CiA Draft Standard Proposal 415

Device profile for road construction machinery

This draft standard proposal may be changed without notification.

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1 Scope

The CANopen device profile for road construction machinery specifies the communication behavior of OSYRIS compliant modules. Devices compliant to this profile shall use communication techniques, which conform to those in the CiA Draft Standard 301. This specification should be consulted in parallel to this device profile specification.

The profile covers the following machine types: paver, compactor, grader, dozer, mill, heater and, truck. The on-board computer shall provide the type of machine by means of wireless LAN (local area network) communication services.

This device profile has been jointly developed with the OSYRIS (Open System for Road Information Support) consortium (www.osyris.org) and the European Asphalt Pavement Association (EAPA).

2 Normative references

/1/: CiA DS 301 V4.02: CANopen application layer and communication profile, February 2002

/2/ CiA DSP 302 V3.2.1: Framework for programmable CANopen devices, May 2003

3 Acronyms and abbreviations

CAN

Controller Area Network. Data link layer protocol for serial communication as specified in ISO 11898-1 (2003).

COB

Communication OBject, which is made of one or more CAN frames. Any information transmitted via CANopen has to be mapped into COBs.

COB-ID

COB-Identifier. Identifies a COB uniquely in a CAN network. The identifier determines the priority of that COB in the data link layer, too.

SDO

Service Data Object. Peer-to-peer communication with access to the Object Dictionary of a CANopen device.

OSYRIS

Open SYstem for Road Information Support. Product model for the road construction process.

RPDO

Receive Process Data Object. Communication object of a device, which contains output data.

SDO

Service Data Object. Peer-to-peer communication with access to the Object Dictionary of a CANopen device.

TPDO

Transmit Process Data Object. Communication object of a device, which contains input data.

4 Definitions and operating principles

4.1 Introduction

Devices compliant to this profile require an application master device with CANopen manager functionality capable to support self-configuration (Configuration manager) of the CANopen network. The CANopen manager shall scan the entire network during the start-up phase as defined by *figure 1*.

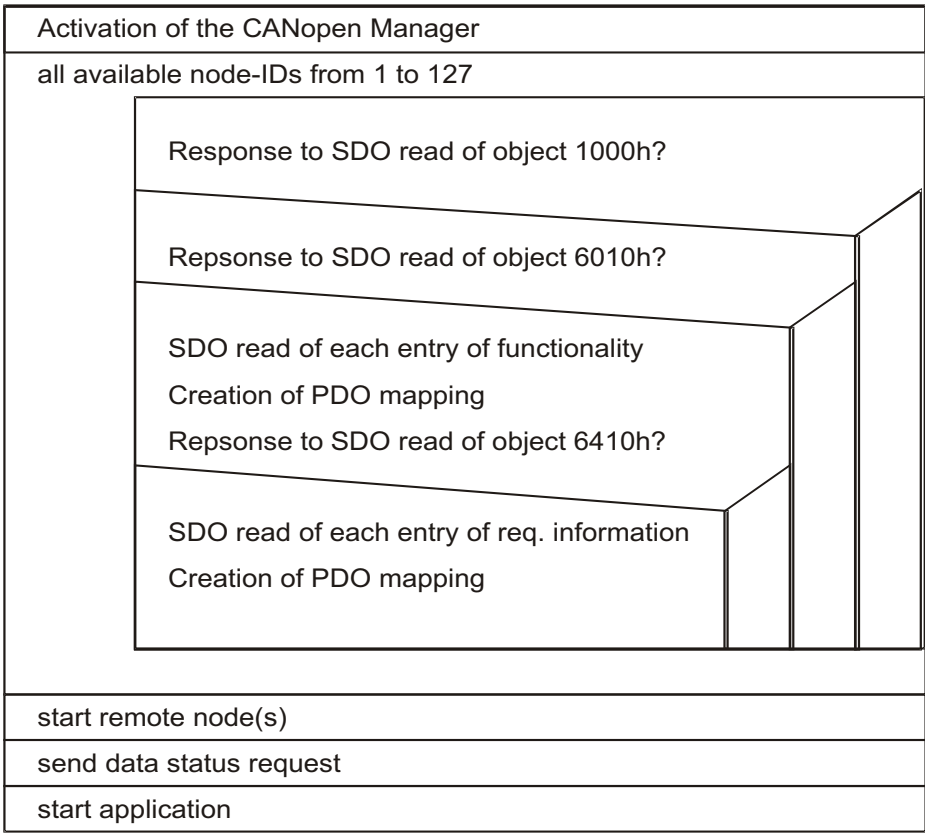


Fig. 1: CANopen boot-up procedure

The CANopen manager device shall start scanning the CANopen network for existing CANopen nodes by trying to access each node's object dictionary entry 1000_h using an SDO upload service. If the SDO upload fails, the corresponding node shall be ignored. After that, the functionality (number of supported objects) of each node at object 6010_h sub-index 0_h shall be read and the values shall be detected using a plausibility test, if any value seems illogically, the corresponding node shall be ignored. When receiving the valid number of entries, each sub-index entry shall be read out and a PDO-mapping for each node shall be created and written back to the corresponding node. At last the transmission type for each node shall be configured individually by the master according to the configuration of the system. The same procedure as with 6010_h shall be repeated with 6410_h. After running through this scanning process, the not ignored nodes shall be switched to Operational state by the NMT master. The application master shall send to each node by means of PDO write service a Data Status Request expecting 'Data OK' or 'Data error' (for further information see events, *chapter 4.2*).

4.2 Events

4.2.1 Introduction

By sending events the CANopen network is given the opportunity to exchange important system information of high priority. So defined events are always available for the CANopen manager device (in most application this will be the onboard computer), this is that the CANopen manager can manage measurements and appearing errors.

4.2.2 Event description

Send Data Status

Server sends a data status request before starting the CAN network to receive information about connected/disconnected sensors (available/not-available data).

Data Status

Nodes answer with a data status report according data status request. This event could also appear during the operation of the machine, not only as an answer on a data status request.

Example: Message size for event 'Wind speed' (object 6520_h sub-index 0_h), statement: 'Sensor disconnected'

Byte 4	Byte 3	Byte 2	Byte 1
Sub-index: 0_h	Index: 6520_h	Code: 1_h	Category: 1_h
MSB			LSB

General errors

No specific error is defined.

