



Laser Scanner

– with Orientation Computer –

HG 43600XA

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1 General Annotations

This is the description of the Laser Scanner HG 43600XA produced by Götting KG. The Laser Scanner enables a flexible vehicle handling. On the basis of reflective marks it is possible for a vehicle, depending on its programming, to almost be guided autonomously.

In combination with sensors detecting obstacles (ultrasound or optical systems) it is possible to guide the vehicle over an alternative route to its destination in the event of an obstacle occurring. The accuracy of positioning is as sufficient as that the high demands during the automatical take over of loads are met.

1.1 Intended Use

ATTENTION! The Laser Scanner HG 43600XA may only be used in industrial areas!



The Laser Scanner has exclusively be designed to recognize reflective markings (reference: see section 2.5 on page 10) in its environment and to calculate its position and orientation.

In order to be able to guide and position a vehicle, it is necessary to construct a positioning system, which is able to control a vehicle based on the available positioning data. Due to this the Laser Scanner will then be part of this system.

1.2 Safety Advice (Laser)

Figure 1 Laser Class 1

The optical output power of the Laser is not visible for the eyes (in general: human tissue) and **not dangerous**. The optical output power of the Laser is limited and eye-safe according to

- EN 60825-1, VDE 0837 and IEC 825-1.

The sensor therefore meets the requirements of the 'Laser Class 1'.

Using **invisible laser radiation** the sensors search for reflective markings in the environment. In stand-by, the laser is switched off and will not be turned on until the sensor reaches a certain minimum speed of rotation.

LASER CLASS 1

1.3 Special Advice regarding Positioning Accuracy

The accuracy of the position calculation depends on the accurate placement of the reflecting marks (reflectors). As long as a minimum of four marks with a distance of at least 15° between each other and a distance to the sensor of not more than 15 m are recorded, the repeating accuracy of the absolute positioning measurement will be **better than ± 5 mm**. The difference between the absolute and the repeat accuracy results from possible mistakes during the reflector placement.

NOTE!

The measurement of the coordinates and the positioning of the reflectors has to be carried out by experienced and specialised staff. Inaccuracy during this measurement will inevitably lead to inexact determination of the position and in the overall view to an incorrect navigation.



1.4 Maintenance Instructions

To guarantee an operation free from interference the window of the Laser Scanner has to be clean. Only use very soft fabric, e. g. slightly dampened microfibre cloth or pre-moistened lens cleaning wipes, to clean the transparent cover. Do not use paper tissues!

2 Mounting Instructions

2.1 Mounting

Three screw thread holes M5 are required on the mounting site of the Laser Scanner (e.g. vehicle outer body).

NOTE! Even and strong material has to be underneath the whole surface of the Laser Scanner so that it can be leveled out after the installation!



ATTENTION! The maximum lapping torsional moment of the mounting screw is 5 Nm!

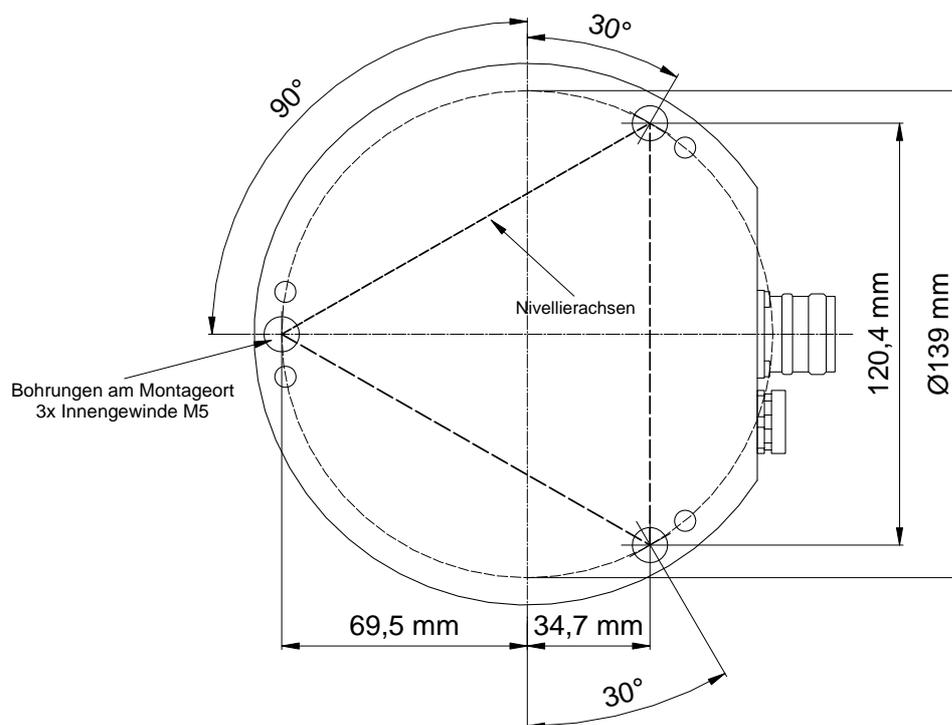


Figure 2 Position of the M5-mounting bore

Fasten the Laser Scanner with the M5-screws in the screw thread holes. Do not pull the screws tight yet because there has to be a gap between the Laser Scanner and the mounting surface, so that the Laser Scanner can be levelled out (see also Figure 4 on page 8).

2.1.1 Output Height of the Laser Beam

The height of the rotating laser beam is required, so that the reflective marks are attached in the right height. This is 125 mm above the assembly site of the Laser Scanner (refer to Figure 3).

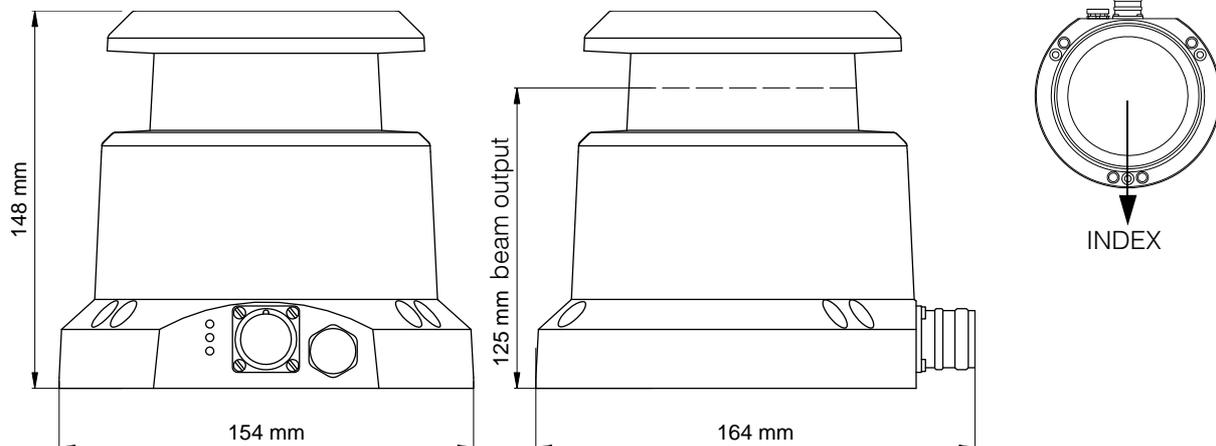


Figure 3 Measurements of the casing/ output height of the laser beam

2.1.2 Levelling the Laser Scanner

Following the mounting of the Laser Scanner it needs to be levelled out in order for the laser beam to be in the right level.

With a manual rotating laser pointer on the top of the Laser Scanner the visibility of the marks can be verified very quickly.

TIP! With a manual rotating laser pointer on the top of the Laser Scanner the visibility of the markings can be verified very quickly.



Here it has to be observed, that the top level differs to the laser beam output level by 23 mm. In addition, the difference between the output height of the laser pointer beam and the top level has to be considered at the assessment. Is the laser pointer beam output 5 mm above the top level, then the visible laser beam will overall be about 28 mm higher than the infrared beam of the Laser Scanner.

At its underside the casing has four M5-threads and three drillings for M5-screws, which are there for the mounting and the levelling of the Laser Scanner.

