

LaseASC

User Manual

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1 General

This document describes the Laser Measurement System LaseASC for automatic stacking cranes. The LaseASC is a 3-dimensional laser scanning measurement system which will be used to control the load position and lowering to prevent collision with adjacent container stacks and to control the load position for exact landing. In addition to these, the laser scanner system will be used for stack profile measurement in stack verification mode and in the truck lanes for placing containers in automatic mode.

The document describes the configuration and calibration of the measurement system, the handling and the operation of the software as well as the hardware components. It also provides references to malfunction messages and their possible cause and elimination are given.

This document gives information about following topics:

- **General overview**
- **Hardware components**
- **Mechanical installation**
- **Electrical installation**
- **Handling and Set-up**
- **System software**
- **System calibration**
- **Maintenance**

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1.1 Target group

This document is directed to persons performing following activities:

1.1.1 Mounting, electrical Installation, Maintenance and device changing

Industrial electrician and Service engineers

1.1.2 Commissioning, set-up, handling and service

Technicians and Engineers

1.2 Used symbols



The book symbol shows, that in the text is referred to additional documents or documentations of the respective manufacturer of the component



ATTENTION! - This symbol with the yellow triangle indicates in the document to hazards. With this symbol marked text parts should accurately be read and observed to avoid accidents!



The „I“ symbol indicates text passages, in which special notes/information are contained which are to be observed. This text passages are to be read accurately.

1.3 Used abbreviations

2D	2-dimensional
3D	3-dimensional
3D-Unit	3-dimensional Laser Scanning System (1xLASE2000D + swivelling platform with servo drive)
2000D Laser scanner	Individual laser scanner without swivel platform
3000D Laser scanner	LASE Servo platform (LSP + 2D-Laser scanner as complete unit)
ASC	Automatic Stacking Crane
CAN	Controller Area Network (standardized Fieldbus system with communications orientated data exchange protocol)
CCS	Crane Control System
FMDS	Fault reporting and diagnostic System
IPC	Industrial PC
LCU	LASE Control Unit = IPC
LMS	2D-Laser Measuring system
LSP	LASE Servo platform
Spreader Position Measurement System	Load Position Measurement System
TCP/IP	Transmission Control Protocol/Internet Protocol – network protocol
LaseASC	<u>T</u> ar <u>g</u> e <u>t</u> <u>P</u> o <u>s</u> i <u>t</u> i <u>o</u> n <u>M</u> e <u>a</u> s <u>u</u> r <u>e</u> m <u>e</u> n <u>t</u> <u>S</u> y <u>s</u> t <u>e</u> m
WS	Water side
LS	Land side

2 General overview

The LaseASC is a laser scanning system which processes 3-dimensional measurement data provided by two swiveling platforms with a mounted laser scanner. The LaseASC application collects the scanning data and calculates all needed information from these data.

In the Automatic Stacking Crane (ASC) the crane control system (CCS) will use LaseASC measurement results as one input to control the load position during lowering. LaseASC measurements are also used to prevent collision with adjacent container stacks, as well as for stack profile measurement in stack verification mode.

The measurement system for each crane consists of following components:

- IPC with installed LaseASC application and all needed software modules
- 2 x 3D-Scanner (2D LASE2000D + servo drive)

The measurements will be started by a special trigger message from PLC. All measurements will be made when ASC has reached the nominal slot position.



Note!

LaseASC is not developed for doing measurements during ASC approaches to a nominal position!

LaseASC operation can be divided into 6 functions:

1. To detect possible misplaced containers in the clearance zone of the target slot.
2. To recognize the top edges of the container underneath at which the hanging container or empty spreader shall be landed on and to determine its location relative to a reference within the field of view of the scanners.
3. To measure distance to stack underneath and determine stack height in stack verification mode.
4. To recognize a truck cabin roof at landside transfer point and to determine cabin location relative to a reference within the field of view of the scanners.
5. To recognize a terminal chassis frame and to determine chassis location relative to a reference within the field of view of the scanners.

Reference point is a common point of origin with Spreader Position Measurement System.

2.1 Configuration of the Measurement system

Inside the e-house on each of the ASC a measurement PC (LCU) is mounted, on which the LaseASC application is installed. The application contains all necessary modules for the communication to the laser systems and to PLC, as well as the analysis and visualisation of the measurement data.

The both 3D-Scanners are mounted at a special frame under the trolley. Like shown on figure below the scan plane (triangle shape) goes from the trolley to the ground. It is running alongside the containers in the gap between the slots. During the measurement the scan plane is swivelled in bay direction indicated by the both yellow arrows.

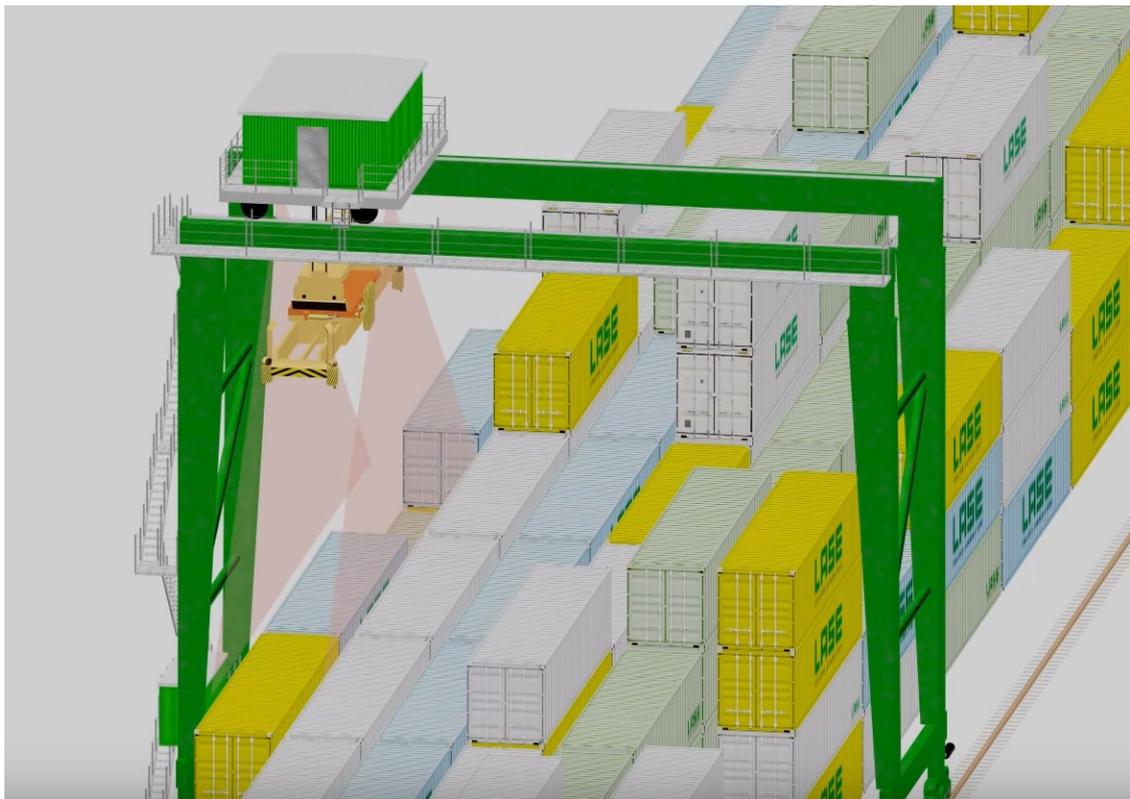


Figure 1: Locations/Notation

The pictures on the next page are showing the trolley of an ASC with the frame and the two 3D-Laserscanners.



Figure 1: Mounting position of the laser scanner at ASC (frame)



The internal numbering of the both scanners is 0 and 1. Due to the circumstance that the alignment of the cranes (flexible/fixed side related to block origin) is different also the auxiliary frame is rotated at some cranes.

To make the scanner handling easier on LaseASC side it was agreed to have the alignment of the scanners related to the block origin the same on all cranes. Thus 3D-Scanner 0 is always closer to the LaseASC X axis than 3D-Scanner 1.

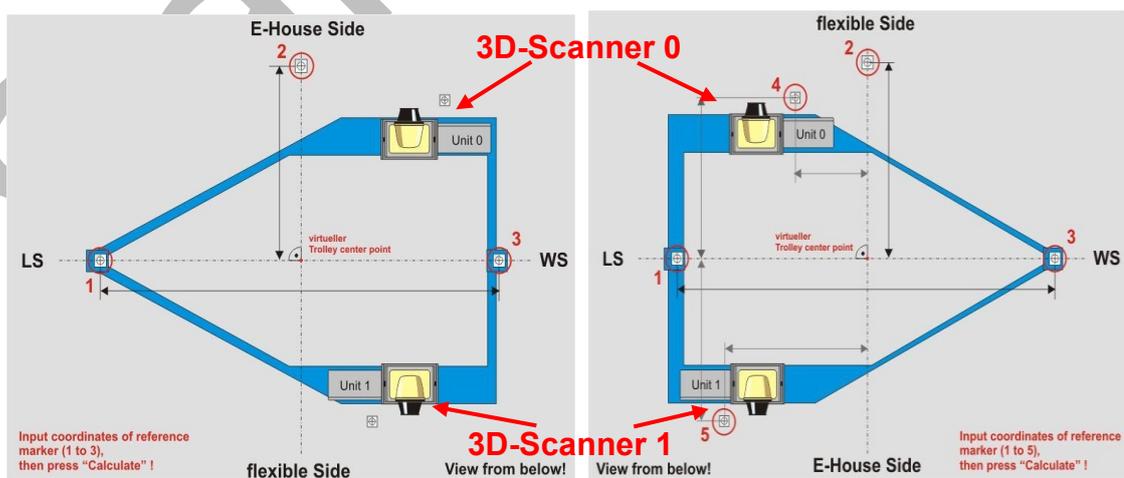


Figure 2: Numbering of laser scanners at ASC (frame)

2.1.1 Hardware Overview

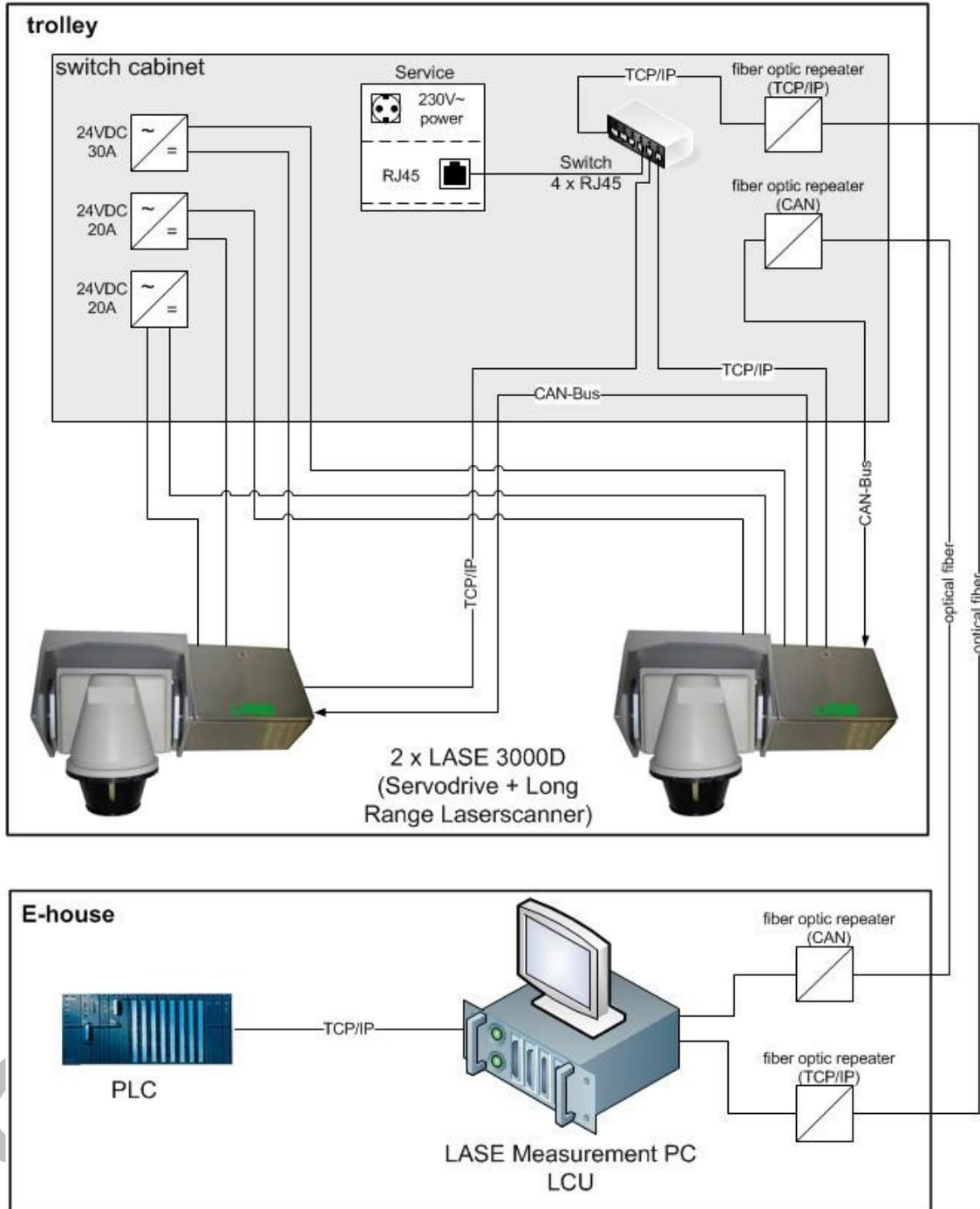


Figure 3: Hardware-Overview

3 Software Concept

3.1 General

The software of the measurement system is been developed and tested in C++ (MFC, Doc/View architecture) with help of the development environment Visual Studio 2008 for Windows XP Professional and Windows 7.

