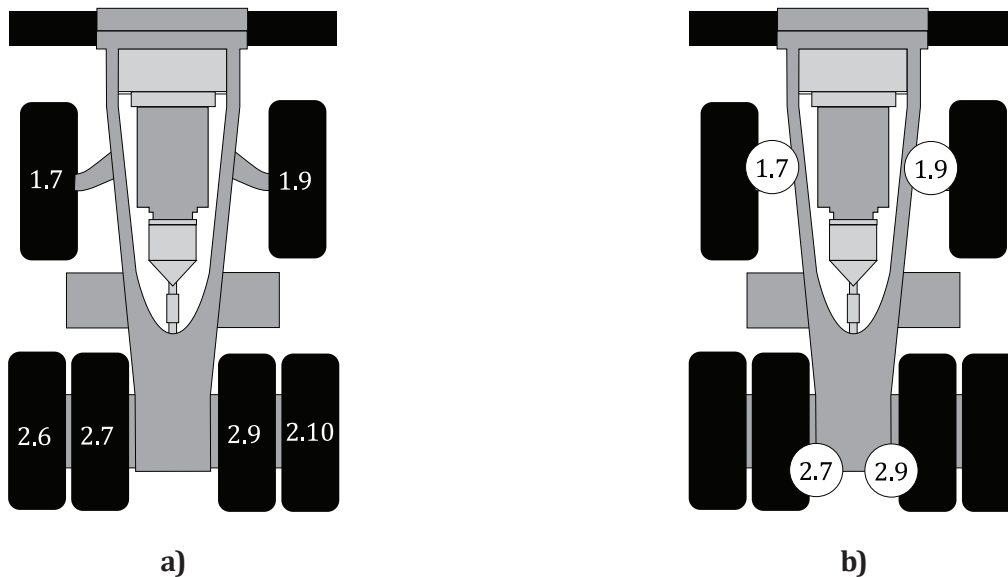


Figure 2 — Example of tire and strut numbering on a rigid dump truck

[Figure 2 a\)](#) is numbering the tires of a rigid dump truck. The procedure is

- to orient the machine's front pointing upwards.
- All tires of the first row start with a "1.", the one to the left is "1.7" and the one on the right is "1.9". There is no "1.8" because there is no tire in the middle.
- All tires of the second row start with a "2.", the one to the most left is "2.6", then its right neighbour is "2.7". The 2 tires to the right of the middle are "2.9" and "2.10" is the right most.

[Figure 2 b\)](#) is simpler as we're numbering the truck struts, use the same approach, the machine is oriented forward then follow the algorithm.

5 Messaging

5.1 Overview

The interface shall use asynchronous messaging and be compliant to the rule set in [Clause 4](#), which defines the transport, container, encoding and behaviour.

[Annex A](#) contains a set of sequence diagram as examples of how the messages are expected to be used between the systems. [Annex A](#) should be consulted to understand how they are intended to be used under typical circumstances.

5.2 Event based messaging

- A message shall be sent when a state or measurement is changed within the monitored system. Continuously changing measurements shall be limited to a maximum message sending frequency.
- The maximum frequency shall be configurable on a per message type basis on the sending application during commissioning.
- Unchanged state messages shall not be sent periodically based on a timer.

5.3 Message header

5.3.1 General

All messages in conformity with to this document shall contain the message header as described in [Table 3](#).

Table 3 — Message header

Attribute	Req. Level	Type	Exactly	Description
Protocol	shall	UKey	ISO23725	A unique human readable string used to identify that this message object is compliant with the ISO 23725 interface.
Version	shall	integer	1	The version of the protocol in use. This version shall change if there is a break in backward compatibility in: — New mandatory field in the header — Presentation layer
Timestamp	shall	ISO 8601 (all parts)	<YYYY-MM-DD>T<HH:mm:ss[.sss]>Z	UTC Time (+0 Zulu). When the data or event contained in the message was measured. Milliseconds are optional and should be added if meaningful. The timestamp is used to mark when the data or event occurred, not when the message was serialized or when it left the computer.
EquipmentId	should	GUID		If the message is pertaining to a specific machine, then the message shall include the Equipment Identification in the header. The GUID is a unique Identification number that represents one-and-only-one piece of equipment defined in the fleet.

NOTE Stuffing arrays of objects intended for different pieces of equipment in a single message is prevented by design. This is achieved by placing the equipment ID in the message header. This implies that communication targeted to multiple equipment, (but not the entire fleet) needs to be sent in separate messages.

