



Antenna location and orientation sensor
AISG-ST-ALS
vALS3.0.3.1

Revision History

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1. FOREWORD (Informative)

This standard has been produced by the Antenna Interface Standards Group (AISG) to introduce and define new features and enhancement of the management system for antenna line devices (ALDs) with remote control and monitoring facilities. AISG v3.0 base standard describes the common behaviour of antenna line devices with AISG interfaces and type-specific functionality is defined in subunit type standards.

This subunit type standard defines the antenna location and orientation sensor (ALS) subunit type. This subunit is able to provide the following information from sensor or previously stored data.

- Geographical location of an antenna (called *coordinate sensor* capability).
- Altitude of an antenna (called *altitude sensor* capability).
- Azimuth, tilt and roll of an antenna (called *orientation sensor* capability).

ALS subunit also has the following additional features:

- If there is no corresponding sensor (that is, a capability is not supported), store and return the corresponding data. An ALS shall support at least one capability.
- Ability to generate alarms if the orientation of the antenna monitored by ALS changes outside of the set orientation alarm limits.
- Ability to record the minimum and maximum antenna orientation values since the last time orientation monitor values were cleared.

This standard is independent of previous 3GPP specifications.

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2. SCOPE (Informative)

AISG v3.0 specifies the standard data interface between a primary, typically a base station, and antenna line devices (ALDs) which are manageable units, usually associated with base station antennas.

The standard is divided into the base standard and several subunit type standards. This subunit type standard document describes the specific behaviour of the Antenna Location and orientation Sensor (ALS) subunit type.

This standard defines the functional behaviour of ALS subunits.

2.1. Interpretation (Normative)

The text of the standard defines explicitly what is required or permitted. Anything that is not explicitly allowed is not permitted.

All statements in this document are normative, unless indicated as informative, notes or as an example.

For purposes of compliance and AISG interoperability, users should note that the implementation of this subunit type standard is optional. However, once it is selected for inclusion in a product, the entire standard becomes mandatory.

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3. REFERENCES

This AISG Standard incorporates provisions from other publications. These are cited in the text and the referenced publications are listed below. Where references are listed with a specific version or release, subsequent amendments or revisions of these publications apply only when specifically incorporated by amendment or revision of this AISG standard. For references listed without a version or release, the latest edition of the publication referred to applies.

- 1 AISG v3.0: “Base Standard AISG v3.0”
- 2 AISG v3.0 STCM: “Subunit Type Compliance Matrix”
- 3 NIMA TR8350.2 U.S. Department of Defence World Geodetic System 1984, Third Edition – Amendment 1

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4. VERSION COMPLIANCE (Informative)

The compliance of this standard with different version of AISG v3 baseline standard is defined in [2].

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5. ABBREVIATIONS (Informative)

Where abbreviations or acronyms are used in this document they have the following meanings:

ALD	Antenna Line Device
ALS	Antenna Location and orientation Sensor
MALD	Multi-primary ALD
SALD	Single-primary ALD
TCC	Time-Consuming Command
3GPP	3 rd Generation Partnership Project
WGS	World Geodetic System

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6. TERMINOLOGY

Where the following terms are used in this document, they have the following meanings:

Altitude	The elevation of a point or object from the surface of the WGS84 [3] geoid. Altitude is reported in meters, to one decimal place in accuracy.
Altitude precision	A value that represents the standard deviation of values from its arithmetic mean measured by the ALS. This value may be used to judge the credibility of the values from the relevant sensor. Precision is reported in meters, to one decimal place of accuracy.
Measured altitude	A value representing the “best estimate” by the ALS of the altitude. This value may be the result of averaging historical data, or any other means of processing deemed appropriate by the ALS vendor for producing a consistently accurate result.
Measured location	Coordinates representing the “best estimate” by the ALS (of the latitude and the longitude). This value may be the result of averaging historical data, or any other means of processing deemed appropriate by the ALS vendor for producing a consistently accurate result.
Measured mechanical azimuth / tilt / roll	A value representing the “best estimate” of an antenna in one of three axes measured by the ALS (azimuth, tilt, roll). This value is the result of averaging historical data, or any other means of processing deemed appropriate by the ALS vendor for producing a consistently accurate result.
Electrical tilt	The electrical tilt angle is, in the vertical cut, the angle between the antenna mechanical boresight and the half-power beam axis. Positive tilt values represent main beam position below boresight. Negative tilt values represent main beam position above boresight.
Half-power beam axis	The half-power beamwidth is, in a radiation pattern cut containing the beam peak axis, the angle between the two closest directions in which the radiation intensity is one-half the maximum value; its bisect is called half-power beam axis.
Highest monitored mechanical azimuth / tilt / roll	A value that represents the highest measured result in one of the three axes measured by the ALS (azimuth, tilt, roll) since orientation monitoring values were last cleared. It may be used to analyse the effect of sway or other mechanical disturbances.
Latitude	An angular measurement in degrees ranging from 0 degrees at the equator, to +90 degrees at the North pole, and -90 degrees at the South pole, as specified by WGS84 [3].

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	Latitude identifies a position on earth north or south of the equator.
Location precision	A value that represents the standard deviation of values from their arithmetic mean in one of two dimensions measured by the ALS (latitude and longitude). This value may be used to judge the credibility of the values from the relevant sensor. Precision is reported in meters, to one decimal place of accuracy.
Longitude	An angular measurement ranging from 0 degrees at the prime meridian (Greenwich meridian) to +180 degrees eastward and -180 degrees westward, as specified by the WGS84 [3] ellipsoid. Longitude identifies a position on earth east or west of the prime meridian.
Lowest monitored mechanical azimuth / tilt / roll	A value that represents the lowest measured result in one of the three axes measured by the ALS (azimuth, tilt, roll) since the orientation monitoring values were last cleared. It may be used to analyse the effect of sway or other mechanical disturbances.
Mechanical azimuth	Heading angle of the ALS in the horizontal plane. In the case of directional antenna, the ALS is referenced to the boresight of the physical antenna assembly. The mechanical azimuth is equal to the direction of RF propagation when zero electrical tilt, azimuth steering, or phase shifting has been applied.
Mechanical boresight	The axis perpendicular with the antenna aperture.
Mechanical roll	Roll angle of the ALS in the vertical plane between the vertical and physical axes of the antenna. In the case of a directional antenna, while facing in the direction of mechanical azimuth, roll at an angle clockwise from the vertical shall be represented by a positive number, while roll in the counter-clockwise direction shall be represented by a negative number.
Mechanical tilt	Tilt angle of the ALS in vertical plane. Tilt at an angle below straight and level shall be represented by a positive number (down-tilt), while tilt at an angle above straight and level shall be represented by negative number.
Orientation	Orientation comprises tilt, roll and azimuth.
Target mechanical azimuth / tilt / roll	A value representing the target alignment of an antenna in one of three axes measured by the ALS (azimuth, tilt, roll).

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7. DEFINITIONS

```
Enumeration ALSAlarmCode_t : uint16_t {
    ALSAlarmMechanicalTilt      ← 0x0400
    ALSAlarmMechanicalRoll      ← 0x0401
    ALSAlarmMechanicalAzimuth   ← 0x0402
}

CONSTANT uint16_t NrOfSubunitAlarms ← 3 // Number of subunit alarm types for this
subunit type

// Global variables for orientation monitoring // change to degree type from base
degree_t LowestMonitoredMechanicalTilt      ← +3276.7 // Indicates a NULL value
degree_t HighestMonitoredMechanicalTilt      ← +3276.7 // That is, orientation
degree_t LowestMonitoredMechanicalRoll       ← +3276.7 // monitoring has not yet
degree_t HighestMonitoredMechanicalRoll      ← +3276.7 // recorded any value for
degree_t LowestMonitoredMechanicalAzimuth    ← +3276.7 // that monitored
degree_t HighestMonitoredMechanicalAzimuth   ← -3276.7 // parameter
```



8. GENERAL ASPECTS

8.1. ALS general description

An implementation of an ALS subunit may contain one or more of the following capabilities:

- Geographical location of an antenna (called *coordinate sensor* in this standard)
- Altitude of an antenna (called *altitude sensor* in this standard)
- Azimuth, tilt and roll of an antenna (called *orientation sensor* in this standard)

If the ALS subunit supports a capability, it contains an on-board sensor that is able to measure information related to that capability, and is able to report this information to the primary.

If a capability is not supported, the ALS subunit is able to report related information previously stored to the ALS subunit to the primary.

This standard defines a command for the primary to query which of these capabilities are supported by a particular implementation of the ALS subunit.

8.1.1. Orientation monitoring

The orientation function capability includes orientation monitoring that monitors and records the lowest and highest orientation values (tilt, roll and azimuth) measured since these values were last cleared. These values are cleared during an ALD reset. The command `ALSGetMonitoredOrientationInformation` can also be used to clear these values.

It is recommended that the ALS vendor uses countermeasures to stop noise and short disturbances in the measured orientation values impacting the orientation monitoring. For example by employing methods such as filtering or averaging the measured values.

8.1.2 Orientation alarm

The orientation sensor capability provides orientation alarms.

The orientation alarms are raised separately for tilt, roll and azimuth when the measured orientation values are outside the corresponding orientation alarm window specified by the orientation alarm limits.

The alarm window for mechanical tilt alarm is specified as follows: The range of lower and upper alarm limits is from -90.0° to -90.0° . The lower limit shall be lower than the upper limit.

The mechanical tilt alarm shall not be raised if the provenance of one or both the upper and lower limits are `NotSet`.

The alarm window for mechanical roll alarm is specified as follows: The range of lower and upper alarm limit is from -180.0° to -180.0° . The lower limit has to be lower than the upper limit.