Start/Stop

State of the machine (movement, working status). Describes, if the machine stopped, is working or runs in the transfer mode (driving, but not working). The operator sends those events.

Leveling

Leveling status of the machine (manual, auto, and error). The operator sends manual and auto leveling mode, errors and 'hydraulic output disabled' are sent.

Project

The operator decides about the beginning of a new project or a new mission, important for the initialization of the nodes (reset mode).

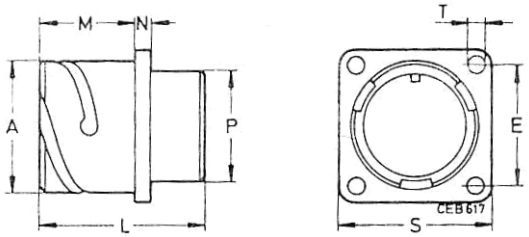
Note: The following list of events is common for compactor and paver.

Event	Sub-index	Index	Code	Category	Explanation	Remarks
Send Data Status	00_h	0000_h	0_h	0_h	-	Data status request of measured values
Data Status	Sub index	Index	0_h	1_h	Data available	Data OK (e.g. sensor connected)
	Sub index	Index	1_h	1_h	Data not-available	Data error: sensor disconnected, other error
	Sub index	Index	2_h	1_h	Data not-available	Data error: over-range
	Sub index	Index	3_h	1_h	Data not-available	Data error: under-range
General errors	00_h	0000	0_h	2_h	-	reserved
Start/Stop	00_h	0000_h	1_h	3_h	Stop	Machine stops
	01_h	0000_h	1_h	3_h	Work	Machine is moving and working
	02_h	0000_h	1_h	3_h	Transfer	Machine is moving but not working
Leveling left	00_h	0000_h	1_h	4_h	Auto-Leveling off	Manual leveling
	01_h	0000_h	1_h	4_h	Auto-Leveling on	Auto leveling
	00_h	0000_h	2_h	4_h	Leveling error off	-
	01_h	0000_h	2_h	4_h	Leveling error on	Error and hydraulic output is disabled
Leveling right	00_h	0000_h	1_h	5_h	Auto-Leveling off	Manual leveling
	01_h	0000_h	1_h	5_h	Auto-Leveling on	Auto leveling
	00_h	0000_h	2_h	5_h	Leveling error off	-
	01_h	0000_h	2_h	5_h	Leveling error on	Error and hydraulic output is disabled
Project	00_h	0000_h	1_h	6_h	Start Project	Begin of project
	00_h	0000_h	2_h	6_h	Start Mission	Begin of mission

5 Physical layer definitions

The definitions given in /2/ shall apply to devices compliant to this profile.

As an universal hardware interface between on-board computers and construction machinery the connector shown in *figure 2* shall be used, where the female connector shall be fixed on the machine, and the male connector shall be used by the on-board computer:



A	E	L	M	N	P	S	T
27.4	24.6	24.7m	14.2m	3.2 mm	22.4	32.5	3.2 mm

Fig. 2: 7-pin plug manufactured by ITT-Cannon "CA-02-COM-E16S-1S/P-B"

The following pin assignment shall be used:

A – V_{cc}
B – CAN_H
C – GND
D – CAN_L

6 Error handling

6.1 Principle

Emergency Messages shall be triggered by internal errors in the device and they are assigned the highest possible priority to ensure that they get access to the bus without latency. By default, the Emergency Messages shall contain the error field with pre-defined error numbers and additional information.

6.2 Error behavior

If a severe device failure is detected the module shall enter by default autonomously the pre-operational state. If object 1029_h is implemented, the device can be configured to enter alternatively the stopped state or remain in the current state in case of a device failure. Device failures shall include the following communication errors:

- Bus-off conditions of the CAN interface
- Life guarding event with the state ‘occurred’
- Heartbeat event with state ‘occurred’

Severe device errors also can be caused by device internal failures.

6.3 Additional error code meanings

No additional error codes have been defined.

7 Predefinitions

7.1 General

For general definitions see /1/.

7.2 Complex data types

7.2.1 Record 80_h: Curvilinear

Index	Sub-Index	Description	Data Type
80_h	0_h	Number of entries	Unsigned8
	1_h	Distance traveled low	Unsigned32
	2_h	Distance traveled high	Unsigned16
	3_h	Abscissa	Unsigned32
	4_h	Ordinate	Unsigned32

7.3 Predefined communication objects

7.3.1 1000_h: Device type

The object at index 1000_h describes the type of device and its functionality. For multiple device modules the Additional information parameter shall contain $FFFF_h$. In this case, the object $67FF_h$ shall be implemented.

VALUE DEFINITION

31 24	23 16	15 0
-		Device profile number
Additional information		*General information*
MSB		LSB

General information:
Device profile number: 415_d

Additional information:
Reserved for future use (shall be set to 0_h)

7.3.2 1001_h: Error register

The device-specific bit in the error register object is reserved.

7.3.3 1029_h: Error behavior

This object specifies to which state the device shall be set, when a communication error or a device-internal error is detected.

VALUE DEFINITION

0 = pre-operational (only if current state is operational)
1 = no state change
2 = stopped

OBJECT DESCRIPTION

INDEX	**1029_h**
Name	error_behavior
Object Code	Array
Data Type	Unsigned8
Category	Optional

ENTRY DESCRIPTION

Sub-Index	0_h
Description	number_of_error_classes
Access	ro
Entry Category	Mandatory
PDO Mapping	No
Value Range	1_h to 2_h
Default Value	No

Sub-Index	1_h
Description	communication_error
Access	rw
Entry Category	Mandatory
PDO Mapping	No
Value Range	0_h to 2_h
Default Value	1_h

Sub-Index	2_h
Description	internal_device_error
Access	rw
Entry Category	Mandatory
PDO Mapping	No
Value Range	0_h to 2_h
Default Value	1_h

7.3.4 $67FF_h$: Device type

This objects shall describe the first virtual device in a multiple device module according to /2/.

7.4 PDO communication and mapping parameter

There are no default PDOs defined at all. The TPDOs and RPDOs are generated dynamically during the boot-up procedure as described above.