5.3.2 Header example

A message that is meant for the AHS, and not machine specific, should have a header that follows this example of a non-machine specific message header:

Header of message that is not specific to a machine.
<pre>{ "Protocol": "ISO23725", "Version": 1, "Timestamp": "2018-10-31T09:30:10.711Z" }</pre>

A message that applies to a specific machine, in this example machine “2248d535-3daf-4a86-b1e1-4951a22bec6” should have a header that follows this example of a machine specific message header

Header of message that is specific to machine identified by an equipment GUID.

```
{
  "Protocol": "ISO23725",
  "Version": 1,
  "Timestamp": "2018-10-31T09:30:10.511Z",
  "EquipmentId": "2248d535-3daf-4a86-b1e1-4951a22beec6"
}
```

5.4 Messages during connection outage

The actors participating in messaging should persist important messages during communication outages for a configurable time duration. When the communication is re-established, any persisted messages shall be sent over the re-established communication channel. The original timestamp of when the events occurred shall remain unchanged.

NOTE The main goal is to ensure that equipment data is not lost in the case there is an outage. It is up to the integrators to decide which message are important to be persisted to reach the desired application goal.

5.5 Out of standard message

5.5.1 General

Any message without a JSON attribute bearing a "Protocol": "ISO23725" attribute shall be IGNORED by the message interpreter. The message interpreter shall continue to operate normally after ignoring a message.

The websocket communication channel may be used to interweave out of standard messages that are not defined by this document, but supported by vendor specific implementations. All compliant message processors shall support the ability to discard unknown JSON messages that do not have a Protocol attribute or where the Protocol attribute is not equal to ISO23725 and shall continue to operate normally thereafter. The rejection of the message may be logged by the interpreter.

Out of standard messages that are sent on the same stream shall follow these conditions:

- The message shall be compliant with the formatting as defined in the presentation layer (see [4.2](#)).
- There shall NOT be any attribute named "Protocol" that equals to "ISO23725".

5.5.2 Out of standard examples

Two valid examples of what could consist "out of standard" messages are provided as follows:

```
{
  "MySpecificMessage": "The Blue Turtle",
  "MySpecificData": "Too Secret to be public"
}
```

A site specific extension to a standard message

```
{
  "Protocol": "MyCustomizedStandard",
  "Timestamp": "2018-10-31T09:30:10.43.711Z",
  "GUID": "2248d535-3daf-4a86-b1e1-4951a22beec6",
  "BetterMachinePosition": {
    "Heading": 211,
    "Latitude": 49.176854678267288,
    "Longitude": -123.0718674232,
    "Elevation": 175.23,
    "LatitudeAccuracy": 0.3164,
    "LongitudeAccuracy": 0.2743,
    "HeightAccuracy": 0.58,
    "HeadingAccuracy": 2.1,
    "Speed": 0,
    "PDOP": 2.75,
    "ReceiverModel": "Ublox",
    "GyroUsed": "yes"
  }
}
```

5.6 Common attribute enumeration

5.6.1 General

This clause will define a common set of enumerated values and their semantic that can be assigned to message attributes.

5.6.2 Actor

The following actor enumeration shall be used when referencing a specific actor in a message (see [Table 4](#)).

Table 4 — Actor enumeration

Actor Enumeration	Meaning
AHS	The whole self driving functionality composed of onboard and possibly back office services.
FMS	The whole Fleet Management functionality
MAP	The service sharing the information describing the road map. Including road segments, intersections and open area.

5.6.3 Action request

Table 5 — Action request enumeration

Action Enumeration	Meaning
Apply	Request a service provider for an action to be executed
Remove	Request a service provider for an action to be halted

5.6.4 Action response

Table 6 — Action response enumeration

Enumeration	Meaning
Accepted	Answer by the service provider that the requested action will be executed
Rejected	Answer by the service provider that the requested action will NOT be executed

5.6.5 Action status

Table 7 — Action status enumeration

Enumeration	Meaning
On	The action is being executed
Off	No action executing

5.6.6 Autonomy mode

Table 8 — Autonomy mode enumeration

Enumeration	Meaning
Manual	The machine is under human control
Autonomous	The machine is under computer control
TransitionToAutonomous	A human is transitioning the machine control to the computer in a safe manner
TransitionToManual	The computer is transitioning the machine control to a human in a safe manner
AllStop	The machine is under computer control, but immobilized. Remote human intervention will be required to allow machine movement.
EmergencyStop	The machine is now under human control and all fail-safe, emergency stopping, physical controls are engaged on the machine.
RemoteControl	The machine is under human control, where the human is usually not in line of sight of the machine. The human controls the machine through computers and a communication channel.