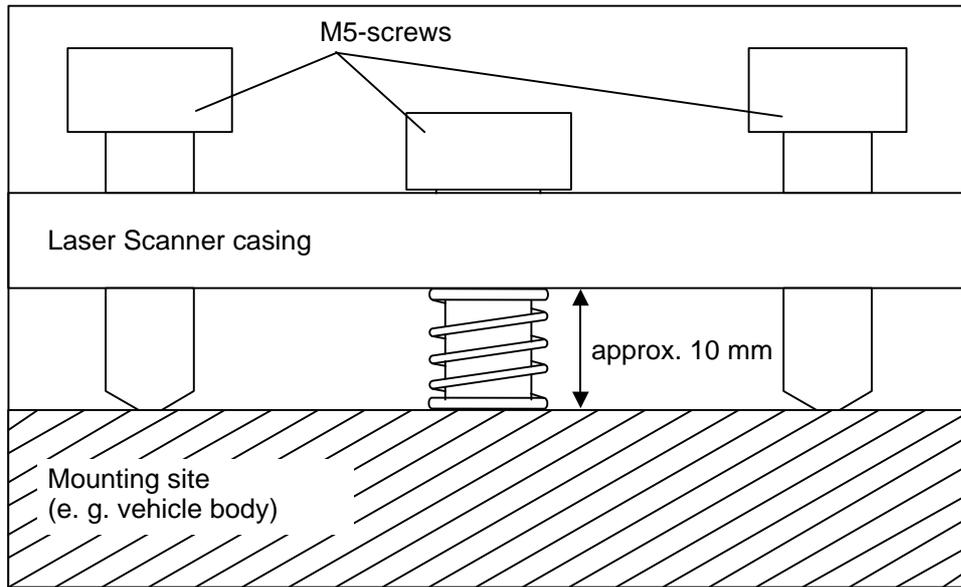


Figure 4 Mounting of the Laser Scanner

Levelling the sensor is done by the three-point adjuster of the casing. The edges of an imaginary triangle of which the M5-screws are the corners from the levelling axes.

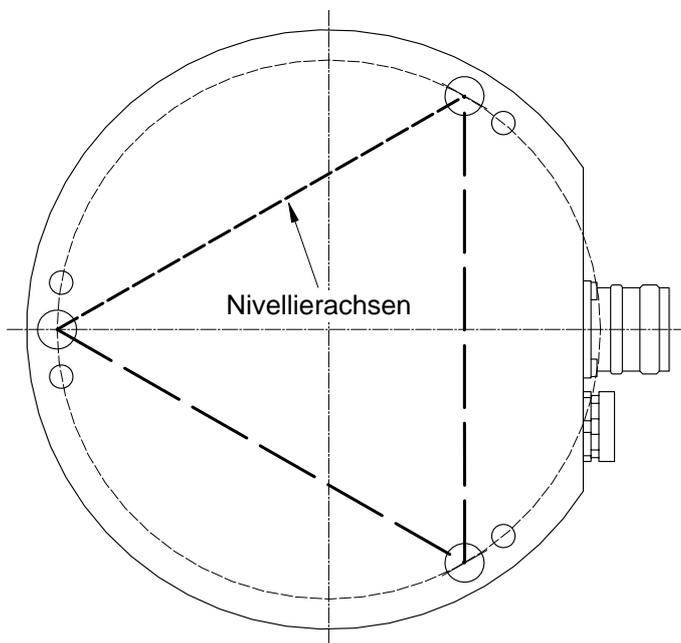


Figure 5 Levelling the Laser Scanner using the M5-screws.

If a M5-screw is tightened, the sensor axis leans towards the direction of the operated M5-screw (over the levelling axis being located on the opposite side of the screw).

2.2 Electrical interface: Pin assignment of the M23-socket on the device

Pin	ø [mm]	Color	Description
1	1		
2	1		
3	1	green	TxD2
4	1	yellow	RxD2
5	1		
6	1,5	red	power supply U=24V
7	1	purple	Ethernet TxD+
8	1	white-green	RxD3
9	1	black	Ethernet TxD-
10	1	brown-green	TxD3
11	1	red-blue	Ethernet RxD+
12	1,5	white	RxD1
13	1	grey-pink	Ethernet RxD-
14	1	brown	TxD1
15	1		
16	1	pink	CAN-High
17	1		
18	1	grey	CAN-Low
19	1,5	blue	supply GND

Table 1 Plug allocation

2.3 Connection via 100baseT Ethernet (RJ 45)

In order to connect to the device via Ethernet, the RJ 45 plug has to be connected with the following leads of the connection cable / the socket described above.

Laserscanner			RJ 45 Pin
Pin	Color	Function	
7	purple	TxD+	1
9	black	TxD-	2
11	red-blue	RxD+	3
13	grey-pink	RxD-	6

Table 2 Ethernet connection pins

2.4 Signification of the LEDs on the device

LED-Display	
● Red	Voltage supply applied, device switched on
● Yellow	- Continuous light: heating switched on - Flashing light: temperature < 10° C, motor switched off
● Green	Flashes at each index-pulse, respectively every 200 ms at the latest

Table 3 Signification of LEDs

2.5 Reflective marks

In order to use the Laser Scanner, reflective marks are essential. They may be self produced, according to the signals needed. A high contrast between the mark and its background and the strong reflecting bar is important.

NOTE! While determining the size of the reflective marks, please note, that the height of the laser beam may vary depending on the loading of the vehicle and on bumps and holes in the ground!



The Laser Scanner has been tested with reflective marks made from the material **FD 1403** by the company Reflexite. This self-adhesive material is available on rolls in different widths:

- ♦ 25 mm x 45,7 m
- ♦ 50 mm x 45,7 m

For further information please refer to the Reflexite homepage at <http://www.reflexite.eu/>.

2.6 Reflecting Tag Codes

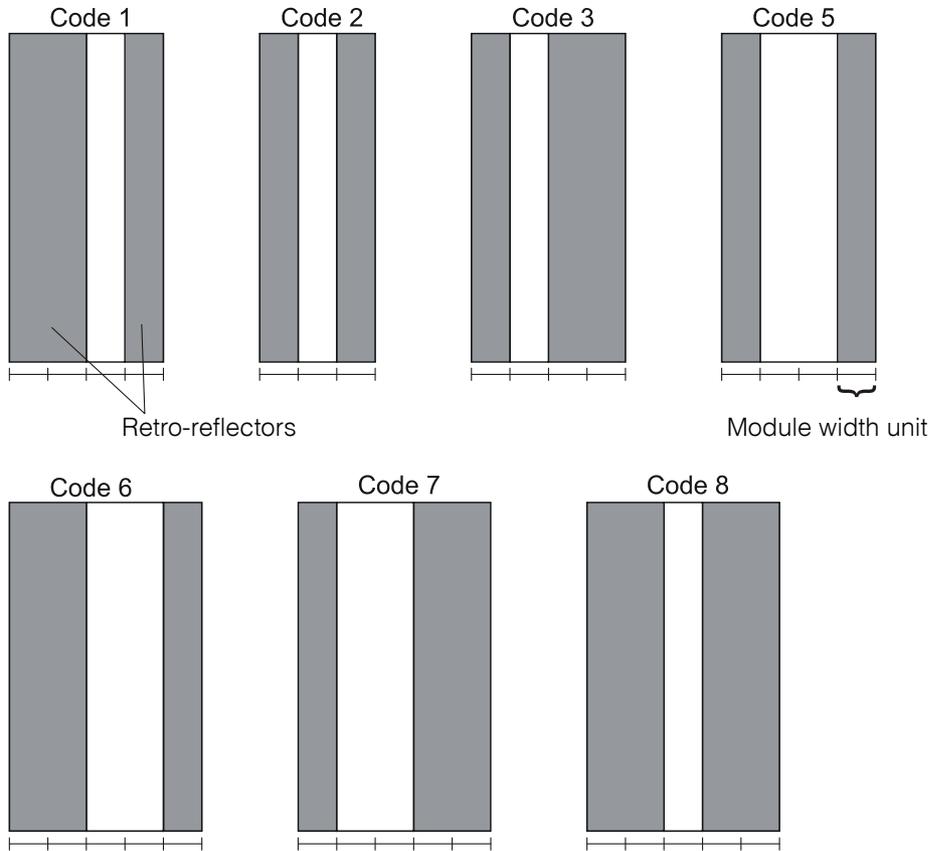


Figure 6 Predefined reflecting tag codes

The absolute width of the retro-reflector, as well as the gap in between, may be selected freely. Only the relations to each other - the proportion between the reflective stripes and gaps (the modular width unit) on each tag- has to be kept the same.

3 Software

3.1 Service programme of LST

This software is for the diagnosis and parameterization of the Laser Scanner.