3.2 Software modules

Software for the LaseASC consists of following modules:

- Communication laser scanners (Ethernet)
- Communication swiveling unit (CAN)
- Communication PLC (Ethernet)
- Application core:, container and chassis position detection, reference marker measurement, diverse calculations
- Visualization
- Operating signals and notices of malfunction
- Commissioning and service
- Calibration

The different modules are activated by a program sequence control (see: 3.3 Application control sequence). The program sequence control works with an internal cycle time of approximately 20ms. Which modules are activated depends on which functionality is ordered by the PLC. The picture at the next page shows an overview about the program sequence.

For storing (logging) of all events and error messages the measurement system uses human readable log-files. There is no database used. In case of error analysis this files can be opened e.g. with Microsoft Excel or with any other text editor. It is also possible to activate the logging of all incoming data (scanner, servo drive, PLC communication). This feature will be used during the commissioning and in case of analysis of malfunction. The size and amount for the log-files respectively the log-folder is adjustable. If the amount of log-files or the adjusted maximum sizes will be overstepped, the oldest files will be deleted.

3.2.1 Communication (scanner, 3D-Scanner, PLC)

The application has to communicate with the both laser scanners, the two swiveling units and the PLC.

After the application is started, it tries to communicate with all connected devices. All connections are monitored cyclic. If one of the connections is lost or disconnected, the application tries to reconnect the lost device until it is connected again. If it is not possible to connect a device after a timeout an error message will be shown.

- For the communication to the both LRS the software uses a separate network interface card which is fitted in the IPC. Each scanner has a unique IP-address which is registered in the application. During the operation the application gets scans with a corresponding timestamps from each scanner.
- The both servo motors of the 3D-Scanners are connected via a CAN-Bus interface card to the IPC. Each 3D-Scanner has its unique module number (ID). With each of this module numbers the application can control the different units. For the different measurement tasks it is necessary to positioning the units to a special angle or let them swivel in different ranges. The 3D-Scanner support several working modes. By the application the 3D-Scanner is set into the required mode. After the mode is set, the 3D-Scanner works autarkic until it gets a new order. Now the application has only to read the current angle, the corresponding timestamps and trigger signals from the units.

- For the communication with the PLC a second network interface card is used. The measurement IPC works as a client and tries to connect to the PLC over an Ethernet TCP/IP socket connection to a port the PLC provides. For each measurement task, the PLC has to send following messages:
 - update message must include all information needed for the measurement
 - prepare message at least two seconds before actual measurement is started
 - start measurement activates the according measurement task
 - stop measurement stops the current measurement task

From the PLC the LaseASC application gets all operation orders which are necessary for the measurement tasks (see: 3.5 Measuring tasks). The application also transmits all important data to the PLC. The communication protocol is described in a separate document (MessagesBetweenLaseASCv2andPLC_v1.docx)



All important values (IP-addresses, port numbers, module numbers etc.) are adjustable in a human readable configuration-file and have to be set during the first commissioning.

3.2.2 Application core

In this part of the LaseASC application all necessary calculations and measurement functions are included.

For analysis of the measurement data the application uses an internal 3-dimensional data view. The scenario underneath the both 3D-Units is mapped as a 3-dimensional image.

A main functionality is to transform the incoming scanner data into the used coordinate system which is represented through the 3-dimensional image mentioned above. The scans from the scanners are received in polar coordinates. That means each scan (several points defined as distance and angle) has to be transformed into the Cartesian system. Afterwards each scan has to move along and rotate about the three axis (positions are determined during calibration) to positioning the scanners (measurement points) into the coordinate system. For the rotation about the x-axis the angle of the servo motor of the according 3D-Scanner is also important. Via the timestamp from the scan, the timestamp from the angle and a trigger signal of the servo motor it is possible to put the according scans and angles together.



The application includes all methods to separate container edges, edges of a trailer or edges of a truck cabin and reference marker from the transformed data. About these edges and the positions of the trolley the software is able to calculate the distance between the trolley center and the container center respectively the trailer center.

Depending of the current measurement mode the 3D-Scanners are switched to the needed swivel mode. For the different measurement modes it is necessary to let the 3D-Scanner swivel in different ranges. These ranges are also calculated in this part of application.

3.2.3 Visualization

The application supports several views and dialog boxes with different functions.

For example:

- Main view: shows all important working data
- 2D view: shows the scanner lines (view directions and scanners are selectable)
- Dialog box: parameter adjustments
- Dialog box: calibration wizard
- Dialog box: 3D-Scanner manual control
- Event and Error list

Most of these views and dialog boxes are only for commissioning and maintenance cases and to change some parameters.

For a short overview the main view (diagnostic view) supports all important information like

PLC status, status of LRS and 3D-units and a list with event and error messages.
All different views and their special functionalities will be described in chapter: 6 Software.

3.2.4 Operating signal (events) and notice of malfunction (errors)

The application provides a "service" view for maintenance. It shows all, for the operation important, information (e.g. 3D-Scanner status, PLC status etc.). Additionally all occurred events or errors are listed on this view. Furthermore all errors will be transmitted via Ethernet to the PLC. Events and errors are stored in a human readable log-file. In case of error analysis this file can be opened with Microsoft Excel or with any other text editor.

For each day the application creates a new log-file (name + date and time, e.g.: PROG_LOGS_130825_085637.CSV) in the directory "LOGS". If the directory exceeds the adjustable (in configuration-file) maximum memory size the oldest files will be deleted by the application. It is also possible to store (data logging) an adjustable amount of all working data (scans, telegrams etc.).

3.2.5 Commissioning and service

Commissioning:

All needed files, dll's, drivers etc. for the case of commissioning are combined on an installation CD. How to install will be described in the user manual.

To ensure the measurement system is able to work in an appropriate way, it is important that the LaseASC application knows the exact positions (x, y, z-directions, x, y, z-skews) of the 3D-Scanners relative to the crane/trolley. Therefore at the first commissioning all these parameters have to be inscribed in according fields on an applications view. In first step only the approximate values are inscribed. As second step it is necessary to do a calibration. During the calibration sequence the exact positions of all devices are determined.

Service (Maintenance):

In cases of service (e.g. after a changing of a scanner) it is necessary to run the calibration sequence to ensure that all calibration values are still valid, or if not, to replace the old values with new ones.

To check if all calibration values (positions) are still valid and the measurement system is still able to work in an appropriate way, it is expedient to verify all position values from time to time.

Further the application supports different views and Dialog boxes for commissioning and service. For example the status of all interfaces and devices is shown and it is possible to let the 3D-Scanner swivel manually.

3.2.6 Calibration

At the initial commissioning and later on in a given time interval during the operating it is necessary to calibrate the measurement system (q.v. **Fehler! Verweisquelle konnte nicht gefunden werden. Fehler! Verweisquelle konnte nicht gefunden werden.**).

The preliminary mechanical work for the calibration is described at point 3.6 Calibration. All by hand measured positions and if necessary the skews of the calibration device have to be inscribed in according fields on calibration view. During the calibration sequence the application determines the position of the 3D-Scanners relative to the crane/trolley by measuring landmarks and the calibration device (special calibration frame).

Further information and the complete calibration procedure will also be described in the user manual.

3.3 Application control sequence

3.3.1 Overview

The following flowchart gives a short overview how the LaseASC is working internally. The sequence will pass through cyclic. The application core works as a state machine like described succeeding. Independent from the current state in each cycle new PLC data will read or write (if present) and the status of application, all devices and interfaces will be checked. In case of state measurement also all incoming measurement data will be processed.

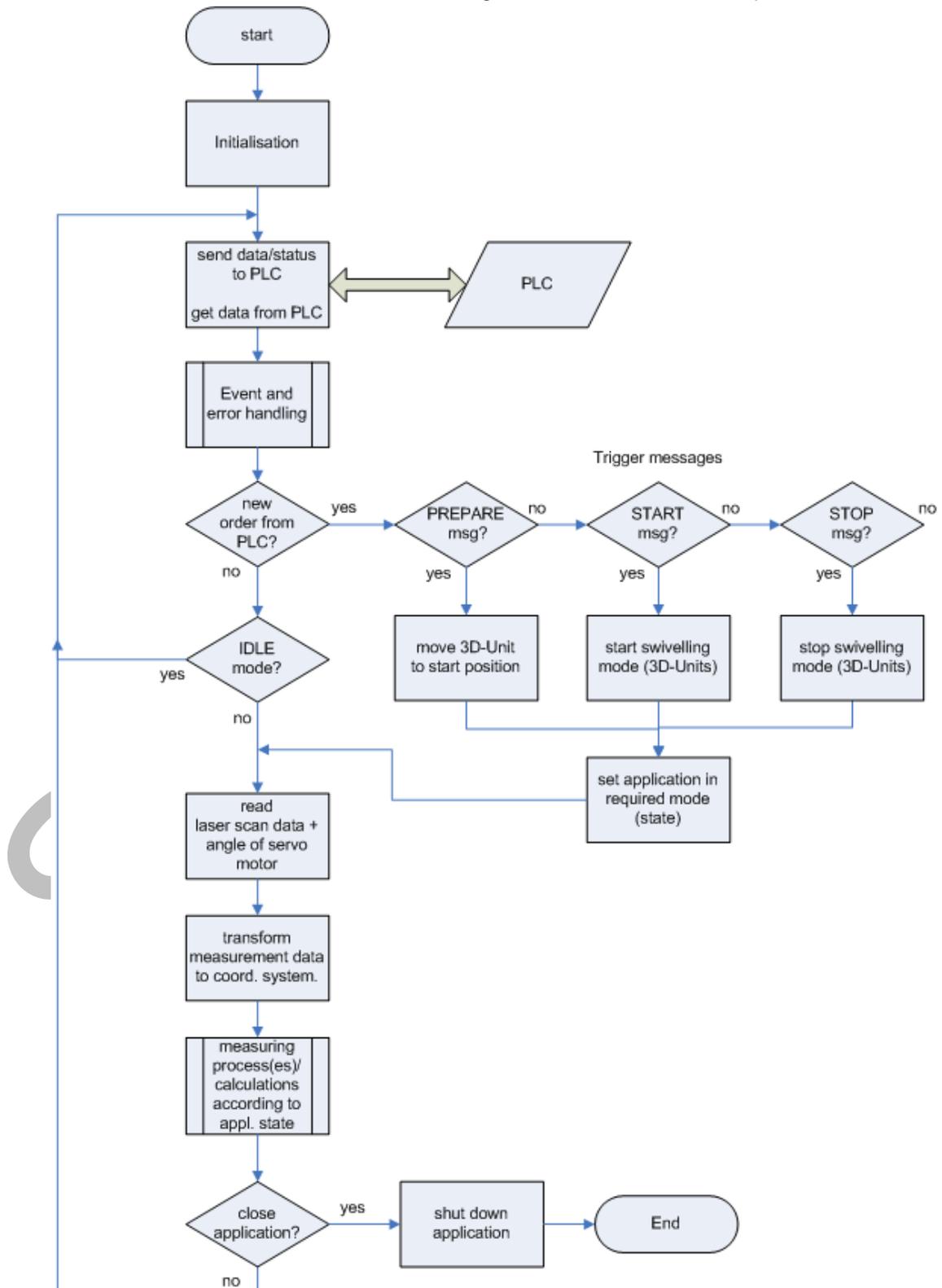


Figure 4: Application flowchart

3.3.2 Application states

The LaseASC application core functionality is controlled with help of several state machines. There is one state machine (Main state machine) which controls the main functionalities and few other state machines (Sub state machines) which controlling some single states from the main state machine (e.g. state measurement).

The main state machine includes all states and general application functionalities like e.g. error handling and interfaces control.

States:

- **“Init”** state after start of application. Initialization of application, interfaces, 3D-Scanner etc.
- **“Idle”** state of application if there is no measurement current task
- **“Search 3D-Unit reference points”**
sub state machine which controls the 3D-Scanner reference point search. Each unit needs a reference point (inductive switch and mark at axle) which have to be found if the unit is switched on the first time or after power was disconnected.
- **“Error”** error handling of all interfaces or general application errors
- **“Measure”** sub state machine which controls all measurement functionalities
- **“Calibration”** sub state machine which control the calibration sequence
- **“Service swivel”**
state to activate the so called service swivel which lets the 3D-Scanner will swivel in a wider range from time to time (adjustable)
- **“Stop 3D-Units”**
State after Button stop units was pressed. This state is active until the button was pressed a second time. The button is to stop the units immediately in case of maintenance or emergency for example.
- **“Manual mode”**
State for maintenance for example. A dialog box which allows manual control of 3D-Scanner is opened. Note! No automatic measurements are possible in this state.