Each autonomy provider has their unique way to safely transition a machine from manual mode to autonomous mode. During integration, the autonomy supplier shall provide a document to the end-user mapping their implementation specific modes to the ones that best fit the meaning description above.

EXAMPLE If there are multiple states within the TransitionToAutonomous, the autonomy supplier would document that to say "TransitionToAutonomous" = "Machine Selection" + " Machine Authentication" + "Button Pressing" + "Move to safe location" or any dominant state. Another example, if AllStop is dominant on a RemoteControl state, the autonomy provider needs to document that while in AllStop, a person in Remote control would lose control of the machine and the computer would keep it immobilized.

6 System messaging

6.1 General

System messages shall not have an `EquipmentId` attribute in their header.

6.2 Fleet definition message

6.2.1 General

The fleet definition message shall be the first message to be sent by both actors upon connection.

Actors shall be able to receive and process a new fleet definition message with updated content at runtime. This message shall be re-sent by an actor when the list of machines monitored by the actor is changed. The list can change by adding, deleting or modifying a machine. Both actors shall use the same GUID and use an equivalent description for the same physical machine so the semantic is preserved across both systems.

On fleet change, only the actor owning the list that was modified shall send an updated fleet definition message.

Actors shall send and receive the fleet definition message in accordance to [Table 9](#).

Table 9 — Fleet definition message initiator and trigger

	AHS to FMS	FMS to AHS
Trigger: at connection	Yes	Yes
Trigger: runtime change	Yes	Yes

NOTE The purpose of this message is to catch important AHS-FMS fleet discrepancies and have end-users complete the configuration of the machine definition in the respective systems with their respective tools. This message is primarily to ensure that both systems are aware of the active machines that the other system manages.

The purpose is not to have a single synchronized source of Equipment definition. Rather a means to automatically monitor and alert a person when there are important discrepancies between the two systems. Each systems has a very distinct data model defining the machine attribute it requires per machine definition, there is no common data model that will covers all actor's needs.

Each system has their own proprietary machine data model that is configured with their respective native tools. The FleetDefinition is a simplified information exchanged to ensure that people managing both systems will be able to rapidly identify that they are talking about the same physical machine in both systems. The fleet definition can be validated by people because new autonomous equipment is rarely commissioned.

The content of a fleet definition message shall comply with (see [Table 10](#)).

Table 10 — Fleet definition structure

Member	Req. Level	Type	Description	Example
FleetDefinitionV2	shall	Object	Identifies this structure as a Fleet Definition	
AHSId	shall	GUID	A unique "key" that represents an AHS instance. This key is static across session and used for the life of the AHS instance it represents.	5318e44c-e9f0-42e2-9965-a4a1ff364f4b
Equipment	shall	Array of objects	Identifies this as a collection of equipment objects. The array can be empty but shall not be null.	"Equipment": []
EquipmentId	shall	GUID	The unique static "key" used in other messages to reference this piece of equipment.	0c83193f-8772-446a-89c0-a3977e282b8a
HID	shall	String	Human readable label as defined in the source system. Only meant to be meaningful to people.	LV033, "Bucyrus 05"
Type	shall	Enumeration	Describes the equipment category	HaulTruck, Shovel
OEM	shall	String	Original Equipment Manufacturer. The brand name that is stamped all over the equipment.	Honda
Model	shall	String	OEM model number / name	Civic, 793D

Table 10 (continued)

Member	Req. Level	Type	Description	Example
Autonomous	shall	Boolean	Autonomy capable	true, false
Length	shall	Decimal	The distance in meters from the front most to the rear most of the equipment	4,56
Width	shall	Decimal	The distance in meters from the left most to the right most of the equipment	1,43

NOTE Any future editing of the fleet, deleting or marking a machine as inactive, will simply have the machine disappear from the new equipment list in the fleet definition message. There is no delete command.

6.2.2 Fleet ID

The fleet id shall be unique amongst all fleets connecting to one FMS instance.

The fleet id shall be immutable across connection sessions and system reboot.

A fleet definition shall have exactly one Fleet id associated with it.

