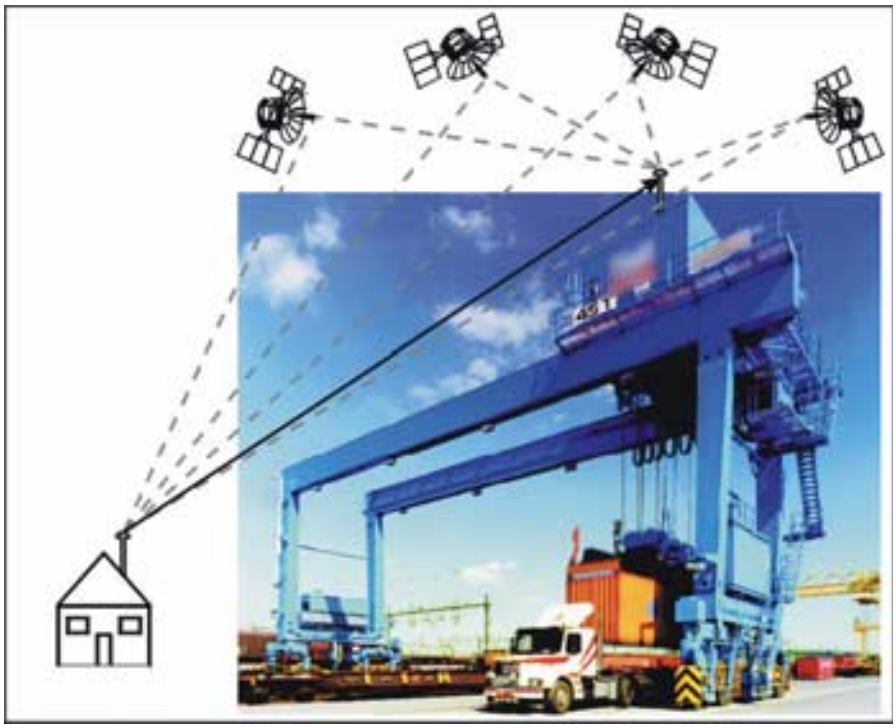

DGPS Positioning of Gantry Cranes (RTGs)

DGPS Positioning for

- Automatic Steering of RTGs
- Automatic Container Tracking

S_G57650-A

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1 Introduction

1.1 Systems Function

With the, in general use, Global Positioning System (GPS) it is possible to determine a geographical position. The commonly used standard GPS provide an accuracy of approx. 10 m.

With the aid of additional equipment and under certain area conditions it is possible to achieve a geographic position with an accuracy of up to ±3 cm.

1.1.1 Container Tracking

The temporary storage of containers by use of visual means with manual confirmation leads to an error rate in the storage handling, which disrupts the efficient turn over time of the container ships. Therefore it is better to use GPS to control the positioning and documentation of containers within the container port environment.

It has been possible for years for Rubber Tired Gantry Cranes (RTG), working on container transport within a seaport, to communicate with the controlling container management system, via a data Radio Transceiver, when it picks up or sets down a container at a predesignated position within the container yard. This takes some of the load off of the driver as well as reduce the error rate, which a complicated and time exhaustive container search entails.

1.1.2 RTG Autosteering

Due to the achievable positional determination of approx. ±3 cm, it is possible to track a vehicles movements. Consequently by using a series of measurements along with the geographical positional data it is possible to determine the vehicles direction of travel and velocity.

With the aid of these functions it is possible to automatically steer a RTG over a predetermined route within the container yard. This means, that apart from the free movability that the rubber tired vehicles provide, they like the rail mounted vehicles can be used within the container storage area without disrupting the drivers attentiveness, with unnecessary requirement to control the tracking and manually steer the crane. A special advantage of this system is that for both functions there is absolutely no requirement to mount equipment within the track surface of the container yard.

All these points serve to aid the operational safety and therefore remove some of the stress placed on the driver, which in turn reduces the error rate. A looped memory stores all relevant information so that in the event of a disruption with the systems function or during testing, a quick and easy error diagnoses is available. For special or emergency uses all these functions are manually operable so that a complete operational shut down can be avoided.

1.2 Employed Technologies

The system incorporates a combination of systems, (sensor fusion), the advantages of satellite navigation with the advantages of odometry (dead reckoning).

1.2.1 PDGPS Positioning

GPS offers every one the chance to find out their Geographical position by use of a special GPS receiver. To do this the signals from the GPS satellites are decoded. For normal civilian uses, only a signal that gives an accuracy of approx. 10 m is available.

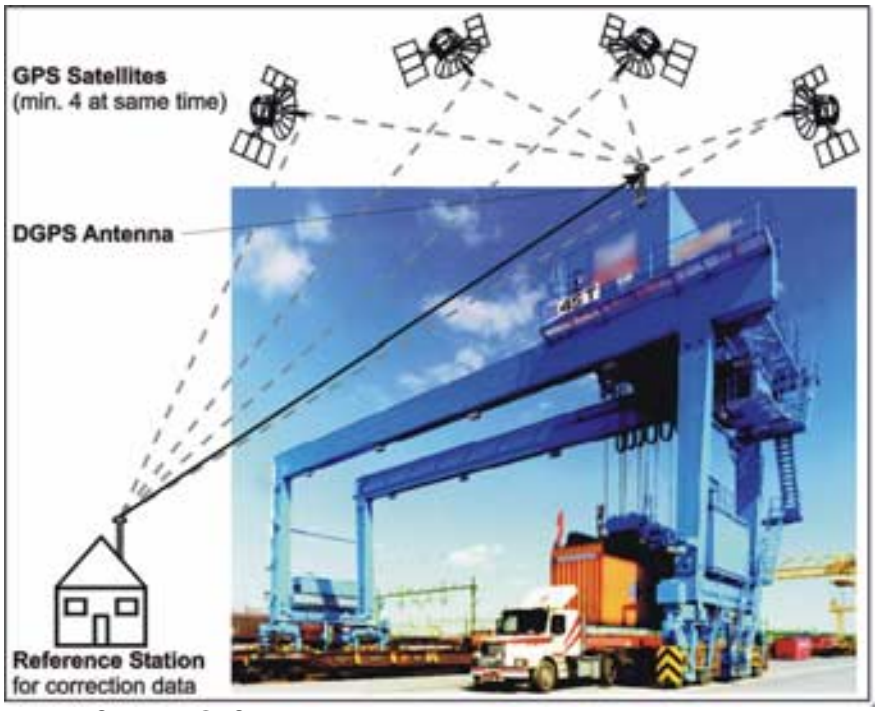

Figure 1 Sketch DGPS

This accuracy is not enough for the presented system. Therefore alongside the GPS system fitted to the Crane (mobile unit) a further stationary GPS system (Base station) is set up, the base stations position can be exactly calculated, it can then compare it's actual position with that of the GPS, and Transmits this error factor via a Data radio Transceiver to the mobile systems. These can then calculate there positions with an accuracy of up to 3 m (differential GPS; **DGPS**).

Via the determination of the carrier wave of the GPS signal it is possible to increase this accuracy level to ±3 cm (Precision DGPS; **PDGPS**).

NOTE! The system requires approx. 15 minutes after a new start to effectively calculate the carrier wave!

The GPS system seen over a long period of time offers a very stable service but can due to shadowing, or reflection become temporary unstable.

1.2.2 Odometry

The odometric (dead reckoning) navigational system calculates the cranes position in a different way. Here the wheel revolutions are ascertained, via rotary encoders. It is then possible to calculate, from the wheel revolutions, the vehicles position and any alteration of angle.

The Odometric system is permanently available and has a high degree of accuracy over a short distance. It's draw backs are however that it can not determine the starting position of the crane and angle of error rises over time, so that the system becomes increasingly unstable.

1.2.3 Sensor Fusion

In system S_G57650-A Satellite navigation and odometry are so combined, that long term exact positional data can be delivered. In order to do this the PDGPS calculates the cranes starting position and passes this onto the Odometry, with which the crane is driven. The PDGPS is then used to correct the worsening positional information delivered by the Odometry, a further advantage to this system fusion is that should the PDGPS become inoperable for short periods the crane is still operable over the Odometry.