System requirements

- ♦ IBM-compatible hardware
- ♦ Microsoft® Windows® version 95 and higher
- ♦ A free serial RS 232-interface

Choice of the serial interface

Effective resolution of the Laser Scanner per revolution

Temperature of the Laser Scanner

Index

State of Communication

„only filtered tags“ reduces the information shown in the table to make it clear

This filtered view only lists the columns shown above

Exit of programme

Open parameter window (see Figure 8 on page 13)

Retrorefl. surface

Gap

Retrorefl. surface

	angle	flag	width	tag width	code
1	9322	+			
2	9379	-	57		
3	9489	+		110	
4	9595	-	106	273	6
5	11215	+			
6	11257	-	42		
7	11301	+	44		
8	11342	-	41	127	2
9	12651	+			
10	12715	-	64		
11	12781	+	66		
12	12814	-	33	163	7
13	18364	+			
14	18447	-	83		
15	18487	+	40		
16	18530	-	43	166	3
17	27516	+			
18	27550	-	34		
19	27581	+	31		
20	27614	-	33	98	2
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					

	angle	tag width	code
1	9458	273	6
2	11279	128	2
3	12732	163	7
4	18447	166	3
5	27585	98	2

Figure 7 Service programme of LST

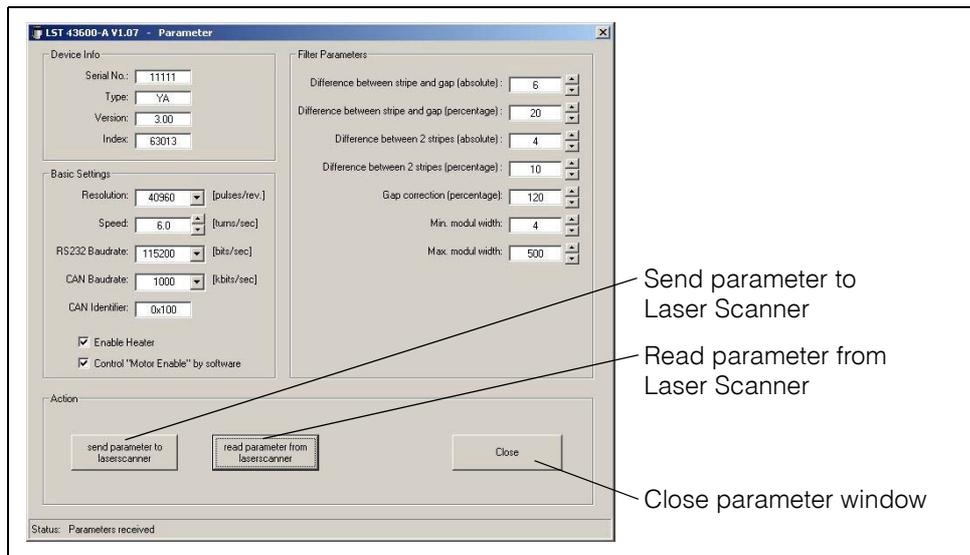


Figure 8 Parameterization of the Laser Scanner

Serial No.	Assigned by manufacturer.
Type	Hardware version of the Laser Scanner.
Index	Device type index present by manufacturer.
Version	Firmware version of the Laser Scanner.
Resolution	Resolution of the Laser Scanner Possible settings are: 8192, 16384, 24576, 32768, 40960, 65536 increments/rotation
Speed	Rotation speed of the Laser Scanner Possible values are: 6,0 to 18,0 rotations/second
RS232 Baudrate	Transmission speed to position calculator regarding RS 232. Possible settings are: 9600, 19200, 38400, 57600, 115200 bit/sec (see Figure 8 above)
CAN Baudrate	Data transmission speed to position calculator regarding CAN Bus. Possible settings are: 50, 125, 250, 500, 1000 kbit/sec
CAN Identifier	11 bit identifier in hexadecimal spelling
Enable Heater	Enable or disable heater operation
Control „Motor Enable“ by software	Enable or disable the possibility to switch the motor on/off using serial interface to the guidance computer.

Filter-parameter for the tag-decoding functionality

Difference between stripe and gap [absolute]

Maximal allowable difference between the width of the first retro-reflective stripe of a tag and the gap between both reflectors in absolute increments.

Difference between stripe and gap [percentage]

Maximal allowable difference between the width of the first retro-reflective stripe of a tag and the gap between both reflectors in percentage.

Difference between 2 stripes [absolute]

Maximal allowable difference between the width of the first and the second retro-reflective stripe in absolute increments.

Difference between 2 stripes [percentage]

Maximal allowable difference between the width of the first and the second retro-reflective stripe in percentage.

Gap correction [percentage]

Correction of the gap - width as a percentage.

Min. modul width

Minimum allowable width of an individual retro-reflective stripe in increments, so it will be included in further measurements/tag decoding at all.

Max. modul width

Maximum allowable width of an individual retro-reflective stripe in increments, so it will be included in further measurements/tag decoding at all.

3.2 Software Update

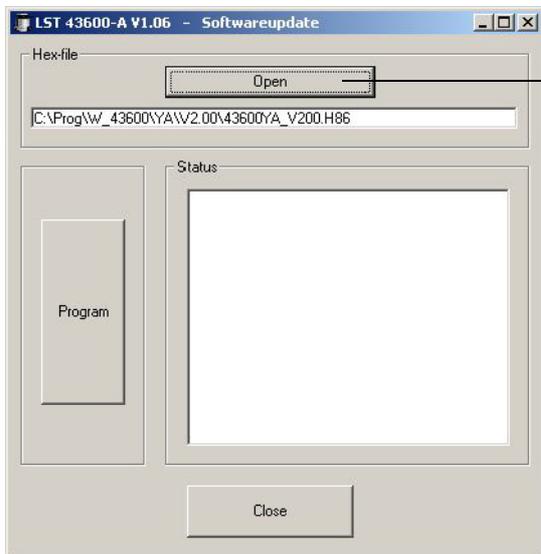


Figure 9 Software update step 1

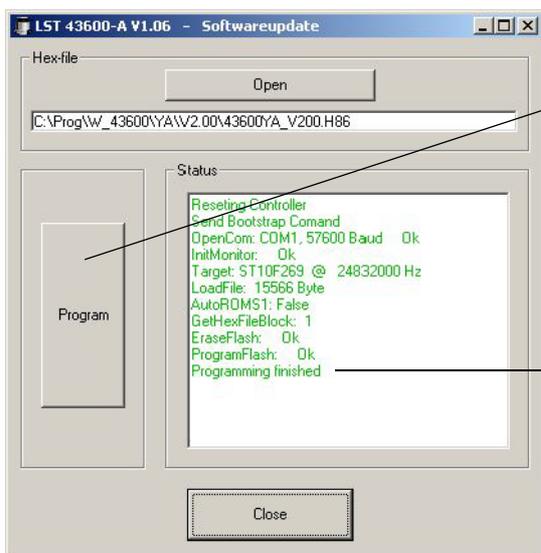


Figure 10 Software update step 2

4 The Integrated Orientation Computer

4.1 Function Description

Due to the integration of the Orientation Computer in the Laser Scanner it is possible to receive an absolute position. The data of the scanned reflective marks and the internal odometrical position determination, which takes a coordination system of the reflective marks into account, enable this calculation. The absolute position is output to the navigation controller via a selectable interface (based on a protocol).

The Laser Scanner establishes an initial starting position, based on the scanned marks in the room, after the system is switched on. Some more calculations of the odometry refer to this starting position. Under optimal conditions this position calculation can be carried out with a minimum of four visible marks.

The laser position, which is continuously established, merges with the parallel calculated, odometrical position data in the Orientation Computer. The now occurring position results in connection with the receipt of the newest odometrical data (steering angle, incremental encoder data) to the Laser Scanner is returned to the navigation controller.

4.2 Position Calculation Laser

The requirement for the establishment of the laser position is to have at least four visible and precisely surveyed reflective marks in a fixed coordinate system.

The established coordinates of the marks are saved over the terminal program of the Orientation Computer. They are persistently saved in the system within 10 different marking tables, called plots. Up to 255 marks can be entered in one plot. Editing and deleting of the marking data is possible over the same application.

The system provides an integrated surveying support so that newly positioned reflective marks can be added later on and that those can be used for the navigation (see also section C on page 39).

ATTENTION! This function should only be used for single marks and not for the surveying of all the reflective marks!



The system scans the room for visible reflective marks and identifies those with the help of saved coordinations and the orientation of the actively applied plot of the marking table to determine the laser position.

With those identified reflective marks, a laser position for the then occurring position fusion will be calculated in addition using triangulation.

4.3 Position Calculation Odometry

The Orientation Computer requires the counted increments of the encoder for the determination of the necessary odometrical position and depending on the odometry model the additional to the steering angle. The system cyclically calculates the chang-

es in position and orientation of the vehicle from this information. Based on the last known place and direction of the vehicle, the established changes of the new position and orientation of the vehicle can be determined.