Each telegram, send from LaseASC to PLC, includes information about the current main and sub state.

The following pictures are showing the implemented state machines. The pictures shall give an overview over the internal state machines. LASE excepted to change or adapt single states or state machines for the final version of LaseASC application.

**(Main) Statemachine:
Application Sequence**

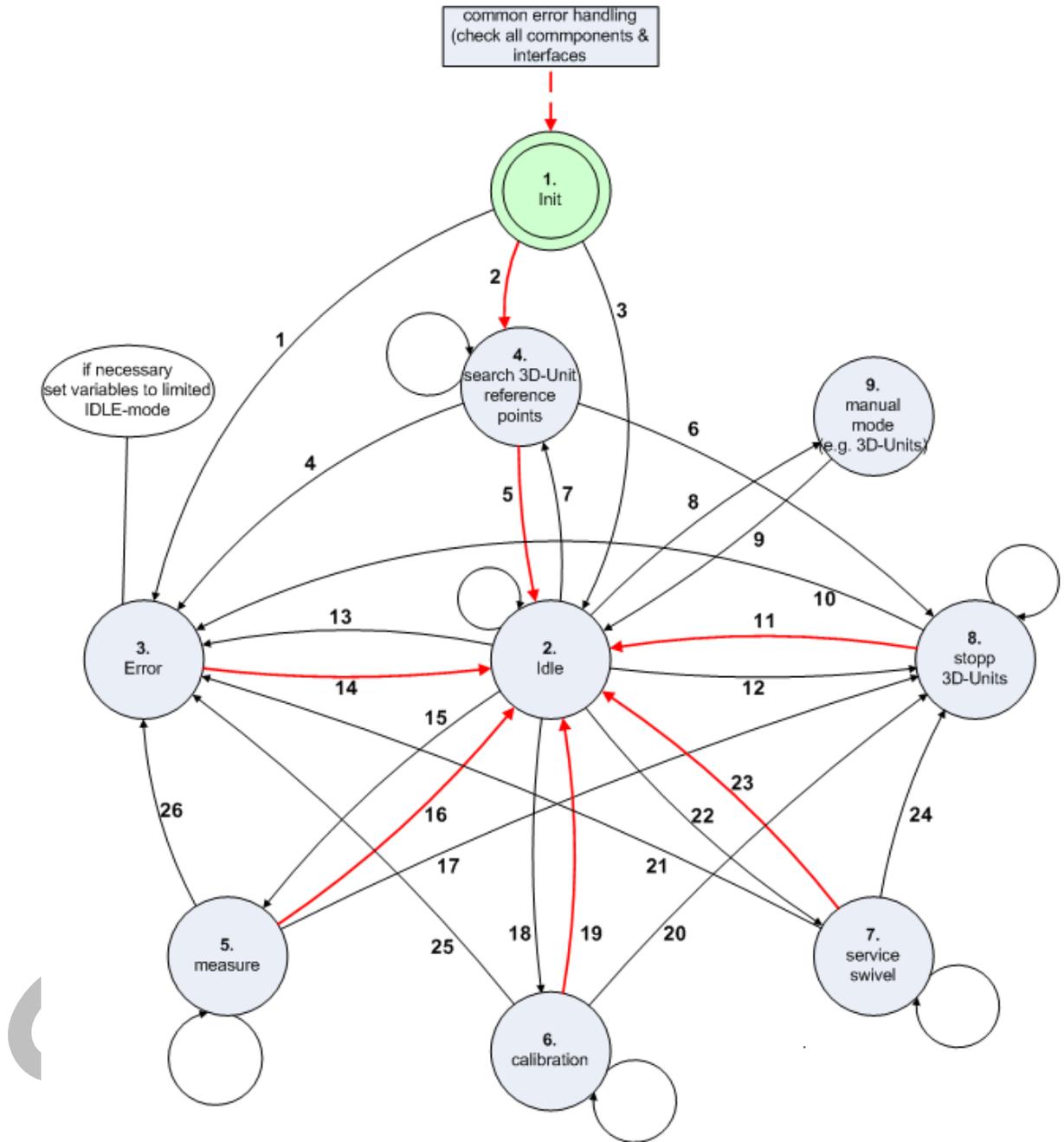
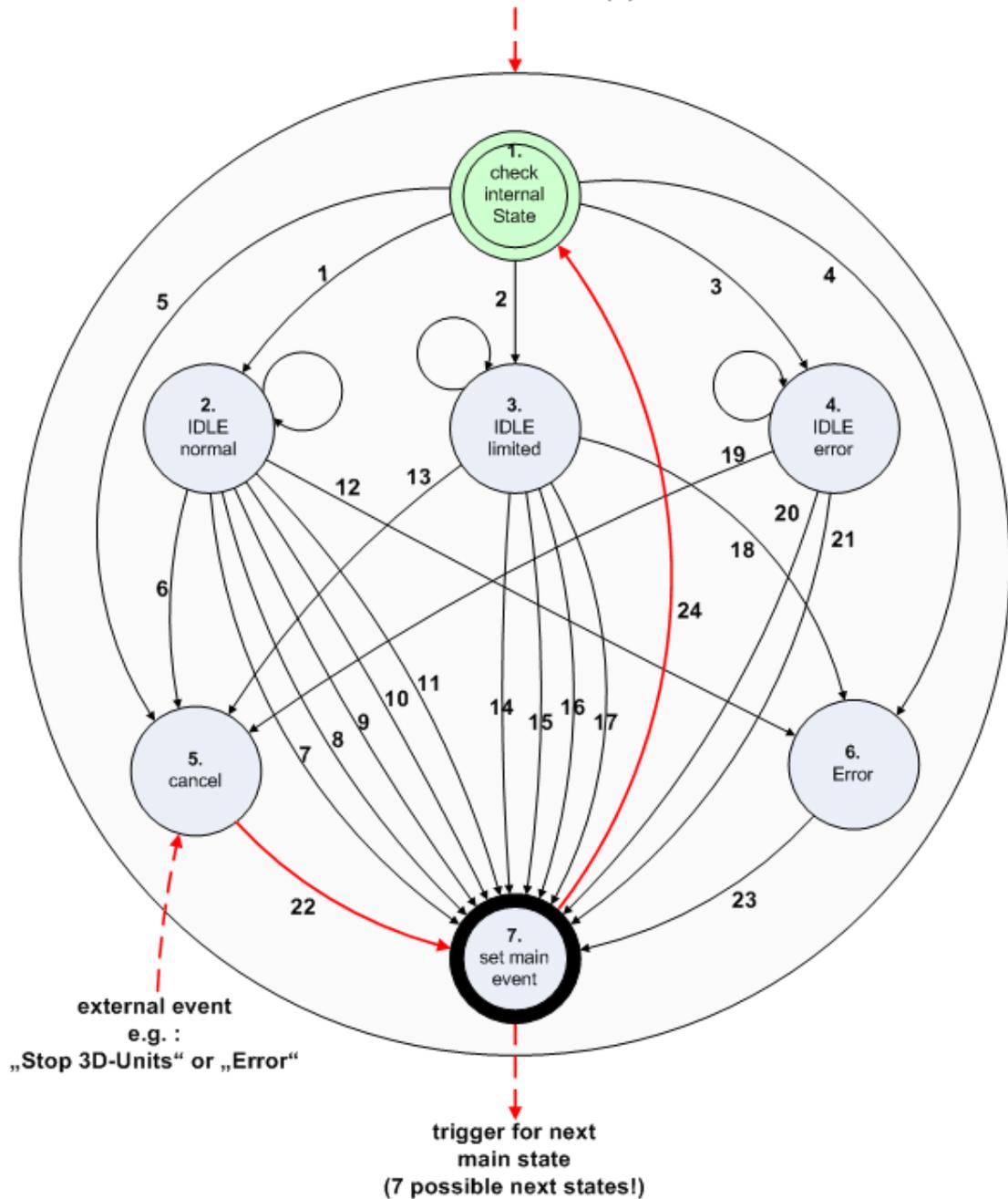


Figure 5: application control (main state machine)

**Sub Statemachine:
Main-State: Idle (2)**



Events for transitions:

1	EVENT_SUB_IDLE_NORM_MODE	13	EVENT_SUB_IDLE_CANCEL
2	EVENT_SUB_IDLE_LIMITED_MODE	14	EVENT_SUB_IDLE_SET_MEASURE
3	EVENT_SUB_IDLE_ERROR_MODE	15	EVENT_SUB_IDLE_SET_SERVICE
4	EVENT_SUB_IDLE_ERROR	16	EVENT_SUB_IDLE_SET_MANUAL
5	EVENT_SUB_IDLE_CANCEL	17	EVENT_SUB_IDLE_SET_REF_PT
6	EVENT_SUB_IDLE_CANCEL	18	EVENT_SUB_IDLE_ERROR
7	EVENT_SUB_IDLE_SET_MEASURE	19	EVENT_SUB_IDLE_CANCEL
8	EVENT_SUB_IDLE_SET_CALIB	20	EVENT_SUB_IDLE_SET_MANUAL
9	EVENT_SUB_IDLE_SET_SERVICE	21	EVENT_SUB_IDLE_SET_ERROR
10	EVENT_SUB_IDLE_SET_MANUAL	22	EVENT_SUB_IDLE_SET_CANCEL
11	EVENT_SUB_IDLE_SET_REF_PT	23	EVENT_SUB_IDLE_SET_ERROR
12	EVENT_SUB_IDLE_ERROR	24	EVENT_SUB_IDLE_SM_RESET

Figure 6: sub state machine (Idle)

3.4 Swivel control (3D-Scanner)

Before a measurement can start the PLC must send a special trigger message (PREPARE) to LaseASC application. With information from the last data update message from PLC LaseASC application can calculate and set all needed swivel settings to the swivel control.

The range for the swiveling during the single measurement tasks depends on the task, the area and the tier etc. That does mean for example if a container shall be placed, first the target area will be scanned, afterwards the scan runs towards the adjacent stacks (gap detection). The swivel range and swivel velocity also depends on the target height and the area. For example: In truck lanes the range is larger than in normal stacking area, because the distance in Y-direction between the reference markers is wider. The swivel velocity is changing during the swivel is active. If the container is scanned the velocity rises until short before the reference markers will be scanned. The velocity during scanning the reference markers will be slower again. The procedure is to decrease the measurement time.

The scanner platforms swiveling with a velocity that the moving distance of scan points at ground in Y direction is about 40mm every 100ms. Consequently the velocity for measurements in higher tiers is faster than in lower tiers.

Usual swiveling sequence:

PREPARE message	both 3D-Scanner are swiveled in that way that both scan planes running over the target area (in direction to slot center).
START message	the scan planes are swiveling from start position to the outer edges of the container towards the adjacent stacks and back to. In case of reference markers are measured (in truck lane position measurement) the swivel will continue until Stop message
STOP message	swiveling stops

3.5 Measuring tasks



The LaseASC gets information from the PLC which measurement task is the next. Therefore the PLC sends a special trigger messages. First trigger message is a **PREPARE** message, sent **at least 2 seconds before the crane has reached the nominal target position**. According to the task both 3D-units will swivel to an appropriate start angle. This start angle depends on the target tier. If the crane has reached the target area and fully stopped, a **START** measurement message is send by the PLC. The measurement ends when PLC sends a **STOP** message

All below described possible measurement tasks will be handled in the state measurement!

3.5.1 Measuring Target Container (Target Below)

First measurement after trigger message START is that LaseASC starts to recognize the top edges of the container underneath on which the hanging container or empty spreader shall be landed. From the measured container edges LaseASC application determines the skew and the deviation of the container center point to the nominal slot position. If a container shall be placed at ground level (tier 1) this function is not used.

By building average values of several scans for the 4 outline edges accuracy for container position in crane travel axis and in trolley travel axis can be of +/-20mm.

The target below measurement is a relative measurement, thus the result is the deviation between the trolley center point and the calculated center point of the target container.



Note:

When measuring containers in the highest tier, it is not always possible for both 3D-Scanners to see the scenery underneath the spreader or containers at the spreader. In this case the target container will be measured only by one 3D-Scanner which is able to see the top container edges.

We recommend using micro-motion to shift the spreader to one side to allow at least one 3D-Scanner having an appropriate view to the target container.