NOTE Be mindful that the set of equipment in this fleet will vary over time as machines are put in and out of commission. The fleet ID allows the actors to implement these use cases:

- Allow multiple different AHS fleet to connect to a single FMS. The FMS will use the Fleet Id to differentiate between the different AHS actors.
- Single AHS instances to share multiple fleets with a single FMS. For instance, when fleets are operated independently in different pits or sites.
- Allow for a single AHS to connect multiple concurrent sessions to the FMS and provides the FMS with a way to identify that these multiple sessions are aggregated and "act as one" and that they control the same fleet.

6.2.3 Equipment type

Only a valid enumeration contained in [Table 11](#) shall be used as an equipment type.

Table 11 — Machine type enumeration

Machine Type Enumeration
<pre>{ HaulTruck, Shovel, Excavator, Loader, LightVehicle, WaterCart, Grader, FuelTruck, LubeTruck, Dozer, RubberTireDozer, Drill, Crusher, Scraper, BellyDumper, EmergencyVehicle, Ambulance, Dragline, SurfaceMiner, Bus, Train, Trailer }</pre>

NOTE Equipment to equipment interactions are defined by the machine type and their capabilities, hence the need to identify and define the types of machines in the system. An autonomous truck will cross the path of other machines in the pit and could behave differently (slowdown, keep away or stop) depending on the machine type, model and if it's manned or autonomous.

6.2.4 Autonomous

This attribute shall be set to true if the machine can be used autonomously by an AHS otherwise it shall be set to false.

6.2.5 Equipment length and width

The length shall be the distance in meters from the front most to the rear most of the equipment.

The width shall be the distance in meters from the left most to the right most of the equipment.

NOTE The purpose of the equipment length and width are there so the systems have a general footprint of the equipment on the road. Each system is independently responsible for the level of data accuracy and integrity required for their application.

6.2.6 Fleet definition example

This is an example of what a very small fleet message could look like:

A Fleet with one truck and one light duty vehicle.

```
{
  "Protocol": "ISO23725",
  "Version": 1,
  "Timestamp": "2018-10-31T09:30:10.43.511Z",

  "FleetDefinitionV2": {
    "AHSId": "5318e44c-e9f0-42e2-9965-a4a1ff364f4b",
    "Equipment": [
      {
        "EquipmentId": "0c83193f-8772-446a-89c0-a3977e282b8a",
        "HID": "HT042",
        "Type": "HaulTruck",
        "OEM": "ETF",
        "Model": "Virtual-F",
        "Autonomous": true,
        "Length": 14.57 ,
        "Width": 9.02
      },
      {
        "EquipmentId": "2248d535-3daf-4a86-b1e1-4951a22beec6",
        "HID": "LV033",
        "Type": "LightVehicle",
        "OEM": "Ford",
        "Model": "F350",
        "Autonomous": false,
        "Length": 4.67 ,
        "Width": 2.52
      }
    ]
  }
}
```

An empty fleet during commissioning.

```
{
  "Protocol": "ISO23725",
  "Version": 1,
  "Timestamp": "2018-10-31T09:30:10.43.511Z",

  "FleetDefinitionV2": {
    "AHSId": "5318e44c-e9f0-42e2-9965-a4a1ff364f4b",
    "Equipment": [ ]
  }
}
```

6.3 Machine all-stop

6.3.1 Optional feature

The machine All-Stop functionality should only be enabled if a risk assessment has shown that the all-stop integration is safe and desired in the final solution.

If the machine All-Stop functionality is enabled, then these messages shall be implemented:

- a) MachineAllStopV1;
- b) MachineAllStopRequestV1;
- c) MachineAllStopResponseV1.

If machine All-Stop is disabled, then these messages above shall not be sent.

While the All-Stop is active the whole autonomous fleet

- shall remain under computer control,
- shall be immobilized,

To allow first responders to drive safely in the AOZ and reach the emergency as fast as possible without negotiating the road with moving autonomous machines.

NOTE The machine all-stop function is not an emergency stop. It is a best effort function only and it is not fail-safe. The all-stop is not to be used as a means to stop an autonomous machine that went rogue or that is about to collide with an object. A different system will need to be used for these use cases. Therefore a risk assessment is required to properly implement the Machine All-Stop.

6.3.2 Scope of effect

The machine all-stop functionality shall affect all fleets connected to the FMS. The All-Stop is applied to each autonomous machine in each fleet.

6.3.3 Machine all-stop status message

The machine All-Stop status shall be sent from the AHS to the FMS at connection time and immediately when it changes as per [Table 12](#).

Table 12 — Messages initiator and trigger

	AHS to FMS	FMS to AHS
Trigger: at connection	Yes	No
Trigger: runtime change	Yes	No

The All-Stop status {On,Off} shall not be used to determine if autonomous machines are immobilized.