8 Object dictionary

8.1 Introduction and overview

Each device compliant with this device profile shall share the CANopen Object Dictionary entries from index 6000_h to $67FF_h$, where the measurements available from each node are listed in the area 6000_h to $63FF_h$ and the values needed by each node are specified in the area 6400_h to $67FF_h$. The entries 6000_h (type of machine), 6010_h (sensor functionality) and 6410_h (required information) are mandatory, every other entry is optional. The device implements only those objects that are relevant to the functionality of the node. Object Description and Entry Description are specified in /1/.

General sensor objects:

- Object 6010_h: Sensor functionality
- Object 6020_h: Event

Objects providing position and speed measurements:

- Object 6100_h: Position
- Object 6101_h: Angle position
- Object 6102_h: Curvilinear coordinates
- Object 6103_h: Level deviation
- Object 6110_h: Paver speed
- Object 6190_h: Tow arm slope

Objects providing geometrical measurements:

- Object 6200_h: Thickness
- Object 6210_h: Evenness
- Object 6240_h: Screed width
- Object 6250_h: Volume

Objects providing geometrical measurements:

- Object 6300_h: Material core temperature
- Object 6310_h: Ambient temperature
- Object 6311_h: Base temperature
- Object 6320_h: Wind speed
- Object 6330_h: Surface temperature

Objects providing special measurements:

- Object 6340_h: Pre compaction value
- Object 6341_h: Vibration frequency
- Object 6342_h: Tamper frequency

General receive object:

- Object 6410_h: Required information

Objects receiving position and speed measurements:

- Object 6500_h: Position
- Object 6501_h: Angle position
- Object 6502_h: Curvilinear coordinates
- Object 6503_h: Level deviation
- Object 6510_h: Paver speed
- Object 6590_h: Tow arm slope

Objects receiving geometrical measurements:

- Object 6600_h: Thickness
- Object 6610_h: Evenness

- Object 6640_h: Screed width
- Object 6650_h: Volume

Objects receiving geometrical measurements:

- Object 6700_h: Material core temperature
- Object 6710_h: Ambient temperature
- Object 6711_h: Base temperature
- Object 6720_h: Wind speed
- Object 6730_h: Surface temperature

Objects receiving special measurements:

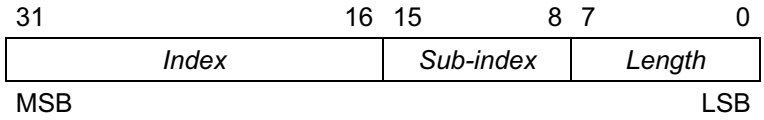
- Object 6740_h: Pre compaction value
- Object 6741_h: Vibration frequency
- Object 6742_h: Tamper frequency

8.2 6010_h: Sensor functionality

This object shall provide the description of the sensor functionality (which sensors are implemented) by means of a supported object list (all objects in the range of 6100_h to $63FF_h$).

VALUE DEFINITION

Sub-index 1_h to 254_h:



OBJECT DESCRIPTION

INDEX	**6010_h**
Name	sensor_functionality
Object Code	ARRAY
Data Type	Unsigned32
Category	Mandatory

ENTRY DESCRIPTION

Sub-Index	0_h
Description	highest_subindex_supported
Entry Category	Mandatory
Access	ro
PDO Mapping	No
Value Range	1_h to FE_h
Default Value	No

Sub-Index	1_h
Description	1_st_object
Entry Category	Mandatory
Access	ro
PDO Mapping	No
Value Range	See value definition
Default Value	No

Sub-Index	2_h
Description	2_nd_object
Entry Description	Optional
Access	ro
PDO Mapping	No
Value Range	See value definition
Default Value	No

to

Sub-Index	FE_h
Description	254_th_object
Entry Category	Optional
Access	ro
PDO Mapping	No
Value Range	Value definition
Default Value	No

Example 1: Speed sensor; it measures only the speed of the paver.

Index	*Sub-Index*	*Content*
6010_h	0_h	01_h
	1_h	6110 00 10_h

Example 2: Combined environmental sensor; it measures ambient temperature and wind.

Index	*Sub-Index*	*Content*
6010_h	0_h	04_h
	1_h	6520 00 10_h
	2_h	6510 01 10_h
	3_h	6510 02 10_h
	4_h	6510 03 10_h

8.3 6020_h: Event

This object shall provide the event message.

VALUE DEFINITION

See *chapter 4.2.2.*

OBJECT DESCRIPTION

INDEX	**6020_h**
Name	event
Object Code	VAR
Data Type	Unsigned32
Category	Optional

ENTRY DESCRIPTION

Sub-Index	0_h
Access	ro
PDO Mapping	Optional
Value Range	See value definition
Default Value	No

8.4 6100_h: Position

This object shall provide the 3-D absolute position by measuring the position in the four cardinal points and the geodesic height.

VALUE DEFINITION

Sub-index 1_h: E

Positive values: east direction; negative values: west direction shall be given in 1 mm per bit. An invalid measurement shall be indicated by a value of FFFF $FFFF_h$.

Sub-index 2_h: N

Positive values: north direction; negative values: south direction shall be given in 1 mm per bit. An invalid measurement shall be indicated by a value of FFFF $FFFF_h$.

Sub-index 3_h: H

Geodesic height shall be given in 0.1 mm per bit. An invalid measurement shall be indicated by a value of FFFF $FFFF_h$.

OBJECT DESCRIPTION

INDEX	**6100_h**
Name	Position
Object Code	ARRAY
Data Type	Signed32
Category	Optional

ENTRY DESCRIPTION

Sub-Index	0_h
Description	highest_subindex_supported
Entry Category	Mandatory
Access	ro
PDO Mapping	No
Value Range	1_h to 3_h
Default Value	No

Sub-Index	1_h
Description	E
Entry Category	Optional
Access	ro
PDO Mapping	Possible
Value Range	0131 $2C00_h$ to 8131 $2C00_h$
Default Value	No

Sub-Index	2_h
Description	N
Entry Description	Optional
Access	ro
PDO Mapping	Possible
Value Range	0131 $2C00_h$ to 8131 $2C00_h$
Default Value	No

Sub-Index	3_h
Description	H
Entry Category	Optional
Access	ro
PDO Mapping	Possible
Value Range	Signed32
Default Value	No

8.5 6101_h: Angle position

This object shall provide slope measurement (long slope, cross slope) and heading.

