

# NAV350

2D LiDAR sensor

**SICK**  
Sensor Intelligence.



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**Described product**

NAV350

**Manufacturer**

SICK AG  
Erwin-Sick-Str. 1  
79183 Waldkirch  
Germany

**Legal information**

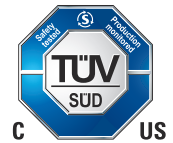
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**Original document**

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## 1 Abbreviations

<b>CoLa</b>	Communication Language = proprietary SOPAS ET communication language (ASCII = CoLa A or Binary = CoLa B)
<b>EEPROM</b>	Electrically Erasable Programmable Read-only Memory
<b>AGV</b>	Automated guided vehicle
<b>LED</b>	Light emitting diode
<b>RAM</b>	Random Access Memory = direct-access volatile memory
<b>ROM</b>	Read-only Memory (non-volatile)
<b>SOPAS ET</b>	SICK OPEN PORTAL for APPLICATION and SYSTEMS ENGINEERING TOOL = Configuration software for configuring the device

## 2 About this document

### 2.1 Purpose of this document

These operating instructions are intended to allow the technical personnel to perform mounting, electrical installation work, configuration, commissioning, and maintenance on the device.

### 2.2 Target group

The target group for this document consists of people in the following roles:

Activities	Target group
Mounting, electrical installation, maintenance and device replacement	Company electrician and service technician
Commissioning, operation and configuration	Technicians and engineers

### 2.3 Information depth

These operating instructions contain the following information about the device:

- Product description
- Mounting
- Electrical installation
- Commissioning and configuration
- Maintenance
- Troubleshooting
- Ordering information
- Conformity and certification

When planning and using the device, technical skills are required that are not covered by this document.

### 2.4 Explanation of symbols

Warnings and important information in this document are labeled with symbols. Signal words introduce the instructions and indicate the extent of the hazard. To avoid accidents, damage, and personal injury, always comply with the instructions and act carefully.



#### **DANGER**

... indicates a situation of imminent danger, which will lead to a fatality or serious injuries if not prevented.



#### **WARNING**

... indicates a potentially dangerous situation, which may lead to a fatality or serious injuries if not prevented.



#### **CAUTION**

... indicates a potentially dangerous situation, which may lead to minor/slight injuries if not prevented.



### NOTICE

... indicates a potentially harmful situation, which may lead to material damage if not prevented.

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### NOTE

... highlights useful tips and recommendations as well as information for efficient and trouble-free operation.

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## 2.5 Further information

More information can be found on the product page.

The product page can be accessed via the **SICK Product ID: [pid.sick.com/{P/N}/{S/N}](https://pid.sick.com/{P/N}/{S/N})**

**{P/N}** corresponds to the part number of the product, see type label.

**{S/N}** corresponds to the serial number of the product, see type label (if indicated).

**The following information is available depending on the product:**

- Data sheets
- This document in all available language versions
- CAD files and dimensional drawings
- Certificates (e.g., declaration of conformity)
- Other publications
- Software
- Accessories

## 3 Safety information

### 3.1 Authorized personnel

The product must only be mounted, commissioned, and maintained by properly qualified safety personnel.

Repair work on the product may only be performed by qualified and authorized service personnel from SICK AG.

The following qualifications are necessary for the various tasks:

Activities	Qualification
Mounting and maintenance	<ul style="list-style-type: none"> <li>• Basic practical technical training</li> <li>• Knowledge of the current safety regulations in the workplace</li> </ul>
Electrical installation and device replacement	<ul style="list-style-type: none"> <li>• Practical electrical training</li> <li>• Knowledge of current electrical safety regulations</li> <li>• Knowledge of the operation and control of the devices in their particular application (e.g. crane, mounting system)</li> </ul>
Commissioning, operation, and configuration	<ul style="list-style-type: none"> <li>• Knowledge of the operation and control of the devices in their particular application (e.g. crane, mounting system)</li> <li>• Knowledge of the software and hardware environment in their particular application (e.g. crane, mounting system)</li> <li>• Basic knowledge of the Windows operating system used</li> <li>• Basic knowledge of data transmission</li> </ul>

### 3.2 Intended use

The NAV350 is used to determine the position of automated guided vehicles (AGVs) along a course of the programmed route. The NAV350 is attached to the automated guided vehicle and continuously measures the positions of identified reflectors as well as the surrounding contour. Depending on the selected operating mode, the NAV350 outputs the position of the reflectors or its own position as well as the distance, the angle, and the reflectance of the visible surrounding contour on the automated guided vehicle's computer. The vehicle computer can use this information to correct the course of the automated guided vehicle accordingly to keep it on track.

The NAV350 is a sensor for indoor use.



#### NOTE

In the event of any other usage or modification to the NAV350, e.g., due to opening the housing during mounting and electrical installation, or to the SICK software, any claims against SICK AG under the warranty will be rendered void.



#### NOTE

The device is intended for use in industrial environments. Radio interference may arise when used in residential areas.



#### NOTE

The device may only be operated within the permissible ambient temperature range, see "Data sheet", page 54.

### 3.3 General safety notes and protective measures

Observe the following to ensure the safe use of the device as intended.

- The notes in these operating instructions (e.g., regarding the use, mounting, installation, or integration into the machine controller) must be observed.
- All official and statutory regulations must be observed when operating the device.
- The national and international legal specifications apply to the installation and use of the device, to the commissioning of said device, and to recurring technical inspections, in particular:
  - The accident prevention regulations / work safety regulations
  - Any other relevant safety regulations
- The manufacturer and operator of the system in which the device is installed are responsible for coordinating and complying with all applicable safety specifications and regulations, in cooperation with the relevant authorities.
- Through checks must be carried out by qualified safety personnel or specially authorized and instructed personnel and must be documented such that they can be replicated and traced at any time.
- These operating instructions must be made available to the operator of the system in which the device is used. The system operator must be instructed by qualified safety personnel and must read the operating instructions.
- The device does not constitute personal protection equipment in accordance with the respective applicable safety standards for machines.

#### Electrical installation work

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#### **WARNING**

#### **Electrical voltage!**

Electrical voltage can cause severe injury or death.

- Work on electrical systems must only be performed by qualified electricians.
  - The power supply must be disconnected when attaching and detaching electrical connections.
  - The product must only be connected to a voltage supply as set out in the requirements in the operating instructions.
  - National and regional regulations must be complied with.
  - Safety requirements relating to work on electrical systems must be complied with.
- 



#### **WARNING**

#### **Danger due to improper use!**

Any improper use can result in dangerous situations.

Therefore, observe the following information:

- Product should be used only in accordance with its intended use.
  - All information in the documentation must be strictly observed.
  - Shut down the product immediately in case of damage.
- 
- Only authorized personnel are allowed to perform electrical installation work.
  - Be sure to disconnect the voltage supply before attaching or detaching any electrical connections.
  - Select and implement wire cross-sections and their correct fuse protection in accordance with the applicable standards.
  - Do not open the housing.
  - Observe the current safety regulations when working on electrical systems.

### Laser radiation

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#### CAUTION

##### Optical radiation: Class 1 Laser Product

The accessible radiation does not pose a danger when viewed directly for up to 100 seconds. It may pose a danger to the eyes and skin in the event of incorrect use.

- Do not open the housing. Opening the housing may increase the level of risk.
  - Current national regulations regarding laser protection must be observed.
- 

## 3.4 Quick stop and quick restart

### Switching off the device

- ▶ Switch off the voltage supply (power supply unit) to the device.

The device retains permanently stored parameters in the internal memory. Measured values in the working memory are lost.

### Switching the device back on

- ▶ Switch on the voltage supply (power supply unit) to the device.

The device restarts operation with the last saved parameters.

## 3.5 Protection of the environment

The device has been designed to minimize its impact on the environment. It consumes only a minimum of energy.

Always act in an environmentally responsible manner at work. For this reason, please note the following information on disposal.

### Power consumption

The device consumes a maximum of 36 W in operation.

### Disposal after final de-commissioning

- ▶ Always dispose of unusable or irreparable devices in accordance with the applicable waste disposal regulations specific to your country.
- ▶ Dispose of all electronic assemblies as hazardous waste. The electronic assemblies can be easily removed.

### 4 Product description

#### 4.1 Scope of delivery

The delivery of the device includes the following components:

No. of units	Component	Note
1	Device	-
1	Safety note	Included in the device packaging
1	Lens cloth	-

## 4.2 Construction of the device

### 4.2.1 Device view



- ① LEDs
- ② Laser output aperture
- ③ Scanner head
- ④ Threaded mounting hole, M6×12
- ⑤ Back
- ⑥ LED yellow (1)

- ⑦ LED yellow (2)
- ⑧ Green LED
- ⑨ Red LED
- ⑩ Alignment hole for locating pin
- ⑪ Threaded mounting hole, M6×12
- ⑫ Device connection, M12 plug connector, supply voltage
- ⑬ Device connection, M12 plug connector, Ethernet
- ⑭ Base

**4.2.2 Control and display elements**

**User interface**

The device runs fully automatically in normal operation and requires no operator intervention.

The SOPAS ET configuration software (included) allows interactive configuration. The related software runs on a computer with the Windows operating system that is connected to the device via one of the interfaces.


Use the graphic scan view in SOPAS ET to verify the generated measured values and the measuring range online. Please note that SOPAS ET cannot display the data in real time and therefore not all measured values are visualized.

**Display elements**

The LEDs indicate the operational status of the device.

The device has four LEDs. These visually indicate the current operational status, and the status of the continuous self-monitoring. The LEDs are located on the front of the device.

Table 1: Meaning of the LEDs

	Yellow LED (1)	Yellow LED (2)	Green LED	Red LED	Meaning
 <p>① Yellow (1) ② Yellow (2) ③ Green ④ Red</p>	Off	Off	Off	Off	Device is switched off. Supply voltage is absent.
	On	On	On	On	LED test for 5 s after switching on. The switching output is active.
	Off	On	Any	Any	Command is being processed
	Off	Any	Flashes 1 Hz	Any	Standby
	Off	Any	Flashes 4 Hz	Any	Measuring mode
	Flashes 4 Hz	Off	Flashes 1 Hz	Off	Firmware update
	Any	Any	Any	On	System error in the device. For troubleshooting information, see "Troubleshooting", page 51

### 4.3 Special features of the device

Specific features	Characteristic
Performance	<ul style="list-style-type: none"> <li>• Use along a route with max. 12,000 reflectors</li> <li>• Can be divided into up to 320 layers (therefore backwards compatible with the NAV200)</li> <li>• Detection of reflector marks at a 360° scanning angle</li> <li>• Detection of reflector marks in the measuring range 0.5 m to 70 m</li> <li>• Position measurement accuracy ± 4 mm to ± 25 mm (depending on the average reflector distance)</li> <li>• Contour measurement up to 35 m (for objects with a remission of 10 %)</li> <li>• Angular accuracy ± 0.1°</li> <li>• Installation position with optical axis parallel to the traversed surface, overhead installation also possible</li> </ul>
Safety and convenience	<ul style="list-style-type: none"> <li>• Rugged, compact metal housing (max. IP 65), CE marking</li> <li>• Laser class 1</li> <li>• Maintenance-free</li> </ul>
Configuration/operation	<ul style="list-style-type: none"> <li>• Configuration using the SOPAS ET computer software</li> <li>• Alternatively using telegrams CoLa-A (ASCII) or CoLa-B (binary) (command strings)</li> <li>• Mapping (teach-in) of reflector positions</li> </ul>
Result output	<p><b>Landmark detection</b></p> <ul style="list-style-type: none"> <li>• Reflector measurement and output of the reflector position in the local coordinate system of the device</li> <li>• Output of distance and angle of a reflector</li> <li>• Optional: Output of distance, angle and remission value of the visible surrounding contour</li> </ul> <p><b>Navigation</b></p> <ul style="list-style-type: none"> <li>• Continuous position determination</li> <li>• Output of the absolute position value of the device in a global coordinate system</li> <li>• Optional: Output of distance, angle and remission value of the visible surrounding contour</li> </ul>
Electrical Interfaces	<ul style="list-style-type: none"> <li>• Supply voltage 24 V DC</li> <li>• Data interfaces: Ethernet, serial RS-232</li> <li>• 1 x switching output for synchronization</li> </ul>

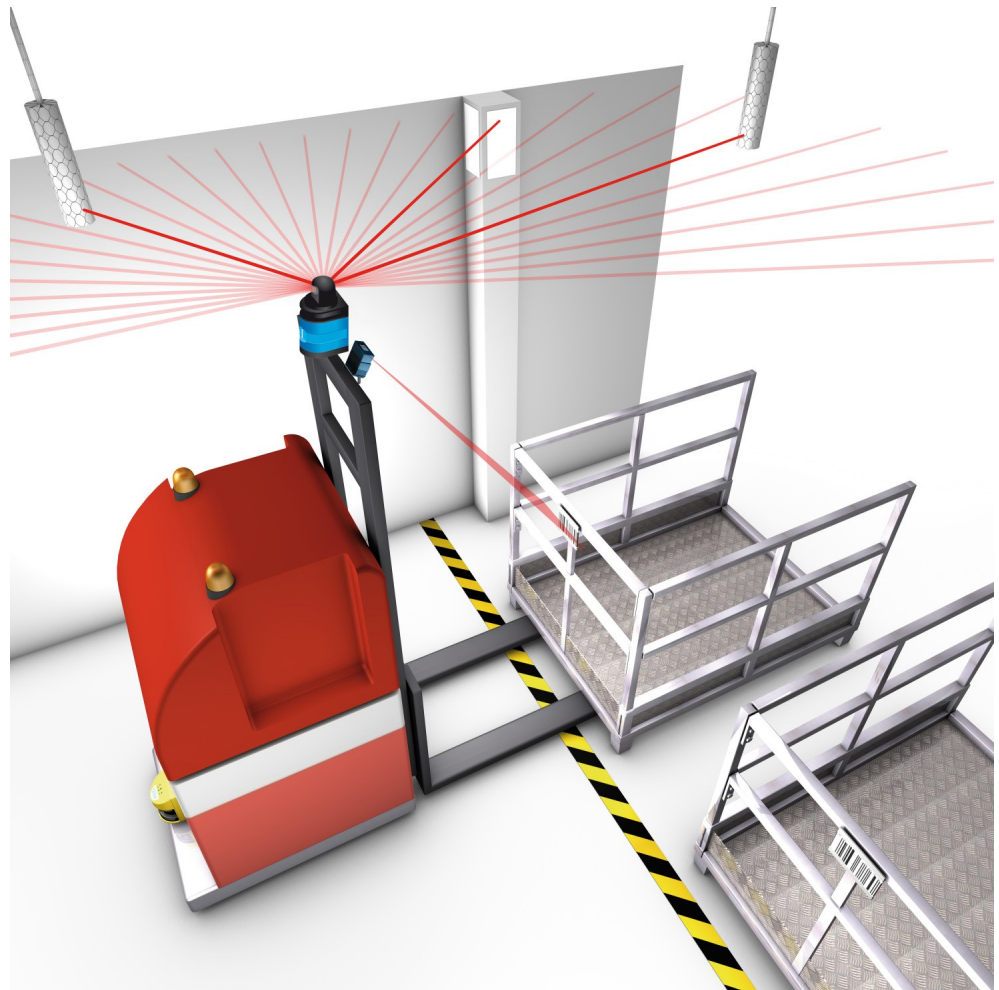
### 4.4 Fields of application

AGV line guidance based on contour and reflector measurements (mixed mode navigation):

- Shuttle system
- Freely moving forklift
- Truck loading
- Automated guided vehicles in general

### 4.5 Operating principle of the device

The device is an opto-electronic laser scanner that uses laser beams for non-contact scanning of the outline of its environment on a plane. The device measures its environment in two-dimensional polar coordinates. If a measuring beam strikes an object, the position of that object is determined in terms of distance, direction, and remission.