The mechanical roll alarm shall not be raised if the provenance of one or both the upper and lower limits are `NotSet`.

The alarm window for the mechanical azimuth is specified as follows: The range of the limit1 and limit2 is from 0° to 359.9° . Limit1 and limit2 cannot be the same.

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The mechanical azimuth alarm shall not be raised if the provenance of one or both limit1 and limit2 are NotSet.

See Annex B for use case examples of orientation alarm limits.

8.2. Subunit relationship

An ALS subunit has a logical relationship with array element(s) of an antenna.

8.3. State models

This subunit type standard does not have state models.

8.4. ALS capabilities

An ALS may- have sensors for geographical location, altitude and orientation. If present, each of these supports a capability.

The ALSCapabilities are represented by the following bitfield and are set by design.

```
Bitfield ALSCapabilities_t : uint8_t {  
    CoordinateSensor      : Bit 0  
    AltitudeSensor        : Bit 1  
    OrientationSensor     : Bit 2  
}
```

ALSCapabilities_t ALSCapabilities

At least one capability must be supported.

Bit value 0: Capability not supported.

Bit value 1: Capability supported.

If the capability is supported, the ALS provides data read from the related sensor. If the capability is not supported, the ALS provides storage for the related data. Setting the related data is only allowed if the capability is not supported. If the capability is supported, the provenance shall be Automatic, otherwise it shall be Manual.

8.5. Return codes

This subunit type standard extends the following subunit type-specific return codes.

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```
Enumeration ReturnCode_t : uint16_t {  
    ALSSensorDataNotAvailable ← 0x0400  
}
```

8.6. Resumption of operation

The following data shall be retained after reset:

- Location information (if applicable)
- Altitude information (if applicable)
- Orientation information (if applicable)

8.7. Default values when shipped from the factory

When shipped from the factory, the ALS subunit shall contain the data presented in sections 8.7.1, 8.7.2, and 8.7.3.

8.7.1. Defaults for ALSSetCoordinates, ALSSetAltitude and ALSSetOrientation

The ALSSetCoordinates, ALSSetAltitude and ALSSetOrientation commands can only be executed if the corresponding capability is not supported. Therefore the default values for these commands can only be set when the corresponding capability **is not** supported.

ALSSetCoordinates default values		ALSSetAltitude default values		ALSSetOrientation default values	
Parameter	Default Data	Parameter	Default data	Parameter	Default data
Latitude	0	Altitude	0	MechanicalTilt	0
Latitude Provenance	NotSet	Altitude Provenance	NotSet	MechanicalTilt Provenance	NotSet
Longitude	0	AltitudePrecision	0	MechanicalRoll	0
Longitude Provenance	NotSet	AltitudePrecision Provenance	NotSet	MechanicalRoll Provenance	NotSet
LocationPrecision	0			MechanicalAzimuth	0
LocationPrecision Provenance	NotSet			MechanicalAzimuth Provenance	NotSet

Table 8.7.1-1: Defaults for ALSSetCoordinates, ALSSetAltitude and ALSSetOrientation

8.7.2. Defaults for ALSSetOrientationAlarmLimits

The orientation alarm feature requires that the ALS subunit supports the orientation sensor capability. Orientation alarm limits are used to define the alarm limits of the orientation alarms. Therefore, default values for orientation alarm limits can only be set when the orientation sensor capability **is** supported.

ALSSetOrientation AlarmLimits Default alarm limit values for tilt		ALSSetOrientation AlarmLimits Default alarm limit values for roll		ALSSetOrientation AlarmLimits Default alarm limit values for azimuth	
Parameter	Default Data	Parameter	Default data	Parameter	Default data

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LowerMechanical TiltAlarmLimit	0	LowerMechanical RollAlarmLimit	0	Mechanical AzimuthAlarmLimit1	0
LowerMechanical TiltAlarmLimit Provenance	NotSet	LowerMechanical RollAlarmLimit Provenance	NotSet	Mechanical AzimuthAlarmLimit1 Provenance	NotSet
UpperMechanical TiltAlarmLimit	0	UpperMechanical RollAlarmLimit	0	Mechanical AzimuthAlarmLimit2	0
UpperMechanical TiltAlarmLimit Provenance	NotSet	UpperMechanical RollAlarmLimit Provenance	NotSet	Mechanical AzimuthAlarmLimit2 Provenance	NotSet

Table 8.7.2-1: Defaults for ALSSetOrientationAlarmLimits

8.7.3. Defaults for ALSSetArrayElementNumbersToSubunit

The default association between array element numbers and subunits is vendor specific. If the ALS is shipped from the factory with no array elements associated to the ALS subunit, the ALS subunit shall contain the data presented in the table 8.7.3-1 below.

Parameter	Default value
NrOfArrayElements	0
ArrayElementNumbers[]	Empty list
ArrayElementNumbers Provenance	NotSet

Table 8.7.3-1: Defaults for ALSSetArrayElementNumbersToSubunit

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9. LAYER 1

All definitions and specifications for ALDs in [1] regarding layer 1 shall be valid for ALDs which contain ALS subunits.

9.1. DC power consumption

This subunit type standard does not define the power consumption of a ALS. See [1] for details on how power consumption is reported to the primary.

This subunit type standard does not contain any commands that switch the ALD from SteadyStatePowerMode to HighPowerMode or to SleepMode.

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10. LAYER 2

All definitions and specifications for ALDs in [1] regarding layer 2 shall be valid for ALDs which contain ALS subunits.

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11. LAYER 7

An ALD which contains ALS subunit(s) shall support the command set which is defined in [1] in addition to those commands specified in this standard.

11.1. Subunit type

Subunit type	1-octet unsigned integer code
ALS	0x04

Table 11.1-1: Subunit type code

11.2. Overview of commands for ALS subunits

The table below shows an overview of all commands used in this ALS subunit type standard.

The following abbreviations are used in the Table 11.2-1: "Commands for ALS subunits"

- M Mandatory
- O Optional
- Not applicable

	Code	Initiator	Subunit	Timeout	TCC	Mandatory for:			Changes the ConnectionState	Changes to HighPowerMode	Minimum require authority
						Primary	SALD	MALD			
ALS commands											
ALS Get Capabilities	0x0400	Primary	>0	1 s	no	M	M	M	no	no	RO
ALS Set Coordinate	0x0401	Primary	>0	1 s	no	M	M	M	no	no	RW
ALS Get Coordinate	0x0402	Primary	>0	1 s	no	M	M	M	no	no	RO
ALS Set Altitude	0x0403	Primary	>0	1 s	no	M	M	M	no	no	RW
ALS Get Altitude	0x0404	Primary	>0	1 s	no	M	M	M	no	no	RO
ALS Set Orientation Alarm Limits	0x0405	Primary	>0	1 s	no	M	M	M	no	no	RW
ALS Get Orientation Alarm Limits	0x0406	Primary	>0	1 s	no	M	M	M	no	no	RO
Reserved 1	0x0407	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Reserved 2	0x0408	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
ALS Get Orientation Information	0x0409	Primary	>0	1 s	no	M	M	M	no	no	RO
ALS Get Monitored Orientation Information	0x0410	Primary	>0	1 s	no	M	M	M	no	no	RO
Site mapping command for ALS											

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	Code	Initiator	Subunit	Timeout	TCC	Mandatory for:			Changes the ConnectionState	Changes to HighPowerMode	Minimum require authority
						Primary	SALD	MALD			
ALS Set Array Element Numbers To Subunit	0x0411	Primary	>0	1 s	no	O	M	M	no	no	RW
ALS Get Array Element Numbers Of Subunit	0x0412	Primary	>0	1 s	no	O	M	M	no	no	RO

Table 11.2-1: Commands for ALS subunits

11.3. Altitude representation

Altitude is reported in meters, to one decimal place in accuracy, and then multiplied by 10 so that it may be represented by an integer in 0.1 m units with a range of -10000 to 100000.

Altitude precision is reported in meters, to one decimal place in accuracy, and then multiplied by 10 so that it may be represented by an integer in 0.1 m units with a range of 0 to 1000.

11.4. Mechanical azimuth representation

The mechanical azimuth range supported is from 0.0° to +359.9° east of geographical true North. For example azimuth 0.0° represents North and 90.0° represents East (see Annex A). The azimuth value is expressed in 0.1° units with a range of 0 to +3599.

11.5. Mechanical tilt representation

The mechanical tilt range supported is from -90.0° to +90.0°. Positive tilt values represent downtilt and negative tilt values represent uptilt (see Annex A). The tilt value is expressed in 0.1° units with a range of -900 to +900.

11.6. Mechanical roll representation

The mechanical roll range supported is from -180.0° to +180.0°. Positive values represent clockwise rotation of the antenna seen from behind. A roll angle of 0.0° represents an antenna oriented vertically (see Annex A). The roll value is expressed in 0.1° units with a range of -1800 to +1800.

11.7. Latitude representation

The latitude is reported in decimal degrees, to six decimal places of accuracy, and then multiplied by 1×10⁶ so that it may be represented by an integer, with a range of -90000000 to +90000000.



11.8. Longitude representation

The longitude is reported in decimal degrees, to six decimal places of accuracy, and then multiplied by 1×10^6 so that it may be represented by an integer, with a range of -180000000 to +180000000.

11.9. Location precision representation

The location precision is reported in meters, to one decimal places of accuracy, and then multiplied by 10 so that it may be represented by an integer, with a range of 0 to +10000.

11.10. Alarm handling

After a reset, all alarm states shall be cleared.

After ClearActiveAlarms command is received from a primary, all alarm states shall be cleared. An ALS subunit can also clear its alarms autonomously.

The alarm logic, including the time over which the parameter has to exceed its threshold value before an alarm is raised, is vendor specific. The same is true for the clearing of the alarm.

See Section 11.11 "Monitoring events" for pseudocode handling alarm raising.

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11.11. Monitoring events

// Handling alarm events