VALUE DEFINITION

Sub-index 1_h: Long slope
The value shall be given in 0.01% per bit (positive value: uphill; negative value: downhill). An invalid measurement shall be indicated by a value of $FFFF_h$.

Sub-index 2_h: Cross slope
The value shall be given in 0.01% per bit (negative value: clockwise rotation). An invalid measurement shall be indicated by a value of $FFFF_h$.

Sub-index 3_h: Heading
The value shall be given in 0.0055° per bit (0000_h = north; 4000_h = west; $FFFE_h$ = full rotation). An invalid measurement shall be indicated by a value of $FFFF_h$.

OBJECT DESCRIPTION

INDEX	**6101_h**
Name	angle_position
Object Code	ARRAY
Data Type	Signed32
Category	Optional

ENTRY DESCRIPTION

Sub-Index	0_h
Description	highest_subindex_supported
Entry Category	Mandatory
Access	ro
PDO Mapping	No
Value Range	1_h to 3_h
Default Value	No

Sub-Index	1_h
Description	long_slope
Entry Category	Optional
Access	ro
PDO Mapping	Optional
Value Range	Signed32
Default Value	No

Sub-Index	2_h
Description	cross_slope
Entry Description	Optional
Access	ro
PDO Mapping	Optional
Value Range	Signed32
Default Value	No

Sub-Index	3_h
Description	Heading
Entry Category	Optional
Access	ro
PDO Mapping	Optional
Value Range	See value definition
Default Value	No

8.6 6102_h: Curvilinear coordinates

This object shall provide the curve measurement, containing traveled distance, abscissa (distance relative to stationing) and ordinate (distance from axis to the right) value. The onboard computer (application master) or CANopen manager may reset the measured values (e.g. distance traveled low) by means of SDO services.

VALUE DEFINITION

Sub-index 1_h: Distance traveled low

The value shall describe the total distance traveled (project/mission-specific or global) and shall be given in 1 mm per bit. An invalid measurement shall be indicated by a value of FFFF $FFFF_h$.

Sub-index 2_h: Distance traveled high

The value is increased by 1 each 2^{32} mm (4,294 km).
An invalid measurement shall be indicated by a value of $FFFF_h$.

Sub-index 3_h: Abscissa
The value shall provide the measured distance relative to stationing, count down when maneuvering backwards. It shall be given in 1 mm per bit. An invalid measurement shall be indicated by a value of FFFF $FFFF_h$.

Sub-index 4_h: Ordinate
The value shall provide the measured distance from the axis to the right. It shall be given in 1 mm per bit (positive value: right-hand curve; negative: left-hand curve). An invalid measurement shall be indicated by a value of FFFF $FFFF_h$.

OBJECT DESCRIPTION

INDEX	**6102_h**
Name	curvilinear_coordinates
Object Code	RECORD
Data Type	80_h (curvilinear)
Category	Optional

ENTRY DESCRIPTION

Sub-Index	0_h
Description	highest_subindex_supported
Entry Category	Mandatory
Access	ro
PDO Mapping	No
Value Range	1_h to 4_h
Default Value	No

Sub-Index	1_h
Description	distance_traveled_low
Entry Category	Optional
Access	rw
PDO Mapping	Optional
Value Range	Unsigned32
Default Value	No

Sub-Index	2_h
Description	distance_traveled_high
Entry Description	Optional
Access	ro
PDO Mapping	Optional
Value Range	Unsigned16
Default Value	No

Sub-Index	3_h
Description	abscissa
Entry Category	Optional
Access	rw
PDO Mapping	Optional
Value Range	Unsigned32
Default Value	No

Sub-Index	4_h
Description	ordinate
Entry Category	Optional
Access	rw
PDO Mapping	Optional
Value Range	Unsigned32
Default Value	No

8.7 6103_h: Level deviation

This object shall provide the level measurement.

VALUE DEFINITION

Sub-index 1_h and 2_h:

The values shall be given in 0.1 mm per bit (positive value: level too high; negative value: level too low). An invalid measurement shall be indicated by a value of $FFFF_h$.

OBJECT DESCRIPTION

INDEX	**6103_h**
Name	level_deviation
Object Code	ARRAY
Data Type	Signed16
Category	Optional

ENTRY DESCRIPTION

Sub-Index	0_h
Description	highest_subindex_supported
Entry Category	Mandatory
Access	ro
PDO Mapping	No
Value Range	2_h
Default Value	2_h

Sub-Index	1_h
Description	level_deviation_left
Entry Category	Mandatory
Access	ro
PDO Mapping	Optional
Value Range	Signed16
Default Value	No

Sub-Index	2_h
Description	level_deviation_right
Entry Description	Mandatory
Access	ro
PDO Mapping	Optional
Value Range	Signed16
Default Value	No

8.8 6110_h: Paver speed

This object shall provide the current speed of the paver.

VALUE DEFINITION

The value shall be given in 1 mm/s per bit. An invalid measurement shall be indicated by a value of $FFFF_h$.

OBJECT DESCRIPTION

INDEX	**6110_h**
Name	paver_speed
Object Code	VAR
Data Type	Unsigned16
Category	Optional

ENTRY DESCRIPTION

Sub-Index	0_h
Access	ro
PDO Mapping	Optional
Value Range	Unsigned16
Default Value	No

8.9 6190_h: Tow arm slope

This object shall provide the slope measurement for the tow arm of the paver.

VALUE DEFINITION

Sub-index 1_h and 2_h:

The values shall be given in 0.01% per bit (positive value: tow arm up; negative value: tow arm down). An invalid measurement shall be indicated by a value of $FFFF_h$.

OBJECT DESCRIPTION

INDEX	**6190_h**
Name	tow_arm_slope
Object Code	ARRAY
Data Type	Signed16
Category	Optional

ENTRY DESCRIPTION

Sub-Index	0_h
Description	highest_subindex_supported
Entry Category	Mandatory
Access	ro
PDO Mapping	No
Value Range	2_h
Default Value	2_h

Sub-Index	1_h
Description	towarm_slope_left
Entry Category	Mandatory
Access	ro
PDO Mapping	Optional
Value Range	Signed16
Default Value	No

Sub-Index	2_h
Description	towarm_slope_right
Entry Description	Mandatory
Access	ro
PDO Mapping	Optional
Value Range	Signed16
Default Value	No

8.10 6200_h: Thickness

This object shall provide thickness measurements of the laid layer. There are three mandatory measurements: average thickness over the entire width (sub-index 1_h), thickness left side of the layer (sub-index 2_h), and thickness left side of the layer (sub-index 3_h). Additional thickness measurements may be supported in order to get a more precise profile of the laid layer.