The now received odometrical position merges together with the laser position.

Supported odometry models:

- ♦ Number of revolution difference
- ♦ Ackermann (three wheel)

Table 4 List of the supported vehicle models

4.4 Position Calculation Navigation-point

In order to have any point, relative to the odometric point of the vehicle, guided by the vehicle control, a navigation-point can be defined over a parametrical X- and Y-offset.

Basically, the coordinate of the navigation-point is passed on to the navigation control unit, so if an offset is missing the coordinate of the odometrical point is translated/converted (see also section B on page 39).

4.5 Commissioning of the Orientation Computer

- Configuration of the Laser Scanner according to previous instruction (section 2 and 3).
- Set up a connection with the navigation control unit via CAN- **or** the third serial interface of the Laser Scanner.
- Connection of the terminal via a second serial interface for the settings of parameters of the Orientation Computer.
- Set up a connection with the supply voltage.
- Parameterization according to requirements. Save of the new adjusted parameters.
- Re-start the system → Switch on and off.

4.6 Service Interface

When the Laser Scanner is activated, the software of the Orientation Computer is loaded automatically. The parameterization interface of the terminal program will be selected on the second serial interface of the Laser Scanner

The interface parameters are 115200 baud, 8 data bits, no parity, 1 stop bit. Terminal emulation VT100.

4.6.2 Main Monitor

The main monitor is selected with the key **M**. To leave the menu press key **Q**. You will then return to the main menu.

```

HG 43600XA GOETTING 2009
+-- Main Monitor -----+
|
| Laser:                Odometry:                NavPoint:
| Pos X :      0 [mm]    Pos X :      0 [mm]    Pos X :      0 [mm]
| Pos Y :      0 [mm]    Pos Y :      0 [mm]    Pos Y :      0 [mm]
| Angle :    0.00 [DG]    Angle :    0.00 [DG]    Angle :    0.00 [DG]
|
|
| Act. Area :      1 []    Incr. L :      0 []    Devi X:    0.0
| Vsbl.Tags :      0 []    Incr. R :      0 []    Devi Y:    0.0
| Idnt.Tags :      0 []    Steering :    0.00 [DEG]    Devi W: 0.0000
| Sys.Stat :    2000 []    Speed :      0.000 [m/s]
| FreePath :      0.0 [mm]    Yaw Rate :    0.000 []
|                               Vhcl.Type : Ackerman
|
| Idx.Time :      0.0 [ms]
| ODO Time :      0.00 [ms]
|
+----- <q> Returns to Top -----+
    
```

Figure 12 Screenshot: Main Monitor

The most important operating time data of the system will be displayed in the main monitor. The output will normally be updated every 250 ms. Due to the minor priority condition of the terminal output this interval can be greater or vary depending on the calculating load of the Orientation Computer.

In the upper area the three positions of the system can be followed. Underneath those the following data is displayed from left to right:

Value	Meaning
Act. Area	The current selected marking plot.
Vsbl. Tags	The amount of the current visible marks.
Idnt. Tags	The amount of the current identified marks.
Sys.Stat	The hexadecimal system state.
FreePath	The driven odometrical path without support of the Laser Scanner. The path will be added independently to the direction of motion.
Idx. Time	The time between two index marks of the Laser Scanner.
Odo. Time	The time interval between two assigned odometrical telegrams of the Orientation Computer.

Table 5 Menu Main Monitor: Meaning of the value output (part 1 of 2)

Value	Meaning
Incr. L	The increments of the left wheel send from the navigation controller.
Incr. R	The increments of the right wheel send from the navigation controller.
Steering	The steering angle send from the navigation controller.
Speed	The signal speed (direction depending) calculated and transferred to the navigation computer.
Yaw Rate	The measured rotation rate of the Laser Scanner.
Vhcl. Type	The selected odometrical model.
Dev. X	Difference of the odometric to the moved laser position in X.
Dev. Y	Difference of the odometric to the moved laser position in Y.
Dev. Hdg	Difference from the odometric to the laser heading.

Table 5 Menu Main Monitor: Meaning of the value output (part 2 of 2)

4.6.3 Tag Menu

The tag menu will be selected with the key **T**. To leave the menu press key **Q**. You will then return to the main menu.

```

HG 43600XA  GOETTING 2009
+-- Tag Menu -----+
| TAG | ID | X | Y | ANGLE | MODUL | 1: Select Area
|     |    |   |   |       |       | 2: Edit Tag
| #1  | 1  | 187 | 956 | 225 | 25 | 3: Delete Tag
| #2  | 3  | 147 | 6002 | 180 | 25 | 4: Calculate Tag
| #3  | 2  | 210 | 14372 | 135 | 25 |
| #4  | 6  | 2447 | 14468 | 90 | 25 | S: Save Taglist
| #5  | 5  | 8116 | 14463 | 90 | 25 | A: Set Area for Navigation
| #6  | 1  | 13139 | 14480 | 90 | 25 |
| #7  | 2  | 16116 | 13830 | 90 | 25 | U: Taglist up (Row)
| #8  | 6  | 19156 | 15130 | 90 | 25 | D: Taglist down (Row)
| #9  | 8  | 24448 | 15139 | 90 | 25 | T: Taglist up (Block)
| #10 | 3  | 27775 | 14877 | 45 | 25 | B: Taglist down (Block)
| #11 | 5  | 28148 | 9095 | 0 | 25 |
| #12 | 3  | 27688 | 57 | 315 | 25 |
| #13 | 2  | 24471 | -4 | 270 | 25 | Selected Area: 1
| #14 | 1  | 20038 | 1229 | 270 | 25 |
|     |    |   |   |   |   |
+-----<q> Returns to Top -----+
    
```

Figure 13 Screenshot: Tag Menu

In this menu one of the selectable marking areas can be observed and edited. Furthermore, it is possible to use an initial measurement over this menu and with this it is possible to add new reflective marks to the table (see also section C on page 39).

On the left side of the screen, the currently selected marking plot, in this case plot 1, with the recorded marks and their coordinates is displayed.

For each marking plot 255 marks can be entered, of which 14 are shown simultaneously on the screen. To look at the rest of the marking data, the keys **U** for up, **D** for down, **T** for top and **B** for bottom are used to scroll from top to bottom to show the rest of the markings. For this it can be scrolled line-by-line (**U** and **D**) or side-by-side (**T** and **B**).

The other possible selecting points are:

1. **Select Area:**
Any of the 10 possible marking tables can be selected by entry of the associated number. After the selection of one plot, the marks with their coordinates, which are entered here, and are shown. The current shown marking plots are checked over the display *Selected Area*.
 2. **Edit Tag:**
A mark can be edited in a selected marking table plot with Edit Tag. The data, which has to be entered, will be requested on the bottom of the terminal window and shown after completion of the entry in the table. If no value is input, the original value is maintained.
 3. **Delete Tag:**
Choosing this option, any mark can be deleted via the selection of the mark number in the table.
 4. **Calculate Tag:**
This menu point provides the initial measurement support for new reflective marks. The data, which is going to be entered will be requested on the bottom of the terminal window (see section C on page 39).
- **S: Save Taglist:**
By selecting this, the changed marking data will be permanently saved in the system. Furthermore, the additional system internal information with regards to the marking table will be calculated.
 - **A: Set Area for Navigation:**
With the selection of this point it is possible to use the new selected marking plot in the foundation for the navigation. This function is helpful for testing purposes or in a small area in which only a marking plot is required. Also, the system internal information with regards to the marking table will be calculated and used for the current navigation. The selection of this plot will be kept during the re-start.

NOTE! A changed marking table content **must still be** saved with the selection of **s :**. Otherwise are newly changed marking data is deleted after the re-start of the system.



Basically, a newly started entering process has to be completed until the end. An interruption with the entry of **ESC** is not possible.

TIP! If for example a mark for editing is selected accidentally, by entering <Return> the original value will be kept instead of a new one.



The function of the back space key is being operative in a correctly adjusted VT100 environment. With this an incorrect entry can be edited.

Marking Information

When editing the reflective marks into the table, more information besides the X-Y coordinates are required. So, the requested ID of each marking code will be entered (see section 2.6 on page 11), for example for the mark with code 2 the ID 2.

Furthermore, the orientation of the mark has to be stated. For this the direction in relation to the coordinate system of the room, in which the observer looks when he views the reflective side has to be entered. If the observer looks along the positive Y-axis to the reflective side of the mark, then this mark has an adjustment of 90°. This value is going to be entered into the table.