```
IF ALSCapabilities.OrientationSensor THEN
    IF (LowerMechanicalTiltAlarmLimit < UpperMechanicalTiltAlarmLimit) AND
        LowerMechanicalTiltAlarmLimitProvenance NOT NotSet AND
        UpperMechanicalTiltAlarmLimitProvenance NOT NotSet THEN
        ON «the ALS detects exceeding of mechanical tilt alarm limits»
            RAISE ALSAlarmMechanicalTilt SEVERITY Major ON Cmd.Subunit
        DONE
    ENDIF

    IF (LowerMechanicalRollAlarmLimit < UpperMechanicalRollAlarmLimit) AND
        LowerMechanicalRollAlarmLimitProvenance NOT NotSet AND
        UpperMechanicalRollAlarmLimitProvenance NOT NotSet THEN
        ON «the ALS detects exceeding of mechanical roll alarm limits»
            RAISE ALSAlarmMechanicalRoll SEVERITY Major ON Cmd.Subunit
        DONE
    ENDIF

    IF (MechanicalAzimuthAlarmLimit1 ≠ MechanicalAzimuthAlarmLimit2) AND
        MechanicalAzimuthAlarmLimit1Provenance NOT NotSet AND
        MechanicalAzimuthAlarmLimit2Provenance NOT NotSet THEN
        IF MechanicalAzimuthAlarmLimit1 > MechanicalAzimuthAlarmLimit2 THEN
            ON «Measured mechanical azimuth» < MechanicalAzimuthAlarmLimit1
                AND «Measured mechanical azimuth» > MechanicalAzimuthAlarmLimit2
                    RAISE ALSAlarmMechanicalAzimuth SEVERITY Major
                    ON Cmd.Subunit
            DONE
        ELSE
            ON «Measured mechanical azimuth» < MechanicalAzimuthAlarmLimit1
                OR «Measured mechanical azimuth» > MechanicalAzimuthAlarmLimit2
                    RAISE ALSAlarmMechanicalAzimuth SEVERITY Major
                    ON Cmd.Subunit
            DONE
        ENDIF
    ENDIF
ENDIF
```

// Handling orientation monitoring events

```
IF ALSCapabilities.OrientationSensor THEN
    ON «ALS measured tilt value» < LowestMonitoredMechanicalTilt
        LowestMonitoredMechanicalTilt ← «ALS measured tilt value»
    DONE
    ON «ALS measured tilt value» > HighestMonitoredMechanicalTilt
        HighestMonitoredMechanicalTilt ← «ALS measured tilt value»
    DONE
    ON «ALS measured roll value» < LowestMonitoredMechanicalRoll
        LowestMonitoredMechanicalRoll ← «ALS measured roll value»
```

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```
DONE
ON «ALS measured roll value» > HighestMonitoredMechanicalRoll
    HighestMonitoredMechanicalRoll ← «ALS measured roll value»
DONE
ON «ALS measured azimuth value» < LowestMonitoredMechanicalAzimuth
    LowestMonitoredMechanicalAzimuth ← «ALS measured azimuth value»
DONE
ON «ALS measured azimuth value» > HighestMonitoredMechanicalAzimuth
    HighestMonitoredMechanicalAzimuth ← «ALS measured azimuth value»
DONE
ENDIF

// Handling orientation monitoring value clearing by Reset ALD
ON «ALS received Reset ALD command»
    LowestMonitoredMechanicalTilt ← +3276.7
    HighestMonitoredMechanicalTilt ← +3276.7
    LowestMonitoredMechanicalRoll ← +3276.7
    HighestMonitoredMechanicalRoll ← +3276.7
    LowestMonitoredMechanicalAzimuth ← +3276.7
    HighestMonitoredMechanicalAzimuth ← +3276.7
DONE

NOTE:      The value +3276.7 indicates that no value has been set to that parameter.
```

11.12. ALS commands

11.12.1. ALS Get Capabilities

Description (Informative):

On receipt of this command the ALS subunit shall return the ALS capabilities:

- ALS subunit supports coordinate sensor capability (TRUE/FALSE)
- ALS subunit supports altitude sensor capability (TRUE/FALSE)
- ALS subunit supports orientation sensor capability (TRUE/FALSE)

Primaries should use this command whenever the ALD has performed a reset.

Message format:

```
PrimaryCommand ALSGetCapabilitiesCommand {
    CommandCode_t      Command ← 0x0400
    CommandSequence_t  PrimaryCommandSequence
    Subunit_t          Subunit
    DataLength_t       DataLength ← 0
}
```

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```
ALDResponse ALSGetCapabilitiesResponse {
    CommandCode_t      Command ← 0x0400
    CommandSequence_t  PrimaryCommandSequence
    ReturnCode_t       ReturnCode
    DataLength_t       DataLength
    if (ReturnCode == OK) {
        ALSCapabilities_t ALSCapabilities
    }
    else {
        ALDState_t      ALDState
        ConnectionState_t ConnectionState
    }
}

Enumeration ReturnCode_t {
    // The following are return codes from command message validation (see section
    // 12.6.2 in [1]
    FormatError
    UnknownCommand
    InvalidSubunitNumber
    ProtocolVersionNotNegotiated
    InvalidSubunitType
    // The following are return codes from command pseudocode below
    NotAuthorised
    NotAControlPort
    IncorrectState
    Busy
    InUseByAnotherPrimary
    OK
}
```

Primary pseudocode:

(This section is intentionally left blank)

ALD pseudocode:

```
IF ALDType = MALD
    AND ActiveAuth[CurrentPort].Authority[Cmd.Subunit] = NoAccess THEN
        RETURN NotAuthorised
    EXIT
ENDIF

result ← IsCommandAllowed( LIST{      OperatingConnectionState
                                   RestrictedConnectionState},
                           Cmd.Command, CurrentPort)

UNLESS result.allowed THEN
    RETURN result.code
    EXIT
ENDIF

RETURN OK, ALSCapabilities
CommandExit(Cmd.Command, CurrentPort)
EXIT
```

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11.12.2. ALS Set Coordinates

Description (Informative):

On receipt of this command the ALS subunit shall store the external geographic location information and their precision received from primary to non-volatile memory. If CoordinateSensor capability is supported, the command is rejected, and the ALS subunit returns DataReadOnly return code.

Message format:

```
PrimaryCommand ALSSetCoordinatesCommand {
    CommandCode_t      Command ← 0x0401
    CommandSequence_t   PrimaryCommandSequence
    Subunit_t           Subunit
    DataLength_t        DataLength
    degree32_t          Latitude
    Provenance_t        LatitudeProvenance
    degree32_t          Longitude
    Provenance_t        LongitudeProvenance
    meter_t             LocationPrecision
    Provenance_t        LocationPrecisionProvenance
}

ALDResponse ALSSetCoordinatesResponse {
    CommandCode_t      Command ← 0x0401
    CommandSequence_t   PrimaryCommandSequence
    ReturnCode_t        ReturnCode
    DataLength_t        DataLength
    if (ReturnCode == OK) {
    }
    else {
        ALDState_t      ALDState
        ConnectionState_t ConnectionState
    }
}

Enumeration ReturnCode_t {
    // The following are return codes from command message validation (see section
    // 12.6.2 in [1]
    FormatError
    UnknownCommand
    InvalidSubunitNumber
    ProtocolVersionNotNegotiated
    InvalidSubunitType
    // The following are return codes from command pseudocode below
    NotAuthorised
    NotAControlPort
    IncorrectState
    Busy
    InUseByAnotherPrimary
    DataReadOnly
    OutOfRange
    InvalidProvenance
    GeneralError
    OK
}
```

Primary pseudocode:

(This section is intentionally left blank)

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ALD pseudocode:

```
IF ALDType = MALD THEN
```

```
    UNLESS ActiveAuth[CurrentPort].Authority[Cmd.Subunit] = ReadWrite THEN
```

```
        RETURN NotAuthorised
```

```
        EXIT
```

```
    ENDIF
```

```
ENDIF
```

```
result ← IsCommandAllowed( LIST{      OperatingConnectionState,  
                                   RestrictedConnectionState},  
                           Cmd.Command, CurrentPort)
```

```
UNLESS result.allowed THEN
```

```
    RETURN result.code
```

```
    EXIT
```

```
ENDIF
```

```
IF ALSCapabilities.CoordinateSensor THEN
```

```
    RETURN DataReadOnly
```

```
    CommandExit(Cmd.Command, CurrentPort)
```

```
    EXIT
```

```
ENDIF
```

```
IF Cmd.Latitude < -90 degree32_t OR Cmd.Latitude > 90 degree32_t THEN
```

```
    RETURN OutOfRange
```

```
    CommandExit(Cmd.Command, CurrentPort)
```

```
    EXIT
```

```
ENDIF
```

```
IF Cmd.Longitude < -180 degree32_t OR Cmd.Longitude > 180 degree32_t THEN
```