VALUE DEFINITION

Sub-index 1_h and FE_h:

The values shall be given in 0.1 mm per bit. An invalid measurement shall be indicated by a value of $FFFF_h$.

OBJECT DESCRIPTION

INDEX	**6200_h**
Name	thickness
Object Code	ARRAY
Data Type	Unsigned16
Category	optional

ENTRY DESCRIPTION

Sub-Index	0_h
Description	highest_subindex_supported
Entry Category	Mandatory
Access	ro
PDO Mapping	No
Value Range	3_h to FE_h
Default Value	No

Sub-Index	1_h
Description	thickness
Entry Category	Mandatory
Access	ro
PDO Mapping	Optional
Value Range	Unsigned16
Default Value	No

Sub-Index	2_h
Description	thickness_left
Entry Description	Mandatory
Access	ro
PDO Mapping	Optional
Value Range	Unsigned16
Default Value	No

Sub-Index	3_h
Description	thickness_right
Entry Category	Mandatory
Access	ro
PDO Mapping	Optional
Value Range	Unsigned16
Default Value	No

Sub-Index	4_h
Description	thickness_1
Entry Category	Optional
Access	ro
PDO Mapping	Optional
Value Range	Unsigned16
Default Value	No

to

Sub-Index	FE_h
Description	thickness_251
Entry Category	Optional
Access	ro
PDO Mapping	Optional
Value Range	Unsigned16
Default Value	No

8.11 6210_h: Evenness

This object shall provide the evenness measurement of the laid layer.

VALUE DEFINITION

The values shall be given in 1 mm/m per bit (positive value: uphill; negative value: downhill). An invalid measurement shall be indicated by a value of $FFFF_h$.

OBJECT DESCRIPTION

INDEX	**6210_h**
Name	evenness
Object Code	VAR
Data Type	Signed16
Category	Optional

ENTRY DESCRIPTION

Sub-Index	0_h
Access	ro
PDO Mapping	Optional
Value Range	Signed16
Default Value	No

8.12 6240_h: Screed width

This object shall provide the screed width measurements of the laid layer by measuring screed width extensions left and right as well as total screed width.

VALUE DEFINITION

Sub-index 1_h to 3_h:

The values shall be given in 0. 1 mm per bit. An invalid measurement shall be indicated by a value of $FFFF_h$.

OBJECT DESCRIPTION

INDEX	**6240_h**
Name	screed_width
Object Code	ARRAY
Data Type	Unsigned16
Category	Optional

ENTRY DESCRIPTION

Sub-Index	0_h
Description	highest_subindex_supported
Entry Category	Mandatory
Access	ro
PDO Mapping	No
Value Range	3_h
Default Value	3_h

Sub-Index	1_h
Description	screed_width_left
Entry Category	Mandatory
Access	ro
PDO Mapping	Optional
Value Range	Unsigned16
Default Value	No

Sub-Index	2_h
Description	screed_width_right
Entry Description	Mandatory
Access	ro
PDO Mapping	Optional
Value Range	Unsigned16
Default Value	No

Sub-Index	3_h
Description	total_screed_width
Entry Category	Mandatory
Access	ro
PDO Mapping	Optional
Value Range	Unsigned16
Default Value	No

8.13 6250_h: Volume

This object shall provide volume measurements since the beginning of the project (sub-index 1_h) and beginning of the mission (sub-index 2_h).

VALUE DEFINITION

Sub-index 1_h and 2_h:

The values shall be given in 0.001 m^3 per bit. An invalid measurement shall be indicated by a value of FFFF $FFFF_h$.

OBJECT DESCRIPTION

INDEX	**6250_h**
Name	volume
Object Code	ARRAY
Data Type	Unsigned32
Category	Optional

ENTRY DESCRIPTION

Sub-Index	0_h
Description	highest_subindex_supported
Entry Category	Mandatory
Access	ro
PDO Mapping	No
Value Range	2_h
Default Value	2_h

Sub-Index	1_h
Description	total_volume
Entry Category	Mandatory
Access	ro
PDO Mapping	Optional
Value Range	Unsigned32
Default Value	No

Sub-Index	2_h
Description	mission_volume
Entry Description	Mandatory
Access	ro
PDO Mapping	Optional
Value Range	Unsigned32
Default Value	No

8.14 6300_h: Material core temperature

This object shall provide temperature measurements of the material.

VALUE DEFINITION

Sub-index 1_h to 4_h:

The values shall be given in 0.1 °C per bit. An invalid measurement shall be indicated by a value of $FFFF_h$.

OBJECT DESCRIPTION

INDEX	**6300_h**
Name	material_core_temperature
Object Code	ARRAY
Data Type	Signed16
Category	Optional

ENTRY DESCRIPTION

Sub-Index	0_h
Description	highest_subindex_supported
Entry Category	Mandatory
Access	ro
PDO Mapping	No
Value Range	1_h to 4_h
Default Value	No

Sub-Index	1_h
Description	temperature_average
Entry Category	Mandatory
Access	ro
PDO Mapping	Optional
Value Range	Signed16
Default Value	No

Sub-Index	2_h
Description	temperature_left_side
Entry Description	Optional
Access	ro
PDO Mapping	Optional
Value Range	Signed16
Default Value	No

Sub-Index	3_h
Description	temperature_right_side
Entry Category	Optional
Access	ro
PDO Mapping	Optional
Value Range	Signed16
Default Value	No

Sub-Index	4_h
Description	temperature_center
Entry Category	Optional
Access	ro
PDO Mapping	Optional
Value Range	Signed16
Default Value	No

8.15 6310_h: Ambient temperature

This object shall provide temperature measurements around the machinery including an average of all measured points (mandatory).

VALUE DEFINITION

Sub-index 1_h to FE_h:

The values shall be given in 0.1 °C per bit. An invalid measurement shall be indicated by a value of $FFFF_h$.

