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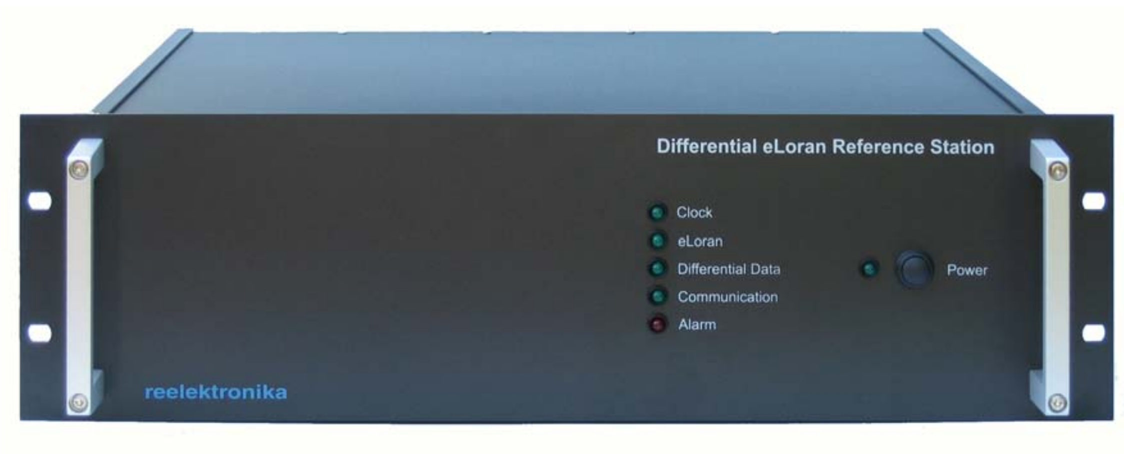

Differential eLoran Reference Station

Installation and operational manual

Version 1.0

www.reelektronika.nl info@reelektronika.nl

Manual version	1.0
LORADD firmware version	ASF 2.47_D_Jul 7 2008
Windows Diff eLoran version	1.0
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1 Introduction

reelektronika's Differential eLoran Reference Station is designed to calculate differential eLoran corrections for a set of eLoran stations at a particular Reference Station Location. The correction data is communicated in real-time via a secure VPN connection to a Eurofix equipped eLoran Transmitter. The basis for this Reference Station is **reelektronika**'s eLoran receiver, which was released early 2005. The standard receiver has been modified with additional hardware logic and analogue electronics to allow maximum flexibility in functionality of the receiver. Further, the receiver's firmware has been modified to allow processing and outputting of the additional measurements.

The receiver is designed for differential eLoran monitoring applications and requires trained eLoran experts in order to control and interpret the measurements taken by the unit.

This manual describes the hardware of the Differential eLoran Reference Station and the software to configure, control and monitor it. For this purpose the Differential eLoran Reference Station is equipped with an onboard PC platform running Windows® XP and Reelektronika's Differential eLoran Reference Station application. As the receiver is based on **reelektronika**'s integrated GPS/eLoran receiver the general operation of the receiver is described in its manual. The latest version of the manual can be downloaded from www.reelektronika.nl.

1.1 Functional description

The Differential eLoran Reference Station consists of the following:

1. The LORADD eLoran receiver engine
   The LORADD engine is the heart of the Differential eLoran Reference Station. It provides the eLoran digital signal processing, acquisition of stations and eLoran measurements.
2. The eLoran Digital Platform
   The eLoran Digital Platform provides real-time accurate digital processing of the timing signals from eLoran and GPS, necessary to tie eLoran and GPS measurements to a common time reference (UTC). It further supplies an accurate eLoran simulator signal for real-time calibration of the H-field antenna, analogue and digital processing paths through the receiver.
3. Temex SRO GPS disciplined Rubidium oscillator
   The Rubidium clock provides a stable clock source to improve the tracking of the eLoran signals and additionally provides a 1 PPS to tie eLoran and GPS to a common timeframe.
4. Motorola MT12 GPS timing receiver
   The Motorola MT12 GPS timing receiver is used to discipline the Temex SRO Rubidium oscillator. This way, the Differential eLoran Reference Station is provided with an accurate absolute clock synchronised to UTC.
5. Differential eLoran Reference Station PC platform
   Differential eLoran Reference Station PC platform is integrated into the housing. The PC platform runs Windows® XP and Reelektronika's Differential eLoran Reference Station application for configuration, control, monitoring and data logging.

6. eLoran H-field antenna
   The eLoran H-field antenna is modified to accept a simulator signal input for real-time calibration. The simulator signal is tracked by the LORADD engine to provide the calibration measurements. The antenna also houses a GPS patch antenna for the GPS timing receiver.

Figure 1 shows the functional block diagram of the Differential eLoran Reference Station with all its components.

The Differential eLoran Reference Station calculates a set of differential corrections based on the TOA measurements and pre-set ASF values. The Differential eLoran Reference Station application selects a couple of corrections for broadcast and communicates them to the Eurofix equipped eLoran transmitter.

Part of the monitoring functionality of the Differential eLoran Reference Station is Horizontal Positioning Error monitoring. For this, the LORADD Receiver engine is fed with a single point ASF map consisting of the nominal ASF values. The receiver than calculates a “zero-baseline” position solution based on the measured TOAs, the ASF map and received differential corrections. The resulting position error exceeds the set Horizontal Protection Limit an alarm is raised.

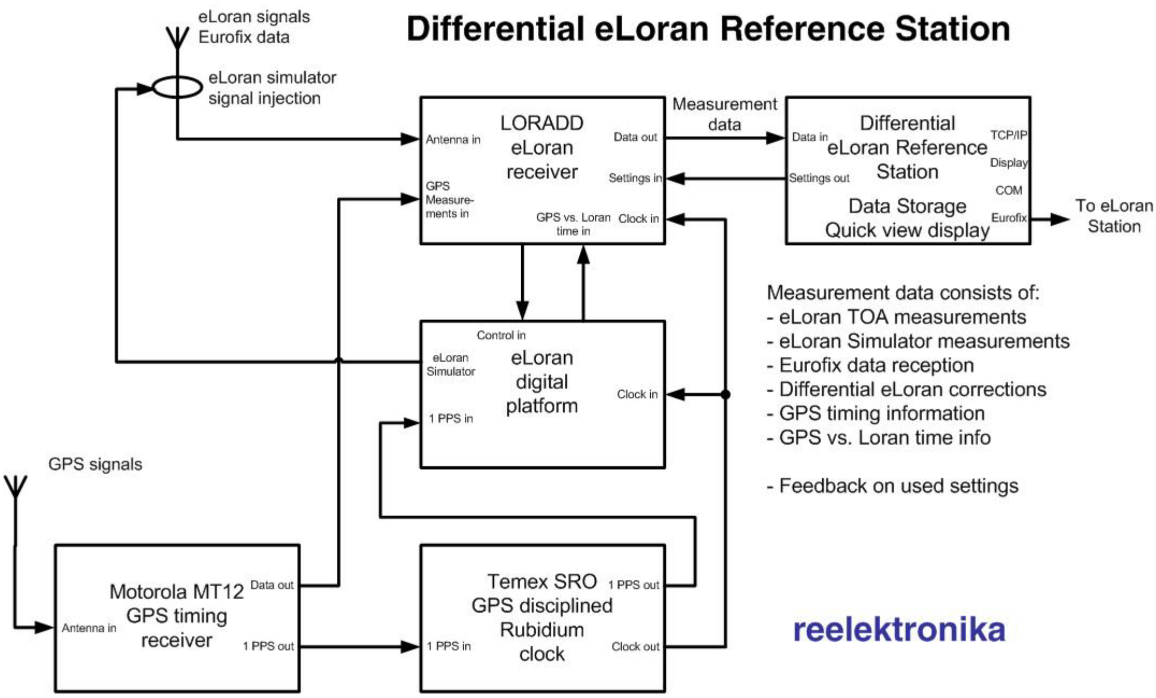


Figure 1 – Functional block diagram of the Differential eLoran Reference Station.

2 Installation

Installation of the Differential eLoran Reference Station should be performed carefully. The quality of the installation directly reflects on the quality of the provided Differential eLoran service provided through the station. Special attention should be placed on the H-field antenna installation. The Differential eLoran Reference Station measurements allow analysis of the chosen antenna location.

2.1 Differential eLoran Reference Station hardware input/output

Figure 2 shows the front and the back side of the Differential eLoran Reference Station.

