OPERATING INSTRUCTIONS

LiDAR localization software

LiDAR localization

SICK
Sensor Intelligence.

Described product

LiDAR localization software

Manufacturer

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Legal information

Original document

This document is an original document of SICK AG.

Contents

1 About this document

1.1 Purpose of this document

This document explains the necessary steps to configure and operate localization software LiDAR Localization (LiDAR-LOC).

1.2 Scope

This document is included with the following SICK part numbers (this document in all available language versions):

- 8025192

The following documents contain information about possible components of LiDAR-LOC:

Table 1: Available documents

Document type	Title	Part number
Technical notes	Hardware integration	8025193
Technical notes	Telegram listing	8024818

1.3 Target groups

This document is intended for the following target groups:

- Project developers (planners, developers, designers)
- Electricians
- Operators
- Maintenance personnel

The target groups are reflected in the user management of LiDAR-LOC.

1.4 Symbols and document conventions

The following symbols and conventions are used in this document:

Safety notes and other notes

DANGER
Indicates a situation presenting imminent danger, which will lead to death or serious injuries if not prevented.

WARNING
Indicates a situation presenting possible danger, which may lead to death or serious injuries if not prevented.

CAUTION
Indicates a situation presenting possible danger, which may lead to moderate or minor injuries if not prevented.

NOTICE
Indicates a situation presenting possible danger, which may lead to property damage if not prevented.

NOTE
Indicates useful tips and recommendations.

Instructions to action

▸ The arrow denotes instructions to action.

1. The sequence of instructions for action is numbered.
2. Follow the order in which the numbered instructions are given.

✓ The check mark denotes the result of an instruction.

2 Safety information

2.1 Correct use

LiDAR-LOC is a software for determining the position of automated guided vehicles (AGVs).

2.2 General cybersecurity notice

Protection against cybersecurity threats requires a comprehensive and holistic cybersecurity concept that must be continuously monitored and maintained. Such a concept consists of organizational, technical, process-related, electronic and physical defense levels and sets up appropriate measures for the different types of risk. SICK's products and solutions must be regarded as an integral part of this concept.

Information on Cybersecurity can be found at: www.sick.com/psirt .

2.3 Requirements for the qualification of personnel

LiDAR-LOC must be configured, installed, connected, commissioned and serviced only by qualified personnel.

Project planning

For project planning, a person is considered competent when he/she has expertise and experience in the selection and use of localization and is familiar with the relevant technical rules and national work safety regulations.

Configuration

For configuration, a person is considered competent when he/she has the expertise and experience in the relevant field and is sufficiently familiar with the application of localization.

Commissioning

For commissioning, a person is considered competent when he/she has the expertise and experience in the relevant field and is sufficiently familiar with the application of localization that he/she can assess its operational function.

Operation and maintenance

For operation and maintenance, a person is considered competent when he/she has the expertise and experience in the relevant field and is sufficiently familiar with the application of localization and has been instructed by the machine operator in its operation.

3 Product description

3.1 Design and function

Localization

LiDAR-LOC is a software for determining the position of automated guided vehicles (AGVs). LiDAR-LOC calculates the positions based on contour data. The sensor detects this contour data and the localization controller compares the data to a reference map. The reference map has an absolute coordinate system. The result of the continuous position calculation are poses in X, Y, and yaw. The poses are represented in the map's coordinate system and sent to the vehicle controller. This whole process is called localization.

Maps

For the localization you need a reference map of the environment in which you want to localize the AGV. The reference map is created before using the software and contains the contour data of the LiDAR sensors as well as further information from optional additional sensors.

System overview

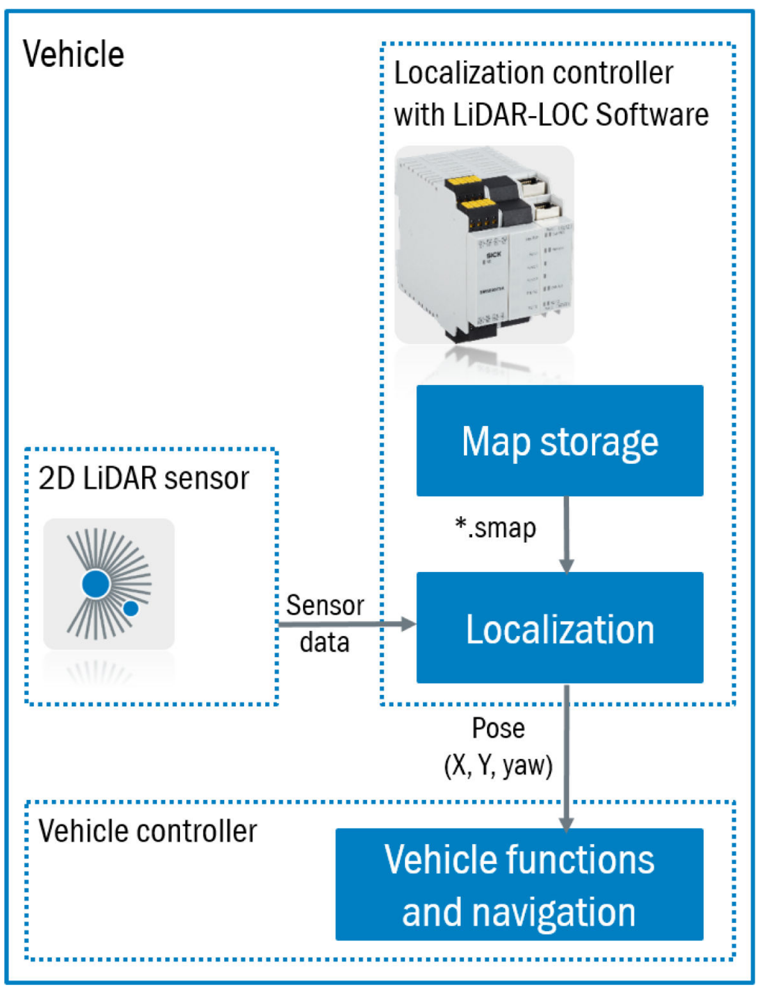


Figure 1: System overview for the integration of LiDAR-LOC

Further topics

- "SICK support and further services", page 90
- "About localization", page 44
- "About maps", page 38
- "About pose accuracy", page 42
- "About Dynamic Environment Handling", page 42

3.2 System requirements

Requirements for the environment

Consider the following requirements for using LiDAR-LOC.

- The system is suitable 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.
  The LiDAR scan data of all sensors combined shall at least detect 60 % of the static mapped surrounding contour. The map produced during commissioning should include structures in the direction of motion as well as transverse direction. The scans measured during operation should be able to reproduce these structures. Localisation might also be possible with less than 60 % detected contour. However, this must be tested in each individual environment.
- The surrounding ambient conditions for individual components, for example, the temperature, must comply with the data sheets.

NOTE
SICK Service can assess your factory site and create a reference map.

Requirements for the vehicle configuration

Consider the following aspects when configuring your vehicle.

- Ensure that you use a suitable sensor type for your application. Use a 2D LiDAR sensor with high values for accuracy, range, resolution, and cycle time to improve the accuracy of the overall system. (Data sheet)
- To increase the accuracy and robustness of the localization, a field of view of 360° from all LiDAR sensors combined is recommended. If necessary, use several LiDAR sensors to achieve a maximum field of view of 360°.
- The field of view of all LiDAR sensors together must be at least 200° to operate LiDAR-LOC reliably.
- It is recommended to use additional odometry components to further increase the reliability of the localization. (About odometry for support)

Requirements for the 2D LiDAR sensor

Consider the following aspects when choosing the mounting height of the sensor.

- The sensor must be installed at a height that ensures a good field of view of the fixed elements in the facility from every location. Fixed elements include, for example, walls, columns, and fixed racks.
- The angular scan range of the 2D LiDAR sensor should not be obstructed.

LiDAR-LOC tolerates individual objects that move into the scan plane. This means that less than 100 % of the scan points can match the reference map. The system works even if the scan data deviates from the contour, for example, because the hall layout changes slightly or because objects move into the scan plane.

You should not install the sensor at one level with wall protrusions or other objects that can cause ambiguity when measuring the distance to the wall. Instead, install the sensor at a height above or below the protrusion to make clear which part of the building contour the sensor measures.

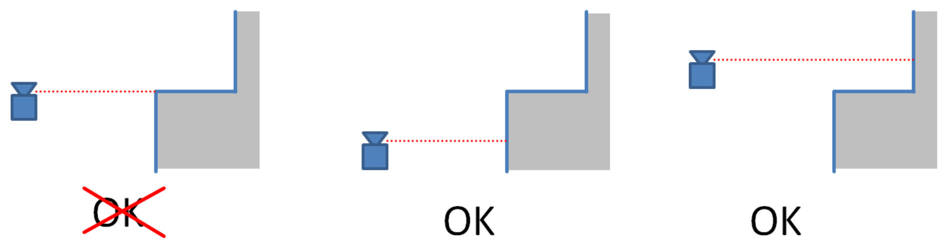


Figure 2: Sensor installation height at wall protrusions

Consider the following aspects when aligning the sensor horizontally:

- It should be possible to tilt the sensor mount in all directions in order to be able to align the sensor horizontally.
- The scan plane of the sensor shall run parallel to the floor surface.
  - In general, at a scan height of 150 mm, the scanner shall only be pitched by 0.15° in all directions in the field of view of the sensor.
    Note: This is important to prevent floor detections, but also to not cause ambiguity when measuring the distance to the wall at wall protrusions or other protuded objects.
  - As a minimum requirement, align the sensor with a spirit level or the alignment aid.
- Align the sensor in an area with an even floor, which is intended for service work.
- Make sure that the sensor is fixated on a vehicle in such a way that the alignment of the sensor cannot be changed by accident.

SICK offers an alignment tool: Alignment aid, part number 2101720.

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

Further topics

- "About pose accuracy", page 42
- "SICK support and further services", page 90
- "About maps", page 38
- "Creating a reference map", page 41

4 User interfaces

Overview

You can control, set and call all localization functions with different user interfaces.

Interfaces

Table 2: Overview of the interfaces

Interface	Description
SOPASair	Control and setting of most localization functions via the web-interface.
CoLa-A	Control and setting of most localization function via telegrams.
UDP	Reception of sensor measurement data or pre-processed data of the external vehicle controller via the binary protocol, for example, from 2D-LiDAR sensor or odometry.
TCP/IP	Sending the localization results via the binary output telegram to the external vehicle control
ROS	Optional: When using ROS, the interfaces CoLa-A, pre-processed UDP data and TCP/IP can be replaced with the ROS driver.

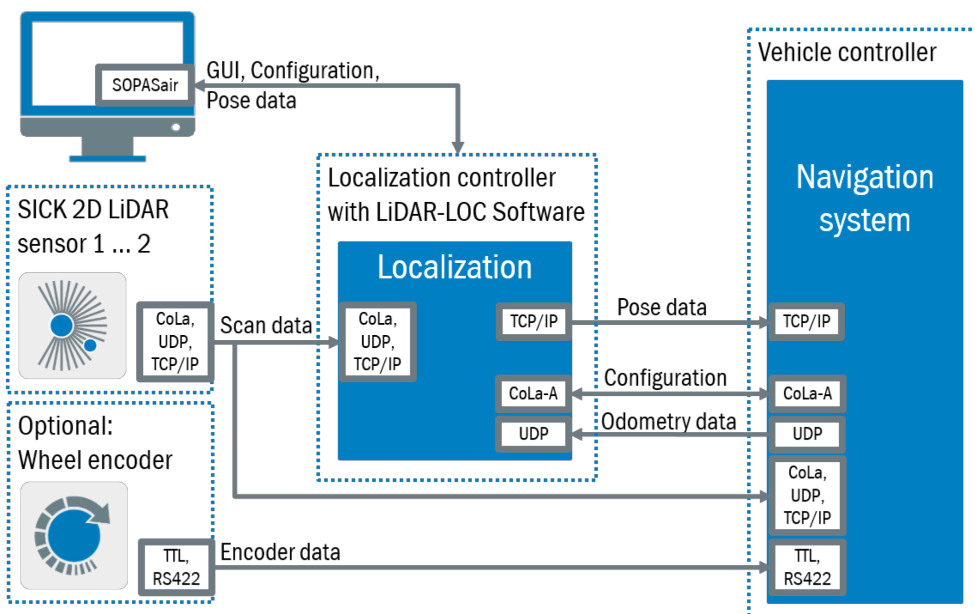


Figure 3: Overview of the interfaces

Further topics

- "User interface SOPASair", page 11
- "About CoLa-A telegrams", page 70
- "About odometry for support", page 58
- "About result port telegrams", page 75
- "User interface ROS", page 17

4.1 User interface SOPASair

Overview

SOPASair is a web-interface included in the LiDAR-LOC software package and runs on the localization controller.

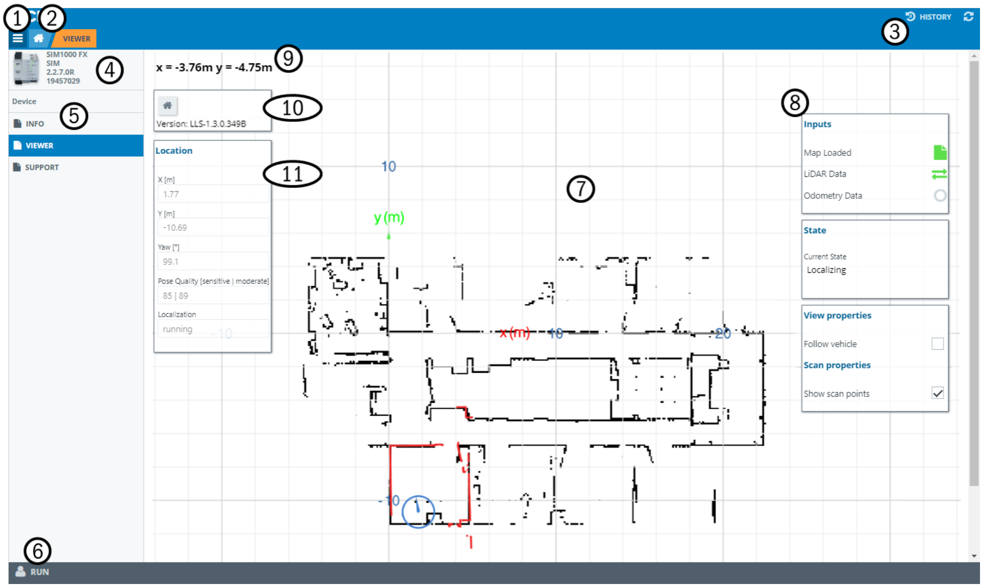


Figure 4: Overview of the user interface SOPASair

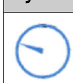
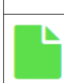
① Menu
② Home
③ History
④ Device Info
⑤ Software menu
⑥ User group
⑦ Main window
⑧ Setting panels
⑨ Mouse pointer coordinates
①⓪ Initialization panel
①① Location output panel

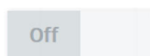
Further topics

- "Logging into SOPASair", page 32

4.1.1 Colors and symbols in SOPASair

Table 3: Colors and symbols in SOPASair

Symbol	GUI element	Description
	Vehicle	Vehicle on the map in idle or localization state.
	Vehicle	Vehicle on the map, ready for initial positioning.
	Status indicator	Reference map is not loaded.
	Status indicator	Reference map is loaded.
	Status indicator	Data connection between localization controller and sensor is not established.

Symbol	GUI element	Description
	Status indicator	Data connection between localization controller and sensor is active.
	Status indicator	Odometry is inactive and is not used for localization.
	Status indicator	Odometry is active but the data is corrupted.
	Status indicator	Odometry is active and is used for localization.
	Status indicator	Sensor is inactive and is not used for localization.
	Status indicator	Sensor is active and is used for localization.
	Switch	Function is deactivated.
	Switch	Function is activated.
	Check box	Option is not selected.
	Check box	Option is selected.
	Sliding scale	Sets a range of values, for example, the scanning angle.

4.1.2 Viewer window

Viewer window

The viewer displays the reference map and shows the position of the automated guided vehicle (AGV). Additionally, you can load a different map, check the localization status, and change viewer settings.

To open the viewer window: Main screen > Viewer

NOTE
Use at least the user level **Maintenance** display the settings.

Figure 5: Viewer window

Initialization panel

x = -10.32m y = -19.01m Current X and Y positions of pointer in meters.

Home
Centers the view on the origin of the coordination system.

Initialize pose
Sets the initial pose and automatically adjust the pose to match the measured scan data in the loaded map. The button is a combined command of **Set pose** und **Update pose.** This is only possible during localization.

- Light gray: Initial positioning is inactive.
- Dark gray: Initial positioning is active, and pose can be selected.

CoLa-A telegram:

- LocInitializePose

Set pose
Sets the initial pose.

- Light gray: Initial positioning is inactive.
- Dark gray: Initial positioning is active, and pose can be selected.

CoLa-A telegram:

- LocSetPose

Update pose
Forces the localization system to update the vehicle position. This is only possible during localization.
CoLa-A telegram:

- LocForceUpdate

Location

X [m]
Current position of the vehicle along the X-axis of the map's coordinate system.

Y [m]
Current position of the vehicle along the Y-axis of the map's coordinate system.

Yaw [°]
Current orientation of the vehicle with respect to the map's coordinate system. 0 means that the vehicle is oriented in positive X-direction.

Pose quality
Pose quality of the detected position during localization. Indicates the stability of the current localization.
There are two values (sensitive and moderate) separately output for the pose quality in the result port (see "Payload of the result port telegram", page 77).

- sensitive: Deviations of the current LiDAR sensor data from the mapped contour and reflectors have a stronger effect on the sensitive pose quality. The value adapts more quickly to external influences, that is, the pose quality can fall as well as rise faster.
- moderate: Deviations of the LiDAR sensor data from the mapped contour and reflectors affect the moderate pose quality more slowly and, with short-term changes, to a lesser extent.

Localization
The localization status

- halted: The localization is off.
- running: LiDAR-LOC continously calculates the vehicle position.

Inputs

Map
Map that is currently loaded. Can be a demo map or a reference map.

Map Loaded
Indicates if the selected map is loaded.

- Map is loaded.

- Map is not loaded.

LiDAR Data
Status of data connection between localization controller and sensor. Sepcific information is given in Main screen > LiDAR Configuration.

- Receiving data from all active sensors.

- Not receiving data from at least one active sensor..

Odometry Data
The circle color indicates the status of the received odometry messages sent by the vehicle controller.
The function can be activated in Main screen > „Localization Configuration“.

Receiving odometry messages from the vehicle controller.

Odometry messages are received but not processed by the localization software. The following cases lead to discarded messages:

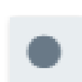
- The odometry header or the payload is incorrect. This is for example the case if the wrong number of bytes are sent or the message type is not an odometry message.
- The difference between the time stamps of two consecutive odometry messages is greater than 100 ms.
- The change in the angular velocity of two consecutive odometry messages is greater than 10 000 deg/s. Contact SICK support if your vehicle configuration allows other settings.

Odometry telegrams are not received.

State

Current state	The localization state • Booting: LiDAR-LOC is not yet ready for operation. • Idle: LiDAR-LOC is started. All functions are ready for operation. • Localizing: Localization is active. Pose is calculated continuously. • DemoMapping: Demo map creation is running.
Localization	Select the button to switch localization on or off.
Demo Mapping	Select the button to switch demo mapping on or off.

Sensor Data Recorder



Starts the data recording for extended support.

View properties

Follow vehicle	Check or uncheck to center the view over the current vehicle's position. Used for larger sites or when the vehicle leaves the user's field of vision. Checked: View follows the vehicle and keeps it centered. Unchecked: View is stationary.
Show scan points	Check or uncheck to show or hide the scan points on the map. Checked: Scan points are displayed on the map in red. Unchecked: Scan points are not displayed on the map.

Further topics

- "Setting the initial pose manually", page 50
- "Starting the localization", page 46

4.1.3 Info window

Overview

The info window gives you the version information for the components of your system.

You can find the info window here: Main screen > Info.

Device info

Figure 6: Info window

Table 4: Device info

Device Type	Model name of the localization controller that is currently connected.
Ident Version	Firmware version of the localization controller that is currently connected.
Manufacturer	Manufacturer of the localization controller.
Firmware Version	Firmware version of the localization controller that is currently connected.
LLS Version	Version of LiDAR-LOC that is currently installed on the localization controller.

Further topics

- "Setting the initial pose manually", page 50
- "Starting the localization", page 46

4.2 User interface ROS

All localization functions can be implemented via the ROS (Robot Operating System) interface. Therefore ROS must be fully integrated into the vehicle controller of the AGV.

The ROS framework provides software developers with program libraries and tools to create robot applications. Among other things, it offers a hardware abstraction layer, device drivers, visualization tools, message exchange functions and a package management. ROS is open source and published under the BSD license.

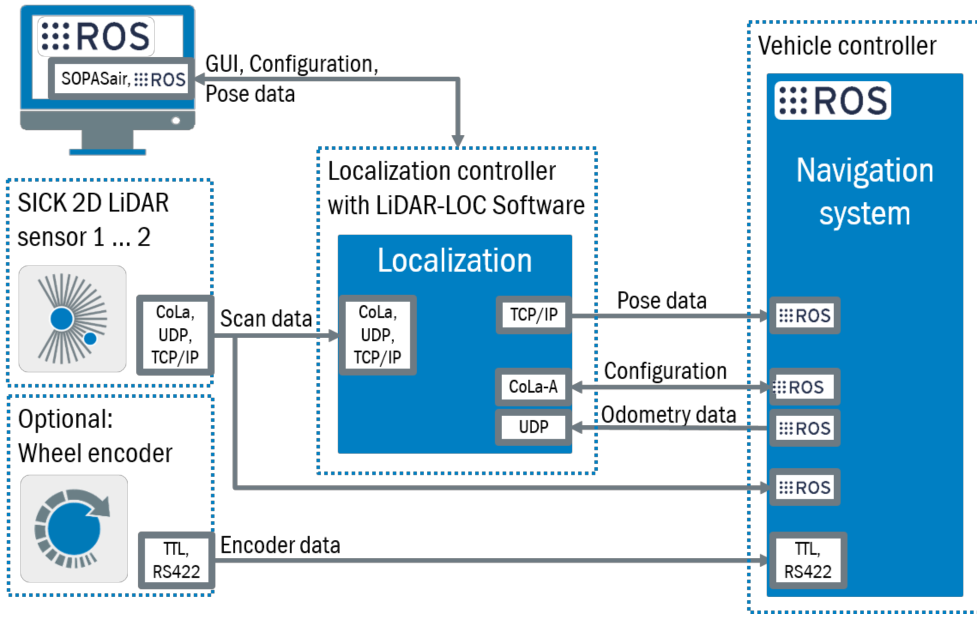


Figure 7: Überblick ROS-Schnittstelle

You can find the required ROS driver and documentation on GitHub:

https://github.com/SICKAG/sick_lidar_localization

5 Installation

5.1 Installing the hardware

This document describes the software installation. The following document contains information about the installation about possible components of LiDAR-LOC:

Table 5: Available documents

Document type	Title	Part number
Technical notes	Hardware integration	8025193

5.2 Deploying the software to the localization controller

Overview

LiDAR-LOC is not pre-installed on the localization controller and must be installed before usage.