OBJECT DESCRIPTION

INDEX	**6310_h**
Name	ambient_temperature
Object Code	ARRAY
Data Type	Signed16
Category	Optional

ENTRY DESCRIPTION

Sub-Index	0_h
Description	highest_subindex_supported
Entry Category	Mandatory
Access	ro
PDO Mapping	No
Value Range	1_h to FE_h
Default Value	No

Sub-Index	1_h
Description	temperature_average
Entry Category	Mandatory
Access	ro
PDO Mapping	Optional
Value Range	Signed16
Default Value	No

Sub-Index	2_h
Description	temperature_1
Entry Description	Optional
Access	ro
PDO Mapping	Optional
Value Range	Signed16
Default Value	No

to

Sub-Index	FE_h
Description	temperature_253
Entry Category	Optional
Access	ro
PDO Mapping	Optional
Value Range	Signed16
Default Value	No

8.16 6311_h: Base temperature

This object shall provide surface temperature measurements of the layer below the paver before laying of the new asphalt layer.

VALUE DEFINITION

The value shall be given in 0.1 °C per bit. An invalid measurement shall be indicated by a value of $FFFF_h$.

OBJECT DESCRIPTION

INDEX	**6311_h**
Name	base_temperature
Object Code	VAR
Data Type	Signed16
Category	Optional

ENTRY DESCRIPTION

Sub-Index	0_h
Access	ro
PDO Mapping	Optional
Value Range	Signed16
Default Value	No

8.17 6320_h: Wind speed

This object shall provide wind speed measurements around the machinery. It is required for the description and calculation of other measurements (e.g. temperature).

VALUE DEFINITION

The value shall be given in 0.01 m/s per bit. An invalid measurement shall be indicated by a value of $FFFF_h$.

OBJECT DESCRIPTION

INDEX	**6320_h**
Name	wind_speed
Object Code	VAR
Data Type	Unsigned16
Category	Optional

ENTRY DESCRIPTION

Sub-Index	0_h
Access	ro
PDO Mapping	Optional
Value Range	Unsigned16
Default Value	No

8.18 6330_h: Surface temperature

This object shall provide surface temperature measurements of the new laid layer including an average of all measured points (mandatory).

VALUE DEFINITION

Sub-index 1_h to FE_h:

The values shall be given in 0.1 °C per bit. An invalid measurement shall be indicated by a value of $FFFF_h$.

OBJECT DESCRIPTION

INDEX	**6330_h**
Name	surface_temperature
Object Code	ARRAY
Data Type	Signed16
Category	Optional

ENTRY DESCRIPTION

Sub-Index	0_h
Description	highest_subindex_supported
Entry Category	Mandatory
Access	ro
PDO Mapping	No
Value Range	1_h to FE_h
Default Value	No

Sub-Index	1_h
Description	temperature_average
Entry Category	Mandatory
Access	ro
PDO Mapping	Optional
Value Range	Signed16
Default Value	No

Sub-Index	2_h
Description	temperature_1
Entry Description	Optional
Access	ro
PDO Mapping	Optional
Value Range	Signed16
Default Value	No

to

Sub-Index	FE_h
Description	temperature_253
Entry Category	Optional
Access	ro
PDO Mapping	Optional
Value Range	Signed16
Default Value	No

8.19 6410_h: Required information

This object shall indicate the description of the required sensor information to be received from other nodes by means of an object list (all objects in the range of 6500_h to $67FF_h$).

VALUE DEFINITION

See object 6010_h.

OBJECT DESCRIPTION

INDEX	**6410_h**
Name	required_information
Object Code	ARRAY
Data Type	Unsigned32
Category	Mandatory

ENTRY DESCRIPTION

Sub-Index	0_h
Description	highest_subindex_supported
Entry Category	Mandatory
Access	ro
PDO Mapping	No
Value Range	1_h to FE_h
Default Value	No

Sub-Index	1_h
Description	1_st_object
Entry Category	Mandatory
Access	ro
PDO Mapping	No
Value Range	See value definition
Default Value	No

Sub-Index	2_h
Description	2_nd_object
Entry Description	Optional
Access	ro
PDO Mapping	No
Value Range	See value definition
Default Value	No

to

Sub-Index	FE_h
Description	254_th_object
Entry Category	Optional
Access	ro
PDO Mapping	No
Value Range	Value definition
Default Value	No

8.20 6500_h: Position

This object shall receive the 3-D absolute position by measuring the position in the four cardinal points and the geodesic height.

VALUE DEFINITION

See object 6100_h.

OBJECT DESCRIPTION

INDEX	**6500_h**
Name	Position
Object Code	ARRAY
Data Type	Signed32
Category	Optional

ENTRY DESCRIPTION

Sub-Index	0_h
Description	highest_subindex_supported
Entry Category	Mandatory
Access	ro
PDO Mapping	No
Value Range	1_h to 3_h
Default Value	No

Sub-Index	1_h
Description	E
Entry Category	Optional
Access	rw
PDO Mapping	Possible
Value Range	0131 $2C00_h$ to 8131 $2C00_h$
Default Value	FFFF $FFFF_h$

Sub-Index	2_h
Description	N
Entry Description	Optional
Access	ro
PDO Mapping	Possible
Value Range	0131 $2C00_h$ to 8131 $2C00_h$
Default Value	FFFF $FFFF_h$

Sub-Index	3_h
Description	H
Entry Category	Optional
Access	ro
PDO Mapping	Possible
Value Range	Signed32
Default Value	FFFF $FFFF_h$

8.21 6501_h: Angle position

This object shall receive slope measurement (long slope, cross slope) and heading.

VALUE DEFINITION

See object 6101_h.

OBJECT DESCRIPTION

INDEX	**6501_h**
Name	angle_position
Object Code	ARRAY
Data Type	Signed32
Category	Optional

ENTRY DESCRIPTION

Sub-Index	0_h
Description	highest_subindex_supported
Entry Category	Mandatory
Access	ro
PDO Mapping	No
Value Range	1_h to 3_h
Default Value	No

Sub-Index	1_h
Description	long_slope
Entry Category	Optional
Access	rw
PDO Mapping	Optional
Value Range	Signed32
Default Value	FFFF $FFFF_h$

Sub-Index	2_h
Description	cross_slope
Entry Description	Optional
Access	rw
PDO Mapping	Optional
Value Range	Signed32
Default Value	FFFF $FFFF_h$

Sub-Index	3_h
Description	Heading
Entry Category	Optional
Access	rw
PDO Mapping	Optional
Value Range	See value definition
Default Value	FFFF FFFF$_h$

8.22 6502_h: Curvilinear coordinates

This object shall receive the curve measurement, containing traveled distance, abscissa (distance relative to stationing) and ordinate (distance from axis to the right) value. The onboard computer (application master) or CANopen manager may reset the measured values (e.g. distance traveled low) by means of SDO services.