The module width (see section 2.6 on page 11) is the width of **one** reflective module on a reflective mark to be entered. The conventionally delivered reflective material will be delivered with a width of 1 inch - about 25 mm. So, in a predominant case a value of 25 has to be entered here.

4.6.4 Special Parameter

The menu Special Parameter will be selected with the key **A**. To leave the menu press key **Q**. You will then return to the main menu.

```

HG 43600XA  GOETTING 2009
+-- Special Parameter -----+
|
| Position calculation                Start Position Estimate
| 1: Pos Quality Tol.      : 1.000 [--]  D: Trigger SPE
| 2: Tag Window Tol.      : 0.100 [RD]   E: Perm. SPE      : OFF
| 3: Width Tolerance      : 0.003 [RD]   F: Min.Tags SPE  : 5
| 4: percentage Width Tol.: 4 [--]      G: SPE Tol.      : 0.002 [RD]
| 5: Tag Window          : 0.250 [RD]   H: Quality biggest Area
|
| Controller
| 6: Controller Heading   : 0.100 [--]
| 7: Controller dX       : 0.050 [--]
| 8: Controller dY       : 0.050 [--]
|
| Peak Elimination
| A: Peak max. dW        : 3.14159 [RD]
| B: Peak max. dX        : 100.0 [mm]
| C: Peak max. dY        : 100.0 [mm]
|
+----- <q> Returns to Top -----+
```

Figure 14 Screenshot: Special Parameter

1. Pos. Quality Tol.:
Maximum allowable difference of the laser position quality (integral 1-20). A small value means good quality and a big value bad quality.
2. Tag Window Tol.:
Size of the angle identification window, in which the angle of a mark is expected. The entry will be in radian.
3. Width Tol.:
Tolerance of the allowable difference of the calculated marking width (see also section E on page 41).
4. Perct. Width Tol.:
Percentally allowable difference in the marking width. This parameter is down-streamed to point 3. With this an influence of displacement will be compensated (see also section E on page 41).
5. Tag Window:
Size of the window, which, from a specific amount of seen reflectors, limits the number of marks for a position calculation.
For this the last seen mark of the parametric value will be maintained long before the identification of a new visible mark will be arranged.
6. Controller Heading:
Regulation factor for the influence of the heading fusion.
7. Controller dX:
Regulation factor for the influence of the X-coordinate fusion.
8. Controller dY:
Regulation factor for the influence of the Y-coordinate fusion.
 - a) Peak max. dW:
Threshold heading difference. If this value is crossed no sensor fusion with this position result will be carried out.
 - b) Peak max. dX:
Threshold coordination difference in X. If this value is crossed no sensor fusion with this position result will be carried out.
 - c) Peak max. dY:
Threshold coordination difference in Y. If this value is crossed no sensor fusion with this position result will be carried out.
 - d) Trigger SPE:
Manual resolution of the drop-off action. Only active when the vehicle is fixed and non-moving and with compliance of the minimum required marks (parameter F).
 - e) Permanent SPE:
Permanent calculation of an estimated position in stop position.
Only applicable for testing purposes or for measuring demonstration, where no odometrical data is available.

- f) Min. Tags SPE:
Amount of minimum required visible marks for the procedure of the drop-off action, in which an estimated position is calculated.
- g) SPE Tol.:
Allowed maximum difference of the marking width for the assignment for an estimated position. This value varies from parameter 3, in such a way that limits the overall number of possible marking combinations for the determination of the estimates position (see also section D on page 40).
- h) Quality biggest area:
Selection of the algorithm for the quality determination. At the point in time of the document production only the function of the biggest area as a characteristic is available.

4.6.5 Parameter Laser Scanner

The menu Parameter Laser Scanner will be selected with the key . To leave the menu press key . You will then return to the main menu.

NOTE! You can find a sketch of the meaning of the parameter in Figure 27 on page 39.



```

HG 43600XA  GOETTING 2009
+-- Parameter Laserscanner -----+
|
| 1: Offset Sensor Hdg      : 180.30 [DEG]
| 2: Offset Sensor  X -> OdoPt : 0 [mm]
| 3: Offset Sensor  Y -> OdoPt : 0 [mm]
|
+-----<q> Returns to Top -----+
```

Figure 15 Screenshot: Parameter Laser Scanner

In this menu the X- and Y-offset of the Laser Scanner in relation to the coordinate of the odometrical point and the angle orientation of the scanner in relation to the vehicle coordinate system can be adjusted.

1. Offset Sensor HDG:
Parameter for the setting of the angle offsets (the rotation) of the Laser Scanner in relation to the vehicle coordinate system.
2. Offset Sensor X → OdoPt:
Parameter for the setting of the X-offsets of the Laser Scanner in relation to the X-coordinate of the odometrical point in the coordinate system of the vehicle.
3. Offset Sensor Y → OdoPt:
Parameter for the setting of the Y-offsets of the Laser Scanner in relation to the Y-coordinate of the odometrical point in the coordinate system in the vehicle.

4.6.6 Parameter Vehicle

The menu Parameter Vehicle will be selected with the key **V**. To leave the menu press key **Q**. You will then return to the main menu.

NOTE!

You can find a sketch of the meaning of the parameter in Figure 27 on page 39.



```
HG 43600XA  GOETTING 2009
Parameter Vehicle
A: Odometry Type : Ackermann Model
1: Offset Wheel X :      0 [mm]
2: Offset Wheel Y :      0 [mm]
3: Offset NavPt X :      0 [mm]
4: Offset NavPt Y :      0 [mm]
5: Inc/m  Left   :    0.00 [--]
6: Inc/m  Right  :    0.00 [--]
7: Wheel spacing :      0 [mm]
8: Axles spacing :      0 [mm]
9: Speed Jitter  :      1 [mm/s]
B: Speed Leap   :   7000 [mm/s]
C: Steering Angle : Left  Wheel
<q> Returns to Top
```

Figure 16 Screenshot: Parameter Vehicle

In this menu the parameter for the odometrical distance calculation of the vehicle is adjusted. The following parameters are selectable:

- a) Odometry Type: With this menu point it can be chosen between different odometrical kinematics. At the point in time when this document was printed, the following odometries are supported:
Differential → differential odometry
Ackermann → three wheel odometry

1. Offset Wheel X:
X-offset of the controlled wheel.
 2. Offset Wheel Y:
Y-offset of the controlled wheel.
 3. Offset NavPt X
X-offset of the navigation point in relation to the odometrical point.
 4. Offset NavPt Y
Y-offset of the navigation point in relation to the odometrical point.
 5. Inc/m Left:
Increments per driven metre of the left wheel.
 6. Inc/m Right:
Increments per driven metre of the right wheel.
 7. Wheel Spacing :
Wheel distance between the encoder wheels. This parameter is required for the odometry calculation of the differential model.
 8. Axles Spacing :
Axis distance between the controlled wheel/axis and the fixed axis. This parameter is required for the odometry calculation Ackermann model.
 9. Speed Jitter:
Maximum allowable speed at which the vehicle is defined as still-standing. For high resolution encoders the vibration of the vehicle standing could lead to continuous counting. This would lead to an unintentional detected movement. This prevents the vehicle from establishing an estimated position.
- b) Speed Leap
Recognition threshold speed jump.
A jump in encoder values can happen due to a re-start of the navigation control unit. This will result in a speed jump in the Orientation Calculator, which can be detected due to crossing the parametrical values.
In this case the navigation control unit of the system receives a bad navigation quality. Following, the Orientation Computer establishes a new estimated position for the still-standing vehicle.

NOTE! In this case it is necessary that the vehicle will be stopped by the controller! Otherwise no estimated position can be calculated due to movement of the vehicle.



- c) Steering Angle:
The parameter selects the wheel for the odometry calculation according to Ackermann, of which the steering angle and the increments of the wheel sensor will be evaluated.

4.6.7 Parameter System

This menu Parameter System will be selected with the key **P**. To leave the menu press key **Q**. You will then return to the main menu.

```
HG 43600XA GOETTING 2009
Parameter System
1: Terminal Baudrate : 115200 bd
2: CAN Transferrate  : 500 kb/s
3: SIO Baudrate      : 115200 bd
4: NAV Control IO    : CAN
5: CAN ID Odometry   : 0x294
6: CAN ID Position   : 0x292
7: CAN ID System     : 0x800
<q> Returns to Top
```

Figure 17 Screenshot: Parameter System

In the parameter system menu the communication parameter will be adjusted.

