OPERATING INSTRUCTIONS

NAV-LOC

Laser positioning system

SICK
Sensor Intelligence.

Product described

NAV-LOC

Manufacturer

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Legal notes

Original document

This document is an original document of SICK AG.

Contents

1 About this document

1.1 Information on the operating instructions

These operating instructions are intended to allow the technical personnel to perform safe mounting, electrical installation work, configuration, commissioning, and maintenance on the 2D LiDAR sensor and the “Sensor Integration Machine” (SIM) for localization based on contour data. The SIM2000-0A20A00 and a 2D LiDAR sensor are used together and referred to as NAV-LOC in the following description. The system components are referred to as 2D LiDAR sensor and SIM (Sensor Integration Machine) for short, unless a clear distinction needs to be made.

This document describes solely how to operate NAV-LOC in a general sense. The instructions stated below are supplementary device-specific documents for 2D LiDAR sensors, which can be combined with the SIM2000-0A20A00 as a data source. These are required in addition as they describe the specific connection options and configuration for each sensor:

- NAV-LOC: SIM2000, NAV310 operating instructions (German 8023449, English 8023450)
- NAV-LOC: SIM2000, NAV245 operating instructions (German 8023451, English 8023452)
- NAV-LOC: Telegram Listing (English 8021387)

1.2 Explanation of symbols

All symbols used in this document and their meaning, warnings, and important information are marked with symbols in this document and are compiled below. The warnings are introduced by signal words that indicate the extent of the danger. These warnings must be observed at all times and care must be taken to avoid accidents, personal injury, and material damage.

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

WARNING
... indicates a situation of possible danger, which can lead to a fatality or serious injuries if not prevented.

CAUTION
... indicates a situation of possible danger, which can lead to minor or moderate injuries if not prevented.

IMPORTANT
... indicates a situation, which can lead to property damage if not prevented.

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

1.3 Further information

NOTE

All the documentation available for the device can be found on the online product page at:

www.sick.com

Solely type the specific document or device number in the search field.

This document describes solely how to operate NAV-LOC in a general sense. The instructions stated below are supplementary device-specific documents for 2D LiDAR sensors, which can be combined with the SIM2000-0A20A00 as a data source. These are required in addition as they describe the specific connection options and configuration for each sensor. The following information is available for download from this page:

- NAV-LOC variants:
  - NAV-LOC: SIM2000, NAV310 operating instructions (German 8023449, English 8023450)
  - NAV-LOC: SIM2000, NAV245 operating instructions (German 8023451, English 8023452)
- Model-specific online data sheets for device variants, containing technical data, dimensional drawings and diagrams e.g.:
  - Operating instructions of the SIM2000 (German 8020763, English 8020764)
  - Operating instructions of the NAV310 (German 8016534, English 8016535)
  - Operating instructions of the NAV245 (German 8018477, English 8018478)
- NAV-LOC: Telegram Listing (English 8021387)
- EU declaration of conformity for the product family
- Dimensional drawings and 3D CAD dimension models in various electronic formats
- These operating instructions, available in English and German, and in other languages if necessary
- Other publications related to the devices described here
- SOPAS ET configuration software for SIM and NAV 2D LiDAR sensors configuration (SOPAS Engineering Tool)
- Support is also available from your sales partner: www.sick.com/worldwide.
- Publications dealing with accessories.

1.4 Customer service

NAV-LOC requires a valid map of its surroundings in order to operate.

The map will be created by SICK customer service. Contour data from the intended area of operation are needed for this purpose. Please contact the responsible agency for the exact process of recording measurement data and creating a map. See the last page of this document.

NOTE

Before calling, make a note of all type label data such as type code, serial number, etc., to ensure faster processing.

2 Safety information

2.1 General safety notes

The following safety notes must always be observed regardless of specific application conditions:

- The device must only be mounted, commissioned, operated, and maintained by professionally qualified personnel.
- Electrical connections with peripheral devices must only be made when the voltage supply is disconnected.
- The device is only to be operated when mounted in a fixed position on a vehicle.
- The device voltage supply must be protected in accordance with the specifications.
- The specified ambient conditions must be observed at all times.
- The electrical connections to peripheral devices must be screwed on or clamped correctly.
- The cooling fins must not be covered or restricted in their functionality.
- The pin assignment of pre-assembled cables must be checked and adjusted if necessary.
- These operating instructions must be made available to the operating personnel and kept ready to hand.

2.2 Hazard warnings and operational safety

NAV-LOC uses a 2D LiDAR sensor that contains a laser light source as data source. LEDs are used for indication in the SIM. Please note the respective warning information in the respective operating instructions.

2.3 Intended use

NAV-LOC is used for detecting the position of manned or automated guided vehicles (AGVs) on the programmed route and is used to localize the AGV. The 2D LiDAR sensor is attached to the AGV and continuously measures the surrounding contour. NAV-LOC determines its own position from the contour data and a previously created map related to the optical axis of the 2D LiDAR sensor used and the orientation. The vehicle computer can use this to correct deviations from the course of the AGV in order to keep it on the planned route.

NAV-LOC is intended for localizing indoors (halls and rooms) and is not suitable for use outdoors.

Ethernet is used to connect the system to the AGV vehicle control.

Setup and parameterization require various technical skills, depending on how the device is used.

IMPORTANT

In the event of any other usage or modification to the components such as the 2D LiDAR sensor or the SIM, 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.

Depending on the vehicle and surroundings, the local safety requirements must be complied and protected with safety laser scanners or other measures may be necessary. The laser positioning system is not used for collision avoidance with other objects.

2.4 Improper use

Use of the device is generally only permitted in the ambient conditions specified in the technical data.

NAV-LOC is not suitable for certain application conditions, including:

- Use in areas with explosive atmosphere (hazardous area)
- Use in safety-related applications, particularly the use of the localization system for collision avoidance, e.g., the positions detected by NAV-LOC are not to be viewed as safe in terms of the Machinery Directive
- Use in extreme ambient conditions (see technical data)
- Use under water or in a corrosive atmosphere

2.5 IP technology

NOTE

SICK uses standard IP technology in its products for network communication. The focus is on availability of products and services. SICK always assumes that the integrity and confidentiality of the data and rights affected by the use of the aforementioned products will be ensured by the customer. In all cases, appropriate security measures, such as network separation, firewalls, virus protection, and patch management, must be taken by the customer on the basis of the situation in question.

See also the manuals for the specific 2D LiDAR sensors used and the SIM2000.

2.6 Requirements for operating personnel

WARNING

Risk of injury due to insufficient training.

Improper handling of the device may result in considerable personal injury and material damage.

- All work must only ever be carried out by the stipulated persons.

The operating instructions state the following qualification requirements for the various

Areas of work:

- **Instructed personnel** have been briefed by the operating entity about the tasks assigned to them and about potential dangers arising from improper action.
- **Skilled personnel** have the specialist training, skills, and experience, as well as knowledge of the relevant regulations, to be able to perform tasks assigned to them and to detect and avoid any potential dangers independently.
- **Electricians** have the specialist training, skills, and experience, as well as knowledge of the relevant standards and provisions, to be able to carry out work on electrical systems and to detect and avoid any potential dangers independently. In Germany, electricians must meet the specifications of the BGV A3 Work Safety Regulations (e.g., Master Electrician). Other relevant regulations applicable in other countries must be observed.

The following qualifications are required for various activities:

Activities	Qualification
Mounting, maintenance	• Basic practical technical training • Knowledge of the current safety regulations in the workplace
Electrical installation, device replacement	• Practical electrical training • Knowledge of current electrical safety regulations • Knowledge of the operation and control of the devices in their particular application
Commissioning, configuration	• Basic knowledge of the Windows™ operating system in use • Basic knowledge of the design and setup of the described connections and interfaces • Basic knowledge of data transmission protocols • In-depth programming knowledge in the area of vehicle control
Operation of the device for the specific application	• Knowledge of the operation and control of the devices in their particular application • Knowledge of the software and hardware environment for the particular application concerned

3 Product description

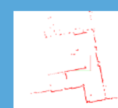
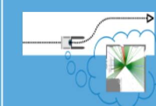
This chapter provides information on the special properties of NAV-LOC.

It describes the design and operating principle, in particular the various operating modes.

Read this chapter before you install and commission NAV-LOC.

3.1 Scope of delivery

NAV-LOC is available in a range of variants depending on the requirements:

Variant	Description					
		2D LiDAR Sensor	SIM2000 + SW Order No.: 1086073	Data Recording Optional by SICK: Order No. 1612196	Map Creation Oder No. 1612195	Map Commissioning Optional by SICK: Order No. 1612197
Order Options:						
Option 1	New Project	✓	✓	✓	✓	✓
Option 2	Expansion of project (additional AGV)	✓	✓			✓
Option 3	Change to NAV-LOC (2D-LiDAR existing)		✓	✓	✓	✓
Option 4	Retrofit NAV-LOC (2D-LiDAR existing; Map in operation)		✓			✓
Option 5	Update / extension of map (due to change of factory)			✓	✓	✓

The delivery of NAV-LOC includes the following components:

No. of units	Component
1	2D LiDAR sensor
1	SIM2000-0A20A00 including embedded application for localization

Please note: Cables for the voltage supply and data lines are not included with delivery and can optionally be ordered as accessories.

No. of units	Additional accessories[1]
1	Power cabling for 2D LiDAR sensor: M12 A-coded, 5-pin
1	Ethernet cabling for 2D LiDAR sensor: (RJ45 to M12, D-coded)
1	Power cabling for SIM2000-0A20A00
	Ethernet for SIM2000 to vehicle controller: RJ45 to RJ45

Sources for obtaining more information

Additional information about the SIM2000-0A20A00 and the 2D LiDAR sensor and their optional accessories can be found in chapter 1.3.

[1] Additional accessories like power and network cabling or mounting brackets can be ordered at the NAV-LOC product page. Under option "recommended accessories" is the minimum setup material.

3.2 Design and function of NAV-LOC

NAV-LOC is intended for determining the position of automated guided vehicles (AGVs). The vehicle positions are calculated based only on contour data observed at the respective position.

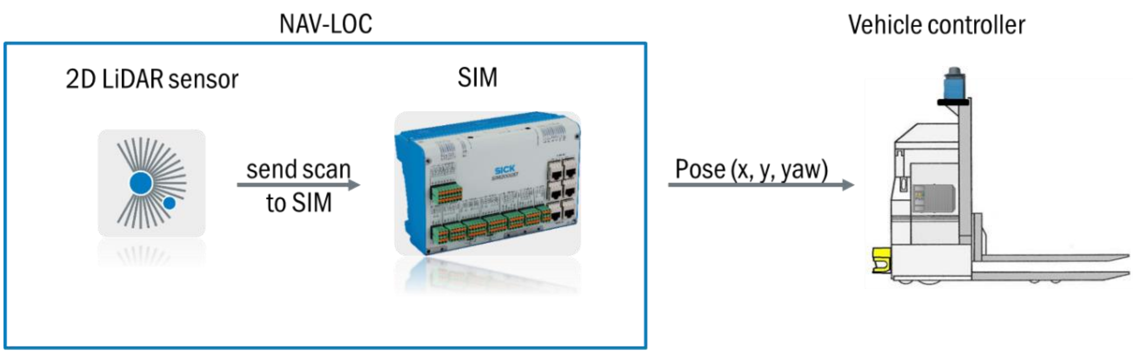


Figure 1: System overview for the integration of NAV-LOC

The vehicle surroundings are measured using laser beams based on the measured data of a 2D LiDAR Sensor. The current position is calculated based on contour data and a previously created reference map. This is transmitted to the vehicle controller as x-/y- coordinates and a yaw angle together with a time stamp. The vehicle computer controls the AGV along the programmed route and corrects any route deviation with the help of NAV-LOC.

An absolute coordinate system with an origin must be defined for the use of NAV-LOC for position output. For example, the origin point of the coordinate system can be at the corner of a factory hall.

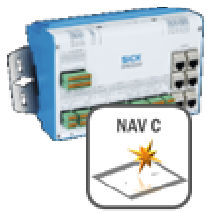
For the commissioning of NAV-LOC, a reference map of the current surroundings must have been created and installed (loaded).

Contact your SICK Service to create a reference map for your plant.

Figure 2: Example of a reference map for localizing in an industrial environment.

Device view:

Examples for a 2D LiDAR sensor



SIM2000-0A20A00 including NAV-LOCs embedded application software

3.3 Sensor Integration Machine (SIM)

Additional information on the SIM2000-0A20A00 with notes on mounting, installation, and commissioning can be found online in the operating instructions[2].

3.4 Measurement accuracy

The achievable measurement accuracy of NAV-LOC depends on the respective conditions during the ride and their influence on the recording of measurement data.

The measurement accuracy in drive mode is influenced by:

- The accuracy of the 2D LiDAR sensor used
- Limitation of the visual range due to vehicles, persons and objects
- Speed of the vehicle (particularly rotational movements)
- Distance between vehicle and contour
- Degradation of measurement performance due to fog, dust and like
- Evenness of the route (e.g., uneven areas, ramps, and bumps)
- Permanent changes to the surroundings (e.g. newly-built racks and walls/doors)

NOTE

The measurement accuracy specifications are listed in the data sheet in chapter 12.

3.5 Telegram listing

The specific CoLa A (**Co**mmand **La**nguage **A**SCII) commands for communication between the SIM module and the vehicle controller is described in a separate document[3].

3.6 Data interfaces

The SIM features 4 Ethernet interfaces for the connection to the network of the vehicle, which also contains the 2D LiDAR sensor.

3.7 Diagnosis

The operation state of the embedded application can be monitored via three ways:

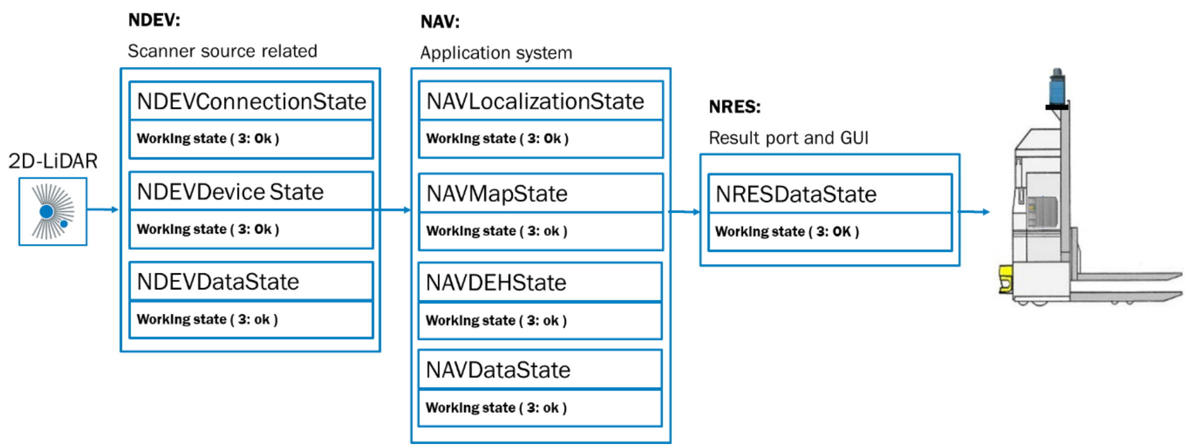
- Via LED
- Via SOPAS AIR web GUI
- Via CoLa telegram

[2] Open the page www.sick.com and enter the part number of the operating instructions of the SIM2000 (German 8020763, English 8020764) into the search field.

[3] Open the page www.sick.com and enter the part number of the NAV-LOC telegram listing 8021387 (English) into the search field.

In the CoLa communication, there are also three function blocks (NDEV, NAV and NRES) which have to be initialized for the reception of data via the result port.

NDEV:
Handles the communication between NAV-LOC and the connected 2D LiDAR sensor
NAV:
Is responsible for the map handling and the localization.
NRES:
Handles the results (localization with pose and scan results) from NAV-LOC.



Besides the correct initialization, also following root causes may be checked:

- Power supply of 2D LiDAR sensor
- 2D LiDAR sensor type
- Interfacing of 2D LiDAR sensor as type, cable, IP address

3.7.1 Diagnostic via LED status indicators

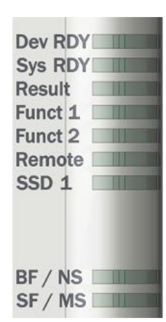
When the device is operating, the operational status is indicated visually by status LEDs.

Using these status indicators, the operator can find out quickly and easily whether the device and the peripherals are working properly or whether any faults or errors have occurred.

Monitoring the visual indicators is part of the routine inspection carried out on the device and the machine/plant area into which the device is incorporated.

The SIM LEDs are controlled by the embedded application and signal different states.

Meaning of display	Action	Color
Idle- / Interim state	Wait	Grey
Ok	No action required	Green
Warning	Act, if necessary	Yellow
Error	Action required	Red



The following schematics illustrate the logical operation for the LEDs.