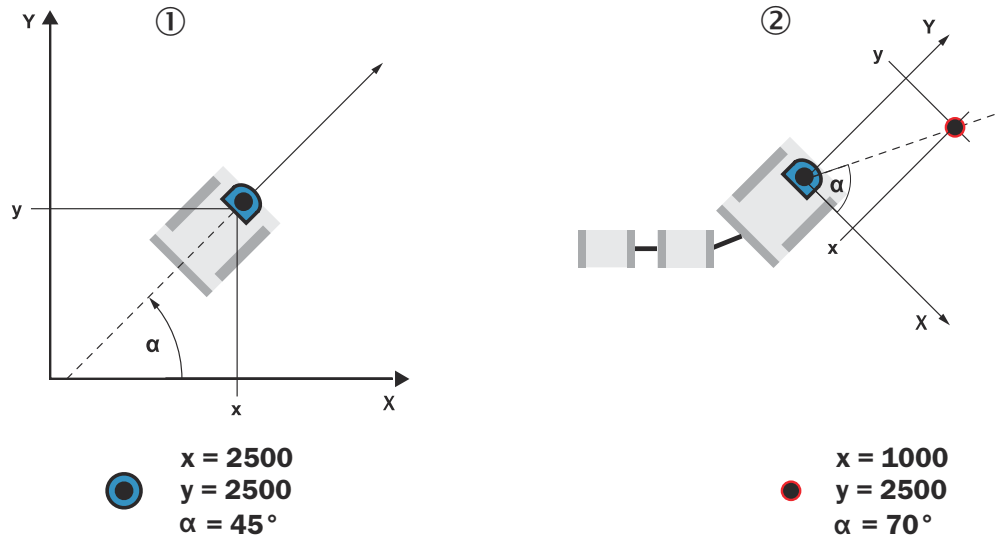
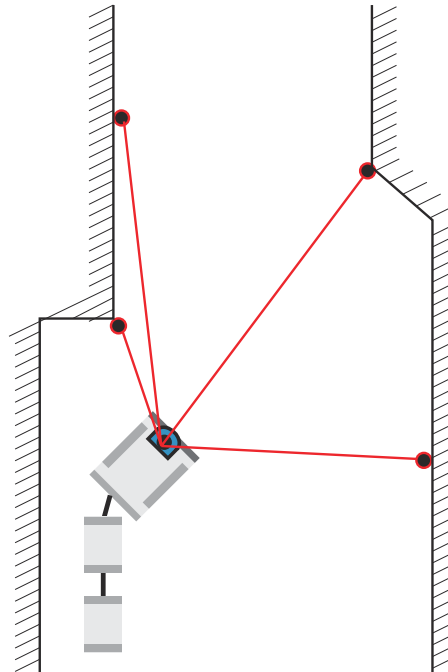


The device calculates the distance from the object using the elapsed time that the light requires between sending and receiving the reflection in the sensor.

The scanning sector is  $360^\circ$ . The scanner head rotates at a frequency of 8 Hz. A laser pulse and thus a distance measurement is triggered continuously after each angle increment of  $0.25^\circ$ .

### 4.5.1 Navigation and landmark detection operating modes

The device has integrated application software which detects reflectors continuously. The reflectors can be used to determine the absolute position of the device (see "[Navigation](#)", page 20), the relative position of the detected reflectors (see "[Landmark detection](#)", page 20) or a combination of both can be output to the connected vehicle computer.



- ① Navigation (output of absolute position data)
- ② Landmark detection (output of reflector positions)

In addition to navigation and landmark detection, the device can also display the measured surrounding contour on the connected vehicle computer (mixed mode).

#### 4.5.2 Impact of objects on the measurement

Most surfaces produce a diffuse reflection of the laser beam in all directions. The structure and color of the surface determine how well the laser beam is reflected. Bright surfaces reflect the laser beam better than dark surfaces and can be detected by the device over greater distances. Brilliant white plaster reflects approx. 100 % of the light, while black foam rubber reflects approx. 2.4 %. On very rough surfaces, part of the energy is lost due to shadowing. The scanning range of the device is therefore reduced.

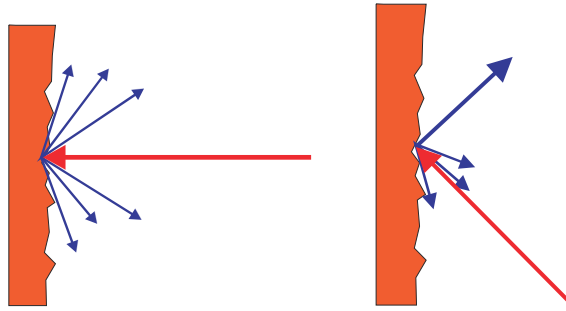


Figure 1: Diffuse reflection of objects

The angle of reflection corresponds to the angle of incidence. If the laser beam hits a surface at right angles, the energy is optimally reflected (left). If the laser beam hits a surface at an oblique angle, energy, and range are lost accordingly (right).

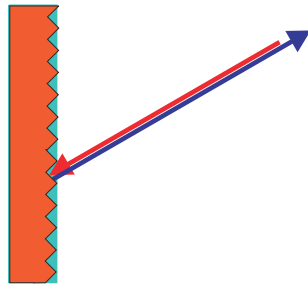


Figure 2: Targeted reflection of reflectors

The beam is not reflected diffusely in all directions; instead it is reflected in a targeted way. Thus a large part of the emitted energy can be received by the device. The device utilizes this in order to be able to measure the positions of the reflectors extremely accurately.

**Possible sources of error**

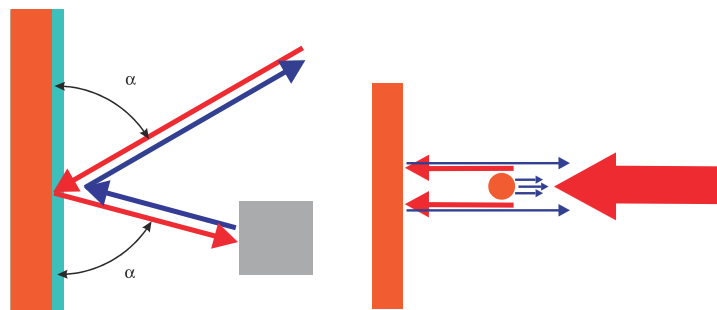


Figure 3: Possible sources of error when measuring

The laser beam is almost completely deflected on reflective surfaces (left). This means that an object hit by the deflected beam may be detected instead of the reflective surface.

Objects that are smaller than the diameter of the laser beam (right) cannot reflect the laser light's full energy. The energy of the non-reflected part of the laser light is lost. This means the scanning range is less than would theoretically be possible due to the reflective property of the object's surface.

### 4.5.3 Scanning range of the device

The scanning range of the device depends on the remission of the object to be detected. The better a surface reflects the incident beam, the greater the scanning range.

Table 2: Typical remissions and scanning ranges

Material	Remission factor	Scanning range
Black car paint, matte	5 %	0.5 ... 24 m
Black photo mounting board, matte	10 %	0.5 ... 35 m
Gray concrete	18 %	0.5 ... 45 m
White cardboard	90 %	0.5 ... 100 m
White plaster	100 %	0.5 ... 110 m
Reflective tape	> 3000%	0.5 ... max. 250 m

### 4.5.4 Beam diameter and measuring point distance

As the distance from the device increases, its laser beam expands. As a result, the beam diameter increases on the surface of the object.

The range-dependent beam diameter corresponds to the distance (mm) × 0.005 rad + 20 mm.

As the distance from the device increases, the individual measuring points also grow further apart from one another. The following diagram shows the beam diameter and measuring point distance as a function of the distance from the device.

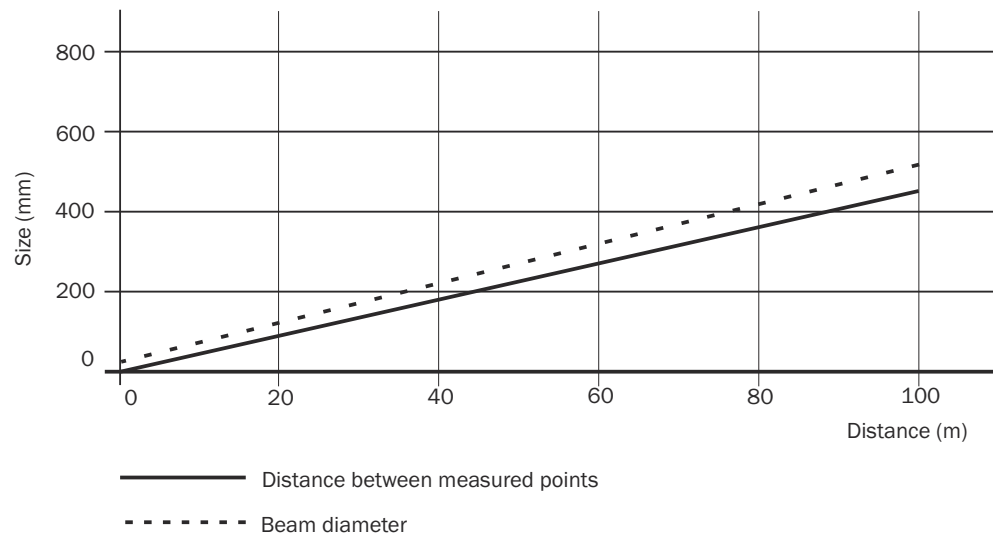


Figure 4: Beam diameter and measuring point distance at 0 to 100 m

For an object to be detected reliably, it must be completely hit by the light beam once. If it is only partially hit, less energy will be reflected from the object than is required in some cases, see figure 3, page 18.

#### How to calculate the minimum object size:

Beam diameter + measuring point distance = minimum object size

- The beam diameter and measuring point distance as a function of the distance from the device can be seen in the diagram, see figure 4, page 19.



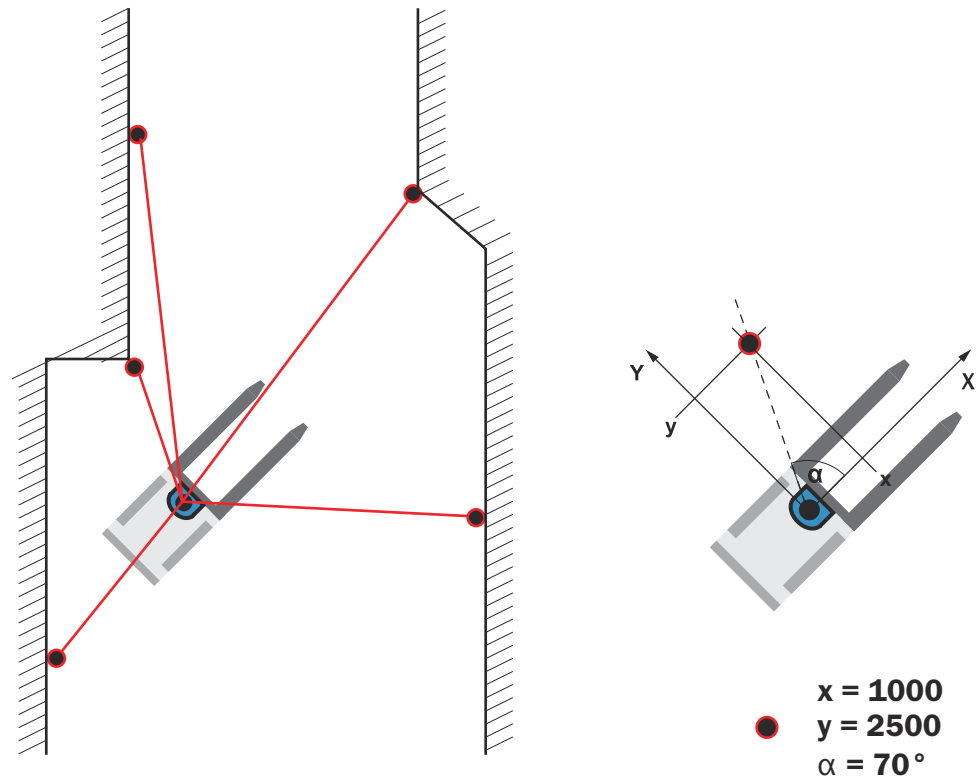
**NOTE**

For reliable measurement, in particular when using the device to output measured values, the laser needs to hit the object several times.

**4.6 Landmark detection**

In **Landmark detection** operating mode, the device generates an image of its current reflector surroundings within one rotation of the scanner head.

The 40 most dense reflectors from up to 250 measured reflectors are taken into account for positioning to limit the output size. These can be output by means of a telegram. The device calculates the exact position from the next four to eight reflectors in an asymmetrical arrangement [see figure 18, page 35](#). The reflectors are selected adaptively.



In live operation, this enables the vehicle computer of the AGV to directly access the landmark coordinates (reflectors) measured by the device. The vehicle computer can evaluate the directly accessed data using its own algorithms in order to calculate the vehicle's position. If necessary, this is done by including additional data from other sensors, such as encoders.

**4.7 Navigation**

In **Navigation** operating mode, the device continuously determines its own current position while the AGV is moving along the route. This is done by means of reflectors placed in fixed positions in the environment. Three detected reflectors are sufficient to determine the position.