1. Terminal Baud rate:
This parameter adjusts the data transfer rate of the serial interface for the monitor mode.
Possible selection: 115200;57600;38400;19200 baud. At the point in time when this document was printed the data transfer rate has to be **firmly adjusted at 115200**, even though it can be selected.
2. CAN Transfer rate:
This parameter adjusts the data transfer rate of the CAN bus for the communication with the navigation controller.
Possible selection: 1000; 500; 250;125 kb/s
3. SIO Transfer rate:
This parameter adjusts the data transfer rate for the serial communication with the navigation controller.
Possible selection: 115200;57600;38400;19200 baud.
4. NAV Control IO:
Selection of the communication start with the navigation controller.
Possible selection: SIO (serial) / CAN (CAN-Bus) communication.
5. CAN ID Odometry:
Adjustment of CAN-ID for the transmission of the odometrical data from the navigation control unit. This value will be expected in a hexadecimal numbers.

6. CAN ID Position:
CAN-ID for the transmission of the estimated position and status data from the Orientation Computer of the navigation control unit.
This value will be expected to be in a hexadecimal numbers.
The position data requires another CAN-ID for the transmission of the data. This is firmly adjusted to a value (parametrical ID+1) and is not allowed to be allocated in any other form.
7. CAN ID System:
CAN-ID for settings the parameters of of the Orientation Computer via the CAN Bus. This feature is not implemented at the time this document was printed. It is advised to supply the parameter with a hexadecimal value of 0x800.

For the odometrical data to reach the Orientation Computer within the required period of 50 milliseconds, the prioritization of the odometrical data on the CAN Bus has to be considered. Small CAN ID's have a high priority in transport and big ID's low priority.

With an additional allocation of the CAN bus on the communication of the Orientation Computer in the navigation control unit will take place, the timing can seriously be affected if a too big ID will be parametered for the odometrical data.

In the worst case this can lead to mistakes in the position calculation. A constant timing in the main monitor can be controlled with the help of the display of the Odo Time (see Figure 12 on page 19).

4.6.8 Save Parameter

With the selection of the menu point Save Parameter with the key , the parameter, which were adjusted in the previous menu, will be permanently saved in the system - after a security request.

NOTE! The contents of the marking table will not be saved in this point. The saving of the marking table content will take place in the marking table menu.



NOTE! After the new settings of parameters, in particular of the interface, the system has to be re-started.



4.6.9 Status / Logging

The menu Status/Logging will be selected with the key **[E]**. To leave the menu press key **[Q]**. You will then return to the main menu.

```

HG 43600XA  GOETTING 2009
-----
Status & Logging
-----
Error Logging Threshold
1: Status Display      A: Deviation X:    0 [mm]
2: Visible Tags       B: Deviation Y:    0 [mm]
3: Log Datastream    C: Deviation W: 0.000 [RAD]
4: Error Memory       D: Reset Trigger Event
-----
                                <q> Returns to Top
-----
```

Figure 18 Screenshot: Status/Logging

1. Status Display:
This display is mainly intended for service purposes. The set parameters are displayed. Please note that the terminal application is only updated every 250 ms. A real-time assessment is not possible.
2. Visible Tags:
This menu shows an overview of the marks which are seen by the scanner and which are also identified by the visible marks, which means an entry in the marking table will be allocated.
In addition, the scan angles are read as precise incremental values. This value will be required for the initial measurement support in the marking menu next to the separately arranged distance measurement.
3. Log Datastream:
With this menu the important variable values of the time period will be recorded. The key „Return“ starts the output of the variable values on the screen in CSV dimensions.
Following, the course of a recording with Hyperterm will be shown:
 - Transfer → select Capture Text → select destination of the log file.
 - Press Return → variable values will be given out on the screen.
 - For ending the recording press key **[Q]**. The output will stop.
 - In the hyperterminal transfer → Capture Text → access stop.

- Another pressing of the key  will lead back to the main menu.

4. Error Memory:

With this menu the error record will be read out. The key return starts the output of the variable values on the screen in CSV dimension. The course of a recording of the output is to be carried out as explained in the previous point.

NOTE!

It is possible that some rows of the output will be incomplete/corrupted. Those can be easily found in the table calculation program via the search for empty spaces in the last column. Rows which are overlong have to be deleted as well.



a) Deviation X:

With this parameter the threshold value of the difference from the coordinate X for the recording of an error storage of a data recording can be adjusted.

b) Deviation Y:

With this parameter the threshold value of the difference from the coordinate Y for the recording of an error storage of a data recording can be adjusted.

c) Deviation W:

With this parameter the threshold value of the difference of the angle for the recording of an error storage of a data recording can be adjusted.

d) Reset Trigger Event:

When entering this, the event of the recording of a data recording as an error protocol will be deleted.

4.6.10 Information

The menu Information will be selected with the key **I**. To leave the menu press key **Q**. You will then return to the main menu.

```

HG 43600XA  GOETTING 2009
-----
Information
-----
Firmware Version:  V1.1-11-gb480c52
Compiling Date:   May 19 2011
Compiling Time:   15:22:13
System Temp. C/F:  35.0/95.0
-----
<q> Returns to Top
-----
```

Figure 19 Screenshot: Information

This menu offers additional information: operating temperature in degrees Celcius and degrees Fahrenheit, as well as the used software version.

NOTE! The display of the operating temperature must not exceed 70° Celsius / 158° Fahrenheit.



NOTE! A service request should always be adjusted with the data of the menu. With this a fast identification of the running software on the system is possible for the manufacturer service.



4.6.11 Software Updates

For the Laser Scanner to be updated via an integrated Ethernet interface a tool has to be installed under Windows, with which a so called TFTP service is allocated.

NOTE! These arrangements do not have to be undertaken if the update via the integrated webserver application will be installed (see section 4.6.11.2.2 on page 34)!



The recommended and tested tool is called Tftpd32 and can be obtained via <http://tftpd32.jounin.net>. This tool is offered under the *European Union Public Licence V. 1.1* and can be used freely.

4.6.11.1 Preparation for the Update of the Software via the Ethernet interface

Firstly, the IP address of the computer, on which the TFTP32 runs, has to be adjusted to the number 192.168.0.133. For this the following steps in a windows PC are required:

1. Right click onto network environment.
2. Select properties.
3. Right click onto network card/network connection.
4. Select properties.
5. Select internet protocol (TCP/IP) properties.

TIP! Write down the current settings so they can be changed back to their original settings if required!



6. Enter the IP address 192.168.0.133 and subnet mask 255.255.255.0 into the shown dialogue.
7. Close with OK.

In the program TFTP32 select the setting menu and adjust the settings under the terms of the following picture. Confirm with **OK** and the re-start of TFTP32 has to be necessary for the new settings to be effective.

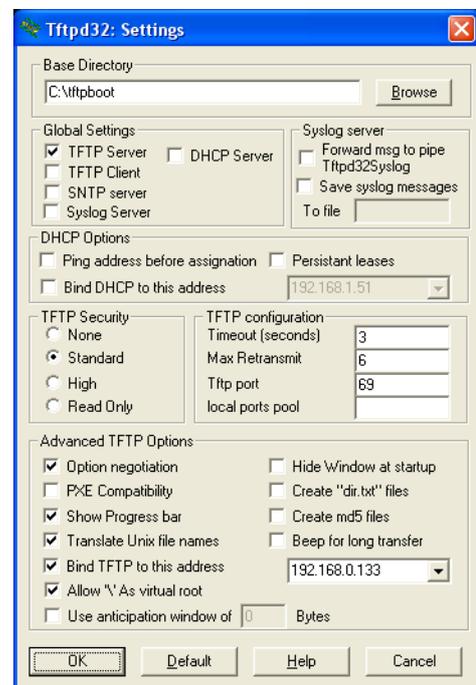
Figure 20 Screenshot: Tftpd32 Settings

For the **direct** connection of the Laser Scanner with network card of the server processor a **Cross-Link** network cable will be required. If a network switch with auto negotiation is available, simple patch cables will be enough. A `ping -t 192.168.0.50` from the command line of the TFTP-processor shows the switched-on Laser Scanner, if a functional connection is available.

To arrange the different updates the corresponding files have to be uploaded into the sub-directories, which are also selected in TFTP32.

NOTE! The files for the possible update are only transferred if a service is requested.

- A file with the name `uImage` is required for an update of the operating system.
- A file with the name `uRamdisk` is required for an update of the firmware.



4.6.11.2 Software Update with Ethernet access

4.6.11.2.1 Over the Boot Loader

For images to be uploaded into the Laser Scanner Orientation Computer with Ethernet access, the Boot Loader of the Orientation Computer has to be stopped during booting. This is only possible when the letters **HG** (in capital letters) are entered after the initialization of the SRAM component.