On the front panel of the Differential eLoran Reference Station the following status LEDS are available:

LED	Description
Clock	Indicates whether the Rubidium is locked to the GPS PPS input
eLoran	Indicates whether a valid eLoran position is available
Differential Data	Indicates whether Differential Data is available
Communication	Indicates whether Communication with the Eurofix installation is established
Alarm	Indicates whether the Differential eLoran Reference Station raised an alarm
Power	Indicates whether the Differential eLoran Reference Station is powered on

On the back the following connectors are available (from left to right):

- 3-pin 100-240 V AC power connector.
- Panel with standard PC connectors (COM1, LPT1, VGA, LAN, USB, Mouse,

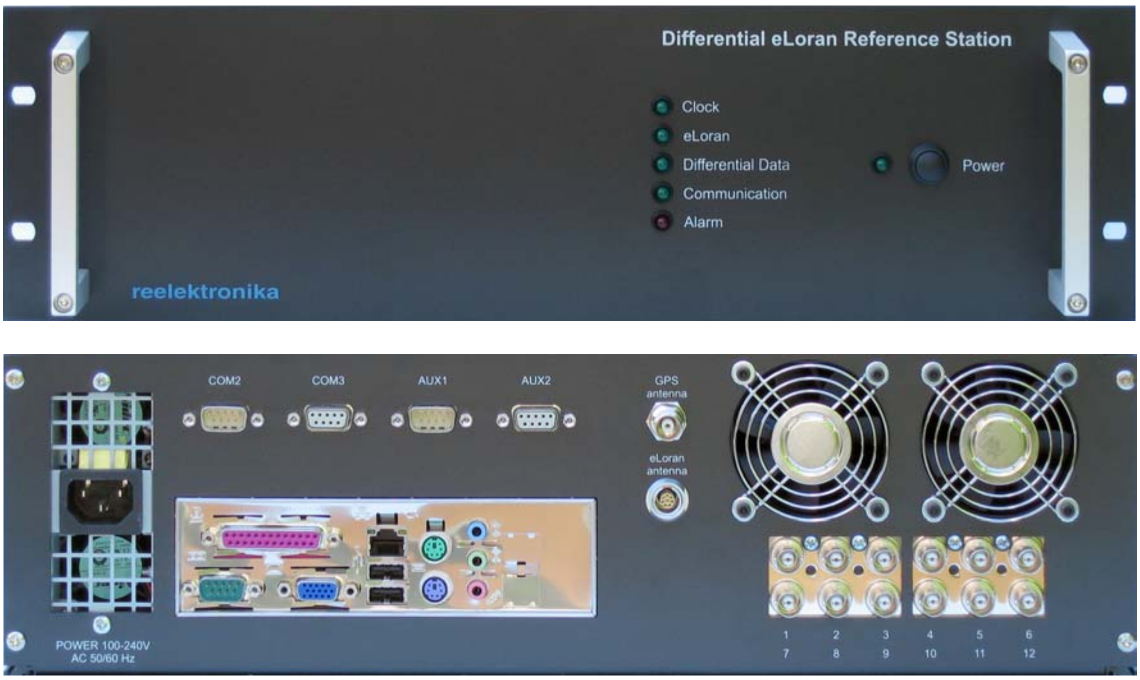


Figure 2 Differential eLoran Reference Station front view (top) and rear view (bottom)

Keyboard)
- 1 DB9 male comport connectors COM2, connected to COM2 of the PC
- 1 DB9 female comport connectors COM3, connected to COM2 of the LORADD
- 1 DB9 male connector AUX1 for future use
- 1 DB9 female connector AUX2 for future use
- 1 TNC GPS connector
- 1 8-pin antenna connector (LEMO) for connection of the eLoran H-field antenna
- 12 BNC input/output connectors

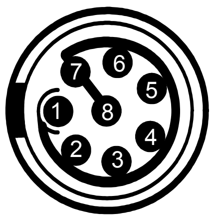
Below a further description of the connectors is given.

2.1.1 H-field antenna connector

The H-field antenna connector is the same as the antenna connector for all other LORADD Series equipment and can be connected to **reelektronika**'s H-field antenna using a standard antenna cable. In addition to the standard inputs, the antenna connector provides a simulator signal for calibration purposes consisting of a standard Master sequence of Loran pulses at a user selectable GRI (default 7823).

The connector on the Differential eLoran Reference Station is LEMO ECG.1B.308; the cable connecter should be LEMO FGG.1B.308 to match.

Pin layout as seen from the outside of the housing:

	Pin 1: Channel 1+ Pin 2: Channel 1- Pin 3: +5 V DC Pin 4: Channel 2+ Pin 5: Channel 2- Pin 6: Simulator Signal Pin 7: Reserved Pin 8: Ground

2.1.2 Comports

The comports on the Differential eLoran Reference Station are provided for troubleshooting and maintenance purposes only. No external comport connection is necessary for the proper functioning of the Differential eLoran Reference Station.

COM1	On the standard PC panel is COM1 of the PC
COM2	COM2 of the PC
COM3	COM2 of the LORADD

2.1.3 BNC Input/Output connectors

The 12 BNC connectors for input and output are provided for troubleshooting and maintenance purposes only. No connection to any BNC is necessary for the proper functioning of the Differential eLoran Reference Station. By default the BNC connectors are assigned as described below.

Port	Description	Input/Output
BNC 1	Simulator Output	Out
BNC 2	10-MHz Sine wave Clock Output (Temex SRO-100)	Out
BNC 3	Simulator Trigger Output	Out
BNC 4	Spare	Out
BNC 5	1PPS Output of Temex SRO-100	Out
BNC 6	1PPS Output of Reference	Out
BNC 7	Spare	NC
BNC 8	Spare	Input
BNC 9	Spare	Input
BNC 10	Spare	Input
BNC 11	Spare	Input
BNC 12	Spare	Input

2.1.4 H-field antenna and antenna cable

The Differential eLoran Reference Station comes with a **reelektronika** H-field antenna. This antenna is modified to accept the eLoran simulator signal from the Differential eLoran Reference Station.

The eLoran antenna is integrated with a GPS patch antenna which needs to be connected to the Differential eLoran Reference Station to feed the GPS signals to the Motorola timing receiver.

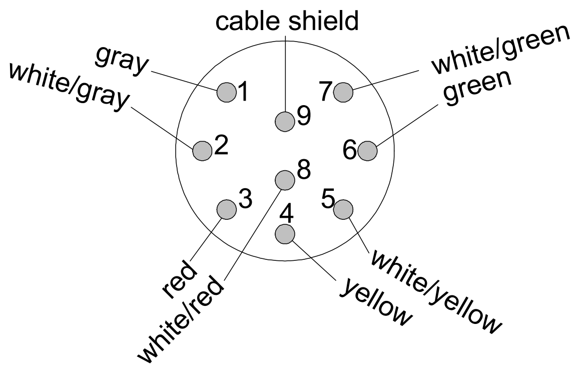
The eLoran antenna is an active antenna. Therefore, the LORADD receiver outputs +5 V DC on pen 6 of the eLoran antenna connector. Figure 3 shows the integrated eLoran/GPS patch antenna.

The H-field antenna is connected using an 8-wire Tasker C185 cable. On the receiver end, the cable is connected using a LEMO FGG.1B.308 connector. On the antenna end the cable is connected using a CONXall Multi-Con-X282-92G-3XX connector. The cable is connected to the connectors using the following pin information and cable color

Figure 3 H-field antenna with GPS patch included

codes:

CONXall Multi-Con 282-9SG-3XX cable connector female solder side (TASKER C185 colorcode)	LEMO FGG.1B.308 cable connector male solder side



Connector @ antenna (CONXall Multi-Con-X 282-9SG-3XX)	Cable colour (Tasker C185)	Connector @ receiver (LEMO 308: FGG.1B.308.CLCD72)
1. CH 1+	gray	1. CH 1+
2. CH 1-	white/gray	2. CH 1-
4. CH 2+	yellow	4. CH 2+
5. CH 2-	white/yellow	5. CH 2-
3. +5V (200 mA)	red	3. +5V (200 mA)
8. GND	white/red	8. GND
6. Simulator	green	6. Simulator
7. Reserved	white/green	7. Reserved
9. Shield	cable shield	Connector shield
The shield of the antenna cable is connected with the LEMO 308 housing and with pin 9 of the CONXall connector		

CH1 and CH2 indicate the signals coming from the two separate antenna rods in the H-field antenna.

2.2 The Motorola M12+ GPS receiver

The Differential eLoran Reference Station is equipped with a Motorola M12+ GPS receiver providing GPS derived timing signals. The GPS receiver communicates directly to the LORADD receiver, but can also be accessed through COM3 of the Differential eLoran Reference Station. Default this comport is configured to communicate at 115200 baud. Please refer to the M12+ user manual [Motorola] for further instructions on the GPS receiver http://www.synergy-gps.com/images/stories/guides/m12+userguide.pdf, the WinOncore windows program can be downloaded at http://www.synergy-gps.com/images/stories/exe/WinOncore12_1_2.zip

The LORADD receiver initiates the following configuration commands to the GPS receiver at start-up. The GPS receiver does not have non-volatile memory to store settings, therefore the receiver reverts to these default settings every time the LORADD receiver is power cycled. Motorola configuration commands are:

@@Hb01 // Output short channel msg once per second
@@Hn01 // Output TRAIM Status message once per second
@@Ge01 // Enable TRAIM
@@Gc03 // Output PPS only if TRAIM valid
@@Bo01 // Request UTC offset, every time it is updated

For proper operation of the GPS components within the LORADD-UTC receiver, the receiver assumes the above configuration is present.

2.3 Installation guidelines

The Differential eLoran Reference Station is delivered with all software pre-installed and tested. After hardware installation the Differential eLoran Reference Station only needs to be properly configured. Installation requires the following steps:

1. Install the 19” Differential eLoran Reference Station equipment in a dry and air-conditioned room. Connect Monitor, Keyboard and Mouse. Connect a network cable to the Local Area Network and make sure the Differential eLoran Reference Station has access to the internet. After boot, the Differential eLoran Reference Station application will start automatically.
2. Install the eLoran and GPS antenna cables. Make sure you know the length of the cables for configuration purposes. Follow the guidelines below (Section 2.3.1) for installing the H-field antenna.
3. Configure the Differential eLoran Reference Station according to Section 3.1. After initial configuration the settings are stored in Windows XP’s registry and reloaded every time the Differential eLoran Reference Station application is restarted.