SICK recommends that you regularly update LiDAR-LOC on the localization controller.

SICK supports only the latest software release which can be downloaded in Support Portal https://supportportal.sick.com/products/localization/lidar-localization/lidar-loc/ in section "Releases".

Important information

NOTICE
By default, the localization controller is a programmable device. When using the localization controller with the application software LiDAR-LOC, the controller is converted into an application device. This means that the device cannot be programmed any longer; it is locked for any additional application and cannot be unlocked.

Prerequisites

- You are registered at the SICK Support Portal.
- You have downloaded the current LiDAR-LOC software package LLS-X.X.X.XR.spk from the SICK Support Portal.
- You have downloaded the locking file LLSLock.spk.
- You have downloaded and installed the current SICK AppManager from the SICK website.
- The localization controller has a data connection to your desktop computer. Your desktop computer needs to be in the same subnetwork as the localization controller, for example, if the localization controller has the IP address 192.168.0.1, your computer's IP address has to be 192.168.0.X, where X is a number between 2 to 254.

Approach

1. Open the SICK AppManager.
2. In **Device search**, scan for devices and select the localization controller, for example, SIM1000 FX.
3. From your download folder, drag and drop the locking file LLSLock.spk to the tab **Firmware**.
4. Select **Install**.

✓ The SICK AppManager installs the locking file LLSLock.spk. The localization controller is converted into an application device and locked for additional applications.

5. Drag and drop the software package LLS-X.X.X.XR.spk from the download folder to the Firmware tab.

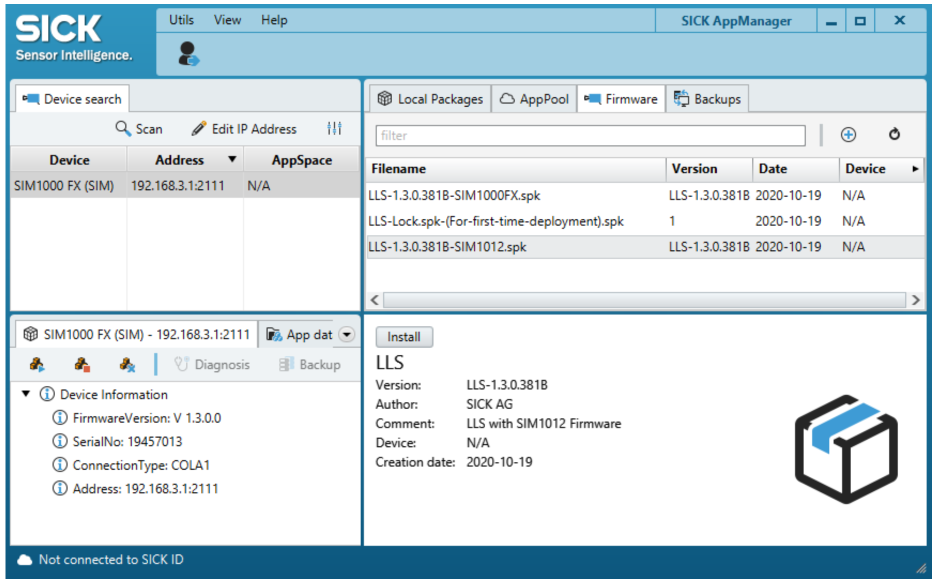


Figure 8: Installation of LiDAR-LOC with the SICK AppManager

6. Select **Install**.

✓ The SICK AppManager installs the software package LLS-X.X.X.XR.spk.

NOTE
If the SICK AppManager stops installation at 0 %, restart the SICK AppManager and repeat the installation process.

NOTE
If the installation continues to fail, copy all maps that you want to use from the localization controller to your desktop computer. Delete the maps from the localization controller and restart the installation process. Copy all maps back to the localization controller.

7. In SOPASair, open **Info**.
8. In **LLS Version**, check if the software version has been updated successfully.

Complementary information

- Download the firmware LLS-X.X.X.XR.spk and locking file LLSLock.spk here: **https://supportportal.sick.com/products/localization/lidar-localization/lidar-loc/**
- Download the SICK AppManager here: **https://www.sick.com/de/de/softwareprodukte/sick-appspace-software/sick-appmanager/c/g446551**

Next steps

- "Logging into SOPASair", page 32

Further topics

- "Info window", page 17
- "SICK support and further services", page 90

5.3 Activating the software

Overview

LiDAR-LOC must be activated on the localization controller after the software has been deployed.

You must store a valid license on the localization controller to use the localization functionalities of LiDAR-LOC. A license is only valid for the localization controller that it is activated for. The localization controller is identified by a so-called Container ID.

To obtain a license file, you must use your Ticket ID. The Ticket ID is a unique code the user obtains after purchasing LiDAR-LOC. A Ticket ID can contain multiple licenses. Each license can be activated in the SICK license server. If you do not have a Ticket ID, please contact your local distributor.

If no license or an invalid license is stored on the localization controller while it boots, the CoLa-A telegram **IsSystemReady** returns an error code. All SOPASair pages concerning the localization show an activation reminder.

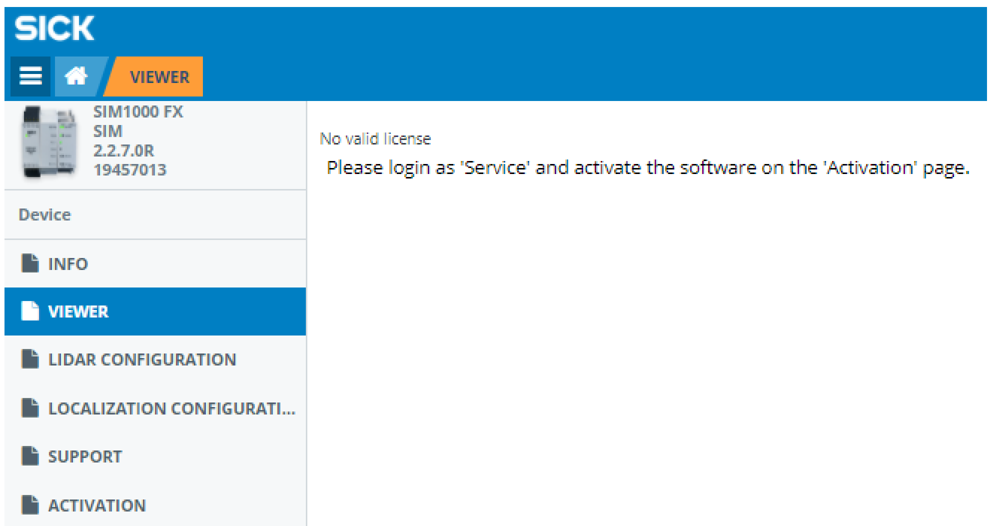


Figure 9: Example of an activation reminder

Prerequisites

- You have a valid Ticket ID from your purchase order. You may activate multiple licenses on different localization controllers with a single Ticket ID.
- Your host computer is connected to the internet.
- You are logged in into SOPASair.

Approach

1. In SOPASair, login as **Service**.
2. Open **Activation**.

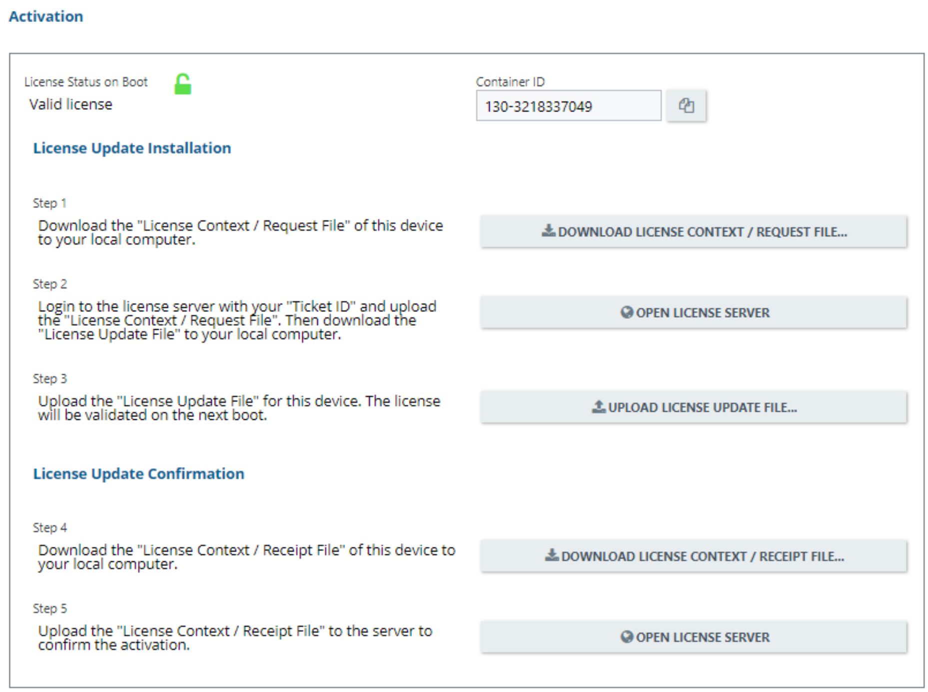


Figure 10: Opening the license activation page in SOPASair

3. In **Step 1**, click **Dowload License Context File...** .
✓ A license request file will be generated and downloaded (*.WibuCmRaC).
4. In **Step 2**, click **Open License Server** to open the SICK license server.
https://license.sick.com/
5. In the SICK license server, insert your personal **Ticket-ID** from your purchase order.

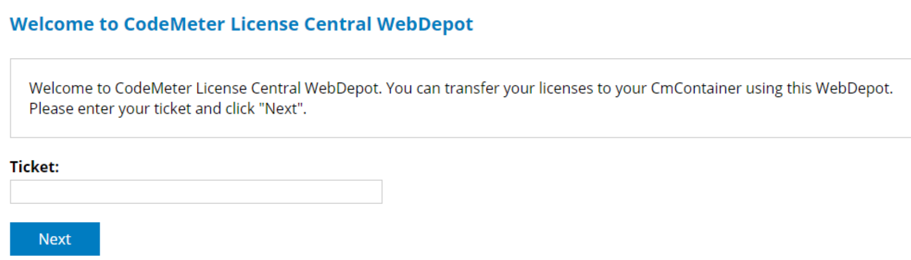
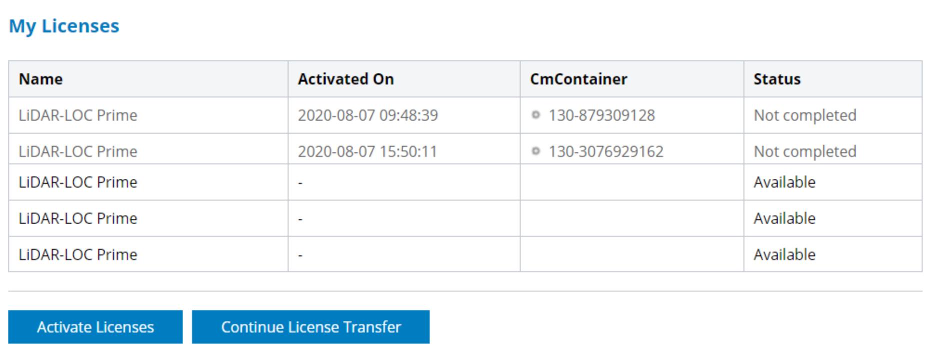


Figure 11: Logging into SICK license server

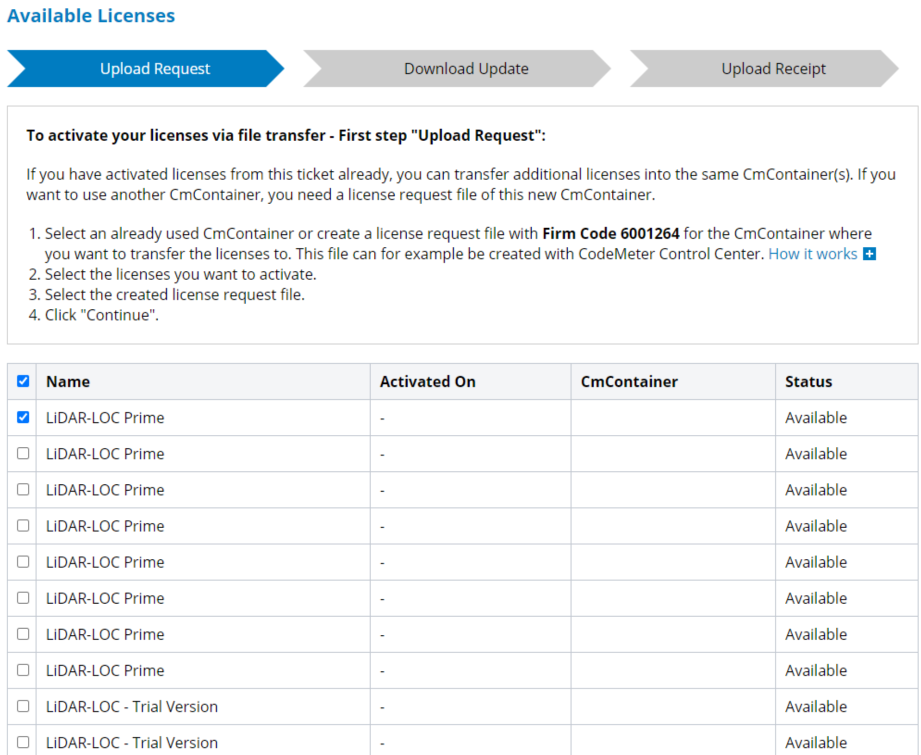
6. Click **Next.**
7. In the overview page, choose **Activate Licenses.**


My Licenses

Name	Activated On	CmContainer	Status
LiDAR-LOC Prime	2020-08-07 09:48:39	130-879309128	Not completed
LiDAR-LOC Prime	2020-08-07 15:50:11	130-3076929162	Not completed
LiDAR-LOC Prime	-		Available
LiDAR-LOC Prime	-		Available
LiDAR-LOC Prime	-		Available

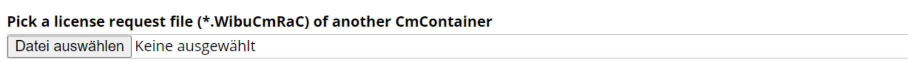
Activate Licenses | Continue License Transfer

8. In step **Upload Request**, select a single product you want to activate and de-select the others (here **LiDAR-LOC Prime**).



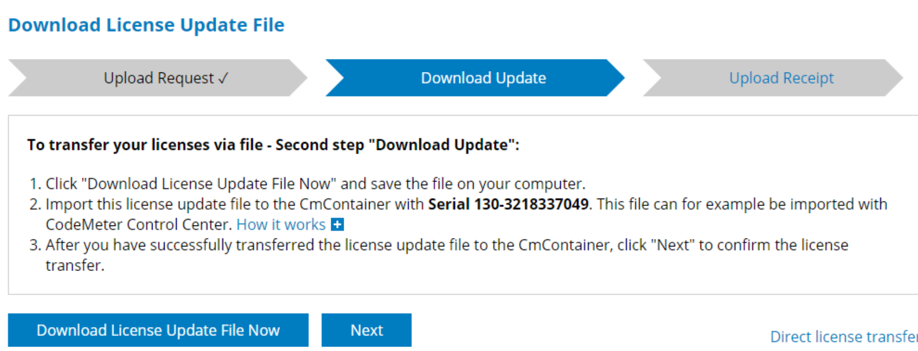
☑	Name	Activated On	CmContainer	Status
☑	LiDAR-LOC Prime	-		Available
☐	LiDAR-LOC Prime	-		Available
☐	LiDAR-LOC Prime	-		Available
☐	LiDAR-LOC Prime	-		Available
☐	LiDAR-LOC Prime	-		Available
☐	LiDAR-LOC Prime	-		Available
☐	LiDAR-LOC Prime	-		Available
☐	LiDAR-LOC Prime	-		Available
☐	LiDAR-LOC - Trial Version	-		Available
☐	LiDAR-LOC - Trial Version	-		Available

9. Upload the **license request file (*.WibuCmRaC)** which you have downloaded in SOPASair before.



10. Select **Start Activation Now.**

11. In step **Download Update**, click **Download License Update File Now.**



✓ A license update file will be generated and downloaded (*.WibuCmRaU).

12. In SOPASair **Step 3**, select **Upload License Update File...** and choose the previously downloaded file (*.WibuCmRaU).

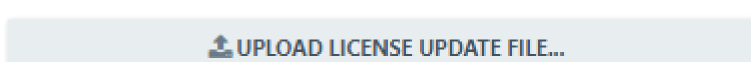


Figure 12: Uploading the license into SOPASair

13. To activate the license, you must restart the localization controller. In the following dialog, select **OK**.

Figure 13: Dialog: Reboot now

14. Wait until the LEDs indicate that the localization controller is online.
15. To see the new license status in the user interface, refresh your browser content (F5).
16. In SOPASair, check if the license is stored. Check the field **License Status on Boot**: it should display **Valid license**.

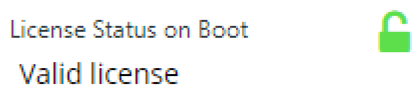
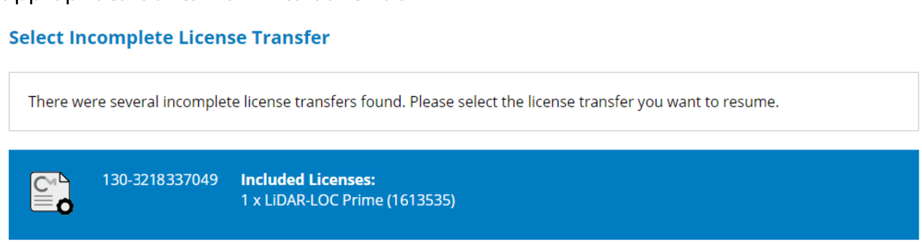


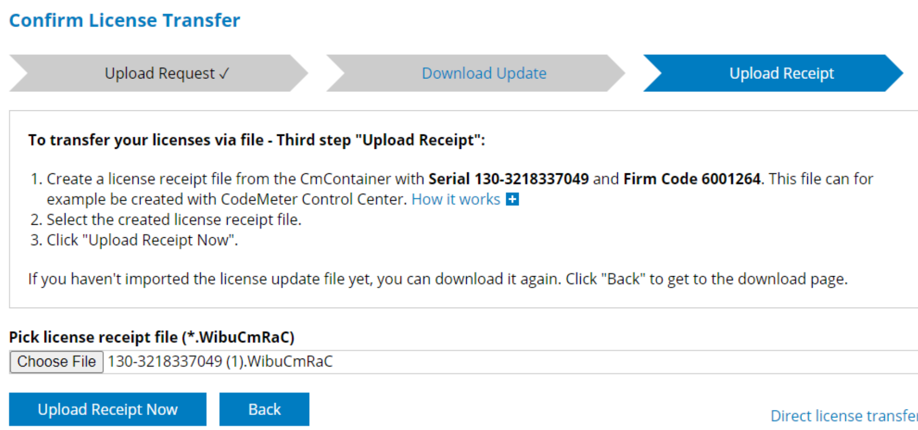
Figure 14: License status on boot: Valid license

NOTE
You can now generate a receipt that indicates that you have successfully activated the license. This allows you to revoke the license on an addressable device and use it on another device. If you do not need this feature, you can ignore the following steps.

17. To confirm the activation and to generate the receipt, in SOPASair, download the license request file (*.WibuCmRaC) again. To do so, in **Step 4**, click on **Download License Context File....**
18. Switch to the SICK license server.
19. Optional: If you have closed the SICK license server in the meantime, open it again by clicking in **Step 5** on **Open License Server.**
https://license.sick.com/
20. Optional: Log in with your Ticket ID.
21. Optional: Click on **Continue License Transfer.**
22. Optional: If you have several incomplete license activations pending, select the appropriate Container ID to continue.

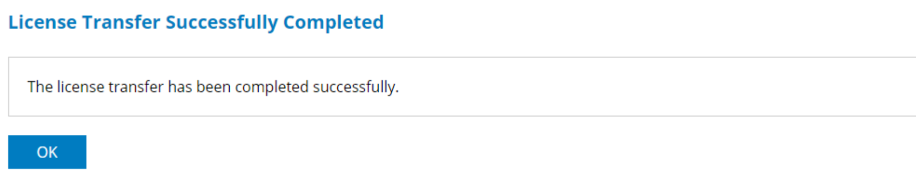


23. In the step **Upload Receipt**, choose the **license receipt file (*.WibuCmRaC)** that you have downloaded in SOPASair previously.



24. Select **Upload Receipt Now**.

✓ The activation of the license is confirmed.



Glossary

Table 6: Glossary licensing

Term	Example	Definition
CodeMeter Container		Container including all licenses activated on a specific hardware. Also CmContainer.
Container ID	130-3218337 049	Unique identification number that identifies the localization controller. Also CmContainer ID (CodeMeter Container ID).
License Context File	*.WibuCmRaC	Generic term for the identification file of a localization controller on which the software is to be activated. Examples are license request files or the license receipt files.
License Request File	*.WibuCmRaC	Identification file of a localization controller for the software activation.
License Receipt File	*.WibuCmRaC	Identification file of a localization controller used to confirm the software activation.
License Update File	*.WibuCmRaU	Hardware-bound license file to be uploaded to a localization controller.
SICK License Server		Web-interface from SICK that provides the user interface for the activation process. Also CodeMeter License Central WebDepot. https://license.sick.com/
Ticket ID	29AWT-*****-*****-*****-V8CHC	The Ticket ID is a unique code the user obtains after purchasing LiDAR-LOC. A Ticket ID can contain multiple licenses. Each license can be activated in the SICK license server. If you do not have a Ticket ID, please contact your local distributor.

Next steps

- "2D LiDAR sensor configuration", page 33

Further topics

- "Deactivate the software license", page 26
- "Updating the software", page 30
- "User groups", page 32

5.4 Deactivate the software license

Overview

An activated LiDAR-LOC license can be re-hosted for a hardware change in case of a defect localization controller, if the controller is still responding. In order to transfer the license to another localization controller, the license must be revoked. LiDAR-LOC can only be used again after reactivation.