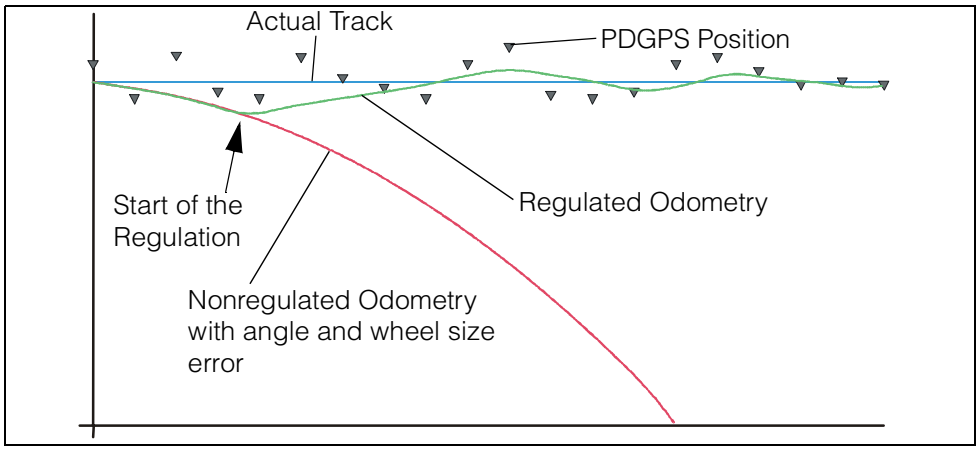

Figure 2 Sensor Fusion: Fusion of PDGPS and Odometry

1.2.4 Behaviour of the Sensor-Fusion in case of GPS Failure: Container Matching

In addition to the above described functions, the sensor-fusion controller is capable of conducting container tracking even already approx. 10 seconds after switch-on and during a complete GPS failure. Following the switching on of the system the last recorded position is used for the initialization of the odometric system. Now, the below described container matching can be carried out:

Every time a container is picked up or dropped off, the position is determined by the odometric system is compared to the defined container slot positions. If a slot can be found, that is less than 2 m off th eposition given by the odometry, this position is imported as current position. This feature enables to travel up to 100 m during GPS failure. Even longer travels are enabled by picking up and dropping off, or vice-versa, containers in defined slots several times on the way.

As soon as the GPS signal is available again, its position is imported by the odometric system (for accuracy default values e. g. <= 1 m (factory set; adjustable)). At a second adjustable accuracy default value (10 cm factory set), the control function is activated and now an accuracy sufficient for automatic steering is available.

1.3 Operational overview

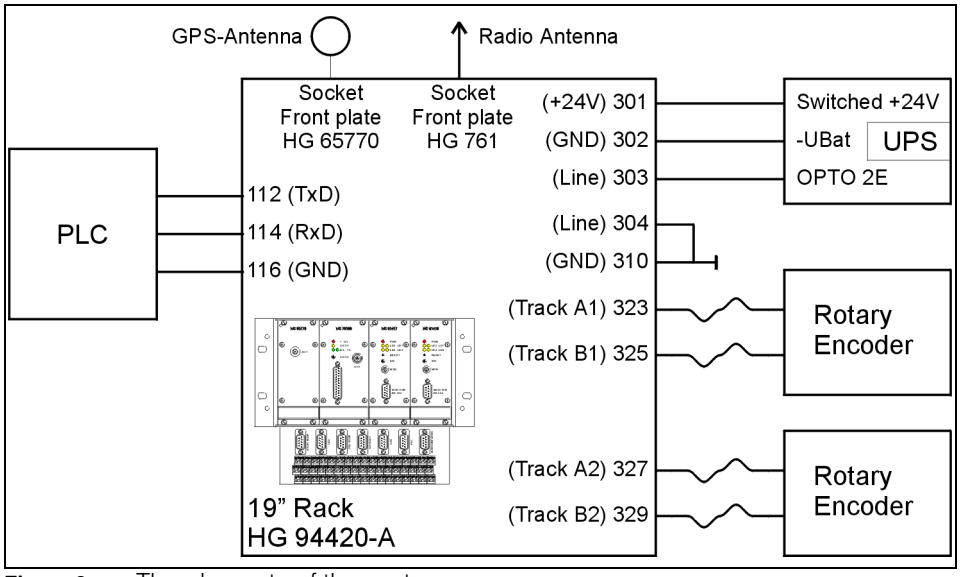

Figure 3 The elements of the system

The rack consists of, a GPS receiver HG 65770, a radio modem HG 76100 to enable the receipt of the correction data from the base station, a GPS controller HG 61417, which prepares the GPS signal and a Sensor Fusion Controller HG 61418 which calculates the position from the data given by PDGPS and Odometry and passes it on to the Crane Control unit (PLC).

Connected to the rack are the GPS antenna, radio antenna, and both rotary encoders, which are fitted to the wheels. Apart from this a UPS is fitted to the system, which can in the invent of a power failure provide enough power to keep the system operable for approx. 75 min's. Over output ports the data is transferred to the PLC.

During the initial set up, all necessary parameters, which the crane requires, can with use of the software incorporated within the controllers be incorporated into the system. These highly explicit software menu's are described in more detail in the included Controller Manuals. It is to be noted that any changes within the parameters can only be carried out by schooled personnel as the software is protected by a password. An overview of the relevant values for the cranes parameters or shown in Figure 4 on page 8.

It is important to know that for service reasons it is possible to store all relevant values, set during the initial set up, onto a hard disk via a laptop, they can then be re-entered if necessary. You can find more information over this subject in paragraph 2.2 „Re-Start“ on page 10 and C.2 „Minimum Requirements for a Laptop for configuring and monitoring the System“ on page 31.

1.3.1 Determining important values for the Crane

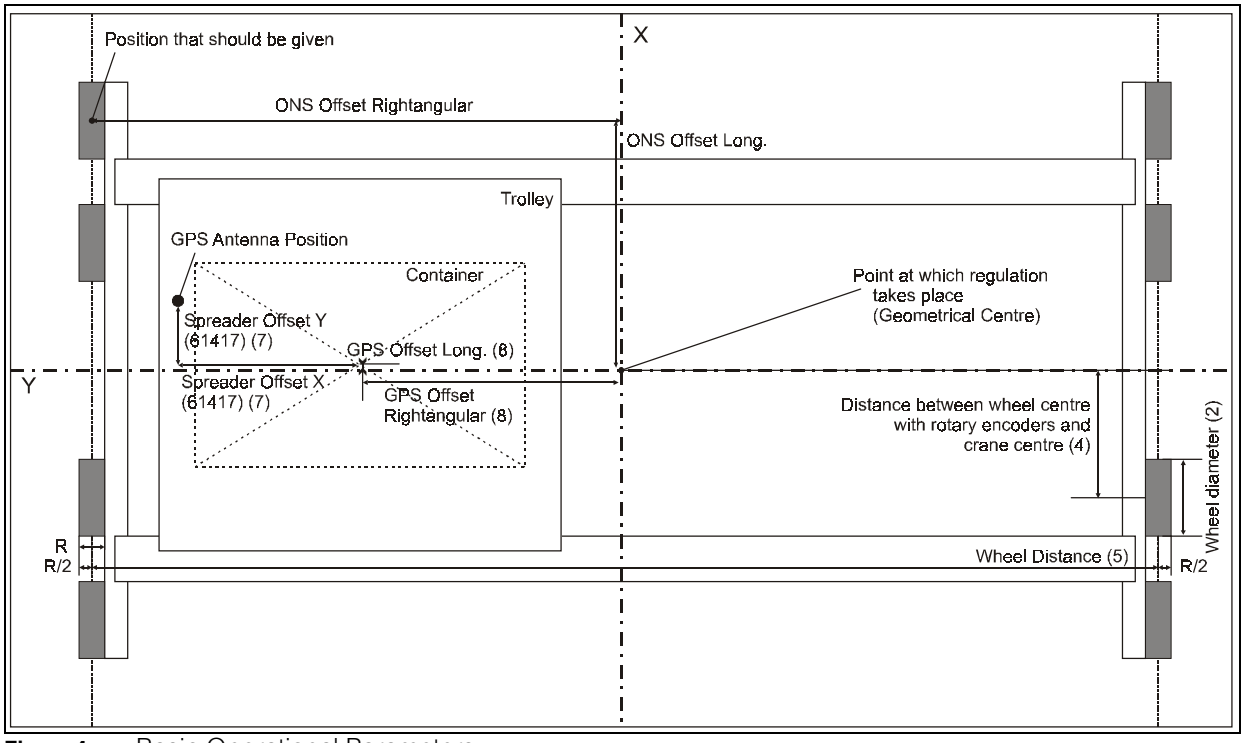

Figure 4 Basic Operational Parameters

Figure 4 shows the distances that the system needs to know in order to calculate, using the GPS antenna on the Trolley and the Rotary Encoders on the wheels, the crane's geometrical centre point.