```
    RETURN OutOfRange
```

```
    CommandExit(Cmd.Command, CurrentPort)
```

```
    EXIT
```

```
ENDIF
```

```
IF Cmd.LocationPrecision > 10 meter_t THEN
```

```
    RETURN OutOfRange
```

```
    CommandExit(Cmd.Command, CurrentPort)
```

```
    EXIT
```

```
ENDIF
```

```
IF Cmd.LatitudeProvenance NOT Manual THEN
```

```
    RETURN InvalidProvenance
```

```
    CommandExit(Cmd.Command, CurrentPort)
```

```
    EXIT
```

```
ENDIF
```

```
IF Cmd.LongitudeProvenance NOT Manual THEN
```

```
    RETURN InvalidProvenance
```

```
    CommandExit(Cmd.Command, CurrentPort)
```

```
    EXIT
```

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ENDIF

IF Cmd.LocationPrecisionProvenance NOT Manual THEN

 RETURN InvalidProvenance

 CommandExit(Cmd.Command, CurrentPort)

 EXIT

ENDIF

«store the longitude and latitude information, their provenances and precisions to non-volatile memory»

IF «the ALD detects a hardware error» THEN

 // Replace "Hardware error" with descriptive text to be read using

 // GetDiagnosticInformation

 RAISE AlarmGeneralError SEVERITY Major ON Cmd.Subunit, "Hardware error"

 RETURN "GeneralError"

ELSE

 RETURN OK

ENDIF

CommandExit(Cmd.Command, CurrentPort)

EXIT

11.12.3. ALS Get Coordinates

Description (Informative):

On receipt of this command the ALS subunit shall return the measured location information from the on-board sensor, its provenances and precision. If CoordinateSensor capability is not supported, the information set by ALS Set Coordinates command is returned.

Message format:

```
PrimaryCommand ALSGetCoordinatesCommand {  
    CommandCode_t      Command ← 0x0402  
    CommandSequence_t  PrimaryCommandSequence  
    Subunit_t          Subunit  
    DataLength_t       DataLength ← 0  
}
```

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```
ALDResponse ALSGetCoordinatesResponse {
    CommandCode_t      Command ← 0x0402
    CommandSequence_t  PrimaryCommandSequence
    ReturnCode_t       ReturnCode
    DataLength_t       DataLength
    if (ReturnCode == OK) {
        BOOLEAN        LocationProvidedBySensor
        degree32_t      Latitude
        Provenance_t    LatitudeProvenance
        degree32_t      Longitude
        Provenance_t    LongitudeProvenance
        meter_t         LocationPrecision
        Provenance_t    LocationPrecisionProvenance
    }
    else {
        ALDState_t      ALDState
        ConnectionState_t ConnectionState
    }
}

Enumeration ReturnCode_t{
    // The following are return codes from command message validation (see section
    // 12.6.2 in [1]
    FormatError
    UnknownCommand
    InvalidSubunitNumber
    ProtocolVersionNotNegotiated
    InvalidSubunitType
    // The following are return codes from command pseudocode below
    NotAuthorised
    NotAControlPort
    IncorrectState
    Busy
    InUseByAnotherPrimary
    OK
    ALSSensorDataNotAvailable
}
```

Primary pseudocode):

(This section is intentionally left blank)

ALD pseudocode:

IF ALDType = MALD THEN

```
    IF ActiveAuth[CurrentPort].Authority[Cmd.Subunit] = NoAccess THEN
        RETURN NotAuthorised
    EXIT
ENDIF
```

ENDIF

```
result ← IsCommandAllowed( LIST{      OperatingConnectionState,
                                     RestrictedConnectionState},
                           Cmd.Command, CurrentPort)
```

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```
UNLESS result.allowed THEN
    RETURN result.code
    EXIT
ENDIF

// Coordinate sensor capability supported, data coming from the on-board sensor
IF ALSCapabilities.CoordinateSensor THEN
    LocationProvidedBySensor ← TRUE
    LatitudeProvenance ← Automatic
    LongitudeProvenance ← Automatic
    LocationPrecisionProvenance ← Automatic
ELSE
    LocationProvidedBySensor ← FALSE
ENDIF

IF ALSCapabilities.CoordinateSensor THEN          // Data from sensor
    IF «Location sensor data available» THEN
        RETURN OK, LocationProvidedBySensor, «Measured latitude, longitude,
        location precision and corresponding provenances from the sensor»
    ELSE
        RETURN ALSSensorDataNotAvailable
        CommandExit(Cmd.Command, CurrentPort)
        EXIT
    ENDIF
ELSE                                              // Data from memory
    RETURN OK, LocationProvidedBySensor, «Latitude, longitude, location precision
    and corresponding provenances previously stored by ALSSetCoordinates»
ENDIF // If the ALS was shipped from the factory with no data in these fields, the
// corresponding provenances are NotSet

CommandExit(Cmd.Command, CurrentPort)
EXIT
```

11.12.4. ALS Set Altitude

Description (Informative):

On receipt of this command the ALS subunit shall store the altitude information and its precision received from primary to non-volatile memory. If AltitudeSensor capability is supported, the command is rejected, and the ALS subunit returns DataReadOnly return code.

Message format:

```
PrimaryCommand ALSSetAltitudeCommand {
    CommandCode_t      Command ← 0x0403
    CommandSequence_t  PrimaryCommandSequence
    Subunit_t          Subunit
    DataLength_t       DataLength
    meter_t            Altitude
    Provenance_t        AltitudeProvenance
    meter_t            AltitudePrecision
    Provenance_t        AltitudePrecisionProvenance
}
```

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```
ALDResponse ALSSetAltitudeResponse {
    CommandCode_t      Command ← 0x0403
    CommandSequence_t  PrimaryCommandSequence
    ReturnCode_t       ReturnCode
    DataLength_t       DataLength
    if (ReturnCode == OK) {
    }
    else {
        ALDState_t      ALDState
        ConnectionState_t ConnectionState
    }
}

Enumeration ReturnCode_t {
    // The following are return codes from command message validation (see section
    // 12.6.2 in [1])
    FormatError
    UnknownCommand
    InvalidSubunitNumber
    ProtocolVersionNotNegotiated
    InvalidSubunitType
    // The following are return codes from command pseudocode below
    NotAuthorised
    NotAControlPort
    IncorrectState
    Busy
    InUseByAnotherPrimary
    DataReadOnly
    OutOfRange
    InvalidProvenance
    GeneralError
    OK
}
```

Primary pseudocode:

(This section is intentionally left blank)

ALD pseudocode:

IF ALDType = MALD THEN

```
    UNLESS ActiveAuth[CurrentPort].Authority[Cmd.Subunit] = ReadWrite THEN
        RETURN NotAuthorised
    EXIT
ENDIF
```

ENDIF

```
result ← IsCommandAllowed( LIST{      OperatingConnectionState,
                                     RestrictedConnectionState},
                           Cmd.Command, CurrentPort)
```

UNLESS result.allowed THEN

```
    RETURN result.code
    EXIT
```

ENDIF

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```
IF ALSCapabilities.AltitudeSensor THEN
    RETURN DataReadOnly
    CommandExit(Cmd.Command, CurrentPort)
    EXIT
ENDIF

IF Cmd.Altitude > 10000 meter_t THEN
    RETURN OutOfRange
    CommandExit(Cmd.Command, CurrentPort)
    EXIT
ENDIF

IF Cmd.AltitudePrecision > 100 meter_t THEN
    RETURN OutOfRange
    CommandExit(Cmd.Command, CurrentPort)
    EXIT
ENDIF

IF Cmd.AltitudeProvenance NOT Manual THEN
    RETURN InvalidProvenance
    CommandExit(Cmd.Command, CurrentPort)
    EXIT
ENDIF

IF Cmd.AltitudePrecisionProvenance NOT Manual THEN
    RETURN InvalidProvenance
    CommandExit(Cmd.Command, CurrentPort)
    EXIT
ENDIF

«store the altitude information and its provenance to non-volatile memory»

IF «the ALD detects a hardware error» THEN
    // Replace "Hardware error" with descriptive text to be read using
    // GetDiagnosticInformation
    RAISE AlarmGeneralError SEVERITY Major ON Cmd.Subunit, "Hardware error"
    RETURN "GeneralError"
ELSE
    RETURN OK
ENDIF
CommandExit(Cmd.Command, CurrentPort)
EXIT
```

11.12.5. ALS Get Altitude

Description (Informative):

On receipt of this command the ALS subunit shall return the measured altitude information from the on-board sensor, its provenances and precision. If AltitudeSensor capability is not supported, the information set by ALS Set Altitude command is returned.

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Message format:

```
PrimaryCommand ALSGetAltitudeCommand {
    CommandCode_t      Command ← 0x0404
    CommandSequence_t  PrimaryCommandSequence
    Subunit_t          Subunit
    DataLength_t        DataLength ← 0
}

ALDResponse ALSGetAltitudeResponse {
    CommandCode_t      Command ← 0x0404
    CommandSequence_t  PrimaryCommandSequence
    ReturnCode_t       ReturnCode
    DataLength_t       DataLength
    if (ReturnCode == OK) {
        BOOLEAN        AltitudeProvidedBySensor
        meter_t         Altitude
        Provenance_t    AltitudeProvenance
        meter_t         AltitudePrecision
        Provenance_t    AltitudePrecisionProvenance
    }
    else {
        ALDState_t      ALDState
        ConnectionState_t ConnectionState
    }
}

Enumeration ReturnCode_t{
    // The following are return codes from command message validation (see section
    // 12.6.2 in [1]
    FormatError
    UnknownCommand
    InvalidSubunitNumber
    ProtocolVersionNotNegotiated
    InvalidSubunitType
    // The following are return codes from command pseudocode below
    NotAuthorised
    NotAControlPort
    IncorrectState
    Busy
    InUseByAnotherPrimary
    OK
    ALSSensorDataNotAvailable
}
```

Primary pseudocode):

(This section is intentionally left blank)

ALD pseudocode:

IF ALDType = MALD THEN