Prerequisites

- You have a valid Ticket ID from your purchase order. You may activate multiple licenses on different localization controllers with a single Ticket ID.
- Your host computer is connected to the internet.
- You are logged in into SOPASair.
- LiDAR-LOC is activated.

Approach

1. In SOPASair, login as **Service**.
2. Open **Activation**.

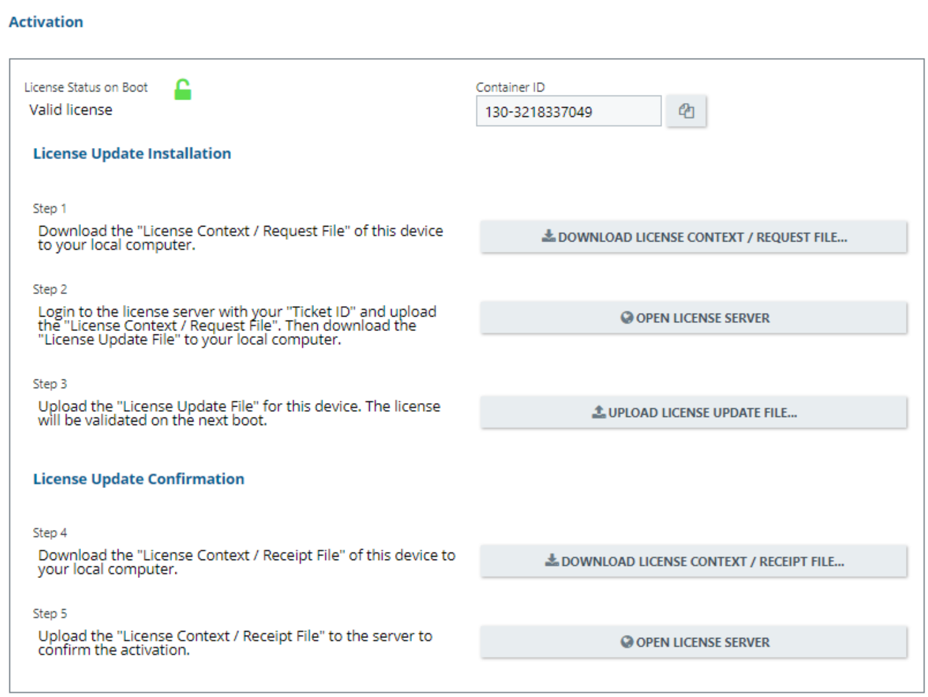


Figure 15: Opening the license activation page in SOPASair

3. In **Step 1**, click **Dowload License Context File...** .

✓ A license request file will be generated and downloaded (*.WibuCmRaC).

4. In **Step 2**, click **Open License Server** to open the SICK license server. https://license.sick.com/
5. In the SICK license server, insert your personal **Ticket-ID** from your purchase order.

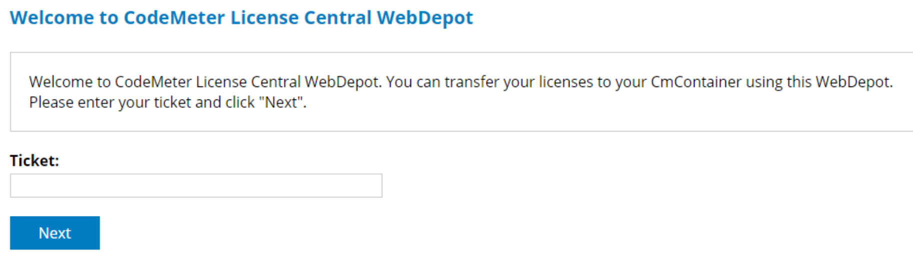
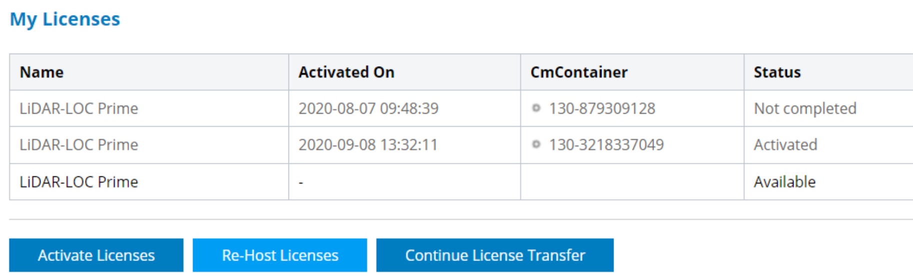


Figure 16: Logging into SICK license server

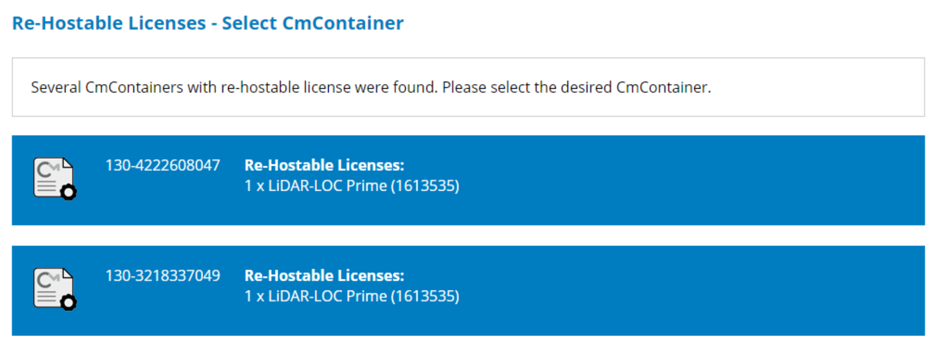
6. Click **Next**.
7. In the overview page, choose **Re-Host Licenses**.



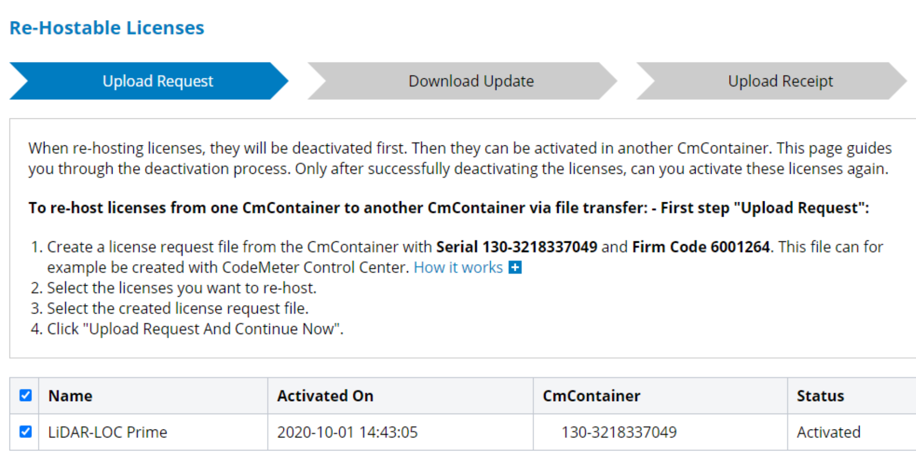
Name	Activated On	CmContainer	Status
LiDAR-LOC Prime	2020-08-07 09:48:39	130-879309128	Not completed
LiDAR-LOC Prime	2020-09-08 13:32:11	130-3218337049	Activated
LiDAR-LOC Prime	-		Available

Figure 17: Re-host license

8. Optional: If you have activated multiple licenses, select the appropriate Container ID.

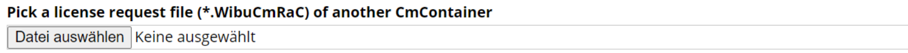


9. In step **Upload Request**, select your product you want to activate and de-select the others (here **LiDAR-LOC Prime**



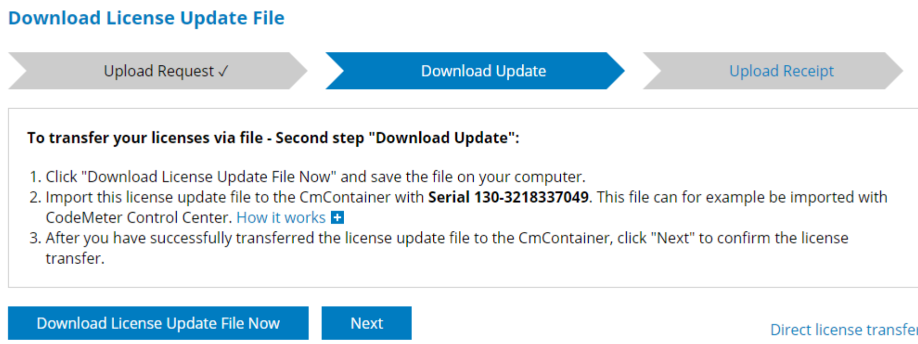
☑	Name	Activated On	CmContainer	Status
☑	LiDAR-LOC Prime	2020-10-01 14:43:05	130-3218337049	Activated

10. Upload the **license request file (*.WibuCmRaC)** which you have downloaded in SOPASair before.



11. Select **Upload Request and Continue Now**.

12. In step **Download Update**, click **Download License Update File Now**.



✓ A license update file will be generated and downloaded (*.WibuCmRaU).

13. In SOPASair **Step 3**, select **Upload License Update File...** and choose the previously downloaded file (*.WibuCmRaU).

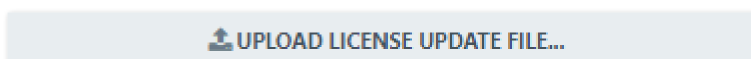


Figure 18: Uploading the license into SOPASair

14. To deactivate the license, you must restart the localization controller. In the following dialog, select **OK**.

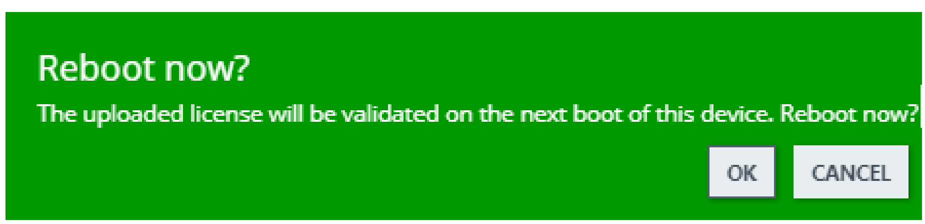


Figure 19: Dialog: Reboot now

15. Wait until the LEDs indicate that the localization controller is online.
16. To see the new license status in the user interface, refresh your browser content (F5).
17. In SOPASair, check if the license deactivation has been saved. Check the field **License Status on Boot**: it should display **No license saved** again.

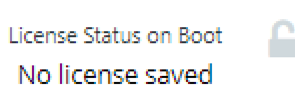
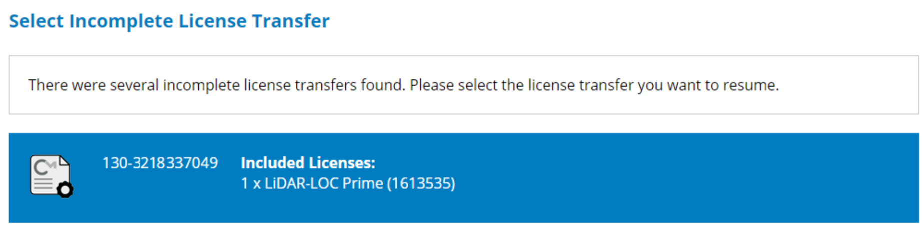
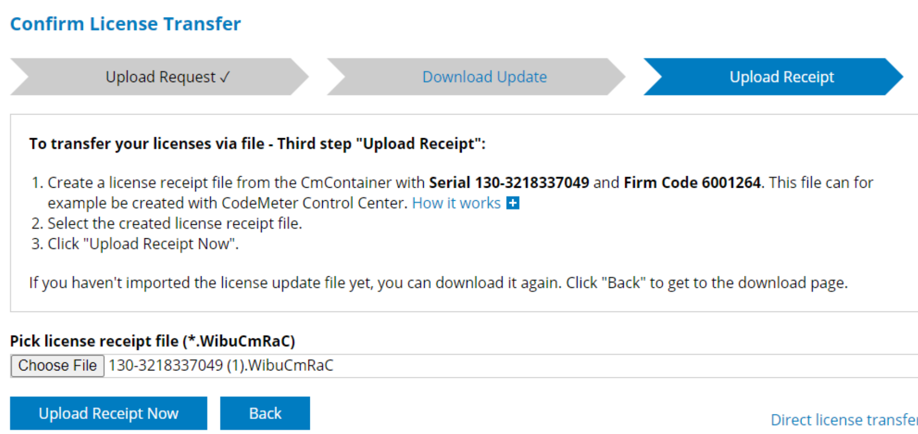


Figure 20: License status on boot: Invalid license

18. To confirm the deactivation and to generate the receipt, in SOPASair, download the license request file (*.WibuCmRaC) again. To do so, In **Step 4** (Schritt 4), click on **Download License Context File...**.
19. Switch to the SICK license server.
20. Optional: If you have closed the SICK license server in the meantime, open it again by clicking in **Step 5** on **Open License Server**.
    https://license.sick.com/
21. Optional: Log in with your Ticket ID.
22. Optional: Click on **Continue License Transfer**.
23. Optional: If you have several incomplete license deactivations pending, select the appropriate Container ID to continue.

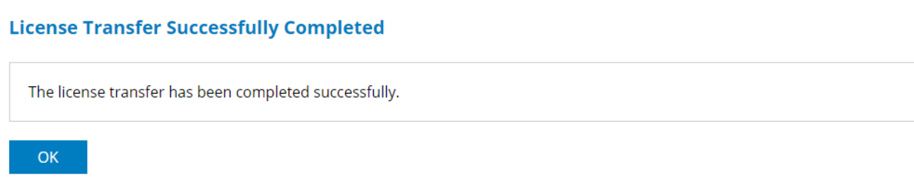


24. In the step **Upload Receipt**, choose the **license receipt file (*.WibuCmRaC)** that you have downloaded in SOPASair previously.



25. Select **Upload Receipt Now**.

✓ The deactivation of the license is confirmed.



Next steps

- "Activating the software", page 21

Further topics

- "User groups", page 32

5.5 Updating the software

Overview

SICK recommends that you regularly update LiDAR-LOC on the localization controller.

SICK supports only the latest software release which can be downloaded in Support Portal https://supportportal.sick.com/products/localization/lidar-localization/lidar-loc/ in section "Releases".

Prerequisites

- You are registered at the SICK Support Portal.
- You have downloaded the current LiDAR-LOC software package LLS-X.X.X.XR.spk from the SICK Support Portal.
- You have downloaded and installed the current SICK AppManager from the SICK website.
- The localization controller has a data connection to your desktop computer. Your desktop computer needs to be in the same subnetwork as the localization controller, for example, if the localization controller has the IP address 192.168.0.1, your computer's IP address has to be 192.168.0.X, where X is a number between 2 to 254.
- You are logged in into SOPASair.

Approach

1. In SOPASair, select **Info**.
2. In **LLS Version**, check if the software version of LiDAR-LOC is up-to-date.
3. In **Firmware Version**, check if the firmware version of the localization controller is up-to-date.

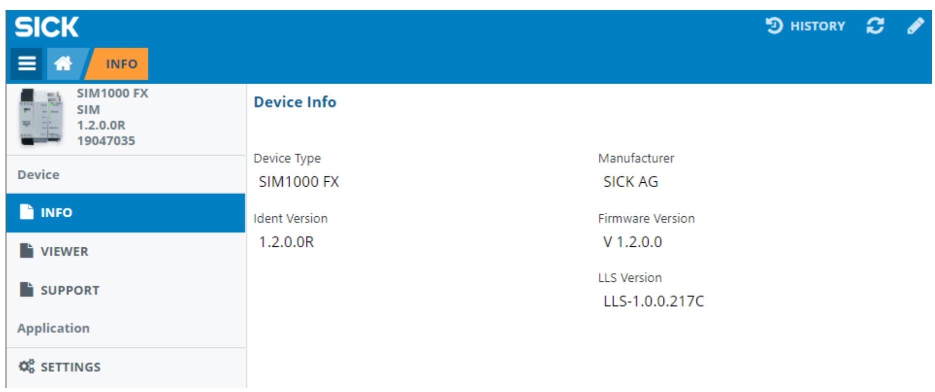


Figure 21: Checking software and firmware versions

4. Open the SICK AppManager.
5. In **Device search**, scan for devices and select the localization controller, for example, SIM1000 FX.
6. In **Device search**, select the localization controller on which you want to update LiDAR-LOC.
7. Drag and drop the file package LLS-X.X.X.XR.spk from the download folder to the **Firmware** tab.

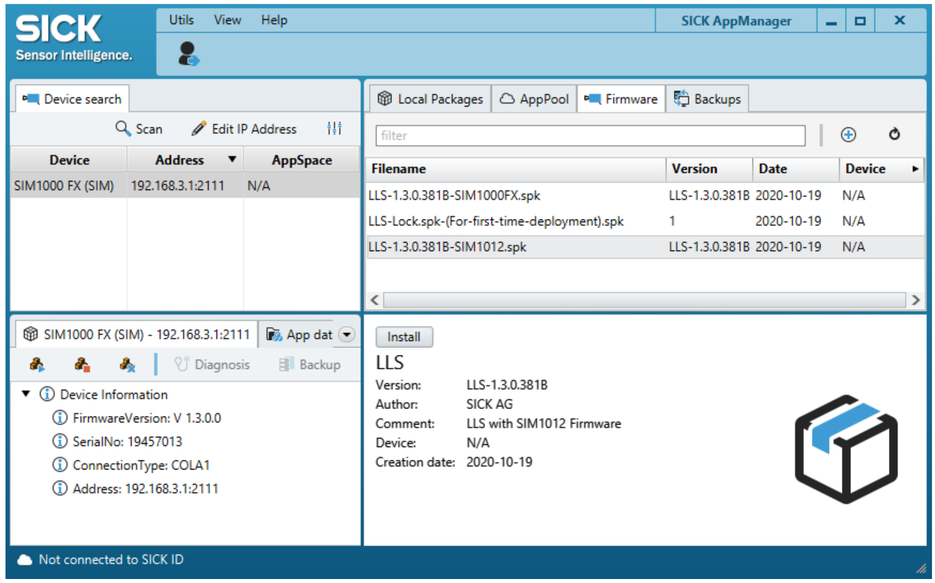


Figure 22: Installation of LiDAR-LOC with the SICK AppManager

8. Select **Install**.

✓ The SICK AppManager installs the software package LLS-X.X.X.XR.spk.

NOTE
If the SICK AppManager stops installation at 0 %, restart the SICK AppManager and repeat the installation process.

NOTE
If the installation continues to fail, copy all maps that you want to use from the localization controller to your desktop computer. Delete the maps from the localization controller and restart the installation process. Copy all maps back to the localization controller.

9. In SOPASair, open **Info**.
10. In **LLS Version**, check if the software version has been updated successfully.

Complementary information

- Download the firmware LLS-X.X.X.XR.spk and locking file LLSLock.spk here: **https://supportportal.sick.com/products/localization/lidar-localization/lidar-loc/**
- Download the SICK AppManager here: **https://www.sick.com/de/de/softwareprodukte/sick-appspace-software/sick-appmanager/c/g446551**

Next steps

- "Changing the user group", page 33

Further topics

- "Info window", page 17
- "SICK support and further services", page 90

6 Configuration and operation

6.1 Logging into SOPASair

Overview

To access the localization controller, you can use the user interface SOPASair on your computer, which is included in the LiDAR-LOC software package. In SOPASair, you can configure the 2D LiDAR sensor, set a map, activate/deactivate the localization or create a demo map.

Prerequisites

- You have set up the localization controller and LiDAR-LOC is deployed to the localization controller.

Approach

1. Open a web browser on your computer.
   SICK recommends using the Google Chrome browser.
2. In the address bar, enter the IP address of the localization controller.

NOTE
The default address of the SIM of Ethernet port 1 is 192.168.0.1.

✓ SOPASair opens and connects to the localization controller.

Next steps

- "Activating the software", page 21
- "Changing the user group", page 33

Further topics

- "Info window", page 17
- "Viewer window", page 13
- "User groups", page 32

6.2 User groups

LiDAR-LOC has user groups implemented which are based on the personnel qualifications.

Table 7: User levels

User level	Password	Authorization
Run (Standard)	–	See the user interface. Download application log files for service support.
Maintenance	main	All functions from user level **Run** and in addition: Load maps Initialize the pose Start and stop localization and demo mapping Enforce an update of the position
Service	servicelevel	All functions from user level **Maintenance** and in addition: Activate the software Edit the settings of the 2D LiDAR sensor Edit localization settings

6.2.1 Changing the user group

Overview

If you want to change the localization settings or configure the sensor(s), you must change the user group.

Prerequisites

- You are logged in into SOPASair.

Approach

1. To change the user group, select the button for the current level in the left lower corner. In the example, the user group is **RUN**.

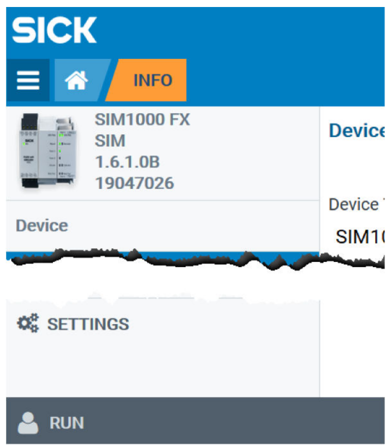


Figure 23: Changing the user level of SOPASair

✓ The login dialog opens.

2. Enter the credentials for the selected user group.
3. Select **Keep me logged in** if the user level should be stored remanent even after restart.

Next steps

- "Configuring the 2D LiDAR sensor", page 37

Further topics

- "User groups", page 32
- "Logging into SOPASair", page 32

6.3 2D LiDAR sensor configuration

2D LiDAR sensor configuration

Before you start to localize on your site, you can check and adjust the sensor settings. You can connect multiple 2D LiDAR sensors to the localization controller. For each sensor, you enter the IP address and port number, specify the mounting position of the sensor on the automated guided vehicle (AGV), and adjust the scanning range and angle to scan.

NOTE
Deactivate the localization to access the LiDAR sensor configuration.

You can find the settings here: Main screen > LiDAR Configuration > {selected sensor}.