1.3.2 Determining important values for a stack

When defining a Stack or route which a Crane should take, the following values are important:

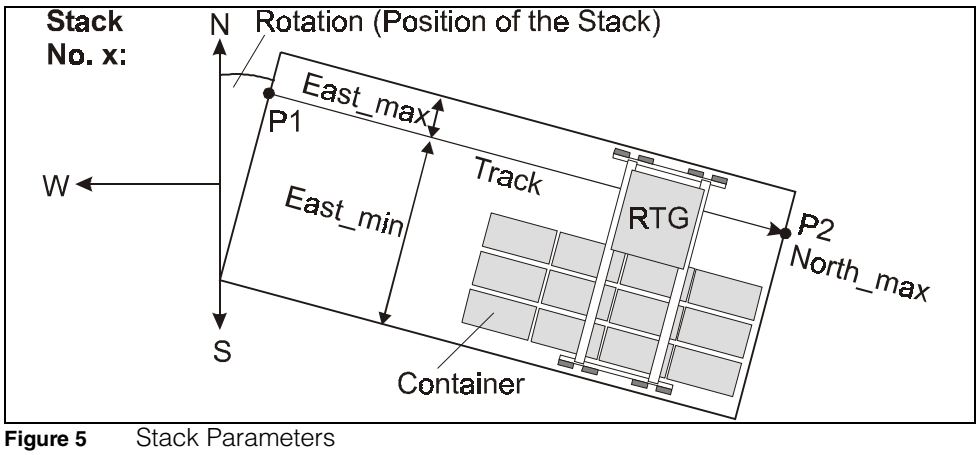

Figure 5 Stack Parameters

Introduction

For every stack the following values have to be set, the stacks inclination over the geographical North pole (rotation), P1 is the cranes starting point in this stack, via East_min and East_max informs the crane of the stacks sideward expansion in relation to the position of the GPS antenna. P2 is the end point of the crane. The connection between P1 and P2 give the stacks direction.

2 Start-up

2.1 Initial Start-up

ATTENTION! Only specialized personnel of Goetting is allowed to do the initial start-up of the system!

The parameters of every crane are saved on disk after the commissioning.

NOTE! These disks have to be archived by the yard operator for possible re-starts.

2.2 Re-Start

For a re-start it is assumed, that all system components have been installed and connected by qualified personnel. Since all system parameters are permanently stored within the system, the system will be fully operationable after a power breakdown and re-connection to power supply (however, the re-start will take a few minutes, since the system has be re-initialized).

In case it is necessary to exchange one of the two controllers (all other components are pre-configured and will be delivered in the same pre-configured manner), it is simply necessary to download the parameters set during the initial start-up which are stored on a disk. Use the corresponding parameter disk for the crane which was produced during the initial start- up (s. a.).

ATTENTION! Make sure you only use the suitable parameter disk for each crane, since there may be differences in parameter settings between the different cranes!

NOTE! In order to be able to download the parameters from disk it is necessary to know the parameter password of the corresponding controller. This password should only be given to specialized personnel.

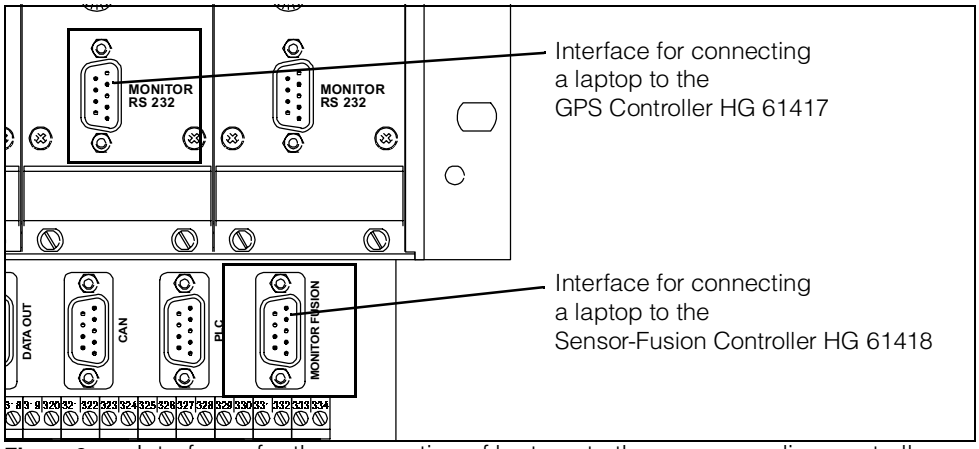

Figure 6 Interfaces for the connection of laptops to the corresponding controllers

Connect a laptop (as described in section C.2 on page 31) using a serial cable to the monitor port of the corresponding controller. For the GPS Controller HG 61417 use the Monitor/RS 232 port located on its front panel. For the Sensor-Fusion Controller HG 61418, however, it is necessary to use the Monitor Fusion Port on the rack, since its port Monitor/RS232 on the front panel may exclusively be used for updating the controller software.

Start a terminal program with ANSI terminal emulation (e.g. Hyperterminal of Microsoft® Windows®) on the laptop. Set the following interface parameters:

- interface parameters HG 61417: 19200, 8, N, 1
- interface paramters HG 61418: 38400, 8, N, 1

In case the baud rate was set to the wrong value, non-readable characters will appear on the display. Provided that all parameters were set correctly, press the space bar when working with the GPS Controller HG 61417 and the M key for the Sensor-Fusion Controller and their respective main menus will appear.

```
 HG 61417GG1.03        Copyright (C) 1997-1999 Goetting KG, Germany

    Installation                              Reports from Receiver

1 - Set Positions and Time                R - Receiver Status
2 - Set Vehicle Parameters                N - Navigation UTM
3 - Set Stacks                            S - Receiver Summary
4 - Supervisory Parameters                K - RTK Kalman Status
5 - Output Port Setup




    Other Functions

H - History
O - Firmware/Parameter Options
```

Figure 7 Screenshot: Main menu GPS Controller HG 61417

```
      Main Menu



      P: Edit Parameters

      D: Display Output

      T: Output as Textfile


      'M' always returns to Main Menu
```

Figure 8 Screenshot: Main menu Sensor-Fusion Controller HG 61418

Press O for the GPS Controller and P for the Sensor-Fusion Controller in order to enter the respective parameter menus. The Sensor-Fusion Controller HG 61418 will now prompt with the request for the password. Then the following menus will appear:

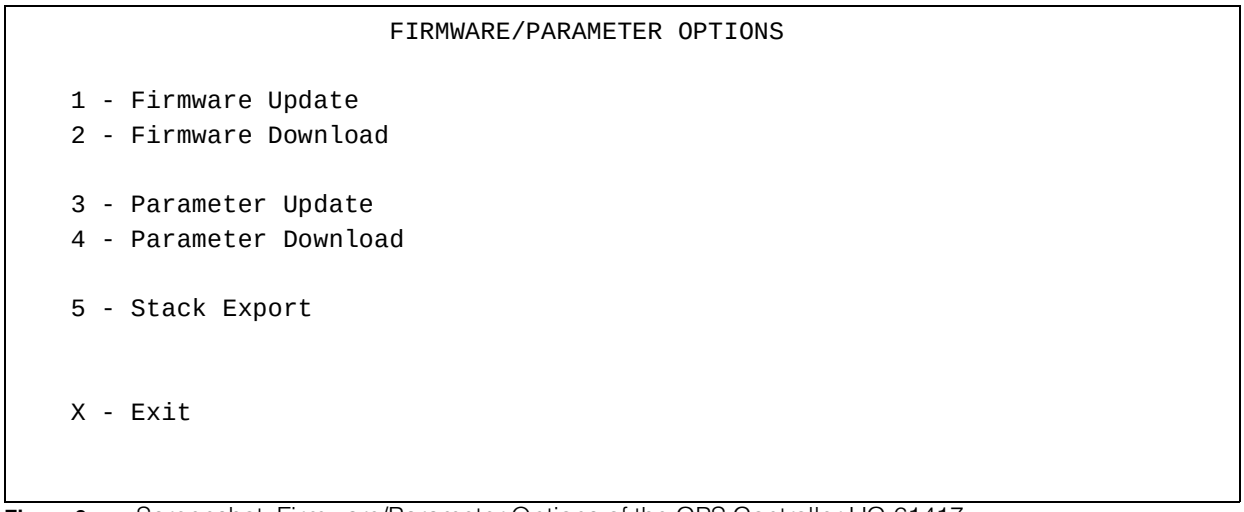

Figure 9 Screenshot: Firmware/Parameter Options of the GPS Controller HG 61417

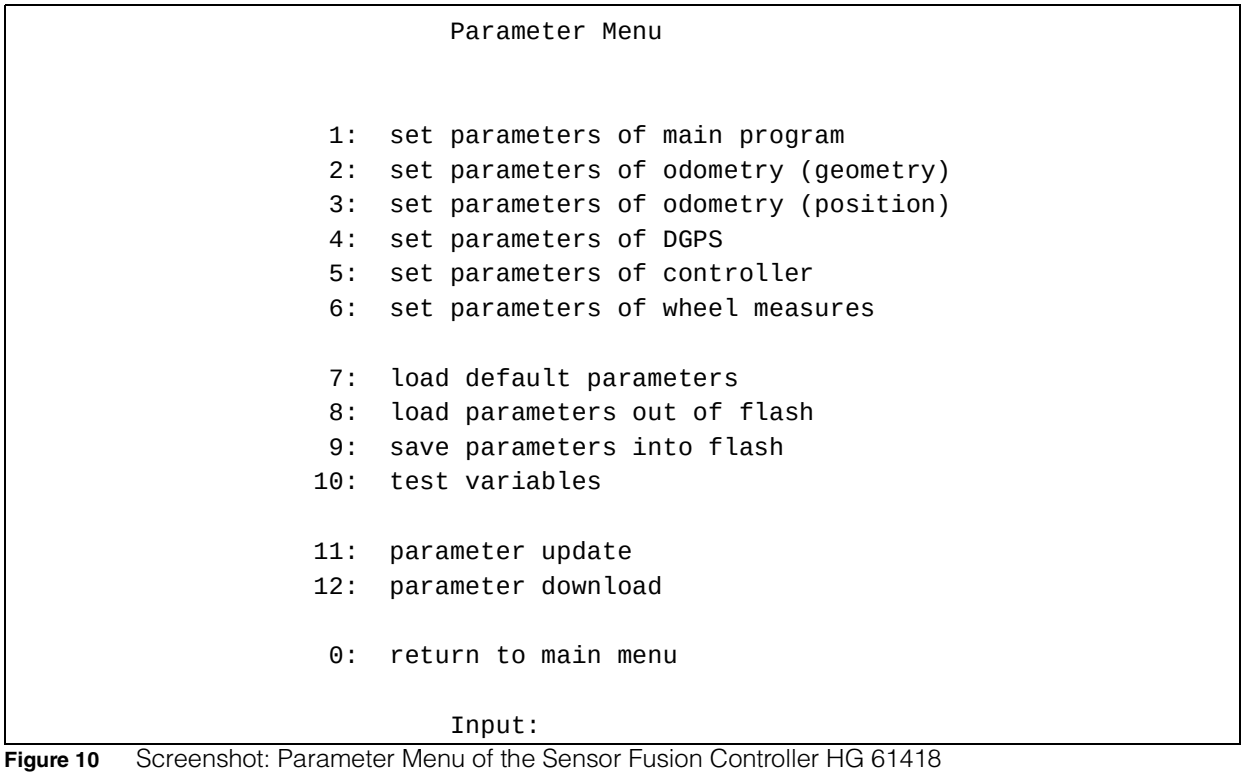

Figure 10 Screenshot: Parameter Menu of the Sensor Fusion Controller HG 61418

Selecting the function `Parameter Update` (3 for the GPS Controller / 11 + ↵ – Return – for the Sensor-Fusion Controller) sets the respective controller to the waiting function. It will then wait for the transfer of a valid parameter file from a laptop. The respective menu of the Sensor-Fusion Controller is as follows:

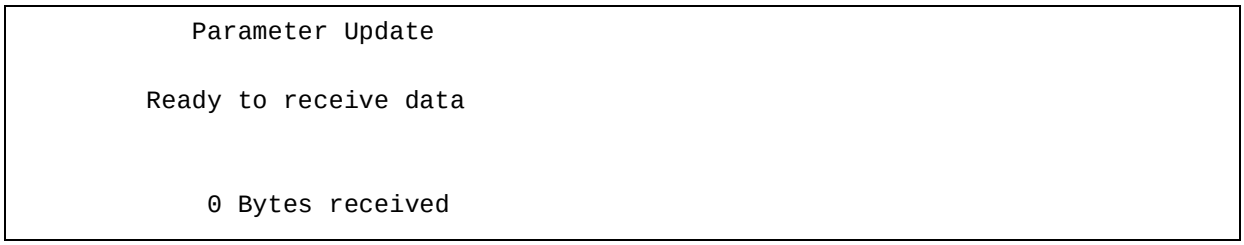

Figure 11 Screenshot: Parameter Update of the Sensor Fusion Controller HG 61418

Start the transmission of a text file from the terminal program on the laptop. Now select the correct parameter file for the corresponding crane and controller from the parameter disk. Once the update has been completed, the parameter menu of the corrsponding controller reappears on the display.

Now press [X] if you are working with the GPS Controller in order to return to the main menu. The controller will then automatically start using these transferred parameters.

When working with the Sensor-Fusion Controller it is necessary to first press [9] in order to permanently save the parameters and then return to the main menu with the sequence [1][0] + [↵] – Return –. Now the controller will start using the transferred parameters. The detailed description of the respective controller software is included in the two controller descriptions available with this service manual.

3 Trouble Shooting

The PDGPS Vehicle Navigation System G 57650 is designed to independently operate after the initial start-up (only to be effected by specialized Goetting personnel) without any intervention. The system is so complex, that only especially trained engineers are allowed to open it. Its perfect operation highly depends on the correct operation of all other involved electrical equipment – e. g. the crane control.

This section shall enable the reader in case of a system failure, to determine whether this failure was caused by System G 57650 and if so, which system component is responsible. Please always draw up a detailed description of the failure before contacting Goetting.

3.1 Maintenance

The design of the system only requires a minimum of maintenance. The maintenance is limited to

- the regular visual inspection of the equipment in general and
- the regular inspection of the connections and the terminals
- a plausibility check of the wheel diameters determined by the Sensor-Fusion Controller using a Terminal Program with ANSI Terminal Emulation on a PC, which is connected to the controller (for further information refer to the detailed System Description of the Sensor-Fusion Controller HG 61418)

approx. every four weeks.

3.2 Function Tests

Both controllers, the GPS Controller HG 61417 as well as the Sensor-Fusion Controller HG 61418, are equipped with a serial service interface (monitor). For the GPS Controller HG 61417 this interface is located directly on the front panel. For the Sensor-Fusion Controller HG 61418 use the Monitor Fusion interface on the rack (also refer to Figure 6 on page 11; the interface on the front panel is exclusively used for updating the controller software).

These interfaces enable connecting the controllers to a PC (or laptop; also refer to section C.2 on page 31). The interfaces operate with the following settings: HG 61417: 19200, 8, N, 1; HG 61418: 19200/38400, 8, N, 1 (if the baudrate of the PC is incorrect, the display will only show cryptical strings). A Terminal Program with ANSI Terminal Emulation enables checking all system functions as well as adjusting parameters. For further information, please refer to section 2.2 on page 10 and the also supplied System Descriptions of the controllers.