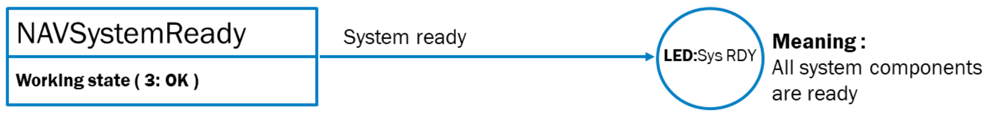


Figure 3: States related to the system

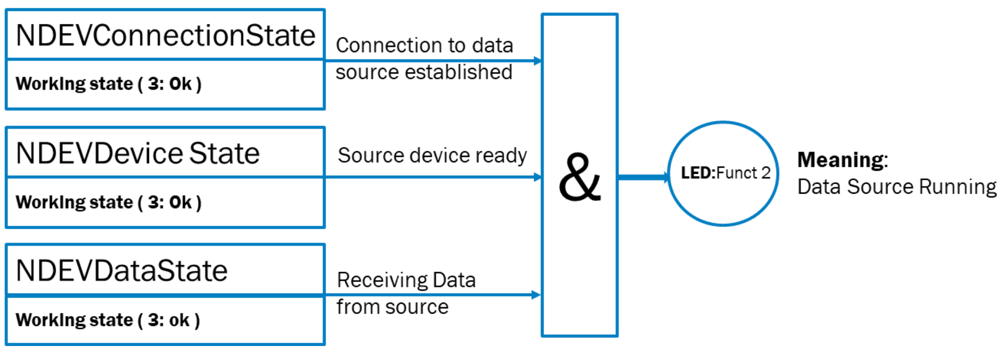


Figure 4: States related to the data source NDEV (2D LiDAR sensor)

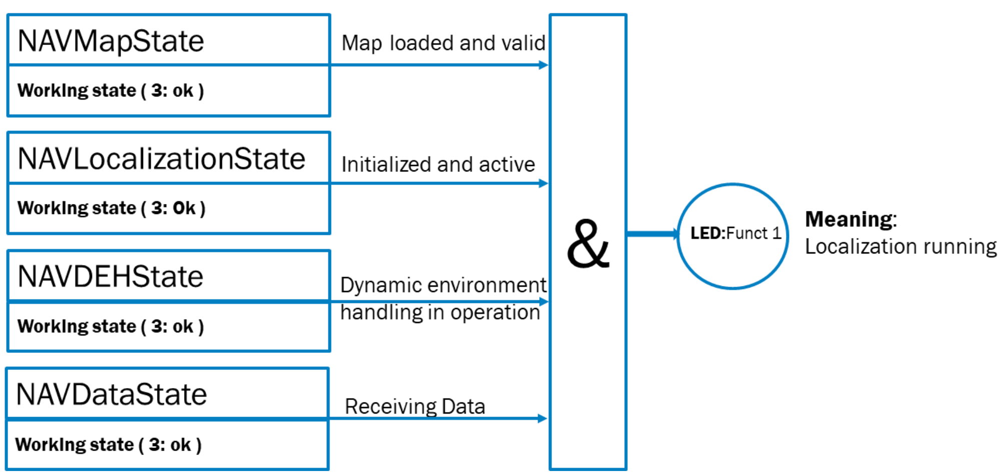


Figure 5: States related to the application:

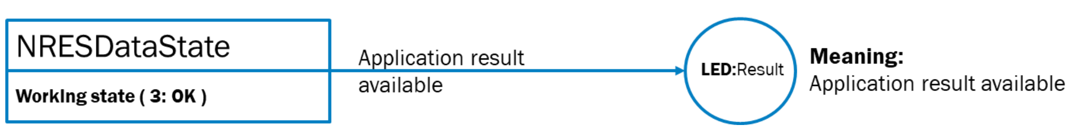
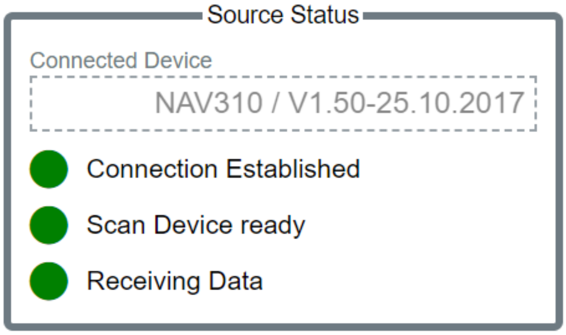


Figure 6: States related to the application:

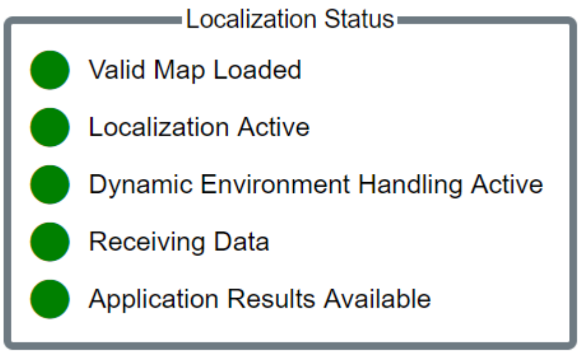
3.7.2 Diagnostic via SOPAS AIR

A further analysis could be done via the SOPAS Air interface. The logical states are shown in the visualization. For a working condition, the simulated LEDs shall show a green light.

States related to the data source NDEV (2D LiDAR sensor):



States related to the application:



3.7.3 Diagnostic via telegram

For the diagnostic via telegram, please refer to the telegram listing document chapter “Status commands (read-only)”[4].

3.8 Reference map

A reference map which shows the contour of the factory site is required for operation of the localization system.

Contact your SICK Service to create a reference map for your plant. You will find a contact address for your country on the last page of this document.

When mapping, the factory site is measured from the point of view of the 2D LiDAR sensor and entered in a reference map.

Either a movable frame with a battery can be used, whereby the 2D LiDAR sensor must be aligned on the same level as on the designated AGV, or the AGV with the mounted 2D LiDAR sensor is moved with the manual control.

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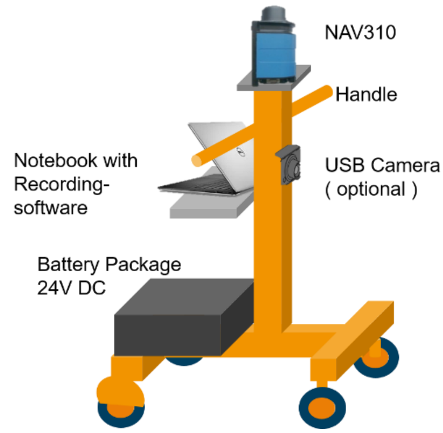
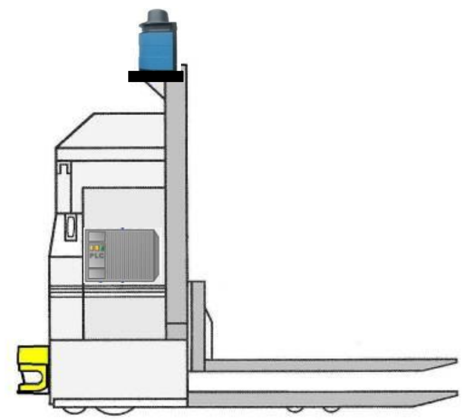
[4] Open the page www.sick.com and enter the part number of the NAV-LOC telegram listing 8021387 (English) into the search field.



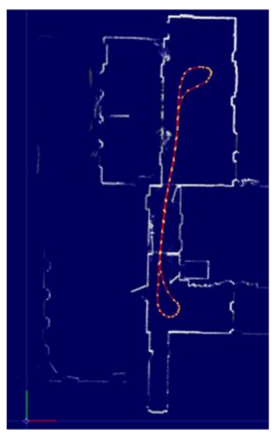
Example for measurement device



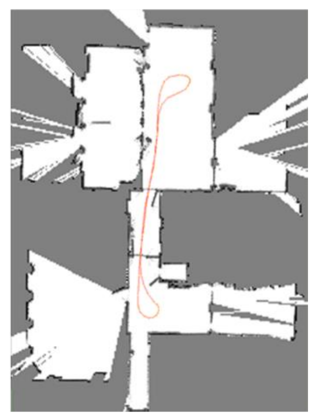
Example for AGV with NAV310

The two steps for creating a reference map are shown below.

Architecture drawing (Red: measured area)



Step 1: Raw data



Step 2: Completed reference map

The contour visible from the sensor is dependent on the installation height of the 2D LiDAR sensor. That is why it is necessary to observe the configuration notes in chapter 4.2 "Requirements for the position of the 2D LiDAR sensor" when selecting the scan height and preparing the sensor for map creation.

A coordinate system (x, y) is defined for the reference map in which the position and orientation of the sensor is determined numerically during localization. The orientation and the origin point of this coordinate system can only be configured when creating the map and must therefore be defined for the respective plant before creating the reference map.

The reference map must be loaded on the SIM to operate NAV-LOC. This step is described in chapter 7.5.

The map used must cover the entire vehicle operation area.

If needed, for example when operating on different levels connected by an elevator, different reference maps can be used. However, only one map can be active at a time.

NOTE

If modifications are made in the factory site which result in a considerable change to the contour visible from the sensor, for example due to modified walls, racks or other large structures, the accuracy of the localization in the affected area is reduced or the localization itself is impaired. In this case, the affected area must be re-mapped. Contact SICK Service about this.

The reference map is in the *.smap data format. You will receive a graphic representation of the reference map documentation. An imprinted grid enables orientation.

3.9 Dynamic Environment Handling

The Dynamic Environment Handling enables that contour navigation is stable even when small and gradual changes are made to the surroundings.

The system detects deviations between the visible contour and the saved reference map. All detected deviations from the saved map are written to an internal additional layer, while the original map file remains unchanged.

The system uses the reference map and the deviations described in the working map to obtain enough valid ambient properties to ensure stable localization.

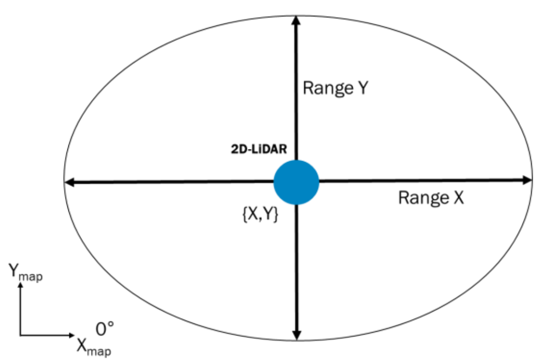
At the same time, NAV-LOC outputs additional information, which is described in chapter 3.11. The parameter described there, *Local Map Modification*, defines the extent of the adjustment performed in the current surroundings.

3.10 Initial position

When switching on localization mode, the position in the coordinate system of the reference map must be provided to the system one time. Required is the information about the current position (x, y) and the orientation angle. A value for uncertainty (“uncertainty range”) for all three coordinates has to be specified for the provided position.

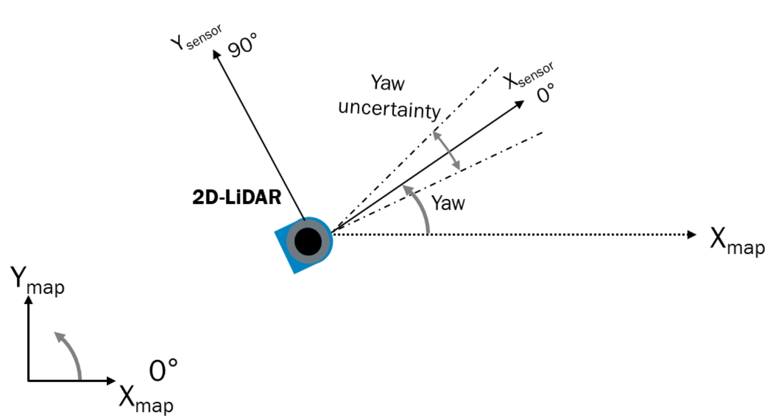
3.10.1 X,Y (position uncertainty)

The {X,Y} position is defined according to the maps global coordinate system. The corresponding uncertainty value in x and y specifies the area around this specified position within which the actual position is located. The range is also specified in accordance to maps global coordinate system.



3.10.2 Yaw (orientation uncertainty)

The orientation and uncertainty of the yaw angle are to be provided accordingly. In difference to the x-y-pose, the alignment of the 2D LiDAR sensor in the maps global coordinate system must be considered. The X-axis (in direction of LEDs) defines the sensor orientation and the direction the 2D LiDAR sensor is pointing to.



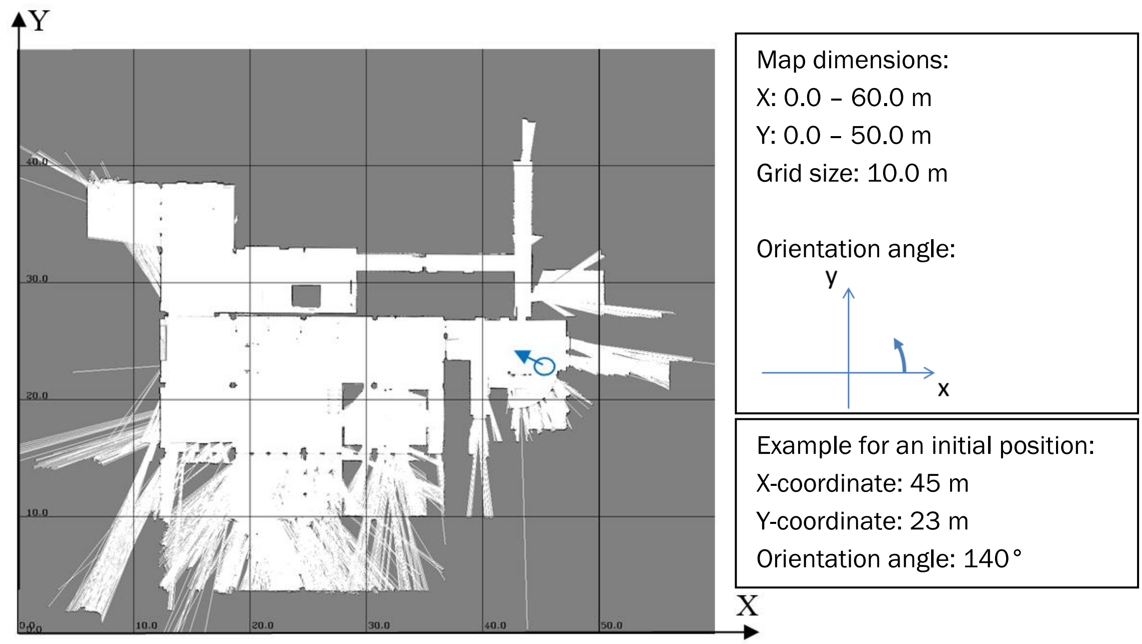
3.10.3 Environment specific considerations

The map required for localization is provided in *.smap format by SICK Service.

It is loaded onto the SIM, as described in chapter 7.5.

In addition, SICK Service provides documentation of the reference map, which features a grid, in *.pdf format. This grid can be used to estimate the initial position.

For example, a grid image of the factory system could be displayed for operation using the touch screen of an automated guided vehicle system. An operator could use this grid to specify the initial position.



Example of map documentation with coordinate system and grid

The specified position and orientation must correspond with the current position of the AGV in the map coordinate system and should be within a position uncertainty of ± 5 m and ± 15°from the actual position and orientation. Depending on the environment, it may be necessary to specify an initial position with a higher accuracy.

NOTE

The following contains descriptions of situations which require closer inspection of the uncertainty.

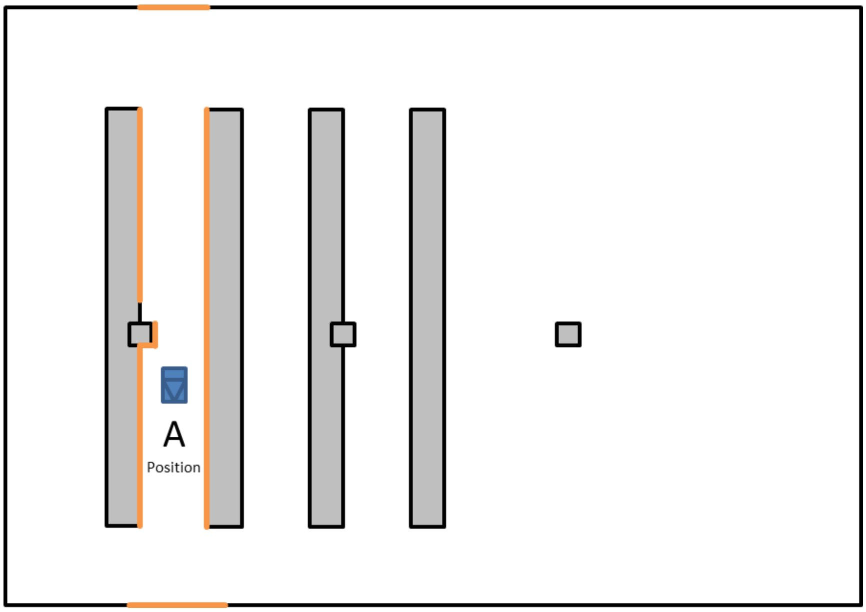
During initial positioning, there are different requirements for the uncertainty range depending on the surroundings.

Some situations are described below in which increased requirements for the accuracy of the initial position and the uncertainty range exist.

Initial situation

Vehicle is located at position A.

The sensor measures the contours marked in red as scan data.



Problem

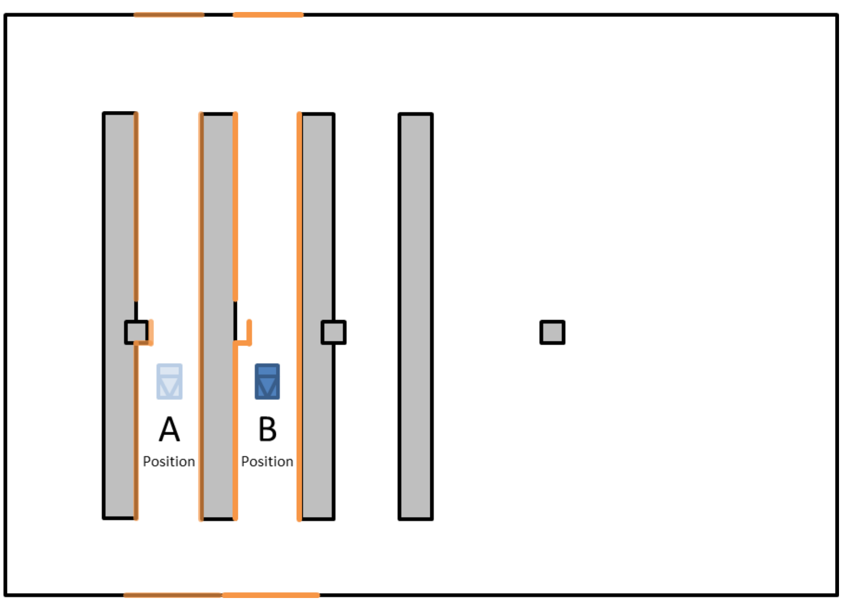
The vehicle is at position A, but during initial localization,

position B is entered as the initial position (incorrectly).