VALUE DEFINITION

See object 6102_h.

OBJECT DESCRIPTION

INDEX	**6502_h**
Name	curvilinear_coordinates
Object Code	RECORD
Data Type	80_h (curvilinear)
Category	Optional

ENTRY DESCRIPTION

Sub-Index	0_h
Description	highest_subindex_supported
Entry Category	Mandatory
Access	ro
PDO Mapping	No
Value Range	1_h to 4_h
Default Value	No

Sub-Index	1_h
Description	distance_traveled_low
Entry Category	Optional
Access	rw
PDO Mapping	Optional
Value Range	Unsigned32
Default Value	FFFF FFFF$_h$

Sub-Index	2_h
Description	distance_traveled_high
Entry Description	Optional
Access	rw
PDO Mapping	Optional
Value Range	Unsigned16
Default Value	$FFFF_h$

Sub-Index	3_h
Description	abscissa
Entry Category	Optional
Access	rw
PDO Mapping	Optional
Value Range	Unsigned32
Default Value	FFFF $FFFF_h$

Sub-Index	4_h
Description	ordinate
Entry Category	Optional
Access	rw
PDO Mapping	Optional
Value Range	Unsigned32
Default Value	FFFF $FFFF_h$

8.23 6503_h: Level deviation

This object shall receive the level measurement.

VALUE DEFINITION

See object 6103_h.

OBJECT DESCRIPTION

INDEX	**6503_h**
Name	level_deviation
Object Code	ARRAY
Data Type	Signed16
Category	Optional

ENTRY DESCRIPTION

Sub-Index	0_h
Description	highest_subindex_supported
Entry Category	Mandatory
Access	ro
PDO Mapping	No
Value Range	2_h
Default Value	2_h

Sub-Index	1_h
Description	level_deviation_left
Entry Category	Mandatory
Access	rw
PDO Mapping	Optional
Value Range	Signed16
Default Value	$FFFF_h$

Sub-Index	2_h
Description	level_deviation_right
Entry Description	Mandatory
Access	rw
PDO Mapping	Optional
Value Range	Signed16
Default Value	$FFFF_h$

8.24 6510_h: Paver speed

This object shall receive the current speed of the paver.

VALUE DEFINITION

See object 6110_h.

OBJECT DESCRIPTION

INDEX	**6510_h**
Name	paver_speed
Object Code	VAR
Data Type	Unsigned16
Category	Optional

ENTRY DESCRIPTION

Sub-Index	0_h
Access	rw
PDO Mapping	Optional
Value Range	Unsigned16
Default Value	$FFFF_h$

8.25 6590_h: Tow arm slope

This object shall receive the slope measurement for the tow arm of the paver.

VALUE DEFINITION

See object 6190_h.

OBJECT DESCRIPTION

INDEX	**6590_h**
Name	tow_arm_slope
Object Code	ARRAY
Data Type	Signed16
Category	Optional

ENTRY DESCRIPTION

Sub-Index	0_h
Description	highest_subindex_supported
Entry Category	Mandatory
Access	ro
PDO Mapping	No
Value Range	2_h
Default Value	2_h

Sub-Index	1_h
Description	towarm_slope_left
Entry Category	Mandatory
Access	rw
PDO Mapping	Optional
Value Range	Signed16
Default Value	$FFFF_h$

Sub-Index	2_h
Description	towarm_slope_right
Entry Description	Mandatory
Access	rw
PDO Mapping	Optional
Value Range	Signed16
Default Value	$FFFF_h$

8.26 6600_h: Thickness

This object shall receive thickness measurements of the laid layer. There are three mandatory measurements: average thickness over the entire width (sub-index 1_h), thickness left side of the layer (sub-index 2_h), and thickness left side of the layer (sub-index 3_h). Additional thickness measurements may be supported in order to get a more precise profile of the laid layer.

VALUE DEFINITION

See object 6200$_h$.

OBJECT DESCRIPTION

INDEX	**6600$_h$**
Name	thickness
Object Code	ARRAY
Data Type	Signed16
Category	optional

ENTRY DESCRIPTION

Sub-Index	0$_h$
Description	highest_subindex_supported
Entry Category	Mandatory
Access	ro
PDO Mapping	No
Value Range	3$_h$ to FE$_h$
Default Value	No

Sub-Index	1$_h$
Description	thickness
Entry Category	Mandatory
Access	rw
PDO Mapping	Optional
Value Range	Signed16
Default Value	FFFF$_h$

Sub-Index	2$_h$
Description	thickness_left
Entry Description	Mandatory
Access	rw
PDO Mapping	Optional
Value Range	Signed16
Default Value	FFFF$_h$

Sub-Index	3$_h$
Description	thickness_right
Entry Category	Mandatory
Access	rw
PDO Mapping	Optional
Value Range	Signed16
Default Value	FFFF$_h$

Sub-Index	4_h
Description	thickness_1
Entry Category	Optional
Access	rw
PDO Mapping	Optional
Value Range	Signed16
Default Value	$FFFF_h$

to

Sub-Index	FE_h
Description	thickness_251
Entry Category	Optional
Access	rw
PDO Mapping	Optional
Value Range	Signed16
Default Value	$FFFF_h$

8.27 6610_h: Evenness

This object shall receive the evenness measurement of the laid layer.

VALUE DEFINITION

See object 6210_h.

OBJECT DESCRIPTION

INDEX	**6610_h**
Name	evenness
Object Code	VAR
Data Type	Signed16
Category	Optional

ENTRY DESCRIPTION

Sub-Index	0_h
Access	rw
PDO Mapping	Optional
Value Range	Signed16
Default Value	$FFFF_h$

8.28 6640_h: Screed width

This object shall receive the screed width measurements of the laid layer by measuring screed width extensions left and right as well as total screed width.

VALUE DEFINITION

See object 6240_h.