The Machine all-stop status message shall follow the structure described in [Table 13](#).

Table 13 — Machine all-stop status structure

Member	Req. Level	Type	Description	Example
MachineAllStopV1	shall	Object	Identifies this object as an: All-Stop Status	
ModeAllStop	shall	Action Status enumeration	States the status of the All-Stop mode for the fleet controlled by AHS. On means that it is active and Off is deactivated.	“On” or “Off”
ModeAllStopId	shall	GUID	Value of the GUID comes from: — The last GUID inside the MachineAllStopRequest message of the FMS that changed the status. — A random GUID generated by AHS if the activation was not triggered by the FMS. (when triggered by the native AHS application) — A random GUID generated by AHS when a new connection is established and All-Stop is active. — Null if All-Stop is deactivated on initial connection.	0c83193f-8772-446a-89c0-a3977e282b8a

6.3.3.1 ModeAllStop

The value of the mode all-stop shall be Off in normal AHS Operation. The value of the mode all-stop shall be On if the All-Stop mode is active on the AHS.

6.3.3.2 ModeAllStopId

The value of the mode all-stop id shall be the latest GUID value used during the latest ModeAllStop status change.

The source of the GUID shall be the latest of

- FMS side generated GUID provided inside the MachineAllStopRequest message from the FMS
- AHS side generated GUID provided by AHS when the activation was triggered on AHS.
- AHS side generated GUID provided by AHS when a new connection is established and All-Stop is already active.

6.3.4 Machine all-stop request message

The message request to Apply or Remove an All-Stop shall be sent from the FMS to the AHS when initiated by an FMS user. [Table 14](#) specifies which actor shall send the message and when this message is expected.

Table 14 — Messages initiator and trigger

	AHS to FMS	FMS to AHS
Trigger: at connection	No	No
Trigger: runtime change	No	Yes

NOTE The dispatcher is normally the centre of all voice communication for the fleet, this functionality allows for a dispatcher to initiate the safe immobilization of the autonomous fleet when the dispatcher is made aware that first responders will need to enter the AOZ. The standard operation procedure (people, process, guards and tools) of how the All-Stop function is operated at site is site specific and out of scope.

The Machine all-stop request message shall follow the structure described in [Table 15](#).

Table 15 — Machine all-stop request structure

Member	Req. Level	Type	Description	Example
MachineAllStopRequestV1	shall	Object	Identifies this object as an: All-Stop Request	
ModeAllStop	shall	Action Request enumeration	Field that specifies the type of request from the FMS: { Apply, Remove }	"Apply","Remove"
ModeAllStopId	shall	GUID	A GUID specific to this request transaction. The Response to this request will be matched using this GUID.	"0c83193f-8772-446a-89c0-a3977e282b8a"

6.3.4.1 ModeAllStop

The FMS shall set this attribute to Apply to request to enable an All-Stop; alternatively set it to Remove to request that the All-Stop be lifted.

6.3.4.2 ModeAllStopId

The FMS shall generate a new GUID for each new request message. The FMS shall use the GUID to match the AHS reply to know the outcome of the request.

NOTE The GUID lifespan is only for a single request-response between the client and the server. Two different GUIDs need to be used when requesting to apply and when requesting to remove the All-Stop as it constitutes 2 different request-response. Using the same GUID for multiple requests may yield unexpected behaviours and is prohibited. The GUID is not used to link the "Apply" and "Remove" requests; but rather link the Request, the Reply and the source of change in the Status message.

6.3.5 Machine all-stop response message

The message response to the request shall be sent from the AHS to the FMS, moments after the FMS has sent an all-stop request see [Table 17](#).

[Table 16](#) specifies which actor shall send the message and when this message is expected.

Table 16 — Messages initiator and trigger

	AHS to FMS	FMS to AHS
Trigger: at connection	No	No
Trigger: runtime change	Yes	No

Table 17 — Machine all-stop response structure

Member	Req. Level	Type	Description
MachineAllStopResponseV1	shall	Object	Identifies this object as an: All-Stop Request
Response	shall	Enum	Consult Table 6 . The response indicates if AHS will comply with the FMS request.
ModeAllStopId	shall	GUID	The GUID corresponding to the specific FMS request instance.
Detail	may	String	Localized Human readable message explaining in more details the AHS Response; especially in the case of a rejection.

6.3.5.1 Response

The value of response shall be either one of "Accepted" or "Rejected". AHS shall set it to "Accepted" if AHS will execute the requested action, otherwise it shall be set to "Rejected".