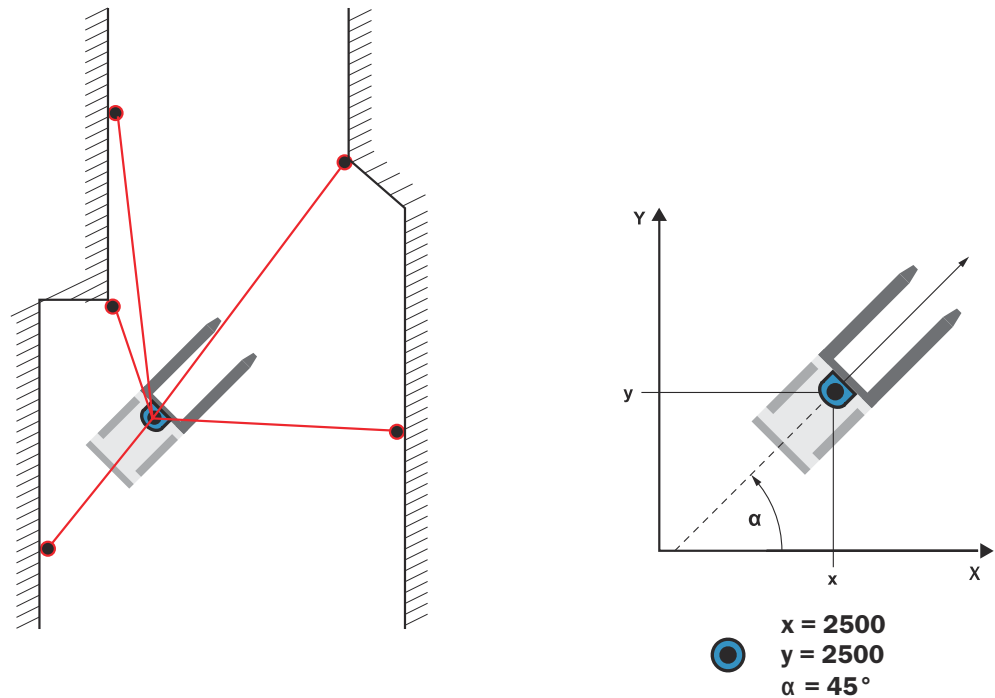


Figure 5: Position determination of the device by detecting reflector arrangements

- An absolute coordinate system with a zero point must be defined for the position output (usually at a corner point of a factory hall, see "Absolute coordinate system", page 32).
- Reflectors must be attached within a course to indicate the position (see "Reflector arrangements", page 34). These reflectors are either measured and their coordinates stored in the device or they are taught in by the device (mapping).

The device transmits the position data to the AGV's vehicle computer on request. The vehicle computer steers the AGV along the programmed and therefore pre-defined route and uses the device to correct any course deviations.

#### 4.7.1 Operating principle of the device during position determination

The device has three operational statuses when determining the position:

- Initial positioning
- Continuous positioning
- Virtual positioning

##### Initial positioning

After switching from another operating mode (e.g. Standby) to **Navigation** operating mode, the device calculates and identifies the reflector positions by comparing the pattern between the measured reflectors and the stored reflector positions in the current layer.

Prerequisites for successful initial positioning are:

- The vehicle is not moving.
- There are at least three reflectors in the viewing range of the device.

Depending on the number of measured reflectors and reflectors in the current layer, initial positioning can take several seconds. If the last position is still known, the vehicle computer can activate continuous positioning via the `SMN MNPOSETPOSE` software telegram with position specification and thereby re-establish contact with the layer.

### Continuous positioning

After successful **initial positioning**, the device automatically switches to the **continuous positioning** operational status. This eliminates the computationally-intensive pattern matching of the **initial positioning**. The device can provide new position data at a refresh rate of approx. 8 Hz. During **continuous positioning**, the device has an expectation of the approximate positions of the reflectors (see following figure). For this purpose, the device places an identification window of a configurable radius  $r$  (factory default: 300 mm) around each reflector coordinate.

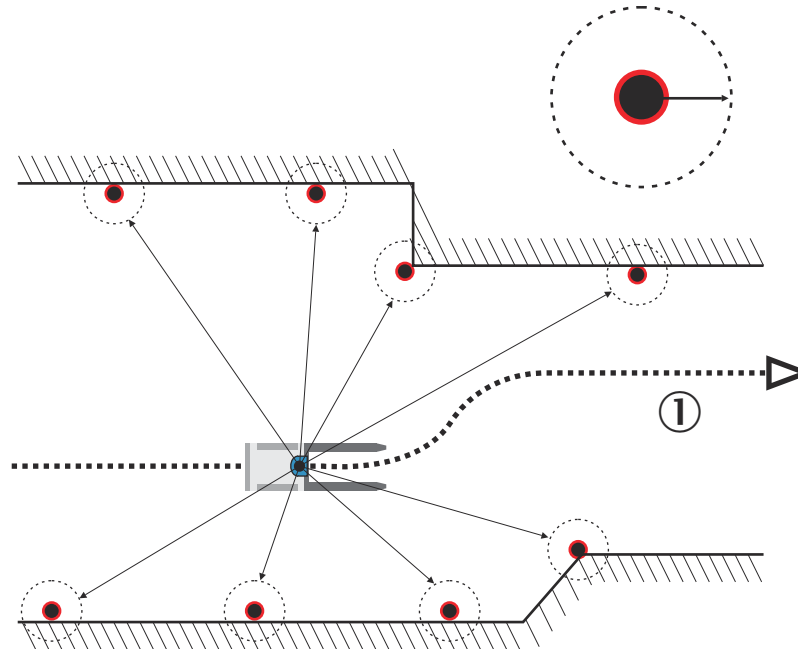


Figure 6: Identification of reflectors in the "continuous positioning" operational status

① Route

Reflectors are measured within the identification window. The relevant reflectors are used to calculate the position by means of the adaptive selection.

By configuring larger identification windows, the device can be optimized e.g. for very dynamic speed changes of the AGV, and by reducing the size for extreme conditions caused by false reflections.

The radius of the identification window can also be configured depending on the distance between the device and the reflector. For this purpose, the start and end points of a straight line function and the size of the identification window are transmitted to the device at the start and end points respectively.

The start point of the straight line can be a minimum of 0.5 m at  $\text{dist}_{\text{Low}}$ , and the end point a maximum of 70 m at  $\text{dist}_{\text{High}}$ . The radius of the identification window can be set in the range from 100 ... 2,000 mm.

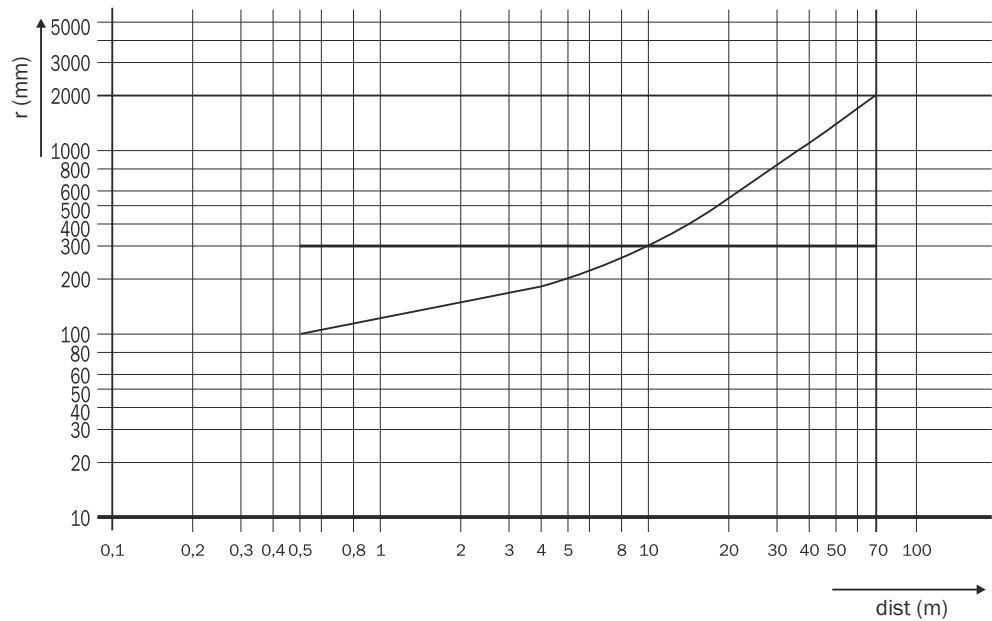


Figure 7: Radius of the detection window depending on the distance

If the position is lost due to disruptive factors (e.g. simultaneous coverage of several reflectors), the device instigates an **initial positioning**.

#### Virtual positioning

If the initial positioning fails, a position is estimated based on the entered speeds and motion model for max. 3 m. After 3 m, the virtual position estimate is stopped.

#### Measurement quality as an indicator of the reliability of the position data

Together with the position data, the device transmits the measurement quality to the vehicle computer. The measurement quality evaluates the agreement between the stored reflector positions and the detected reflector positions. It is a relative measure of the reliability of the position data. The measurement quality is output as standard deviations of all measured values for the detected reflectors determined per scan in millimeters. Errors in the measurement are output via the optional position data.

For further information on the quality, see the "Telegram listing NAV350" document, article no.: 8013893.

If there are large deviations between stored and detected reflector positions, it is advisable to check the reflector arrangement and the speed specifications and to limit the acceleration of the AGV if possible.

The measurement quality affects the control loop in the vehicle computer. It allows the system integrator to determine how much the position data of the odometry is to be corrected by the position data of the device. The influence of the position data of the device on the correction is application-specific and depends on the quality of the odometry and the allowed positioning tolerances in the system.

### 4.7.2 Measurement accuracy

Landmarks within a limited radius of action of the device are measured more accurately and thus improve the result of a position determination [see "Data sheet", page 54](#).

Attach the reflectors at docking stations (e.g. pallet transfer points) and, when cornering, within the defined, restricted radius of action of the device or to the route.

The device selects the 4 to 8 best distributed reflectors from the measured reflectors and uses these to determine the position.

#### Reducing the radius of action

The minimum and maximum radius are parameterized via a software telegram from the vehicle computer.

It must be ensured that at least 3 reflectors are visible from every position of the device within the restricted radius of action. If, for example, there are only 2 reflectors in the restricted radius of action, the device automatically switches to the full radius of action.

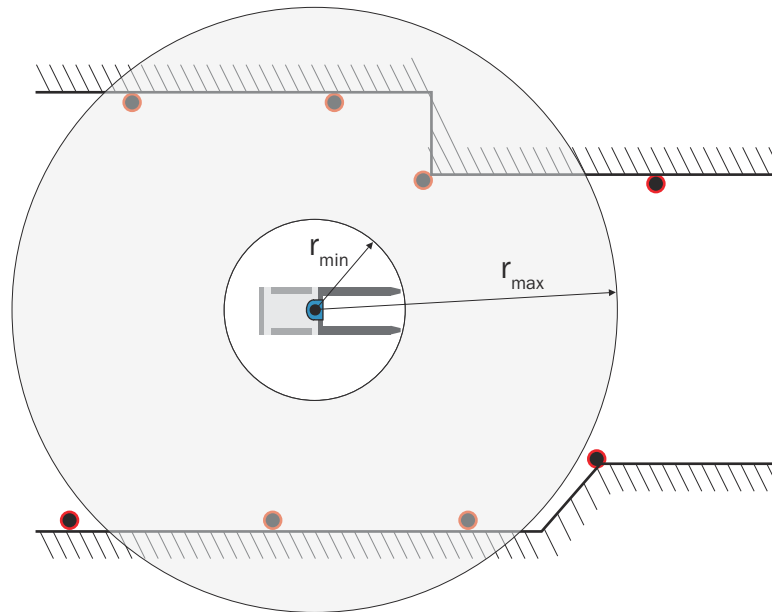


Figure 8: Restricted radius of action

The example shows a defined, restricted radius of action with the parameters  $r_{\min} = 500 \text{ mm}$  and  $r_{\max} = 15,000 \text{ mm}$ , in which the device detects five reflectors within one scan.

#### Suppressing sectors (sector muting)

In certain applications, it may be necessary to suppress individual angle segments (sectors) within the scanning range of the device, e.g., if individual reflectors are partially hidden by a raised load and therefore the middle of the reflectors cannot be determined accurately. This can lead to reduced measurement accuracy when determining the position.

The device does not use measurements to determine the position of reflectors that lie completely or partially within the suppressed sectors. Suppressed sectors are set in **Navigation** mode. Sector suppression then becomes active for the following position request. The setting cannot be saved, however.



#### NOTE

The reflector layout must be designed in such a way that at least three reflectors are always visible to the device in the non-suppressed sectors. If this is not the case, the device determines the position using all visible reflectors and outputs this in the **Diagnostic information** telegram section of the response to the next position request (see "Telegram listing NAV350", part no.: 8013893).

The limits of the suppressed sectors are output in a mathematically positive direction as angles in mdeg. Up to four sectors are possible.

The sectors must not overlap and the start angle must be defined in an ascending sequence beginning with a value  $\geq 0$ .

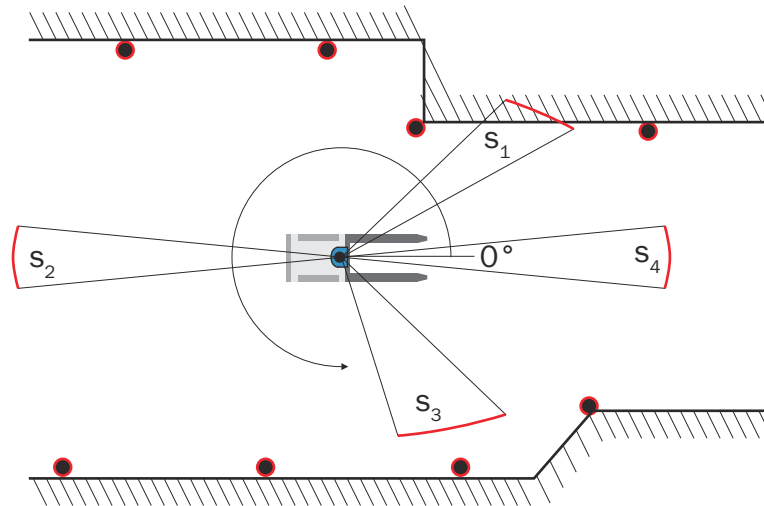


Figure 9: Example for defining suppressed sectors

### 4.7.3 How the device deals with sources of error

#### Covered reflectors

When cornering or in narrow aisles, two reflectors positioned behind one another from the point of view of the device always fully or partially cover one another. The positions of these reflectors can then no longer be clearly determined and would falsify the position calculation of the device. The device recognizes such a situation and automatically suppresses the use of overlapping reflectors.

A covered reflector appears when the angle between two reflectors from the point of view of the device is smaller than  $0.6^\circ$ .

In this case, the reflector arrangement must be chosen in such a way that at least three additional reflectors are in the viewing range of the device.