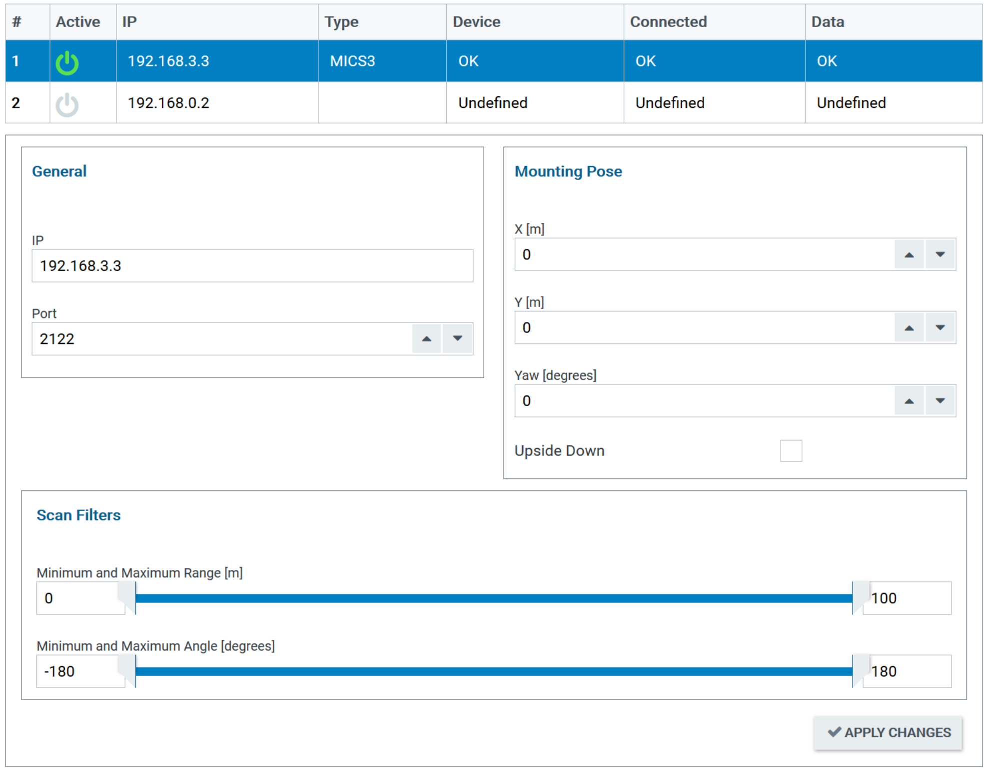


Figure 24: Window LiDAR configuration

Sensors

#	The number of the sensor.

NOTE
The first sensor is always active and cannot be deactivated. If only one sensor is used, it must be configured in the first line.

Active
The activation state of the sensor.
(The description about the sensors connection state is provided below)

- Green: Sensor is active and is used for localization.
- Gray: Sensor is inactive and is not used for localization.

IP
The IP address of the sensor.

Type
The sensor model type. In the example, MICS3 stands for the sensor type microScan3.

Device
The sensor state.

- ERROR (0): Sensor is not supported.
- UNDEF (1): LiDAR-LOC is unable to receive type information. This may be caused by a lost physical connection or wrong parameters.
- OK (2): Sensor communication is established.

Connected
The connection state of the sensor.

- ERROR (0): Localization controller connected to the sensor, but device could not be started.
- UNDEF (1): Connection state between localization controller and sensor is unknown. This may be caused by a lost physical connection or wrong parameters.
- OK (2): Device started successfully.

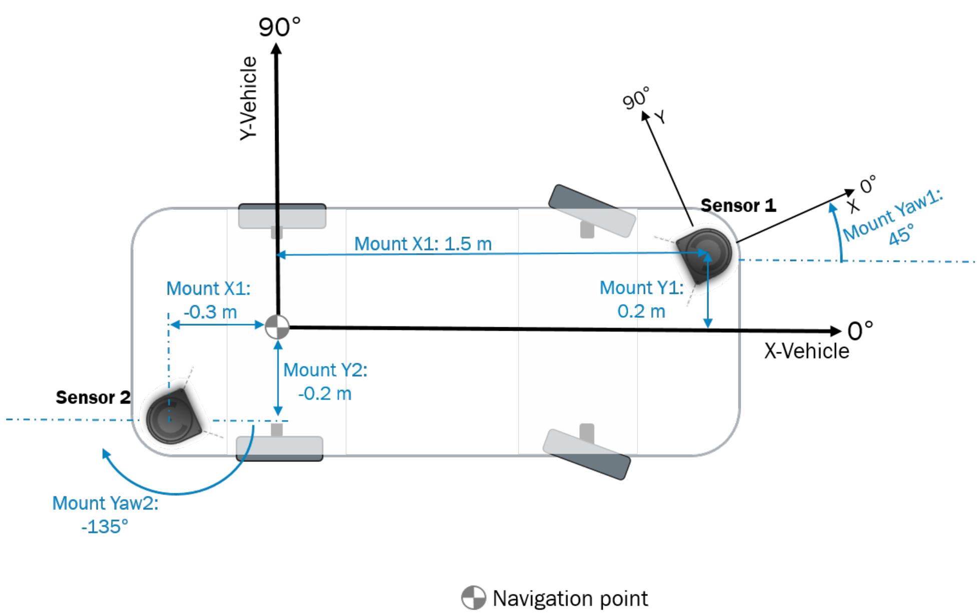
Data	The ability of the localization controller to receive data from the sensor. • ERROR (0): Sensor started successfully but the localization controller is not receiving scan data. • UNDEF (1): Connection of the sensor is unknown. This may be caused by a lost physical connection or wrong parameters. • OK (2): Localization controller is receiving scan data from the sensor.
Apply changes	Select to apply all current settings to the sensor.

General

IP	Enter the IP address of the selected sensor.
Port	Enter the port number of the selected sensor.
Apply changes	Select to apply all current settings to the sensor.

Mounting position

In general, the mounting position of the sensor is not identical with the navigation point of the vehicle. Except that, the sensor is mounted on top of the vehicle, right above the navigation point. In this case, the mounting pose remains X = 0, Y = 0, Yaw = 0.



If the mounting position is not included in the calculation of the localization, the localization results, wrongly, refer to the sensor's origin coordinates and not to the vehicle's navigation point.

To include the offset of the mounting into the calculations, you enter the distances in meters and the yaw, which represents the deviating sensor orientation, in degrees.

X [m]	Enter the sensor's offset from the X-axis of the navigation point in meters.
Y [m]	Enter the sensor's offset from the Y-axis of the navigation point in meters.
Yaw [degrees]	Enter the sensor's orientation if it deviates from the X-axis of the navigation point in degrees. The possible range of the angle is -180° to +180°.

Upside Down	Check the box if the sensor is mounted upside down. This setting does not revert the sensor's coordinate system, but it converts the scan data for the software.
Apply changes	Select to apply all current settings to the sensor.

Scan Filters

To prevent the sensor from scanning the vehicle on which it is mounted, you can set a scanning range and angle. The scanning range determines the minimum and maximum distance of scan points considered within the localization.

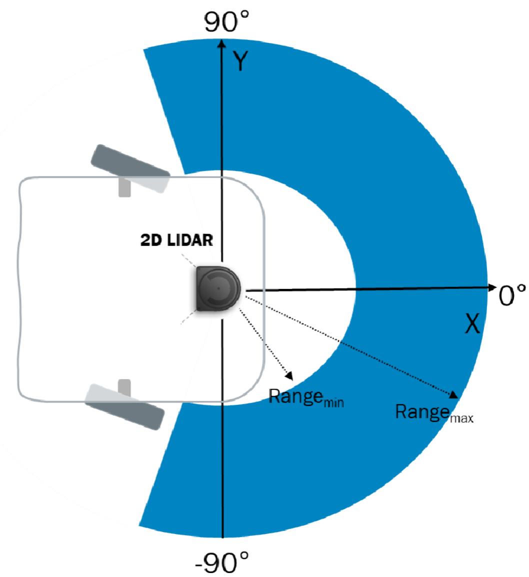


Figure 25: Scanning range

By default, the software uses the full scanning angle of the corresponding sensor. To account for visual obstructions, for example the edges or tires of the vehicle, you can reduce the scanning angle.

NOTE

The more the sensor's field of view is restricted, the more difficult it is for the software to localize itself. Therefore, set the scan filters according to the sensor's environment. To reach the full accuracy that is stated in the technical data, set a scanning angle above 220°. Lower values are possible but can cause localization instability.

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

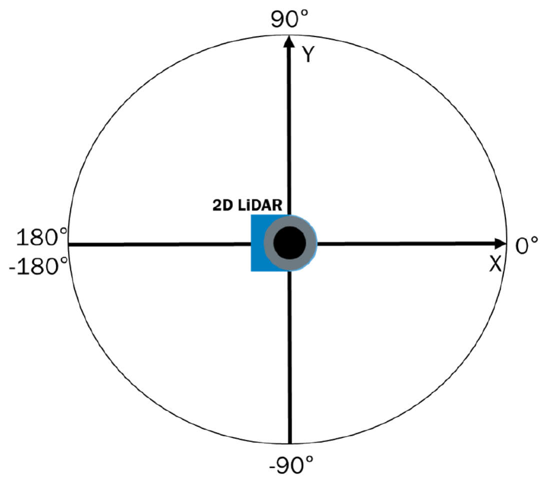


Figure 26: Coordinate definition for all LiDAR sensors

Minimum and maximum range [m]	Use the sliding scale to set the scanning range. Alternatively, enter the values in meters. The maximum scanning distance is 100 meters.
Minimum and maximum angle [degrees]	Use the sliding scale to set the scanning angle in degrees.
Apply changes	Select to apply all current settings to the sensor.

Further topics

- "Configuring the 2D LiDAR sensor", page 37
- "About CoLa-A telegrams", page 70

6.3.1 Configuring the 2D LiDAR sensor

Overview

Before you start to localize on your site, you can check and adjust the sensor settings. You can connect multiple 2D LiDAR sensors to the localization controller. For each sensor, you enter the IP address and port number, specify the mounting position of the sensor on the automated guided vehicle (AGV), and adjust the scanning range and angle to scan.

Prerequisites

- The 2D LiDAR sensor(s) are connected to the localization controller and has/have been installed on the AGV.
- The user level **Service** is selected.

Approach

1. In SOPASair, open **Viewer**.
2. Make sure that **Localization** is **Off**.
3. Open **LiDAR configuration**.
4. Select the first sensor in the list.

✓ All setting panels open.

5. Configure the settings for the sensor:
   - **General:** IP address and port number of the sensor.
     CoLa-2 (Safety laser scanners): 2122
     CoLa-A (non-safe 2D LiDAR sensors): 2111 or 2112

  - **Mounting pose**: sensor's offset from the navigation point of the vehicle on the X-axis and Y-axis of the navigation point. Also, sensor orientation from the X-axis of the navigation point.
  - **Scan filters**: scanning range and scanning angle according to your vehicle and surrounding conditions.
6. If you use more than one sensor, select the next sensor you want to configure and activate it.

NOTE
The first sensor is always active and cannot be deactivated. If only one sensor is used, it must be configured in the first line.

7. Select **Apply changes**.

✓ The sensor settings are stored and applied.

Complementary information

Configuring the 2D LiDAR sensor is only possible in user level **Service** or higher.

Next steps

- "Creating a demo map", page 39 (only for testing)
- "Creating a reference map", page 41

Further topics

- "2D LiDAR sensor configuration", page 33
- "Creating a reference map", page 41
- "About maps", page 38
- "About localization", page 44

6.4 About maps

Overview

To localize the automated guided vehicle (AGV) in an environment, LiDAR-LOC needs a reference map of the surroundings. The reference map is a two-dimensional contour map of the environment in which the AGV is used.

Mapping process

To measure the surroundings of the site, the sensor collects so-called scan points. The sensor receives these scan points by scanning its surroundings with laser beams. When the light of the laser beams strikes an object, the light is reflected. The sensor receives the reflected light and calculates the distance to the object based on the time interval between the moment of transmission and the moment of receipt. These calculated distances, or scan points, form the contour on the reference map.

Figure 27: Example of reference map

During localization, LiDAR-LOC uses the reference map to determine the position of the vehicle by matching scan points to the contour of the reference map.

Complementary information

You can create your own reference map with the SICK Map Engineering Tool (SMET).

SICK service can support you and create a reference map for you.

Further topics

- "SICK support and further services", page 90
- "About localization", page 44
- "About pose accuracy", page 42
- "About Dynamic Environment Handling", page 42

6.4.1 Creating a demo map

Overview

To visualize the features of LiDAR-LOC and to test its functionalities on site, you can create a demo map of the surroundings. The demo map is limited to an area of ±20 meters in the X and Y direction from the start point.

Important information

NOTICE
You cannot use the demo map for operation, since the used algorithm doesn’t optimize the map. If you do not have a reference map of your site, contact SICK service or create your own reference map with SMET (SICK Map Engineering Tool) for high accuracy localization.

Prerequisites

- The 2D LiDAR sensor(s) are connected and integrated to the localization controller and has/have been installed on the AGV.
- The localization controller receives scan data from the 2D LiDAR sensor.

Approach

1. In SOPASair, open **Viewer**.
2. Make sure that **Localization** is **Off**.
3. Make sure that **Current state** is **Idle**.
4. In **Demo Mapping**, select **On**.

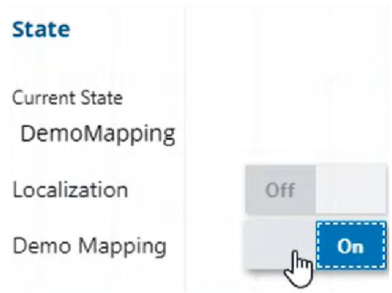


Figure 28: Activate demo mapping

5. Move the AGV with the sensor around the area of which you want to create a demo map.

✓ The sensor adds all scan points to a map.

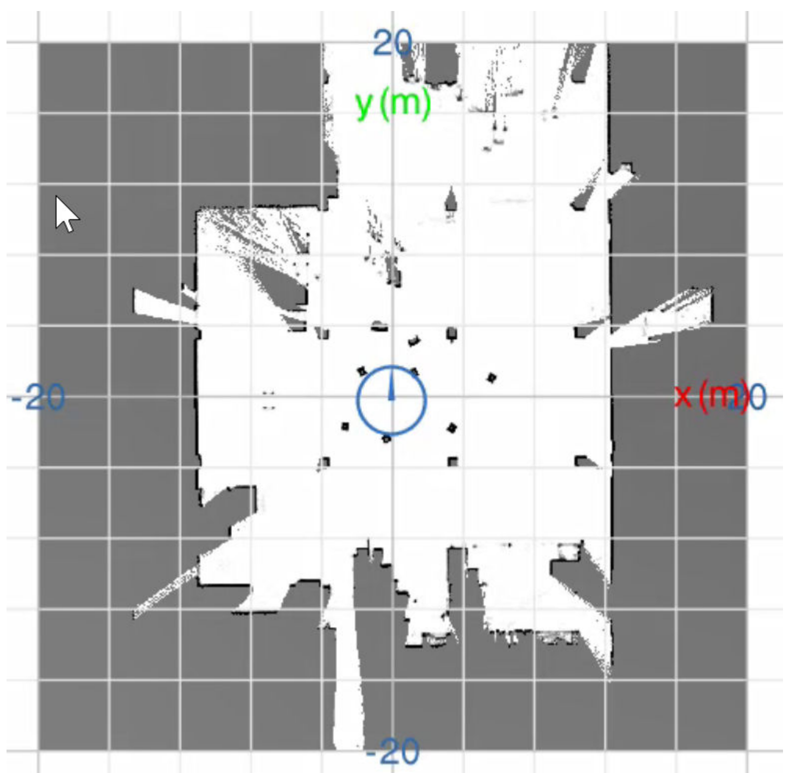


Figure 29: Example of a demo map

6. Once the map covers the region that you want to localize in, turn off **Demo Mapping** by selecting **Off**.

✓ LiDAR-LOC automatically stores the demo map on the localization controller. The system is ready for localization.

Next steps

- "Setting the initial pose manually", page 50

Further topics

- "About maps", page 38
- "About localization", page 44
- "Viewer window", page 13

6.4.2 Creating a reference map

Overview

To localize the automated guided vehicle (AGV) in an environment, LiDAR-LOC needs a reference map of the surroundings. The reference map is a two-dimensional contour map of the environment in which the AGV is used.

You can create your own reference map with the SICK Map Engineering Tool (SMET). For this, SMET is used to record sensor data of the environment during a reference run first. Then SMET processes the data with automatic software functions to generate a map. For more information on how to create a reference map, refer to the operating instructions of SMET.

Complementary information

SICK service can support you and create a reference map for you.

Next steps

- "Deploying a reference map to the localization controller", page 41

Further topics

- "About maps", page 38
- "SICK support and further services", page 90
- "About localization", page 44

6.4.3 Deploying a reference map to the localization controller

Overview

Before you can start localizing, you must transfer the reference map of your site to the localization controller with an FTP client.

Prerequisites

- A reference map has been created and is stored on your desktop computer.
- An FTP client is installed on your desktop computer, for example, FileZilla.

Important information

NOTE

File names should not contain language-specific characters, for example 'äöü' or sign language, for example Japanese '本'. This causes the data transfer to fail.

Alpha numerical characters and common special characters like blanks, underscores, minus, ... can be used.

Approach

1. Open the FTP client on your desktop computer.
2. In the login field of the FTP client, enter the connection information for the localization controller.

Figure 30: Login field of the FTP client - maps

The localization controller uses the following default values for FTP connections to the **maps** directory:

- Host: IP address of the localization controller, default of the SIM of Ethernet port 1 is 192.168.0.1
- Username: maps
- Password: client
- Port number: 2300

3. Connect the FTP client to the localization controller. In Filezilla, you select Quickconnect.
4. Select the reference map you want to use and upload it.
   In Filezilla, in the desktop computer's directory you right-click the reference map and select **Upload**.

✓ The reference map is deployed to the controller and can be displayed on the **Viewer** window in SOPASair.

Next steps

- "Starting the localization", page 46

Further topics

- "About maps", page 38

6.5 About Dynamic Environment Handling

About Dynamic Environment Handling

The LiDAR-LOC feature Dynamic Environment Handling (DEH) ensures a stable free localization over an extended period of time. The system detects deviations of the contour from the reference map. This ensures a stable localization, if the environment changes modestly over time.

Further topics

- "SICK support and further services", page 90
- "About localization", page 44
- "Deploying a reference map to the localization controller", page 41

6.6 About pose accuracy

About pose accuracy

The operating conditions and the surroundings of the AGV can influence the pose accuracy of LiDAR-LOC and the scan data.

To achieve high pose accuracy in LiDAR-LOC, you should consider these aspects and eliminate as many interfering factors as possible:

- Limited visual range caused by vehicles, persons and objects.
  - The LiDAR scan data of all sensors combined shall at least detect 60 % of the static mapped surrounding contour. The map produced during commissioning should include structures in the direction of motion as well as transverse direction. The scans measured during operation should be able to reproduce these structures. Localisation might also be possible with less than 60 % detected contour. However, this must be tested in each individual environment.
  - When you follow a vehicle, keep some distance or use an additional sensor which is facing a different direction.
  - Adjust the scan filter to exclude any static parts of the vehicle, which are in the sensor's field of view.
- The configuration of the vehicle
  - Eliminate inaccuracies in the settings for the mounting pose.
  - Ensure that you use a suitable sensor type for your application. Use a 2D LiDAR sensor with high values for accuracy, range, resolution, and cycle time to improve the accuracy of the overall system. (Data sheet)
  - To increase the accuracy and robustness of the localization, a field of view of 360° from all LiDAR sensors combined is recommended. If necessary, use several LiDAR sensors to achieve a maximum field of view of 360°.
  - The field of view of all LiDAR sensors together must be at least 200° to operate LiDAR-LOC reliably.
  - It is recommended to use additional odometry components to further increase the reliability of the localization. (About odometry for support)
- The speed and acceleration of the vehicle, particularly rotational speed and acceleration
  - Keep the speed below the specified values of 3 m/s translational and 45 °/s rotational velocity.
  - Try to reduce acceleration.
- The distance between the vehicle and the contour
  - Let the vehicle move along a wall at a minimum distance of 1 m and at a maximum distance of 15 m. Greater distances are possible but can reduce accuracy.
- Visual impairments, for example fog or dust
  - Only use LiDAR-LOC indoors.
  - Use LiDAR-LOC in clean and dust-free environments.
- Uneven areas, ramps or bumps in the route
  - Mark ramps with additional sensors (RFID, 1D or 2D barcodes, etc.) and change the map when the vehicle reaches a different vertical level.
  - Try to avoid bumpy routes.
- Changes to the surroundings, including temporary obstructions or changes (for example, boxes, containers, pallets, and doors) and permanent obstructions or changes (for example, newly-built racks or walls)
  - LiDAR-LOC comes with a feature called Dynamic Environment Handling (DEH), which makes it possible to respond to changes in the environment. However, if there are too many changes, LiDAR-LOC can lose the pose.
  - Level your sensor scan field and adjust mounting pose parameters.

Complementary information

Find the specifications for pose accuracy in the technical data.

Further topics

- "About localization", page 44
- "About Dynamic Environment Handling", page 42
- "Configuring the 2D LiDAR sensor", page 37
- "2D LiDAR sensor configuration", page 33

6.7 About localization

Overview

During localization, LiDAR-LOC locates the automated guided vehicle (AGV) on the reference map with a 2D LiDAR sensor and sends the AGV's current position to the external vehicle controller. This process is repeated continuously during localization.

Localization process

LiDAR-LOC is a software for determining the position of automated guided vehicles (AGVs). LiDAR-LOC calculates the positions based on contour data. The sensor detects this contour data and the localization controller compares the data to a reference map. The reference map has an absolute coordinate system. The result of the continuous position calculation are poses in X, Y, and yaw. The poses are represented in the map's coordinate system and sent to the vehicle controller. This whole process is called localization.

The vehicle controller has the purpose to direct the AGV along a programmed route with the pose information sent by LiDAR-LOC. This makes localization a part of the site's overall navigation system.

figure 31 illustrates the localization process.