The measured contour of the 2D LiDAR sensor matches to the expectation from the map for position B.

=> The system is localized to the incorrectly specified initial position B.

(A perfect match of the contour to the map is not necessary here.)



Solution

The initial position must be sufficiently accurate in surroundings with repetitive structures. An initial position must not deviate from the actual position by more than half of the repeat grid (here: aisle distance).

That means the uncertainty range must be smaller than the grid of the hall aisles or the distances between the structures/columns.

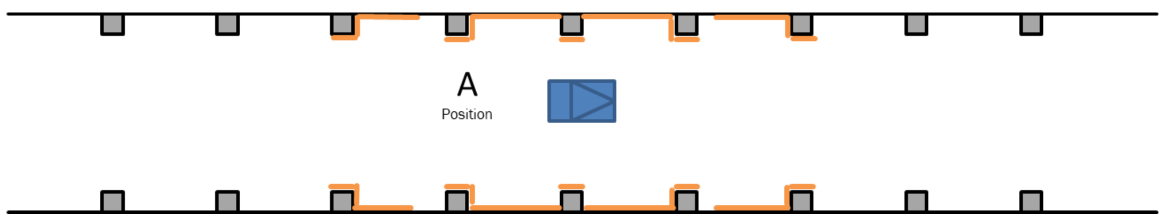
In the following situations, it must also be ensured that the initial position is accurate enough due to the repeating surrounding structure.

Example of aisle/corridor

The vehicle is located at position A in an aisle with a column grid repeating at a short distance.

The walls cannot be measured at the front and rear since they are outside of the range of the 2D LiDAR sensor.

The sensor only receives the contour located on the side as scan data.

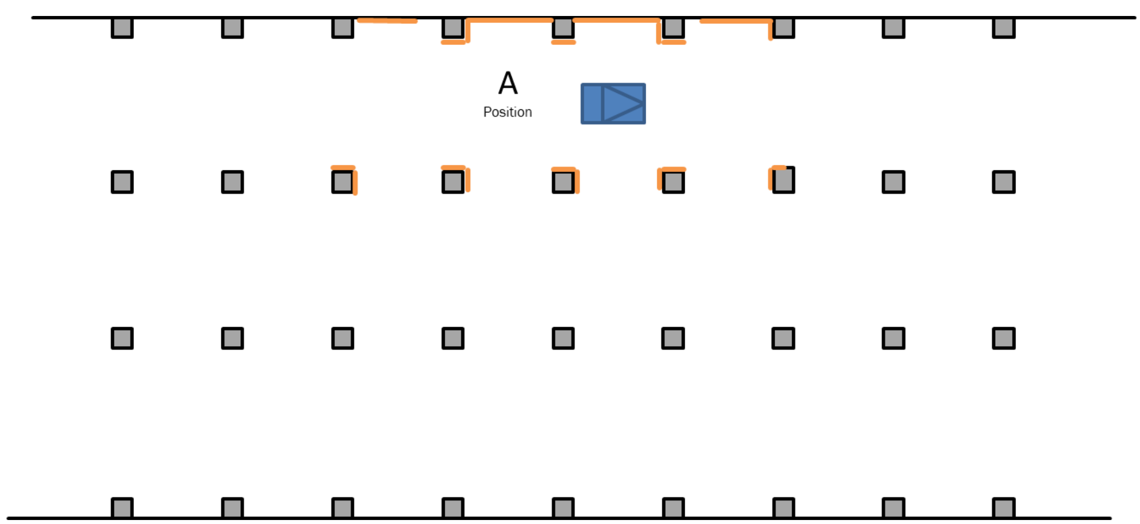


The uncertainty range must not exceed the grid dimensions of the columns grid here: uncertainty range = column distance

Example of factory hall with columns

The vehicle is located at position A in a hall with a repeating column grid.

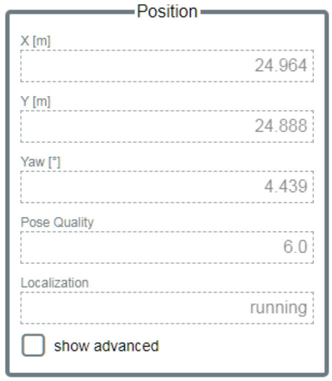
The walls can be measured depending on the position only to one side since the other walls are outside the range of the 2D LiDAR sensor.



The uncertainty range must also not exceed the grid dimensions of the columns here: uncertainty range = column distance.

3.11 Output of position and additional information

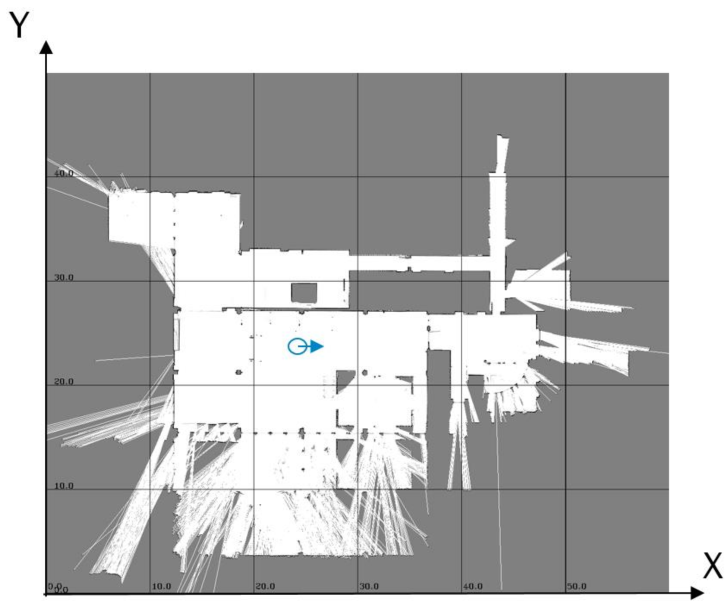
Outputs of the NAV-LOC system are:



- Current position (X,Y) in the coordinate system of the reference map
- Current yaw angle in the coordinate system of the reference map
- Pose quality of the detected position
- Status of the localization

  - initializing: localization initializes to the stated position
  - halted: localization detects that the vehicle is stationary
  - running: localization continuously calculates the vehicle position

A time stamp in milliseconds is also output in the telegram for every position output.



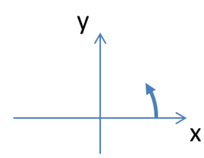
Map dimensions:

X: 0.0 – 60.0 m

Y: 0.0 – 50.0 m

Grid size: 10.0 m

Orientation angle:



Example for position output:

X-coordinate: 24 m

Y-coordinate: 24 m

Orientation angle: 0 °

3.11.1 Pose quality

In addition, a quality assessment of the detected “pose quality” position is output which specifies the reliability of the pose result. Its values are represented in a range of 0 to 100.

NOTE

The quality value does not show the accuracy of the pose, but the values indicate the stability of the localization process, which led to the pose result.

Individual outliers should be observed, but should not cause immediate reaction.

The following ranges can be used for orientation:

High level of accuracy: typ. 0 – 30

A high level of accuracy with the data given below in the data sheet requires optimum application conditions.

For accurate localization as defined by the data sheet, the average value should stay below 30.

Stable localization: typ. 0 – 60

Stable localization means that an unambiguous and reliable position can be detected. For stable localization, the average quality value should stay below 60.

Please note: This value range does not apply for initial localization. During initialization, wait until the value has reached a “stable” range.

Further causes for a high value in the quality assessment are:

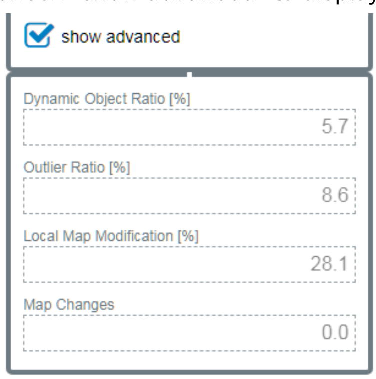
- Large deviations of the surroundings from the reference map
- Speed/yaw rate of the vehicle is too high
- The 2D LiDAR sensor optics are dirty or need to b cleaned

The following causes lead to a deviation of the measured scan to the map:

- The vehicle is moving on a ramp
- The vehicle is deformed by a load which changes the scan plane
- The 2D LiDAR sensor is not horizontally aligned

3.11.2 Advanced options

Check “show advanced” to display more information.



Dynamic Object Ratio [%]

A filter reduces measurement noise to increase the stability of position determination.

The proportion of measuring beams that were filtered out is output. A high value indicates a high ratio of dynamic changes in the surroundings.

Outlier Ratio [%]

Proportion of measuring beams which could not be assigned to the current reference map.

A low value means the current measurement data largely hits objects included on the map. A high value means many of the objects currently being detected by the sensor have not yet been entered in the reference map.

Local Map Modification [%]

Shows the percentage of available measuring beams which deviate from the initial reference map.

A low value means many of the measuring beams currently available have already been entered in the reference map created originally. A high value means many of the objects currently used for localization on the map were not entered in the initial reference map; rather, they were entered during operation by the algorithm of the Dynamic Environment Handling.

Map Changes

Number of map changes made using this measurement data update.

A value of zero means the Dynamic Environment Handling (DEH) function has not yet made any changes to the map. A value greater than zero means the DEH function has made changes to the map. The changes from the DEH algorithm are not made in every localization step; rather, a number of changes are always grouped together and then entered in the map together.

Adaptive map adjustment is only performed if the following parameters remain within a defined range:

Local Map Modification	< 50%
Yaw Rate	< 8°/s
Pose Quality	< 30

Figure 7: AGV block diagram

4 System requirements of NAV-LOC

4.1 Requirements for the environment

The following requirements exist for using NAV-LOC:

- The system is suited for navigation in closed buildings with even floors.
- Walls, columns, and other fixed structures represented in the map must be sufficiently visible from all positions in the building.
- Installation of the components in the temperature range and with IP protection acc. to data sheet
- Note: SICK Service can make a professional assessment of the factory site and then create the map.

4.2 Requirements for the 2D LiDAR sensor

Ideal mounting is at a height above the heads of workers since typically only small changes of the surroundings are expected here.

The sensor must be installed at a height which offers a good field of vision of the fixed elements of the facility (for example walls, columns, fixed racks) from every location.

The sensor height should be above the height of movable objects.

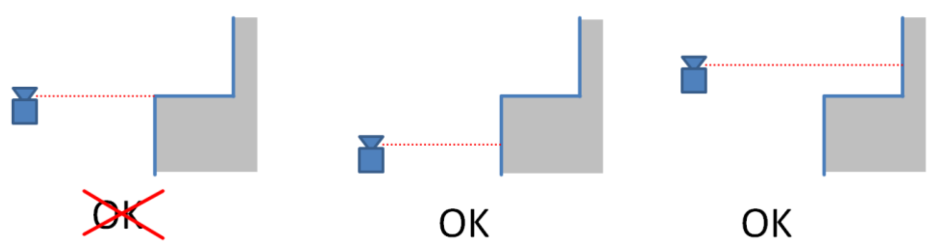
NOTE

During installation, make sure that the visual range of the 2D LiDAR sensors is not restricted.

However, NAV-LOC is tolerant of individual movable objects protruding into the scan plane; this should be the case only for a limited part of the scan data of the 2D LiDAR sensor for optimal accuracy at every point. This means that 100% of the scan data does not necessarily have to match the map, but rather that the system works even if the scan data deviates a bit from the contour, for example due to small changes to the hall (e.g., single pallets or other vehicles) or covering by moving objects.

The sensor should not be installed at the height of wall projections or other objects, which can result in ambiguity when measuring the distance to the wall. Instead, the sensor height should be selected above or below the threshold so that it is clear which part of the building contour the sensor is measuring.

See also the figure below:



The 2D LiDAR sensor should be installed according to the description in the operating instructions. It should be possible to tilt the sensor mount in all directions in order to be able to align the sensor horizontally so that the scan plane of the sensor runs parallel to the floor surface.

The sensor must be fixed to a vehicle on a way that the alignment of the sensor cannot be changed on accident.

Ideally, the sensor alignment is done in an area with an even floor area intended for service work. As a minimum requirement, an alignment should be carried out with a spirit level.

Alternatively the SICK Alignment Tool, order no. 2101720, may be used.

This device is operated by an internal rechargeable lithium-ion battery and indicates the received laser beam depending on the beam size by one or more red LEDs.

Figure 8: SICK Alignment Tool order no, 2101720

5 Operating modes of NAV-LOC

The embedded application has 3 main operating modes. After connecting the supply voltage and starting, the embedded application is in IDLE mode.

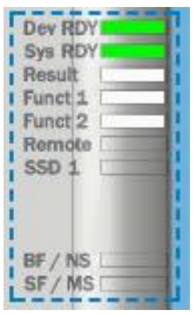
There are two ways to switch states IDLE → READY → PREPARE → LOCALIZE, either by setting the relevant parameter or, if parameters are permanently saved, with a separate command.

The embedded application is switched to LOCALIZE mode by specifying the reference map and initial position.

The map and the initial position can also be permanently saved and invoked for the initialization.

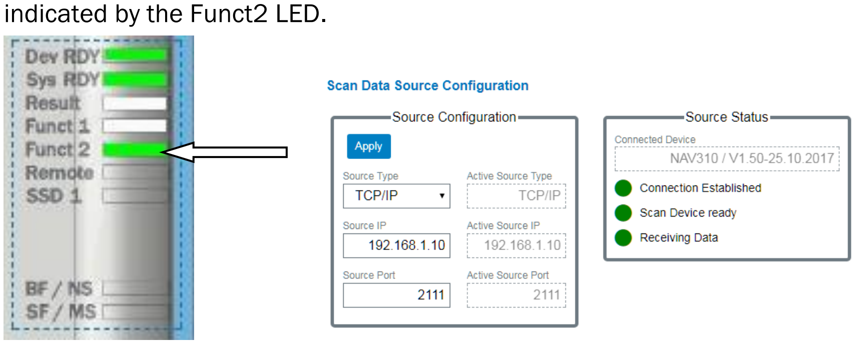
5.1 IDLE mode

The embedded application is started and all functions are ready for operation. In this state, at least the Dev RDY and Sys RDY LEDs are green and communication can be established with the SIM.



5.2 READY mode

After assigning a valid data source, the embedded application switches to READY mode. This will be indicated by the Funct2 LED.



NOTE

When switching from IDLE to READY mode, take the start times of the connected 2D LiDAR sensors into account. The typical start times are approx. 10 s for the NAV310 and approx. 40 s for the NAV245.

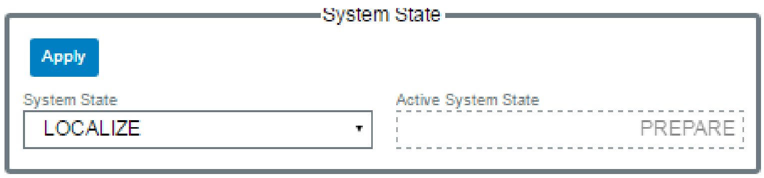
NOTE

If the connection for the data source is set and permanently saved, the mode can be switched directly from IDLE to READY via the sMN NAVSetActiveState command.

5.3 PREPARE mode

It can take several seconds to initialize a pose with a large reference map.

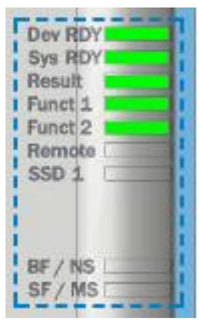
During loading, the system uses PREPARE to indicate that the mode is being changed.



5.4 LOCALIZE mode

The embedded application has been assigned a valid data source and is acquiring scan data.

After loading a map and setting the initial position, the embedded application switches to LOCALIZE.

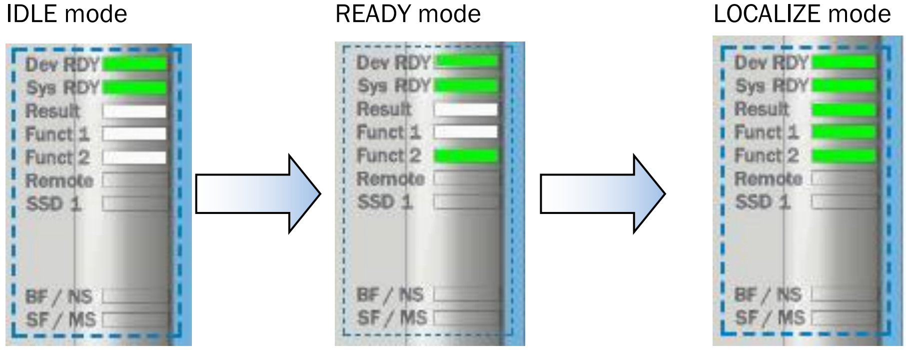


The embedded application cyclically runs a comparison of the contour data detected by the 2D LiDAR sensor and the previously stored and selected reference map.

The embedded application detects the global position based on this.