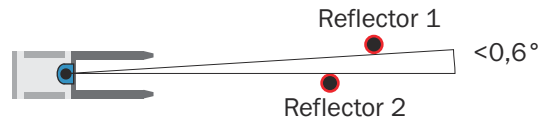


Figure 10: Covering two reflectors

#### Incorrect reflection

Incorrect reflections may arise due to highly reflective objects. Highly reflective objects include windows, stainless-steel casings, or metal pipes. The incorrect reflections occur when the measuring beam of the device meets these objects vertically.

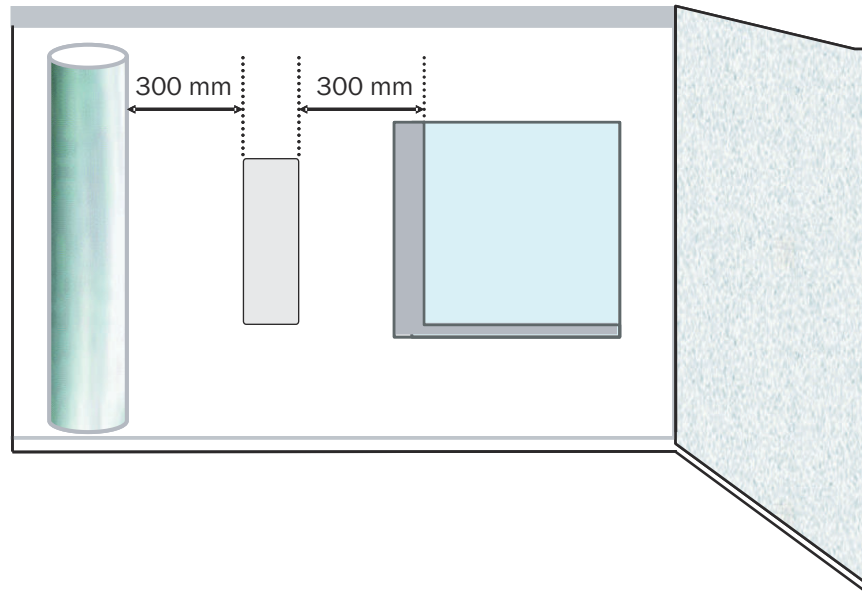


Figure 11: Minimum distance between reflectors and other reflective surfaces

To prevent these incorrect reflections from being interpreted as reflectors, please ensure that the fitted reflectors are always at least 300 mm away from these objects. If it is not possible to comply with the minimum distance for certain objects, then you must cover these objects with a material with low reflective properties.

### Subsequent movement of reflectors

Reflector movements that are still within the measuring range of the device after movement distort the measurement result and must be corrected. To correct this, the reflector must be moved back to its original position or the coordinates of the new reflector position must be measured using the **Mapping** function and transferred to the device using SOPAS ET.

### Subsequent removal or covering of reflectors

If reflectors are covered or removed, the device continues to determine its position using the remaining reflectors without interruption as long as at least three reflectors are still visible from the position of the scanner head.

## 4.8 Output of measured values

In addition to navigation and landmark detection, the device can also display the measured surrounding contour on the connected host (mixed mode).

The measured values can be transferred to a connected computer system and evaluated there, see ["Communicating data via telegrams", page 27](#). The host can compute the position of the automated guided vehicle using these measured values.

Navigation by means of the measured surrounding contour is useful at locations where no reflectors can be fixed, such as in the cargo area of a truck.

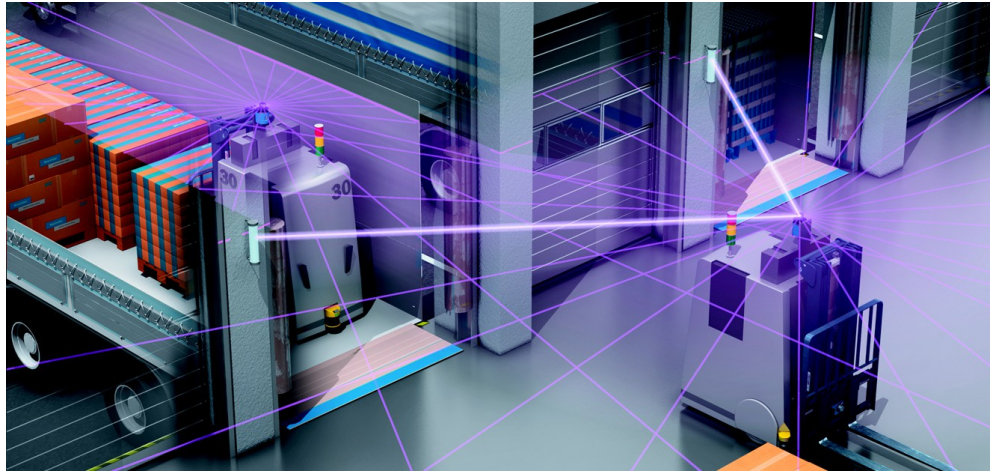


Figure 12: Output of measured values for truck loading

The device outputs the following measured values at its data interfaces:

- Profile of the viewing range in two-dimensional polar coordinates
- Content of one revolution (360°): including start angle of the scan, increment, time stamp for the start of the scan, number of measured values, value and direction of the measured distance, remission value of the measured object.



#### NOTE

It is only possible to output all measured values of a 360° scan in real time using the Ethernet interface.

## 4.9 Integration of the device into the controller of an AGV

Integrating a device into the controller of an automated guided vehicle requires in-depth programming knowledge in the area of vehicle control. You also need knowledge on exchanging data between a 2D LiDAR sensor like the device and the vehicle computer.

### 4.9.1 Data interfaces

The device has a serial host interface and an Ethernet interface. The device is configured via these interfaces using SOPAS ET.

The device also communicates with the computer of the automated guided vehicle via its interfaces.

### 4.9.2 Communicating data via telegrams

- Setting parameters via the AGV computer to configure the device
- Retrieving parameters and status protocols via the automated guided vehicle's computer
- Requests for landmark positions (incl. the measured contour values, if applicable) by the AGV computer, subsequent device response
- Requests for positions (incl. the measured contour values, if applicable) by the AGV computer, subsequent device response

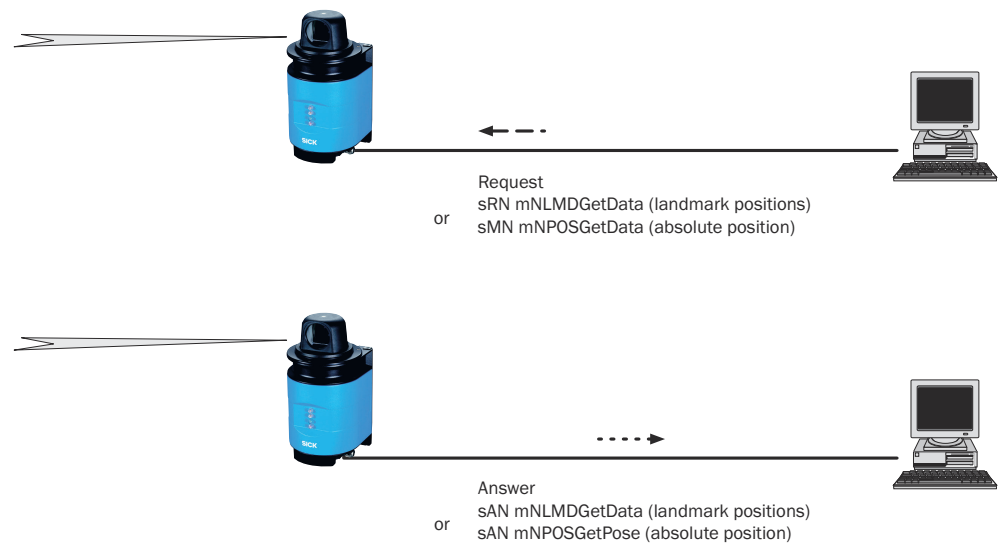


Figure 13: Request for an absolute position or landmark positions

Depending on the frequency of data requests from the vehicle computer, the device transmits data to the vehicle computer up to eight times per second. Each telegram comprises a frame and the payload.

**Frame and coding for the telegrams**

Table 3: Frame for the telegrams with ASCII coding

	Frame	Telegram	Frame
<b>Designation</b>	STX	Payload	ETX
<b>Length (Byte)</b>	1	≤35 kB	1
<b>Description</b>	Start of text character	ASCII-coded. This length depends on the previous send telegram.	End of text character

A detailed list of the telegrams that can be used can be found in the “Telegram listing NAV350”, part no.: 8013893.

**4.9.3 Relative positioning system and absolute positioning system**

The automated guided vehicle uses two positioning systems for lane control – a relative positioning system and an absolute positioning system.

The **relative position system** obtains its data from the odometry (incremental encoder). The odometry provides new data with a high update rate. The vehicle computer can calculate the position of the vehicle from this data. However, the relative position calculation is prone to errors. The error develops as more and more distance is covered.

The **NAV350 absolute positioning system**, on the other hand, provides absolute position data within the course. Using these absolute positions, the vehicle computer of the AGV can minimize the error from the odometry.

The following figure shows schematically how the device is integrated into a complete navigation system:

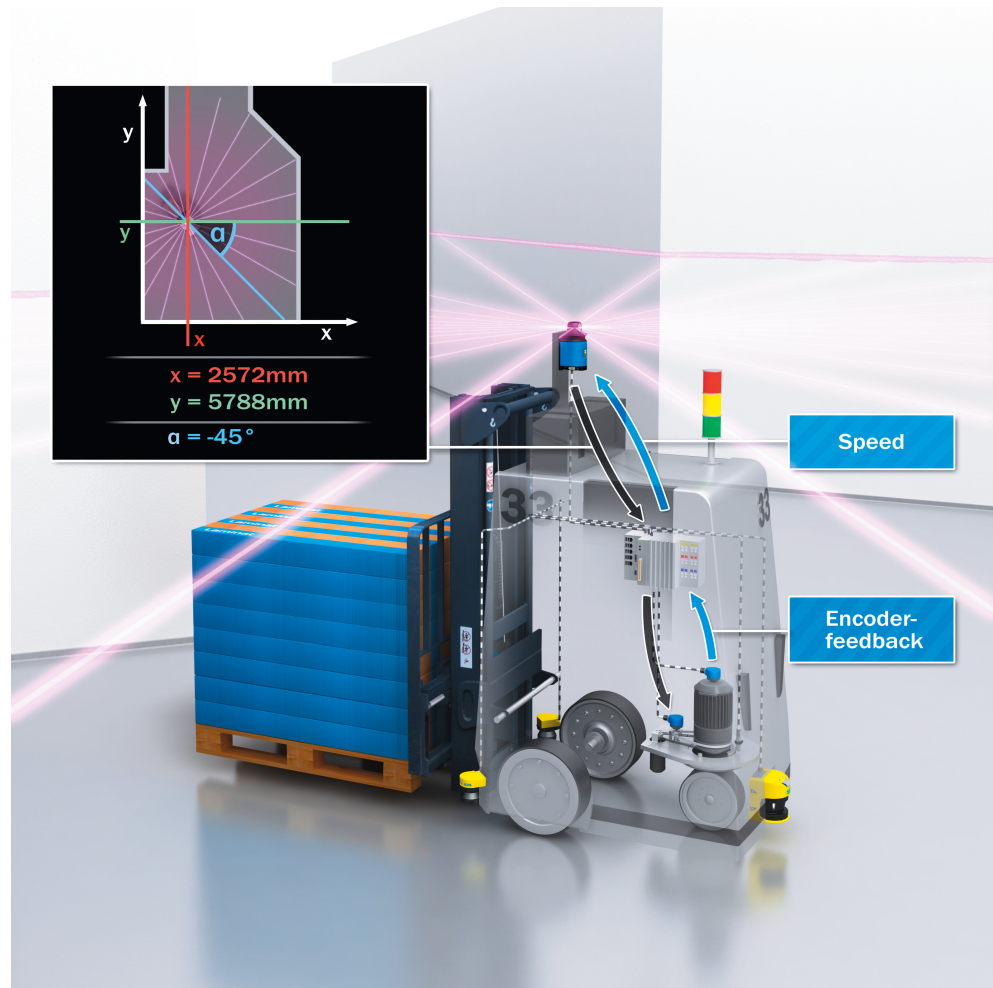


Figure 14: Integrating the device into a navigation system

### Overview of the integration of the device into the controller of an AGV

The vehicle computer informs the device of the current speed and the rotational speed of the AGV from its odometry [see "Communicating data via telegrams", page 27](#). To optimize control, the vehicle computer can transmit the speed to the device several times between two position requests.

The device uses the speed data for three calculations:

- An expected position for reflectors in the following measurement cycle is calculated from the speed data, thereby equalizing the measurement of the reflectors within a head rotation [see figure 6, page 22](#).
- Calculated position data is extrapolated to the time of data transmission.
- By transmitting the speed several times between two position requests, the device calculates a movement profile to take account of significant changes in the AGV's movement.



#### NOTE

If no speed data is transmitted to the device by the vehicle controller, the device internally calculates the speed between two position determinations. This speed determination only allows low accelerations and is only suitable for testing purposes. Speed transmission via the vehicle controller is required for practical operation.

The speed and the rotational speed of the AGV must be transformed to the position of the device on the AGV.

### 4.9.4 Digital output

The device has a digital output which is used to synchronize the internal clock of the device and that of the external vehicle computer.

Depending on the synchronization method, the output supplies a 10 or 128 ms pulse, see ["Synchronization of the clock in the AGV and the clock in the device"](#), page 30.

The pulse is output depending on the synchronization method.

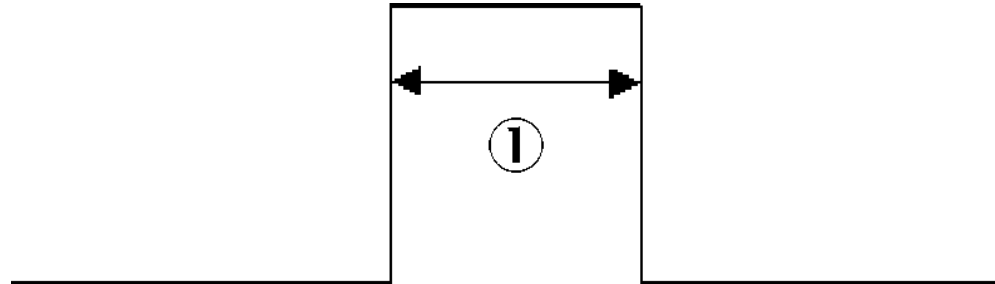


Figure 15: Synchronization pulse

① min. 10 ms

### 4.9.5 Synchronization of the clock in the AGV and the clock in the device

For precise control, you must synchronize the timings of the navigation and landmark data from the device and the calculations in the vehicle computer as accurately as possible.

The measurement data from the device is provided with the internal time stamp of the device. The internal time stamp in the device is a 32-bit counter which increases in increments of 1 every 1 ms.