For secure communication between different components of the eLoran network, a Virtual Private Network is set-up using OpenVPN. The Differential eLoran Reference Station communicates over the VPN with the Eurofix Reference Station in Anthorn to broadcast the differential corrections. The VPN will automatically be set-up after boot-up of the Differential eLoran Reference Station. In case the VPN is not configured properly the reader is referred to Section 2.3.2.

2.3.1 Installation of the H-field antenna

For installation of the antenna the following guidelines have to be taken into account. The H-field eLoran antenna needs to be installed in a location free from interference in the 100 kHz frequency range, such as computer monitors, processors, power supplies or other electrical equipment, spark ignition engines or engine alternators. The presence of these noise sources may limit the eLoran performance of the Differential eLoran Reference Station. Further, antenna installation close to large metal objects might have a negative influence on the accuracy of reception of eLoran signals due to reradiation. Although the reradiation effects are likely to remain constant over time, it is bad practice to operate a Differential eLoran Reference Station in a reradiation rich environment.

The arrow of the antenna housing need not be pointed in any particular direction in case of static operation. In dynamic applications, the H-field antenna allows determination of real headings even without movement of the vehicle.

For eLoran signal environment analyses the receiver is capable of outputting a received spectrum (FFT) plot of both H-field loops combined, through the FFTA log, which can be made visible in the Differential eLoran Reference Station application. Figure 4 shows the FFT screen with the location of the notches. For this view the FFTA and NOTCHA logs need to be enabled. See Section 4 for more information on these logs.

2.3.2 Virtual Private Network

In order to secure the communication between a Eurofix Reference Station (at the eLoran transmitter site) and remote clients (such as a Differential eLoran Reference

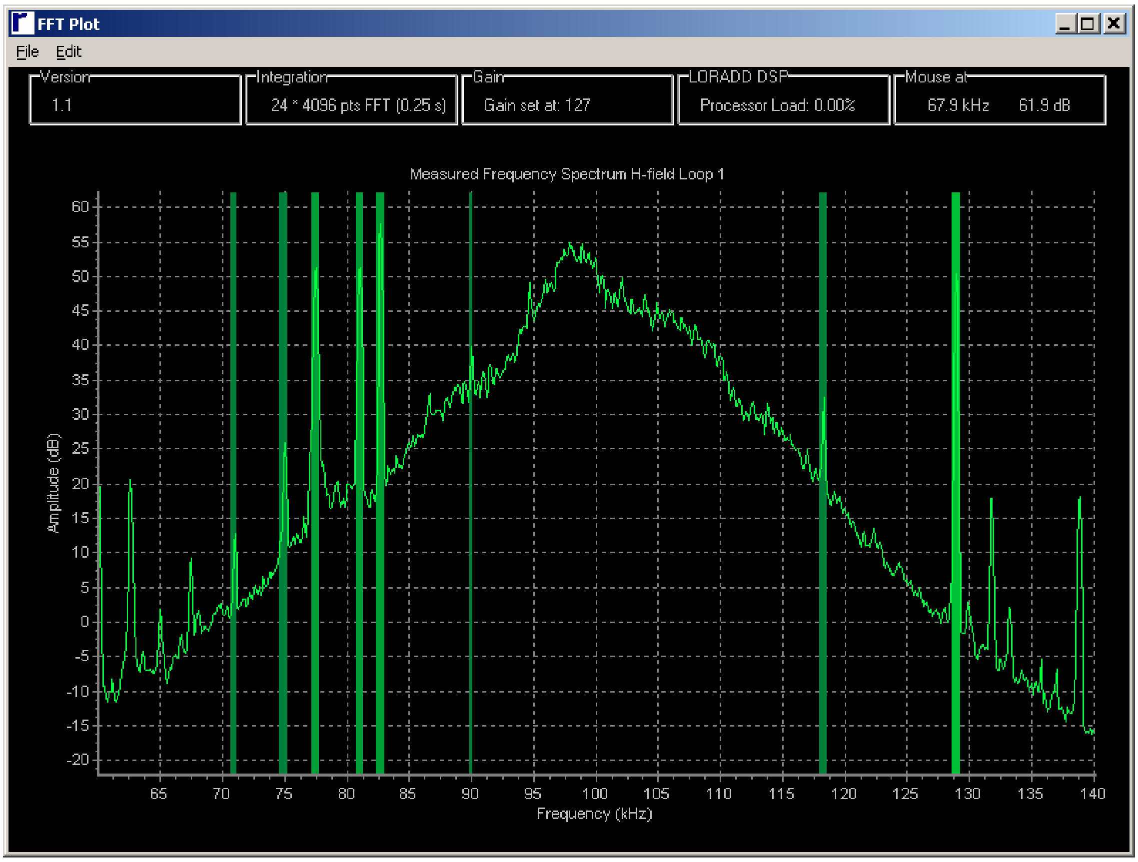


Figure 4 Screen capture of FFT screen

Station), it is recommended that the eLoran communication is done over a Virtual Private Network. This helps in preventing unauthorized access to the communication between the various components of the system, as well separating the communication from other traffic and thus making IT Network management easier.

For this purpose, the computer running the Local System Controller of the Eurofix Reference Station is set up as an OpenVPN server. The server listens at port 5901. More information regarding OpenVPN can be found at http:// openvpn.net .

The basics of the OpenVPN authentication are as follows:

- Each of the nodes in the VPN has its own secret Key.
- Each of the Keys has an associated Certificate. The Certificate is public.
- The Certificate has been issued by a central Certificate Authority (CA).
- The Certificate Authority itself also has a Certificate which is know to all nodes.
- Using the CA Certificate, all nodes are able to verify that a given Key Certificate carries a valid Certificate Authority signature.
- Successful communication between two nodes is established when both sides have verified that they each have keys that have been signed by the (trusted) Certificate Authority.

To configure an OpenVPN client, 4 files are necessary:
- ca.crt . This is the certificate of the (trusted) Certificate Authority. It is the same for all nodes in the VPN.
- Client_xx.key . This file contains the key for this particular node. Each node should have a unique key. This file should be kept secret.
- Client_xx.crt . This is the certificate that carries the CA’s signature generated based on the Client_xx.key file.
- Client.ovpn . This file contains the configuration of the client-side of the VPN connection. Apart from specific references to the key and certificate files for this particular client, the configuration is equal for all client nodes.

All 4 files should normally be stored in C:\Program Files\OpenVPN\config .

The OpPenVPN server is configured in such a way that it acts as a DHCP server. It itself has IP address 192.168.101.1 . Each of the Clients will receive an address in the 192.168.101.x subnet. The Clients are identified based on the Key that they provide. Once a Client has been issued an IP address, this IP address will be reserved and re-issued every time the Client reconnects to the Server. The IP address will not be provided to other Clients.

The server is configured to allow client-to-client communication via the VPN. All communication will pass through the Server, though.

The Differential eLoran Reference Station communicates to the Eurofix Reference Station via the OpenVPN server in order to have the differential corrections broadcast over Eurofix.

2.4 Firmware updates

The Differential eLoran Reference Station consists of three processing platforms:
- The standard LORADD-OEM DSP type receiver board
- The LORADD-FPGA digital signal processing board
- The Differential eLoran Reference Station application on the PC

Contrary to standard LORADD receivers, firmware updates are not provided through **reelektronika**'s website. If you require firmware or FPGA updates, please contact **reelektronika** directly.

3 Operation of the Differential eLoran Reference Station

The Differential eLoran Reference Station is specialised eLoran equipment and requires trained eLoran experts to control and interpret the measurements taken by the unit.

At boot-up the VPN connection will be made and the Differential eLoran Reference Station application will automatically start using the settings saved in the Windows XP's registry.

Operation of the Differential eLoran Reference Station is described in three sections; Configuration, Monitoring and Status Reporting, and Troubleshooting.