The following similar display is going to be shown on the terminal:

```
U-Boot 2009.06-00298-g3672cd5-dirty (Jul 15 2009 - 09:47:53)

CPU:   MPC5200B v2.2, Core v1.4 at 396 MHz
       Bus 132 MHz, IPB 132 MHz, PCI 66 MHz
Board: TQM5200S (TQ-Components GmbH)
       on a HG43630 carrier board
I2C:   85 kHz, ready
DRAM:  64 MB
POST memory PASSED
FLASH: 32 MB
In:    serial
Out:   serial
Err:   serial
Net:   FEC ETHERNET
POST i2c PASSED
POST cpu PASSED
SRAM:  512 kB
```

```
Type "run flash_nfs" to mount root filesystem over NFS
```

```
=>
```

Figure 21 Initialization message

The system is now in the Boot Loader and the update can be started.

NOTE! It has to be ensured that the Laser Scanner Orientation Computer will be physically connected with the computer, on which a TFTP service is running.



On the Boot Loader prompt (=>) with this instruction

```
=> run update_ramdisk
```

the update process of the firmware can be initiated. Now the image can be loaded into the Ram of the Boot Loader and following it can be written into the flash memory permanently. As a last step for monitoring the check value will be built via the image of the flash. With a

```
=> reset
```

the Boot Loader can be brought to a restart. During the output of the terminal the booting process can be followed with the new firmware.

4.6.11.2.2 Via the Web Server Application

From the firmware version V1.1-g8f9d145 (see also menu point Information in section 4.6.10 on page 31) the firmware update can be alternatively installed via an integrated Web Server Application. For this, it only has to be ensured that the configuration-PC controls over an IP in the network environment of the Laser Scanner. When the Laser Scanner is delivered it has the IP address **192.168.0.50**, so that the IP address of the PC also has to be in the net area of 192.168.0.xxx (i. e. 192.168.0.51, see also section 4.6.11.1 on page 32 to the configuration of the IP-address).

With an internet browser, the display of the tool can then be achieved via the entry of the Laser Scanner's IP address.

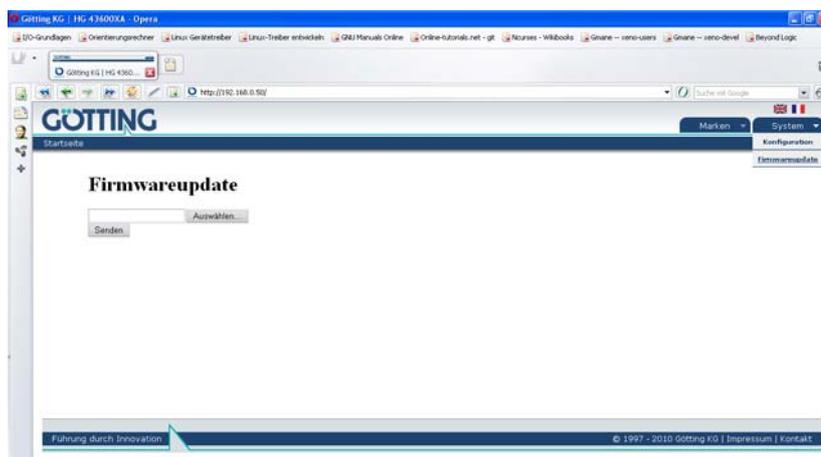


Figure 22 Screenshot: Web Server Application

With a click on the button **Browse** a dialogue window for the data file selection will be opened. In this window the firmware, which has to be installed, can be selected. With a click in the button **Submit query** the update will be started. Within a period of one to two minutes the update will be carried out. This procedure ends with the re-start of the Orientation Computer. An incomplete transfer will end the update earlier. Following, it has to be repeated.

In addition this web application can also load the marking table- and configuration data from the system. A browser based upload of this data is at this point in time, when this document was printed, not yet implemented.

4.6.11.3 Software Update without Ethernet access

To be able to load the images onto the Laser Scanner Orientation Computer without Ethernet access, during the booting, the Boot Loader of the Orientation Computer has to be stopped. This is only possible if the display of the initialization of the SRAM the module the letter **HG** (in capital letters) is entered.

```
U-Boot 2009.06-00298-g3672cd5-dirty (Jul 15 2009 - 0 9:47:53)
```

```
CPU: MPC5200B v2.2, Core v1.4 at 396 MHz
      Bus 132 MHz, IPB 132 MHz, PCI 66 MHz
Board: TQM5200S (TQ-Components GmbH)
      on a HG43630 carrier board
I2C: 85 kHz, ready
DRAM: 64 MB
POST memory PASSED
FLASH: 32 MB
In: serial
Out: serial
Err: serial
Net: FEC ETHERNET
POST i2c PASSED
POST cpu PASSED
SRAM: 512 kB
```

```
Type "run flash_nfs" to mount root filesystem over NFS
```

```
=>
```

Figure 23 Initialization message

The system is now in the Boot Loader and the update can be started.

For the update file to be loaded via the second serial interface in the Ram storage of the Orientation Computer, the following command has to be entered on the Boot Loader prompt.

```
=> loady 100000
```

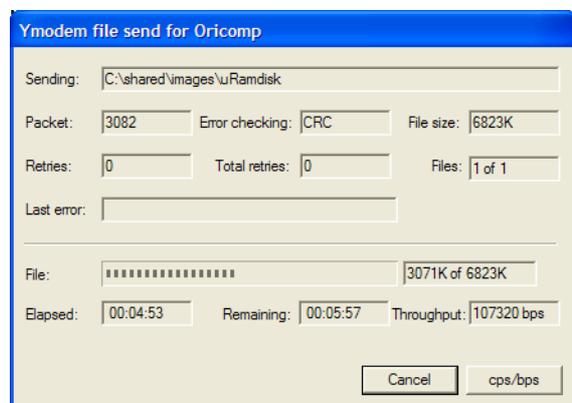
In the next step the program Hyperterminal under the selection of **Transfer** → **Send a transfer with YMODEM** protocol has to be selected. The image, which has to be uploaded has to be selected via **Browse**.

The system is now waiting for a transfer with YMODEM protocol. Hyperterminal shows the adjacent dialogue for the control of the update.

Figure 24 Screenshot Hyperterminal YMODEM transfer control

Is the transfer successful, then the image in the Ram of the Boot Loader will be loaded via

```
=> run flash_ramdisk
```



and following persistently written into the flash memory. In the last step the inspection of the check value over the image in the flash is build. With a:

```
=> reset
```

the Boot Loader will be led to a re-start. On the display in the terminal the booting process will be followed with the new firmware.

4.6.12 Up- and Download of the configuration- or marking data

To supply more than one Orientation Computer more than once with the same marking- or configuration data, it is possible to download the data via a serial interface as separate data from an already configured Laser Scanner and following to upload them in another Orientation Computer. Following, this data will be available after the re-start of the Laser Scanner.

With the selection of the menu point  the Orientation Computer is booting automatically in service mode. Here the configuration- or marking data can be up- or downloaded as separate data. This transfer occurs serial, protocol based via the Zmodem dimension.

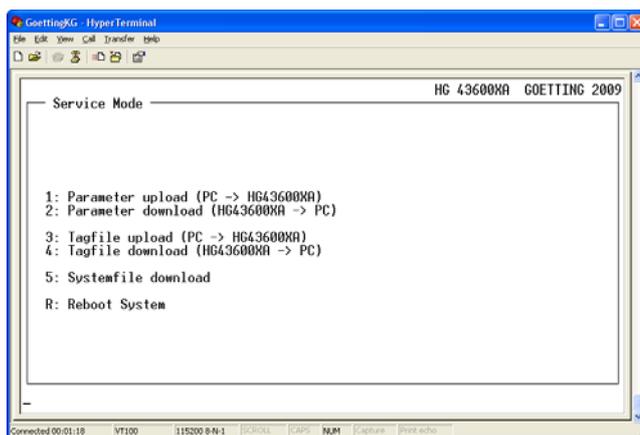


Figure 25 Screenshot: Service mode

In the case of the terminal application Hyperterminal the files on the drop down menu Transfer → Receive File are stored in a chosen place in the data system on the PC. In this menu the required transport protocol, in this case Zmodem, will be selected.

1. Parameter Upload
Option for the upload of the configuration data from the PC in the Orientation Computer.

NOTE! This data/file has to be called `config.dat`!



2. Parameter download
Option for the download of the configuration data of the Orientation Computer of the PC.

3. Tagfile upload
Option for the upload of the marking table data from the PC in the Orientation Computer.

NOTE! This data/file has to be called `mtab.dat`!