The device has three options available for synchronizing the internal time of the device with the system time of the vehicle controller:

- Via telegram: The vehicle computer queries the internal time of the device using a telegram. The device writes its internal time in a telegram and sends this to the vehicle computer. Sending can happen with a delay time of up to 3 ms, which results in some uncertainty.
- Via "Timer Read" telegram: The vehicle computer queries the internal time of the device using a telegram. The hardware output provides a pulse of at least 10 ms once the internal time stamp is written in the telegram. If the telegram is then received by the vehicle computer, this can add the delta between the pulse and receipt to the time entered in the telegram. This enables the AGV to determine the actual time in the device.
- Based on the pulse at the hardware output: The hardware output is configured via a telegram in order to generate an output pulse of 128 ms based on the 32-bit counter in a fixed cycle. The parameterization is a bit mask of 10 ... 20 bits. Depending on the parameterized bit, the output pulse is generated in the event of an overflow of this bit in the counter. A parameterization of 15 bits, for example, generates an output pulse every 32,768 ms. When the pulse is received, the vehicle computer knows that the lower 14 bits of the counter in the device are 0. Using the time stamp in the subsequently received telegram, the vehicle computer can now determine the time that has elapsed since the pulse and add it to the telegram time.



#### NOTE

Program the vehicle controller so that it responds to the leading edge of the output pulse

#### 4.9.6 Result port

The device software has a result port, a simplified telegram with its own port.

The result port provides scan data and landmark data in parallel to the CoLa dialect.

The result port is configured via the SOPAS user interface. Alternatively, the result port can also be configured using the CoLa diagrams.

### 4.10 Project planning

#### 4.10.1 System requirements on the device

The user will require the following to commission and operate the device:

- Supply voltage 24 V DC  $\pm$  15 %, generated in accordance with IEC 60364-4-41 (VDE 0100, Part 410), minimum power output 40 W [see "Supply voltage", page 40](#)
- Standard Intel Pentium computer or compatible, at minimum Pentium III, 500 MHz
  - RAM: at least 256 MB, 512 MB recommended
  - Operating system: MS Windows 2000, XP, VISTA, or 7
  - Monitor: at least 256 colors, recommended 65,536; screen resolution at least 800×600
  - Hard drive: at least 220 MB free disk space available
  - RS-232 or Ethernet data interface [see "General requirements on the data interface", page 41](#) and, if required, an RS-232 converter if the computer interface and device interface do not match

#### 4.10.2 Mounting requirements

The device must be mounted stably.

A mounting bracket part no. 5311055 with mounting materials is available for the device.

Alternatively, you can use a stable mounting device that allows the alignment of the device in the X and Y axes to be adjusted. The device weighs approx. 2.4 kg.

#### 4.10.3 Distance between the device and the object/surface to be measured

The measuring range of the device starts 0.5 m in front of the optics (light emission window).

With recessed installation of the device, it is important to consider how the laser beam expands as the distance increases in order to avoid incorrect measurements.

If the device is mounted in an unfavorable position, depending on the distance, this could therefore mean that objects in the scanning area are detected constantly as they are hit by the laser beam.

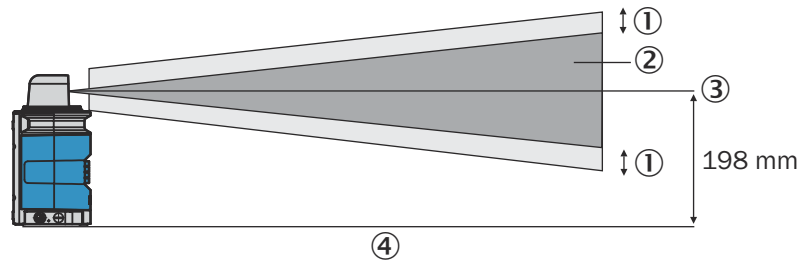


Figure 16: Beam expansion and supplement

- ① Supplement 5 mm/m
- ② Expanded laser beam
- ③ Optical axis
- ④ Distance

The optical axis is located around 198 mm above the lower edge of the housing when the device is mounted vertically. This is used as a reference plane for the distance that must be maintained from the wall.

The distance-dependent beam expansion can be calculated using the formula: Beam diameter = (distance (mm) × 5.0 mrad) + 20 mm<sup>1)</sup>

The table below provides a few values as examples:

Distance [m]	5	10	15	20	25	30	40	50	60	70
Beam diameter [mm]	45	70	95	120	145	170	220	270	320	370

When assessing whether the laser beam can meet an object, the distance from the half beam diameter to the optical axis is used.



**NOTE**

Use a supplement of 5 mm per meter at the top and bottom, [see figure 16, page 32](#).

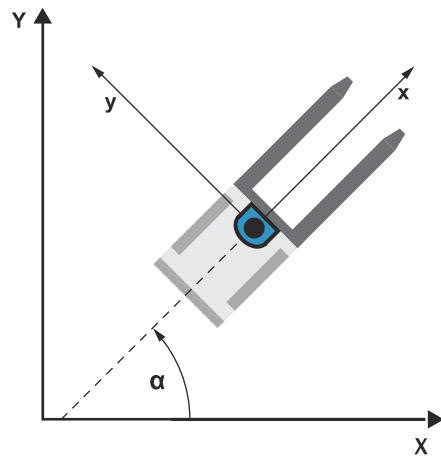
You can use a value of 16 mm per meter to make it easier to calculate the sum from the beam expansion and the supplement.

**4.10.4 Absolute coordinate system**

When planning the reflector positions, a common coordinate system is defined in a site plan. This absolute coordinate system corresponds to the coordinate system of the industrial plant. This determines the zero point and axes of the absolute coordinate system.

In this coordinate system, the device determines its absolute position in the X and Y directions, including the angular position  $\alpha$  of its local coordinate system in relation to the absolute coordinate system. The angular position is understood to be the angle that the X-axis of the sensor forms with the X-axis of the absolute coordinate system. The angles are mathematically positive in an anticlockwise direction.

1) Due to the sender lens.



$X, Y$  = absolute coordinate system of the plant

$x, y$  = local coordinate system of the device

$\alpha$  = direction of the device in the absolute coordinate system

The coordinate origin of the device lies on the mid-axis of the scanner head.

#### 4.10.5 Reflectors

The device assigns the measurement data determined from its environment to the stored reflector positions. To do this, it must distinguish between the reflectors and other reflective surfaces. The device does so by analyzing the measurement data using characteristic values stored in its memory. These characteristics apply for the 983-10 reflective tape (part no. 5320565), which can be obtained as an accessory from SICK AG by quoting REF-DG.

The reflector marks are designed as cylindrical reflectors. Cylindrical reflector marks can be detected from any angle.

##### Reflector height

The height and vertical position of the reflectors are to be selected such that the measuring beam hits the reflectors even if the floor is uneven.

The maximum scanning range of the device is 70 m on reflectors.

Depending on the ground conditions and the resulting measurement distance, the minimum height of the reflectors can be derived from this. The measuring beam of the device expands by around 5 mm per meter of measuring distance, see ["Distance between the device and the object/surface to be measured"](#), page 31. Any tilting of the automated guided vehicle caused by uneven ground must be addressed accordingly (incl. supplement). The recommended reflector heights are 500 mm for a measuring distance of up to 30 m, 750 mm for a measuring distance of up to 46 m, and 1000 mm for a measuring distance of up to 70 m.

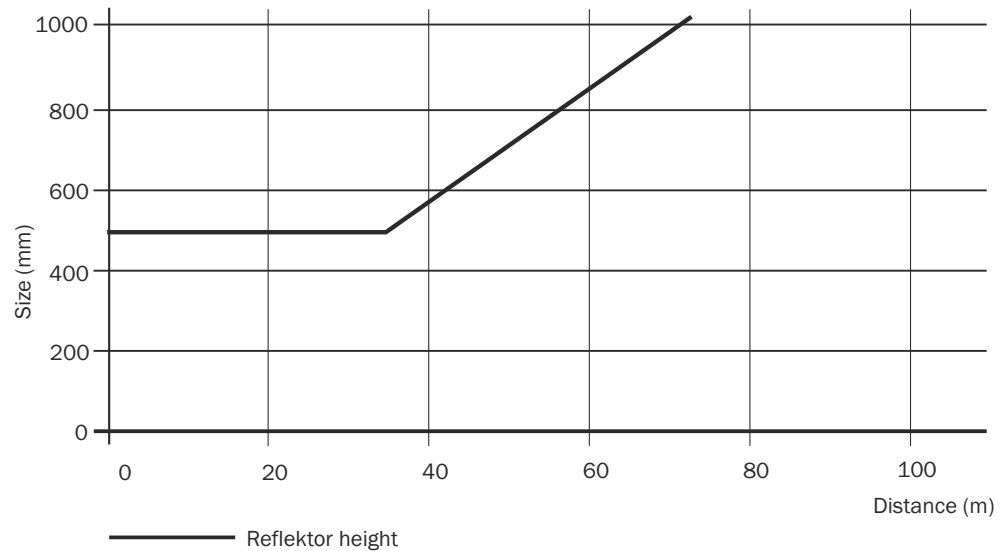


Figure 17: Reflector height as a function of distance from 0 to 70 m



### NOTE

The specified values do not take into account uneven floors and tilting of the AGV due to loading!

### Reflector diameter

The recommended diameter of cylindrical reflectors is 80 mm.

If the diameters of the reflectors differ, it can lead to deviating measurement characteristics.

The diameter of cylindrical reflectors can vary within a layer. If you intend to map the entire layer, however, only reflectors with the same diameter should be used.

### Reflector reference points

To clearly determine the coordinates of a reflector using the device, the reflector surface must be reduced to a reference point: With cylindrical reflectors, the reference point is located at the point of intersection between the vertical center axis of the cylinder and the scan plane, which is generally halfway up the reflector.

#### 4.10.5.1 Reflector arrangements

Reflector arrangements must be planned in such a way that the device has a clear view of at least 3 reflectors from any position. A clear view of 4 to 5 reflectors is recommended to ensure reliable positioning even when several AGVs are in operation. An equal number of reflectors should be fitted on both sides of the route.

The device identifies a reflector arrangement by assigning individual reflector position measurements to the stored reflector coordinates. Special requirements for the reflector arrangement must be observed during initial positioning. To enable the device to clearly identify a reflector arrangement during initial positioning, it requires a specific arrangement. In such a pattern, all the distances between the reflectors differ by at least 500 mm.

The following figure shows two examples of a correct and an incorrect reflector arrangement.

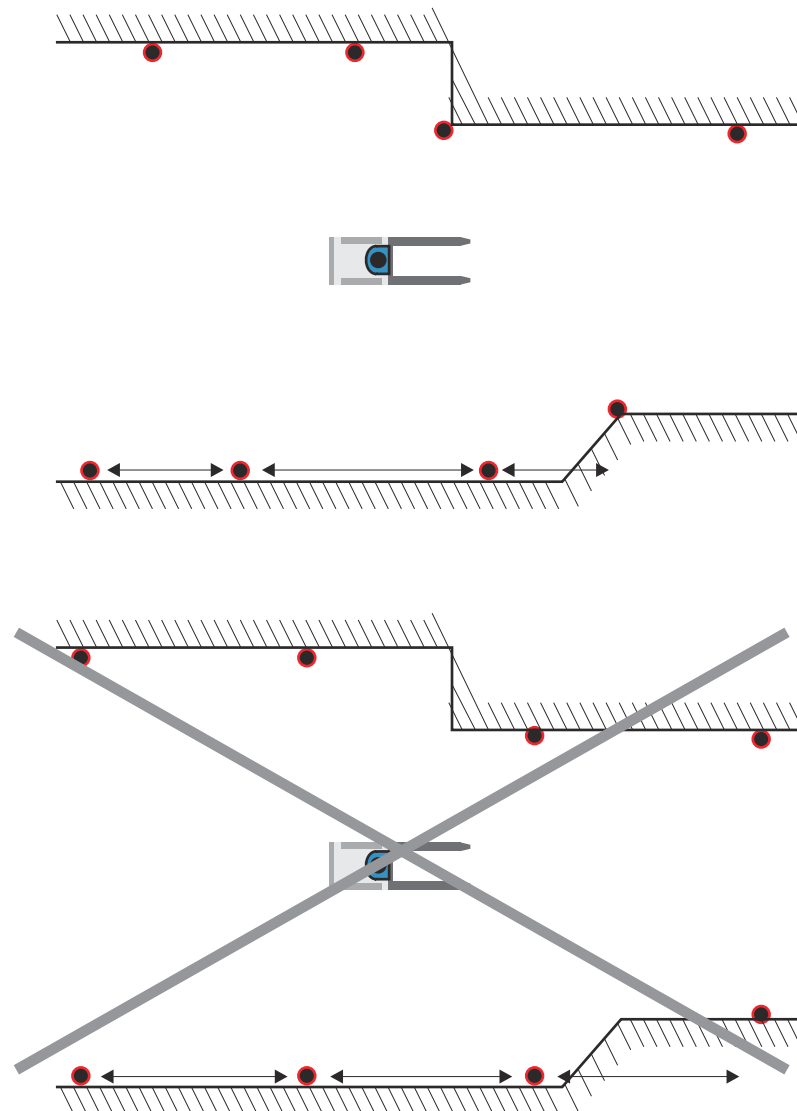


Figure 18: Correct, asymmetrical arrangement and incorrect, symmetrical arrangement of reflectors

With continuous positioning, the device can also process symmetrical reflector arrangements.

**Recommendation**

- As not all reflectors may be detected or may be temporarily obscured while driving, more than 3 reflectors per layer should always be used. A quantity of 5 reflectors is recommended. The route of the vehicle must be checked to ensure that at least 3 reflectors can always be detected simultaneously.
- If possible, the same number of reflectors should be fitted on both sides of the route. If the reflectors are only on one side when viewed from the device, the positioning accuracy may be reduced due to unfavorable geometric conditions.
- At positions where very high accuracy is required and in curves, there should be 4 or more reflectors within the radius of action of the device if possible. In addition, the angle between 2 reflectors should not exceed 120°.
- At least 4 to 6 reflectors should be within the measuring range of the device at positions where the device is placed on the route. In addition, the angle between 2 reflectors should not exceed 120°.

The above recommendations are not always feasible in practice. The reflector positions must therefore be planned as well as possible in accordance with these recommendations.

### 4.10.5.2 Measuring and entering the reflector coordinates

After planning and installing the reflectors, the reflector coordinates must be measured precisely. The device requires these coordinates in live operation to determine its position. The coordinates of the reflectors used are stored in the non-volatile reflector memory of the device as a reference basis.