3.1 Configuration

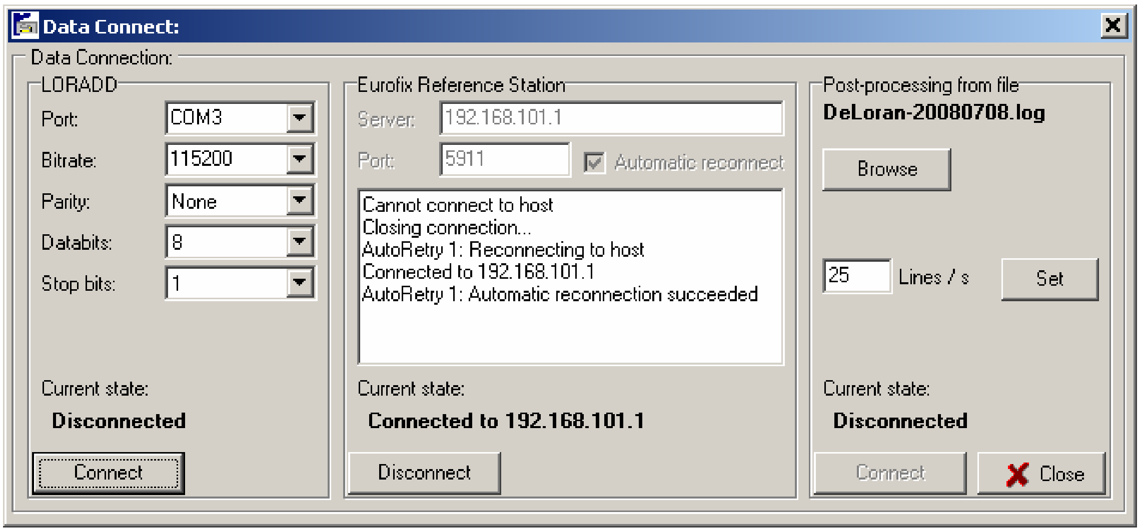
After the installation or reinstallation of the Differential eLoran Reference Station the following connections and settings need to be configured before correction generation can commence:

1. Connection to the internal LORADD Engine and the Eurofix Reference Station
2. Differential eLoran Correction generation configuration

Once properly configured, the Differential eLoran Reference Station operates automatically, even after a reboot.

3.1.1 Connection to the internal LORADD Engine and the Eurofix Reference Station

By opening **File->Data source** on the Differential eLoran Reference Station application menu the following form is displayed:



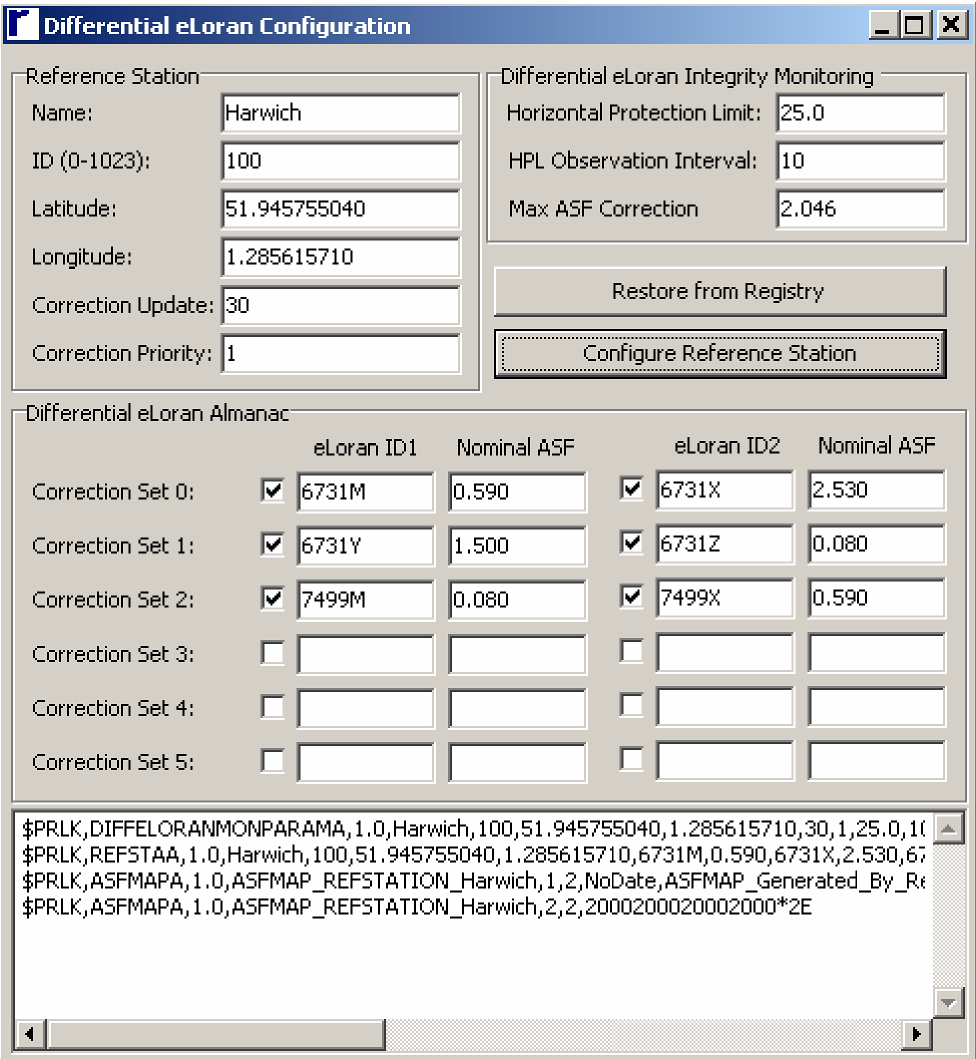
The internal LORADD receiver engine is connected using COM3@115200 baud. The connection to the Eurofix Reference Station is made through the VPN to 192.168.101.1 port 5911. By ticking **Automatic reconnect** the application will reconnect in case of loss of communication.

If all connections are made correctly, the Application will show communication logs on the eLoran Receiver I/O (LORADD) and eLoran Transmitter I/O (RSIM) monitor forms.

The Application can also be used to replay recorded log files for post-processing data analysis purposes. For this, the LORADD and Eurofix Reference Station should be disconnected before a log-file can be selected.

3.1.2 Differential eLoran Correction generation configuration

By selecting **View->Differential eLoran Configuration** from the Application menu, the following form is displayed:



This form allows for the configuration of the LORADD Engine's and Application's correction generation parameters and consists of the following fields:

Reference Station		
Field	**Default**	**Description**
Reference Station Name		Alphanumeric name (no spaces)
Reference Station ID		Unique ID between 0 and 1023
Latitude		In degrees, decimal degrees
Longitude		In degrees, decimal degrees
Correction Update	30	Interval in seconds before a new set of corrections is broadcast

Correction Priority	1	Number of Eurofix messages allowed to proceed before the differential correction message is issued (0 is immediate broadcast)

The Reference Station position needs to be surveyed to within 1 meter accuracy.

Differential eLoran Almanac		
Field	**Default**	**Description**
eLoran ID		In eLoran format XXXXC with XXXX the 4 digit GRI and C the Station indicator (M,X,Y,Z)
Nominal ASF		Nominal ASF value in µs at the Reference Station location. Corrections will be calculated with respect to this value.

The differential eLoran corrections are broadcast in sets of 2 corrections each. The Eurofix data format is given in Annex A. In case the operator wants to disable the use of a certain Loran station, the Eurofix message content for that station can be set to “Do not use” by unticking the checkbox before the Loran ID field.

Differential eLoran Integrity Monitoring		
Field	**Default**	**Description**
Horizontal Protection Limit	25.0	HPL in meters
HPL Observation Interval	10	Interval in seconds
Max ASF Correction	2.046	Maximum ASF correction value allowed to be broadcast. The data format allows for corrections between -2.046 and 2.046 µs.

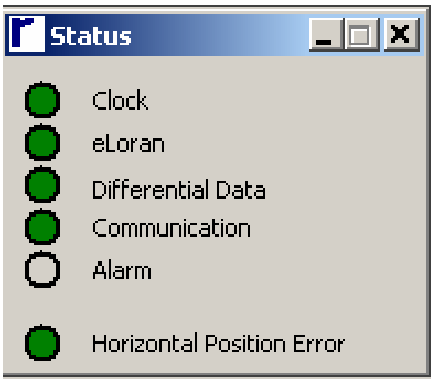
If the calculated horizontal position error exceeds the HPL for the duration of the Observation Interval an alarm is raised. If the receiver reports positions within the HPL for the duration of the Observation Interval the alarm is cleared again.

Every time a change is made to the configuration, the LORADD engine needs to be reconfigured and restarted. If a reconfiguration is necessary the caption of the push button **Configure Reference Station** is bold. By pressing the button, the Application will configure the Receiver and issue a restart.

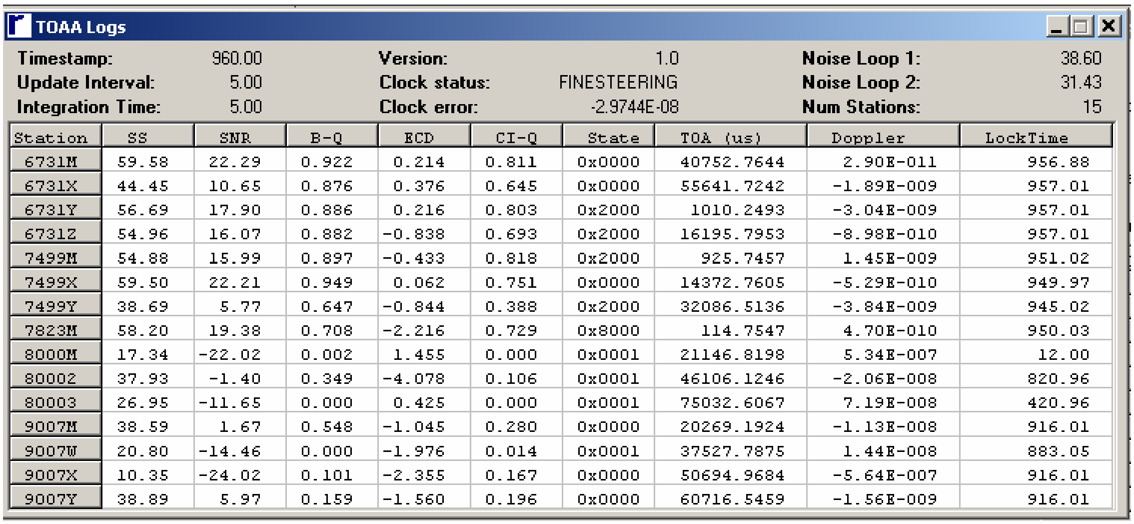
All settings are automatically stored in Windows XP’s registry.