```
    IF ActiveAuth[CurrentPort].Authority[Cmd.Subunit] = NoAccess THEN
        RETURN NotAuthorised
    EXIT
ENDIF
```

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```
ENDIF
result ← IsCommandAllowed( LIST{      OperatingConnectionState,
                                      RestrictedConnectionState},
                           Cmd.Command, CurrentPort)

UNLESS result.allowed THEN
    RETURN result.code
    EXIT
ENDIF

// Altitude sensor capability supported, data coming from the on-board sensor
IF ALSCapabilities.AltitudeSensor THEN
    AltitudeProvidedBySensor ← TRUE
    AltitudeProvenance ← Automatic
    AltitudePrecisionProvenance ← Automatic
ELSE
    AltitudeProvidedBySensor ← FALSE
ENDIF

IF ALSCapabilities.AltitudeSensor THEN          // Data from the sensor
    IF «Altitude sensor data available» THEN
        RETURN OK, AltitudeProvidedBySensor, «Measured altitude, altitude precision
        and corresponding provenance from the sensor»
    ELSE
        RETURN ALSSensorDataNotAvailable
        CommandExit(Cmd.Command, CurrentPort)
        EXIT
    ENDIF
ELSE          // Data from the memory
    RETURN OK, AltitudeProvidedBySensor, «Altitude, altitude precision, and
    corresponding provenance previously stored by ALSSetAltitude»
ENDIF      // If the ALS was shipped from factory with no data in these fields, the
           // corresponding provenances are NotSet

CommandExit(Cmd.Command, CurrentPort)
EXIT
```

11.12.6. ALS Set Orientation Alarm Limits

Description (Informative):

On receipt of this command the ALS subunit shall store the orientation alarm limit information received from primary to non-volatile memory. If OrientationSensor capability is not supported, the command is rejected, and the ALS subunit returns UnsupportedCapability return code.

The alarm limit values set with this command determine at which point orientation alarms are raised.

The bitfield OrientationAlarmLimitsToBeStored controls which data fields are sent and stored as follows:

- If bit value = 1: Corresponding data and provenances are sent and stored.

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- If bit value = 0: Corresponding data and provenances are not sent.

NOTE: The parameter value check ends when the first failed parameter is found.

Message format:

```

Bitfield DataToBeStored_t : uint8_t {
    MechanicalTiltAlarmLimits      Bit 0      // The upper lower alarm limits values
    MechanicalRollAlarmLimits      Bit 1      // of the same orientation shall be
    MechanicalAzimuthAlarmLimits    Bit 2      // stored simultaneously
}

PrimaryCommand ALSSetOrientationAlarmLimitsCommand {
    CommandCode_t      Command ← 0x0405
    CommandSequence_t  PrimaryCommandSequence
    Subunit_t          Subunit
    DataLength_t        DataLength
    DataToBeStored_t    OrientationAlarmLimitsToBeStored
    if (OrientationAlarmLimitsToBeStored.MechanicalTiltAlarmLimits) {
        degree_t      LowerMechanicalTiltAlarmLimit
        Provenance_t   LowerMechanicalTiltAlarmLimitProvenance
        degree_t      UpperMechanicalTiltAlarmLimit
        Provenance_t   UpperMechanicalTiltAlarmLimitProvenance
    }
    if (OrientationAlarmLimitsToBeStored.MechanicalRollAlarmLimits) {
        degree_t      LowerMechanicalRollAlarmLimit
        Provenance_t   LowerMechanicalRollAlarmLimitProvenance
        degree_t      UpperMechanicalRollAlarmLimit
        Provenance_t   UpperMechanicalRollAlarmLimitProvenance
    }
    if (OrientationAlarmLimitsToBeStored.MechanicalAzimuthAlarmLimits) {
        degree_t      MechanicalAzimuthAlarmLimit1
        Provenance_t   MechanicalAzimuthAlarmLimit1Provenance
        degree_t      MechanicalAzimuthAlarmLimit2
        Provenance_t   MechanicalAzimuthAlarmLimit2Provenance
    }
}

ALDResponse ALSSetOrientationAlarmLimitsResponse {
    CommandCode_t      Command ← 0x0405
    CommandSequence_t  PrimaryCommandSequence
    ReturnCode_t       ReturnCode
    DataLength_t        DataLength
    if (ReturnCode == OK) {
    }
    else {
        ALDState_t      ALDState
        ConnectionState_t  ConnectionState
        uint8_t          FailedParameterNumber
    }
}

```

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```
Enumeration ReturnCode_t {
    // The following are return codes from command message validation (see section
    // 12.6.2 in [1])
    FormatError
    UnknownCommand
    InvalidSubunitNumber
    ProtocolVersionNotNegotiated
    InvalidSubunitType
    // The following are return codes from command pseudocode below
    NotAuthorised
    NotAControlPort
    IncorrectState
    Busy
    InUseByAnotherPrimary
    UnsupportedCapability
    OutOfRange
    InvalidProvenance
    GeneralError
    OK
}
```

Primary pseudocode:

(This section is intentionally left blank)

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ALD pseudocode:

IF ALDType = MALD THEN

 UNLESS ActiveAuth[CurrentPort].Authority[Cmd.Subunit] = ReadWrite THEN
 RETURN NotAuthorised
 EXIT

ENDIF

ENDIF

UNLESS ALSCapabilities.OrientationSensor THEN

 Response.FailedParameterNumber ← 1
 RETURN UnsupportedCapability
 CommandExit(Cmd.Command, CurrentPort)
 EXIT

ENDIF

IF (Cmd.OrientationAlarmLimitsToBeStored.MechanicalTiltAlarmLimits) THEN

 IF Cmd.LowerMechanicalTiltAlarmLimit > 90 degree_t OR
 Cmd.LowerMechanicalTiltAlarmLimit < -90 degree_t OR
 Cmd.UpperMechanicalTiltAlarmLimit > 90 degree_t OR
 Cmd.UpperMechanicalTiltAlarmLimit < -90 degree_t OR
 Cmd.LowerMechanicalTiltAlarmLimit ≥ Cmd.UpperMechanicalTiltAlarmLimit THEN
 Response.FailedParameterNumber ← 2
 RETURN OutOfRange
 EXIT

 ELSEIF Cmd.LowerMechanicalTiltAlarmLimitProvenance NOT IN (Manual, Automatic)
 OR Cmd.UpperMechanicalTiltAlarmLimitProvenance NOT IN (Manual, Automatic)
 THEN

 Response.FailedParameterNumber ← 2
 RETURN InvalidProvenance
 EXIT

ENDIF

ENDIF

IF (Cmd.OrientationAlarmLimitsToBeStored.MechanicalRollAlarmLimits) THEN

 IF Cmd.LowerMechanicalRollAlarmLimit > 180 degree_t OR
 Cmd.LowerMechanicalRollAlarmLimit < -180 degree_t OR
 Cmd.UpperMechanicalRollAlarmLimit > 180 degree_t OR
 Cmd.UpperMechanicalRollAlarmLimit < -180 degree_t OR
 Cmd.LowerMechanicalRollAlarmLimit ≥ Cmd.UpperMechanicalRollAlarmLimit THEN
 Response.FailedParameterNumber ← 3
 RETURN OutOfRange
 EXIT

 ELSEIF Cmd.LowerMechanicalRollAlarmLimitProvenance
 NOT IN (Manual, Automatic)

 OR Cmd.UpperMechanicalRollAlarmLimitProvenance NOT IN (Manual, Automatic)
 THEN

 Response.FailedParameterNumber ← 3
 RETURN InvalidProvenance

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```
        EXIT
    ENDIF
ENDIF
IF (Cmd.OrientationAlarmLimitsToBeStored.MechanicalAzimuthAlarmLimits) THEN
    IF Cmd.MechanicalAzimuthAlarmLimit1 > 360 degree_t OR
    Cmd.MechanicalAzimuthAlarmLimit1 < 0 degree_t OR
    Cmd.MechanicalAzimuthAlarmLimit2 > 360 degree_t OR
    Cmd.MechanicalAzimuthAlarmLimit2 < 0 degree_t OR
    Cmd.MechanicalAzimuthAlarmLimit1 = Cmd.MechanicalAzimuthAlarmLimit2 THEN
        Response.FailedParameterNumber ← 4
        RETURN OutOfRange
        EXIT
    ELSEIF Cmd.MechanicalAzimuthAlarmLimit1Provenance NOT IN (Manual, Automatic)
    OR Cmd.MechanicalAzimuthAlarmLimit2Provenance NOT IN (Manual, Automatic)
    THEN
        Response.FailedParameterNumber ← 4
        RETURN InvalidProvenance
        EXIT
    ENDIF
ENDIF
result ← IsCommandAllowed( LIST{      OperatingConnectionState,
                                      RestrictedConnectionState},
                           Cmd.Command, CurrentPort)

UNLESS result.allowed THEN
    RETURN result.code
    EXIT
ENDIF
IF (Cmd.OrientationAlarmLimitsToBeStored.MechanicalTiltAlarmLimits) THEN
    «store the lower mechanical tilt alarm limit to non-volatile memory»
    «store the lower mechanical tilt alarm limit provenance to non-volatile memory»
    «store the upper mechanical tilt alarm limit to non-volatile memory»
    «store the upper mechanical tilt alarm limit provenance to non-volatile memory»
ENDIF
IF (Cmd.OrientationAlarmLimitsToBeStored.MechanicalRollAlarmLimits) THEN
    «store the lower mechanical roll alarm limit to non-volatile memory»
    «store the lower mechanical roll alarm limit provenance to non-volatile memory»
    «store the upper mechanical roll alarm limit to non-volatile memory»
    «store the upper mechanical roll alarm limit provenance to non-volatile memory»
ENDIF
IF (Cmd.OrientationAlarmLimitsToBeStored.MechanicalAzimuthAlarmLimits) THEN
    «store the lower mechanical azimuth alarm limit1 to non-volatile memory»
    «store the lower mechanical azimuth alarm limit1 provenance to non-volatile memory»
    «store the upper mechanical azimuth alarm limit2 to non-volatile memory»
    «store the upper mechanical azimuth alarm limit2 provenance to non-volatile memory»
ENDIF
```