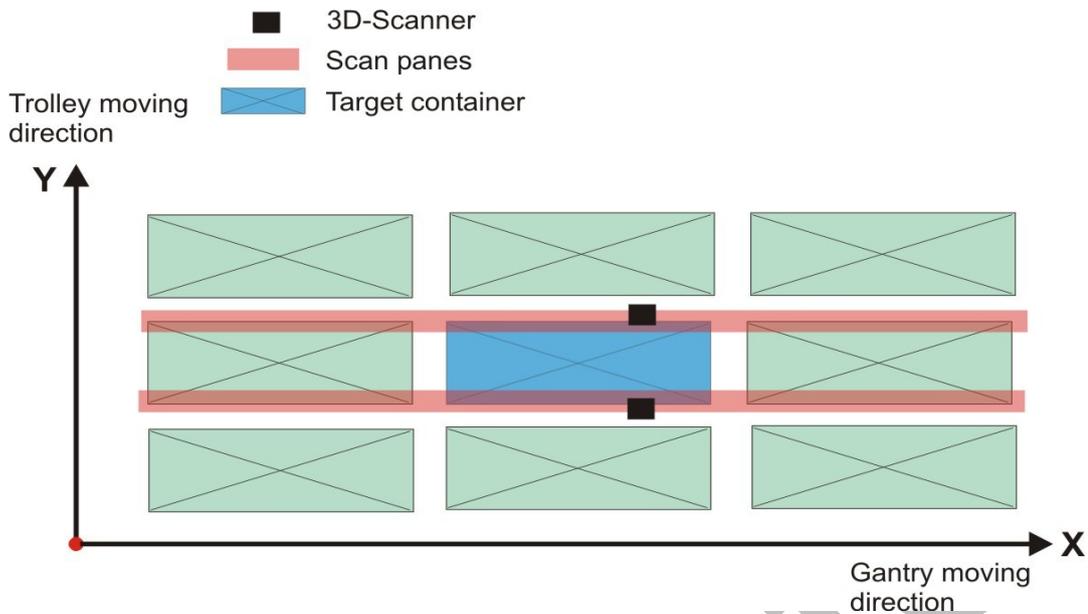


Figure 7: Measuring of target area (top view)

Different algorithms are used to filter the measurement points and to recognise the edges of the target container.

First step is to measure the scenario (3D-Scan). With the knowledge of the trolley position and the nominal target position the search area (for container edges) can be limited. It is only possible to detect edges of the highest container, which should be the target container. Next step is to separate the highest measurement points, which are representing the upper edges, from other points. Therefore gaps in X and Y direction are searched to roughly find the outer edges. Result is a “ribbon” of measurement points (see: Figure 8: 3D-view of measurement data (target container)). Through the outer points of these remaining measurement points a straight line is placed which represent the outer edge in Y direction. To find the edges in X direction a virtual cube is placed at the ends of the points. With different filters and calculations the edge is determined from the points inside of the cube. The container skew is determined by compare the line with the alignment of the recognised land markers.

This procedure is the same for both 3D-Units. If there are measurement points from both units the container width is the distance between both lines. If there are only points from one unit the LaseASC uses the width information (from PLC) for the expected target container.

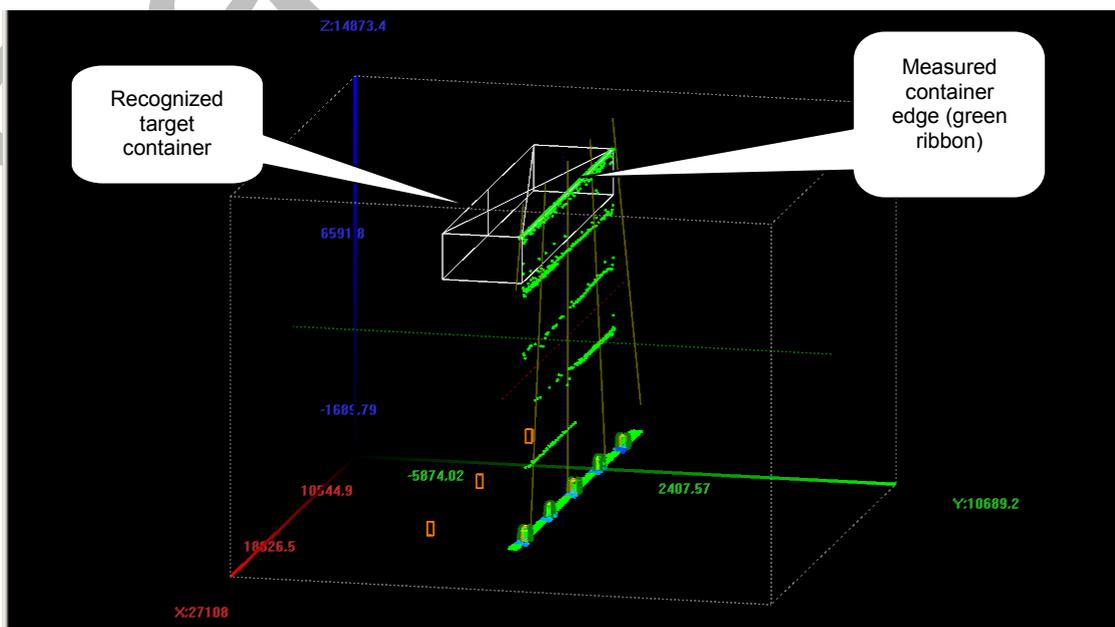


Figure 8: 3D-view of measurement data (target container)

The picture above shows the measurement data of only one 3D-Scanner (light green points). The data from the other 3D-Scanner are blinded out.

The white box is a detected container at top of a five high stack. It's also possible to see parts of the container edges of the lower containers (light green lines).

LaseASC is able to detect 20', 40' and 45' containers which can be placed in different combinations.

In the following figures different setups (combinations) of containers in the stack area are shown. The red container shows the respective target position. The small green dots are representing the corners of the 20' slot pattern with distances of usually 6500mm in X and 2900mm in Y direction.

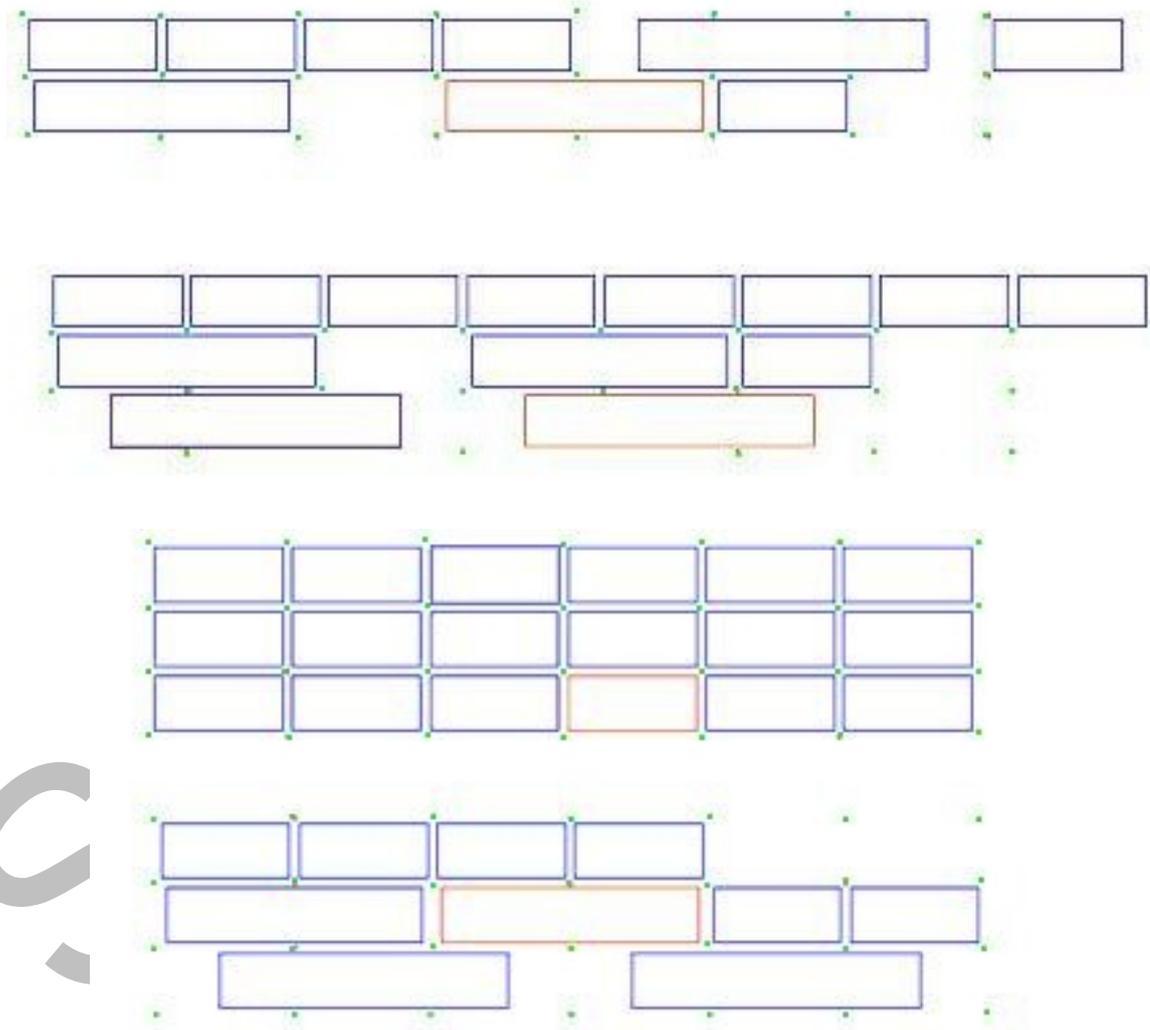


Figure 9: different combinations 45, 40 and 20 foot containers

3.5.2 Measuring space between target slot and adjacent stacks (gap detection).

If it is required by PLC the LaseASC measures the gap between the target slot and the adjacent stacks. This is to avoid any collision while lowering or pick up the spreader or a container at spreader (decided by PLC).

The gap detection takes place when the 3D-Scanners swivelling from the target area towards the adjacent stacks. After the gap area is measured and all data are stored in LaseASC application, two adjustable 3 dimensional cubes are added to the measurement points (at target position). If the areas between both cubes are violated by more than 40mm a collision warning will be send to the PLC.

The gap detection works only until the height of the target area.

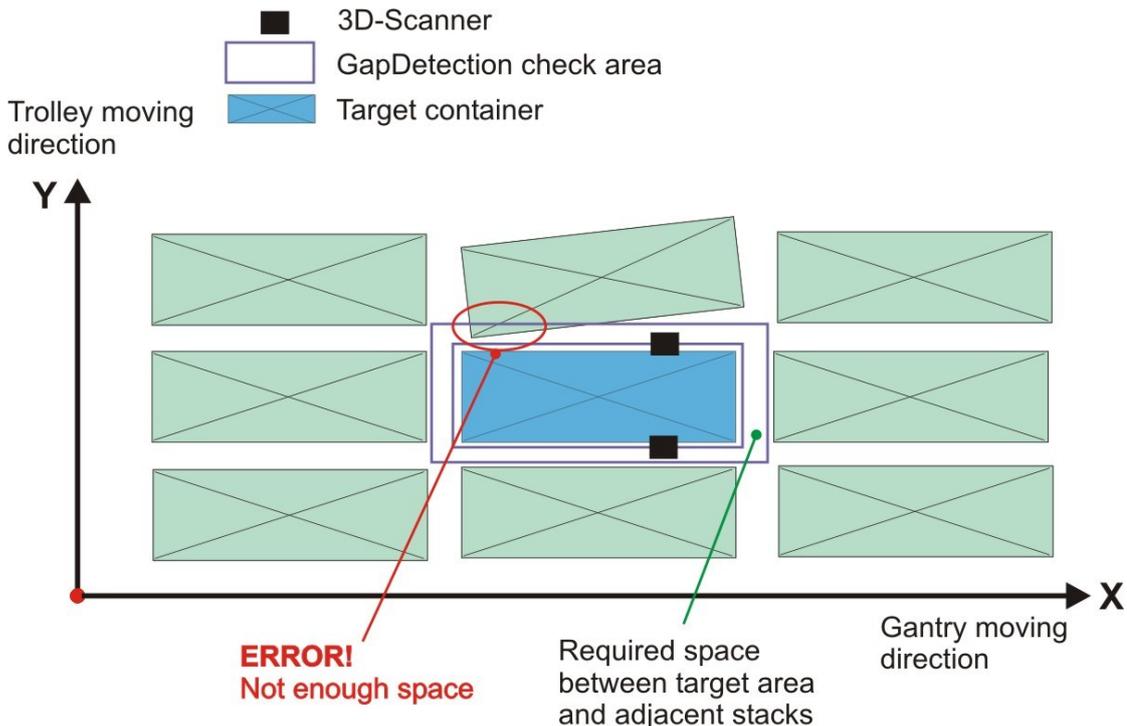


Figure 10: gap detection (top view)

The picture above shows the top view to a target area surrounded by several container stacks. The both violet rectangles are the cubes mentioned above. If the area between this both violet rectangles is violated (e.g. not enough space for place for lowering a container), shown at the top part of the picture, a collision message will be send to PLC.