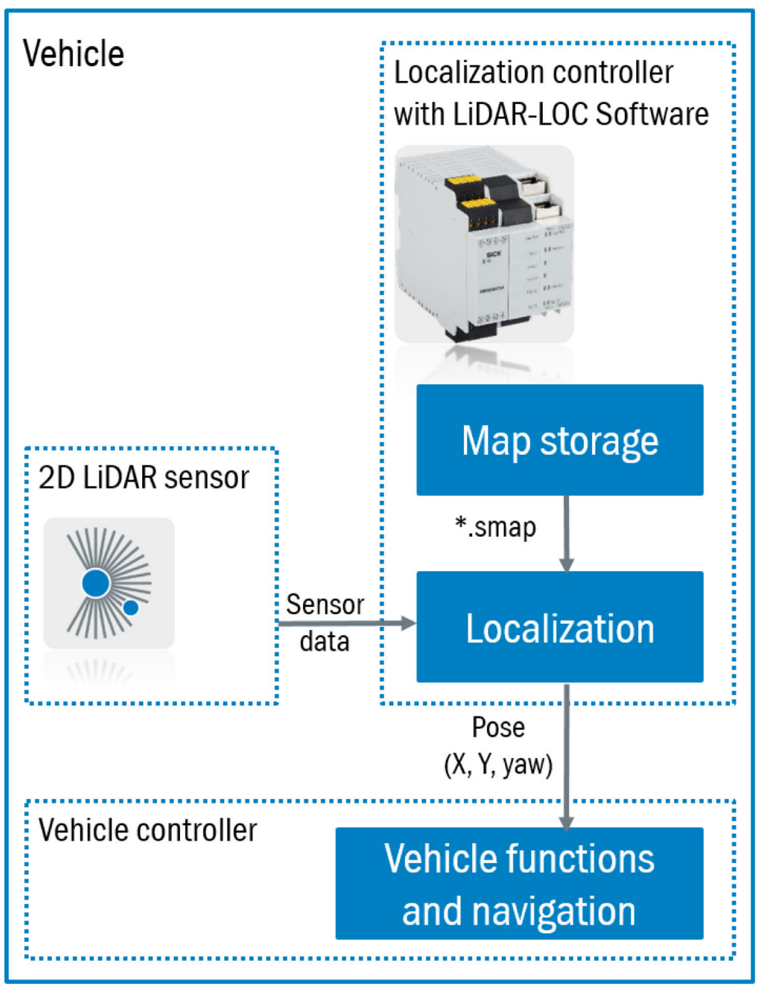


Figure 31: System overview for the integration of LiDAR-LOC

Pose quality

The pose quality of the localization indicates how stable the localization is currently running. The localization controller continuously returns this value during localization. Its value ranges from 0 to 100.

NOTICE
If wrongly initialized as described in "About initial positioning", page 46, the quality value could be high even so the pose is wrong. This is an effect of an ambiguous environment.

The following criteria are used as parameters to calculate the pose quality:

- Covariance of the particle filter
- Outlier ratio: Proportion of measuring beams that cannot be assigned to the contour points of the map (pixels). This means the pose quality is updated with each new scan.
  - Low value: Most current measurement data hits objects that are included in the map.
  - High value: Many of the objects currently being detected by the sensor have not been entered in the reference map.
- Proportion of measuring beams that detect reflectors that cannot be assigned to the reflectors on the map.

There are two values (sensitive and moderate) separately output for the pose quality in the result port (see "Payload of the result port telegram", page 77).

- sensitive: Deviations of the current LiDAR sensor data from the mapped contour and reflectors have a stronger effect on the sensitive pose quality. The value adapts more quickly to external influences, that is, the pose quality can fall as well as rise faster.
- moderate: Deviations of the LiDAR sensor data from the mapped contour and reflectors affect the moderate pose quality more slowly and, with short-term changes, to a lesser extent.

As an alternative to the pose quality, you can set your own quality criteria using the parameters that the result port transmits.

NOTE
The pose quality does not show the accuracy of the pose.

The following ranges can be used for orientation:
- High level of accuracy: typically 80 ... 100
  A high level of accuracy requires optimum application conditions.
  For accurate localization, as defined in the data sheet, the average value should stay above 80.
- Stable localization: typically 60 ... 100
  Stable localization means that an unambiguous and reliable position can be detected. For stable localization, the average quality value should stay above 60.

NOTE
These ranges do not apply to initialization. During initialization, the value is usually lower but should stabilize after moving the vehicle for a few meters. Individual outliers should be observed, but should not cause immediate reaction.

Complementary information

Before you start localizing, make sure that the reference map of your site is loaded in LiDAR-LOC. If you do not have a reference map, you can create one yourself with the SICK Map Engineering Tool (SMET) or you can contact SICK service.

Further topics

- "About maps", page 38
- "Creating a reference map", page 41
- "About pose accuracy", page 42
- "About Dynamic Environment Handling", page 42
- "About initial positioning", page 46
- "Setting the initial pose manually", page 50
- "About result port telegrams", page 75
- "SICK support and further services", page 90

6.7.1 Starting the localization

Overview

During localization, LiDAR-LOC locates the automated guided vehicle (AGV) on the reference map with a 2D LiDAR sensor and sends the AGV's current position to the external vehicle controller.

Approach

1. In SOPASair, open **Viewer**.
2. Make sure that reference map of the environment in which you want your vehicle to be localized is loaded.
3. In Localization, select **On**.

✓ The sensor starts scanning the environment. Based on the current scan data, LiDAR-LOC continuously calculates the pose of the vehicle and sends it to the vehicle controller.

4. To stop the localization, select **Off**.

Complementary information

- Corresponding CoLa-A command: LocStartLocalizing

Next steps

- "Setting the initial pose manually", page 50
- "Setting the initial pose automated", page 52

Further topics

- "About maps", page 38

6.8 About initial positioning

Initial pose

When the localization mode is activated, you must one-time initialize the pose of the automated guided vehicle (AGV) with respect to the coordinate system of the reference map. The localization controller needs this information:

- Current position (X, Y)
- Orientation (yaw)
- Position uncertainty (standard deviation of X and Y)

Use cases

You must transmit the current position and orientation of the AGV on the reference map to the localization controller in the following situations.

- You are setting up the localization controller for the first time.
- You have loaded a demo map.
- You have loaded a new reference map, for example, because you reached an adjacent area.
- You want to chang the start position of the AGV on the reference map manually, for example, after maintenance or manual movement of the AGV.

NOTE

- For productive operation, use the function Automatic Start (About automatic start). This way it is not necessary to set the pose.
- The initial pose can be set manually or automatically. The manual initialization is recommended if the vehicle is moving while setting the pose. When stationary, an automated initialization is recommended.

Position uncertainty of X and Y

The X and Y position of the vehicle is defined with respect to the reference map's global coordinate system. This position is further parameterized by the uncertainty. Assuming an initial normal distribution around the given position, the position uncertainty value specifies the standard deviation for both X and Y.

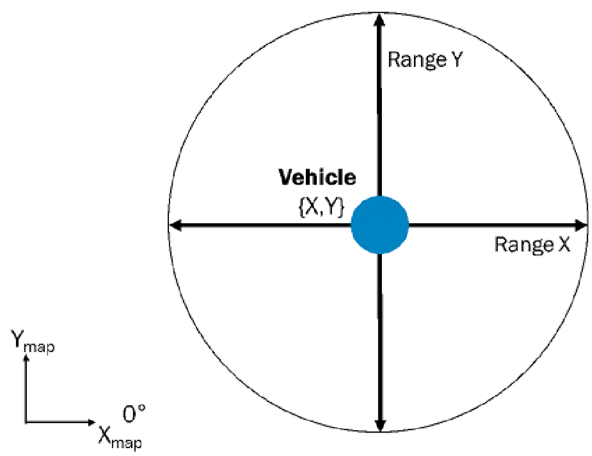


Figure 32: Position uncertainty range

The specified position must correspond with the current position of the AGV in the reference map's coordinate system. The specified position should be within an uncertainty range of ± 5 m and ± 10° from the actual position and orientation. Depending on the environment, it may be necessary to specify an initial position with a higher accuracy.

Further topics

- "About localization", page 44
- "About pose accuracy", page 42
- "About automatic start", page 54
- "Environment dependent configurations", page 48
- "Setting the initial pose manually", page 50
- "Setting the initial pose automated", page 52

6.8.1 Environment dependent configurations

Overview

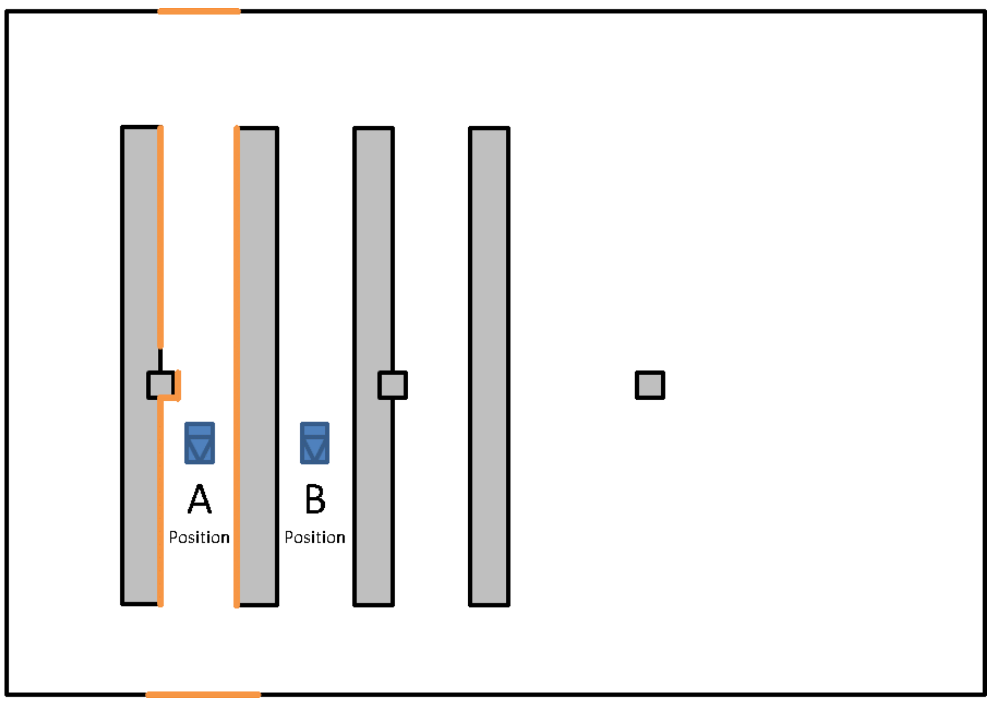
During initial positioning, there are different requirements for the uncertainty range, which depend on the surroundings.

The following section describes set-ups for which you should increase the accuracy of the initial position and hold the uncertainty range below an individual minimum.

Example of a wrong initial position

The vehicle is located at position A.

The sensor detects the contour, which is marked in orange, as scan data.

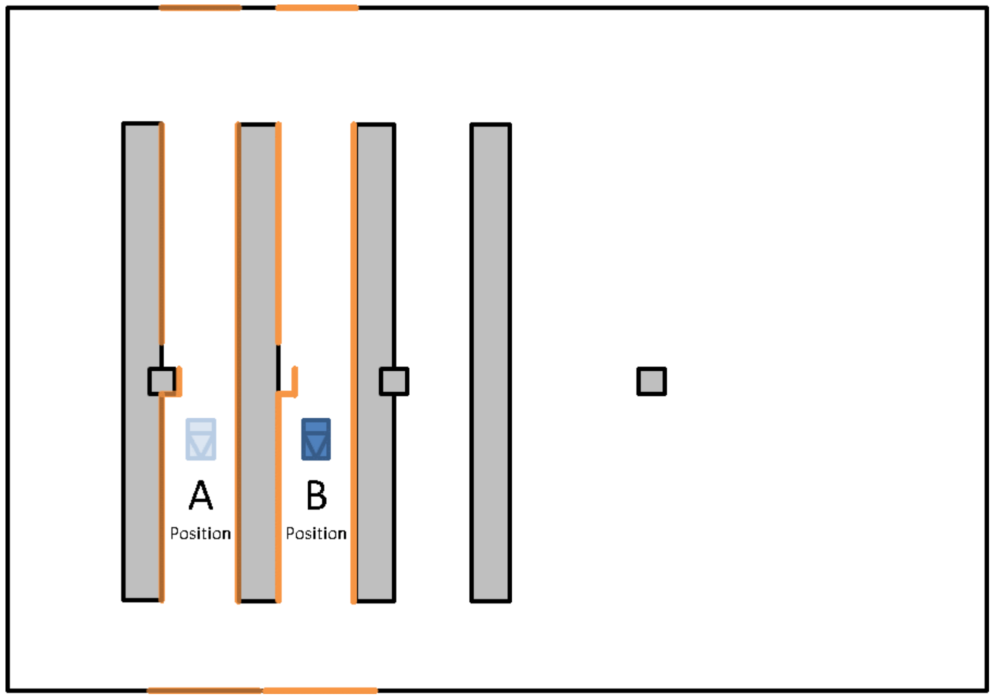


Problem

The vehicle is at position A but during initial localization, position B is falsely entered as the initial position or the uncertainty when entering positon A was chosen to high.

The measured contour of the 2D LiDAR sensor matches to the values for position B on the reference map.

Result: The system is localized to position B.



Solution

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

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

Examples of repeated column grids

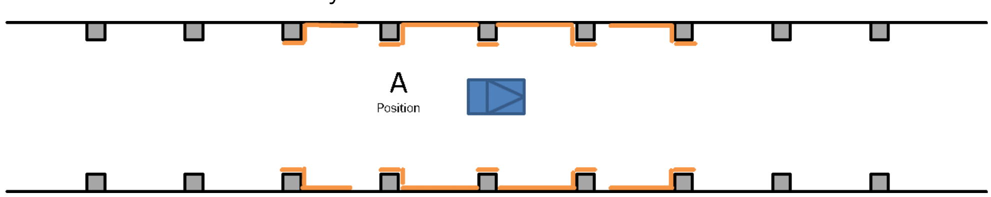
In the following situations, you must also ensure that the initial position is accurate enough due to the repeating surrounding structure.

Situation 1

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

Problem

The walls cannot be measured at the front and rear since they are outside of the range of the sensor. The sensor only receives the contour located on the side as scan data.



Solution

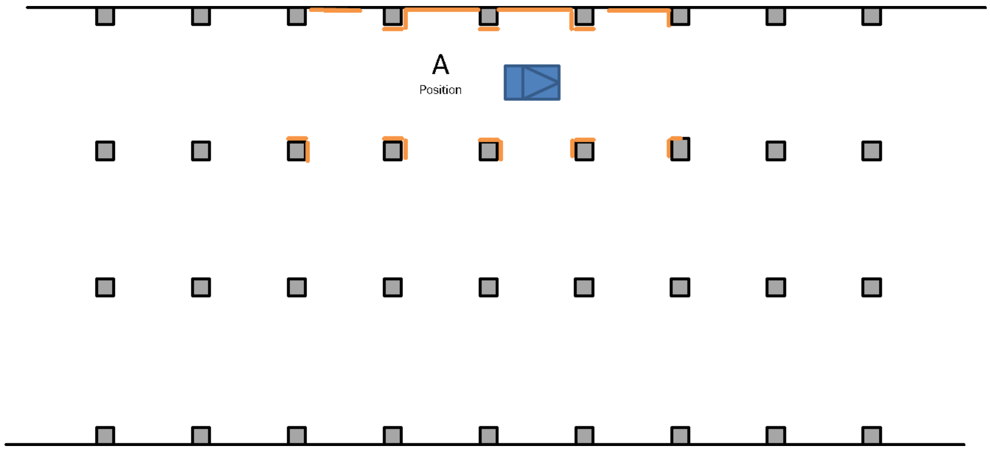
The uncertainty range must not exceed the grid dimensions of the columns grid: the uncertainty range equals the column distance.

Situation 2

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

Problem

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



The uncertainty range must not exceed the grid dimensions of the columns grid: the uncertainty range equals the column distance.

Next steps

- "Setting the initial pose manually", page 50
- "Setting the initial pose automated", page 52

Further topics

- "About localization", page 44
- "About pose accuracy", page 42

6.8.2 Setting the initial pose manually

Important information

CAUTION
Danger of collision

When localizing from the initial position, the vehicle may collide with persons or obstacles in the localization area.

▶ Ensure that a safety system is implemented in the vehicle to avoid collisions.

Prerequisites

- A reference map is created and stored on the localization controller.
- The 2D LiDAR sensor(s) are connected and integrated to the localization controller and has/have been installed on the AGV.
- The localization controller receives scan data from the 2D LiDAR sensor.
- The user level **Maintenance** or higher is selected.
- Localization is started.

Approach

1. In SOPASair, open **Viewer**.
2. Select the reference map in the drop-down list.
3. Select the localization pin button.

Figure 33: Localization pin button

✓ The vehicle symbol turns red and initial localization is initiated.

4. Move the mouse pointer to the position on the map where you assume the vehicle to be positioned.
5. Click and hold your left mouse button and draw a circle to where you estimate the position and orientation of the vehicle to be.

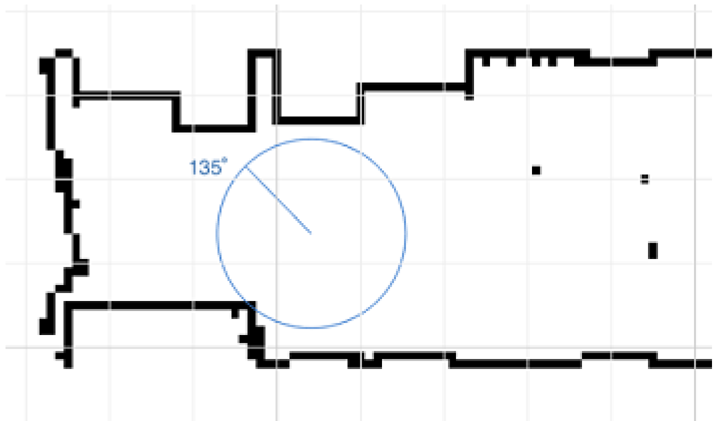


Figure 34: Initial pose and uncertainty

NOTE
The circle represents the level of pose uncertainty and illustrates where you assume the vehicle to be. The bigger the circle, the higher the uncertainty. If you select an uncertainty that is too low, the localization controller has too little freedom to locate the vehicle correctly in the reference map. An uncertainty that is too high results in an inexact localization. Do not initialize outside of the contour of the reference map.

✓ LiDAR-LOC matches the current scan data of the sensor with the contour of the reference map.

NOTE
Due to the uncertainties of the initial position, the scan points of the sensor and the contour on the reference map may initially not match entirely.

6. To improve the pose quality, slightly rotate the vehicle on the spot or move the vehicle around the area by up to 5 meters.
7. Alternatively, you can force the localization system to update the vehicle position manually without moving the vehicle. To do so, select the manual update button.

Figure 35: Manual update button

NOTE
Use the manual update cautiously. The vehicle may localize in a wrong position. Visual inspection is needed.

✓ The initial pose is set.

Complementary information

Corresponding CoLa-A command:
- LocSetPose
- LocForceUpdate

Next steps

- "Activating automatic start with continuous storage", page 55

Further topics

- "About initial positioning", page 46
- "Setting the initial pose automated", page 52
- "Viewer window", page 13
- "About CoLa-A telegrams", page 70
- Technical information LiDAR-LOC Telegram Listing, 8024818

6.8.3 Setting the initial pose automated

Overview

The automated initialization is done by **LocInitializePose** and is a combination of **LocSetPose** and an subsequent update of the pose by **LocForceUpdate.** The detected scan data of the sensor is compared with the contour of the reference map and the pose is adjusted automatically. The pose quality of the localization indicates the stability of the localization.

Important information

CAUTION
Danger of collision

When localizing from the initial position, the vehicle may collide with persons or obstacles in the localization area.

▶ Ensure that a safety system is implemented in the vehicle to avoid collisions.

Prerequisites

- A reference map is created and stored on the localization controller.
- The 2D LiDAR sensor(s) are connected and integrated to the localization controller and has/have been installed on the AGV.
- The localization controller receives scan data from the 2D LiDAR sensor.
- The user level **Maintenance** or higher is selected.
- Localization is started.

Approach

1. In SOPASair, open **Viewer.**
2. Select the reference map in the drop-down list.
3. Select the button for the automated initialization.

Figure 36: Localization pin button

✓ The vehicle symbol turns red and initial localization is initiated.

4. Move the mouse pointer to the position on the map where you assume the vehicle to be positioned.

5. Click and hold your left mouse button and draw a circle to where you estimate the position and orientation of the vehicle to be.

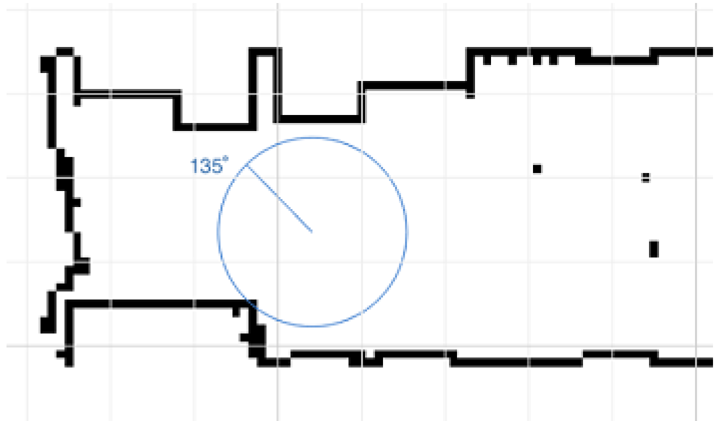


Figure 37: Initial pose and uncertainty

NOTE
The circle represents the level of pose uncertainty and illustrates where you assume the vehicle to be. The bigger the circle, the higher the uncertainty. If you select an uncertainty that is too low, the localization controller has too little freedom to locate the vehicle correctly in the reference map. An uncertainty that is too high results in an inexact localization. Do not initialize outside of the contour of the reference map.

✓ LiDAR-LOC matches the current scan data of the sensor with the contour of the reference map and performs automated updates of the vehicle pose. The initialization is aborted if a pose quality > 80 is reached or the maximum number of update attempts has been executed.

NOTE
Use the automated initialization cautiously. The vehicle may localize in a wrong position. Visual inspection is needed.

✓ The initial pose is set.

Complementary information

Corresponding CoLa-A command:
- LocInitializePose

Next steps

- "Activating automatic start with continuous storage", page 55

Further topics

- "About initial positioning", page 46
- "Setting the initial pose manually", page 50
- "Viewer window", page 13
- "About CoLa-A telegrams", page 70
- Technical information LiDAR-LOC Telegram Listing, 8024818

6.9 About automatic start

Overview

The automatic start function accelerates and simplifies the start-up routine for the LiDAR-LOC after powering down. With this function, the pose does not have to be re-initialized after restart as long as the vehicle pose corresponds to the pose before powering down.

Important information

NOTE
The automatic start function might not work correctly if the vehicle is switched off while moving.

NOTE
The automatic start function might not work correctly if the vehicle is moved after switch-off when automatic start is activated.

- ▶ Only reset the vehicle at the location where it was switched off or initialize the pose manually.