**There are two methods for measuring and entering the coordinates:**

- A (land) surveyor manually measures the positions of all reflectors in relation to a common coordinate system. All these coordinates are recorded in a structured ASCII file on the computer and transferred to the device using the SOPAS ET configuration software [see "Loading reflector data", page 47](#). This transfer can also be carried out from the vehicle computer using the software telegram **Add landmarks** (SMN MNLAYADDLANDMARK).
- The device can automatically teach in the reflector positions using the **Mapping** and then **Add landmarks** (SMN MNLAYADDLANDMARK) function. To do this, the device requires an accurately measured initial position in order to then successively measure the coordinates of all reflectors of the course.

The determination of reflector positions by a surveyor is more precise and ensures greater system accuracy.

**The Mapping function is suitable:**

- for calibrating new reflectors after initial installation.
- for correcting changes in the position of reflectors.
- if only low positioning accuracy is required in the layer/system.
- when quick setup is required, e.g. at trade fairs and exhibitions.

### **Subdivision of the course into layers**

The reflector data stored in the device can be assigned in groups to up to 320 layers (levels). Each layer represents a permanently defined area within the entire course of the AGV through which the route of the AGV passes. By switching to the corresponding layer, the device only ever uses for detection the reflector data that belongs to the area currently being traveled over. The vehicle computer switches the layers depending on the location.

The subdivision into layers serves to keep the NAV350 downwards compatible with the NAV200 and to configure a large course more clearly.

A layer should be set up so that the device can detect as many reflectors of this layer as possible, but as few as possible from the other layers.

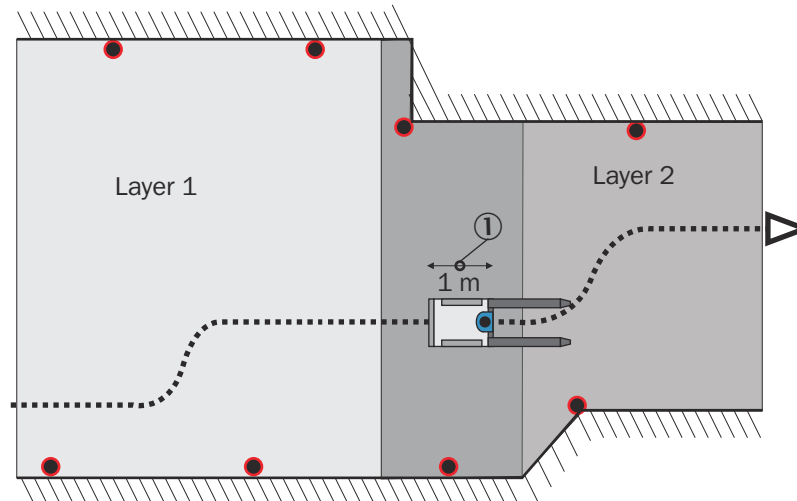


Figure 19: Sharing the reflectors of two adjacent layers

Ideally, the layer transitions should be selected so that they are located on straight sections of the route. The required switchover of the device from the stored reflector data of one layer to the data of the adjacent layer by the vehicle computer should take place in the middle of an approximately 1 m long connecting section.



**NOTE**

One and the same reflector can be assigned to two different layers. Layers can therefore overlap, which is recommended for a smooth transition of the AGV between two layers.

### 5 Mounting

#### 5.1 Overview of the mounting steps

- Select a mounting location for the device
- Mount and adjust the device

#### 5.2 Preparation for mounting

##### Getting the components to be mounted ready

- One device (weight approx. 2.4 kg)

##### Getting the accessories and material ready

##### Brackets to be provided by the user:

- Stable mounting device that provides adjustable alignment of the device on the X and Y axis
- Three M6 screws for the device, screw length dependent on the thickness of the mounting bracket used

#### 5.3 Mounting and aligning the device



##### NOTE

##### Risk of damaging the device!

The maximum screw-in depth of the M6 blind tapped hole is 12 mm. Longer screws damage the device.

- ▶ Use screws of suitable length.

---

The device has three M6 blind tapped holes and is mounted using three M6 screws, see ["Preparation for mounting", page 38](#).

At least three M6 screws with washers and lock washers are required for secure mounting. The supply voltage must be switched off.

The device can be installed in any arbitrary position.

1. Prepare the substrate for mounting the bracket of the device, see ["Preparation for mounting", page 38](#).
2. Insert the screws through the holes in the bracket and screw them into the blind tapped holes of the device. Tighten the screws only lightly.
3. The scanner head of the device must be able to rotate freely.
4. Align the device.
5. Tighten the screws.
6. Check alignment.

#### 5.4 Removing the device

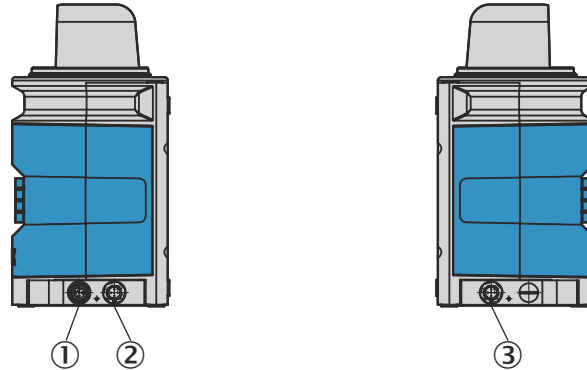
1. Switch off the voltage supply.
2. Disconnect connection cables.
3. Unscrew the screws for mounting the device on the bracket and remove the device.

## 6 Electrical installation

### 6.1 Overview of the installation steps

1. Wire the switching outputs (depending on application).
2. Connect the computer temporarily (configuration).
3. Wire the data interface for operation.
4. Set up the voltage supply for the device.

### 6.2 Connections of the device



- ① Ethernet port M12×4, female connector
- ② Power connection M12×5, male connector
- ③ RS-232 connection M12×8, male connector

The device has three multi-pin M12 round connectors.

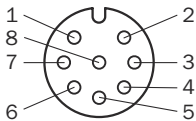
#### Power connection M12×5, male connector, A-coded

	Pin	Signal	Function
	1	$V_s$	Supply voltage
	2	$V_s$	Supply voltage
	3	GND	Mass
	4	OUT 24 V	
	5	GND	Mass

#### Ethernet port M12×4, female connector, D-coded

	Pin	Signal	Function
	1	Ethernet_TX+	Ethernet interface
	2	Ethernet_RX+	Ethernet interface
	3	Ethernet_TX-	Ethernet interface
	4	Ethernet_RX-	Ethernet interface

**RS-232 connection M12×8, male connector, A-coded**

	Pin	Signal	Function
	1	RxD	Serial RS-232 host interface (receiver)
	2	TxD	Serial RS-232 host interface (sender)
	3	-	Do not use
	4	-	Do not use
	5	GND RS-232	RS-232 ground
	6		Do not use
	7		Do not use
	8		Do not use

**6.3 Preparation for electrical installation****Supply voltage**

24 V DC  $\pm$  15 % in accordance with IEC 60364-4-41 (observe permissible cable lengths, [see table 4, page 40](#))

The device consumes the following:

- Maximum 36 W when switching on without wired digital outputs
- Typically 12 W during operation, additional maximum 12 W with wired digital output

The voltage supply/the external power supply unit for the voltage supply must be able to deliver at least 40 W of continuous power, and at least 48 W of continuous power when the digital output is wired.

**WARNING****Use a safety transformer!**

There must be safe electrical separation between the output current circuit of the power supply unit and the input current circuit. This is usually generated by a safety transformer conforming to the IEC 742 standard (VDE 0551).

**Conductor cross-sections**

- ▶ All connections must be wired with copper cables.
- ▶ Use the following wire cross-sections:
  - Supply voltage: at least 0.25 mm<sup>2</sup>, if the local voltage supply (power supply unit) is in the immediate vicinity
  - Supply voltage: at least 0.5 mm<sup>2</sup> with a maximum length of 10 m when connected to available 24 V DC network
  - Data interface: at least 0.25 mm<sup>2</sup>
- ▶ Lay all cables so that there is no risk of tripping and all cables are protected against damage.

When using a typical power supply unit with a nominal voltage of 24 V DC  $\pm$  5 %, the following maximum cable lengths are permissible for the supply voltage:

Table 4: Maximum cable lengths for the supply voltage

Conductor cross section	Length of cable
0.25 mm <sup>2</sup>	5 m
0.5 mm <sup>2</sup>	10 m

### General requirements on the data interface

The following table shows the recommended maximum cable length.

Interface type	Transmission rate	Maximum length of cable
RS-232	115,200 Bd	10 m



#### NOTE

- Use shielded cables (twisted pairs) with at least 0.25 mm<sup>2</sup>.
- To prevent interference factors, do not lay data cables over a longer route in parallel with voltage supply cables and motor cables, for example in cable ducts.

## 6.4 Carrying out the electrical installation on the device

### Auxiliary equipment

- tool
- Digital measuring device (voltage measurement)

### Only connect the device when it is de-energized

- ▶ Make sure that the voltage supply to which the device is connected is switched off.

### Connecting the supply voltage

Pre-assembled cables with open ends are available to supply the device.



Figure 20: Supply voltage connection

### Connection to the Ethernet interface

Pre-assembled cables are available for configuring the device via the Ethernet interface.

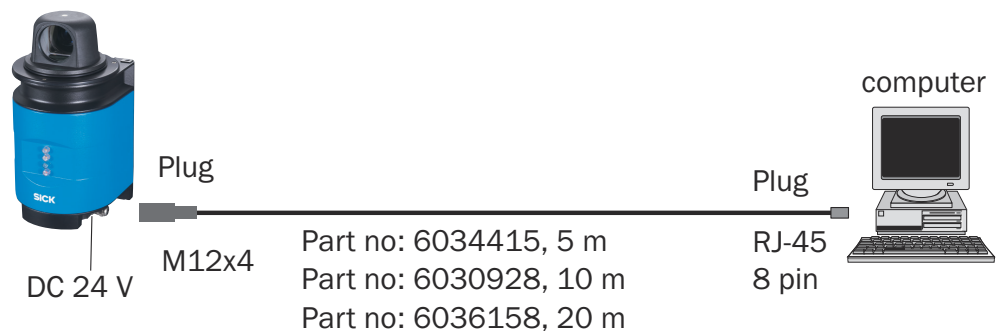


Figure 21: Ethernet connection

### Connection to the RS-232 interface

A shielded cable is required for connecting the RS-232 interface.

- Observe the maximum cable length, see "General requirements on the data interface", page 41

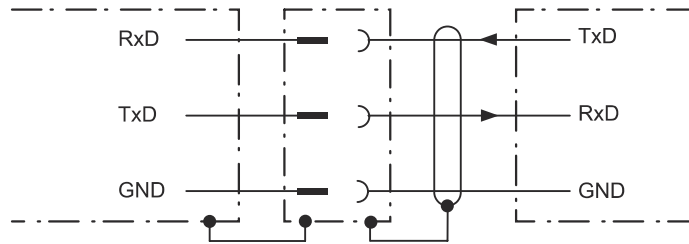


Figure 22: Wiring of the RS-232 interface

Pre-assembled cables are available for configuring the device via the RS-232 interface.

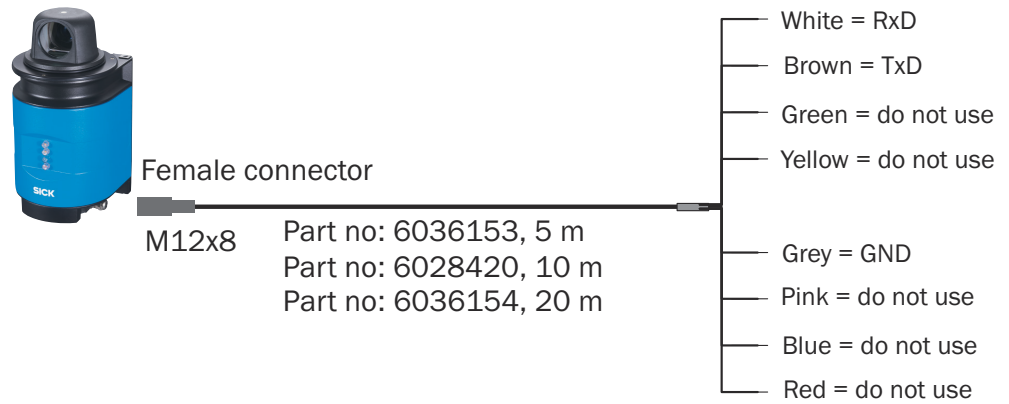


Figure 23: RS-232 connection

## 7 Commissioning and configuration

### 7.1 Overview of the commissioning steps

- Mounting and electrical installation must have been carried out.
- Install the SOPAS ET configuration software.
- Establish communication with the device.
- Create an application-specific parameter set with SOPAS ET and save in the device permanently.
- Test the device for correct functioning.
- For a position output application:
  - Plan the reflector positions and mount the reflectors.
  - Measure or teach-in the reflectors.
  - Enter the positions of the measured reflectors or read them in from the ASCII file and enter the reflector parameters in SOPAS ET.
- For a landmark detection application:
  - Plan the reflector positions and mount the reflectors.
  - Enter the reflector parameters in SOPAS ET.

### 7.2 SOPAS ET configuration software

SOPAS ET makes interactive configuration possible. You can use this configuration software to parameterize and test the measuring properties, evaluation behavior, and output properties of the device as required. The configuration data are stored and archived as a parameter set (project file) on the computer.

Help on using the program user interface as well as for the different options can be found in SOPAS ET:

- **Help menu, Help F1:** Detailed online help on the program user interface and the individual options
- **Help window** (at the bottom left in the program user interface): Context sensitive help for the visible dialog
- **Tool tips:** Move the mouse pointer over an input field. A short text (“tool tip”) with information about valid entries appears.

The main functions are:

- Menu language selection (German/English)
- Setting up communication with the device
- Password-protected communication with different operating levels
- Performing diagnostics on the device

#### 7.2.1 Installing SOPAS ET

Download the SOPAS ET software online from [www.sick.com](http://www.sick.com)

This download is approximately 150 MB in size and contains the Setup.exe for installing SOPAS ET.

Follow the operating instructions to complete the installation.

#### 7.2.2 SOPAS ET default settings

Parameter	Value
User interface language	English (you must restart the software after making any changes)
Units of length	Metric
User group (operating level)	Machine operator

Parameter	Value
Download the parameters to the device	Immediately after a change, temporarily in the RAM of the device
Upload the parameters from the device	Automatically after being switched to online
Window arrangement	3 (project tree, help, workspace)
Serial communication	COM1: Default: 115,200 Bd, 8 data bits, no parity, 1 stop bit

### 7.3 Establishing communication with the device



#### NOTE

To communicate via TCP/IP, the TCP/IP protocol on the computer must be active.

When connecting a computer/host, please adhere to the following sequence:

1. Switch on computer.
2. Connect the computer to the device using a data cable.
3. Switch on the supply voltage for the device.
- ✓ The device performs a self-test and initializes itself.