PICK task

When a container shall be picked from a trailer LaseASC is used to determine the distance between the container centre on the trailer and the trolley centre. Therefore the crane moves over the truck lanes and stops in a safe position close to the water side end of the truck lane. LaseASC is triggered; a 3D-Scan will be performed. According the pre-information from the PLC (slot on the trailer, container length etc.) LaseASC is searching for the container and then calculating the centre coordinates. The distance between both coordinates (Container and Spreader including skew) is send to the crane PLC. The crane is now able to pick-up the container from the trailer

The screenshot below shows a 3D-Scan of a truck with a 20' container in front position. The white cube with the diagonal cross represents the calculated container position.

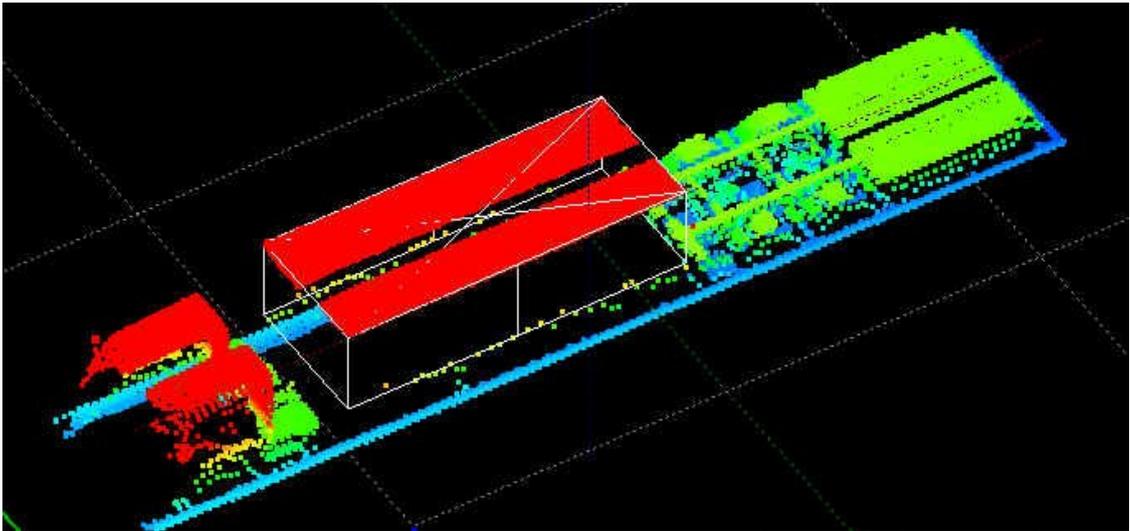


Figure 11: Truck lane – PICK task (3D-view)

PLACE task

During the place task LaseASC is used to cover several tasks. It can measure the position of terminal trailer for an automatic place process but is not capable to measure the position of road-trailer by the different structure of the thousands of different trailer types.

Truck cabin

The position of the truck cabin is measured in case of setting down a container to a chassis at landside transfer point. The LaseASC application determines the truck cabin and provides the PLC the centre point of the back edge of the cabin (see drawing below). The LaseASC application uses a 3-dimensional cube which will be placed around the recorded data (measurement points representing the cabin) to detect the cabin. The given point (X, Y, Z) is the distance to the current trolley position (X = distance to most back edge of cabin, Y = distance to middle of cabin, Z = distance to highest point of roof or mounted parts). Because of too much different devices which can be mounted at the cabin (air deflectors, exhausts, flashing lights etc.) the accuracy is +/-200mm.

Trailer

To measure known terminal chassis or a container on a loaded chassis at landside transfer point and to determine chassis position (centre point of back edge: x, y, z and skew of trailer) or container locations (centre point x, y, z and skew of container) relative to the current trolley position with an accuracy of +/-200mm. For road chassis it is only possible to do an approximately chassis position detection because of too many different shapes.

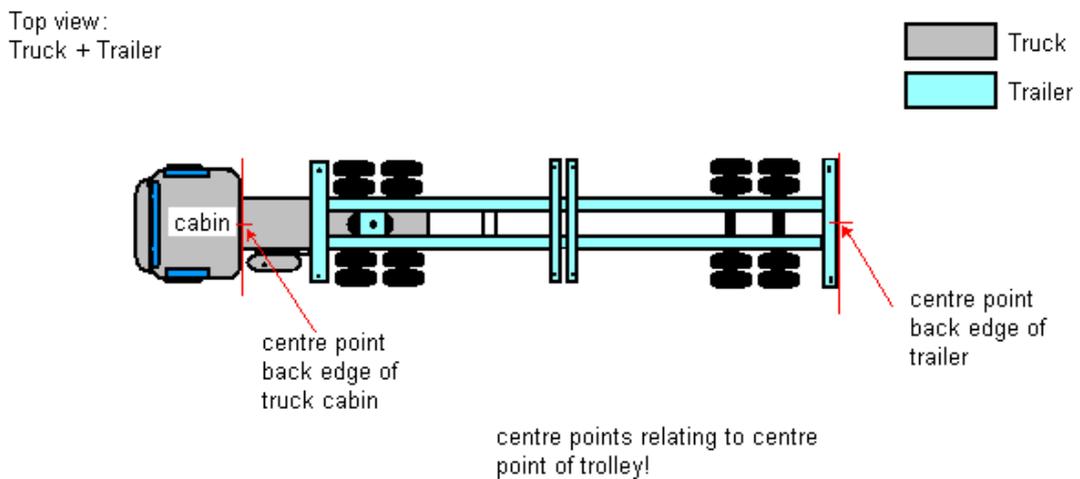


Figure 12: back edges of truck and trailer

The screenshot below shows an example of the internal calculations. The red dots on the right-hand side are representing the back edge of the trailer. The violet points are representing the cabin. Around the cabin there is the above mentioned cube (green) to determine the back edge of the cabin. The yellow and red cubes are auxiliary cubes to find the end of the tractor or to check if there are two trailers.

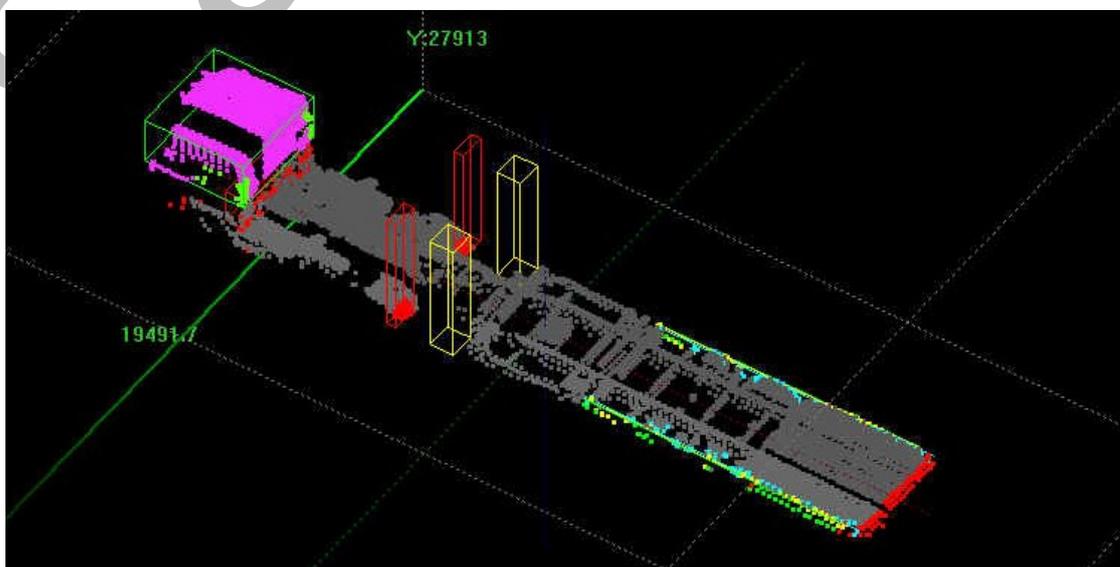


Figure 13: back edges of truck and trailer (3D-image)

3.5.3 Measuring space above target position (faulty stack height detection)

If required by PLC the LaseASC measures the area above the nominal target slot. This is to ensure that there is no unexpected container above the target slot when can cause a collision when grounding a box or landing the spreader.

Therefore the PLC sets a bit to activate the needed function in LaseASC V2. If the function is activated the start point for swiveling after PLC has send a PREPARE message is nearly above land marks. After a START message the scanner will be swiveled with faster velocity and a larger angle to the center of target area. This allows detecting side walls or the roof of an unexpected container. If an unexpected box was detected the LaseASC gives an alarm to the PLC.

If no alarm was set the LaseASC starts automatically the normal measurement sequence.

3.5.4 Measuring stack height in stack verification mode

To check if stocking level is concordant with reality, the crane can drive well directed to positions in the stack to verify the state. Therefore the crane and trolley are positioned upright over the slot which shall be checked. The scanners are swiveled to the middle of the slot and then starting swiveling the edges. After the target area is totally scanned the highest level will be determined from the recorded data and send to PLC.

It is not possible to check several stacks per lanes because of shadowed areas (i.e. perhaps a scanner can't see containers in tier 1 behind a stack of 5 container height, see picture below).

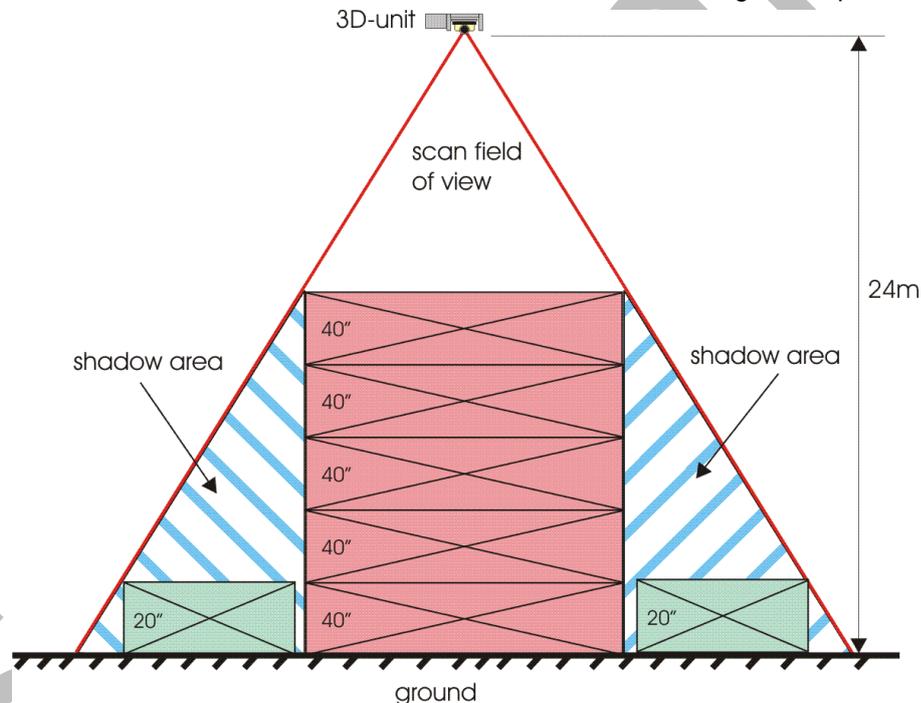


Figure 14: shadow areas in stack verification mode

With the previous knowledge about which scene shall be measured (20', 40', general, open top,...) the measuring system measures the highest point within the predetermined area. Height measurement is made with an accuracy of +/- 50 mm.

Sequence of stack verification mode

- crane moves to position which has to be verified
- if necessary 3D-Scanner swivel to start angle
- crane achieves the position which has to be verified
- 3D-Scanner swivelling to outer edges
- The measurement system measures and calculates the height of stack
- Measurement is ready, data will be send to PLC
- Crane moves to next position or verification mode stops

3.6 Calibration

Calibration is necessary at initial commissioning and after changing a 3-D Scanner. An intervallic inspection of the measuring system is recommended.

**Note!**

Only if the calibration is done successfully LaseASC can deliver accurate and reliable measurement results.

During commissioning only the approximate positions of the 3D-Unit are adjusted in the LaseASC application (the approximate values are known from the technical drawings and from surveying).

By activating the calibration sequence LaseASC application starts to determine the exact mounting position of both 3D-Units relative to a defined "virtual" trolley center point also used by Spreader Position Measurement System.

The Calibration sequence is menu guided and described in chapter: **Fehler! Verweisquelle konnte nicht gefunden werden. Fehler! Verweisquelle konnte nicht gefunden werden.**

The calibration is done in the truck lanes by using the reference markers mounted on top of the fences between the truck lanes.

4 Hardware

4.1 IPC (LASE LCU)

The LASE LCU (LASE Control Unit) is an industrial PC (IPC) with two Ethernet-interfaces and presently common performance data. The laser scanners are connected to the PC via an Ethernet interface card. Data to and from the swiveling platform are sent via CAN bus interface. Via a second Ethernet interface card the LCU is connected to the PLC. The data interface connections (Ethernet + CAN) between the power house and the switch cabinet, at the trolley, are conducted with fiber optical cables (FO). Therefore inside of the power house and in the switch cabinet special converters (Repeater, Ethernet <=> FO + CAN <=> FO) are fitted.