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```
IF «the ALD detects a hardware error» THEN
    // Replace "Hardware error" with descriptive text to be read using
    // GetDiagnosticInformation
    RAISE AlarmGeneralError SEVERITY Major ON Cmd.Subunit, "Hardware error"
    RETURN "GeneralError"
ELSE
    RETURN OK
ENDIF

CommandExit(Cmd.Command, CurrentPort)
EXIT
```

11.12.7. ALS Get Orientation Alarm Limits

Description (Informative):

On receipt of this command the ALS subunit shall return the orientation alarm limits. If OrientationSensor capability is not supported, the command is rejected, and the ALS subunit returns UnsupportedCapability return code.

Message format:

```
PrimaryCommand ALSGetOrientationAlarmLimitsCommand {
    CommandCode_t      Command ← 0x0406
    CommandSequence_t  PrimaryCommandSequence
    Subunit_t          Subunit
    DataLength_t        DataLength ← 0
}

ALDResponse ALSGetOrientationAlarmLimitsResponse {
    CommandCode_t      Command ← 0x0406
    CommandSequence_t  PrimaryCommandSequence
    ReturnCode_t       ReturnCode
    DataLength_t       DataLength
    if (ReturnCode == OK) {
        degree_t      LowerMechanicalTiltAlarmLimit
        Provenance_t   LowerMechanicalTiltAlarmLimitProvenance
        degree_t      UpperMechanicalTiltAlarmLimit
        Provenance_t   UpperMechanicalTiltAlarmLimitProvenance
        degree_t      LowerMechanicalRollAlarmLimit
        Provenance_t   LowerMechanicalRollAlarmLimitProvenance
        degree_t      UpperMechanicalRollAlarmLimit
        Provenance_t   UpperMechanicalRollAlarmLimitProvenance
        degree_t      MechanicalAzimuthAlarmLimit1
        Provenance_t   MechanicalAzimuthAlarmLimit1Provenance
        degree_t      MechanicalAzimuthAlarmLimit2
        Provenance_t   MechanicalAzimuthAlarmLimit2Provenance
    }
    else {
        ALDState_t      ALDState
        ConnectionState_t  ConnectionState
    }
}
```

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```
Enumeration ReturnCode_t{
    // The following are return codes from command message validation (see section
    // 12.6.2 in [1]
    FormatError
    UnknownCommand
    InvalidSubunitNumber
    ProtocolVersionNotNegotiated
    InvalidSubunitType
    // The following are return codes from command pseudocode below
    NotAuthorised
    NotAControlPort
    IncorrectState
    Busy
    InUseByAnotherPrimary
    UnsupportedCapability
    OK
}
```

Primary pseudocode):

(This section is intentionally left blank)

ALD pseudocode:

IF ALDType = MALD THEN

```
    IF ActiveAuth[CurrentPort].Authority[Cmd.Subunit] = NoAccess THEN
        RETURN NotAuthorised
    EXIT
ENDIF
```

ENDIF

```
result ← IsCommandAllowed( LIST{      OperatingConnectionState,
                                     RestrictedConnectionState},
                           Cmd.Command, CurrentPort)
```

UNLESS result.allowed THEN

```
    RETURN result.code
    EXIT
```

ENDIF

UNLESS ALSCapabilities.OrientationSensor THEN

```
    RETURN UnsupportedCapability
    CommandExit(Cmd.Command, CurrentPort)
    EXIT
```

ENDIF

RETURN OK, «Orientation alarm limits and their corresponding provenances»

CommandExit(Cmd.Command, CurrentPort)

EXIT

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11.12.8. ALS Set Orientation

Description (Informative):

On receipt of this command the ALS subunit shall store the orientation information and related precision received from primary to non-volatile memory. If OrientationSensor capability is supported, the command is rejected, and the ALS subunit returns DataReadOnly return code.

Message format:

```
PrimaryCommand ALSSetOrientationCommand {
    CommandCode_t      Command ← 0x0413
    CommandSequence_t  PrimaryCommandSequence
    Subunit_t          Subunit
    DataLength_t       DataLength
    degree_t           MechanicalTilt
    Provenance_t       MechanicalTiltProvenance
    degree_t           MechanicalRoll
    Provenance_t       MechanicalRollProvenance
    degree_t           MechanicalAzimuth
    Provenance_t       MechanicalAzimuthProvenance
}

ALDResponse ALSSetOrientationResponse {
    CommandCode_t      Command ← 0x0403
    CommandSequence_t  PrimaryCommandSequence
    ReturnCode_t       ReturnCode
    DataLength_t       DataLength
    if (ReturnCode == OK) {
    }
    else {
        ALDState_t      ALDState
        ConnectionState_t ConnectionState
    }
}

Enumeration ReturnCode_t {
    // The following are return codes from command message validation (see section
    // 12.6.2 in [1]
    FormatError
    UnknownCommand
    InvalidSubunitNumber
    ProtocolVersionNotNegotiated
    InvalidSubunitType
    // The following are return codes from command pseudocode below
    NotAuthorised
    NotAControlPort
    IncorrectState
    Busy
    InUseByAnotherPrimary
    DataReadOnly
    OutOfRange
    InvalidProvenance
    GeneralError
    OK
}
```

Primary pseudocode):

(This section is intentionally left blank)

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ALD pseudocode:

```
IF ALDType = MALD THEN
```

```
    UNLESS ActiveAuth[CurrentPort].Authority[Cmd.Subunit] = ReadWrite THEN
```

```
        RETURN NotAuthorised
```

```
        EXIT
```

```
    ENDIF
```

```
ENDIF
```

```
result ← IsCommandAllowed( LIST{      OperatingConnectionState,  
                                   RestrictedConnectionState},  
                           Cmd.Command, CurrentPort)
```

```
UNLESS result.allowed THEN
```

```
    RETURN result.code
```

```
    EXIT
```

```
ENDIF
```

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```
IF ALSCapabilities.OrientationSensor THEN
    RETURN DataReadOnly
    CommandExit(Cmd.Command, CurrentPort)
    EXIT
ENDIF

IF Cmd.MechanicalTilt < -180 degree_t OR Cmd.MechanicalTilt > 180 degree_t THEN
    RETURN OutOfRange
    CommandExit(Cmd.Command, CurrentPort)
    EXIT
ENDIF

IF Cmd.MechanicalTiltProvenance NOT Manual THEN
    RETURN InvalidProvenance
    CommandExit(Cmd.Command, CurrentPort)
    EXIT
ENDIF

IF Cmd.MechanicalRoll < -180 degree_t OR Cmd.MechanicalRoll > 180 degree_t THEN
    RETURN OutOfRange
    CommandExit(Cmd.Command, CurrentPort)
    EXIT
ENDIF

IF Cmd.MechanicalRollProvenance NOT Manual THEN
    RETURN InvalidProvenance
    CommandExit(Cmd.Command, CurrentPort)
    EXIT
ENDIF

IF Cmd.MechanicalAzimuth < 0 degree_t OR
    Cmd.MechanicalAzimuth > 360 degree_t THEN
    RETURN OutOfRange
    CommandExit(Cmd.Command, CurrentPort)
    EXIT
ENDIF

IF Cmd.MechanicalAzimuthProvenance NOT Manual THEN
    RETURN InvalidProvenance
    CommandExit(Cmd.Command, CurrentPort)
    EXIT
ENDIF

«store the orientation information and the related provenances to non-volatile memory»

IF «the ALD detects a hardware error» THEN
    // Replace "Hardware error" with descriptive text to be read using
    // GetDiagnosticInformation
    RAISE AlarmGeneralError SEVERITY Major ON Cmd.Subunit, "Hardware error"
    RETURN "GeneralError"
ELSE
    RETURN OK
ENDIF
```

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CommandExit(Cmd.Command, CurrentPort)
EXIT

11.12.9. ALS Get Orientation

Description (Informative):

On receipt of this command the ALS subunit shall return measured orientation information from the on-board sensor and its provenances. If OrientationSensor capability is not supported, the information set by ALS Set Orientation command is returned.

Message format:

```
PrimaryCommand ALSGetOrientationCommand {
    CommandCode_t      Command ← 0x0409
    CommandSequence_t  PrimaryCommandSequence
    Subunit_t          Subunit
    DataLength_t       DataLength ← 0
}

ALDResponse ALSGetOrientationResponse {
    CommandCode_t      Command ← 0x0409
    CommandSequence_t  PrimaryCommandSequence
    ReturnCode_t       ReturnCode
    DataLength_t       DataLength
    if (ReturnCode == OK) {
        BOOLEAN        OrientationProvidedBySensor
        degree_t        MechanicalTilt
        Provenance_t    MechanicalTiltProvenance
        degree_t        MechanicalRoll
        Provenance_t    MechanicalRollProvenance
        degree_t        MechanicalAzimuth
        Provenance_t    MechanicalAzimuthProvenance
    }
    else {
        ALDState_t      ALDState
        ConnectionState_t ConnectionState
    }
}