#### 7.3.1 Connecting data interfaces

- ▶ Connect the computer to the device via Ethernet cable, [see figure 21, page 41](#) or
- ▶ Connect the computer (serial interface) to the device, [see figure 22, page 42](#)

#### 7.3.2 Starting SOPAS ET and opening the Scan Assistant

1. Start SOPAS ET.
- ✓ SOPAS ET opens the program window with an English program interface as standard.
2. To change the language setting, click **Cancel** in the start dialog and change the language of the program interface to **German** via the **Tools, Options** menu.
3. When the language setting has been changed, quit and restart SOPAS ET.
4. In the dialog box, select the **Create new project** option and click **OK** to confirm.
5. In the main window, click the **Configuration** button under **Scan Assistant**.
- ✓ The **Scan Assistant** dialog window appears.

#### 7.3.3 Configuring serial connection

1. In the **Scan Assistant** dialog window under **Serial Connection, Standard Protocol**, select the **Activate Serial Communication** checkbox.
2. Click the **Advanced...** button.
3. Under **COLA dialect**, select the **ASCII** option.
4. Select the following **Port Settings**: 8 data bits, no parity, 1 stop bit.
5. Confirm the settings with **OK**.
- ✓ The **Advanced Scan Settings** dialog window is closed.
6. Confirm the settings in the **Scan Assistant** dialog window by clicking **OK**.
- ✓ The **Scan Assistant** dialog window closes.

#### 7.3.4 Configuring the Ethernet connection

The factory setting for the Ethernet interface of the device is:

- IP address: 192.168.1.10
- Subnet mask: 255.255.255.0
- TCP/IP port for SOPAS ET: 2111

### Configuring with a fixed IP address



#### NOTE

Deactivate all programs on your computer/notebook which access Ethernet or TCP/IP.

1. From the **Start menu**, select **Network connection** in **Settings**.
2. Right-click on **LAN connections** and select **Properties**.
3. On the **General** tab, select **Internet Protocol (TCP/IP)** and click on **Properties**.
4. Select **Use following IP address** and enter the following IP address: 192.168.1.x (e.g. 1).
5. Click **OK** to confirm.

Then set the IP configuration for the device in SOPAS ET:

1. In the **Scan Wizard** dialog box under **Internet Protocol, IP Communication**, select the **IP Communication** checkbox and deselect the **Use Auto IP** checkbox.
2. Click the **Add** button.
3. Enter the following **individual address**: 192.168.1.10
4. Confirm the settings in the **Scan Assistant** dialog box by clicking **OK**. The **Scan Assistant** dialog box closes.
5. Click the **Advanced...** button.
6. Under **TCP-PORT(S)**, deselect 2112 and click **OK** to confirm the setting.

### Configuring with Auto IP



#### NOTE

Deactivate all programs on your computer/notebook which access Ethernet or TCP/IP.

1. In the **Scan Wizard** dialog box under **Internet Protocol, IP Communication**, select the **IP Communication** checkbox and select the **Use Auto IP** checkbox.
2. Click the **Auto IP setting** button.
3. Click the **Search for sensors** button to check whether the device is **Reachable**.
4. If the status is **Not reachable**, mark the device and carry out the following steps. If the status is **Reachable**, click **OK** to close the dialog box and start the network scan.
5. Click the **Change settings** button.
6. Increase the IP address in the **Network adapter of the PC** field by one digit and enter it in the **Use the following IP settings** field, e.g.: IP address under **Network adapter of the PC** = 169.192.88.120; IP address under **Use the following IP setting** = 169.192.88.121
7. Confirm the settings in the **Scan Assistant** dialog box by clicking **OK**. The **Scan Assistant** dialog box closes.

#### 7.3.5 Performing a scan

1. In the **Scan Assistant** dialog window, click the **Start scan** button.
2. Select the listed devices and confirm by clicking **Add Device**.
- ✓ The connection is used to search for connected devices. SOPAS ET adds the devices found to the project tree and loads the current parameter set to the device via upload.

### 7.4 Initial commissioning

The device is adjusted to the situation on site using the SOPAS ET configuration software. To do this, SOPAS ET creates an application-specific parameter set.

The parameter set is then loaded into the device (download). This either happens immediately (**Download immediately** option in SOPAS ET) or manually (**Download all parameters to the device** command in SOPAS ET).



**NOTE**

After you have completed the configuration, you must load the parameter set into the device permanently. You must also save the parameter set on the computer as a project file (spr file with configuration data) and archive it.

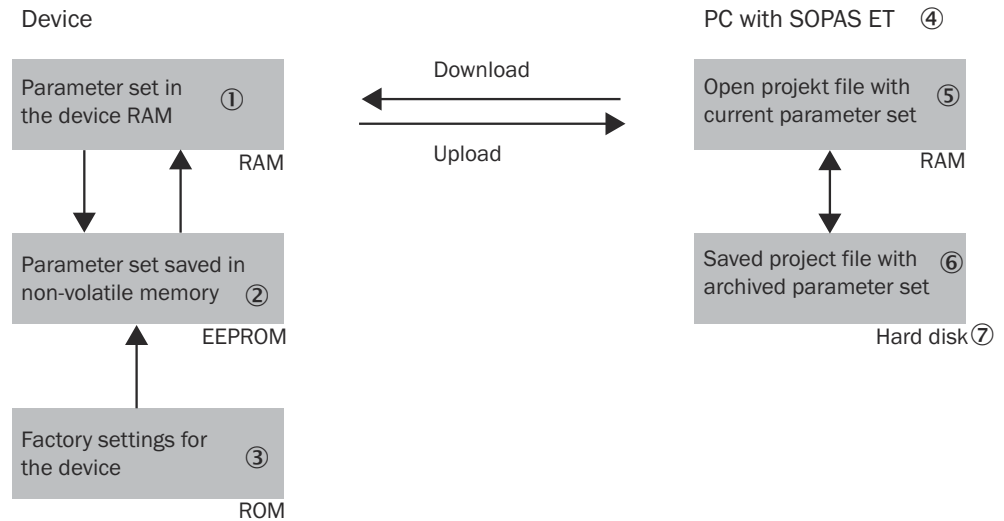


Figure 24: Data storage principle

- ① Parameter set in the working memory of the device
- ② Permanently saved parameter set
- ③ Factory-set pre-settings of the device
- ④ Computer with SOPAS ET
- ⑤ Opened project file with current parameter set
- ⑥ Saved project file with archived parameter set (\*.spr)
- ⑦ Hard drive

**7.4.1 Configuring the device**

You can configure the device in two ways:

- Interactive using SOPAS ET: This section describes the interactive configuration.
- Via configuration telegrams: [see "Communicating data via telegrams", page 27](#)

**Interactive configuration with SOPAS ET**

All configurable parameters of the device are compiled in a corresponding device description (SDD file) for SOPAS ET. You can access these via the project tree for the device description.

Depending on the context, the function of the particular parameters is explained in an online help guide ([F1] button). The **Parameter info** display window lists the valid range and the default setting (right-click when the pointer is placed over the parameter).

Software access to the device is protected by a password. After configuring the device successfully, you must change the password so that it can fulfill its protective function.

User level	Password
Authorized Client	client

Use the project tree in SOPAS ET to configure the necessary parameters for your application.

**NOTE**

Do not switch off the voltage supply during configuration!

If you switch off the voltage supply during the configuration, you will lose all parameters that have already been configured.

1. In the **Options** menu, select the **Log on to device** command and log in as an **Authorized Client** using the password `client`.
2. Configure the device for the required application using the parameters in SOPAS ET.

Help on using the program user interface as well as for the different options can be found in SOPAS ET.

## 7.5 Connecting and performing a test measurement

Use the graphic scan view in SOPAS ET to verify the generated measured values and the measuring range online.

1. In the project tree, select NAV350, **Monitor**, **Scan view**.
2. To start the measurement, click on the **Play** button.
3. Compare the measurement line with the required result.

**NOTE**

The **Scan View** on the **Monitor** depends on the available processing power of the computer and is not output in real time. For this reason not all measured values are displayed. The same restriction also applies to saving the visualized measured values in a file.

4. After you have completed the test measurement, save the configuration permanently in the device: NAV350 menu, **Parameters**, **Save permanently**.

## 7.6 Loading reflector data

Measured reflectors can be written to a text file instead of being entered in SOPAS ET. The reflector data saved in the text file must be in ASCII format and can be changed using any text editor. The files must have the file extension `.IMK`.

Such a file contains all the information for one or more layers: X and Y coordinates as well as the reflector radius.

```
#SICK AG
#NAV Layout data
#FileFormat: 0.01
#Sopas NAV350 V1.00 30.11.2010
#Used Layers:
#LayerID #landmarks
# 000 5
#
globID x[mm] y[mm] type subtype size[mm] layer1 layer2 layer3
000001 1855 218 1 2 80 0
000002 -1254 -486 1 2 80 0
000003 -1243 -1094 1 2 80 0
000004 -111 -752 1 2 80 0
000005 1928 -245 1 2 80 0
```

Figure 25: Example text file with reflector data

The text file is divided into the following elements (from top to bottom):

- The headers are used for version information. (They are marked as comment lines with a hash (#) at the beginning of the line)
- The rows with the actual coordinates contain 9 columns (from left to right):
  - Global identification number
  - X-coordinate (mm)
  - Y-coordinate (mm)
  - Landmark type (1 = reflector (fixed definition))
  - Landmark subtype (2 = cylindrical (fixed definition))
  - Reflector diameter
  - Use in layer no. (in the example, all reflectors in the layer with layer index 0 are used), a reflector can be used in up to 3 layers.



### NOTE

When creating the text file manually, at least one space or tab character must be used as a separator on the data lines.

---

Reflector data can be read from or saved to a corresponding text file on a data card using the **Open and Save** buttons.

## 8 Maintenance

### 8.1 Maintenance during operation

The device operates maintenance-free except for the care measures mentioned below. No maintenance is necessary to ensure compliance with laser class 1.

To maintain the full optical performance of the device, the glass in the scanner head of the device should be checked regularly for contamination. This applies in particular in harsh operating environments (dust, abrasion, moisture).



#### NOTE

##### Damage to the optics in the device!

The glass in the scanner head of the device is made of glass. The optical performance is reduced by scratches and streaks.

- Do not use aggressive cleaning agents.
- Do not use abrasive cleaning agents.
- Use only textile cleaning cloths or wood- and lint-free paper towels.
- Avoid any movements which may scratch or chafe the glass.



#### NOTE

##### Reduced performance due to contamination of the glass in the scanner head!

Static charges cause dust particles to be attracted to the glass of the device. You can reduce this effect by using the anti-static plastic cleaner and the SICK lens cloth (part no. 4003353) for cleaning.



① Glass in the scanner head of the device

#### To clean the glass in the scanner head

1. Switch off the device during cleaning, otherwise the scanner head will rotate.
2. Use a clean, soft brush to remove dust from the glass.
3. Then wipe the optics with a clean, damp cloth.

If the optics is scratched or damaged (cracked, broken), it must be replaced. Contact SICK Service to arrange this.

### 8.2 Replacing a device

As all external cable connections terminate in the plug connections, there is no need to repeat the electrical installation when the device is replaced. The replacement device can simply be connected.

1. Switch off the voltage supply to the device.
2. Remove the connection cables from the device.

3. Mount the replacement device, [see "Mounting", page 38](#).
4. Open the project file (spr file with configuration data) using SOPAS ET and transfer the configuration to the device, [see "Initial commissioning", page 45](#).

## 9 Troubleshooting



### NOTICE

Claims under the warranty rendered void!

The housing screws of the device are sealed. Claims under the warranty against SICK AG will be rendered void if the seals are damaged or the device is opened. The housing must only be opened by authorized SICK service personnel.

### 9.1 Response to errors



### WARNING

Cease operation if the cause of the error has not been clearly identified!

Immediately put the machine/system out of operation if you cannot clearly identify or allocate the error and if you cannot safely remedy the error.

### 9.2 Monitoring error and fault signals

During operation, the device monitors itself:

- After the supply voltage has been switched on, the device runs a self-test before initialization (loading the parameters and initializing the device functions). During this test, it checks important hardware components.
- During operation, the device constantly monitors whether the scanner head is functioning, i.e. rotating correctly.
- If the device detects a device error during the self-test or operation, it displays this via the LEDs.

### 9.3 Troubleshooting

Fault	Possible cause	Corrective measure
All LEDs are dark and the scanner head does not rotate.	<ul style="list-style-type: none"> <li>• No supply voltage at the terminals</li> </ul>	<ul style="list-style-type: none"> <li>▶ Check the supply voltage, (see "Data sheet", page 54)</li> <li>▶ Check whether supply cables are fixed correctly in the connector plug.</li> <li>▶ Check whether the cables are poled correctly.</li> </ul>
No LED lights up. The scanner head only rotates briefly.	<ul style="list-style-type: none"> <li>• Supply voltage too low</li> </ul>	<ul style="list-style-type: none"> <li>▶ Increase the wire cross-section.</li> </ul>
Red LED lights up.	<ul style="list-style-type: none"> <li>• Scanner head does not rotate and is blocked.</li> </ul>	<ul style="list-style-type: none"> <li>▶ Disconnect the supply voltage and reconnect. If the red LED is still lit, inform SICK Service.</li> </ul>

Fault	Possible cause	Corrective measure
SOPAS ET cannot communicate with the device.	<ul style="list-style-type: none"> <li>Supply voltage for the device not switched on</li> </ul>	▶ See the faults above this line.
	<ul style="list-style-type: none"> <li>Computer not connected to device</li> </ul>	▶ Connect the computer to the device (use a suitable data cable for the type of interface).
	<ul style="list-style-type: none"> <li>Incorrect interface selected</li> </ul>	▶ Select the interface in SOPAS ET according to the connection made on the device.
	<ul style="list-style-type: none"> <li>Another application on the computer is already accessing the interface.</li> </ul>	▶ Check the pin assignment of the interface, end the corresponding application if necessary.
	<ul style="list-style-type: none"> <li>Sequence when switching on the device and the connected computer not adhered to</li> </ul>	<ol style="list-style-type: none"> <li>Switch on computer.</li> <li>Connect the computer to the device.</li> <li>Switch on the device.</li> </ol>
Measurements in close range without objects present	<ul style="list-style-type: none"> <li>Contaminated or scratched optics</li> </ul>	▶ Carefully clean the optics with a soft, lint-free cloth. If the optics is scratched, contact SICK Service.
The device does not detect objects that are present.	<ul style="list-style-type: none"> <li>Smoke and dust</li> </ul>	▶ Check whether the scanner head is clean and dry.
The device does not transmit a measurement result.	<ul style="list-style-type: none"> <li>Wiring error in the data connection</li> </ul>	▶ Check the wiring.
Frequent CRC errors via the RS-232 interface.	<ul style="list-style-type: none"> <li>Data transmission time-critical</li> </ul>	▶ Increase the baud rate.