3.2 Monitoring and Status Reporting

The Differential eLoran Reference Station application provides tools to monitor the operation of the station and log data. The status of operation of the Differential eLoran Reference Station is presented by the status LEDs and is repeated on a Status form, as shown below. Additionally, the status of the Horizontal Position Error Monitoring is presented too. In case the station identifies a problem with the Rubidium clock, the eLoran data reception, the differential correction generation, communication with the Eurofix Reference Station or horizontal position error an alarm is raised.



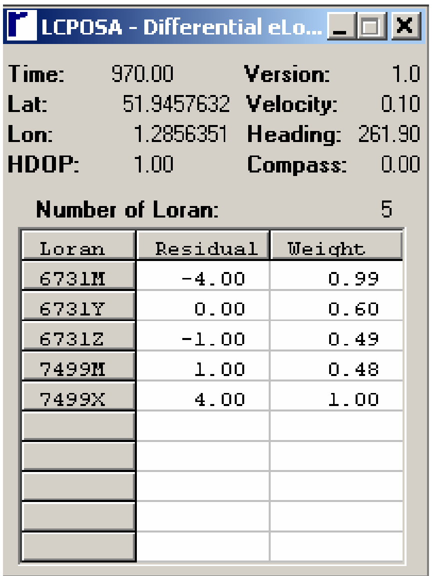
The main window of the application contains forms with detailed information on the measurements on which the differential corrections are based, of which the TOAA log display, the calculated eLoran position (LCPOSA), the Rubidium clock feedback (PTNTA) are displayed here.



TOAA Logs

Timestamp:	960.00	Version:	1.0	Noise Loop 1:	38.60
Update Interval:	5.00	Clock status:	FINESTEERING	Noise Loop 2:	31.43
Integration Time:	5.00	Clock error:	-2.9744E-08	Num Stations:	15

Station	SS	SNR	B-Q	ECD	CI-Q	State	TOA (us)	Doppler	LockTime
6731M	59.58	22.29	0.922	0.214	0.811	0x0000	40752.7644	2.90E-011	956.88
6731X	44.45	10.65	0.876	0.376	0.645	0x0000	55641.7242	-1.89E-009	957.01
6731Y	56.69	17.90	0.886	0.216	0.803	0x2000	1010.2493	-3.04E-009	957.01
6731Z	54.96	16.07	0.882	-0.838	0.693	0x2000	16195.7953	-8.98E-010	957.01
7499M	54.88	15.99	0.897	-0.433	0.818	0x2000	925.7457	1.45E-009	951.02
7499X	59.50	22.21	0.949	0.062	0.751	0x0000	14372.7605	-5.29E-010	949.97
7499Y	38.69	5.77	0.647	-0.844	0.388	0x2000	32086.5136	-3.84E-009	945.02
7823M	58.20	19.38	0.708	-2.216	0.729	0x8000	114.7547	4.70E-010	950.03
8000M	17.34	-22.02	0.002	1.455	0.000	0x0001	21146.8198	5.34E-007	12.00
80002	37.93	-1.40	0.349	-4.078	0.106	0x0001	46106.1246	-2.06E-008	820.96
80003	26.95	-11.65	0.000	0.425	0.000	0x0001	75032.6067	7.19E-008	420.96
9007M	38.59	1.67	0.548	-1.045	0.280	0x0000	20269.1924	-1.13E-008	916.01
9007W	20.80	-14.46	0.000	-1.976	0.014	0x0001	37527.7875	1.44E-008	883.05
9007X	10.35	-24.02	0.101	-2.355	0.167	0x0000	50694.9684	-5.64E-007	916.01
9007Y	38.89	5.97	0.159	-1.560	0.196	0x0000	60716.5459	-1.56E-009	916.01

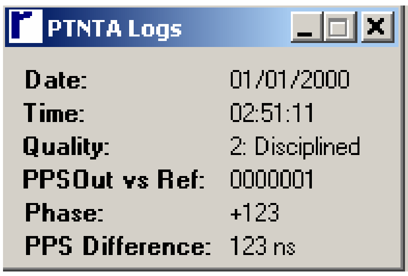


LCPOSA - Differential eLo...

Time:	970.00	Version:	1.0
Lat:	51.9457632	Velocity:	0.10
Lon:	1.2856351	Heading:	261.90
HDOP:	1.00	Compass:	0.00

Number of Loran: 5

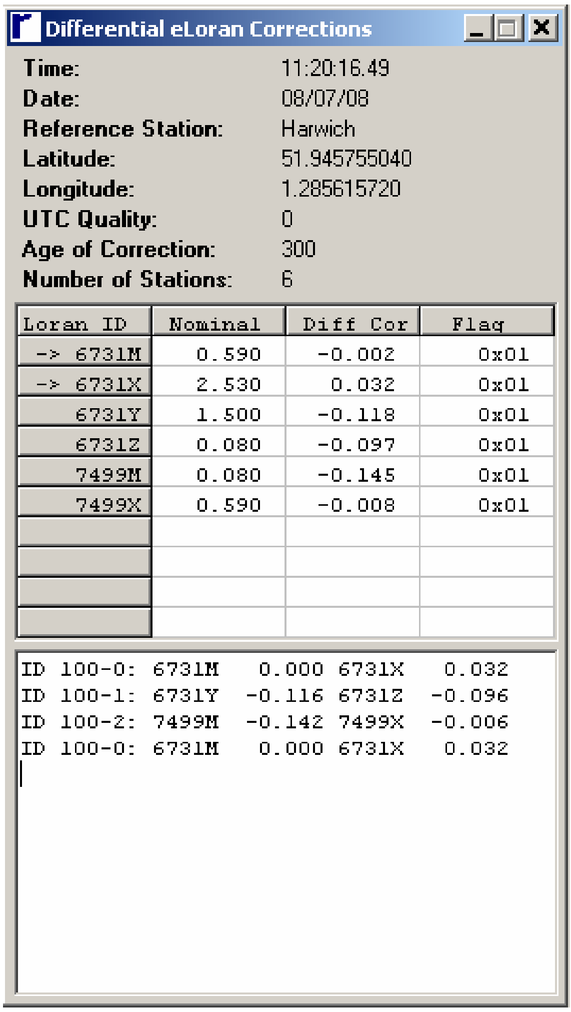
Loran	Residual	Weight
6731M	-4.00	0.99
6731Y	0.00	0.60
6731Z	-1.00	0.49
7499M	1.00	0.48
7499X	4.00	1.00



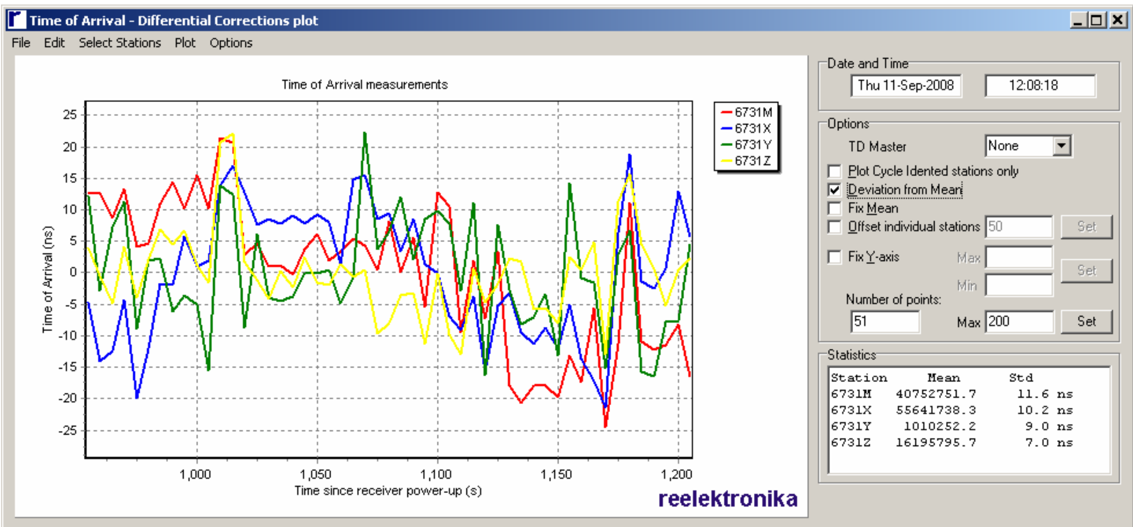
PTNTA Logs

Date:	01/01/2000
Time:	02:51:11
Quality:	2: Disciplined
PPSOut vs Ref:	0000001
Phase:	+123
PPS Difference:	123 ns