Automatic start

Poses must continuously be stored in the localization controller for the automatic start function. The storage interval can be adjusted. The current pose quality and covariance can be stored in addition to the pose. This means reinitialization is not necessary.

In addition to this automated periodic saving option, it is possible to request the saving of the current position at any time. The vehicle can then be switched off.

Automatic start also works if the vehicle is switched off with a “hard shutdown” (disconnection of the energy supply without shutdown routine).

Interval for storing poses

The interval for storing the poses must not be too high or too low. If the interval is set too low, the storage elements are unnecessarily strained. If the interval is set too high, the pose could be outdated, meaning the vehicle could be initialized at the wrong pose after restart.

The setting of the storage interval of the pose depends on how fast the vehicle is powered down after a stop and how fast the vehicle moves.

Options

- For continuous storage of the pose, a setting between 1 ... 5 seconds could be useful.

NOTE
Automatic start also works if the vehicle is switched off with a “hard shutdown” (disconnection of the energy supply without shutdown routine). In this case, use this interval setting to continuously save the pose.

- For continuous storage with additional situationally controlled storage of the pose, a setting between 2 ... 15 seconds could be useful.
- For purely situationally controlled storage routine, you can set the interval to 0 (= off) and store the pose at the time prior to the shutdown, e.g. when stopping at a load handling, parking or charging station.

The poses are continuously stored as long as the automatic start function is active.

Further topics

- "Activating automatic start with continuous storage", page 55
- "Activating automatic start with situational storage", page 55
- "About initial positioning", page 46

6.9.1 Activating automatic start with continuous storage

Prerequisites

- The initial position was set one time and the vehicle successfully initialized (pose quality > 80).

Approach

1. Send the **LocSetAutoStartActive** telegram.
2. Send the telegram **LocSetAutoStartSavePoseInterval** with the desired interval for continuous storage of the pose. Change the default value from 0 (= off) to the desired interval [1 ... 255] in seconds.
3. Send the **SavePermanent** telegram for permanent storage of the settings even after restart.

Complementary information

Corresponding CoLa-A command:
- LocSetAutoStartActive
- LocSetAutoStartSavePoseInterval

Next steps

- "Activating the reflectors for support", page 57

Further topics

- "About automatic start", page 54
- "Activating automatic start with situational storage", page 55
- "About initial positioning", page 46
- "About CoLa-A telegrams", page 70

6.9.2 Activating automatic start with situational storage

Prerequisites

- The initial position was set one time and the vehicle successfully initialized (pose quality > 80).

Approach

1. Send the **LocSetAutoStartActive** telegram.
2. Send the **SavePermanent** telegram for permanent storage of the settings even after restart.
3. Always send the telegram **LocAutoStartSavePose** before the defined shutdown for a situational storage, e.g. when stopping at a load handling, parking or charging station.

Complementary information

Corresponding CoLa-A command:
- LocSetAutoStartActive
- LocAutoStartSavePose

Next steps

- "Activating the reflectors for support", page 57

Further topics

- "About automatic start", page 54
- "Activating automatic start with continuous storage", page 55
- "About initial positioning", page 46
- "About CoLa-A telegrams", page 70

6.10 About reflectors for support

Overview

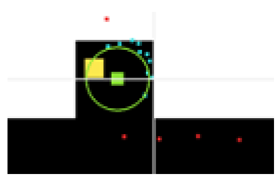
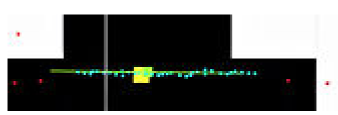
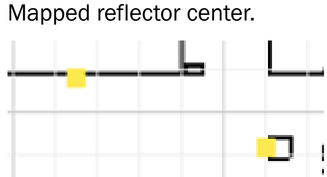
Reflectors can be used to stabilize the contour localization in critical areas. Critical areas are environments with few natural landmarks. Reflectors can also increase the accuracy of the localization.

The reflectors improve the stability of the contour localization due to their high visibility for LiDAR sensors. Reflectors are made of highly reflective materials with high remission values.

Display

To increase the accuracy by using reflectors, their shape is distinguished. The shape is displayed differently in SOPASair.

Table 8: Display of reflectors

Shape and color	Description
Circle, green	Outer contour of the reflector around the calculated reflector center. 
Line, green	Line contour of the reflector along the calculated reflector center. 
Square, green	Calculated reflector center using the adjacent scan points detected as reflectors.
Square, yellow	Mapped reflector center. 
Scan point, turquoise	Scan point is labeled as reflector.

Specifications

Shape:

Round reflectors are preferred over flat shapes due to their higher visibility from different locations. Though both, flat and round reflector shapes, can be used. Different reflector types can be used in one reference map, however, have to be handled differently while map creation.

Size:

The size of the reflector depends on the resolution and spot size of the LiDAR sensor used.

The sizes of the reflectors should be within the following range:

- Diameter of cylindrical reflectors: 80 mm (typical), 200 mm (maximum)
- Size of flat reflectors: 80 mm (typical), 200 mm (maximum)

The heights of the reflectors should be within the following range:

- The height and vertical position of the reflectors must be selected such that the measuring beam reliably hits the reflector even on uneven ground. The height of the reflector must be selected on basis of the maximum range and the spot size of the LiDAR sensor. The minimum height of the reflectors can be derived from the uncertainty caused by the ground conditions and the measuring distance used. Recommended reflector heights are in the following ranges:
  - 500 mm for a measuring distance up to 30 m,
  - 750 mm for a measuring distance up to 50 m,
  - 1000 mm for a measuring distance up to 70 m.

Mounting:

The reflectors must be mounted at a height where they are hit by the laser beams. The distance between two reflectors should be at least 2 m.

The minimum distance between the reflector and the LiDAR sensor is 1 m. The minimum distance depends on the minimum detection range of reflectors of the sensor and must be checked individually for each sensor configuration.

Place reflectors asymmetrically in visible range of the sensor. This creates a unique environment that significantly improves localization.

Requirements for increased accuracy

The following recommendations should be followed if an increased level of accuracy is required.

- Reflector layouts should be planned such that the LiDAR sensor has a clear view of at least 3 reflectors from any position. It is recommended to have a clear view of 4 to 5 reflectors to ensure reliable positioning even when operating in dynamic environments.
- If possible, the same number of reflectors should be mounted on both sides of the driving path. If the reflectors are only on one side seen from the LiDAR sensor, the positioning accuracy may be reduced due to unfavorable geometric conditions.
- The angle between 2 reflectors should not exceed 120°.

In practice, the mentioned recommendations cannot always be implemented. However, they should be considered as closely as possible.

Further topics

- "Activating the reflectors for support", page 57

6.10.1 Activating the reflectors for support

Prerequisites

- The reflectors have been recorded, detected and are included in the used reference map.

Approach

1. In SOPASair, login as **Service**.
2. Open **Localization Configuration**.
3. Select the **Reflectors for Support** button to switch Reflectors for Support **On** or **Off**.

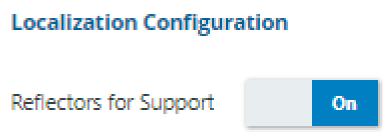


Figure 38: Reflectors for Support button

Complementary information

- Corresponding CoLa-A command: LocSetReflectorsForSupportActive

Next steps

- "Activating odometry support", page 62

Further topics

- "Creating a reference map", page 41
- "About CoLa-A telegrams", page 70

6.11 About odometry for support

Overview

Odometry is the continuous, incremental calculation of the distance traveled, for example using data from wheel encoders or gyroscopes.

Odometry is used to stabilize LiDAR localization. It must be used if there were pose losses, e.g. moving behind another vehicle, when operating in highly dynamic areas or with ramps.

Important information

NOTE
Localization support with odometry does not increase the frequency of the output telegrams.

NOTE
The odometry messages should be sent every 25 ms ± 20 %.

Odometry

Odometry support of LiDAR localization requires the speed vector of the vehicle with v_x, v_y and ω as input information.

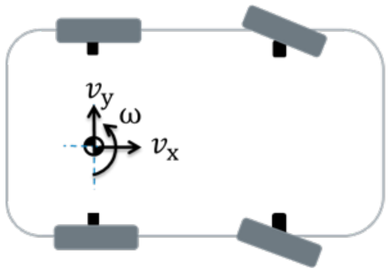


Figure 39: Speed vector of the odometry related to the navigation point

The speed vector is calculated by the vehicle controller from the raw data of the odometry sensors and the existing vehicle kinetics.

The vehicle topology changes with odometry integration, as shown in the following figure.

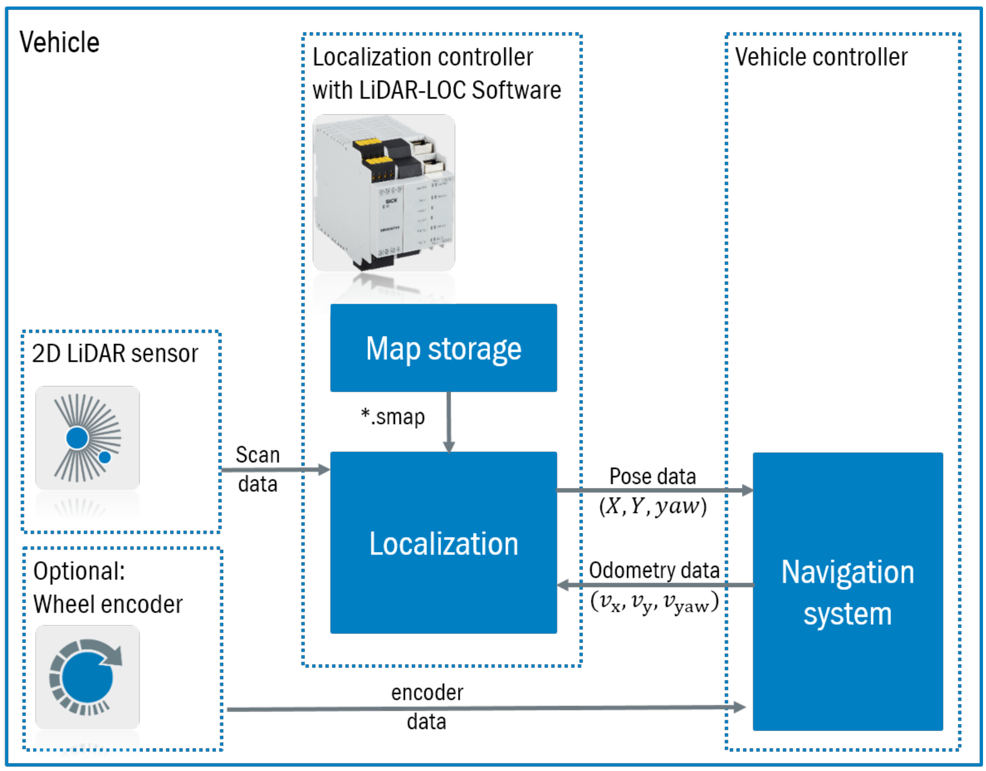


Figure 40: Vehicle topology with optional odometry

Viewer

The status of the odometry is shown in Main screen > „Viewer“.

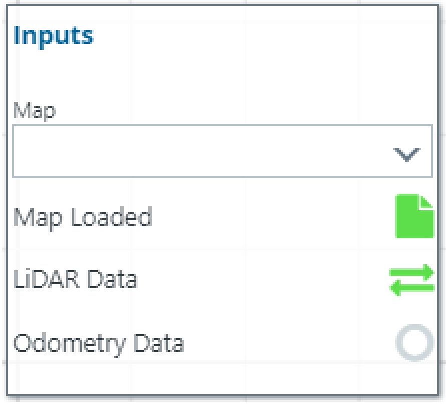
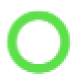


Figure 41: Status indicator for the odometry data

The circle color indicates the status of the received odometry messages sent by the vehicle controller.



Receiving odometry messages from the vehicle controller.

Odometry messages are received but not processed by the localization software. The following cases lead to discarded messages:

- The odometry header or the payload is incorrect. This is for example the case if the wrong number of bytes are sent or the message type is not an odometry message.
- The difference between the time stamps of two consecutive odometry messages is greater than 100 ms.
- The change in the angular velocity of two consecutive odometry messages is greater than 10 000 deg/s. Contact SICK support if your vehicle configuration allows other settings.

Odometry telegrams are not received.

UDP protocol

The localization controller receives the odometry data of the external vehicle controller via the binary UDP protocol. Here, port 3000 is used here by default. The port can be changed via the telegram **LocSetOdometryPort**.

Header

The header of each UDP message is identical during the continuous sending of odometry data.

The header always has Big Endian format.

Table 9: Header

Description	Type	Range of Value (decimal)	Size [byte]
MagicWord	Char32	SMOP	4
PayloadLength	UInt16	0 ... 65 535	2
PayloadType (endianness)	UInt16	(BE: 0x0642, LE: 0x06c2)	2
MsgType	UInt16	0 ... 65 535	2
MsgTypeVersion	UInt16	0 ... 65 535	2

Description	Type	Range of Value (decimal)	Size [byte]
SourceID	UInt16	0 ... 65 535	2

- MagicWord: Sick Mobile Platforms UDP telegram (MagicWord = 'SMOP')
- PayloadLength: Number of bytes per payload, here always 4+4+2+2+4 = 16.
- PayloadType: Configuration of the byte endianness for the payload (Big Endian: 0x0642, Low Endian: 0x06c2). The header always has Big Endian format.
- MsgType: For odometry messages, MsgType = 1 is used.
- MsgTypeVersion: Version of the MsgType payload (previously only MsgTypeVersion = 1)

Example (hex):
- 534d 4f50 0010 0642 0001 0001 0001

Explanation of example:
- MagicWord: SMOP (534d 4f50 hex)
- PayloadLength: 10 (16 dec)
- MsgType: 1 (odometry)
- MsgTypeVersion: 1
- SourceID: 1 (e.g. vehicle controller 1)

Payload

The endianness of the the payload can be configured within the header via Payload-Type.

Table 10: Payload

Description	Type	Range of Value (decimal)	Size [byte]
TelegramCount	UInt32	0 ... 4 294 967 295	4
Time stamp	UInt32	0 ... 4 294 967 295 ms	4
X-component of velocity	Int16	- 32 768 ... 32 768 mm/s	2
Y-component of velocity	Int16	- 32 768 ... 32 768 mm/s	2
Angular velocity	Int32	± 2 147 483 648 mdeg/s	4

- TelegramCount: The counter starts at 0 and should be increased by 1 for each new odometry message. An overflow (reset) of this variable is handled by the software. Example: Message 1: TelegramCount: 0, Message 2: TelegramCount: 1, Message 3: TelegramCount: 2, etc..
- Timestamp: The time stamp corresponds to a current time of the vehicle controller in milliseconds. For example the time passed since the start of the controller (in ms) or the current time of the controller (in ms). The timestamp is used to calculate the time difference between two messages. A synchronization between vehicle and localization controller is not required. An overflow (reset) of this variable is handled by the software. Example (time passed since start of the controller): Message 1: Timestamp: 50 000, Message 2: 50 025, Message 3: Timestamp: 50 050, Message 4: Timestamp: 50 075, etc..

Example (hex):
- 000003E8 0000C350 FE0C 01F4 FFFFFC18

Explanation of example:
- TelegramCount: 1 000
- Timestamp: 50 000 ms
- X-component of velocity: -500 mm/s
- Y-component of velocity: 500 mm/s
- Angular velocity: -1 000 mdeg/s

Example Header + Payload

Example of a complete odometry message. See above for explanations.

Hexadecimal (hex)
- 534d 4f50 0010 0642 0001 0001 0001 000003E8 0000C350 FE0C 01F4 FFFFFC18

Complementary information

Corresponding CoLa-A command:
- LocSetOdometryActive
- LocSetOdometryPort

Further topics

- "Activating odometry support", page 62
- "About reflectors for support", page 56
- "About CoLa-A telegrams", page 70

6.11.1 Activating odometry support

Prerequisites

- There is a connection between the vehicle and localization controller.
- The odometry data is provided via UDP as speed vector.

Approach

1. In SOPASair, login as **Service**.
2. Open the **Localization Configuration** window.
3. Click on the **Odometry for Support** button to active or deactivate odometry support (**On** / **Off**).

Figure 42: “Odometry for Support” button

Complementary information

Corresponding Cola-A commands:
- LocSetOdometryActive
- LocSetOdometryPort

Next steps

- "Activating IMU support", page 63

Further topics

- "About odometry for support", page 58
- "About reflectors for support", page 56
- "About CoLa-A telegrams", page 70

6.12 About IMU for support

Important information

NOTE
Localization controller and sensors have to be rigidly mounted on the vehicle and must not move relative to each other.

About IMU for support

Both SIM1000FXA and SIM1012 localization controllers come with an inertial measurement unit (IMU). The measurement data of the IMU can be used to further increase the stability of the LiDAR localization. In particular, the incremental motion estimation for rotating movements is improved.

The IMU is fully integrated on both the hardware and software side and only needs to be activated.

Complementary information

Corresponding CoLa-A command:

- DevSetIMUActive

Further topics

- "Activating odometry support", page 62
- "About reflectors for support", page 56
- "About CoLa-A telegrams", page 70

6.12.1 Activating IMU support

Prerequisites

- The localization controller SIM1000FXA or SIM1012 is used.
- Localization controller and sensors are rigidly mounted on the vehicle and cannot move relative to each other.

Approach

1. In SOPASair, login as **Service**.
2. Open the **Localization Configuration** window.
3. Click on the **Use IMU Data** button to active or deactivate IMU support (**On** / **Off**).

Figure 43: “IMU for Support” button

Complementary information

Corresponding Cola-A commands:

- DevSetIMUActive

Next steps

- "Activating restrict Y motion", page 64

Further topics

- "About odometry for support", page 58
- "About reflectors for support", page 56
- "About CoLa-A telegrams", page 70

6.13 About restrict Y motion

Important information

NOTE
Localization controller and sensors have to be rigidly mounted on the vehicle and must not move relative to each other.

For vehicles that allow movement in the Y direction (omnidirectional drives), the Y movement must not be restricted.

About restrict Y motion

The quality of the LiDAR localization can be improved by taking the vehicle kinematics into account for the estimation of the pose. If a vehicle's kinematics does not allow movement in Y-direction, the estimation of movement in the localization algorithm can be limited in Y-direction. These are, for example, vehicles with a differential or an Ackermann drive.

Complementary information

Corresponding CoLa-A command:

- LocSetRestrictYMotion

Further topics

- "About CoLa-A telegrams", page 70

6.13.1 Activating restrict Y motion

Prerequisites

- The vehicle kinematic does not allow movement in Y-direction.
- Localization controller and sensors are rigidly mounted on the vehicle and cannot move relative to each other.

Approach

1. In SOPASair, login as **Service**.
2. Open the **Localization Configuration** window.
3. Click on the **Restrict Y Motion** button to active or deactivate restriction of Y motion (**On** / **Off**).

Figure 44: “Restrict Y Motion” button

Complementary information

Corresponding Cola-A commands:

- LocSetOdometryRestrictYMotion

Next steps

- "Synchronizing clocks with the polling method", page 67
- "Synchronizing clocks with the hardware output", page 69

Further topics

- "About CoLa-A telegrams", page 70

6.14 About synchronization

Important information

NOTE
The localization controller is not a real-time system. All time ranges that are issued by the localization controller are expected values and can differ from observed values.

Synchronization

LiDAR-LOC sends localization data with a time stamp. The internal time stamp is given to the millisecond.

To avoid mismatched, uncoordinated communication and mismatched time stamps of the result port between LiDAR-LOC and the vehicle controller, the clocks of both controllers must be synchronized regularly, for example, every 10 seconds. Also, synchronization is recommended after every restart. With that, the vehicle controller knows at which time (in its own time stamp) the vehicle has been at the sent position.

Two synchronization options are available:
- Polling
- Polling with hardware port

In general, the time span between the localization controller receiving the request and sending it to the vehicle controller is usually below 2 to 5 milliseconds. If LiDAR-LOC must queue the request, the delay may amount to a few seconds. Also, telegrams may be delayed due to network latency.

System latencies for localization results

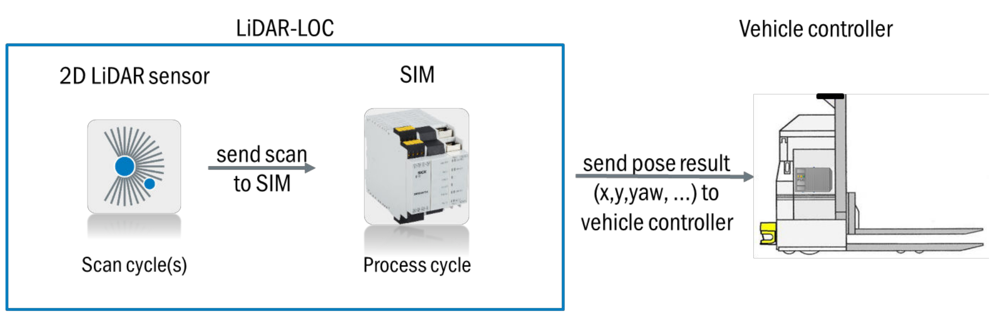


Figure 45: System latencies for localization results

The latencies between data acquisition and receiving the corresponding telegram are listed in the table below. The network transfer time from the localization controller to the vehicle controller depends on the system setup.

The time stamp of the localization result corresponds to the scan acquisition time. The latency between the 2D LiDAR sensor and the localization controller is handled by the localization software.

Assumption: Network (wired) synchronization is < 10 ms.

Table 11: Maximum latency after "start of scan"

2D LiDAR sensor	Maximum latency after „start of scan“
microScan3	typ. below 100 ms + network transfer time

Despite the latency, the update rate of the localization results after initialization remains at the rate specified in "Data sheet", page 87.

Further topics

- "About synchronization with the polling method", page 66
- "About synchronization with hardware output", page 68
- "Synchronizing clocks with the polling method", page 67
- "Synchronizing clocks with the hardware output", page 69

6.14.1 About synchronization with the polling method

Polling

The vehicle controller sends the telegram **LocRequestTimestamp** to the localization controller. LiDAR-LOC writes its internal time stamp into a telegram and sends the telegram to the vehicle controller.

When using polling, it cannot be assumed that the localization controller time stamp is generated shortly after invoking the **LocRequestTimestamp** CoLa-A method. SICK does not guarantee that LiDAR-LOC sends the time stamp without any delay. In general, the time span between the localization controller receiving the request and sending it to the vehicle controller is usually below 2 to 5 milliseconds. If LiDAR-LOC must queue the request, the delay may amount to a few seconds.

figure 46 illustrates the sequence of synchronization steps. Part of the steps for the vehicle controller are exemplary and can also be done differently, for example, by measuring the ping to estimate the network transfer time.