As measuring computer the following LCU will be used. On each ASC is a separate LCU, on which the LaseASC application software is installed.

Basic requirements:

LASE LCU	
Operating system	Windows XP / Windows 7
Processor	Pentium 4 / Intel Core I5/7
HD	250GB 24/7 shock resistant
DVD	1x
Graphic adapter	No onboard adapter / OpenGL 2.0 compatible
Memory	4 GB min.
Ethernet interface	2 x RJ45
CAN interface	1 Esd CAN-Bus adapter (PCIe or USB device)
USB	4 x
Suspension system on hard disk trays, shields from shocks and vibration up to 100 G	

Table 1: IPC technical data

4.2 3D-Scanner

The LASE 3D-Scanner was developed to allow a 3-dimensional scanning of a scenario (e.g. container stacks, truck/trailer combinations, reference marker). With the internal synchronization between scanner and servo drive (measurement points + angle), LaseASC is able to create 3-dimensional images of the scenario under the ASC and to achieve all necessary measurement tasks.

A 3D-Scanner consists of following parts:

- Swivelling platform
- Servo motor
- Switch cabinet
- LASE2000D-139 (2-dimensional laser scanner)

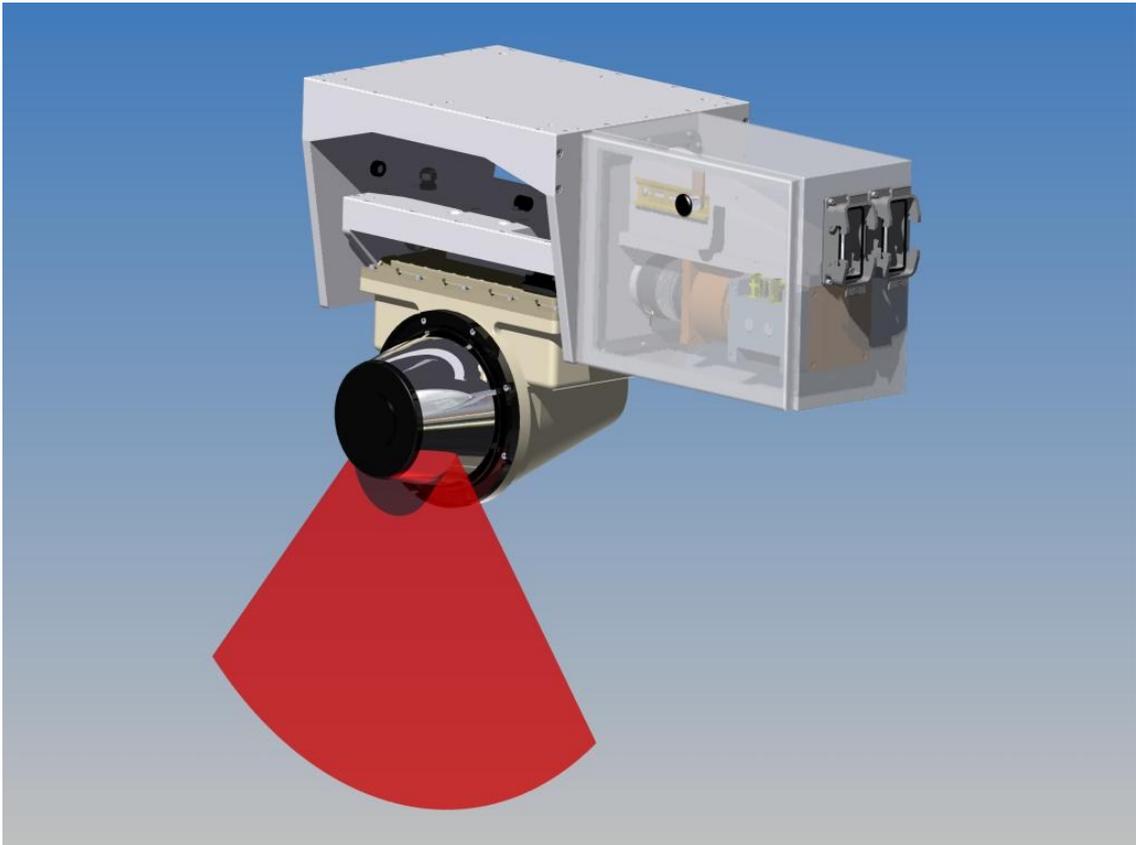


Figure 15: 3D-Scanner (red = scan plane)



Note!

During manufacturing of a 3D-Scanner several internal configuration and calibration parameters are set in the firmware of the servo drive.

The 3D-Scanner has to be handled as a black-box. In case of malfunction the whole unit has to be changed.

The both 3D-Scanners are accessible via the trolley house. There are two potholes in the ground plate of the trolley house through which a service platform beneath each 3D-Scanner can be reached.

Attention!

The 3D-Scanner together with LaseASC application is an automatic working measurement system which needs, in normal operation, no manual input from an operator. That does mean that in case of maintenance or if somebody is working at a 3D-Scanner, the platform may start swivelling automatically!

The following sticker is fixed at each 3D-Scanner to remind the staff about the dangerous.



Before starting work at the system, switch of the fuses for power supply.

4.2.1 Swivelling platform + servo drive

The swiveling platform consists of a fixed drive block (servo motor) and a platform on which a 2-D laser scanner (LRS) is situated. The platform is driven by the servo motor which is mounted inside of the switch cabinet. The servo motor is controlled by the measurement application running on the IPC. Start position (angle), the swivel range and velocity depend on the measurement task, the measurement height and the area in which the LaseASC shall measure. Position data and driving commands are sent via a CAN interface.

3D-Unit data		
Protection class (IP)	IP 66 (servo)	IP67 (Scanner)
Swivel range (max., min.)	+45°	-45°
Power supply (servo)	24V ± 2V DC / 2A (logic)	24V ± 2V DC / 30A (motor)
Power supply (scanner)	24V ± 2V DC / 2A (logic)	24V ± 2V DC / 6A (heating)
weight	Ca. 35Kg	
Temperature range	-25°C - +50°C	

Table 2: 3D-Unit technical data

4.2.2 Switch cabinet

Inside of the switch cabinet the cables from scanner, servo motor and the external plugs are tapped to a connecting block which is fixed on a top-hat rail.

Additional a thermostatic heating is integrated to allow operation in a cold environment.

All connections (power 24VDC + 24VDC, CAN, Ethernet) to the 3D-Unit are realized with two heavy duty "Harting" plugs at the side of the switch cabinet (Further information see: 4.2.5 External interface (power, CAN, Ethernet)).

4.2.3 LRS (long range scanner)

The used laser scanner will be from the latest generation of the LASE2000D-139 series. This laser scanner is characterized by the following data:

- Low beam divergence of 2.8 mrad (e.g. at 20 m the laser point has a diameter of 96mm = 56mm divergence + 40 mm optic diameter)
- The increased range of 80 m at 10% reflectance



Figure 16: LASE2000D-139 (Long Range Scanner)

The laser scanner is designed for outdoor use and for this reason it is suitable even for temperature range of -25°C to +45 °C. Therefore a thermostatic heating is integrated that gets switched on automatically at temperatures < 10 °C and thus avoids bedewing inside the device and at the front glass.

Parameter LASE2000D-139	
IP Address	192.168.0.160 (.170)
Gateway	0.0.0.0
Hz	10Hz
Angle steps	0.0625°
Interlace mode	4-times
Near field suppression	on
Scan-range (Sector 1)	135° - 225°

Table 3: LASE2000D Parameter

4.2.4 Configuration

The LaseASC is connected to two 3D-Scanners (Scanner 0 + Scanner 1). To ensure that LaseASC can handle the 3-dimensional data from the scanners in an appropriate way, the configuration (CAN ID, IP address) of both Scanners is different.

In case of replacing a 3D-Scanner it has to be ensured that the broken scanner will be replaced by a new one with the same configuration.

During start-up of LaseASC application the above mentioned LASE2000D parameters (apart from IP-address and gateway) are automatically set to the scanner.

Following table shows the properly configurations for each scanner:

Scanner 0 (closer to x-axis of LaseASC coordinate system)		Scanner 1	
CAN ID	16	CAN ID	17
IP address	192.168.0.160	IP address	192.168.0.170

Table 4: 3D Scanner – Configuration

4.2.5 External interface (power, CAN, Ethernet)

Pin order Harting plug for Power connection:

Connector 1 (power 48VDC and 24VDC)		
Pin		description
1	24 VDC (+)	30A power supply servo drive
2	GND (48VDC)	
3	24 VDC (+)	10A power supply servo drive electronic and laser scanner electronic
4	GND (24VDC)	
5	24 VDC (+)	10A heating for Laser scanner and switching cabinet
6	GND (24 VDC)	

Table 5: Pin order power connection (3D-Scanner)

Pin order Harting plug data connection:

Connector 2 (data)		
Pin	data	description
1	CANL Input	1. Scanner: Input from LASE-LCU, 2. Scanner: connection to CAN output from 1. Scanner (Pin 9)
2	CANH Input	1. Scanner: Input from LASE-LCU, 2. Scanner: connection to CAN output from 1. Scanner (Pin 10)
3	RxD+	data connection laser scanner (RS422 to service Sub-D plug (9 pol.) in switch cabinet)
4	TxD+	data connection laser scanner (RS422 to service Sub-D plug (9 pol.) in switch cabinet)
5	shield	shield RS422 connection
6	RX+	data connection laser scanner (Ethernet) (TPIP)
7	TX+	data connection laser scanner (Ethernet) (TPOP)
8	shield	shield CAN connection

9	CANL Output	Bus connection to next unit (only 1. Scanner, connected with Pin 3 of 2. Scanner)
10	CANH Output	Bus connection to next unit (only 1. Scanner, connected with Pin 4 of 2. Scanner)
11	RxD-	data connection laser scanner (RS422 to service Sub-D plug (9 pol.) in switch cabinet)
12	TxD-	data connection laser scanner (RS422 to service Sub-D plug (9 pol.) in switch cabinet)
13		
14	RX-	data connection laser scanner (Ethernet) (TPIN)
15	TX-	data connection laser scanner (Ethernet) (TPON)
16		reserve

Table 6: Pin order data connection (3D-Scanner)

5 Installation

This chapter gives an overview about how to install the LaseASC software application on the LCU. It shows which additional programs and files are needed.

5.1 needed programs/applications and files

For the operation of the measuring system following programs and files are needed:

- | | |
|-----------------------------|--|
| • Windows XP/7 Professional | must be installed first (SP 2 min.) |
| • Hardware drivers | all hardware (LCU) related drivers must be installed, including Esd CAN-Bus driver |
| • VC-redist_x86.exe | Microsoft Visual Studio redistributable package must be installed |
| • LaseASC_V2.exe | measuring software |
| • DelayStart.exe | Application to restart LaseASC |
| • MessageDlg_App.exe | creates a message box in case of a crash |
| • GLToolBar.bmp | Bitmap for 3D dialogue box |
| • GLToolBarPre.bmp | ” |
| • BugslayerUtil.dll | for program internal diagnostic purposes |
| • DVPlayer.dll | ” |
| • EWS_Common.dll | Dll for several program functions |
| • EWS_GUI.dll | ” |
| • EWS_RES.dll | ” |
| • EWS_RES_DEU.dll | ” |
| • EWS_RES_ENU.dll | ” |
| • LDATCPDIIManager.dll | ” |
| • License.dll | ” |
| • PoCuV5.dll | ” |

Ini files (located in the sub-folder “Ini”):

- | | |
|----------------------------|--|
| • LaseASC_V2.ini | contains all needed program parameter |
| • BerechnungsParam.ini | contains parameter for calculation algorithms |
| • KalibrierParam.ini | contains crane specific calibration parameter |
| • KalibrierParamUnit_0.ini | contains crane specific calib. parameter for Scanner 0 |
| • Calibration_0.ini | “ |
| • KalibrierParamUnit_1.ini | contains crane specific calib. parameter for Scanner 1 |
| • Calibration_1.ini | “ |
| • MessStation2D_S0.ini | contains all needed parameter for scanner 0 |
| • MessStation2D_S1.ini | contains all needed parameter for scanner 1 |
| • PowerCube_PoCu_0.ini | parameters for servo drive Scanner 0 |
| • PowerCube_PoCu_1.ini | parameters for servo drive Scanner 1 |
| • ReferenceMarker.ini | contains reference marker coordinates |
| • SchwenkParameter.ini | contains all needed swivel adjustments |
| • LaseASC_FMDS_Connect.ini | contains parameter for using FMDS connection |
| • DelayStart.ini | contains parameter for restarting LaseASC |

application

All needed programs and files are available on the consigned CD's. The operating system Windows XP/7 Professional is pre-installed on the LCU and can be restored if needed with help of the Windows-CD.

Sales Info

6 Software

The LaseASC application works automatically together with PLC and needs usually no operation from staff. For the first operation or in case of maintenance/trouble shooting the user has several possibilities shown in this chapter.

6.1 General

The application offers several views and dialogue boxes for the first operation, calibration and monitoring. In the following all for the operation needed functions / arrangements are explained.