6.3.5.2 ModeAllStopId

The value of ModeAllStopId shall be a copy of the GUID that was sent by the FMS in the Request message body that AHS is answering.

6.3.5.3 Detail

A localized human readable string may be provided to supplement the AHS response. The string shall not be longer than 1 024 bytes with an UTF-8 encoding.

NOTE To respect the specific AHS design, SOP and safety; the AHS implementation can always reject the request to remove the All Stop (by design).

6.3.6 Machine all-stop examples

Below are examples to help understand a few use cases of this message:

All Stop Status is Off. The normally expected state.	Sent by AHS
<pre>{ "Protocol": "ISO23725", "Version": 1, "Timestamp": "2018-10-31T09:30:10.43.511Z", " MachineAllStopV1": { "ModeAllStop": "Off", "ModeAllStopId": "34f388ec-09e9-4d95-9965-a4a1ff364f4b" } }</pre>	

A request to apply the All-Stop from the FMS.	Sent by FMS
<pre>{ "Protocol": "ISO23725", "Version": 1, "Timestamp": "2018-10-31T09:30:10.43.511Z", "MachineAllStopRequestV1": { "ModeAllStop": "Apply", "ModeAllStopId": "0e45793f-f1d0-420b-a1fa-85e3f42a7219" } }</pre>	

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Positive answer from AHS for the All-Stop request from the FMS.	Sent by AHS
<pre>{ "Protocol": "ISO23725", "Version": 1, "Timestamp": "2018-10-31T09:30:10.45.812Z ", "MachineAllStopResponseV1": { "Response": "Accepted", "ModeAllStopId": "0e45793f-f1d0-420b-alfa-85e3f42a7219", "Detail": "Sure can do, 27 haulers are stopping." } }</pre>	

All Stop Status is ON. While there is an emergency in the AOZ.	Sent by AHS
<pre>{ "Protocol": "ISO23725", "Version": 1, "Timestamp": "2020-06-06T09:30:10.43.725Z", " MachineAllStopV1": { "ModeAllStop": "On", "ModeAllStopId": "0e45793f-f1d0-420b-alfa-85e3f42a7219" } }</pre>	

A request to remove the All-Stop from the FMS.	Sent by FMS
<pre>{ "Protocol": "ISO23725", "Version": 1, "Timestamp": "2018-10-31T09:30:10.43.511Z", "MachineAllStopRequestV1": { "ModeAllStop": "Remove", "ModeAllStopId": " 34f388ec-09e9-4d95-9866-4eec876b37b2" } }</pre>	

A negative answer from AHS for the All-Stop remove request.	Sent by AHS
<pre>{ "Protocol": "ISO23725", "Version": 1, "Timestamp": "2018-10-31T09:30:10.45.812Z", "MachineAllStopResponseV1": { "Response": "Rejected", "ModeAllStopId": "34f388ec-09e9-4d95-9866-4eec876b37b2", "Detail": "The FMS is not allowed to remove the All Stop on this AHS version." } }</pre>	

7 Generic machine telemetry

7.1 Message content

Machine telemetry messages shall have an `EquipmentId` attribute in their header.

7.2 Data streams

This section defines messages that are related to on-machine data streams for sensors and actuators. Because sensor readings are constantly changing, they can't be sent on change. These messages will typically be time constrained with a period by setting a maximum update frequency.

This document does not prescribe the maximum or minimum frequency at which these messages are to be sent. The system integration team will determine how these streams will be used and what is the appropriate period to send each message. The integration team shall take into consideration the wireless bandwidth utilization, server resources, database space requirement and the end goal of the data collection.

7.3 Machine position

All actors shall send the Machine Position changes in their fleet. All Positions shall use an absolute earth frame of reference (Latitude, Longitude and elevation).

7.3.1 Machine coordinate system and frame of reference

The machine coordinate system shall be 3D cartesian using meters. The machine coordinate system's frame of reference of {0,0,0} of machines shall be

- {0,0,0} At front most protrusion, ground level for wheeled and tracked machines (because this point can be physically reached so can be physically surveyed) with right hand axis Y pointing forward. See Figure 13.
- {0,0,0} At the coupler on the tongue of an attachment (trailer).
- {0,0,0} At centre of rotation for swinging (rotating) machines (easily surveyed with HP GNSS onboard). With right hand axis Y pointing towards ground engagement tool.
- {0,0,0} At centre pin of articulated machines with right hand axis Y pointing forward.