This way you are able to determine whether either one of the controllers are operating correctly or whether they output faulty data or none at all. Thus it is possible to restrict possible malfunctions to one of the controllers or even to the components in front of them. It is also possible to check whether the controllers are using the parameter values set for the respective RTG during the initial start-up.

3.3 Normal Operation

3.3.1 Radio Modem HG 76100

3.3.1.1 Reference Station

In normal operation, the Power LED is permanently on, while the Tx LED of the HG 76100 slip-in card blinks once per second. The Rx LED is always off.

LEDs	LED +12V (red) **O** POWER LED AKTIV (yellow) **O** LED RX (green) **O O** LED TX (green)		
● = LED permanently on, O = LED off, ⊕ = LED blinking, X = LED status of no interest for this issue			
LED Power	**LED TX**	**LED RX**	**Function**
●	O	O	Modem in reception mode and waiting for data transmission
●	⊕	O	Modem transmits data

Table 1 Reference Station Radio Modem LEDs in normal operation

3.3.1.2 Mobile Station

In normal operation, the Power LED is permanently on, while the Rx LED of the HG 761 slip-in card blinks once per second. The Tx LED is always off.

LEDs	LED +12V (red) **O** POWER LED AKTIV (yellow) **O** LED RX (green) **O O** LED TX (green)		
● = LED permanently on, O = LED off, ⊕ = LED blinking, X = LED status of no interest for this issue			
LED Power	**LED TX**	**LED RX**	**Function**
●	O	O	Modem is in reception mode and waiting for data transmission
●	O	⊕	Modem receives data

Table 2 Mobile Station Radio Modem LEDs in normal operation

3.3.2 GPS Controller HG 61417

The GPS Controller HG 61417 is only part of the Mobile Station.

- LED Power permanently on.
- LED 4 blinking at 10 Hz.
- During the power-up period, first LED 1 + LED 3 and LED 2 + LED 4 are blinking during the ROM test, and then LED 1 + LED 2 and LED 3 + LED 4 are blinking during the.
- All other LEDs are off!

LEDs	LED PWR **O** LD2 **O O** LD1 LD4 **O O** LD3				
● = LED permanently on, O = LED off, ⊕ = LED blinking, X = LED status of no interest for this issue					
Mode	**LED 1**	**LED 2**	**LED 3**	**LED 4**	**Function**
Standard	●	●	●	⊕	normal positioning-mode
System start	●	O	●	O	ROM test (blinking at 1 Hz)
	O	●	O	●	
System start	O	O	●	●	RAM test (blinking at 1 Hz)
	●	●	O	O	
Firmware Update	●	X	●	O	Intel-hex file being received (blinking at 10 Hz)
	O	X	●	●	

Table 3 GPS Controller LEDs in normal operation

3.3.3 Sensor-Fusion Controller HG 61418

LED PWR **O**
LD2 **O O** LD1
LD4 **O O** LD3

In normal operation the Power LED is permanently on. LEDs 1 and 2 are blinking 10 times per second, while the 'on' period of LED 2 has to be significantly longer than the 'off' period. LED 3 is either on or blinking. In case LED 3 is blinking, it must take to being permanently on after a short distance travelled in the stack.

3.4 Identifying Malfunctions

3.4.1 Radio Modem HG 761

3.4.1.1 Reference Station

LEDs	LED +12V (red) **O** POWER LED AKTIV (yellow) **O** LED RX (green) **O O** LED TX (green)		
● = LED permanently on, O = LED off, ⊕ = LED blinking, X = LED status of no interest for this issue			
LED Power	**LED TX**	**LED RX**	**Function**
O	O	O	check power supply or exchange HG 76100
●	●	X	Indication for malfunction of Radio Modem. It may happen, that the Rx LEDs of the mobile Radio Modems are also permanently on. Exchange HG 76100.
●	O	O	Reference Station does not transmit correction data. Check GPS Receiver, GPS Antenna and corresponding Antenna Cable. Switch the Reference Station off and then on again. Make sure the accumulator is also disconnected and the UPS switched off, in order to effect a reset of the receiver. If, after 10 minutes, the Tx LED is still off, it is necessary to check with the Sharpe-CDU Program, whether the Reference Station receives more than 4 satellites and is defined as Reference Station. In case it is not possible to locate a defect, first the GPS Receiver has to be exchanged by an other GPS Receiver (also defined as Reference Station). In case 15 minutes later the malfunction is still there, exchange the Radio Modem HG 76100. In case this neither clears the fault, check whether the RTCM Port of the GPS Receiver is correctly configured.
●	X	●	This indicates a defect Radio Modem in a Mobile Station or an external jammer. It is also possible that the Rx LEDs of all mobile Radio Modems are on. Exchange the mobile Radio Modem with the Tx LED permanently on or eliminate the external jammer.
●	●	●	Modem control defective, exchange HG 76100.

Table 4 Radio Modem LEDs of the Reference Station in case of indicating a malfunction

3.4.1.2 Mobile Station

LEDs	LED +12V (red) **O** POWER LED AKTIV (yellow) **O** LED RX (green) **O O** LED TX (green)		
● = LED permanently on, O = LED off, ⊕ = LED blinking, X = LED status of no interest for this issue			
LED Power	**LED TX**	**LED RX**	**Function**
O	O	O	Check power supply; if the Power LEDs of the other components are of, the radio modem is defective –> exchange HG 76100
●	●	X	HG 76100 is defective and has to be exchanged, since it blocks the whole system.
●	O	O	The Reference Station does not transmit correction data. Check the GPS Antenna and the GPS Antenna Cable. Switch Reference Station off and then on again. Make sure the accumulator is also disconnected and the UPS switched off, in order to effect a reset of the receiver. If, after 10 minutes, the Tx LED is still off, it is necessary to check with the Sharpe-CDU Program, whether the Reference Station receives more than 4 satellites and is defined as Reference Station. In case it is not possible to locate a defect, first the GPS Receiver has to be exchanged by an other GPS Receiver (also defined as Reference Station). In case 15 minutes later the malfunction is still there, check the Radio Modem HG 76100. Check the RF Antenna and the corresponding cables. If the Rx LEDs of the other mobile units are blinking, the distance between the Mobile Station and the Reference Station may be too far. If the Tx LED of the Reference Station is not blinking, it is necessary to check the Reference Station. In case none of the above helped, check whether the RTCM port of the GPS Receiver is correctly set.
●	X	●	If the Rx LED is permanently on, an other mobile participant or the Reference Station is permanently transmitting data or a jammer is interfering. Eliminate the permanently jamming transmitter.
●	●	●	Modem control defective, exchange HG 76100.

Table 5 Radio Modem LEDs of the Mobile Station indicating malfunction

3.4.2 GPS Controller

LEDs	LED PWR O LD2 O O LD1 LD4 O O LD3				
● = LED permanently on, O = LED off, ⊕ = LED blinking, X = LED status of no interest for this issue					
LED Power	**LED 1**	**LED 2**	**LED 3**	**LED 4**	**Function**
O	O	O	O	O	Power supply failed. If the power LEDs of the other modules are on, the corresponding module is defective and has to be exchanged.
●	●	X	X	X	Status 2 bit 7 (hardware error with GPS Receiver) or Status 3 Bit 6 (UTM zone does not comply with reference station)
●	X	●	X	X	Power supply is below lower limit. There is a failure in the UPS. This may have been caused by faulty accumulators or a faulty charging unit. Check the UPS fuses. Measure the UPS voltage, it must be at least 24 Volts. Exchange the UPS if the voltage is too low. If the low voltage occurs only in autonomous operation without line voltage, the accumulators have to be exchanged.
●	X	X	●	X	Lock status is not 3D RTK Fix. The GPS Receiver does not supply the highly accurate position signal. If this status remains even after a restart of the GPS Receiver for more than 30 minutes, check whether the other Mobile Stations, too, do not supply accurate positions. Is this the case, the problem is based on the current satellite constellation, or there is a malfunction of the Reference Station or the correction data transmission. Check whether the Reference Station is transmitting correction data. Also refer to the status description for the Radio Modem HG 76100. Via the monitor interface of the GPS Controller HG 61417 it is possible to check on the current satellite constellation. Also refer to the System Description of the GPS Controller HG 61417.
●	⊕ (1s● / 1sO)	X	⊕ (1s● / 1sO)	⊕ (1s● / 1sO)	LEDs 1, 3 and 4 blinking at 0,5 Hz (on for one second, off for one second): The communication with the GPS Receiver failed. The GPS Receiver is probably defective and has to be exchanged.