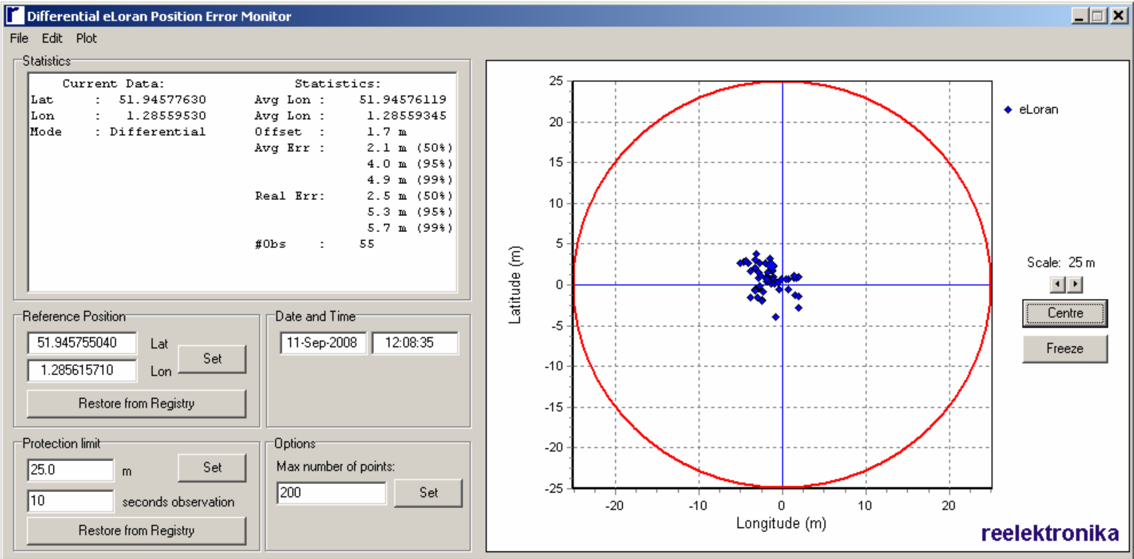
The most recently calculated differential correction set is presented in the following form.



By selecting **View->TOA and Differential Corrections Monitor Plot** the TOA measurements and calculated differential corrections can be monitored graphically. The form allows for different viewing modes and presents statistical information.



By selecting **View->Differential eLoran Position Error Monitor Plot** the horizontal position error monitoring can be viewed. The red circle represents the protection limit, which can also be altered in the form. The graph represents a scatterplot around the surveyed centre position and can be scaled. Statistical information is available where the “Avg err” represents the statistics with the offset removed and the “Real err” with the offset present.



3.3 Troubleshooting

This section will give guidelines for troubleshooting in the form of a “frequently asked questions” guide.

In order to do the troubleshooting, make sure all connections are made properly and the Differential eLoran Reference Station application is running.

Questions regarding the operation of the Differential eLoran Reference Station

Q1: The station does not light any LEDs.

A1: - Check if the power cord is properly connected, input is 100-240 V 50/60 Hz mains.
- Check if the fuse at the back of the power connecter is broken
- If the power is connected and the switch is turned on, the power LED should be lit.

Q2: The station is turned on, and the power LED is lit. However, the Clock LED is off.

A2: The Clock is disciplined by the Motorola MT12 GPS receiver. If the Clock LED is off the Motorola is most likely not getting any valid GPS.
- Check if the station outputs PTNTA messages and verify what its status is.
- Check if the GPS antenna and cable are properly installed, with a clear view at the sky.
- Allow for at least 15 minutes for the GPS receiver to settle.
- View status of the GPS receiver through WinOncore program and comport pass-through program for the LORADD receiver.
- Use the WinOncore software and Motorola receiver manual to troubleshoot the GPS receiver.

Q3: The station is turned on, and the power LED is lit. However, the eLoran LED remains off.

A3: The eLoran LED is triggered by the availability of a good eLoran position solution.
- Verify that the Differential eLoran Reference Station application communicates with the LORADD engine by looking at the LORADD Serial Communication monitor.
- In case there is no communication with the LORADD, open Data source and connect on COM3@115200 baud
- Open the TOA log window and verify that the receiver is tracking stations.
- Verify that the stations are properly cycle identified (last digit in the flag is 0).
- Open the LCPOSA Autonomous window and verify status.
- In case the receiver does not track sufficient stations, verify antenna installation and cable.
- Reset the LORADD receiver by issuing the RESET command or press Configure Reference Station button.

Q4: The station is turned on, the power, Clock and eLoran LEDs are lit, but the station does not calculate any differential corrections.

A4: - Open the Differential eLoran Configuration window.
- Verify the settings.
- Press the Configure Reference Station button, which will reset and reinitialise the station.
- If the station does not start to calculate corrections after reset, open the TOAA log window.
- Verify that the receiver properly tracks the Loran stations with SNR above 5 dB.
- Verify that the receiver properly tracks the Simulator signal (7823M) with SNR above 10 dB.
- Open the TOA and Differential Corrections Monitor Plot and select TOA view.
- Select relevant stations and simulator for display, display with Deviation from Mean ticked.
- Verify that the tracks are horizontal and statistics is good (< 15 ns Std)

Q5: The station is turned on, the Communication LED is off.

A5: The Differential eLoran Reference Station does not communicate with the Eurofix Reference Station.
- Verify that the LAN cable is connected and that the station has access to internet. Use Command window and DOS PING command.
- Verify that the OpenVPN connection is active. If not, restart the OpenVPN program.
- Open the Data source window and verify status of connection. Press connect button if disconnected.
- Verify the Automatic reconnect is ticked t restore connection in case it is lost.
- If the station has communication with the Eurofix Reference Station the RSIM Monitor window should display $PRCM messages on regular intervals.

Q6: The station is turned on and works properly. The Horizontal Position Error status gives an alarm.

A6: - Open the Differential eLoran Position Monitor window.
- Verify HPL threshold is not too tight (>10m).
- Verify that the scatterplot is updated with new position information every 5 seconds.
- Verify that the Current Data mode is “Differential”.
- Open the TOA and Differential Corrections Monitor Plot and select TOA view.

- Select relevant stations and simulator for display, display with Deviation from Mean ticked.
- Verify that the tracks are horizontal and statistics is good (< 15 ns Std)

4 Command and log interface

As mentioned before, the Differential eLoran Reference Station is based on the LORADD Series integrated eLoran/GPS receiver, and takes all command and logs from that receiver. Commands to the LORADD engine can be issued through the Serial Commands field in the LORADD Serial Monitor window of the Differential eLoran Reference Station application. Description of standard commands and logs can be found in the manual of the integrated receiver, to be downloaded from the **reelektronika** website, and is listed here for completeness.

4.1 Differential eLoran Reference Station specific commands

Commands are entered as space separated commands terminated by a Carriage Return <CR>. Commands can be entered using the Serial Commands field in the LORADD Serial Communications monitor. Commands are not case sensitive.

The command 'SETTINGS' is used to list and/or change various parameters in the receiver that influence its operation. The following settings are relevant for Differential eLoran Reference Station operation:

TRACKWISHLIST	List of Loran IDs the receiver will search for
SIMULATOR	Enables/disables or configures the built-in Loran signal simulator
ANTPARM	Sets the H-field antenna calibration parameters
ANT_UPSIDEDOWN	Sets parameter to identify if the antenna is mounted upside down
ECDCOR	Sets ECD correction values for Loran stations
AUTONOTCHES	Enables/disables the use of autonotches in the receiver
EFDGPS	Enables/disables Eurofix DGPS output in RTCM format on COM3

Additional LORADD commands:

SEND	Sends a command to a comport
I2C	For internal use
FPGA	For internal use
ECDCI	Antenna control

SETTINGS TRACKWISHLIST

Syntax:
```
SETTINGS SET TRACKWISHLIST <ID1 ID2 ID.. IDn>
SETTINGS SHOW
SETTINGS RESET
```

Description:
The Trackwishlist is a list of Loran stations that the user wants to track specifically. When both UTC time and position are known to the receiver, it can calculate the moment in time that the signals of a particular station should arrive at the receiver and use that information as a basis to start tracking the station. This is a much faster

method of station acquisition than the normal searchlist-based acquisition. The receiver compares the list of currently tracked stations with the trackwishlist once every second.

The Loran ID 7823M is a special case: it allows for the simulator to be acquired using the TrackWishList, even though it has no fixed relation to UTC.

The TrackWishList holds a maximum of 20 entries.

Example:

```
SETTINGS SHOW TRACKWISHLIST
SETTINGS SET TRACKWISHLIST 7823M 6731M 6731Y 6731Z 7499M 7499Y
SETTINGS SET TRACKWISHLIST 1111M
```

(unknown Loran ID; effectively clears the TrackWishList)

SETTINGS SIMULATOR

Syntax:

```
SETTINGS SET SIMULATOR <GRI>|<OFF>
SETTINGS SHOW
SETTINGS RESET
```

Description:

Enables or disables the built-in Loran signal simulator generation. Although the GRI of the generated signal is programmable, the Differential eLoran Reference Station receiver expects the signal to have a GRI of 7823, so this is the suggested setting.

The output signal is available on BNC 1. A PCI trigger signal is available on BNC 3. Note that the positive edge of the trigger signal corresponds to T=0, while the negative edge of the trigger signal is at T=30 μs.