Overview

IDLE mode | READY mode | LOCALIZE mode



IDLE mode	READY mode	LOCALIZE mode
• Application ready • Embedded application started	• Connection to data source established • Data source provides scan data	• Map valid and loaded • Initial position specified • Localization in operation

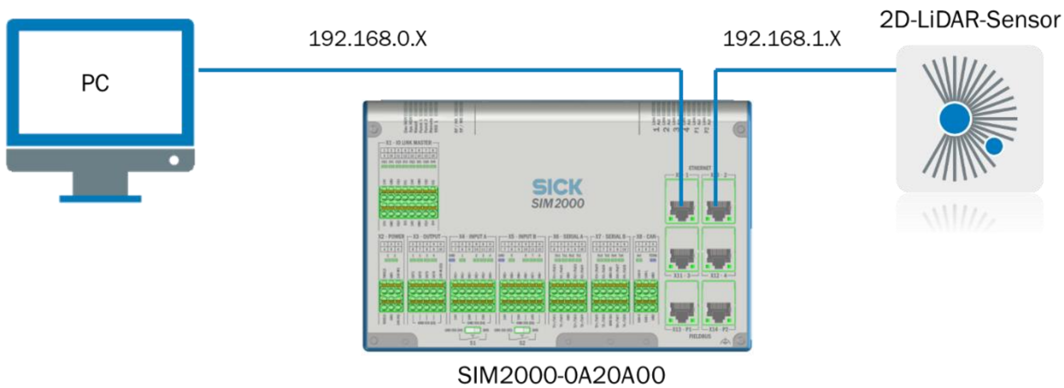
6 Initial commissioning and demonstration mode

NOTE

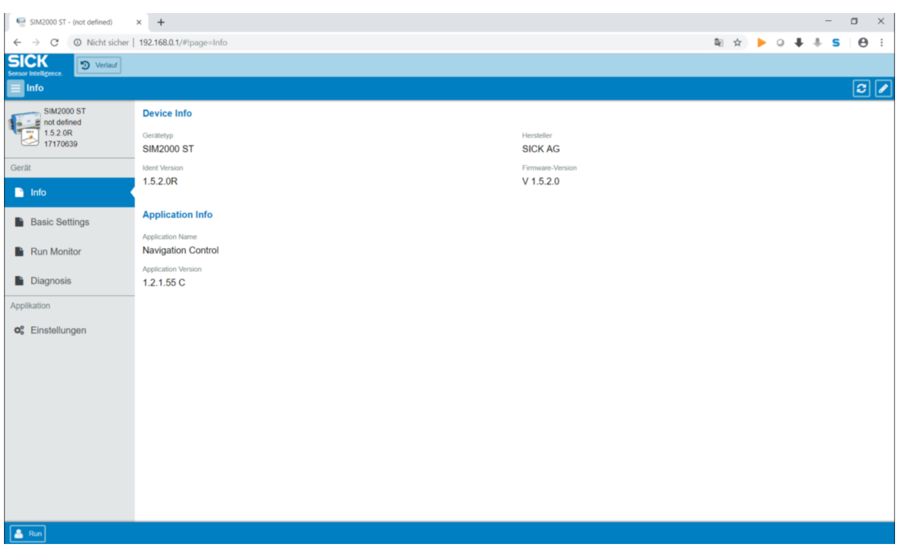
This chapter describes only the initial, first set-up and demonstration process. For further information refer to chapter 7.

6.1 Initial connection setup

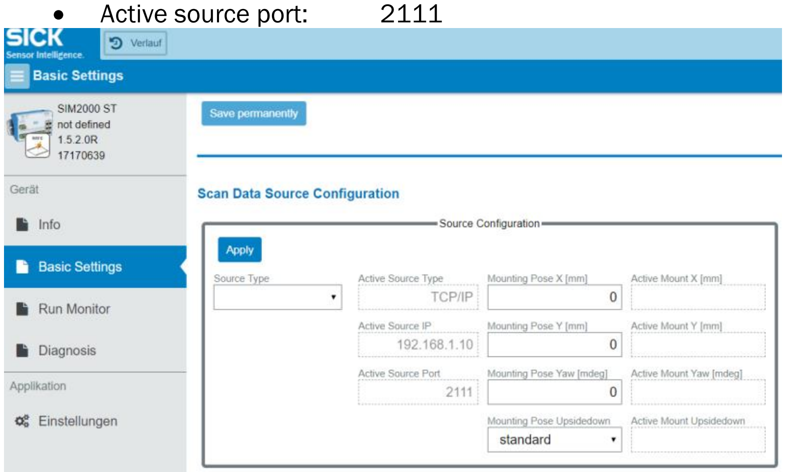
1. Setting up connections for power supply like described in chapter 7.3 and for the network connections like described in chapter 7.4.



2. Open the SOPAS AIR web GUI with a web browser (Chrome is preferred) e. g. with default setting: http://192.168.0.1 for X9-1 from the connected SIM Port



3. Configure the data source (2D LiDAR sensor) corresponding to chapter 7.6.2. If default settings are used this is:
   - Source type: TCP/IP
   - Active source IP: 192.168.1.10[5]
   - Active source port: 2111



6.2 Creating a demo map

A map of the current surroundings can be created via the visualization for demonstration purposes or for a test of the function of NAV-LOC.

The surroundings are limited to a size of 50 x 50 m.

NOTE

The created demo map is used for initial commissioning of NAV-LOC and is not suitable for driving operation.

NOTE

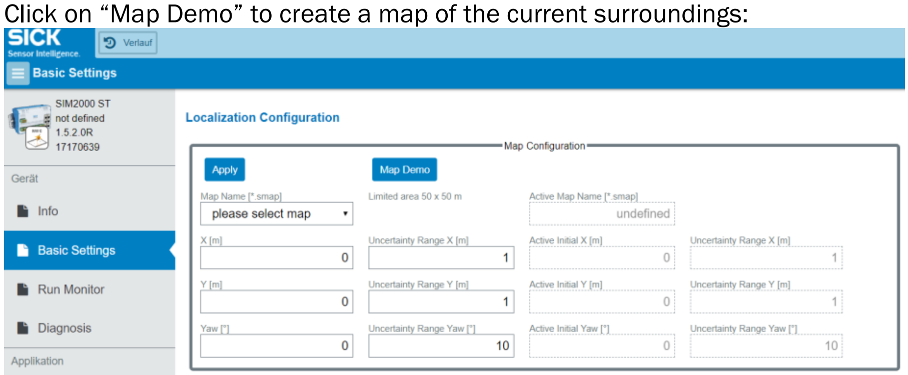
This map can only be created statically, i.e., the sensor must not be moved and must be mounted so that its scan plane runs parallel to the ground when the map is being recorded.

NOTE

Before creating the map, the communication parameters must be entered and the system state must be READY.

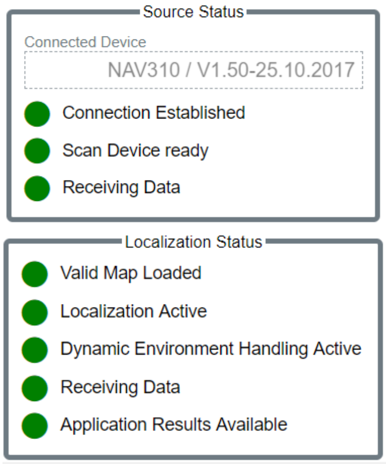
[5] The source IP and the port number can be switched via SOPAS ET (search on sick.com for SOPAS Engineering Tool).

1. Click on “Map Demo” to create a map of the current surroundings:

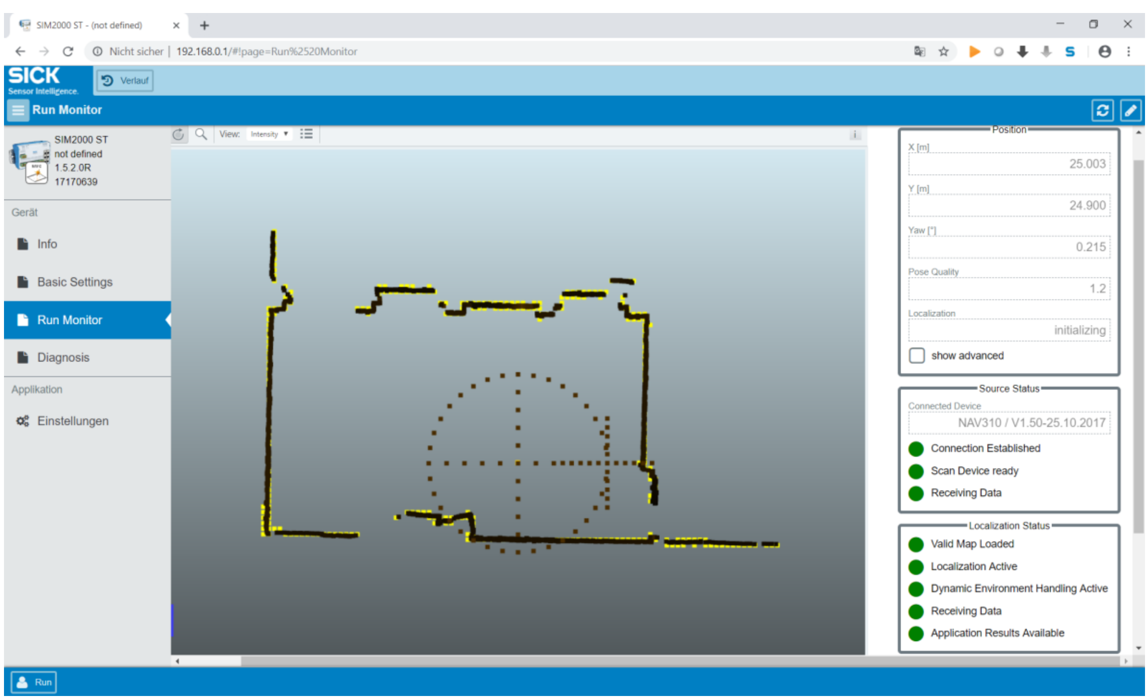


2. Press “Apply” to use the automatically inserted configuration

3. If all indicators are green, switch to the next tab “Run Monitor”



4. After switching to the “Run Monitor” page, the currently measured contour is shown in black and the active map in yellow. The position with a trace of recent locations is shown in orange color.



7 Full Integration and commissioning

7.1 Notes and preparatory information

The following steps should have been carried out prior to commissioning:

- Electrical and mechanical installation is complete.

This must be done in accordance with the supplementary device-specific documents for 2D LiDAR sensors, which can be combined with the SIM2000-0A20A00 as a data source. These are required in addition as they describe the specific connection options and configuration for each sensor. The following information is available for download from this page:

- NAV-LOC: SIM2000, NAV310 operating instructions (German 8023449, English 8023450)
- NAV-LOC: SIM2000, NAV245 operating instructions (German 8023451, English 8023452)

Additional information on the SIM2000-0A20A00 with notes on mounting, installation, and commissioning can be found online in the operating instructions[6].

- The sensor is aligned horizontally, which ensures no areas within the sensor's field of view are concealed.
- The scan data of the facility has been recorded and a reference map has been created.

IMPORTANT

NAV-LOC must only be commissioned by adequately qualified personnel. Before operating the plant fitted with NAV-LOC for the first time, make sure that it is first checked and released by qualified personnel.

NOTE

In addition, the following information must be taken into consideration to ensure an efficient commissioning process:

- Only connect those devices to the SIM that you want to configure or program.
- Operate the connected NAV-LOC in a controlled and contained network environment for the time being to check network communication if necessary.
- Note the company standards that apply to the use of checking and testing devices.
- Use an environment with a simple room contour for initial commissioning.

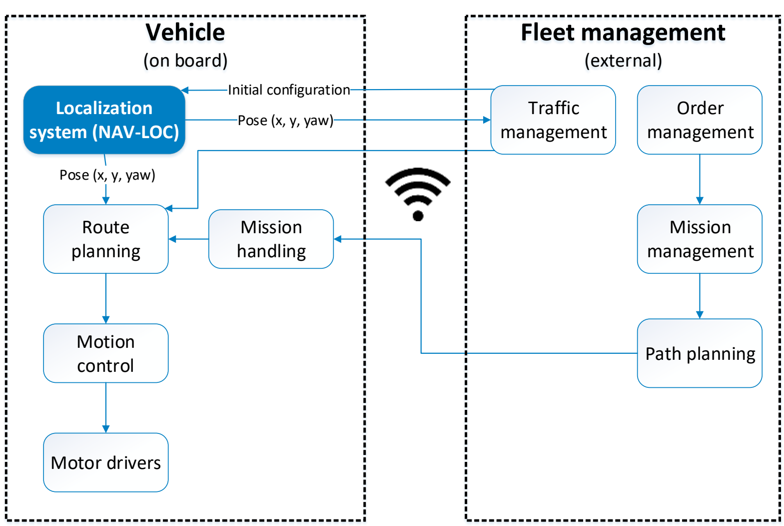


Figure 9: AGV and fleet management communication block diagram

[6] Open the page www.sick.com and enter the part number of the operating instruction of the SIM2000 (German 8020763, English 8020764) into the search field.

7.2 Required software

For the integration of NAV-LOC is some additional desktop software required:

- FTP client for transmission of the maps from the PC to NAV-LOC[7]
- Web browser to operate the SIM[8]
- SOPAS ET[9] to configure of the Ethernet interfaces of the SIM and the NAV sensors.

7.3 Power supply

The supply voltage for the SIM is 24 V DC, ± 10% ES1 acc. to EN 62368-1 or SELV acc. to EN 60950-1. The power consumption is typically 20 W.

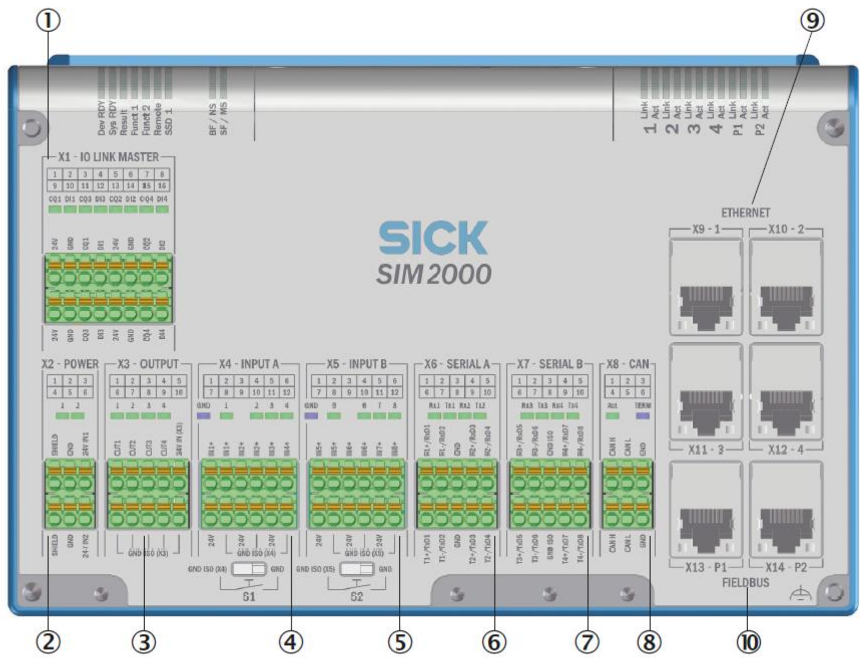


Figure 10: SIM connectors overview

(1) X1 - IO LINK MASTER
(2) X2 - POWER
(3) X3 - OUTPUT
(4) X4 - INPUT A
(5) X5 - INPUT B
(6) X6 - SERIAL A
(7) X7 - SERIAL B
(8) X8 - CAN
(9) X9 ... X12 - ETHERNET
(10) X13 ... X14 - FIELDBUS

[7] E. g. The software Filezilla (client not server) is suitable for this purpose. This program can be down-loaded online at https://filezilla-project.org/ and installed on the PC.

[8] Google Chrome is recommended and supported (https://www.google.com/chrome).

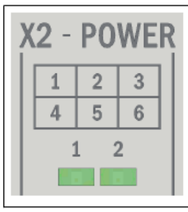
[9] Search on sick.com for SOPAS Engineering Tool.

The connectors (1), (5), (6), (7), (8), and (10) are not used for NAV-LOC and must remain unconnected.
The supply voltage is connected with male connector X2 to pin 3 (24 V In1) and 2 (GND).

Pin	Signal	Function
1	Shield	Shield
2	GND	Ground
3	24V IN1	Supply voltage 1
4	Shield	Shield
5	GND	Ground
6	24V IN2	Supply voltage 2

Figure 11: X2 – Power connections (24V IN1 and 24V IN2 are designed with redundancy)

The X2-power indicators[10] light up if the connection is correct.



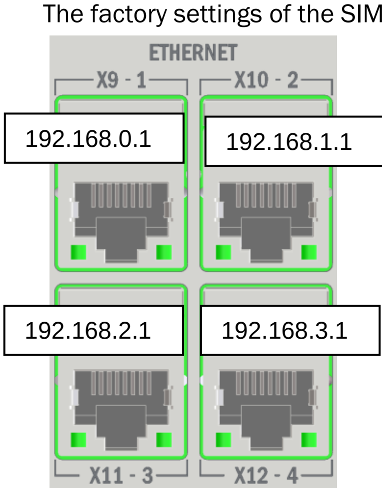
	Supply voltage not applied
	Supply voltage applied

7.4 Network setup

7.4.1 SIM configuration

The SIM features 4 Ethernet interfaces. For each interface, an IP address is preconfigured. However, it can be changed using the SOPAS ET software as described below.

The factory settings of the SIM2000-0A20A00 are shown in the following figure.