Enumeration ReturnCode_t{
    // The following are return codes from command message validation (see section
    // 12.6.2 in [1]
    FormatError
    UnknownCommand
    InvalidSubunitNumber
    ProtocolVersionNotNegotiated
    InvalidSubunitType
    // The following are return codes from command pseudocode below
    NotAuthorised
    NotAControlPort
    IncorrectState
    Busy
    InUseByAnotherPrimary
    OK
    ALSSensorDataNotAvailable
}
```

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Primary pseudocode):

(This section is intentionally left blank)

ALD pseudocode:

BOOLEAN OrientationDataValid

IF ALDType = MALD THEN

 IF ActiveAuth[CurrentPort].Authority[Cmd.Subunit] = NoAccess THEN

 RETURN NotAuthorised

 EXIT

 ENDIF

ENDIF

result ← IsCommandAllowed(LIST{ OperatingConnectionState,
 RestrictedConnectionState},
 Cmd.Command, CurrentPort)

UNLESS result.allowed THEN

 RETURN result.code

 EXIT

ENDIF

// Altitude orientation sensor capability supported, data coming from the on-board sensor

IF ALSCapabilities.OrientationSensor THEN

 OrientationProvidedBySensor ← TRUE

 MechanicalTiltProvenance ← Automatic

 MechanicalRollProvenance ← Automatic

 MechanicalAzimuthProvenance ← Automatic

ELSE

 OrientationProvidedBySensor ← FALSE

ENDIF

IF ALSCapabilities.OrientationSensor THEN // Data from the sensor

 IF «Orientation sensor data available» THEN

 RETURN OK, LocationProvidedBySensor, «Measured orientation information
 and corresponding provenances from the sensor»

 ELSE

 RETURN ALSSensorDataNotAvailable

 CommandExit(Cmd.Command, CurrentPort)

 EXIT

 ENDIF

ELSE // Data from memory

 RETURN OK, LocationProvidedBySensor, «Orientation information and
 corresponding provenances previously stored by ALSSetOrientation»

ENDIF // If the ALS was shipped from factory with no data in these fields, the

 // corresponding provenances are NotSet

CommandExit(Cmd.Command, CurrentPort)

EXIT

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11.12.10. ALS Get Monitored Orientation Information

Description (Informative):

On receipt of this command the ALS subunit shall return the minimum and maximum monitored orientation information since the last time the values were cleared. This information may be used to analyse the effect of sway or other mechanical disturbances. If orientation monitoring has not yet recorded any value for a monitored parameter, the value +3276.7 degree_t is returned to indicated this.

The monitored values shall be cleared during ALD reset or when this command is executed with the flag ClearMonitoredOrientationValues ← TRUE.

If OrientationSensor capability is not supported, the command is rejected, and the ALS subunit returns UnsupportedCapability return code.

Message format:

```
PrimaryCommand ALSGetMonitoredOrientationInformationCommand {
    CommandCode_t      Command ← 0x0410
    CommandSequence_t  PrimaryCommandSequence
    Subunit_t          Subunit
    DataLength_t       DataLength ← 1
    BOOLEAN            ClearMonitoredOrientationValues
}

ALDResponse ALSGetMonitoredOrientationInformationResponse {
    CommandCode_t      Command ← 0x0410
    CommandSequence_t  PrimaryCommandSequence
    ReturnCode_t       ReturnCode
    DataLength_t       DataLength
    degree_t           LowestMonitoredMechanicalTilt
    Provenance_t       LowestMonitoredMechanicalTiltProvenance
    degree_t           HighestMonitoredMechanicalTilt
    Provenance_t       HighestMonitoredMechanicalTiltProvenance
    degree_t           LowestMonitoredMechanicalRoll
    Provenance_t       LowestMonitoredMechanicalRollProvenance
    degree_t           HighestMonitoredMechanicalRoll
    Provenance_t       HighestMonitoredMechanicalRollProvenance
    degree_t           LowestMonitoredMechanicalAzimuth
    Provenance_t       LowestMonitoredMechanicalAzimuthProvenance
    degree_t           HighestMonitoredMechanicalAzimuth
    Provenance_t       HighestMonitoredMechanicalAzimuthProvenance
}
else {
    ALDState_t         ALDState
    ConnectionState_t   ConnectionState
}
}
```

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```
Enumeration ReturnCode_t{
    // The following are return codes from command message validation (see section
    // 12.6.2 in [1]
    FormatError
    UnknownCommand
    InvalidSubunitNumber
    ProtocolVersionNotNegotiated
    InvalidSubunitType
    // The following are return codes from command pseudocode below
    NotAuthorised
    NotAControlPort
    IncorrectState
    Busy
    InUseByAnotherPrimary
    UnsupportedCapability
    OK
}
```

Primary pseudocode):

(This section is intentionally left blank)

ALD pseudocode:

IF ALDType = MALD THEN

```
    IF ActiveAuth[CurrentPort].Authority[Cmd.Subunit] = NoAccess THEN
        RETURN NotAuthorised
    EXIT
ENDIF
```

ENDIF

```
result ← IsCommandAllowed( LIST{      OperatingConnectionState,
                                     RestrictedConnectionState},
                           Cmd.Command, CurrentPort)
```

UNLESS result.allowed THEN

```
    RETURN result.code
    EXIT
```

ENDIF

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```
UNLESS ALSCapabilities.OrientationSensor THEN
    RETURN UnsupportedCapability
    CommandExit(Cmd.Command, CurrentPort)
    EXIT
ENDIF

// Monitored data provenances are automatic because they source is always the sensor
LowestMonitoredMechanicalTiltProvenance ← Automatic
HighestMonitoredMechanicalTiltProvenance ← Automatic
LowestMonitoredMechanicalRollProvenance ← Automatic
HighestMonitoredMechanicalRollProvenance ← Automatic
LowestMonitoredMechanicalAzimuthProvenance ← Automatic
HighestMonitoredMechanicalAzimuthProvenance ← Automatic

RETURN OK, «Lowest and highest orientation values and their corresponding provenances»

IF ClearMonitoredOrientationValues THEN
    LowestMonitoredMechanicalTilt ← +3276.7           // Indicates a NULL value
    HighestMonitoredMechanicalTilt ← +3276.7          // That is, orientation monitoring
    LowestMonitoredMechanicalRoll ← +3276.7           // has not yet recorded any value
    HighestMonitoredMechanicalRoll ← +3276.7          // for that monitored parameter
    LowestMonitoredMechanicalAzimuth ← +3276.7        // after they were cleared
    HighestMonitoredMechanicalAzimuth ← +3276.7
ENDIF

CommandExit(Cmd.Command, CurrentPort)
EXIT
```

11.12.11. ALS Set Array Element Numbers to Subunit

Description (Informative):

On receipt of this command the ALS subunit shall store the provided list of array element numbers to which the ALS subunit has a logical relationship.

The ALD vendor may have defined one or more array element numbers as read only. If the array element numbers are not stored, the ALD will return the DataReadOnly return code.

Message format:

```
PrimaryCommand ALSSetArrayElementNumbersToSubunitCommand {
    CommandCode_t      Command ← 0x0411
    CommandSequence_t  PrimaryCommandSequence
    Subunit_t          Subunit
    DataLength_t        DataLength
    uint8_t            NrOfArrayElements
    uint16_t            ArrayElementNumbers[1..NrOfArrayElements]
    Provenance_t        ArrayElementNumbersProvenance
}
```

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```
ALDResponse ALSSetArrayElementNumbersToSubunitResponse {
    CommandCode_t      Command ← 0x0411
    CommandSequence_t   PrimaryCommandSequence
    ReturnCode_t        ReturnCode
    DataLength_t        DataLength
    if (ReturnCode == OK) {
    }
    else {
        ALDState_t      ALDState
        ConnectionState_t ConnectionState
    }
}

Enumeration ReturnCode_t {
    // The following are return codes from command message validation (see section
    // 12.6.2 in [1])
    FormatError
    UnknownCommand
    InvalidSubunitNumber
    ProtocolVersionNotNegotiated
    InvalidSubunitType
    // The following are return codes from command pseudocode below
    NotAuthorised
    NotAControlPort
    IncorrectState
    Busy
    InUseByAnotherPrimary
    InvalidArrayElementNumber
    DataReadOnly
    GeneralError
    OK
}
```

Primary pseudocode:

(This section is intentionally left blank)

ALD pseudocode:

IF ALDType = MALD THEN

```
    UNLESS ActiveAuth[CurrentPort].Authority[Cmd.Subunit] = ReadWrite THEN
        RETURN NotAuthorised
    EXIT
ENDIF
```

ENDIF

```
result ← IsCommandAllowed( LIST{      OperatingConnectionState,
                                     RestrictedConnectionState},
                           Cmd.Command, CurrentPort)
```

UNLESS result.allowed THEN

```
    RETURN result.code
    EXIT
```

ENDIF

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```
UNLESS Cmd.ArrayElementNumber IN ArrayElementNumberList THEN
    RETURN InvalidArrayElementNumber
    CommandExit(Cmd.Command, CurrentPort)
    EXIT
ENDIF

IF «Array element numbers are read only in this ALS subunit» THEN
    RETURN DataReadOnly
ELSE
    «Store the array element numbers and their provenance for the supplied Subunit to
    non-volatile memory»

    IF «the ALD detects a hardware error» THEN
        // Replace "Hardware error" with descriptive text to be read using
        // GetDiagnosticInformation
        RAISE AlarmGeneralError SEVERITY Major ON Cmd.Subunit, "Hardware error"
        RETURN "GeneralError"
    ELSE
        RETURN OK
    ENDIF
ENDIF
CommandExit(Cmd.Command, CurrentPort)
EXIT
```

11.12.12. ALS Get Array Element Numbers Of Subunit

Description (Informative):

On receipt of this command the ALS subunit shall return the list of array elements to which the ALS subunit has a logical relationship.

Message format:

```
PrimaryCommand ALSGetArrayElementNumbersOfSubunitCommand {
    CommandCode_t      Command ← 0x0412
    CommandSequence_t  PrimaryCommandSequence
    Subunit_t          Subunit
    DataLength_t        DataLength ← 0
}

ALDResponse ALSGetArrayElementNumbersOfSubunitResponse {
    CommandCode_t      Command ← 0x0412
    CommandSequence_t  PrimaryCommandSequence
    ReturnCode_t       ReturnCode
    DataLength_t        DataLength
    if (ReturnCode == OK) {
        uint8_t         NrOfArrayElements
        uint16_t         ArrayElementNumbers[1..NrOfArrayElements]
        Provenance_t     ArrayElementNumbersProvenance
    }
    else {
        ALDState_t       ALDState
        ConnectionState_t ConnectionState
    }
}
```

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```
Enumeration ReturnCode_t{
    // The following are return codes from command message validation (see section
    // 12.6.2 in [1])
    FormatError
    UnknownCommand
    InvalidSubunitNumber
    ProtocolVersionNotNegotiated
    InvalidSubunitType
    // The following are return codes from command pseudocode below
    NotAuthorised
    NotAControlPort
    IncorrectState
    Busy
    InUseByAnotherPrimary
    OK
}
```

Primary pseudocode):

(This section is intentionally left blank)

ALD pseudocode:

```
IF ALDType = MALD
    AND ActiveAuth[CurrentPort].Authority[Cmd.Subunit] = NoAccess THEN
        RETURN NotAuthorised
    EXIT
ENDIF

result ← IsCommandAllowed( LIST{      OperatingConnectionState,
                                     RestrictedConnectionState,
                                     MALDSetupConnectionState},
                           Cmd.Command, CurrentPort)

UNLESS result.allowed THEN
    RETURN result.code
    EXIT
ENDIF
RETURN OK, «for the requested ALS subunit, return the number of stored array elements,
the list of array numbers, and their provenance »

CommandExit(Cmd.Command, CurrentPort)

EXIT
```

ANNEX A: Mechanical Azimuth, Tilt and Roll data representation (Informative):

This annex shows how the real world mechanical azimuth, tilt and roll data is encoded.

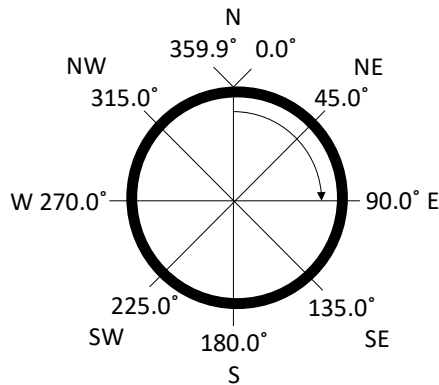


Figure A-1: Mechanical Azimuth data representation

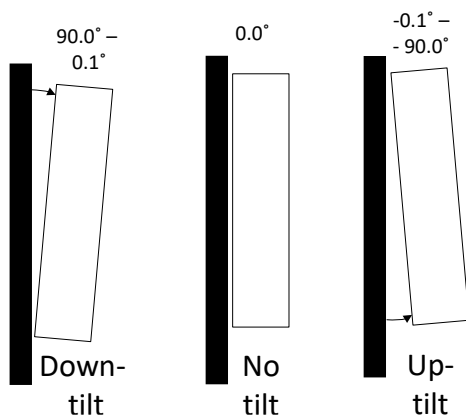


Figure A-2: Mechanical Tilt data representation

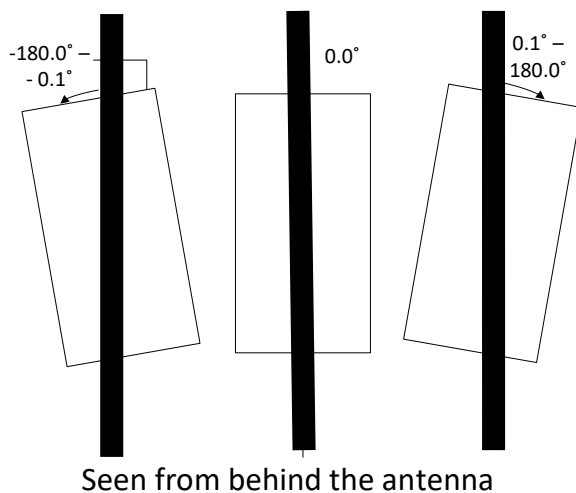


Figure A-3: Mechanical Roll data representation



ANNEX B: Mechanical alarm limits (Informative):

This annex clarifies the functioning of the tilt, roll and azimuth-alarm limits.

B-1.1 Mechanical tilt alarm limits

In the following tilt alarm limits example the following values are used:

- LowerMechanicalTiltAlarmLimit ← 7.0°
- UpperMechanicalTiltAlarmLimit ← 13.0°

NOTE: LowerMechanicalTiltAlarmLimit shall always be lower than the UpperMechanicalTiltAlarmLimit, and both shall not be the same!

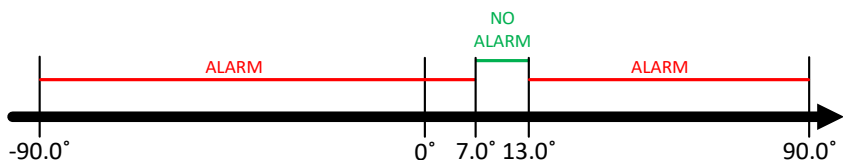


Figure B-1.1-1: Tilt alarm limits

B-1.2 Mechanical roll alarm limits

In the following roll alarm limits example the following values are used:

- LowerMechanicalRollAlarmLimit ← -5.0°
- UpperMechanicalRollAlarmLimit ← 5.0°

NOTE: LowerMechanicalRollAlarmLimit shall always be lower than the UpperMechanicalRollAlarmLimit, and both shall not be the same!

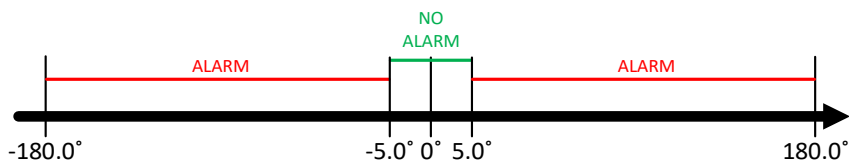


Figure B-1.2-1: Roll alarm limits

B-1.3 Mechanical azimuth alarm limits

When defining alarms on a compass circle, it is not enough to just define two alarm limits. This is because just defining two alarm limits divides the compass circle into two sectors, but leaves unclear in which sector there will be an alarm.

The solution adopted in this standard is to not to specify a required order for the two limits. The azimuth alarm limits are called Limit1 and Limit2.

The examples in sections B-1.3.1. and B-1.3.2. shows the alarm functionality in these cases.

The section B-1.3.3. explains the logic that defines in which part of the compass circle the alarm is off and in which part it is on.

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B-1.3.1 MechanicalAzimuthAlarmLimit1 > MechanicalAzimuthAlarmLimit2

In the following tilt alarm limits example the following values are used:

- MechanicalAzimuthAlarmLimit1 $\leftarrow 315.0^\circ$
- MechanicalAzimuthAlarmLimit2 $\leftarrow 45.0^\circ$

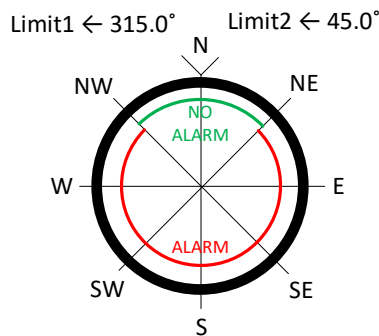


Figure B-1.3.1-1: Azimuth alarm limits, Limit1 > Limit2

B-1.3.2 MechanicalAzimuthAlarmLimit1 < MechanicalAzimuthAlarmLimit2

In the following tilt alarm limits example the following values are used:

- MechanicalAzimuthAlarmLimit1 $\leftarrow 45.0^\circ$
- MechanicalAzimuthAlarmLimit2 $\leftarrow 315.0^\circ$

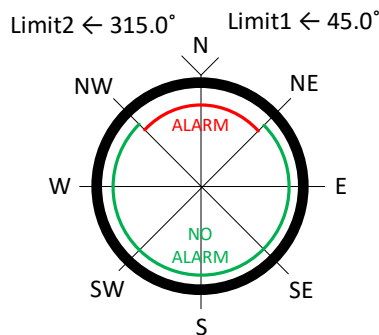


Figure B-1.3.2-1: Azimuth alarm limits, Limit1 < Limit2

B-1.3.3 Mechanical azimuth alarm logic

The following logic determines the alarm status:

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```
IF MechanicalAzimuthAlarmLimit1 > MechanicalAzimuthAlarmLimit2 THEN
    ON «Measured mechanical azimuth» < MechanicalAzimuthAlarmLimit1 AND
    «Measured mechanical azimuth» > MechanicalAzimuthAlarmLimit2
        RAISE ALSAlarmMechanicalAzimuth SEVERITY Major ON Subunit
    DONE
ELSE
    ON «Measured mechanical azimuth» < MechanicalAzimuthAlarmLimit1 OR
    «Measured mechanical azimuth» > MechanicalAzimuthAlarmLimit2
        RAISE ALSAlarmMechanicalAzimuth SEVERITY Major ON Subunit
    DONE
ENDIF
```

NOTE: MechanicalAzimuthAlarmLimit1 and MechanicalAzimuthAlarmLimit2 shall not be the same!