### 9.4 Detailed error analysis

Communication errors can occur when transmitting telegrams to the device. The device then returns an error code which you can evaluate (see “Telegram listing NAV350”, part no.: 8013893).

### 9.5 SICK support

If the fault cannot be rectified using the measures described above, the device may be defective. The device cannot be repaired by the user in order to restore its functionality after a fault.

Rapid replacement of a device by the user is however possible, [see "Replacing a device", page 49](#).

Where a fault cannot be rectified, please contact the SICK Service department, see rear of this document.



**NOTICE**

Repair work on the device may only be performed by qualified and authorized service personnel from SICK AG.

**Monitor**

You can use the monitor to view the measurement data, the detected reflectors, and the position of the device.

SOPAS: Project tree, NAV350, **Monitor**, **Scan view**.

## 10 Technical data



### NOTE

The relevant online product page for your product, including technical data, dimensional drawing, and connection diagrams, can be downloaded, saved, and printed from the Internet.

The product page can be accessed via the **SICK Product ID: [pid.sick.com/{P/N}/{S/N}](http://pid.sick.com/{P/N}/{S/N})** {P/N} corresponds to the part number of the product, see type label.

{S/N} corresponds to the serial number of the product, see type label (if indicated).

Please note: This documentation may contain further technical data.

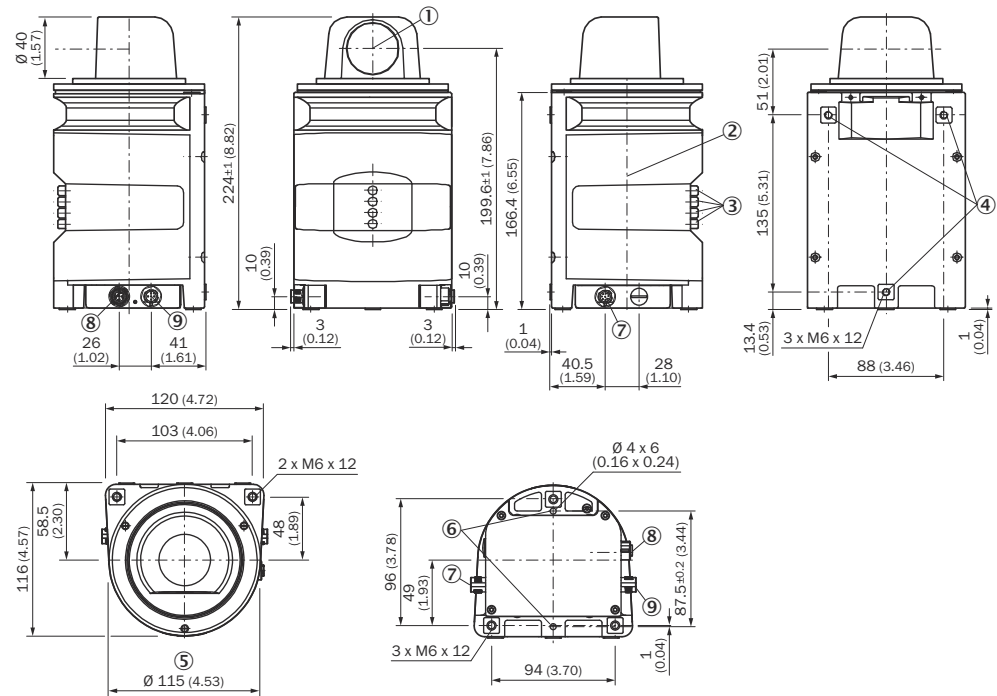
### 10.1 Data sheet

Properties	NAV350
<b>Navigation <sup>1)</sup></b>	
Measuring range <sup>2)</sup>	0.5 ... 70 m on reflectors
Usable scanning angle	360°
Positioning accuracy	4 mm at reflector distance up to 10 m 10 mm at reflector distance up to 20 m 15 mm at reflector distance up to 30 m > 25 mm at reflector distance up to 50 m
Orientation	± 0.10° at reflector distance up to 10 m ± 0.15° at reflector distance up to 30 m ± 0.25° for reflector distance > 30 m
Frequency of position measurement <sup>3)</sup>	8 Hz ± 5 %
<b>Landmark detection <sup>4)</sup></b>	
Measuring range	0.5 ... 70 m on reflectors
Usable scanning angle	360°
Angular resolution	0.1°
Systematic error for distance measurement	± 10 mm (25 °C) on reflectors
Statistical error for distance measurement (1 sigma)	10 mm on reflectors
Systematic error for angle measurement <sup>5)</sup>	± 0.10° at reflector distance up to 10 m ± 0.15° at reflector distance up to 30 m ± 0.25° for reflector distance > 30 m
Statistical error for angle measurement (1 sigma)	0.05° on reflectors
Temperature drift	typ. ± 0.6 mm/K
<b>Output of measured values</b>	
Measuring range <sup>2)</sup>	0.5 ... 35 m, at 10 % remission 0.5 ... 50 m, at 20 % remission 0.5 ... 100 m, at 100 % remission maximum 0.5 ... 250 m
Usable scanning angle	max. 360°
Angular resolution (increment)	0.25° fixed
Scan rate	8 Hz ± 5 %
Measurement resolution	1 mm

<b>Properties</b>	<b>NAV350</b>
<b>Systematic error at 25 °C</b>	± 15 mm at 20 ... 90 % reflection
<b>Statistical distance error (1 sigma)</b>	15 mm at 20 ... 90 % remission
<b>Temperature drift</b>	typ. ± 0.6 mm/K
<b>General data</b>	
<b>Beam divergence</b>	5.0 mrad
<b>Light source</b>	Infrared (wavelength 905 nm, max. output power 35 W, pulse duration 6,5 ns)
<b>Pulse rate</b>	11.5 kHz
<b>Laser class of the device</b>	Laser class 1, EN 60825-1:2014+A11:2021; IEC 60825-1:2014 Conforms to 21 CFR 1040.10 and 1040.11 except for conformance to IEC 60825-1 Ed. 3 as described in Laser Notice No. 56, dated May 8, 2019.
<b>RS-232 data interface</b>	19,200; 38,400; 57,600; Default: 115,200 Bd
<b>Data format</b>	Variable, default: 8 data bits, 1 stop bit, even parity
<b>Ethernet data interface</b>	100 MBit/s, TCP/IP
<b>Switching outputs</b>	1 × (OUT1 for synchronization); semiconductor output, high active, maximum output current 0.5 A at 24 V DC
<b>Supply voltage</b>	24 V DC ± 15 %/IEC 60364-4-41 (VDE 0100 Part 410)
<b>Power consumption of electronics</b>	Switching on: maximum 36 W (1.5 A) at 24 V DC, short-term 2.1 A during start-up
<b>EMC test</b>	In accordance with EN 61000-6-2 (2005-08)/EN 61000-6-4 (2007-01)
<b>Housing</b>	Aluminum die cast
<b>Protection class</b>	III according to EN 61140 (2002-03)
<b>Enclosure rating</b>	IP 65 according to EN 60529 (1991-10); A1 (2002-02)
<b>Vibration check</b>	According to IEC 60068-2-6, Table 2c (frequency range 10 ... 150 Hz, amplitude 0.35 mm or 5 g)
<b>Weight</b>	Approx. 2.4 kg
<b>Ambient operating temperature/storage temperature</b>	0 ... +50 °C/-20 ... +80 °C
<b>Max. relative humidity</b>	max. 85 %, non-condensing

- 1) The technical data are typical values at 25 °C for operation in industrial environments for standing AGV and when using cylindrical reflectors with a diameter of 80 mm from reflective tape 983-10 (part no. 5320565). The following conditions must also be met: At least six reflectors must be visible per measurement, the same number of reflectors must be arranged on each side of the route, and the angle between two reflectors must not exceed 120°.
- 2) Condition: Laser spot fully on the target, warm-up time at least 30 min.
- 3) Valid for position queries using the MNPOSGETPOSE telegram.
- 4) The technical data represents typical values at 25 °C for operation in industrial environments for standing AGV when using cylindrical reflectors with a diameter of 80 mm from 983-10 reflective tape (part no. 5320565).
- 5) The data represents typical values at 25 °C. Condition: laser spot fully on the target, warm-up time at least 30 min.

10.2 Dimensional drawings



- ① Optical axis
- ② Device zero point
- ③ LED (from top: yellow, yellow, green, red)
- ④ Fixing hole (M6x12)
- ⑤ Rotation diameter
- ⑥ Alignment hole
- ⑦ RS-232 connection (M12x4, male connector)
- ⑧ Ethernet connection (M12x4, female connector)
- ⑨ Power connection (12x5, male connector)

## 11 Annex

### 11.1 Glossary

#### Download

The process of transferring the parameter set which has been modified offline in the SOPAS ET configuration software from the computer to the device. SOPAS ET either transfers a complete copy to the random access memory (RAM) of the device (**Communication** menu, **Download all parameters to the device**) or only the parameters which have just been edited (**Communication** menu, **Download modified parameters to device**). The parameter set can be saved permanently in the EEPROM of the device using the device menu **Parameters, Save permanently**.

#### Parameter set

Data set which is used to initialize and activate the implemented functions in the device. It is transferred from the device to SOPAS ET and vice versa using **Upload** and **Download**.

#### Remission factor

Remission is the reflective quality of a surface. The basis for this is the Kodak standard, which is well-known globally in various applications, including photography. The surface-related measure of remission is the remission value.

#### Scan

A scan comprises all measured values determined as a function of scanning angle.

#### SOPAS ET

Configuration software which is used for the offline configuration (adjusting to the local reading situation) and the online operation of the device in the dialog box.

#### Upload

The process of transferring the parameter set from the device to the computer into the SOPAS ET configuration software. Parameter values are displayed in the index cards in the configuration software. This is a requirement if you wish to modify the current parameter set.

### 11.2 Declarations of conformity and certificates

You can download declarations of conformity and certificates via the product page.

The product page can be accessed via the **SICK Product ID: [pid.sick.com/{P/N}/{S/N}](http://pid.sick.com/{P/N}/{S/N})**

**{P/N}** corresponds to the part number of the product, see type label.

**{S/N}** corresponds to the serial number of the product, see type label (if indicated).

### 11.3 Cybersecurity

#### Overview

To protect against cybersecurity threats, it is necessary to continuously monitor and maintain a comprehensive cybersecurity concept. A suitable concept consists of organizational, technical, procedural, electronic, and physical levels of defense and considers suitable measures for different types of risks. The measures implemented in this product can only support protection against cybersecurity threats if the product is used as part of such a concept.

You will find further information at [www.sick.com/psirt](http://www.sick.com/psirt), e.g.:

- General information on cybersecurity
- Contact option for reporting vulnerabilities
- Information on known vulnerabilities (security advisories)



**Australia**  
Phone +61 (3) 9457 0600  
1800 33 48 02 – tollfree  
E-Mail sales@sick.com.au

**Austria**  
Phone +43 (0) 2236 62288-0  
E-Mail office@sick.at

**Belgium/Luxembourg**  
Phone +32 (0) 2 466 55 66  
E-Mail info@sick.be

**Brazil**  
Phone +55 11 3215-4900  
E-Mail comercial@sick.com.br

**Canada**  
Phone +1 905.771.1444  
E-Mail cs.canada@sick.com

**Czech Republic**  
Phone +420 234 719 500  
E-Mail sick@sick.cz

**Chile**  
Phone +56 (2) 2274 7430  
E-Mail chile@sick.com

**China**  
Phone +86 20 2882 3600  
E-Mail info.china@sick.net.cn

**Denmark**  
Phone +45 45 82 64 00  
E-Mail sick@sick.dk

**Finland**  
Phone +358-9-25 15 800  
E-Mail sick@sick.fi

**France**  
Phone +33 1 64 62 35 00  
E-Mail info@sick.fr

**Germany**  
Phone +49 (0) 2 11 53 010  
E-Mail info@sick.de

**Greece**  
Phone +30 210 6825100  
E-Mail office@sick.com.gr

**Hong Kong**  
Phone +852 2153 6300  
E-Mail ghk@sick.com.hk

**Hungary**  
Phone +36 1 371 2680  
E-Mail erteakesites@sick.hu

**India**  
Phone +91-22-6119 8900  
E-Mail info@sick-india.com

**Israel**  
Phone +972 97110 11  
E-Mail info@sick-sensors.com

**Italy**  
Phone +39 02 27 43 41  
E-Mail info@sick.it

**Japan**  
Phone +81 3 5309 2112  
E-Mail support@sick.jp

**Malaysia**  
Phone +603-8080 7425  
E-Mail enquiry.my@sick.com

**Mexico**  
Phone +52 (472) 748 9451  
E-Mail mexico@sick.com

**Netherlands**  
Phone +31 (0) 30 204 40 00  
E-Mail info@sick.nl

**New Zealand**  
Phone +64 9 415 0459  
0800 222 278 – tollfree  
E-Mail sales@sick.co.nz

**Norway**  
Phone +47 67 81 50 00  
E-Mail sick@sick.no

**Poland**  
Phone +48 22 539 41 00  
E-Mail info@sick.pl

**Romania**  
Phone +40 356-17 11 20  
E-Mail office@sick.ro

**Singapore**  
Phone +65 6744 3732  
E-Mail sales.gsg@sick.com

**Slovakia**  
Phone +421 482 901 201  
E-Mail mail@sick-sk.sk

**Slovenia**  
Phone +386 591 78849  
E-Mail office@sick.si

**South Africa**  
Phone +27 10 060 0550  
E-Mail info@sickautomation.co.za

**South Korea**  
Phone +82 2 786 6321/4  
E-Mail infokorea@sick.com

**Spain**  
Phone +34 93 480 31 00  
E-Mail info@sick.es

**Sweden**  
Phone +46 10 110 10 00  
E-Mail info@sick.se

**Switzerland**  
Phone +41 41 619 29 39  
E-Mail contact@sick.ch

**Taiwan**  
Phone +886-2-2375-6288  
E-Mail sales@sick.com.tw

**Thailand**  
Phone +66 2 645 0009  
E-Mail marcom.th@sick.com

**Turkey**  
Phone +90 (216) 528 50 00  
E-Mail info@sick.com.tr

**United Arab Emirates**  
Phone +971 (0) 4 88 65 878  
E-Mail contact@sick.ae

**United Kingdom**  
Phone +44 (0)17278 31121  
E-Mail info@sick.co.uk

**USA**  
Phone +1 800.325.7425  
E-Mail info@sick.com

**Vietnam**  
Phone +65 6744 3732  
E-Mail sales.gsg@sick.com

Detailed addresses and further locations at [www.sick.com](http://www.sick.com)