Example:

```
SETTINGS SET SIMULATOR 7823.0
SETTINGS SET SIMULATOR OFF
```

SETTINGS ANTPARM

Syntax:

```
SETTINGS SET ANTPARM <G1r G1i A21r A21i G2r G2i A12r A12i>
SETTINGS SHOW
SETTINGS RESET
```

Description:

Sets the antenna compensation parameters. G1r and G1i are the real and imaginary components of the gain for Loop 1. A21r and A21i is the amount of cross-talk that Loop 1 receives from Loop 2. G21r and G21i form the complex gain of Loop 2. Finally, A12r and A12i is the amount of cross-talk that Loop 2 receives from Loop 1.

Example:

```
SETTINGS SET ANTPARM 1.0 0.0 0.0 0.0 1.0 0.0 0.0 0.0
```

(the default setting)

SETTINGS ANT_UPSIDEDOWN

Syntax:

```
SETTINGS SET ANT_UPSIDEDOWN [ON|OFF]
```

```
SETTINGS SHOW
SETTINGS RESET
```

Description:
Controls whether the receiver should compensate for the antenna mounted upside down, or not. Note: after changing this setting, the setting will be saved to NVRAM, and the receiver will reboot automatically to accommodate for the new setting.

Example:
```
SETTINGS SET ANT_UPSIDEDOWN ON
```

SETTINGS ECDCOR

Syntax:
```
SETTINGS SET ECDCOR <HField EField> ECD corrections
SETTINGS SHOW
SETTINGS RESET
```

Description:
Sets the ECD corrections, both for H-field and E-field antennas. The receiver automatically applies the correction for the antenna type that it is told to use. This setting applies for all tracked stations.

Example:
```
SETTINGS SET ECDCOR 0.5 2.0
```

SETTINGS AUTONOTCHES

Syntax:
```
SETTINGS SET AUTONOTCHES [ON|OFF|ONCE]
SETTINGS SHOW
SETTINGS RESET
```

Description:
This setting controls whether the automatic placement of notches is done continuously (ON), or is done only once and then frozen (ONCE), or is disabled completely (OFF).

In the ON setting, notch settings are updated approximately once every 5 seconds.

Note that turning the autonotches to OFF disables the automatic placement of notches, but any notches that were already activated prior to switching the autonotches to OFF are still enabled. To remove any active notches, issue NOTCH CLEAR ALL command subsequent to the SETTINGS SET AUTONOTCHES OFF.

The ONCE setting does a spectrum measurement once, and then places the notches. After that, the notches are kept in place at their designated frequency and bandwidth, but are no longer automatically updated.

Example:
```
SETTINGS SET AUTONOTCHES ON
```

SETTINGS EFDGPS

Syntax:
```
SETTINGS SET EFDGPS [ON|OFF]
```

```
SETTINGS SHOW
SETTINGS RESET
```

Description:
Controls whether any received Eurofix DGPS corrections should be output to Port 3 (in RTCM 104 format).

Example:
```
SETTINGS SET EFDGPS ON
```

Command SEND

Syntax:
```
SEND [COM1|COM2|COM3|COM4] [<data>]
```

Description:
Tells the unit to send out a data string over a specific serial port. Can be used to issue commands to other devices that are connected to the receiver. A <CR><LF> is automatically appended to the 'data' parameter before it is sent to the designated port.

Example:
```
SEND COM3 LOG COM1 PSRPOSA ONTIME 1
```

Command I2C

There are a number of built-in components into the Differential eLoran Reference Station that communicate via an I2C bus. This command is for reading and writing to those components directly. This is not part of normal user operating procedures, and should only be done at the direct instruction of Reelektronika.

Command FPGA

The Differential eLoran Reference Station contains a Xilinx FPGA which communicates with the LORADD DSP. The FPGA command is for direct communication to the FPGA. This is not part of normal user operating procedures, and should only be done at the direct instruction of Reelektronika.

Command ECDCI

Syntax:
```
ECDCI FLAG <Value>
ECDCI SAVE
ECDCI SHOW
```

Description:
Sets internal flag value which controls the type of antenna. Value can be decimal or hexadecimal (0x00). The different bits in the flag have different meaning:

Bit 0: 0=H-field 1=E-field
Bit 1: 0=normal 1=Antenna upside down

The new settings only have effect after the command `ECDCI SAVE` and a reset of the receiver (either HW or by command `RESET`.)

Example:
`ECDCI FLAG 0x01` – configures the receiver to use an E-field antenna.

`ECDCI FLAG 0x02` – configures the receiver to use an H-field antenna upside down. This command is equivalent to `SETTINGS SET ANT_UPSIDEDOWN ON`

4.2 General LORADD Series Commands

The following commands can be entered to control the receiver:

HELP	Prints help for all supported commands
VERSION	Prints version information
SHOWSEARCH	Shows the current searchlist
RESET	Performs a software reset
LOG	Command to start logs
UNLOG	Command to stop logs
SETSPEED	Sets the speed of a serial port
READCONFIG	Restores configuration from Non-Volatile Memory
SAVECONFIG	Stores current configuration into Non-Volatile Memory
RESETCONFIG	Restores the current configuration to factory defaults
SETPOSITION	Sets an approximate position
AUTH	Enters an authentication code into the receiver
NOTCH	Configures notches
SETTINGS	Controls various settings of the receiver
LOADREFSTA	Loads the Reference Station almanac
LOADASFMAP	Loads the ASF Map

Command HELP

Syntax: HELP

Response: List of available commands

Syntax: HELP <COMMAND>
Where <COMMAND> is any valid command

Response: Detailed help on the command

Command VERSION

Syntax: VERSION

Response: Version information on firmware

This information is necessary if an error report is sent back to **reelektronika**.

Command SHOWSEARCH

Syntax: SHOWSEARCH

Response: Shows the searchlist of the receiver

Example: Current SearchList:

1: 7499 (4, 32)
2: 6731 (4, 32)
3: 9007 (8, 64)

Where each line shows the search information for one GRI. The numbers in brackets are the minimum and maximum number of GRIs the receiver looks for stations in the chain.

Command RESET

Syntax: RESET

Response: Start of Program!

Resets the firmware of the Loran engine. The receiver starts with the configuration of comport speeds, enabled logs etc. as stored in the non-volatile memory of the receiver.

Command LOG

Syntax: LOG <port> <logtype> <trigger>
Where
<port> is the destination port of the receiver, e.g. COM1, COM2, COM3
<logtype> is one of the logtypes as described in Section 3 and 4, always without $ sign
<trigger> is the trigger for generating a new log, e.g. ONTIME <time> or ONNEW, with <time> is the update interval in seconds that the log should be output

Response: Output of logs

The following table summarizes the possible logs and the possible triggers:

NMEA logs			
Log	Description	Triggers	
GPGGA	Global Positioning System Fix Data		ONNEW
GPGLL	GPS Geographic position, Latitude and Longitude		ONNEW
GPGSA	GPS DOP and active satellites		ONNEW
GPGST	GNSS Pseudorange noise statistics		ONNEW
GPVTG	Course over ground/speed		ONNEW
GPZDA	UTC and local date/time data		ONNEW
GPGSV	GNSS Satellites in view		ONNEW
LCGLC	eLoran Geographic position, Time differences		ONNEW
LCHDT	eLoran Heading		ONNEW
LCGLL	eLoran Geographic position, Latitude and Longitude	ONTIME	

reelektronika proprietary logs			
Log	Description	Triggers	
GPPOSA	GPS calculated position	ONTIME	
LCPOSA	eLoran calculated position	ONTIME	
INPOSA	Integrated position fix using GPS and/or eLoran	ONTIME	
LCRSDA	eLoran range residuals	ONTIME	
TOAA	eLoran Time of Arrival measurements		ONNEW
SMDA	eLoran Station measurement data	ONTIME	
SSDA	eLoran dual loop signal measurements	ONTIME	
HDGA	Heading measurement		ONNEW
DASFA	Differential ASF measurements	ONTIME	
RMSGA	Eurofix decoded messages		ONNEW
RTCMB	Binary output of RTCM SC104 DGPS data received through Eurofix		ONNEW
FFTA	Frequency spectrum data		ONNEW
NOTCHA	Notch frequency and bandwidth information		ONNEW
SYNCA	eLoran to UTC Synchronisation information		ONNEW

Command UNLOG

Syntax: UNLOG <port> <logtype>
Where
<port> is the destination port of the receiver, e.g. COM1, COM2, COM3
<logtype> is one of the logtypes as described in Section 3 and 4, always without $ sign

Response: SerialX >
Where X is the number of serial port the command is entered

Terminates the output of the specified log on the port.

Syntax: UNLOG <port> ALL
Where <port> is the destination port of the receiver, e.g. COM1, COM2, COM3

Response: SerialX >
Where X is the number of serial port the command is entered

Terminates the all output on the port.

Command SETSPEED

Syntax: SETSPEED <port> <speed>

Response: Speed of port <port> now set to <speed>

Sets the speed of a port. Common speeds are:

2400
4800
9600
19200
38400
57600
115200 (default)
400000

Please make sure the communications port on the receiving end is configured at the same speed. Other settings should be 8 databits, No parity, 1 stopbit, no handshaking.

Command READCONFIG

Syntax: READCONFIG

Response: Configuration read OK

Reads the configuration stored in non-volatile RAM previously stored by SAVECONFIG.