Table 6 GPS Controller LEDs indicating malfunction

3.4.3 Sensor-Fusion Controller

LEDs	LED PWR O LD2 O O LD1 LD4 O O LD3				
● = LED permanently on, O = LED off, ⊕ = LED blinking, X = LED status of no interest for this issue					
Power LED	**LED 1**	**LED 2**	**LED 3**	**LED 4**	**Function**
O	O	O	O	O	Check power supply and exchange Sensor-Fusion Controller if necessary
●	● or O	● or O	● or O	● or O	This status indicates, that the power is correctly supplied, but the program does not run. This may happen after a program download (refer to the System Description of the Sensor-Fusion Controller HG 61418), if the programming jumper has not been removed or the necessary reset has not been carried out. If the jumper has been removed and afterwards the reset been carried out, but the status does not change, there is either an error in the program or the slip-in card is defective. - correct programming - remove programming jumper, if necessary, and press reset for 5 seconds - press reset for 5 seconds - exchange slip-in card
●	⊕	X	O or ●	X	This status indicates a malfunction of the interface module. If this error cannot be corrected by a reset, the slip-in card has to be removed. - press reset for 5 seconds - exchange slip-in card
●	⊕	O	X	O	This status indicates, that the Sensor-Fusion Controller does not receive any data from the GPS Controller. The reason may also be a defective GPS. Check HG 61417
●	O or ●	X	X	X	This status indicates an error in the program or a defect of the slip-in card. In case a reset does not eliminate this error, it is necessary to exchange the card. - press reset for 5 seconds - exchange card

Table 7 Possible malfunctions of the Sensor Fusion Controller (Part 1 of 2)

LEDs	LED PWR O LD2 O O LD1 LD4 O O LD3				
● = LED permanently on, O = LED off, ⊕ = LED blinking, X = LED status of no interest for this issue					
Power LED	**LED 1**	**LED 2**	**LED 3**	**LED 4**	**Function**
●	⊕	X	Longer O than ●	X	Data is not acknowledged by the PLC. In normal operation, the LED should be 80 % on and 20 % off. If this is not the case, either the setting of the protocol is incorrect, or the connection to the PLC is interrupted.
●	⊕	O	X	X	In this case the position information supplied by the GPS is not sufficiently accurate. Usually the GPS will supply sufficiently accurate positions (centimeter range) within the first 15 minutes of operation. In case the LED stays off longer than this period, it is necessary to check on the performance of the GPS Controller. Furthermore it is possible that the tolerance for the accuracy threshold of the Sensor-Fusion Controller is set too narrow. - wait 15 minutes - check HG 61417 - check accuracy threshold of HG 61418 - check GPS
●	⊕	⊕	⊕	⊕	Either the initiating drive has not been carried out,the stack was not correctly set within the GPS Controller or the Sensor-Fusion parameters are badly adjusted to the crane. Furthermore it is possible that one of the rotary encoders is defective. - check parameters - update parameters
●	⊕	⊕	⊕ sometimes during travel within the stack	⊕	In this case the parameters and the odometric units are to be checked. Check parameters of HG 61417 and HG 61418.

Table 7 Possible malfunctions of the Sensor Fusion Controller (Part 2 of 2)

3.5 Exchanging Spare Parts

If one of the modules of System G 57650 should be defective, it can only be exchanged completely. For example, exchange the Radio Modem HG 76100 as follows:

1. Disconnect the System Rack HG 94420-A from power.
2. Unscrew the four screws on the front panel of the Radio Modem (since they are secured, it is not possible to remove them completely).
3. Use the handle on the front panel to remove (pull) the Radio Modem from the system rack.
4. Insert the spare part Radio Modem in the guide rail of the system rack and push the card in until it is correctly latched. Only then the contacts will be correctly connected.
5. Use the four screws to rescrew the front panel of the Radio Modem to the system rack.
6. Reconnect the system rack to the power supply. The system will then start-up and be ready for operation.

Follow this routine also for the other modules. Radio Modems and GPS Receivers are always supplied correctly pre-configured. Therefore it is not necessary to do any adjustments when exchanging one of these modules. In case it should be necessary to exchange one of the Controllers HG 61417 or HG 61418, make sure that the parameters saved on disk for the corresponding crane are downloaded into the respective controller. For further information refer to section 2.2 „Re-Start“ on page 10.

4 The System in Detail

4.1 System Components

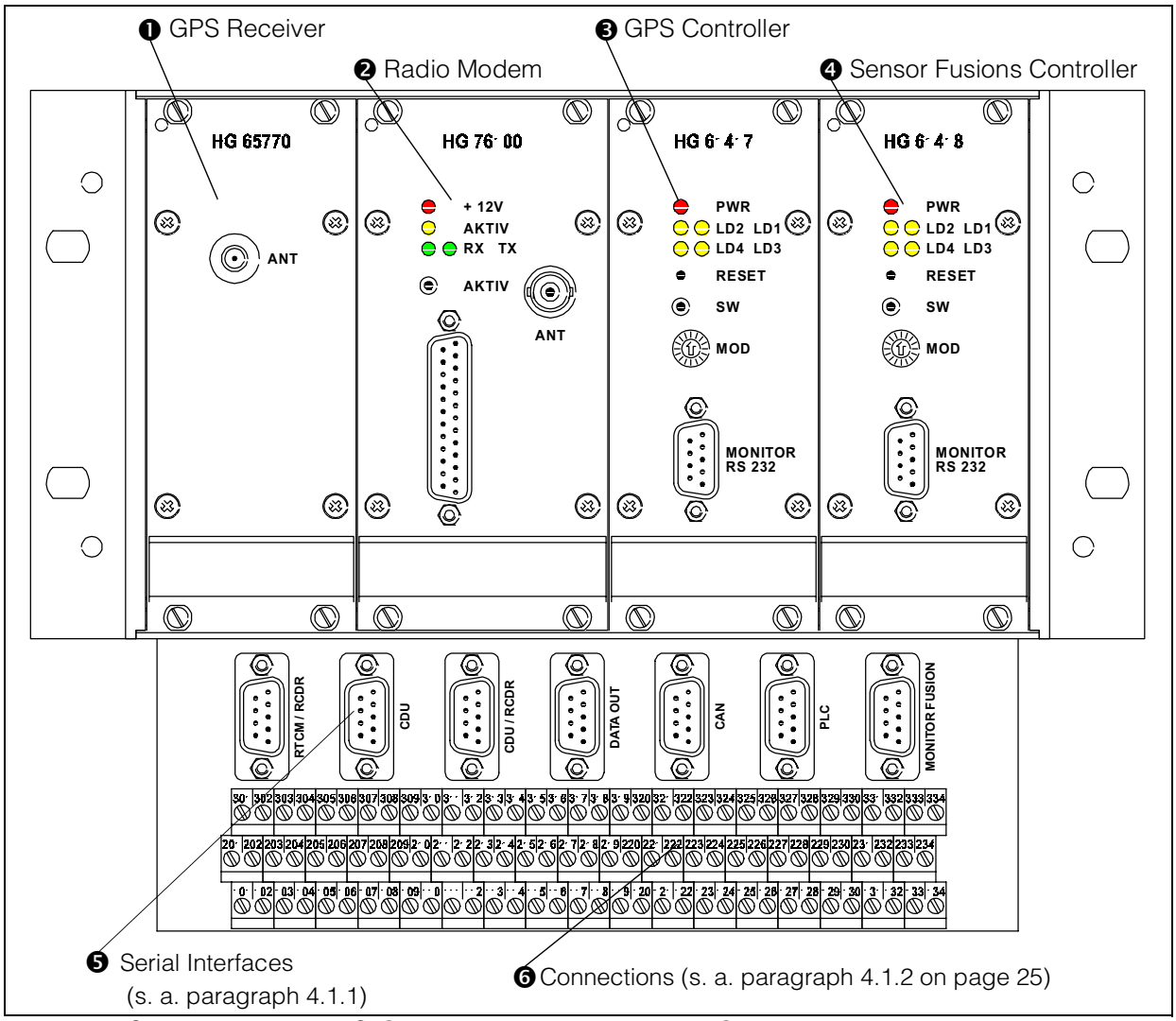

Figure 12 System components S_G57650-A within the 19“ rack HG 94420-A

4.1.1 Serial Interfaces

Table 8 shows, which function each individual interface has.