The figure below shows for instance the application “main” view. This view is called “diagnostic view” and provides all important information to the status of LaseASC.

Further information to the diagnostic view mentioned in: 6.4 Diagnostic view.

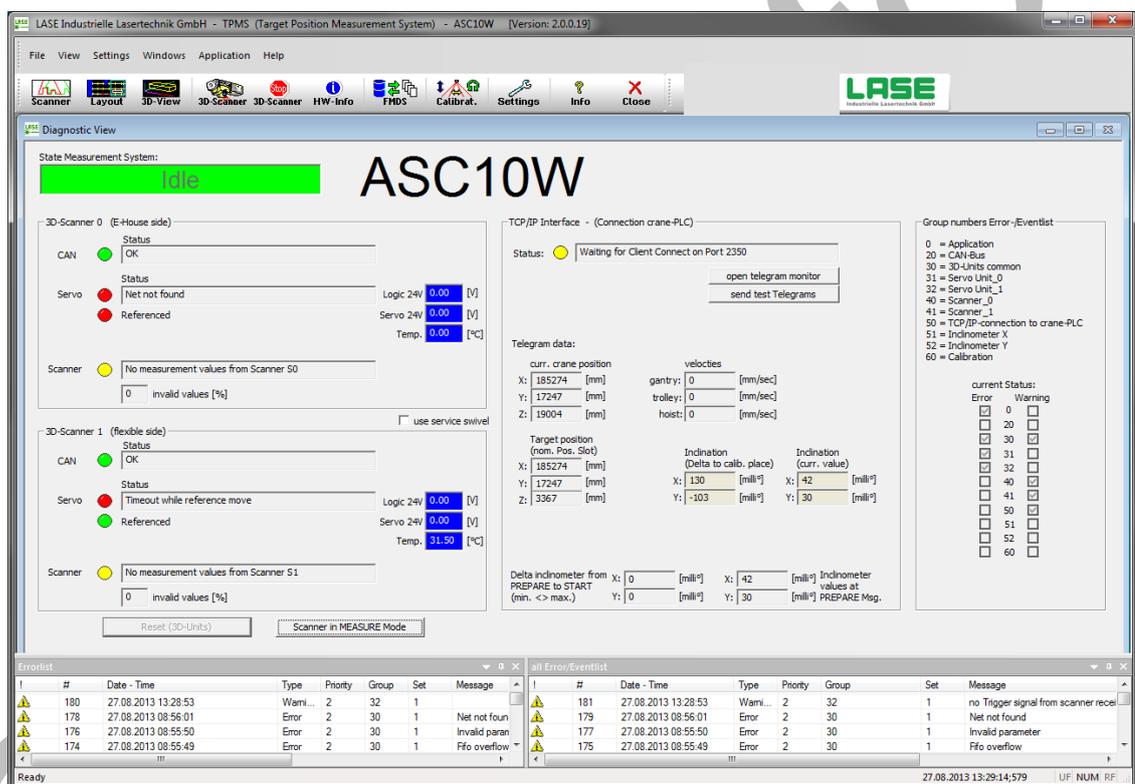


Figure 17: LaseASC application

6.2 Menu bar

About the menu bar at the upper image border several functions can be selected:

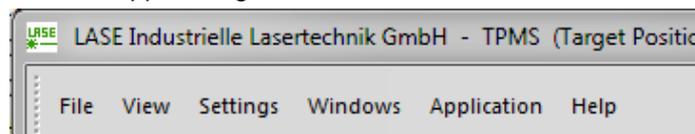


Figure 18: menu bar

- **File** Log In/Off and close application
- **View** offers the possibility to gate out the tool bar as well as the status tool.
- **Settings** allows changing parameters for hardware and application
- **Windows** allows to show/to gate out and modify the views
- **Application** access to first commissioning wizard, load reference marker filter

- Help shows an information dialogue box

Further information to each view or dialog box is given in the according chapter (see following pages).

6.3 Tool bar

The measuring application contains several views and functions, which can be selected about a click on the correspondent button in the tool bar or about the correspondent menu point "View" in the menu bar.



Figure 19: tool bar

Following views/dialog boxes are available:

- Scanner (opens a view for showing scans in 2D)
- 3D-View (Dialog box with 3-dimensional view of scenario)
- 3D-Scanner (Dialog box for manual controlling of 3D-Scanner)
- Stop-3D-Scanner (Stops the swivelling immediately)
- HW-Info (Dialog box with information to 3D-Units)
- FMDS (Dialog box for manual FMDS interaction)
- Calibration (opens a wizard for the calibration sequence)
- Settings (Dialog for basic parameter settings)
- Info (opens an About dialog box)
- Close (shuts-down the LaseASC_V2 application)

6.4 Diagnostic view

The screen diagnostic shows all relevant application information at a glance. The screen is always active. It can be minimised, but not switched off.

On this screen the all status of all scanner and all interfaces can be read. There is a separate area for each 3D-Scanner and all interfaces.

- 3D-Scanner 0 (Status/info scanner 0 + servo 0)
- 3D-Scanner 1 (Status/info scanner 1 + servo 1)
- TCP/IP Schnittstelle (PLC Ethernet Interface)
- Group numbers (assignment of group numbers shown in error/event list)

Some status fields on the screen can change their background colour to get a quicker overview. In front of some status text fields there are hinted LED's for showing the current status.

The background colour and the colour of the LED's can show as follows:

-  Green (Status = OK) – blinking green in measure mode!
-  Yellow (Status = Initialization/Warning)
-  Red (Status = Error)

6.4.1 Application status

In the top left corner of the screen the current status of LaseASC and the name of the ASC the application is installed are shown in the field "Status Measurement System:" and beside of it.



Figure 20: application status

Possible states (shown text):

- Initializing (Initialization mode - after application start – background colour = yellow)
- Idle (Idle mode - normal case if every connected device and all interfaces are OK and the LaseASC is ready to measure the - background colour = green)
- Measurement active (Measurement active (Measure mode - background colour = green)
- Error (Error mode – some error occurred, LaseASC is not able to measure background colour = red)

6.4.2 Status 3D-Scanner 0 + 1

The figure below shows the area for all status and information regarding 3D-Scanner 0. For 3D-Scanner 1 there is a second area on the diagnostic view. All things mentioned here are also valid for the area for 3D-Scanner 1.

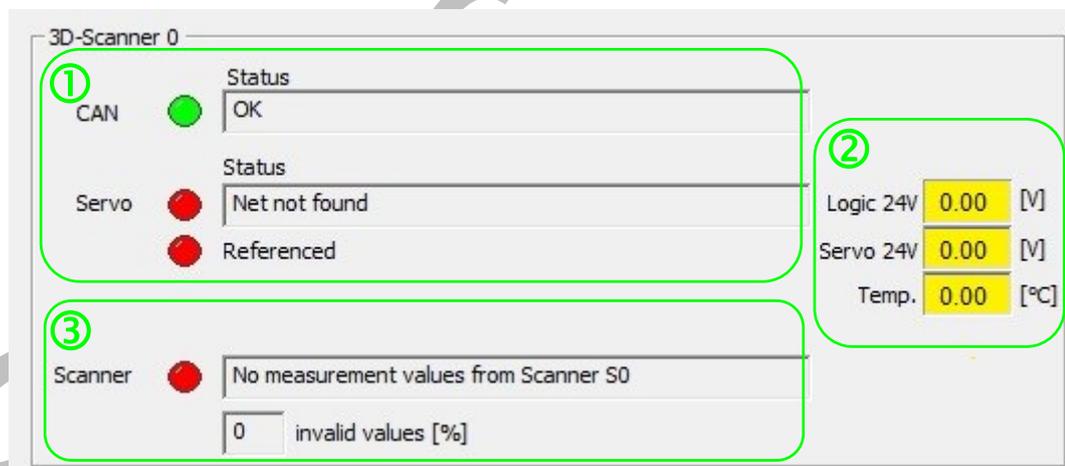


Figure 21: status 3D-Scanner

① The LED's and fields in the upper part are showing current status of servo motor including CAN interface. LED and text field of first line are showing the status of CAN interaction. The second LED shows the status of the servo drive itself. The third LED ("Referenced") indicates if the servo motor has found its zero point after power-on. This happened automatically after start-up of application or during normal operation if one unit has lost its zero point because of a power failure.

② The three fields at the right side are showing the current power and temperature status. All values are provided from servo logic and will request in an interval of approximately three seconds. That does mean that the values are only shown if the connection to the servo is established and if the 24V power supply is ok. Otherwise all fields are showing 0.00 and the background is yellow.

If one of the values is too low or too high (adjustable values) an error message will be shown and the background colour changes to blue (value to low) or to red (value to high).

③ Status of LRS. The LED shows the status like described above. The according message is shown in the text field. The field “invalid values [%]” gives the amount of invalid measurement points per scan in percentage. The value should be less than 10% in normal operation. The value can rise if for example the cover of the LRS is too much polluted or if the surface of the measured object does not reflect the laser beam.

6.4.3 Status PLC / data

On this section of the diagnostic view the status of the TCP/IP connection to the PLC is shown.

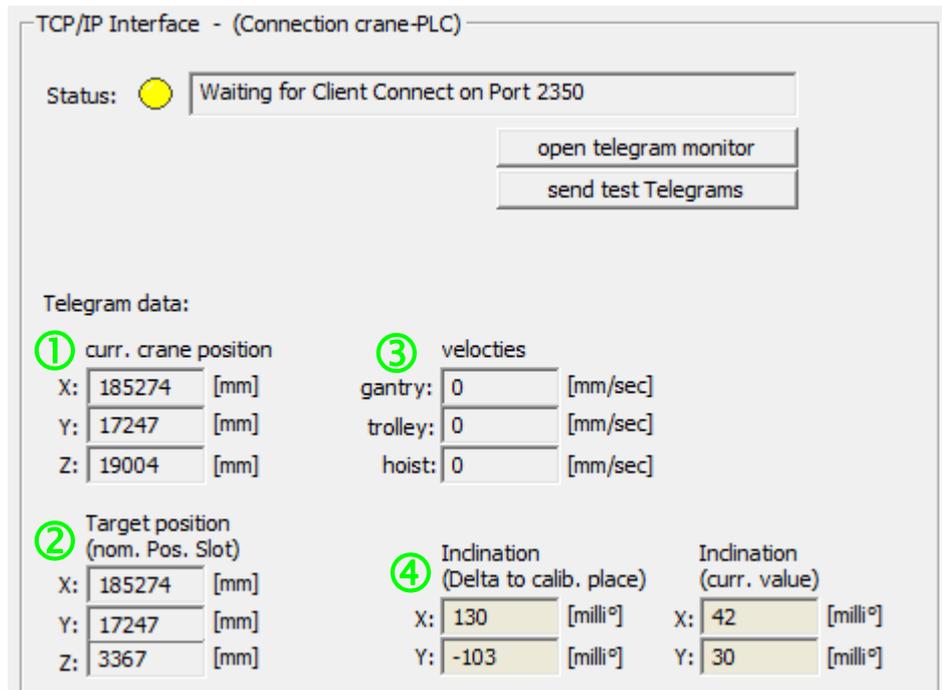


Figure 22: status TCP/IP interface

The upper part (“Status”) shows current status of the Ethernet interface. Like status of 3D-Units also here a LED and according text field is used.

By pressing the button “open telegram monitor” a dialog box appears which shows all incoming and outgoing telegrams sent from LaseASC to PLC respectively sent from PLC to LaseASC. Further information’s are given in: 6.4.6 Telegram monitor .

Button “send test telegrams” opens a dialog box which allows checking the Ethernet connection to PLC. It is possible to do a link test or sending all possible telegrams to PLC. Further information’s are given in: 6.4.7 Sending test telegrams.

The lower part (“Telegram data”) shows a pull-out of values from incoming crane update telegram sent by PLC.

①	“curr. crane position”	=	current crane position [in millimetre] (X = gantry position, Y = trolley position, Z = Spreader height)
②	“Target position”	=	nominal slot (target) position [in millimetre] (X, Y, Z = stack height)
③	“Velocities”	=	velocities (bogie, trolley, hoist) [in millimetre per second]
④	“Inclination (Delta to calib. place)”	=	deviation between current inclination values and inclination values at calibration slot [in milli degree]

**Note!**

If the inclination values exceeding a maximum value or dropping below a minimum value the background colour starts blinking in red and an according error message will be given. These limit values are adjustable (see: **Fehler! Verweisquelle konnte nicht gefunden werden. Fehler! Verweisquelle konnte nicht gefunden werden.**).

In case of invalid inclination values the measurement results are not reliable!

6.4.4 Group numbers

The section (“Group numbers Error-/Eventlist”) at the right of the screen is just for information. If there is an error or an event message shown in one (or both) lists at lower side of application, the message includes also one of this listed numbers. With the listing and the shown number in the message it is easy to see to which part of LaseASC the message can be referred.