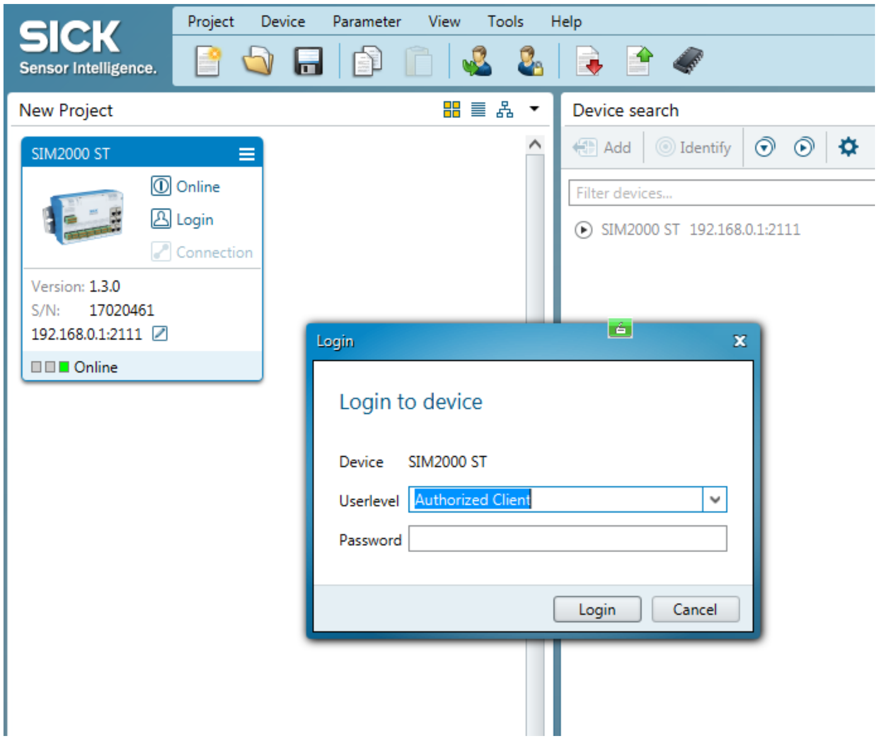
A PC can be connected to an Ethernet interface, for example to port X9-1, for setting the interface configuration.

The interface of the PC must be set to an IP address in the range 192.168.0.2 – 192.168.255 in order to reach the device using the interface with the IP address 192.168.0.1.

If necessary, the 4 Ethernet interfaces can be configured individually.

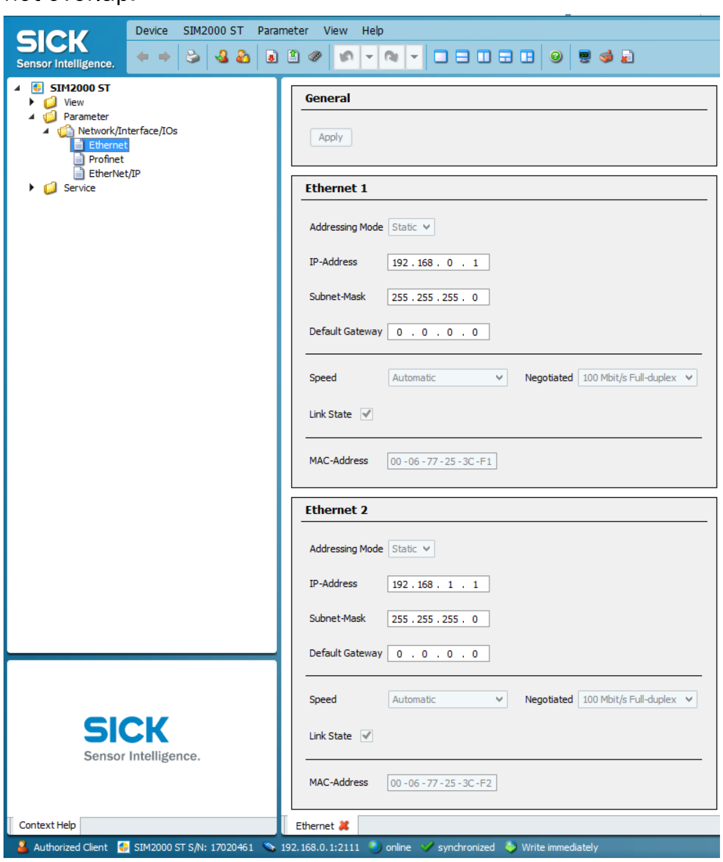
Logging into the device with the “Authorized Client” level with the password “client” is required.

[10] LED 1 for power connection via X2:2 and X2:3, LED 2 for power connection via X2:5 and X2:6



The interfaces can be adjusted in the Network/Interfaces -> Ethernet menu item.

When setting up the Ethernet interfaces, make sure that subnet masks of the 4 Ethernet interfaces do not overlap.



NOTE
When configuring the 4 Ethernet interfaces of the SIM, make sure to avoid an address conflict.

Example :

▸ IP address of an SIM interface:	192.	168.	1.	1
▸ Subnet mask	255.	255.	255.	0
	11111111	11111111	11111111	00000000

=> None of the other network interfaces of the SIM can have an IP address from this range:

192.168.1.1 to 192.168.1.255

7.4.2 Connection setup

The Ethernet interface of the SIM can be used for direct connection of the sensor and the PC.

The connection set-up shown in Figure 12 is based on the default settings of the SIM 192.168.0.1 (Ethernet port X9-1) and 192.168.1.1 (Ethernet port X9-2) and a 2D LiDAR sensor.

The default IP address of the connected 2D LiDAR sensor may have to be changed to an address in the range 192.168.1.2 to 192.168.1.255 in this exemplary case.

The Ethernet interface of the PC has to be set to an IP address in the range 192.168.0.2 to 192.168.0.255 in this exemplary case.

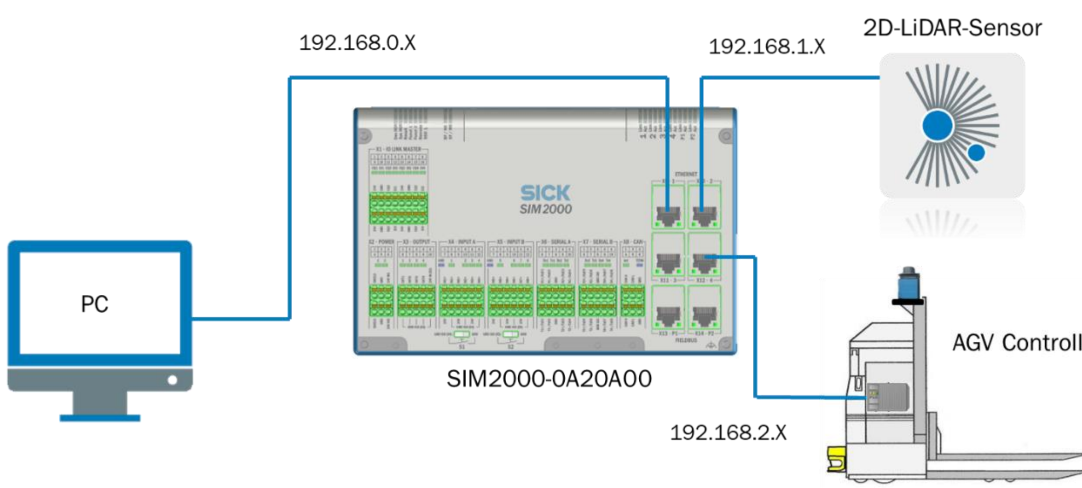


Figure 12: Example connection set-up for live view and configuration of NAV-LOC via a PC

Supplementary device-specific documents for 2D LiDAR sensors, which can be combined with the SIM2000-0A20A00 as a data source. These are required in addition as they describe the specific connection options and configuration for each sensor. The following information is available for download from this page:

- NAV-LOC: SIM2000, NAV310 operating instructions (German 8023449, English 8023450)
- NAV-LOC: SIM2000, NAV245 operating instructions (German 8023451, English 8023452)

Additional information on the SIM2000-0A20A00 with notes on mounting, installation, and commissioning can be found online in the operating instructions[11].

[11] Open the page www.sick.com and enter the part number of the operating instruction of the SIM2000 (German 8020763, English 8020764) into the search field.

7.4.3 Switch usage

The vehicle control unit must have at least one Ethernet interface in order to communicate with NAV-LOC.

NOTE

It is preferred to connect the LiDAR sensor directly to the network interface of the SIM2000, without routing it through additional network switches.

When using a network switch, all components must be set in the same IP number range. In this configuration, access is possible from the PC and vehicle computer to the SIM and the 2D LiDAR sensor. The IP address of the connected 2D LiDAR sensor must be configured accordingly.

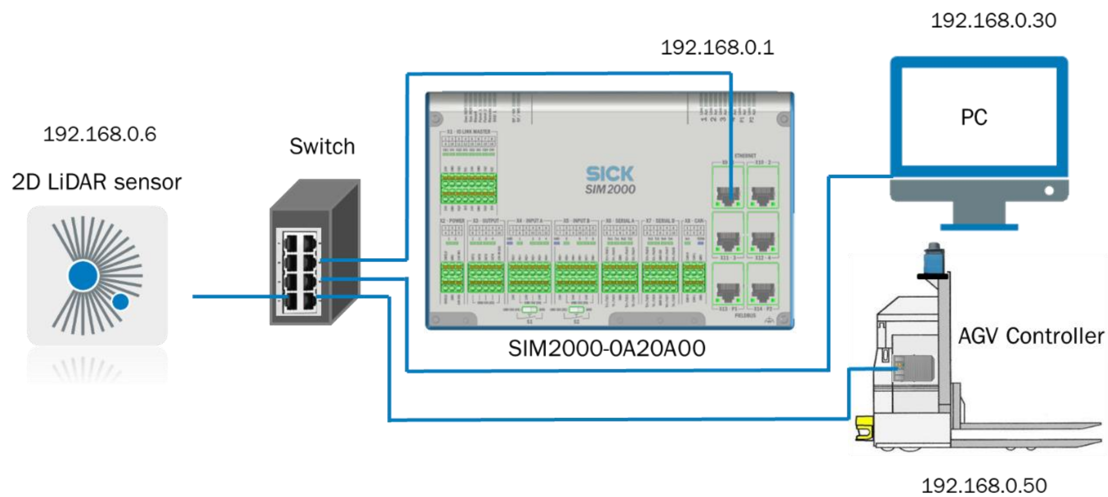


Figure 13: Example connection for switch usage with same address room (IP addresses are exemplary)

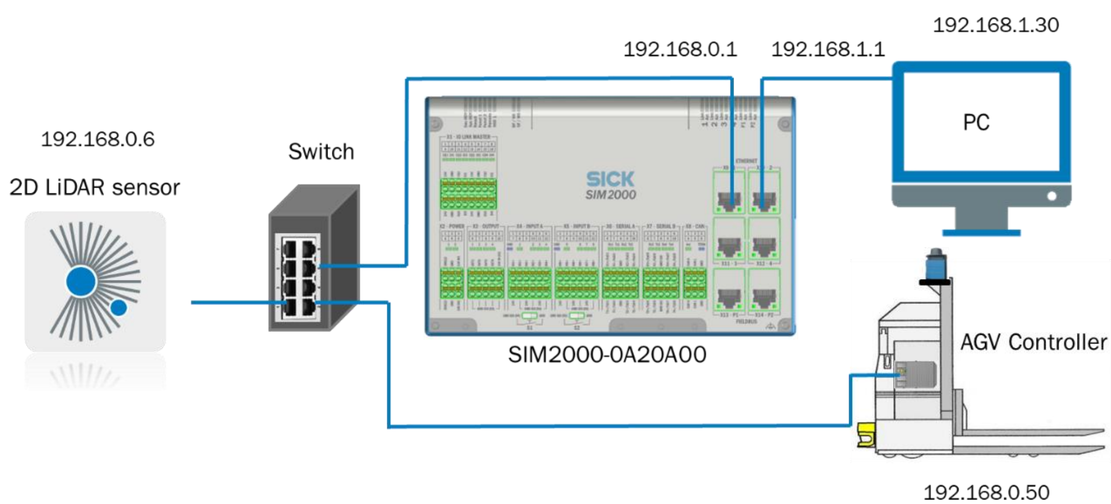


Figure 14: Alternative, example connection for switch usage with direct connection to PC for configuration and visualization (IP addresses are exemplary)

7.4.4 Result port output

NAV-LOC sends telegrams over the interfaces described in Figure 10 to communicate with a connected vehicle computer.

The position is output in the binary result port protocol. There is a separate document for this, which is available for download at www.sick.com. Simply search for the number 8021387.

NAV-LOC provides the following values via its result port data interface:

- Position in X- and Y-coordinates
- Yaw angle
- Time stamp
- Quality indicator for localization

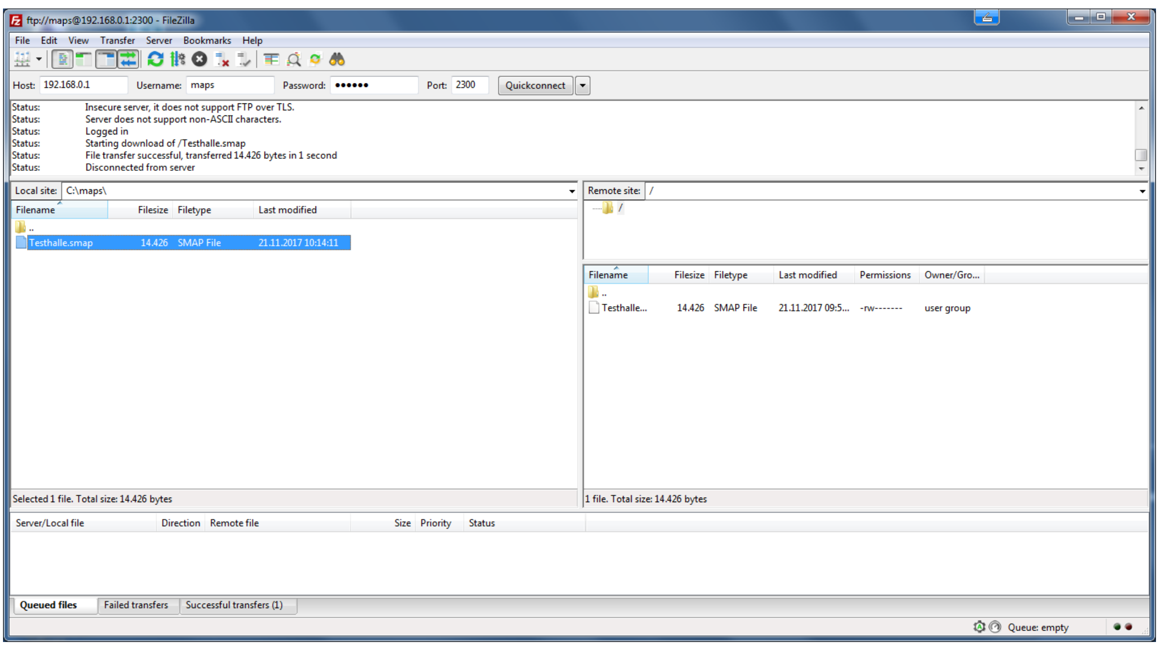
7.5 Transfering the reference map

Requirements

A reference map from the current surroundings is available and the map is stored as an *.smap file on the PC or a USB stick. (More than one map file may be used in a facility.)

Contact your SICK Service to create a reference map for your facility.

An FTP client software, such as the Filezilla freeware, is required for transmission of the maps from the PC to NAV-LOC.



The following parameters must be set to use Filezilla:

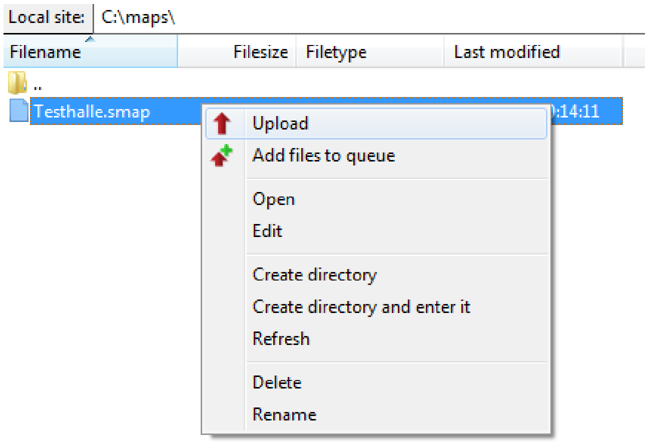
Server (current IP address or SIM): e.g., 192.168.0.1

User name: maps

Password: client

Port: 2300

The map can be transmitted from the computer to the target directory of the SIM by clicking the right mouse button and selecting “Upload”.



7.6 Configuration of the the embedded application

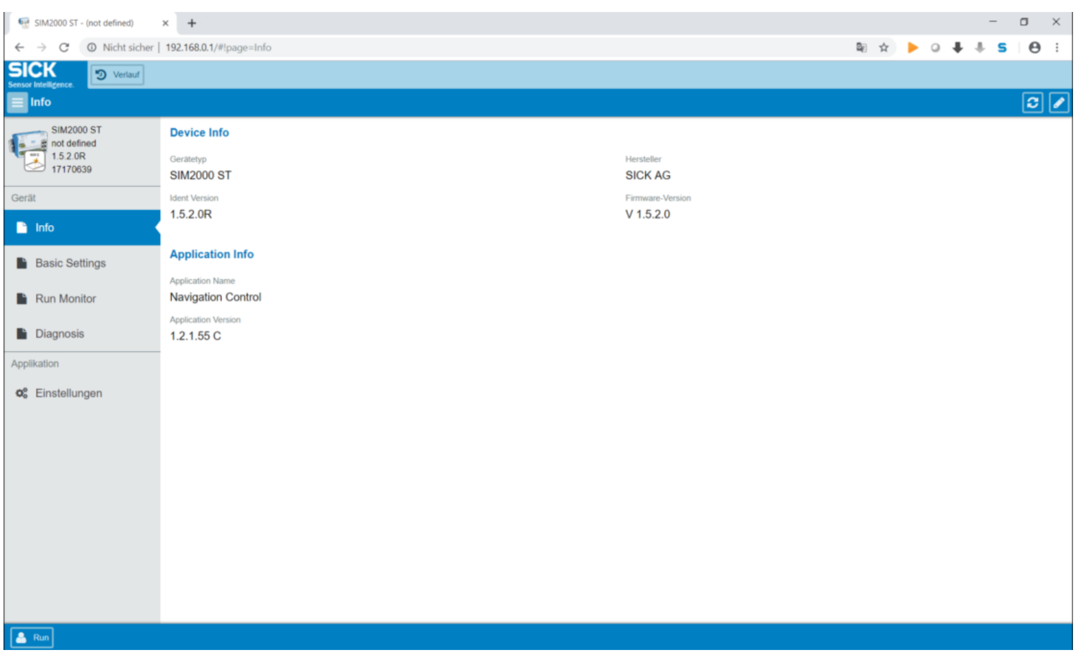
7.6.1 Invoking SOPAS AIR via web browser

NOTE

The same methods for operation and configuration can also be run directly from the vehicle control via the CoLa A protocol, which is described in the telegram listing[12].