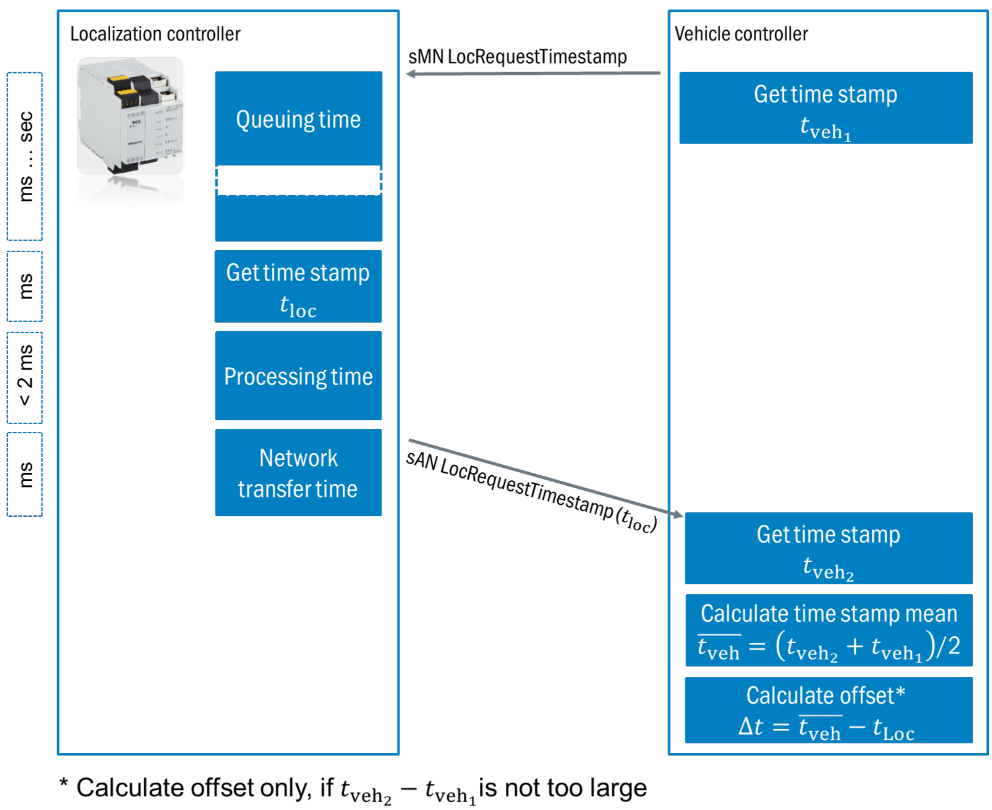


Figure 46: Synchronization sequence of the polling method

Time offset calculation

The vehicle controller uses the following formula to calculate the time offset between the clock of the localization controller and the clock of the vehicle controller:

$$\overline{t_{veh}} = (t_{veh_1} + t_{veh_2})/2$$

$$\Delta t = \overline{t_{\text{veh}}} - t_{\text{loc}}$$

Table 12: Time offset calculation details

Δt	Resulting time difference (offset)
t_{veh_1}	Time stamp of the vehicle controller before sending the request
t_{veh_2}	Time stamp of the vehicle controller after obtaining the response
$\overline{t_{\text{veh}}}$	Time stamp mean of the vehicle controller while processing time of the localization controller
t_{loc}	Time stamp of LiDAR-LOC

Complementary information

- For improved synchronization, you can use an algorithm like TICSync. TICSync is an extremely efficient algorithm for learning the synchronization of distributed clocks, which typically achieves better than millisecond accuracy within just a few seconds.

Further topics

- "Synchronizing clocks with the polling method", page 67
- "About synchronization", page 65
- "About synchronization with hardware output", page 68

6.14.1.1 Synchronizing clocks with the polling method

Overview

This section describes the sequence of requests and responses that the vehicle controller can use to synchronize clocks with the polling method.

Prerequisites

- The localization controller receives scan data from the 2D LiDAR sensor.
- There is a data connection between localization controller and vehicle controller.

Approach

The following approach describes the process illustrated in figure 46.

1. The vehicle controller creates its own time stamp t_{veh1} and stores it.
2. The vehicle controller sends **sMN LocRequestTimestamp** to LiDAR-LOC.
3. LiDAR-LOC queues the telegram. Processing the queue usually takes few milliseconds, but can take up to seconds.
4. LiDAR-LOC obtains its time stamp t_{loc}, processes the telegram, and writes the time stamp into a response telegram. Usually, this takes less than 2 milliseconds.
5. LiDAR-LOC sends the telegram **sAN LocRequestTimestamp** to the vehicle controller or terminal. The telegram's arrival time depends on the network latency.
6. After receiving the response **sAN LocRequestTimestamp**, the vehicle controller creates its own time stamp t_{veh2} again.
7. The mean between t_{veh1} and t_{veh2} is calculated.
8. The vehicle controller calculates the offset between the time stamps of the localization controller and the vehicle controller.

✓ When processing results on the result port, the vehicle controller can now transform the result time stamp from the localization controller time to its own time.

Complementary information

- SICK recommends you set the time stamp request cycle time from the vehicle controller to 10 seconds or higher.
- Corresponding CoLa-A command: LocRequestTimestamp

Further topics

- "About synchronization", page 65
- "About synchronization with the polling method", page 66
- "About synchronization with hardware output", page 68

6.14.2 About synchronization with hardware output

Polling and hardware output

To avoid uncertainty and network latency, you can use the additional hardware (HW) digital output. The hardware port of the localization controller transmits a pulse when LiDAR-LOC writes the internal time stamp in the telegram. The pulse lasts 128 milliseconds.

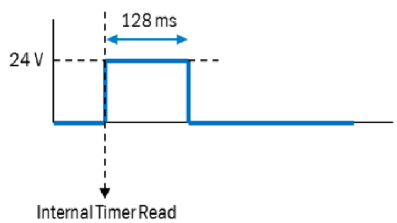


Figure 47: Internal time stamp pulse

To receive the digital output, the synchronization port of the localization controller must be connected to the I/O port of the vehicle controller. Find further information on the hardware installation in the LiDAR-LOC technical information "Hardware integration".

After the vehicle controller has received the hardware trigger, it can correct the time difference between the localization and vehicle controller.

With this method, the vehicle controller can determine the actual time that is set in LiDAR-LOC.

figure 48 illustrates the sequence of synchronization steps.

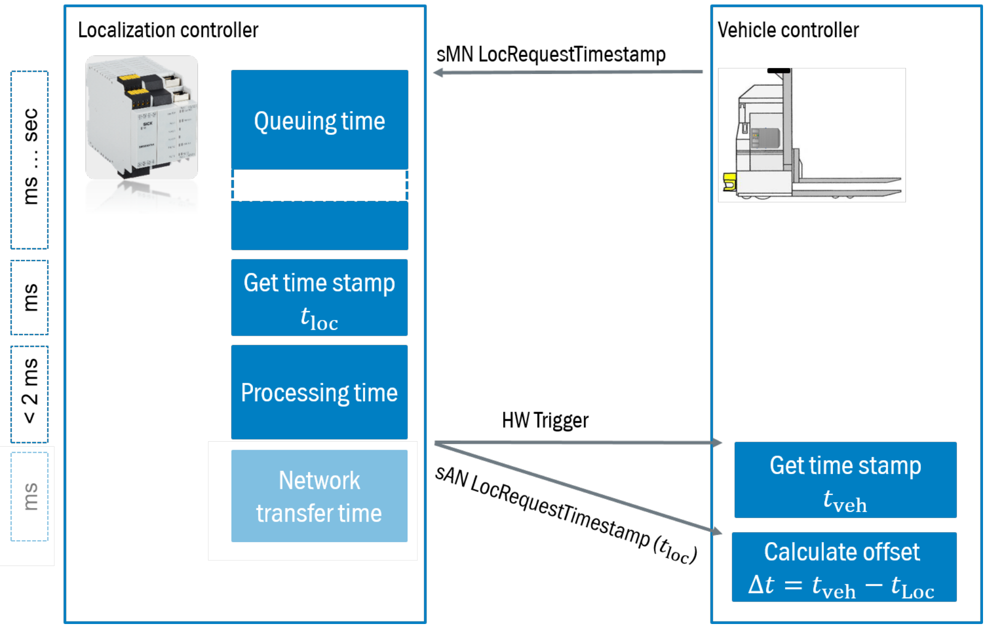


Figure 48: Synchronization sequence with additional hardware output

Time offset calculation

The vehicle controller uses the following formula to calculate the time offset between the clock of the localization controller and the clock of the vehicle controller:

$$\Delta t = t_{veh} - t_{loc}$$

Table 13: Time offset calculation details

Δt	Resulting time difference (offset)
t_{veh}	Time stamp of the vehicle controller
t_{loc}	Time stamp of LiDAR-LOC

Further topics

- "Synchronizing clocks with the hardware output", page 69
- "About synchronization", page 65
- "About synchronization with the polling method", page 66
- Technical information LiDAR Localization Hardware Integration, 8024819

6.14.2.1 Synchronizing clocks with the hardware output

Overview

This section describes the sequence of requests and responses that the vehicle controller can use to synchronize clocks with the hardware output.

Prerequisites

- The localization controller receives scan data from the 2D LiDAR sensor.
- There is a data connection between localization controller and vehicle controller.

Approach

The following approach describes the process illustrated in figure 48.

1. The vehicle controller sends **sMN LocRequestTimestamp** to LiDAR-LOC.
2. LiDAR-LOC queues the telegram. Processing the queue usually takes few milliseconds, but can take up to seconds.
3. LiDAR-LOC obtains its time stamp t_{loc}, processes the telegram, and writes the time stamp into a response telegram. Usually, this takes less than 2 milliseconds.
4. LiDAR-LOC sends trigger to the HW port. The arrival time is **not** delayed by the network latency.
5. After receiving the trigger on the HW port, the vehicle controller creates its own time stamp t_{veh}.
6. LiDAR-LOC sends the telegram **sAN LocRequestTimestamp** to the vehicle controller or terminal. The telegram's arrival time depends on the network latency.
7. The vehicle controller receives the response **sAN LocRequestTimestamp** containing the time stamp t_{loc}.

✓ The vehicle controller calculates the offset between the time stamps of the localization controller and the vehicle controller.

Complementary information

- SICK recommends you set the time stamp request cycle time from the vehicle controller to 10 seconds or higher.
- The vehicle controller must be configured in such a way that it registers the rising edges of the digital output pulse.
- Corresponding CoLa-A command: LocRequestTimestamp

Further topics

- "About synchronization", page 65
- "About synchronization with hardware output", page 68
- "About synchronization with the polling method", page 66

6.15 About CoLa-A telegrams

Overview

To operate LiDAR-LOC on the localization controller, you can either use the web GUI SOPASair or CoLa-A commands. CoLa-A is short for **Co**mmand **La**nguage **A**SCII. CoLa-A commands and SOPASair may be executed in parallel.

Commands must follow the CoLa-A protocol. To generate a CoLa-A command, multiple command parts are combined into a sequence. These sequences are called telegrams.

Telegrams can serve two purposes: request data from LiDAR-LOC, for example localization data, or set parameters on LiDAR-LOC, for example the reference map to be used.

During standard operation, the vehicle controller sends telegrams to the localization controller. To test or set up the system, you can use the terminal program on your computer to send telegrams to the localization controller. SICK provides the terminal program SOPAS ET Terminal for this purpose.

For requests and to transmit settings to the localization controller:

- IP port number 2111 to send telegrams and to request data.
- SOPAS CoLa-A protocols

NOTE

To save configurations persistently (permanently) after they have been changed with CoLa-A methods, for example **sMN DevSetLidarConfig**, **sMN SavePermanent** needs to be called. Otherwise, the configuration is discarded after a reboot.

Representation of integer values

The CoLa-A protocol can process integer values both in decimal and in hexadecimal notation. Both notations may be used within one telegram because LiDAR-LOC interprets each parameter separately.

NOTE
LiDAR-LOC only processes integer values and not floating-point numbers in CoLa-A telegrams.

Integer values in decimal notation are prefixed with + (plus) or – (minus). Values in hexadecimal notation are not prefixed at all.

LiDAR-LOC can only send hexadecimal values in response.

Rules for ASCII telegrams

The following rules apply to ASCII telegrams:

- Framing: begin the telegram with the tag <STX> and end with the tag <ETX>
- Write commands in letters, followed by parameters.
- Use a blank space to separate commands and parameters.
- Use a blank space to separate parameters and parameters.
- State the number of letters when you enter a string.

Two command types are used in LiDAR-LOC:

- Read by name
- Methods

These are the basic command parts of an ASCII telegram:

Table 14: Telegram basics

Description	Value ASCII
{Delimiter}	
Start of text	<STX>
End of text	<ETX>
{SOPAS Commands}	
Read by name (request)	sRN
Read by name (response)	sRA
Method by name (request)	sMN
Method by name (response)	sAN
Additional	
Space	{SPC}
Command name	{Cmd}
Parameter (key) and value	[Data]

The request and response telegrams are thereby structured as following:

<STX>{SOPAS Command}{SPC}{Cmd}{SPC}[Data]{SPC}[Data]{SPC}[...]<ETX>

Example of an ASCII telegram

The table shows the structure of the telegram **sMN SetAccessMode.**

Table 15: Telegram structure for sMN SetAccessMode

Command part	Description	Value ASCII
Command type	Method by name	sMN
Command	Set the user level	SetAccessMode

Command part	Description	Value ASCII
Parameter	New user level	3 = authorized client
Value	"Hash"- value of the user level password for "Maintenance" "Authorized Client"	B21ACE26 F4724744

In ASCII format, the telegram looks like this:

<STX>sMN SetAccessMode 3 F4724744<ETX>

Example of requests and responses

The following example shows a request sent from the user to the localization controller and the response from the localization controller to the user.

NOTE
LiDAR-LOC can only send hexadecimal values in response. If you want to use the decimal value, you must convert it.

Request (user to localization controller): Read the map state. Is the map active or inactive?

Telegram: <STX>sRN LocMapState<ETX>

Response (localization controller to user): Map is active.

Telegram: <STX>sRA LocMapState 1<ETX>

Multiple return values

Some configuration telegrams have multiple return values, for example, **DevSetLidarConfig**. These telegrams are blocking the system while the localization controller collects all return values. When the localization controller is finished executing the telegram, it returns all values. It also responds if the execution of the telegram is aborted, for example, because of a wrong telegram format.

Further topics

- "Using SOPAS ET Terminal to send CoLa-A telegrams", page 73
- "Data types of CoLa-A variables", page 72
- "CoLa-A error messages", page 79
- "About result port telegrams", page 75
- "About localization", page 44

- Technical information LiDAR-LOC Telegram Listing, 8024818

6.15.1 Data types of CoLa-A variables

Data types of CoLa-A variables

The following data types are available for the variable values in the telegram.

Table 16: Data types of variables

Type	Size (bits)	Signedness
Bool_1	8	unsigned
UInt_8	8	unsigned
Int_8	8	signed
UInt_16	16	unsigned
Int_16	16	signed
UInt_32	32	unsigned
Int_32	32	signed

Type	Size (bits)	Signedness
Enum_8	8	unsigned
Enum_16	16	unsigned
String	Depends on content	

Further topics

- "About CoLa-A telegrams", page 70
- "CoLa-A error messages", page 79
- Technical information LiDAR-LOC Telegram Listing, 8024818

6.15.2 Using SOPAS ET Terminal to send CoLa-A telegrams

Overview

You can use the SICK terminal program SOPAS ET Terminal to send CoLa-A telegrams to the localization controller.

NOTE
The terminal program supports two input formats: ASCII and HEX. These input formats are independent of the decimal or hexadecimal representation of integer values in the CoLa-A protocol.

Prerequisites

- SOPAS ET is installed on your computer or a different terminal for sending TCP/IP telegrams.
- The localization controller receives scan data from the 2D LiDAR sensor.
- The localization controller has a data connection to your desktop computer. Your desktop computer needs to be in the same subnetwork as the localization controller, for example, if the localization controller has the IP address 192.168.0.1, your computer's IP address has to be 192.168.0.X, where X is a number between 2 to 254.

Approach

1. Open SOPAS ET.
2. Choose Menu → **Tools** → **Terminal**.

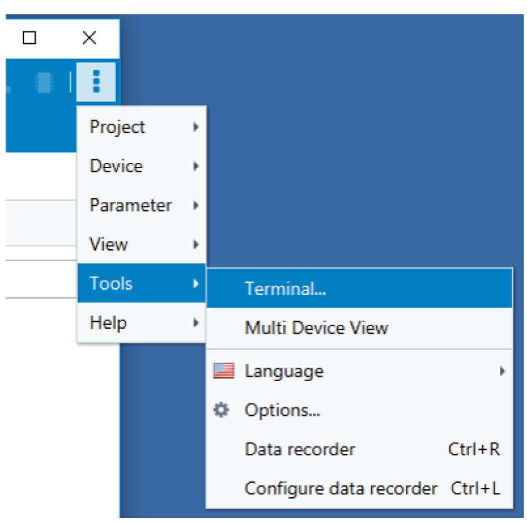


Figure 49: Open SOPAS ET Terminal

3. Choose **New Connection**.

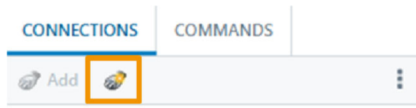


Figure 50: Create a new connection to the localization controller

4. Proceed with default settings.
5. Enter the IP address of the localization controller.
6. Choose **Finish**.
7. Select the **Input format** that you want to use: **ASCII** or **Hex**.

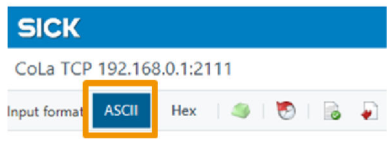


Figure 51: Input format ASCII

8. Select **Cola ASCII** as the **Framing** type.

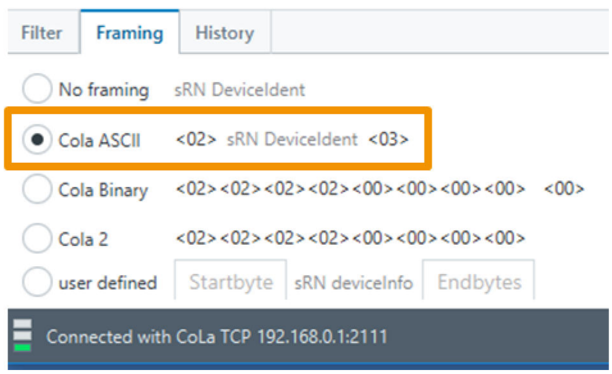


Figure 52: Framing type ASCII

9. Enter the telegram.

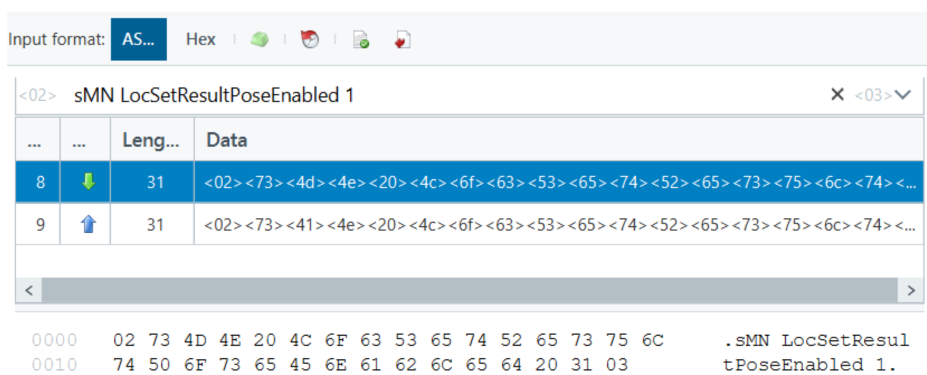


Figure 53: Telegram insertion in ASCII input format, for example, sMN LocSetResultPoseEn- abled

10. Press **Enter**.

✓ Telegrams are listed with a green icon. Responses by the localization controller are listed with a blue icon.

Complementary information

- The CoLa-A protocol can process integer values both in decimal and in hexadecimal notation. Both notations may be used within one telegram because LiDAR-LOC interprets each parameter separately.

Further topics

- "About CoLa-A telegrams", page 70
- "Data types of CoLa-A variables", page 72
- "CoLa-A error messages", page 79
- "About result port telegrams", page 75

- Technical information LiDAR-LOC Telegram Listing, 8024818

6.16 About result port telegrams

Overview

The localization controller uses the result port to send the localization results to the external vehicle controller. It uses the binary protocol TCP/IP. On this communication layer, the localization controller uses telegrams to transmit the results.

Stream mode and poll mode

The localization controller has two modes in which it can send localization results, stream mode and poll mode.

Stream mode:
- The localization controller sends results to the vehicle controller continuously with the sensor's scan rate.
- This mode is used for standard operation.

Poll mode:
- The localization controller sends results only when they are requested by the vehicle controller or by a user.
- This mode is used for development, troubleshooting or maintenance.

NOTE
Requesting results with high frequencies, for example, scan frequency, may cause high data traffic and information losses, or longer processing times in the system. Use the poll mode in low frequency only. SICK recommends using continuous request polls at a maximum of 5 Hz.

IP port number and protocol

To transmit the localization results to the vehicle controller, the localization controller uses:
- IP port number 2201 to send localization results in a single direction to the external vehicle controller.
- Binary result port protocol TCP/IP

Result port framing

The telegram consists of the header, the payload, which contains the localization result, and the checksum CRC.

Table 17: Result port framing

Telegram	Section	Size [byte]
1	Header	52
	Localization payload	52
	Trailer (CRC)	2

Example of a result port response

Responses coming back from the localization controller as displayed in SOPAS ET Terminal.

The result port data is represented in the hex code.

```
          1  2                    ...                   16
0000     53 49 43 4B 00 00 00 6A 06 42 00 01 00 10 C0 58     SICK...j.B....ÀX
0010     01 22 A2 72 00 00 00 00 00 00 00 4C 4C 53 20 56     ."¢r.......LLS V
0020     30 2E 31 2E 39 2E 78 42 00 00 02 6D 83 AA 8C 0C     0.1.9.xB...mfªŒ.
0030     8E 14 78 00 00 00 00 00 02 6F 00 34 EC F3 00 00     Ž.x......o.4ìó..
0040     00 5D 00 00 00 21 00 00 45 E7 00 00 00 00 00 00     .]...!..Eç......
0050     00 00 37 00 00 00 80 89 00 00 99 93 00 12 78 9F     ..7...€‰..™"..xŸ
0060     00 00 00 00 00 00 00 00 62 11                       ........b.
```

Figure 54: Example of a result port response. Pose data is highlighted.