OBJECT DESCRIPTION

INDEX	**6640_h**
Name	screed_width
Object Code	ARRAY
Data Type	Unsigned16
Category	Optional

ENTRY DESCRIPTION

Sub-Index	0_h
Description	highest_subindex_supported
Entry Category	Mandatory
Access	ro
PDO Mapping	No
Value Range	3_h
Default Value	3_h

Sub-Index	1_h
Description	screed_width_left
Entry Category	Mandatory
Access	rw
PDO Mapping	Optional
Value Range	Unsigned16
Default Value	$FFFF_h$

Sub-Index	2_h
Description	screed_width_right
Entry Description	Mandatory
Access	rw
PDO Mapping	Optional
Value Range	Unsigned16
Default Value	$FFFF_h$

Sub-Index	3_h
Description	total_screed_width
Entry Category	Mandatory
Access	rw
PDO Mapping	Optional
Value Range	Unsigned16
Default Value	$FFFF_h$

8.29 6650_h: Volume

This object shall receive volume measurements since the beginning of the project (sub-index 1_h) and beginning of the mission (sub-index 2_h).

VALUE DEFINITION

See object 6250_h.

OBJECT DESCRIPTION

INDEX	**6650_h**
Name	volume
Object Code	ARRAY
Data Type	Unsigned32
Category	Optional

ENTRY DESCRIPTION

Sub-Index	0_h
Description	highest_subindex_supported
Entry Category	Mandatory
Access	ro
PDO Mapping	No
Value Range	2_h
Default Value	2_h

Sub-Index	1_h
Description	total_volume
Entry Category	Mandatory
Access	rw
PDO Mapping	Optional
Value Range	Unsigned32
Default Value	FFFF $FFFF_h$

Sub-Index	2_h
Description	mission_volume
Entry Description	Mandatory
Access	rw
PDO Mapping	Optional
Value Range	Unsigned32
Default Value	FFFF $FFFF_h$

8.30 6700_h: Material core temperature

This object shall receive temperature measurements of the material.

VALUE DEFINITION

See object 6300_h.

OBJECT DESCRIPTION

INDEX	**6700_h**
Name	material_core_temperature
Object Code	ARRAY
Data Type	Signed16
Category	Optional

ENTRY DESCRIPTION

Sub-Index	0_h
Description	highest_subindex_supported
Entry Category	Mandatory
Access	ro
PDO Mapping	No
Value Range	1_h to 4_h
Default Value	No

Sub-Index	1_h
Description	temperature_average
Entry Category	Mandatory
Access	rw
PDO Mapping	Optional
Value Range	Signed16
Default Value	$FFFF_h$

Sub-Index	2_h
Description	temperature_left_side
Entry Description	Optional
Access	rw
PDO Mapping	Optional
Value Range	Signed16
Default Value	$FFFF_h$

Sub-Index	3_h
Description	temperature_right_side
Entry Category	Optional
Access	rw
PDO Mapping	Optional
Value Range	Signed16
Default Value	$FFFF_h$

Sub-Index	4_h
Description	temperature_center
Entry Category	Optional
Access	rw
PDO Mapping	Optional
Value Range	Signed16
Default Value	$FFFF_h$

8.31 6710_h: Ambient temperature

This object shall receive temperature measurements around the machinery including an average of all measured points (mandatory).

VALUE DEFINITION

See object 6310_h.

OBJECT DESCRIPTION

INDEX	**6710_h**
Name	ambient_temperature
Object Code	ARRAY
Data Type	Signed16
Category	Optional

ENTRY DESCRIPTION

Sub-Index	0_h
Description	highest_subindex_supported
Entry Category	Mandatory
Access	ro
PDO Mapping	No
Value Range	1_h to FE_h
Default Value	No

Sub-Index	1_h
Description	temperature_average
Entry Category	Mandatory
Access	rw
PDO Mapping	Optional
Value Range	Signed16
Default Value	$FFFF_h$

Sub-Index	2_h
Description	temperature_1
Entry Description	Optional
Access	rw
PDO Mapping	Optional
Value Range	Signed16
Default Value	$FFFF_h$

to

Sub-Index	FE_h
Description	temperature_253
Entry Category	Optional
Access	rw
PDO Mapping	Optional
Value Range	Signed16
Default Value	$FFFF_h$

8.32 6711_h: Base temperature

This object shall receive surface temperature measurements of the layer below the paver before laying of the new asphalt layer.

VALUE DEFINITION

See object 6311_h.

OBJECT DESCRIPTION

INDEX	**6711_h**
Name	base_temperature
Object Code	VAR
Data Type	Signed16
Category	Optional

ENTRY DESCRIPTION

Sub-Index	0_h
Access	rw
PDO Mapping	Optional
Value Range	Signed16
Default Value	$FFFF_h$

8.33 6720_h: Wind speed

This object shall receive wind speed measurements around the machinery. It is required for the description and calculation of other measurements (e.g. temperature).

VALUE DEFINITION

See object 6320_h.

OBJECT DESCRIPTION

INDEX	**6720_h**
Name	wind_speed
Object Code	VAR
Data Type	Unsigned16
Category	Optional

ENTRY DESCRIPTION

Sub-Index	0_h
Access	rw
PDO Mapping	Optional
Value Range	Unsigned16
Default Value	$FFFF_h$

8.34 6730_h: Surface temperature

This object shall receive surface temperature measurements of the new laid layer including an average of all measured points (mandatory).

VALUE DEFINITION

See object 6300_h.

OBJECT DESCRIPTION

INDEX	**6730_h**
Name	surface_temperature
Object Code	ARRAY
Data Type	Signed16
Category	Optional

ENTRY DESCRIPTION

Sub-Index	0_h
Description	highest_subindex_supported
Entry Category	Mandatory
Access	ro
PDO Mapping	No
Value Range	1_h to FE_h
Default Value	No

Sub-Index	1_h
Description	temperature_average
Entry Category	Mandatory
Access	rw
PDO Mapping	Optional
Value Range	Signed16
Default Value	$FFFF_h$

Sub-Index	2_h
Description	temperature_1
Entry Description	Optional
Access	rw
PDO Mapping	Optional
Value Range	Signed16
Default Value	$FFFF_h$

to

Sub-Index	FE_h
Description	temperature_253
Entry Category	Optional
Access	rw
PDO Mapping	Optional
Value Range	Signed16
Default Value	$FFFF_h$