Group numbers Error-/Eventlist

- 0 = Application
- 20 = CAN-Bus
- 30 = 3D-Units common
- 31 = Servo Unit_0
- 32 = Servo Unit_1
- 40 = Scanner_0
- 41 = Scanner_1
- 50 = TCP/IP-connection to crane-PLC
- 51 = Indinometer X
- 52 = Indinometer Y
- 60 = Calibration

current Status:

Error		Warning
<input checked="" type="checkbox"/>	0	<input type="checkbox"/>
<input type="checkbox"/>	20	<input type="checkbox"/>
<input checked="" type="checkbox"/>	30	<input type="checkbox"/>
<input checked="" type="checkbox"/>	31	<input type="checkbox"/>
<input checked="" type="checkbox"/>	32	<input type="checkbox"/>
<input checked="" type="checkbox"/>	40	<input type="checkbox"/>
<input checked="" type="checkbox"/>	41	<input type="checkbox"/>
<input type="checkbox"/>	50	<input checked="" type="checkbox"/>
<input type="checkbox"/>	51	<input type="checkbox"/>
<input type="checkbox"/>	52	<input type="checkbox"/>
<input type="checkbox"/>	60	<input type="checkbox"/>

Figure 23: group numbers

The checkboxes below are showing the current status (Error or Warning) for each of the above mentioned group numbers. These status flags are also been send via telegram to the PLC.

6.4.5 Switch Scanner into Measure Mode

When LaseASC application is in idle mode the laser scanners are switched into so called rotate mode. In this mode the internal laser diode is switched off. In some cases it might be necessary to switch the scanner back to measure mode manually (e.g. case of service purposes). On the diagnostic view there is a button “Scanner in MEASURE Mode” which allows switching on the scanners manually.

**Note!**

The button has a check box function. It stays enabled until the button is pressed again. Thus as long as the button is pressed the scanners are switched on even if an automatic measurement sequence was performed in-between.

6.4.6 Telegram monitor

The dialog “Telegram Monitor” provides two list fields (1 + 2) and an area for showing current crane update message (3). In case of malfunction the dialog can help to check all incoming and outgoing data.

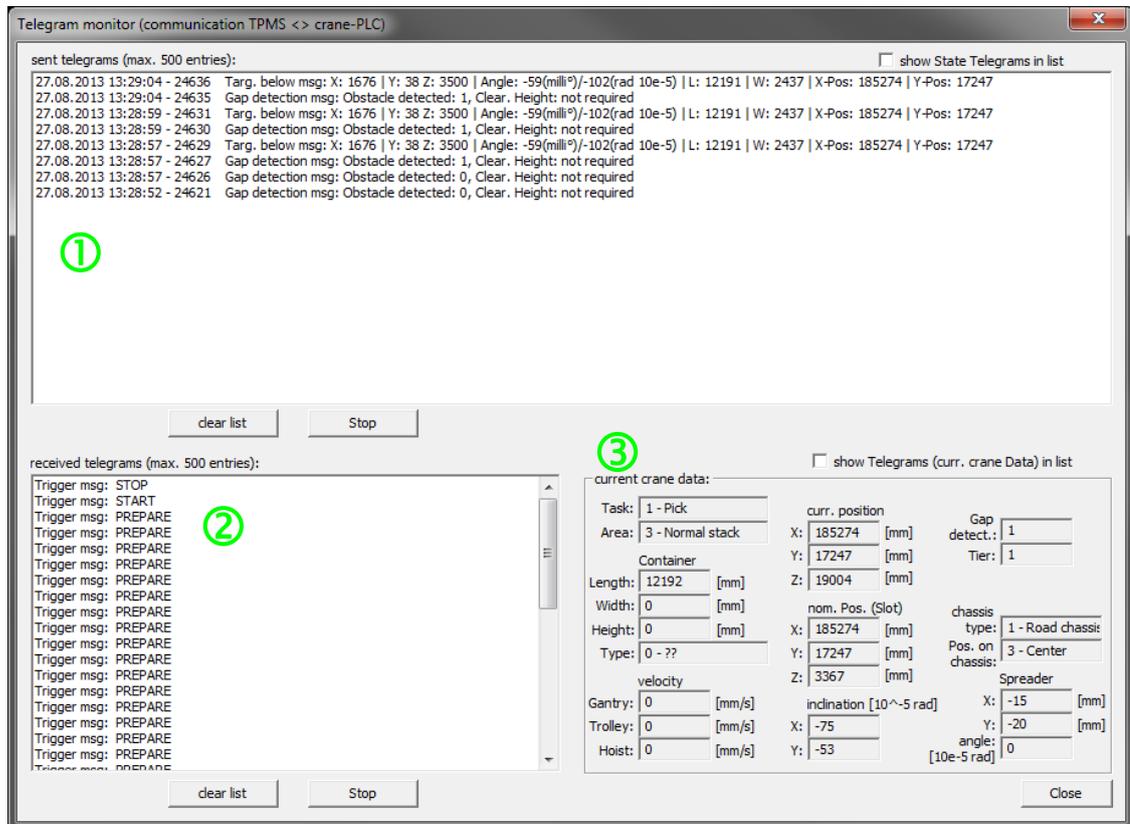


Figure 24: Dialog box “Telegram Monitor” - Data from/to PLC

① These list shows sent telegrams (from LaseASC to PLC). In default setting only measurement result messages (deviation msg., target below msg.) and error messages will be shown in the list field. After activating the checkbox (“show State Telegrams in List”), right above the list, also state messages will be shown in the list field.

② These list field shows incoming telegrams (from PLC to LaseASC V2). In default setting only trigger messages (Prepare msg., Start msg. and Stop msg.) will be shown in the list field. After activating the checkbox (“show Telegrams (curr. Crane data) in list”), right above the list, also all update messages will be shown in the list field.

③ “current crane data”

In these section of the dialog box all current update data (sent by PLC) will be shown. The fields are in accordance with the telegram definition. All values are shown in block coordinates and in units used by customer [millimetre, millimetre/second, radian (10^{-5} rad)].

List fields:

Only the 500 last entries will be shown in the list fields. If there are more than 500 entries, the oldest entry will be deleted. The newest message is the top message. If there are more entry then can show on the dialog a scrollbar appears at the right side of the list, which allows scrolling up and down to show older messages for example.

The both buttons below each list field allow to clear the list or to stop listing of new messages.



If button “Stop” was pressed the lettering of the Stop button changes to “continue”. After pressing the button again new entries will entered to the list again.

6.4.7 Sending test telegrams

For commissioning or in case of malfunction LaseASC application allows sending all defined messages, sent from LaseASC to PLC, manually. Therefore the button “send Test Telegrams” positioned under the status field for PLC communication must be pressed. On the left side all possible messages are listed. After pressing a button, according to the message which shall send, another dialog appears which allows setting some or all values to the message (see example dialog “TGM Target Below”). If the input dialog will be closed by pressing the OK button the button “Send” behind the before selected message is active. The message will send after pressing the “Send” button.

In the lower part there is a field “Link Test TGM”. By pressing the button “Send” a special link test message will send to PLC. In the field “time to Ackn.”, the time until the PLC has send a acknowledge message will be shown (In milliseconds).

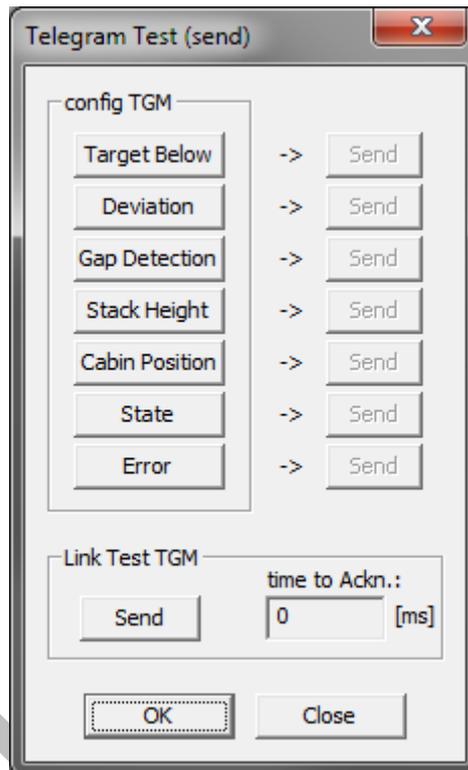


Figure 25: Dialog box sending test messages

This is an example of sending a target below message. Just type-in the values which shall be send and confirm each entry by pressing “Set” button behind the entry. If all entries are set close the dialog box with “Apply” and “OK”

To send the new configured telegram press the send button on previous dialog box.

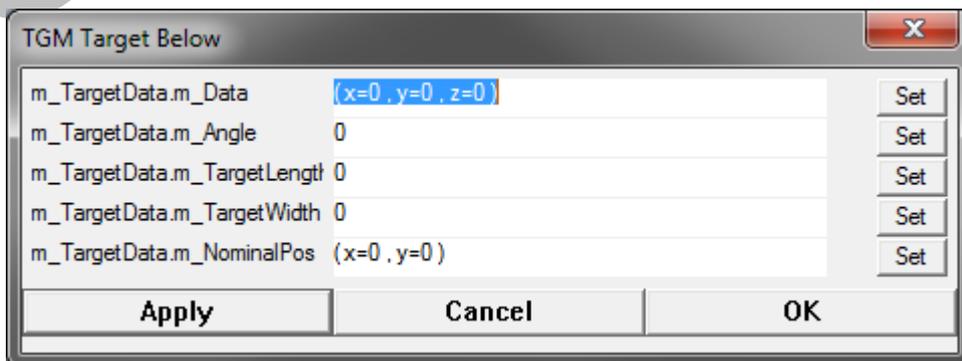


Figure 26: Dialog box Input data for Target below Message

6.5 View Scanner (View Scans 2D)

The screen "Scanner" offers several possibilities to display the measuring data of each single scanner 2-dimensional. This view can be opened many times or it is possible to show both scanner data in one view. All measuring data can be observed out of several directions. In the figure below for instance the data of scanner 0 (red) and scanner 1 (green) are shown in X/Z direction.

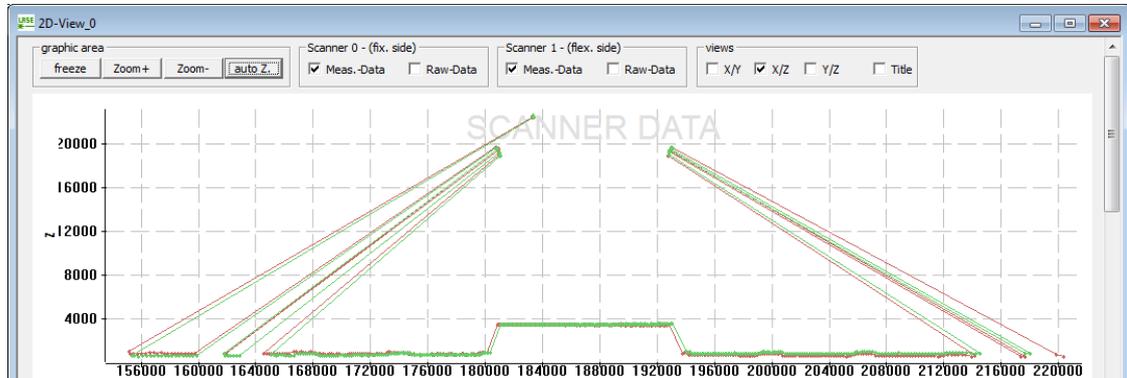
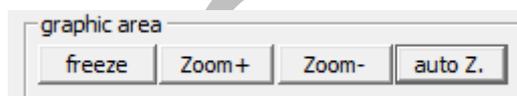


Figure 27: View scanner

This screen will be mostly needed while the first operation and/or while the process of the calibration. This data will be continuously updated, so that the result will be a moved picture. Following options offers the graphic area:

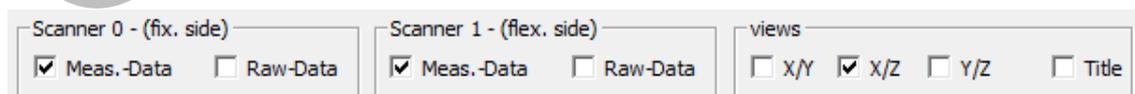
6.5.1 Enlarge/minimise Graphic area



- „freeze“ = freeze image
- „Zoom+“ = graphic area will be enlarged
- „Zoom-“ = graphic area will be minimised
- „auto Z.“ = graphic area will be adjusted in that way, that all data can be seen.

In addition to the four buttons an optional area in the displayed graphic window can be selected and enlarged. Therefore one drives with the mouse pointer in the graphic window, presses the left mouse button and pulls with pressed mouse button a frame (will be shown dashed). If the mouse button now will be released, the area inside the opened frame will be enlarged in the dimension of the graphic window.

6.5.2 Selection of the scanner view



About the two check boxes in the fields „Scanner 0/1“ can be selected, the data of which scanner shall be shown. The first check box “Meas. data” is to show the already transformed, internal used data. By selection of the check box “Raw-Data” all data of the scanner are shown, in the way the scanner sends them, thus without any transformation.

The check boxes “views” are to change the point of view for showing the scan data.