4. Tagfile download
Option for the download of the marking table data from the Orientation Computer onto the PC.
 5. Systemfile download
Service point for internal tests.
- R. Reboot System
Re-start of the Orientation Computer

When using the terminal application Hyperterminal the data will be put down in the drop down menu *Transfer -> Receive File* in the selected place in the data system of the PC. In this menu the required transport protocol, here Zmodem, will also be selected.



Figure 26 Screenshot: Dialog Receive File (Zmodem)

NOTE! After the upload of the configuration- or marking table data the Orientation Computer has to be re-started.



5 Technical Data

Technical Data	
Power supply laser	+18 to +30 VDC Power consumption: - approx. 400 mA at 24 Volt / 6 rotations/second - approx. 600 mA at 24 Volt / 18 rotations/second
Power supply heating	+18 to +30 VDC Power consumption: approx. 1,2 A at 24 Volt
Service interface	2x RS 232
Interface navigation controller	- 1x CAN - 1x RS 232
Environmental requirements	Temperature: - +10 to +50° C without heating - -25 to +50° C with heating max. 80 % humidity, not-condensating
Protection class	IP 67
Laser achievement	1 mW, eye-safe, Class 1 (at less than 300 mm distance to the Laser Scanner it is Class 1M), automatic switch-off during standstill/non-moving
Reading area	1 to 30 metres
Measuring rate	6 to 18 measurings per second (parameter setting)
Capture range	360°
Angle revolution	8192, 16384, 24576, 32768, 40960 or 65536 increments per rotation (parameter settings)
Accuracy	Repetition accuracy of the absolute position measuring better than ±5 mm (see notes in section 1.3 on page 5)
Environmental light	< 10000 lux
Measure	- Ø 153 mm - height 150 mm
Weight	2,3 kg

Table 6 Technical Data of the Laser Scanner

6 Appendix

A Parameter allocation

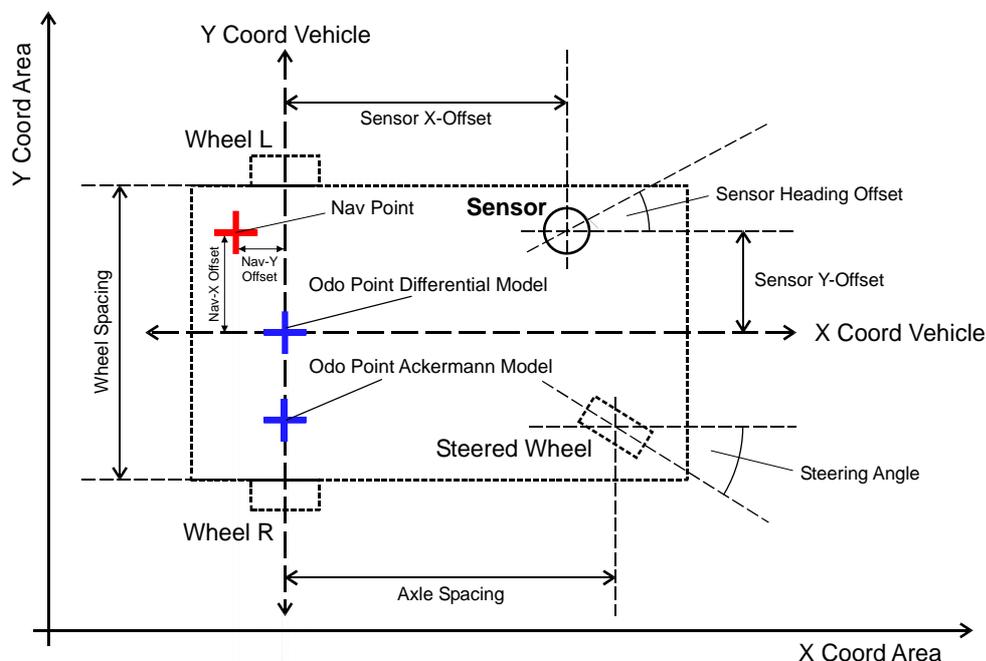


Figure 27 Sketch: Annotation of the important parameters (vehicle, sensor, offsets)

B Additional information for commissioning

For the parameters of the each offset (laser, navigation point) to be correctly entered, it has to be taken care of the following relations:

- The system merges the absolute laser position measurement and the calculated odometrical position always in the odometrical-point.
- The offsets of the navigation-point as well as of the Laser Scanner in relation to the odometrical-point have to be established and entered into the respective entry mask. For assistance look at the sketch in Figure 27 above.
- The navigation-point is the position, which is converted to the navigation controller. On this the vehicle will finally be guided.

C Accomplishment of an initial measurement action of a new reflective mark with the help of the integrated initial measurement function.

To additionally add and measure a new reflective mark, there is an integrated function in the marking table menu for the initial measurement support.

NOTE!

For the initial measurement an exact (min. ± 2 mm) Laser-distance measurement is required.



NOTE! Do not use this function yet! Please read the following text first.



1. Firstly, the angle of the unknown mark has to be established. For this please go the menu *Status/Logging* → *Visible Tags* (see section 4.6.9 on page 29). Here the angle, under which the unknown mark was scanned, of the wanted mark will be shown in increments or in degrees. The incremental angle value should be written down.
2. Next on, the distance to the mark will be measured with the laser-distance measurement. The mark always has to be located exactly in the middle.

NOTE! At the marking code 2 this point lays in the middle between both reflector stripes of the mark. When encoding 1 and 3 the middle lays exactly on the border of the reflector stripes of the mark (see also section 2.6 on page 11).



3. Now the marking table menu can be used and then select the initial measurement function. After this the system will ask for the position in the table which should be used for the calculated mark.
4. Now the code ID of the mark has to be entered (see section 2.6 on page 11).
5. Then it will be asked for the angle in increments. Enter the written-down value from the status menu here.
6. Now only the entry of the measured distance and the orientation of the mark are missing.
7. Finally, the module mass (see section 2.6 on page 11) of the mark has to be entered.

After the entry of all the data the calculated mark will be entered with its coordinates into the system.

ATTENTION! The new entered mark is after the switch-off deleted. It can be persistently saved before switching-off after the initial measurement process via the saving function.



D Annotation for the effect of the parameter <SPE Tolerance> in the menu special function

After the start of the Orientation Computer in the Laser Scanner, the Orientation Computer will be in the 0-position of the room-coordinate system. The current position and orientation of the Laser Scanner, the position, is required to be established now.

For this the data of the scanned reflectors will be available after one rotation of the scanner head. Those data will be processed of the Orientation Computer in the form code, width and angle.

Out of all visible marks a position for every possible reflector combination will be defined via a SPE-algorithm (SPE: Start Position Estimate). Based on every single position the width of the mark will be calculated, which were consulted for the establishment of the position. If the difference between the scanned and the established width for the mark of the set parameter SPE tolerance is crossed, then the position will be revoked.

The larger the tolerance value, the more likely will the detection of very inaccurate and faulty estimation be.

If still no SPE with a clear result takes place, this could be because of symmetrical arrangement of the marks in the room, which the algorithm cannot clearly determine in this position. In this case the vehicle has to be moved and the SPE has to be carried out in a new place.

E Annotation to the effect of the parameter <Tag Width Tolerance> and <Percentage Width Tolerance> in the menu special function

For a visually recognized reflective mark to be allocated in an entry in the marking table, different analyses have to be carried out. One of them is the establishment of the absolute width of the mark viewed from the current position of the Laser Scanner. If this is carried out, the result will be compared with the scanned width. Is the calculation within the tolerance set by the parameter, then the width criterion will be seen as fulfilled.

Is the scanner in direct closeness of a reflective mark, then slight changes in the position of the estimation of the calculated width will be arranged differently, as if the scanned marks stand in some distance to the scanner. With the simple, absolute observation will too many allocation be revoked. In this case too many allocations are revoked with simple and absolute observation.

In addition to the filter criterion for the absolute width there is also one with a relative influence. If the criterion for the absolute width is not fulfilled, then the calculated and the scanned width are compared (relative influence). If both criteria are not fulfilled, this marker position is not used.

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9 Handbook Conventions

At the time this manual was printed, the following symbols and marks were used in all Götting KG documentations:

- ♦ For security advices, the following symbols stand for different degrees of danger and importance:

NOTE!



ATTENTION!



WARNING!



- ♦ Further information or advices are indicated as follows:

TIP!



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- ♦ Whenever the pressing of letter keys is required for program entries, the required **L**etter **K**eys are indicated as such (for any programs of Götting KG small and capital letters are equally valid).
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