The following shows how the embedded application is configured in the SIM using the “SOPAS AIR” web-based interface.

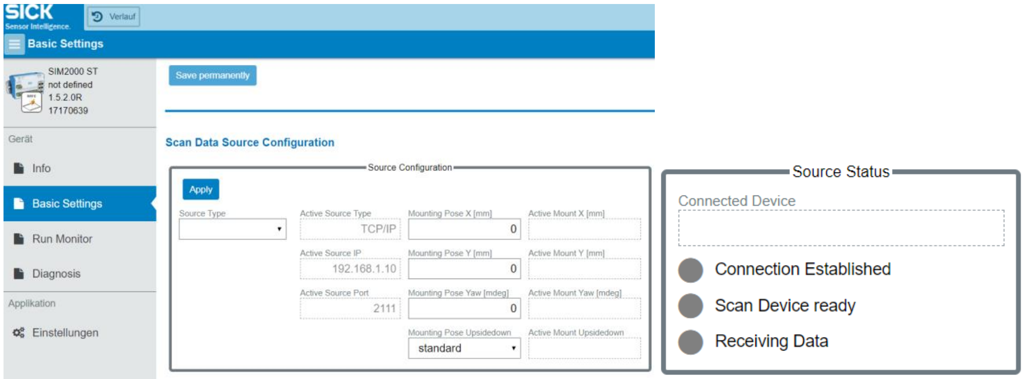
The Chrome web browser is recommend for this purpose. The web interface is invoked by entering the current IP address of the SIM, e.g., http://192.168.0.1 (factory default setting).



[12] Open the page www.sick.com and enter the part number of the NAV-LOC telegram listing 8021387 (English) into the search field.

7.6.2 IDLE: Data source settings

This chapter describes the communication between the sensor (data source) and the SIM.



The configuration for the connected 2D LiDAR sensor can be set in the field “Source Configuration”, for example with:

Source Type: TCP/IP

Active source IP: 192.168.1.10[13]

Source Port: 2111

The inputs are entered when “Apply” is pressed.

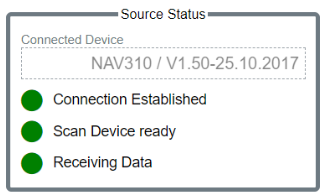


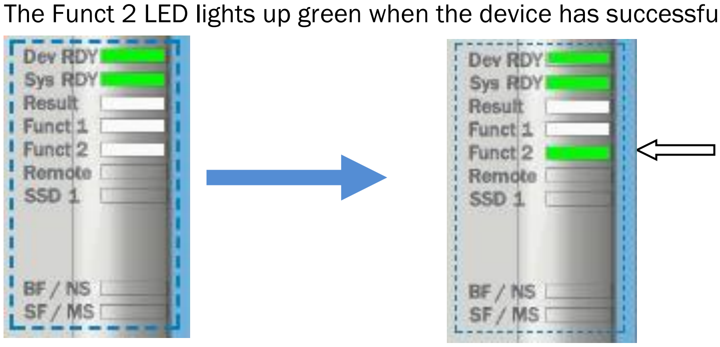
Figure 15: Source configuration (settings for the data source) interface after successful connection to the sensor

If the data is valid, a sensor is connected and ready for use, NAV-LOC will be initialized and started. The state of NAV-LOC changes from IDLE to READY mode.

SIM LED INDICATOR

In IDLE mode, at least the Dev RDY and Sys RDY LEDs are green and communication can be established with the SIM.

The Funct 2 LED lights up green when the device has successfully switched to READY mode.



IDLE mode READY mode

[13] The source IP and the port number can be switched via SOPAS ET (search on sick.com for SOPAS Engineering Tool).

NOTE

When switching from IDLE to READY mode, take the start times of the connected 2D LiDAR sensors into account. The typical start times are approx. 10 s for the NAV310 and approx. 40 s for the NAV245.

NOTE

If a connection between the NAV-LOC and the sensor is not achieved, the IP addresses of the sensor and the used port of NAV-LOC should be checked with a direct connection to the SOPAS ET program and corrected if necessary.

7.6.3 IDLE: Mounting Position (optional)

The navigation point of an AGV, where all position and path planning is related to, depends on the kinematics of the vehicle. Typically, the position of the 2D LiDAR is not located exactly above this navigation point. By entering the deviation from the positon of the sensor axis to the navigation point of the vehicle by the parameters Mounting Pose X, Mounting Pose Y and Mounting Pose Yaw it is possible to get the pose information transformed.

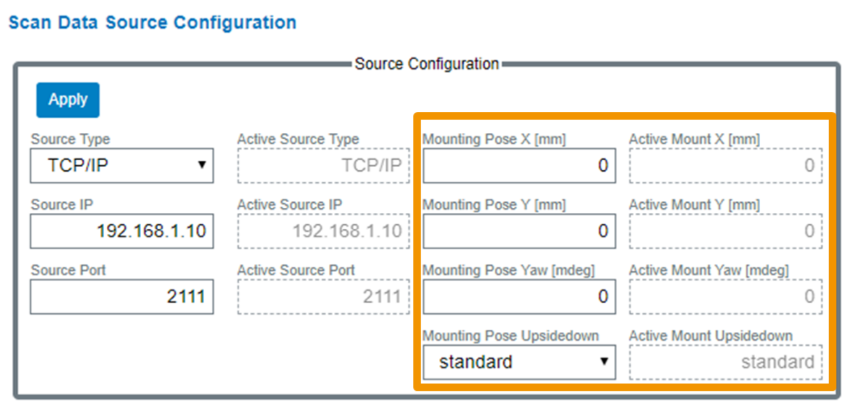


Figure 16: SOPAS AIR configuration or the mounting pose

For the exemplarily illustrated vehicle in Figure 17 the following values would apply:

- Mounting Pose X: 1500 mm
- Mounting Pose Y: 200 mm
- Mounting Pose Yaw: 20°

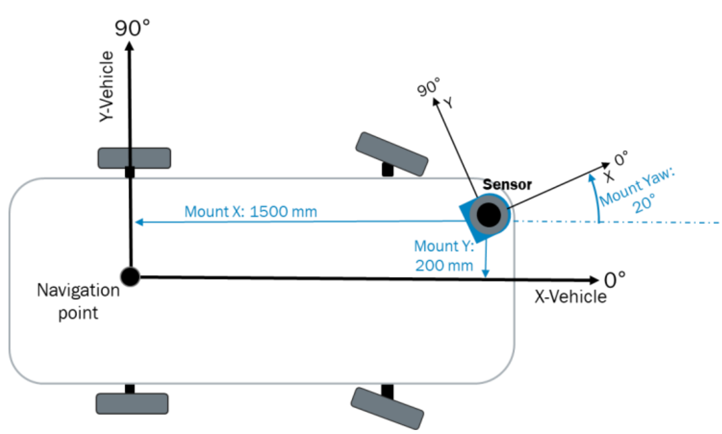


Figure 17: Mounting parameter for 4-wheel vehicle

For the exemplarily illustrated vehicle in Figure 18 the following values would apply:

- Mounting Pose X: 2000 mm
- Mounting Pose Y: -300 mm
- Mounting Pose Yaw: -20°

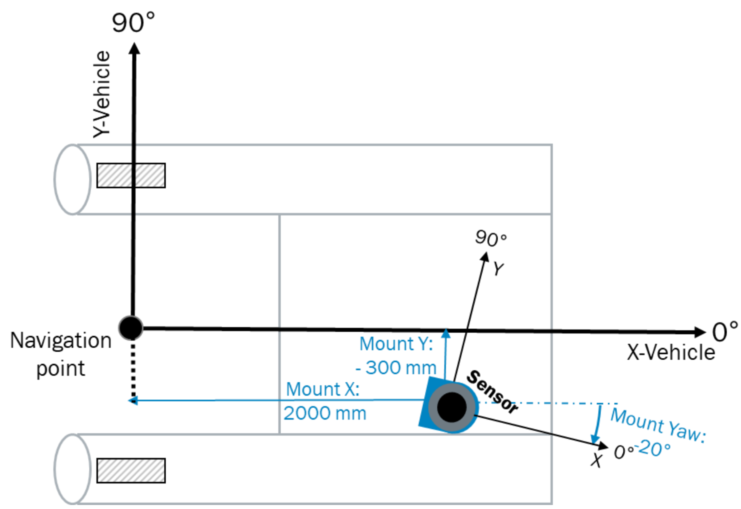


Figure 18: Mounting parameter for 3 wheel vehicle, typical for forklifts

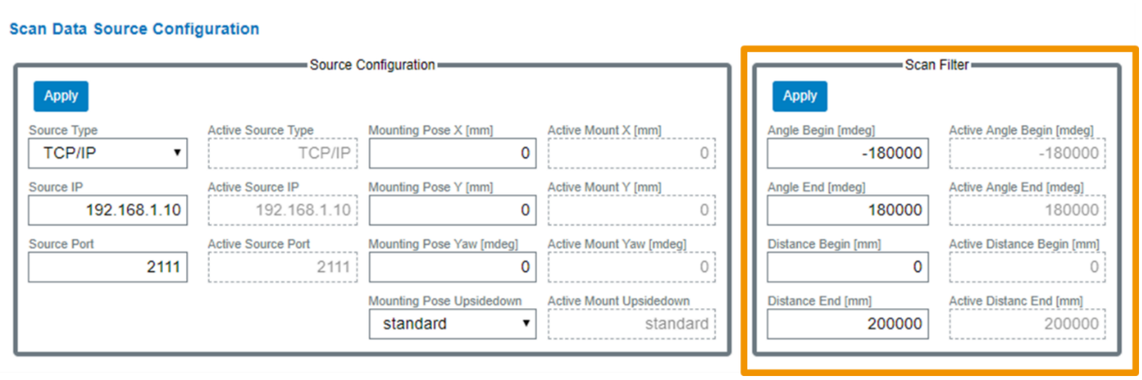
NOTE

The setting of mounting pose UpsideDown does not change the sensor coordinate system. The information is used to convert the scan data to the NAV LOC system.

7.6.4 IDLE: Scan filter (optional)

If there are parts of the vehicle visible in the field of view of the sensor, the corresponding measurements will lead to bad localization stability. The filter should be used to mute these scan sector areas. One has to consider that the more the field of view of the sensor is restricted, the more difficult it is for NAV-LOC to localize itself. The function therefore depends on the environment NAV-LOC is deployed in. As indication to reach the full accuracy mentioned in the data sheet in chapter 12 one should not set a scan range below of 220°. Lower values are possible, however, can lead to bad localization stability depending on the environment.

As default value, the scans are not limited in angle and distance.



The configuration values refer to the sensor position and orientation. There is one unique coordinate definition within the NAV-LOC system to handle all LiDAR sensors. All data is transformed internally to match the specific sensor system.

NOTE

The scan filter does also effect the output scan data via the result port.

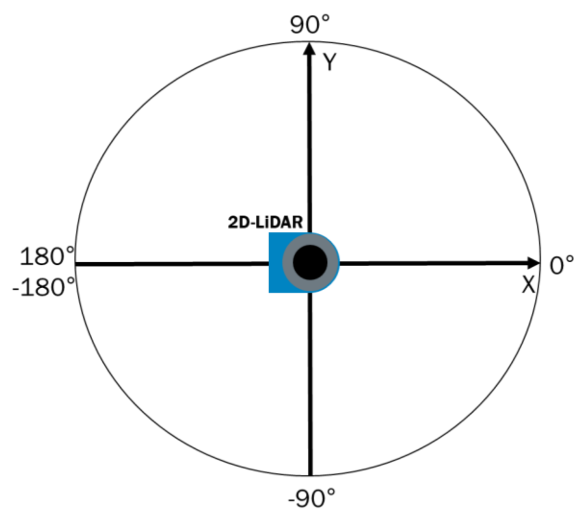
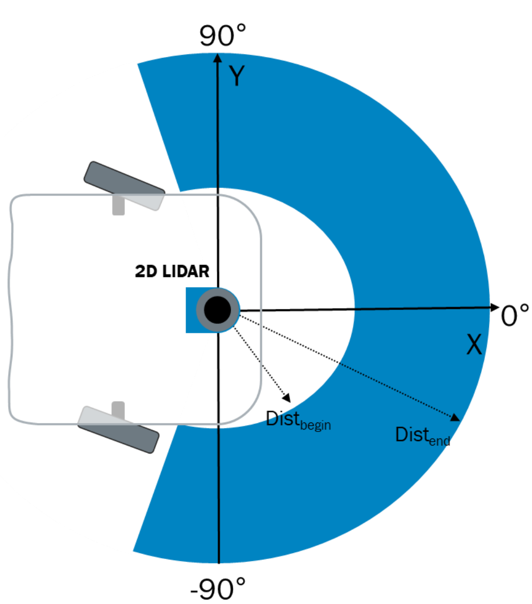


Figure 19: Unique coordinate system for all LiDAR Sensors (angle in mathematical positive direction – counterclockwise)

Example 1:

Distance Begin :	500 mm
Distance End :	200 000 mm
Angle Begin :	-110 000 mdeg
Angle End :	110 000 mdeg



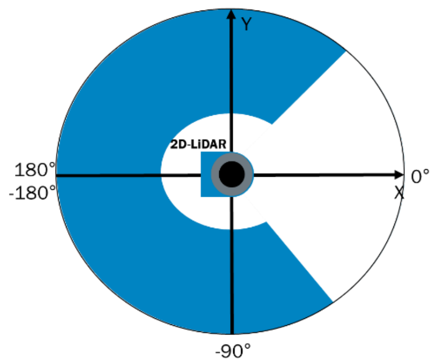
NOTE

The field of view limits from start- to endpoint is counterclockwise (CCW). That means, if the value of *angle begin* is higher than *angle end*, then the scans counting from 0° get suppressed.

Example 2:

Angle Begin : 45 000 mdeg

Angle End : -45 000 mdeg



7.6.5 READY: Settings for localization

A map suitable for the current surroundings must be selected and set for NAV-LOC for localization.

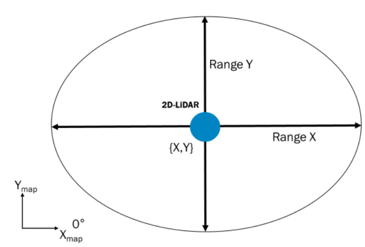
In addition, NAV-LOC needs a start range consisting of the initial position and uncertainty range (for more information, see chapter 3.10).

NOTE

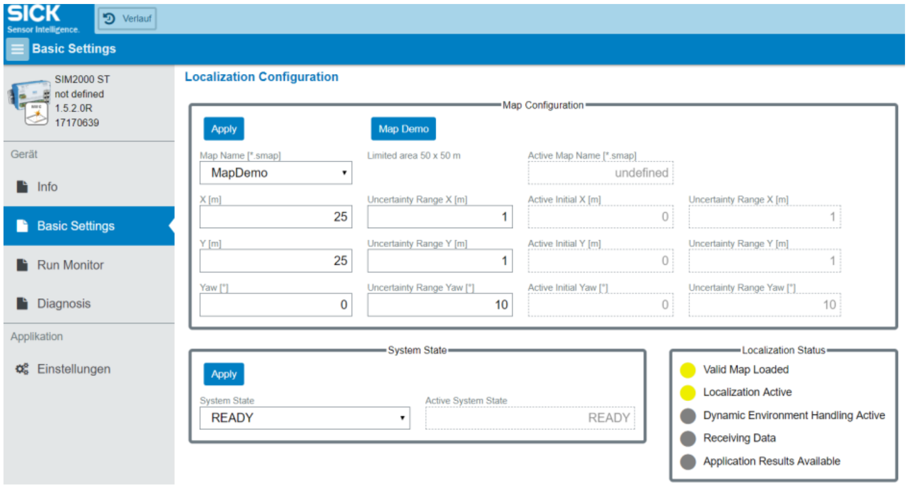
Use only integer values in the GUI –no floating point numbers are allowed.

Map Name example: *Site.smap*

X-coordinate [m]:	25	Uncertainty Range X [m]: 1
Y-coordinate [m]:	25	Uncertainty Range Y [m]: 1
Yaw angle [°]:	0	Uncertainty Range Yaw [°]: 10



Chapter 7.5 describes how the map is transferred to the flash memory of the SIM. The information will be entered when “Apply” is pressed.



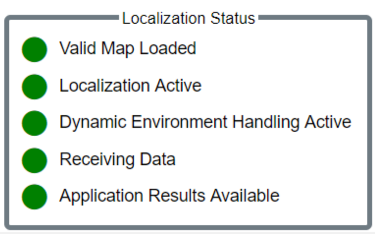
If the data is valid, e.g. the selected map is available in the memory and can be used, the state automatically changes to LOCALIZE and the localization is started.