ATTENTION! These interfaces are only for use within the configuration of the individual components and can not be occupied for other uses when the system is operating, otherwise the signal could be blocked. Exception: Monitor Fusion to enable Parameter upload; see also Figure 6 on page 11!

Description	Function
RTCM/RCDR	RTCM correction data (receipt data from the radio transceiver)
CDU	Control and Display Unit (connection to the GPS receiver)
CDU/RCDR	GPS data from GPS receiver
DATA OUT	Data from GPS controller to sensor fusion controller
CAN	Data from sensor fusion controller CAN
PLC	Data from sensor fusion controller RS 232
MONITOR FUSION	Monitor interface to sensor fusion controller; e. g. enables the connection of a laptop PC to upload parameters

Table 8 Serial interfaces in the 19“ rack

4.1.2 Connection Plan

The following table shows the connection plan for which connection can be used to connect the system to the vehicle.

Connector No.	Signal Description	External Connection to Vehicle
112	PLC data 61418 TxD +	Data output to PLC RS 232 TxD
114	PLC data 61418 RxD +	Data input from PLC RS 232 RxD
116	Signal - GND	Signal ground for PLC
301	+24V input	+24 V power supply from UPS
302	GND	Power supply GND
303	Input +	Control of voltage breakdown HG 61417
304	Input -	Control of voltage breakdown HG 61417
310	GND	Power supply GND
323	Track A1	Rotary encoder chassis right
325	Track B1	Rotary encoder chassis right
327	Track A2	Rotary encoder chassis left
328	GND	Signal GND for rotary encoders
329	Track B2	Rotary encoder chassis left
330	GND	Signal GND for rotary encoders

Table 9 Connections used for connection with the vehicle

4.2 Availability and Restrictions

- Availability of the PDGPS: approx. 95 % with an **accuracy of ±3 cm**
  approx. 99,7 % with an **accuracy of ±5 cm**.
- Prerequisites: Line of sight visibility to the satellites, opening angle from approx. 170°; elevation 5°.
- Maximum distance from the base station should not exceed approx. 1 to 2 km (restricted via HF components for the transmission of the correction data).
- For the sensor fusion two rotary encoders – one on each side of the vehicle – are necessary.
- Rotary encoders are **not** included as part of the delivery package from Götting KG.
- The GPS antenna has to be solidly fixed to either the main frame of the crane or the trolley. Ideally on one of the bridge sides in the centre directly over the wheels.
- The base station should be set up as a redundant system, because the availability of its correction data is a requirement for the functionability of the complete terminal.
- The positional output data is available over RS 422 and RS 232 interfaces. The position is given as a distance (e. g. in mm) from an original reference coordinate system. It is possible to define up to 100 reference coordinate systems per terminal.
- There is no requirement for an inclination encoder if the crane is only moved unload and with the trolley in a precise defined position.
  Should however the crane be moved loaded or unload with no predefined trolley position then an inclination encoder may be necessary prerequisite. The sensor fusion controller can process the data given from the inclination encoder.
  The requirement for an inclination encoder is also dependant upon the construction of the respective RTG.

4.3 UPS supervision HG 20330 (in combination with UPS APU 24-2)

The UPS supervision controls the function of the UPS and switches the system off after a set time when system is running on battery power (UPS), due to a power failure, to avoid the batteries being completely discharged. All conditions are indicated via LEDs (see Table 10 on page 28). Furthermore there are two optically decoupled outputs available, in order to trigger external events.

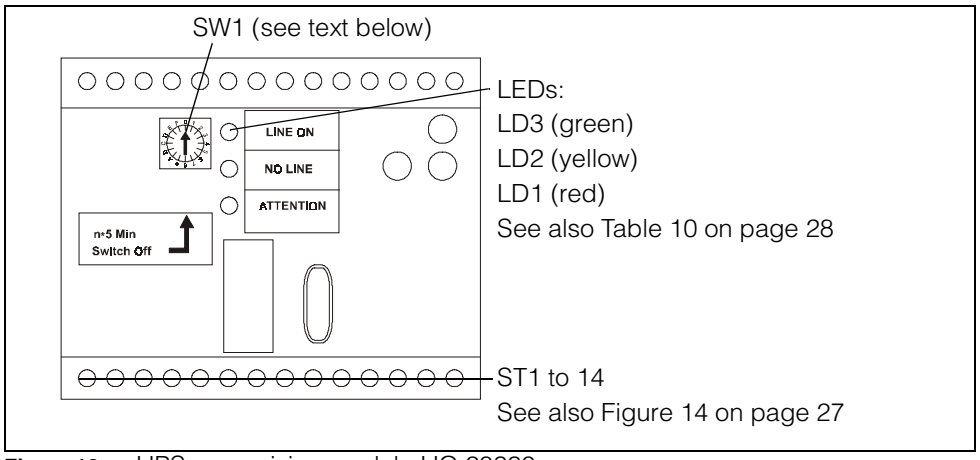

Figure 13 UPS supervision module HG 20330

The duration of the UPS running time is setable via positionable switch (see Figure 13 on page 27). To obtain the time set multiply the switch's position by 5 mins (e. g. SW1 set on 8 –> 8 x 5 minutes = 40 minutes). Changes to SW1 are only transferred to the UPS supervision when the it is switched on and off again.

4.3.1 Connection plan

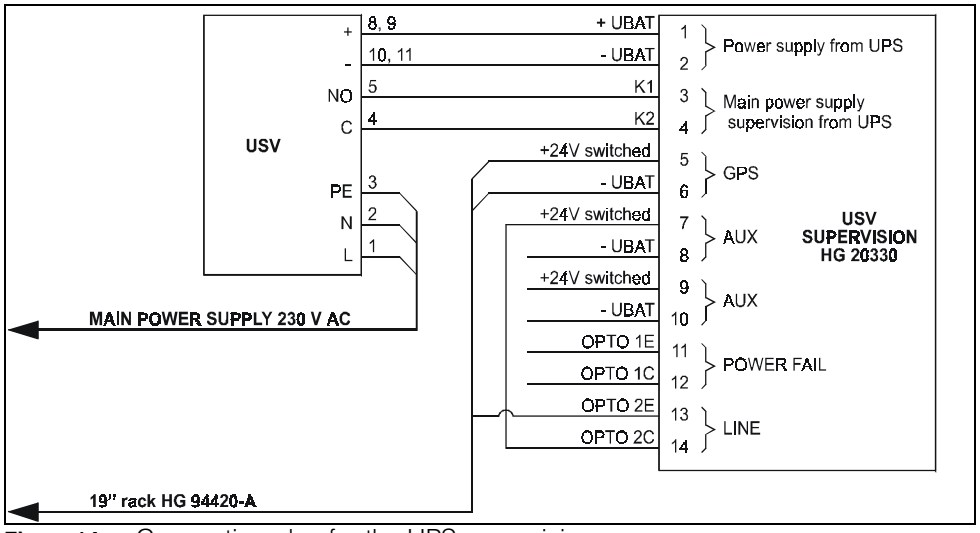

Figure 14 Connection plan for the UPS supervision

4.3.2 Status display

LED Display	Status	Opto Coupler
aa LEDs off	No main power supply, load turned off	Power fail not active line not active
LD3 green blinks	Main power supply on, batteries being charged, UPS is in charging	Power fail active line active
LD3 green on	Main power supply on, batteries charged, UPS is ready	Power fail not active line active
LD2 yellow on	Main power failure, working on battery power for set time	Power fail active line not active
LD1 red on	Main power failure, battery power for one minute	Power fail active line not active
all LEDs blink	Battery power low, main power supply present	Power fail active line not active

Table 10 Interpretation of the status displays on the UPS

For a preset charging time of 30 mins LED 3 (green) blinks. If during this time the main power fails then the load will be separated from the UPS after one minute. This prevents a complete discharge of the batteries caused by a short connection to the main power supply.