Table 18: Example of the pose data in a result port response

Position	Example for the position output
Byte 63 ... 66	X-coordinate: 00 00 00 5D → 93 mm = 0.093 m
Byte 67 ... 70	Y-coordinate: 00 00 00 21 → 33 mm = 0.033 m
Byte 71 ... 74	Orientation (yaw): 00 00 45 E7 → 17 895 mdeg = 17.895°

Further topics

- "Header of the result port telegram", page 76
- "Payload of the result port telegram", page 77
- "Trailer of the result port telegram", page 77
- "About synchronization", page 65

6.16.1 Header of the result port telegram

Header of the result port telegram

The header of a result port telegram has the following structure:

Table 19: Result port header

Fields	Description	Type	Size [byte]
MagicWord	Magic word SICK (0x53 0x49 0x43 0x4B)	4 × UInt8	4
Length	Length of telegram. Header, payload, and trailer.	UInt32	4
PayloadType	Payload type	UInt16	2
PayloadVersion	Version of PayloadType structure	UInt16	2
OrderNumber	Order number of the localization controller	UInt32	4
SerialNumber	Serial number of the localization controller	UInt32	4
FW-Version	Software version of the localization controller	20 × UInt8	20
TelegramCounter	Telegram counter since last start-up	UInt32	4
SystemTime	Not used	NTP	8
Total size [byte]			52

Payload type

The field PayloadType can contain the following information:

Table 20: Payload type

Result payload type	ID	Description
Localization (Little Endian)	0x06c2	Result of the localization in little endian format
Localization (Big Endian)	0x0642	Result of the localization in big endian format

Further topics

- "About result port telegrams", page 75
- "Payload of the result port telegram", page 77
- "Trailer of the result port telegram", page 77
- "Configuring the 2D LiDAR sensor", page 37
- "2D LiDAR sensor configuration", page 33

6.16.2 Payload of the result port telegram

Payload of the result port telegram

Localization results have the following structure:

Table 21: Result port payload

Fields		Description	Type	Size [byte]
ErrorCode		0: OK 1: UNKNOWNERROR	UInt16	2
ScanCounter		Counter of related scan data	UInt32	4
Time stamp		Time stamp of the pose [ms] The time stamp indicates the time at which the pose is calculated.	UInt32	4
Pose	X	Position of the vehicle on the map in cartesian global coordinates [mm]	Int32	4
	Y		Int32	4
	Orienta-tion (yaw)	Orientation of the vehicle on the map [mdeg]	Int32	4
Reserved		Reserved	UInt32	4
Reserved		Reserved	Int32	3
Quality (sensitive)		Sensitive quality of pose [0 ... 100], 0 = bad pose quality, 100 = good pose quality	UInt8	1
Quality (moder-ate)		Moderately changing quality of pose [0 ... 100], 0 = bad pose quality, 100 = good pose quality	UInt8	1
Outliers Ratio		[%] Ratio of beams that cannot be assigned to the current reference map	UInt8	1
Covariance (c1, c5, c9)		Covariance of the particle filter X [mm²] Y [mm²] Yaw [mdeg²]	3 × Int32	12
Reserved		Reserved		8
Total size [byte]				52

Further topics

- "About localization", page 44
- "About result port telegrams", page 75
- "Header of the result port telegram", page 76
- "Trailer of the result port telegram", page 77
- "About synchronization", page 65

6.16.3 Trailer of the result port telegram

Trailer of the result port telegram

The trailer of the result port telegram is a CRC checksum.

Table 22: Result port trailer

Fields	Description	Type	Size [byte]
Checksum	CRC16-CCITT over length of header (52 bytes) and payload (52 bytes) without 2 bytes of this trailer Checksum details: • Width: 16 bits • Truncated polynomial: 0x1021 CRC polynomials with orders of x16 + x12 + x5 + 1 (counted without the leading '1' bit) • Initial value = 0xFFFF	UInt16	2

Further topics

- "About result port telegrams", page 75
- "Header of the result port telegram", page 76
- "Payload of the result port telegram", page 77

7 Troubleshooting

7.1 CoLa-A error messages

CoLa-A error messages

Before a command is executed, the CoLa-A command interpreter must interpret the telegram. If the command interpreter determines an error, it responds with an error message in the form of "sFA <Error number>". This applies to all command requests with direct variable access ("sRN") and methods ("sMN").

These are common errors:

Table 23: Error messages of the command interpreter

Error number (ASCII hex)	Error description
1	No access authorization for the execution of the method (low user level)
2	Unknown method name / index
3	Unknown variable / index
4	Variable or parameter is out of range/value.
5	Invalid data
6	Unknown error
7	Memory overflow
8	Parameter is missing, memory underflow.
9	Unknown error type
A	No access authorization for writing the variable (low user level)
B	Unknown command for the name server
C	Unknown CoLa-A command
D	Synchronous method is still running (only one can run at a time).
E	Flex array is too large.
F	Unknown event name / index
10	CoLa-A type overflow (value is higher than allowed for the type). Tip: Check whether you added the prefix + or – to decimal values.
11	Illegal CoLa-A character (e.g. - or letter). Tip: Type capital letters for hex values.
12	No message from the operating system SOPAS
13	No response from the operating system SOPAS
14	Internal error
41	Invalid number or type
46	Wrong command type Example: sWA instead of sWN
4C	System not ready. Wait a few seconds and try again.
50	Enum type not specified. Tip: Check whether you added the prefix + or – to decimal values.

Further topics

- "About CoLa-A telegrams", page 70
- "Data types of CoLa-A variables", page 72
- Technical information LiDAR-LOC Telegram Listing, 8024818

7.2 Support

Overview

In order to speed up processing of your service request, you can register at https://supportportal.sick.com/ to send requests to SICK service. Create tickets directly at https://supportportal.sick.com/secure/ticket/add/.

To help the SICK service team to understand your problem, please provide the following information.

Description
- Software version number
- What operation does not work properly?
- Is there any error message or notification visible?
- If not obvious: what operation result was expected
- What were the last operation steps leading to the failure?

Additional information
- If applicable, please provide a screenshot indicating the error.
- To provide the support given from SICK with additional information, you can download an application log file (*.log) in SOPASair.
- To allow the SICK service team to simulate the problem, you can record support data of the critical situation and provide this data to the SICK service team.

Further topics

- "Creating an application log", page 80
- "Recording support data - ring buffer", page 81
- "Recording support data - small", page 82
- "Recording support data - large", page 84
- "SICK support and further services", page 90

7.2.1 Creating an application log

Overview

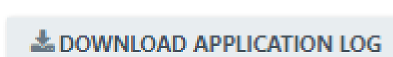
To provide SICK support with additional information, you can download an application log file in SOPASair.

Prerequisites

- You are registered at the SICK Support Portal.
- You are logged in into SOPASair.

Approach

1. In SOPASair, open **Support**.
2. Download the log file, by clicking **Download Application Log**.



3. Open the SICK Support Portal: https://supportportal.sick.com/
4. At the top of the page, click New Support Ticket.
5. Click **Attach files ...**, to upload the downloaded application log file.
6. Include additional information about the problem, such as your network configuration, sensors used, information on the environment, etc.

Further topics

- "Logging into SOPASair", page 32
- "Recording support data - small", page 82

- "Support", page 80
- "SICK support and further services", page 90

7.2.2 About support data - ring buffer

About support data - ring buffer

To record the behavior of the vehicle in critical situations, you can use the ring buffer function to record data during operation. Thereby the data of the 2D-LiDAR sensors and optional additional sensors are stored. You can forward the recorded data to SICK support for further analysis.

Critical situations can occur irregularly, but must be known and detectable. For example, if the pose quality drops below a certain threshold value, a recording can be automatically saved to analyze the problem.

The ring buffer function continuously records data after a one-time activation through the CoLa-A telegram **LocSetRingBufferRecordingActive**. If an event occurs which should be anaysed, the last 60 seconds can be permanently stored from the ring buffer with the telegram **LocSaveRingBufferRecording**. After saving the recording, a new data recording starts automatically in the background.

When the memory is full, the oldest ring buffer recordings are deleted. This preserves the most recently recorded data. Other files than the ring buffer recordings are not deleted.

In order to identify the recording correctly and to simplify the analysis, a short description of the event with the timestamp can be passed with the **LocSaveRingBufferRecording** telegram.

If the ring buffer is active and manual support data recording via SOPASair is started, the ring buffer recording is automatically stopped and restarted after the end of the manual recording.

Important information

NOTE

- The duration of the recording is limited to 60 seconds.
- There must be at least 100 MB of free memory on the SD card of the controller.
- Since the ring buffer function uses additional system resources, activate it only if necessary.

Further topics

- "Support", page 80
- "Creating an application log", page 80
- "SICK support and further services", page 90

7.2.2.1 Recording support data - ring buffer

Prerequisites

- Localization is started.

Approach

1. To activate the ring buffer function, send the **LocSetRingBufferRecordingActive** telegram once.
2. The ring buffer starts to record the data.
3. Optional: To activate the ring buffer function permanently, save the configuration with the telegram **SavePermanent**.
4. To save a recording, send the **LocSaveRingBufferRecording** telegram.

5. Provide SICK Support with the recorded data along with the application log.
6. Include additional information about the problem, such as your network configuration, sensors used, information on the environment, etc.

Complementary information

Corresponding Cola-A commands:
- **LocSetRingBufferRecordingActive**
- **LocSaveRingBufferRecording**

Next steps

- "Transfer support data to the desktop computer", page 85

Further topics

- "Support", page 80
- "Creating an application log", page 80
- "SICK support and further services", page 90

7.2.3 About support data - small

About support data - small

You can record data in SOPASair during operation to provide SICK Support with more information for further analysis. Thereby the data of the 2D-LiDAR sensors and optional additional sensors are stored.

To manually record the behavior of the vehicle, you can use the functions in SOPASair. Scenarios can be regular error cases at certain locations or a known reproducible behavior. For example, the approach to a charging station can be recorded.

The duration of the data recording is limited by a maximum file size of 200 MB and the available storage space on the SD card in the localization controller. Depending on the sensor type and the number of sensors used, the duration of recording is typically 1 ... 2 minutes. If the recording time is not sufficient, please switch to user level service.

Further topics

- "About support data - large", page 83
- "Logging into SOPASair", page 32
- "Support", page 80
- "Creating an application log", page 80
- "SICK support and further services", page 90

7.2.3.1 Recording support data - small

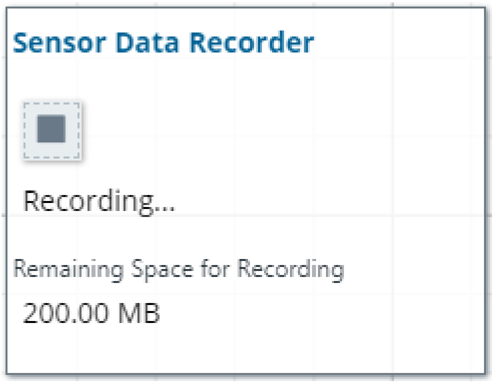
Prerequisites

- You are logged in into SOPASair.
- The user level **Maintenance** is selected.
- Localization is started.

Approach

1. Open the **Viewer** in SOPASair.
2. Before entering an area of interest with the vehicle, click on the **Record data** button.

✓ Data recording starts at 200 MB.



3. Click on the **Stop** button to end data recording.

✓ Optional: The data recording stops automatically as soon as the maximum file size of 200 MB is reached.

4. Click on the **Download Recording** button to download the data.

5. Provide SICK Support with the recorded data along with the application log.
6. Include additional information about the problem, such as your network configuration, sensors used, information on the environment, etc.

Further topics

- "Recording support data - large", page 84
- "Logging into SOPASair", page 32
- "Support", page 80
- "Creating an application log", page 80
- "SICK support and further services", page 90

7.2.4 About support data - large

About support data - large

You can record data in SOPASair during operation to provide SICK Support with more information for further analysis. Thereby the data of the 2D-LiDAR sensors and optional additional sensors are stored.

To manually record the behavior of the vehicle, you can use the functions in SOPASair. Scenarios can be regular error cases at certain locations or a known reproducible behavior. For example, the approach to a charging station can be recorded.

The duration of the data recording is limited by the available storage space on the SD card in the localization controller. Depending on the device type, a larger memory card can be installed.

Further topics

- "About support data - small", page 82
- "Logging into SOPASair", page 32
- "Support", page 80
- "Creating an application log", page 80
- "SICK support and further services", page 90

7.2.4.1 Recording support data - large

Prerequisites

- On the host computer an FTP client is installed, for example, FileZilla.
- You are logged in into SOPASair.
- The user level **Service** is selected.
- Localization is started.

Important information

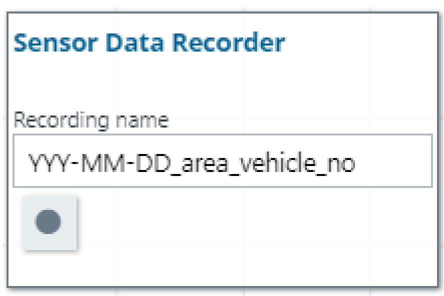
NOTE

File names should not contain language-specific characters, for example 'äöü' or sign language, for example Japanese '本'. This causes the data transfer to fail.

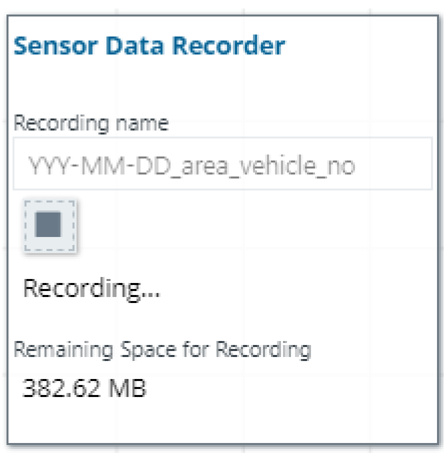
Alpha numerical characters and common special characters like blanks, underscores, minus, ... can be used.

Approach

1. Open the **Viewer** in SOPASair.
2. Enter a unique file name, for example, **YYYY-MM-DD_area_vehicle number.**
3. Before entering an area of interest with the vehicle, click on the **Record data** button.



✓ Data recording starts. The remaining memory capacity is displayed.



4. Click on the **Stop** button to end data recording.

✓ Optional: Data recording stops automatically as soon as no more memory is available.

5. Provide SICK Support with the recorded data along with the application log.
6. Include additional information about the problem, such as your network configuration, sensors used, information on the environment, etc.

Next steps

- "Transfer support data to the desktop computer", page 85

Further topics

- "Recording support data - small", page 82
- "Logging into SOPASair", page 32
- "Support", page 80
- "Creating an application log", page 80
- "SICK support and further services", page 90

7.2.5 Transfer support data to the desktop computer

Overview

To provide SICK Support with the recorded data, you must transfer the recordings to your desktop computer with an FTP client.

Prerequisites

- Support data was recorded.
- An FTP client is installed on your desktop computer, for example, FileZilla.

Approach

1. Open the FTP client on your desktop computer.
2. In the login field of the FTP client, enter the connection information for the localization controller.

Figure 55: Login field of the FTP client - logfiles

The localization controller uses the following default values for FTP connections to the **logfiles** directory:
   - Host: IP address of the localization controller, default of the SIM of Ethernet port 1 is 192.168.0.1
   - Username: logfiles
   - Password: client
   - Port number: 2300
3. Connect the FTP client to the localization controller. In Filezilla, you select Quickconnect.

✓ Select the recording you want and download it. In Filezilla, in the localization controller's directory you right-click the recording files and select Download.
Each recording consists of two files. Both files are required by SICK support for the simulation:
   - *sdr.msgpack
   - *sdri.msgpack

Further topics

- "Support", page 80
- "Recording support data - ring buffer", page 81

- "Recording support data - large", page 84
- "SICK support and further services", page 90

8 Technical data

8.1 Data sheet

LiDAR-LOC technical properties

Table 24: LiDAR-LOC features

Feature	Value
Application	Localization based on contour data in indoor areas
Number of simultaneously supported sensors	2
Communication interface	Ethernet for result data output
Switching outputs	1, for synchronization
Content of output localization result	Pose (X, Y, yaw angle) Quality information and additional data
Map size	≤ 250 000 m^2 (per each map)
Maximum storage size for maps	100 MB The maximum map size of one map is approx. 6 MB.
Update rate	Depending on sensor, ≤ 33 Hz
Velocities	Translational: ≤ 3 m/s Rotational (yaw rate): ≤ 45°/s
Localization resolution	Positon: 1 mm Orientation: 0.001° The resolution refers to the output localization result via result port and not to the measurement resolution of the connected sensor.
Localization accuracy	Position: Typical. 10 mm Orientation: Typical. < 0.25° @ 1σ (RMSE), depending on surrounding conditions and used sensor

Supported sensor types

Table 25: Supported sensor types

<table>
<tr><th>2D LiDAR sensor</th><th>Field sets 1) / Safety</th><th>Aperture angle</th><th>Scanning range with ... remission</th><th>Frequency</th><th>Angular resolution</th><th>Reflector support in LiDAR-LOC</th><th>Documentation</th></tr>
<tr><td>outdoorScan3</td><td rowspan="5">yes / PL d</td><td rowspan="5">275°</td><td rowspan="2">1.8 %: 4 m
100 %: 40 m</td><td rowspan="3">≤ 33 Hz</td><td rowspan="3">0.51° / 0.39°</td><td rowspan="5">yes</td><td>EtherNet/IP™: 8023153
Core I/O: 8023150</td></tr>
<tr><td>microScan3 4.0 m 2)</td><td rowspan="3">EtherNet/IP™: 8020198
PROFINET: 8021217
EFI-pro: 8021911</td></tr>
<tr><td>microScan3 5.5 m 2)</td><td>1.8 %: 5.5 m
100 %: 40 m</td></tr>
<tr><td>microScan3 9.0 m</td><td>1.8 %: 9 m
100 %: 64 m</td><td>≤ 25 Hz</td><td>0.125° / 0.1°</td></tr>
<tr><td>nanoScan3 3 m</td><td>1.8 %: 3 m
Measurement range: ≤ 40 m</td><td>≤ 33 Hz</td><td>0.17°</td><td>I/O: 8024594</td></tr>
</table>

2D LiDAR sensor	Field sets [1] / Safety	Aperture angle	Scanning range with … remission	Frequency	Angular resolution	Reflector support in LiDAR-LOC	Documentation
TiM7xxS	yes / PL b	270°	5 %: 5 m 10 %: 8 m > 50 %: 25 m	15 Hz	0.33°	no	Operating instructions: 8023886 Product information: 8014314
TiM7xx	yes / –		10 %: 8 m Working range: 0 … 25 m				Operating instructions: 8024231 Product information: 8014314
LMS1xx			10 %: 18 m 90 %: 50 m	25 Hz / 50 Hz	0.25° / 0.5°		Operating instructions: 8012471
TiM5xx	no / –		10 %: 2 / 8 m Working range: 0 … 4 / 10 / 25 m	15 Hz	0.33° / 1°		Operating instructions: 8015886 Product information: 8014314
NAV2xx			10 %: 18 m 90 %: 50 m	25 Hz	0.25°	yes	Operating instructions NAV245: 8018478 NAV210: 8024592
NAV310		360°	10 %: 35 m 90 %: 100 m Max: 0.5 m … 250 m	5 Hz … 20 Hz	0.125° … 0.75°		Operating instructions: 8016535
NAV340				8 Hz	0.1°	on request	Operating instructions: 8016197
NAV350							Operating instructions: 8013889

1) Field sets are used for non-safe collision avoidance of obstacles.
2) For microScan3 Core - EtherNet/IP™ (devices with max. protective field range 4.0 m and 5.5 m) data output via UDP and TCP/IP is supported only from version number 1.2.0 and higher.

For additional information, consult the operation instructions of the corresponding sensor.

For high quality of the localization, we recommend to consider the following information about the sensors.

microScan3

- Protective field range 9 m (64 m warning field range):
  The sensors with 64 m measurement range are preferred over the ones with 40 m measurement range. They can be used in both configurations, 50 ms and 40 ms scan cycle time. he configuration is primarily dependent on your risk assessment.
- Protective field range 4 m and 5.5 m (40 m warning field range):
  The sensors with a measuring range of 40 m shall be operated with a scan cycle time of40 ms and a corresponding resolution of 0.39°. A higher resolution allows the detection of smaller objects and when using reflectors a more precise estimation of the reflector position. However, the configuration is primarily dependent on your risk assessment.

Sensor selection TiMxxx, LMS1xx, NAV2xx und NAV3xx

- The sensors of the LMS1xx and NAV2xx family are to be preferred to the sensors of the TiMxxx family due to the higher range, angular resolution and scanning frequency.
- The sensors of the NAV2xx family are to be preferred to the sensors of the LMS1xx family due to the specially integrated evaluation of measurement data for localization.
- The sensors of the NAV3xx family are to be preferred to the sensors of the NAV2xx family due to the higher range, angular resolution, larger field of view and improved angle compensation especially for mast-mounted applications.

9 Ordering information

9.1 Scope of delivery

Scope of delivery

Table 26: Scope of delivery, LiDAR-LOC software

Component	No. of units
Ticket ID to activate LiDAR-LOC software packages for localization	1

Table 27: Scope of delivery, LiDAR-LOC software trial

Component	No. of units
Ticket ID to activate LiDAR-LOC software packages for localization with time limitation.	1

Complementary information

Additional accessories, for example, sensors, power cable, network cable, or mounting brackets, can be ordered on the SICK website. Go to LiDAR-LOC product page > Recommended accessories.

9.2 Ordering information for LiDAR-LOC

Table 28: Ordering information

Part	Part number
LiDAR-LOC software (see table 26, page 89)	1613535
LiDAR-LOC software trial (see table 26, page 89)	1615496

10 SICK support and further services

General requests

In order to speed up processing of your service request, you can register at https://supportportal.sick.com/ to send requests to SICK service. Create tickets directly at https://supportportal.sick.com/secure/ticket/add/.

For additional information on support and application log, see:

- "Support", page 80
- "Creating an application log", page 80

Mapping

LiDAR-LOC requires a valid reference map of the surroundings you want to use it in.

If you do not have a reference map of your site, contact SICK service or create your own reference map with SMET (SICK Map Engineering Tool).

To create a map, you need the contour data of your site. If you are unsure about recording measurement data or creating a map, contact your local office to receive assistance.

Find locations at www.sick.com.

11 List of figures

12 List of tables

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