Requirements for successful initial localization are:

- The vehicle is stationary.
- The surroundings are sufficiently visible and not occluded.
- The initial position data specified by the operator via GUI or by the vehicle computer via telegram consisting of X- and Y-coordinates and orientation match the actual position of the AGV.

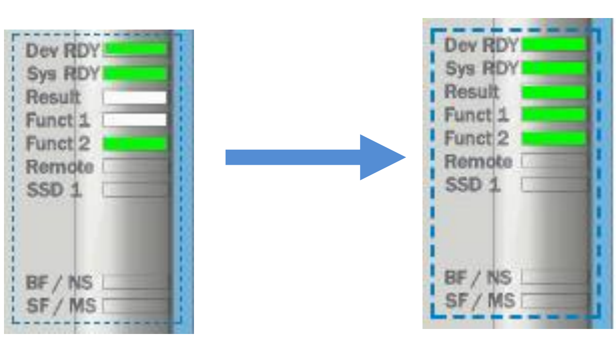
NOTE

If the settings are correct, all LEDs turn green when changing from IDLE mode to LOCALIZE mode.



LED INDICATOR in READY mode on the SIM

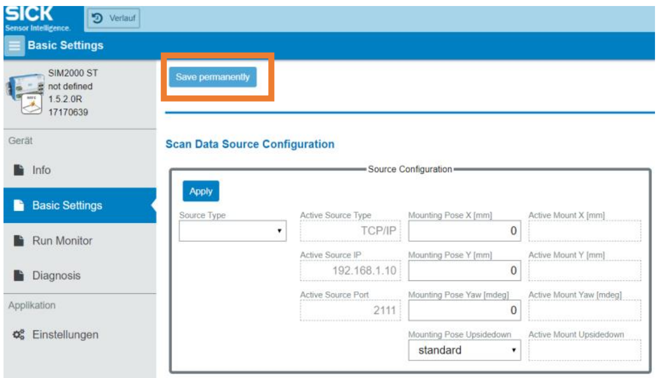
The Funct 1 LED also lights up green when the device has successfully switched to LOCALIZE mode.



READY mode **LOCALIZE mode**

At the end, press the button “edit” on the right side of SOPAS AIR

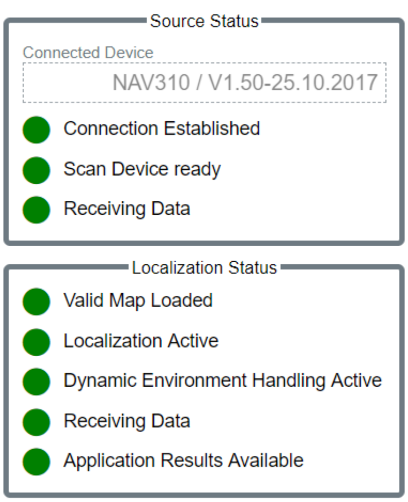
and click “Save permanently” afterwards to store all related data. Which data is stored, is described in the telegram listing[14] in the chapter for the corresponding command `NAVSavePermanent`.



7.6.6 LOCALIZE: Indication of contour and position

Requirements

All status messages on the “Run Monitor” page have a green status indicator.



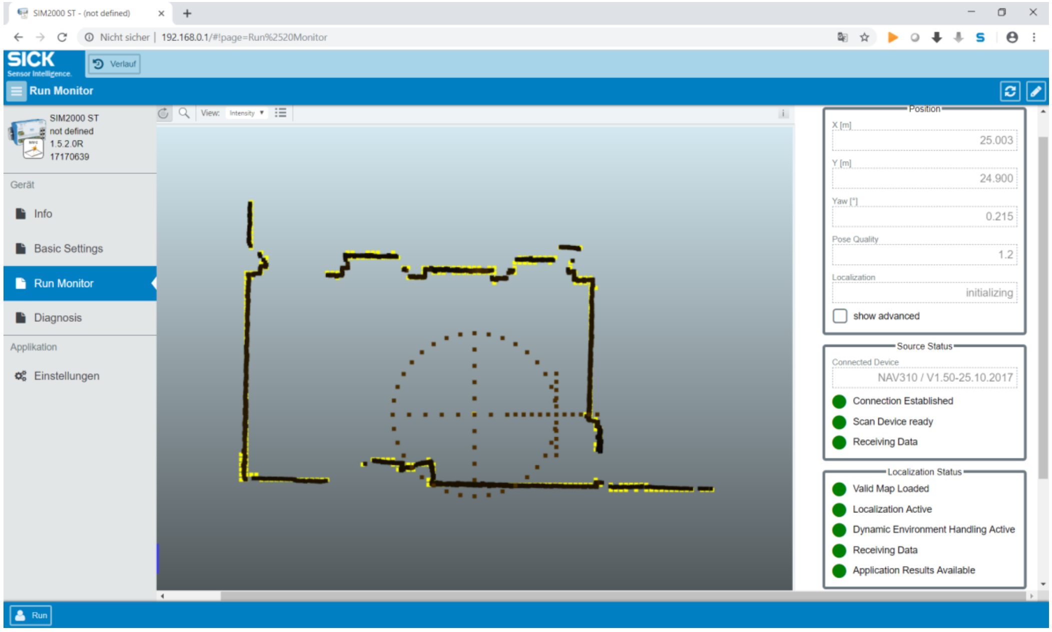
After switching to the “Run Monitor” page, the currently measured contour is shown in black and the active map in yellow.

The position with a trace of recent locations is shown in orange color.

For the “Position” options refer to chapter 3.11.

---

[14] Open the page www.sick.com and enter the part number of the NAV-LOC telegram listing 8021387 (English) into the search field.

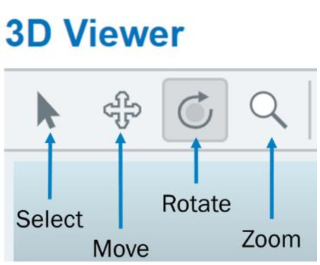


Notes on using the 3D viewer:

In SOPAS Air, the 2D room contour, the map, and the position are shown with a 3D viewer.

The “Rotate” operating mode enables the contour display to be rotated by moving the mouse while holding down the left mouse button.

In “Move” operating mode, move the mouse while holding down the left mouse button to move in the X- and Y-direction.



Always switch from “Rotate” mode to “Move” mode first in order to make operation simpler.

The contour display can be zoomed in or out either by using the mouse wheel or the + or - pushbuttons.

7.6.7 LOCALIZE: Settings for the result port (data output)

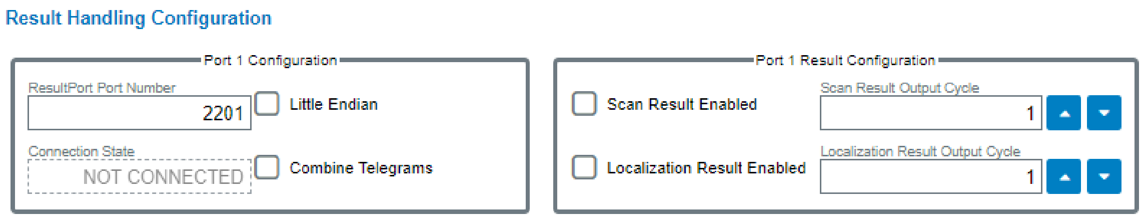
To use the position data in the vehicle control computer, it can be connected to Ethernet port X9-1 or a free port on a switch.

Port X9-1 has IP number 192.168.0.1 as a default setting, i.e., either the vehicle computer is set suitably to, e.g., 192.168.0.3 or port X9-1 can be adjusted with the SOPAS ET program.

Data output between the embedded application and the vehicle computer is described in the telegram listing (see chapter 3.5) and is preset via port 2201.

Different options can be set in “Basic Settings” of the SOPAS AIR interface.

There will be no data output via the result port without activating data output.



Port 1 Configuration

Selection of the Ethernet port for data output, default setting is 2201.

Little Endian

Data is output in Big Endian format, i.e., the high byte (MSB) of the data values is output first. Depending on the processing method and processor type of the vehicle control computer, it is possible to switch to Little Endian format. This switches the byte order of data output and the low byte (LSB) of the data is output first. The change does not become effective until the system has changed to IDLE mode once, then back to LOCALIZE mode.

Combine Telegrams

The data for the pose and the scans are transferred via the result port by default in separate telegram. Some vehicle controllers have input buffers where the second received message may overwrite the first received message. In this case the telegrams of pose and scans message could be combined to a common telegram.

Scan Result Enabled

Enables the output of the scan messages from the connected LiDAR for further processing in the vehicle controller e.g. for visualization.

NOTE

The scan data result refers to the LiDAR sensor's position and orientation. The scan data is not processed to an optionally configured mounting pose.

NOTE

All LiDAR scan data is transformed to one unique sensor coordinate system.

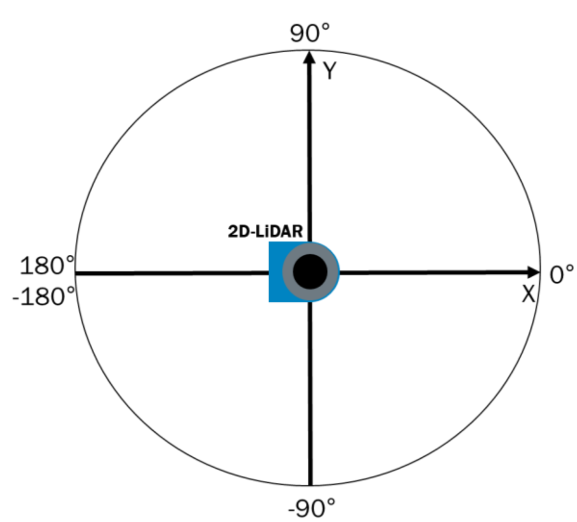


Figure 20: Unique coordinate system for all LiDAR sensors (angle in mathematical positive direction – counterclockwise)

Localization Result Enabled

Enables the output of the position with X- and Y-coordinates, orientation and including additional information.

Scan Result Output cycle

Determines the output cycle of the output of scan data telegrams.

When 1 is entered, the scan data result telegrams are output for each measurement cycle. When 2 is entered, the scan data result telegrams are only output every second scan measurement cycle. The default value is 1.

Localization Result Interval

Determines the output cycle of the output position data telegrams.

When 1 is entered, the localization result telegrams are output for each measurement cycle. When 2 is entered, the localization result telegrams are only output every second scan measurement cycle. The default value is 1.

NOTE

If necessary, the output frequency can be lowered with the pre-selectable output interval.

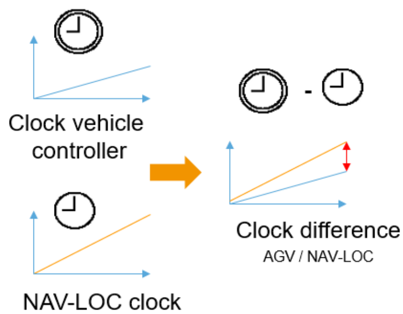
8 Synchronization

A very important aspect in the vehicle control is the time synchronization between the AGV vehicle controller and the internal time stamp of the NAV-LOCs controller called SIM.

The clock of the AGV vehicle controller and the clock of the SIM must be synchronized periodically. For motion control, it is necessary that the AGV controller can assign its own time stamp to each position produced by NAV-LOC.

The system latencies without this synchronization is described in chapter 12.2.

The internal time stamp of the embedded application increases in increments of 1 every 1 ms.



Additionally, the time stamp of the embedded application is synchronized internally by the SIM with the time stamp of the connected 2D LiDAR sensor. Each result (measurement data and localization result) from NAV-LOC is then provided with the internal time stamp of the embedded application.

NOTE

For synchronization, CoLa A commands are used for communication between the SIM module and the vehicle controller or your service computer, which is described in the separate document "Telegram Listing"[15].

NOTE

This chapter elaborates about the synchronization of NAV-LOC and between the AGV vehicle controller. The synchronization between the connected 2D LiDAR sensor and the NAV-LOC controller (SIM) is done internally by the embedded application of and is described in chapter 2.5 of each of the device-specific documents:

- SIM2000, NAV310 operating instructions (German 8023449, English 8023450)
- SIM2000, NAV245 operating instructions (German 8023451, English 8023452)

8.1 Synchronization options

NAV-LOC has three options available for synchronizing the internal time of embedded application with the system time of the vehicle computer.

8.1.1 Synchronization via telegram request (polling)

The vehicle computer retrieves the internal time of the embedded application using the `NAVGet-Timestamp` telegram.

The embedded application writes its internal time into a telegram and sends this to the vehicle computer.

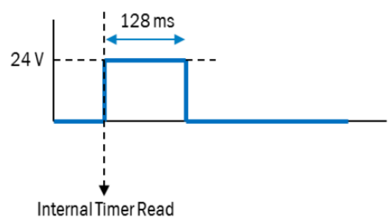
Sending may happen with a delay time of up to a few milliseconds, which results in some uncertainty. This can be overcome with the 2nd synchronization method.

An example could be to request the time stamp from NAV-LOC every 10 seconds.

[15] Open the page www.sick.com and enter the part number of the NAV-LOC telegram listing 8021387 (English) into the search field.

8.1.2 Synchronization via telegram request (polling) and HW port

The vehicle computer retrieves the internal time of the embedded application using the telegram `NAVGetTimestamp`[16] in the same way like used in option 1. Additionally, a hardware (HW) digital output is set via `NAVSyncGetTimestampPort`. The hardware output provides a pulse of 128 ms duration once the internal time stamp is written in the telegram.



Using the hardware port gives the option to calculate the delay for processing the request command and the following response time.

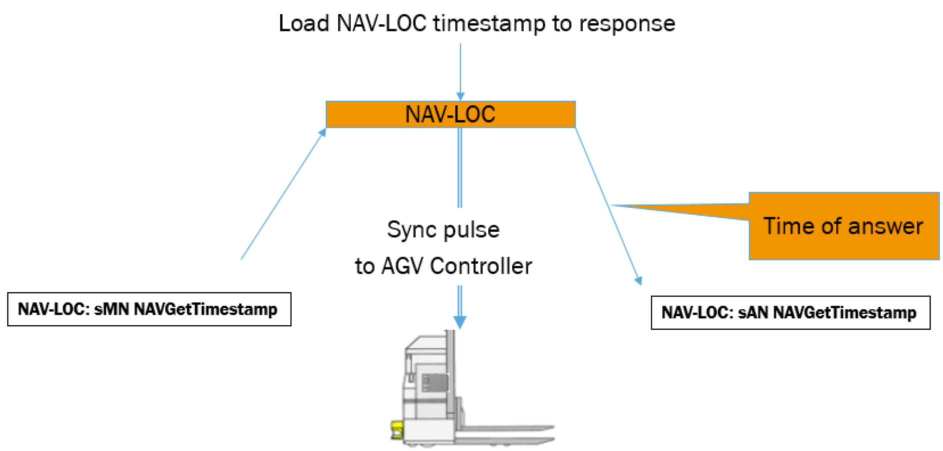
An example could be to request the time stamp from NAV-LOC every 10 seconds.

NOTE

The vehicle computer is to be configured such that it responds to the risings edge of the output pulse.

After the vehicle computer has received the telegram, the AGV computer can correct the time difference between the pulse and the reception of the time stamp included in the telegram.

As a result, the AGV computer can determine the actual time in NAV-LOC.



The following formula is used to calculate the resulting time offset after request of the sensor time between the clock of the SIM and the clock of the vehicle computer:

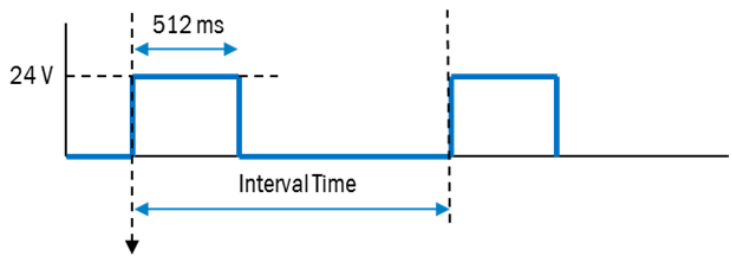
$\Delta t_{offset} = TS_{AGV} - t_{transfer} - TS_{NAV}$

Δt_{offset}	Resulting time difference (offset)
TS_{AGV}	Time stamp of the AGV computer
TS_{NAV}	Time stamp of NAV-LOC
$t_{transfer}$	Transfer time via the Ethernet interface

16 See telegram listing in the Telegram Listing publication

8.1.3 Synchronization via a cyclical pulse provided on HW port

The embedded applications time can also be configured via a telegram in order to generate an output pulse of 512 ms duration based on the 32-bit counter in a fixed cycle.



Configuration is done via the `NAVSyncClockInterval` command. The output pulse is generated at each counter overrun in the specified interval depending on the parameter. The specific hardware port is set with `NAVSyncClockPort`. Using the hardware port gives the option to calculate the delay for processing the request command and the following response time.

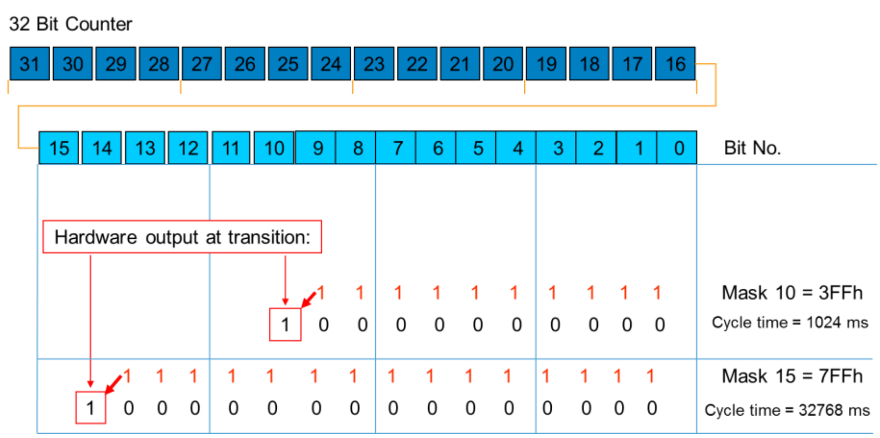
Examples:

NAVSyncClockInterval	Interval time
10	1,024 ms
12	4,096 ms
15	32,768 ms

Configuration of, e.g., 15 bits creates an output pulse every 32,768 ms.