LED 3 (green) is constantly on after the charging time – this signals that the UPS is ready. Should the main power supply now fail then the system's load is supplied by the batteries for the set time, this is indicated by LED 2 (yellow) being on. After the per SW1 preset time has past, the system is provided with power for one more minute; this is indicated when LED 1 (red) is lit. At the end of this time period then the load is completely separated from the UPS. If the main power supply is reinstated before the system is shut down then the charging time starts again.

If the battery voltage drops below a defined limit (approx. 12 V) then the system is immediately shut down.

5 Appendix

A Scope of Supply (Part List)

The following components are part of System G 57650:

Item	Description	Model	Ordering Information
1.	Mobile Station, Subrack completely assembled	Includes items 5, 6, 7, 8, 9, 10, 11, 12, 14, 16, 18, 20	SG57650 Mobile Station
2.	Base Station, Subrack completely assembled	Includes items 5, 6, 7, 10, 11, 12, 13, 15, 17, 19	SG57650 Base Station
3.	Mobile Station, Subrack completely assembled, without Antennas and UPS	Includes items 5, 6, 7, 8, 9	SG57650 Mobile Station w/o Antenna and UPS
4.	Base Station, Subrack completely assembled, without Antennas and UPS	Includes items 5, 6, 7	SG57650 Base Station w/o Antenna and UPS
5.	Subrack with Backplane, without Insert Modules	G 94420	G 94420 - A
6.	GPS - Receiver Insert Module	Sharp Card	HG65770-A / 10TE_HB / SW2.2
7.	Radio - Transceiver Insert Module	HG 76100	HG76100-B / 24V / 12TE_HB / C64 / 445,425 9600 / RS-232 9600 8N1/ HG39720AA3.09
8.	GPS - Controller Insert Module	HG 61417	HG61417 / 24V / 10TE_HB / C64 / 1*RS-422, 3*RS-232 / HG61417GG
9.	Sensorfusion - Controller Insert Module	HG 61418	HG61418 / 24V / 10TE_HB / C64 / 4*RS-232 / HG61418GE
10.	Uninterruptable Power Supply (UPS) without UPS Supervisor (see Pos. 11 and 12)	Thiele APU24-2 w/o Accus	APU 24-2 / XX Ah / 115 / 230
11.	Accumulator Set for UPS (2 Accumulators included)	12 V / 7,2 Ah	2 pieces Panasonic LC-R127R2P
12.	UPS Supervisor	HG20330	HG20330 / N=15 / HG20330AA2.00
13.	Base Station GPS - Antenna	CR - Antenna	GPS - CR - Antenna with Nut and Bolt

Table 11 Part List (Part 1 of 2)

Item	Description	Model	Ordering Information
14.	Mobile Station GPS - Antenna with orig. Mounting Flange	LWS - Antenna	GPS - LWS - Antenna with Nut and Bolt and Mounting-Flange
15.	Base Station Radio - Antenna	Kathrein Omni 450	K75 11 21
16.	Mobile Station Radio - Antenna	Kathrein Gainflex	K71 53 23 6
17.	Base Station GPS - Antenna cable	RG-58, 18m, SMA elbow / TNC even	G09234-A / 18m
18.	Mobile Station GPS - Antenna cable	RG-58, 2m, SMA elbow / TNC even	G09232-A / 2m
19.	Base Station Radio - Antenna cable	RG-58, 9m, BNC elbow / N even	G09233-A / 9m
20.	Mobile Station Radio - Antenna cable	RG-58, 2m, BNC elbow / TNC FlaBu (flat socket)	G09231-A / 2m
21.	Heat Shrink with Glue, 4/1 for Type TNC Plug with RG-58 cable	IAKT 16/4 Bürklin	91 F 3756 / L, (L = required Length in Meter)
22.	Heat Shrink with Glue, 4/1 for Type N Plug with RG-58 cable	IAKT 24/6 Bürklin	91 F 3758 / L, (L = required Length in Meter)

Table 11 Part List (Part 2 of 2)

B Cable Specifications

	Correction Data Transmission	GPS Mobile (Rover)	GPS Reference Station
RG58	l <= 10 m	9 < l < 18	15 < l < 20
RG213	l <= 20 m	10 < l < 30	20 < l < 30

Table 12 Cable specifications

- Temperature range permanently installed: -40 to +90 °C
- Minimum bending radius permanently installed: 6 x cable diameter
- Sea-proof

C General Specifications

C.1 Basic technical Data

Valid for system configurations:	
Operating temperature of electronic components	0 to +50 °C
Operating temperature of antennas	-20 to +65 °C
Update rate of position output with Sensor-Fusion	up to 20 Hz
Power supply	130 V AC or 240 V AC
Minimum 5 minutes start-up time for self-calibration essential	

Table 13 Basic technical data

C.2 Minimum Requirements for a Laptop for configuring and monitoring the System

The laptop has to be connectable to the serial interfaces of the system and has to be able to run a terminal program with ANSI terminal emulation. Therefore almost every available laptop is suitable.

We recommend using a laptop with Microsoft® Windows 95® or higher with the (included in Windows 9x/NT) terminal program HyperTerminal®, since this is the program the Götting engineers use. The laptop has to have a free serial interface. In addition, a serial cable (9pol. Sub-D) is necessary for connecting the system.

C.3 RTG/RMG Specifications

- Sideways sway of less than 5 cm allowed, in any other case is the use of a slope controller necessary.

6 Notices

6.1 Proper Use of Equipment

The system S_G57650-A is used to determine the position of Rubber Tired Gantry Cranes (RTGs). In longitudinal direction a pure positional determination is carried out. Rightangular to the track course a deviation is given as well as the angle of the crane to the required track. The determined position is made available to interconnected superordinate systems. It is therefore realisable to effect a control system for the crane.

The installation, technical maintenance and service is only allowed to be carried out by authorised trained personnel.

6.2 Copyright

This manual is protected by copyright. All rights reserved. Violations are subject to penal legislation of the Copyright.

6.3 Exclusion of Liability

Any information given is to be understood as system description only, but is not to be taken as guaranteed features. Any values are reference values. The product characteristics are only valid if the systems are used according to the description.

This instruction manual has been drawn up to the best of our knowledge. Installation, setup and operation of the device will be on the customer's own risk. Liability for consequential defects is excluded. We reserve the right for changes encouraging technical improvements. We also reserve the right to change the contents of this manual without having to give notice to any third party.

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10 Abbreviations and Glossary

10.1 List of Acronyms and Abbreviations

DGPS	Differential GPS
GPS	Global Positioning System
PDGPS	Precision DGPS
RTG	Rubber Tired Gantry Crane
UPS	Uninterruptable Power Supply

Table 14 Abbreviations

10.2 Glossary

10.2.1 Odometry

Using the wheel rotations of a vehicle, the odometric navigation system calculates changes in position and angle. So-called rotary encoders are used for the determination of the wheel rotations. They are mounted on the wheels and supply the system with large numbers of single pulses (increments), thus enabling the very detailed tracking of the wheel's rotation. The current position is determined by adding the changes in position and angle to the respective last recorded position and angle.

10.2.2 PDGPS

GPS is the Global Positioning System, which enables worldwide position determination via GPS satellites using special GPS Signal Receivers. With special technology the normal accuracy of about 10 m can be improved.

A base station that calculates the difference between the measured by the GPS and the real position (Differential GPS; **DGPS**) and then transmits this difference via radio data transmitters to the mobile stations (cranes) helps positioning these cranes with an accuracy of up to 3 m.

Via the determination of the carrier wave of the GPS signal it is possible to increase this accuracy level to ±3 cm (Precision DGPS; **PDGPS**).

10.2.3 Sensor Fusion

The sensor fusion describes the combination of the two individual systems PDGPS and odometry in such a way that a long term exact position can be determined.