The cyclical sync pulse is always triggered when the lower 15 bits of the counter are zero.

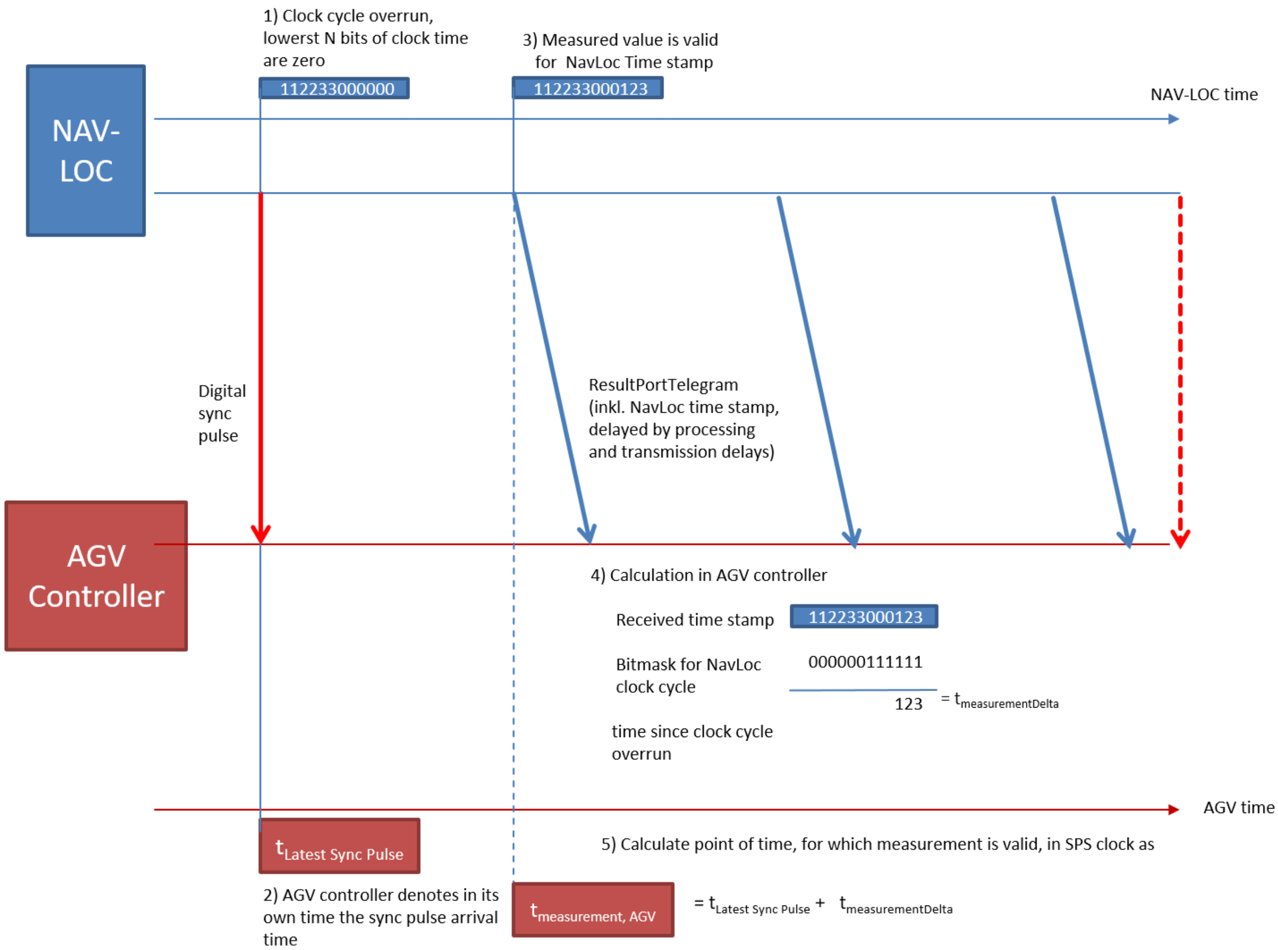
By using this sync pulse, the vehicle computer can synchronize with the clock of NAV-LOC.



NOTE

The vehicle computer is to be configured such that it responds to the rising edge of the output pulse.

The reference between the time stamp in the telegram, which refers to the position in relation to the cyclical output is illustrated in the following diagram.



8.2 Setting of the hardware outputs

NOTE

This chapter is only for usage of option 1 (chapter 8.1.2) or 2 (chapter 8.1.3) for synchronization.

The connector X3 of the SIM is used for outputting the sync pulses. Four outputs, X3-1 ... X3-4, are available. One of these outputs of X3 can be selected with the commands `NAVSyncGet-TimestampPort`[17] or `NAVSyncClockPort`. The command `NAVSyncGetTimestampPort` is used to set the output port for the pulse when receiving the time stamp request (`NAVGetTimestamp`) and `NAVSyncClockPort` is used for the selection for the output of the cyclical pulse.

Once the setting for the port is done, the output is triggered in each state of the system (IDLE, READY, LOCALIZE) and if saved after re-boot.

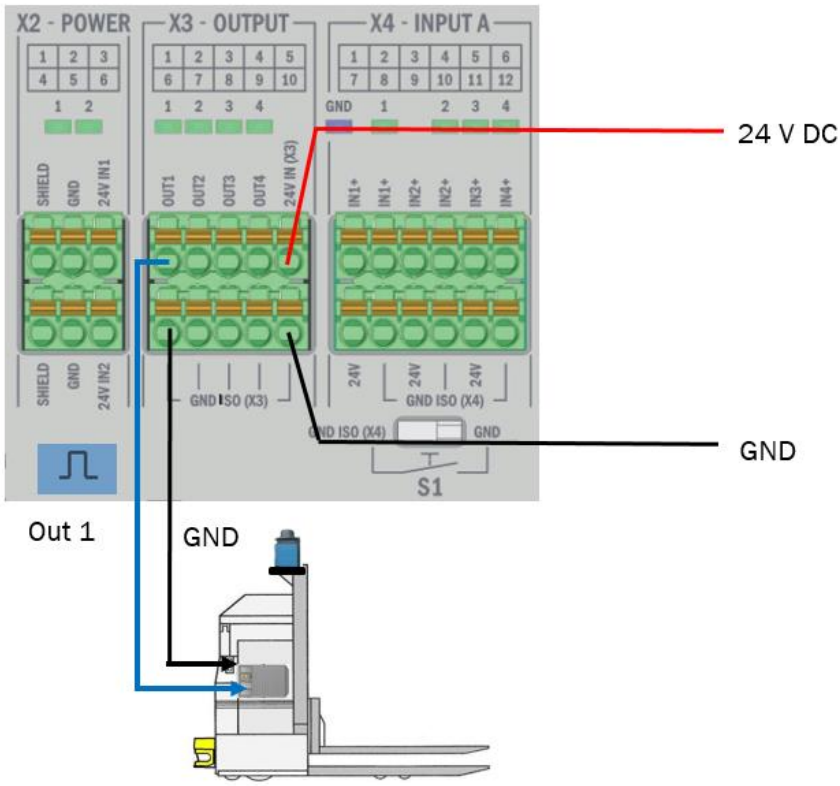
NOTE

The output pulses of both hardware synchronization variants are available at the same time and also on the same port. However, it is highly recommended to assign them to separate outputs of X3.

[17] (See telegram listing in the Telegram Listing publication.)

Although the LEDs of X3 are already flashing when the output X3 is configured, the outputs of the SIM must be supplied with an additional 24 V DC, since the outputs are galvanically separated from the input.

Either the voltage supply of the outputs can be connected together with the supply of the SIM, or if galvanic separation of the outputs is required, it can be supplied separately.



9 Troubleshooting

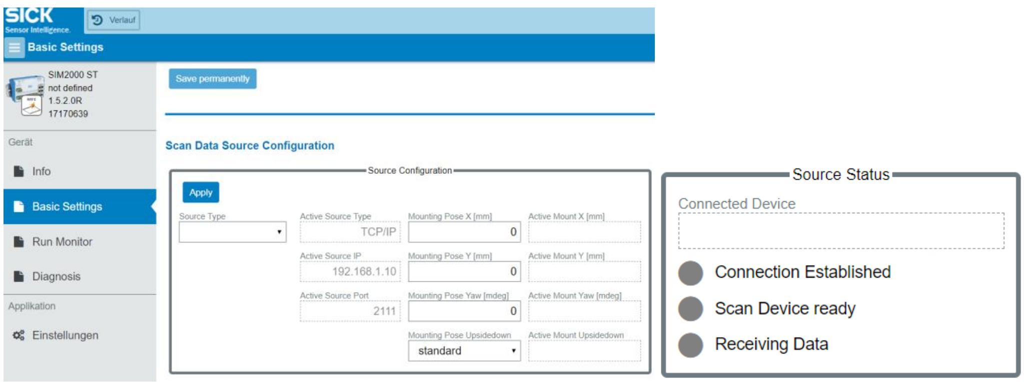
NOTE

Please, refer to the chapter 3.7 “Diagnosis” for general troubleshooting options.

9.1 Hints to the network connection

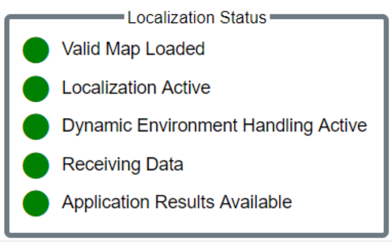
Please note: If a network connection between the SIM and the sensor cannot be established, the IP addresses and the setting of the subnet mask of the sensor and the used port of the SIM should be checked for a possible collision with a direct connection to SOPAS ET and corrected if necessary.

More detailed information can be found in chapter 7.4.



9.2 Hints to initialization

If the mode is not changed from READY mode to LOCALIZE during initialization, the following settings should be checked:



If one or several LEDs do not light up, the following should be analyzed:

NOTE

Depending on which 2D LiDAR sensor is connected, it may take some time after localization starts until the sensor provides data for localization.

Data source ready

Is the 2D LiDAR sensor correctly connected and was the interface correctly configured in the sensor and in the SIM?

Telegrams:

- `<STX>sRN NDEVConnectionState<ETX>`
- `<STX>sRN NDEVDeviceState<ETX>`
- `<STX>sRN NDEVDataState<ETX>`

Valid map loaded and initialized

Is a map loaded and was it called up with the correct name?

Telegram:

- `<STX>sRN NAVMapState<ETX>`

Dynamic Environment Handling Active

Is a data source specified, a valid and available map loaded, and a suitable initial position specified?

Telegram:

- `<STX>sRN NAVDEHState<ETX>`

Localization Active

Is the localization initialized and running?

Telegrams:

- `<STX>sRN NAVActiveState<ETX>`
- `<STX>sRN NAVLocalizationState<ETX>`
- `<STX>sRN NAVDataState<ETX>`

Application Results Available

Is a valid map loaded (name and contents)? Was a valid initial position specified? Is the connected sensor outputting data?

Telegrams:

- `<STX>sRN NRESDataState<ETX>`
- `<STX>sRN ER1St<ETX>`

9.3 Localization hints

Changes of the facility surroundings can cause that the map can no longer be used for the localization. Please check whether moveable objects, which were placed in the area of operation after the map creation can be removed in order to recreate the original contour.

If this is not possible, please contact SICK Service for a change of the map.

9.3.1 Localization does not start

Wait some time (time needed for booting: up to 60 seconds, time needed for loading the map: up to 80 seconds depending on the map size).

9.3.2 No localization data is output

- "Localization result enabled" may need to be activated, see section 7.6.7.
- It is possible that no scan data will be output from the sensor; in this case the sensor cables and the settings of the data source must be checked.

9.3.3 Characters

If the map is not loaded properly, check if the map name contains only valid characters that are:

- Latin letters: A-Z, a-z
- Arabic numbers: 0-9
- Specific signs: - (hyphen), _ (underscore).

10 Transport and storage

10.1 Transport

For your own safety, please read and observe the following notes:

IMPORTANT

Damage to the device due to improper transportation.

- The device must be packaged for transportation with protection against shock and damp.
- Recommendation: Use the original packaging as it provides the best protection.
- Transport should be performed by specialized staff only.
- The utmost care and attention is required at all times during unloading and transportation on company premises.
- Note the symbols on the packaging shortly.
- Do not remove packaging until before mounting.

10.2 Transport inspection

Immediately upon receipt in Goods-in, check the delivery for completeness and for any damage that may have occurred in transit.

In the case of transit damage that is visible externally, proceed as follows:

- Do not accept the delivery or only do so conditionally.
- Note the scope of damage on the transport documents or on the transport company’s delivery note.
- File a complaint.

NOTE

Complaints regarding defects should be filed as soon as these are detected. Damage claims are only valid before the applicable complaint deadlines.

10.3 Storage

Store the device under the following conditions:

- Recommendation: Use the original packaging.
- Do not store outdoors.
- Store in a dry area that is protected from dust.
- Do not package in airtight container, such that any residual damp can evapore.
- Do not expose to any aggressive substances.
- Protect from sunlight.
- Avoid mechanical shocks.
- Storage temperature and relative humidity: see information in the operating instructions of the individual components.
- For storage periods of longer than 3 months, check the general condition of all components and packaging on a regular basis.

11 Service and maintenance

The housing screws of the SIM2000-0A20A00 and 2D LiDAR sensors are sealed.

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

12 NAV-LOC data sheet

12.1 NAV-LOC features

Feature	Value
Application	Localization based on contour data in the indoor area
Supported products	NAV310-3211, NAV340-3232, NAV350-3232, NAV245-10100 SIM2000-0A20A00 Sensor Integration Machine
Communication interface	Ethernet (10/100/1,000 Mbit) Function: data output
Switching outputs	4, for synchronization
Position resolution[18]	1 mm
Angular resolution[19]	0.001°
Content of output localization result	Position (X, Y, yaw angle) Quality information for data fusion and diagnosis of surroundings
Map size	≤ 250,000 m^2 (per each of the 10 maps)
Max. number of supported maps/areas	10
Translational velocity	≤ 2 m/s
Yaw rate (rotational velocity)	≤ 45°/s

Accuracies	2D LiDAR sensor	
	2D LiDAR sensor	
Supported device	NAV310-3211 NAV340-3232 NAV350-3232	NAV245-10100
Aperture angle	360°	270°
Distance Range	10 %: 35m 90 %: 120 m	10 %: 18m 90 %: 50 m
Update rate	Typical 8 Hz	Typical 8.33 Hz
Accuracy[20] (position measurement)	Typical 30 mm	Typical 35 mm
Accuracy[21] (yaw angle)	Typical 0.1° ... 0.4°	Typical 0.1° ... 0.4°
Repeatability[22]	Typical 4 mm ... 17 mm	Typical 6 mm ... 22 mm

[18] The resolution refers to the output localization result via the result port and can differ from the connected sensor's measurement resolution.

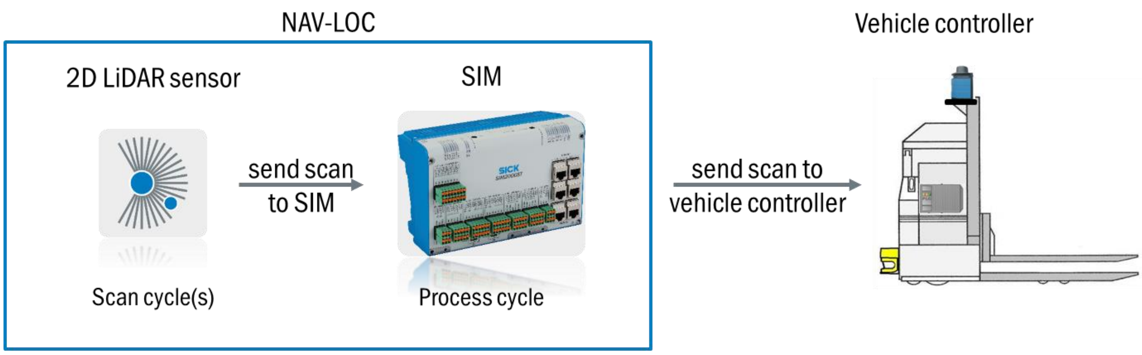
[19] The resolution refers to the output localization result via the result port and can differ from the connected sensor's measurement resolution.

[20] 1 σ, observe the min. warm-up time of 30 minutes; real value depends on ambient conditions

[21] 1 σ, observe the min. warm-up time of 30 minutes; real value depends on ambient conditions

[22] End position reached, observe the min. warm-up time of 30 minutes; real value depends on ambient conditions

12.2 System latencies



The latencies described in the table below can be eliminated by the synchronization options described in chapter 8. The remaining uncertainty for this synchronization between the 2D LiDAR sensor and the SIM is with:

- Digital I/O synchronization < 5 ms[23]
  and with
- Network (wired) synchronization < 10 ms.

2D LiDAR sensor	Maximum latency after „start of scan“[24]
NAV245	typ. below 170 ms + network transfer time[25]
NAV310:	typ. below 260 ms + network transfer time

[23] This value is reached only if one uses the additional digital synchronization port of the NAV310 and NAV245. If not used or for all other 2D LiDAR sensors, the value for “Network (wired) synchronization” holds true.

[24] Despite the latency, the update rate keeps after initialization the rate specified in chapter 12.1.

[25] The network transfer time is depending on the system setup.

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