Command SAVECONFIG

Syntax: SAVECONFIG

Response: Configuration saved

Saves the configuration in non-volatile RAM. Settings that are saved are port speeds and enabled logs. The last position is saved automatically to enable a fast start-up when the receiver is used in approximately the same location.

Command RESETCONFIG

Syntax: RESETCONFIG

Response: None

Resets the current configuration to the factory defaults. All communication port speeds are set at 115200 and default logs are enabled on ports 1 and 2.

Command SETPOSITION

Syntax: SETPOSITION <latitude> <longitude>

Response: SetPosition: Position set

Sets the approximate position on <latitude> <longitude>. This approximate position is needed to generate a searchlist for chains and have a start position for calculating the Loran positions. If a GPS position is available, this position will be used as a start position to search for Loran chains. If no GPS is available the SETPOSITION command will trigger the generation of a searchlist.

Command AUTH

Syntax: AUTH <1> <2> <3> <4>

Response: Auth code accepted

Enters an authentication code into the receiver. The authentication code enables the firmware that came with the receiver or that has been uploaded by the user. Each firmware and/or upgrade may have its own authentication code. Each receiver has its own unique authentication code. The parameters <1> <2> <3> and <4> are hexadigital numbers to be entered. The authentication code will be provided to the user together with the receiver. In case an authentication code is lost, please contact **reelektronika**.

Command NOTCH

Syntax: `NOTCH AUTO [ON|OFF]`

Response: `Automatic placement of notches is now enabled/disabled`

Enables or disables automatic notch setting
If automatic notch placement is turned OFF, the receiver retains the last notch settings. Use `NOTCH CLEAR ALL` after this command to effectively clear all notches.

Syntax: `NOTCH LIST`

Response:

```
Automatic notch placement: ON
Notches:
Notch 0: Active Freq: 128.9 kHz; BW = 336.0 Hz
Notch 1: Active Freq: 77.5 kHz; BW = 568.5 Hz
...
Notch 28: Inactive
Notch 29: Inactive
```

Lists all currently activated notches

Syntax: `NOTCH SET <r> <freq> <bw>`

Response: `Notch <r> activated: f = <freq> kHz; BW =  bw Hz`

Sets notch number `<r>` to frequency `<freq>` (kHz) with bandwidth `<bw>` (Hz)
Note that this command is only effective if the `NOTCH AUTO` is `OFF`.

Example: `NOTCH SET 0 77.5 500` (sets notch 0 to 77.5 kHz, width 500 Hz)

Valid values for `<r>` range from 0 to 29

Syntax: `NOTCH CLEAR <r>|ALL`

Response:

```
Notch <r> deactivated
All notches deactivated
```

Clears the setting of notch `<r>`, or all notches.
Note that this command is only effective if the `NOTCH AUTO` is `OFF`.

Example: `NOTCH CLEAR 5` (to disable notch number 5)
`NOTCH CLEAR ALL` (to clear all notches)

Valid values for `<r>` range from 0 to 29

Command SETTINGS

Syntax: `SETTINGS SHOW`

Response:
```
Current settings:
ANT_UPSIDEDOWN    : OFF
AUTONOTCHES       : ON
EFDGPS            : ON
```

Shows current settings

Syntax: `SETTINGS SET ANT_UPSIDEDOWN [ON|OFF]`

Response:
```
Antenna setting is now upside down/normal
WARNING: The receiver will reset shortly to apply the
new setting
SETTINGS: Setting applied
```

Specifies whether the antenna is mounted upside down or not.
NOTE: After changing the setting, the receiver will restart automatically!

Syntax: `SETTINGS SET AUTONOTCHES [ON|OFF]`

Response: `SETTINGS: Setting applied`

Turns autonotches `ON` or `OFF`. Command does the same as `NOTCH AUTO [ON|OFF]`.

Syntax: `SETTINGS SET EFDGPS [ON|OFF]`

Response: `SETTINGS: Setting applied`

Turns the passthrough of RTCM SC104 data to the internal GPS receiver `ON` or `OFF`. If `EFDGPS` is `ON`, decoded DGPS messages as received from the closest Eurofix station are passed on to the internal GPS receiver. If `EFDGPS` is `OFF` the GPS receiver will use WAAS or EGNOS data if available.

Syntax: `SETTINGS RESET`

Response: `Settings reset to defaults`

Resets the settings to the default values. Note that the `ANT_UPSIDEDOWN` setting is left untouched. Use `SETTINGS SET ANT_UPSIDEDOWN [ON|OFF]` to change this setting.

Command LOADREFSTA

Syntax: LOADREFSTA <$PRLK,REFSTAA ,…*CC>

Response: REFSTAA data accepted

Loads the Reference Station almanac needed to interpret the received differential eLoran corrections.

Command LOADASFMAP

Syntax: LOADASFMAP <$PRLK,ASFMAPA ,…*CC>

Response: ASFMAP data accepted
ASFMAP complete

Loads lines of an ASF map.

4.3 General log interface description

This Section describes the data interface format. All command and log communication is done using one (or more) of the available comports of the UTC receiver. Comports can be set at speeds up to 400 000 baud.

The command and log interface as described in this document adheres to the NMEA 0183 standards for communication between instrumentation aboard maritime vessels. The general format of this interface is:

$aaaaa,…,…,…*CC[CR][LF]

where $aaaaa is the header, identifying the log or command, and CC is an optional checksum. The **reelektronika** receivers will output the checksum. The checksum is the 8-bit exclusive OR (no start or stop bits) of all characters in the sentence, including the "," delimiters, between - but not including - the "$" and "*" delimiters.

The fields in the logs are separated by commas. In contrast to NMEA 0183, most fields are variable in size and can be left blank if data is unavailable. Also, the length of the loglines is in principal unlimited.

Besides NMEA 0183 defined log formats, the receivers also output proprietary **reelektronika** logs, which all start with $PRLK. Commands are entered as space separated strings, not in NMEA 0183 format. In response to a command the receiver outputs status information or a prompt on the comport the command is issued. More information on the commands will be given below.

4.4 NMEA 0183 supported logs

The integrated GPS/eLoran sensor supports general GPS and eLoran position and data logs as defined within the NMEA 0183 standard. These are:

Log	Description
LCGLC	eLoran Geographic position, Time differences
LCHDT	eLoran Heading
LCGLL	eLoran Geographic position, Latitude and Longitude

The logs above are all described in NMEA 0183 documentation. For more information on the formats, definitions of numbers and conventions, the reader is referred to NMEA documentation. The following information on the logs has been extracted from there:

$LCGLC - eLoran Geographic position, Time differences

```
Header
GRI
Master TOA
Signal Quality M 1
TD1
Signal Quality 1 1
TD2
Signal Quality 2 1
TD3
Signal Quality 3 1
TD4
Signal Quality 4 1
TD5
Signal Quality 5 1
Checksum
$LCGLC,xxxx,x.x,a,x.x,a,x.x,a,x.x,a,x.x,a,x.x,a*CC
```

[1] Signal status is:
B = Blink warning

C = Cycle warning
S = SNR warning
A = Valid

Sample log:
$LCGLC,7499,7238.9700,A,14021.7721,A,31696.1800,A*00
$LCGLC,6731,6750.7446,A,14450.7611,A,42178.2373,A*0A

$LCHDT - eLoran Heading

Header	Heading	True heading	Checksum

```
$LCHDT,x.x,T*CC
```

Sample log:
$LCHDT,65.9,T*17

$LCGLL – eLoran Geographic position, Latitude and Longitude

Header	Latitude	N/S	Longitude	E/W	UTC time of fix	Status [1]	Mode Indicator [2]	Checksum

```
$LCGLL,ddmm.mm,a,dddmm.mm,a,hhmmss.ss,a,a*CC
```

[1] Status is A for normal operation, V for invalid position
[2] Mode Indicator is:
A = Autonomous
D = Differential
E = Estimated
M = Manual mode
S = Simulator mode
N = No fix data

Sample log:
$LCGLL,5052.77062,N,00437.01017,E,,A,A*5E

4.5 reelektronika Proprietary logs

Besides the supported NMEA logs for GPS and eLoran the integrated navigation sensor also outputs **reelektronika** proprietary logs. These logs are necessary if the user wants to use the sensor at its most accurate and sophisticated level. The NMEA 0183 logs are then not sufficient to communicate all available and relevant data to other equipment. These logs all begin with the header $PRLK.

Additional to the standard LORADD logs, the following log information is available:

Log	Description
MTOAA	Multiple eLoran TOA measurements
HDGLA	Station Heading measurements
TIMETAGA	Timetag information

The following standard logs are available:

Log	Description
LCPOSA	eLoran calculated position
LCRSDA	eLoran range residuals
TOAA	eLoran Time of Arrival measurements
HDGA	Heading measurement
RMSGA	Eurofix decoded messages
FFTA	Frequency spectrum data
NOTCHA	Notch frequency and bandwidth information
SYNCA	eLoran to UTC Synchronisation information
REFSTAA ASFMAPA	Reference Station almanac and ASF Map information

MTOAA – Multiple eLoran TOA measurements

Sample log:

```
$PRLK,MTOAA,1.0,532045.00,5,5,FINESTEERING,4.30e-06,-13.02,-13.12,1,10,1,
  7823M,0.0,574,0.93,-4.351,0.000,0,8001,0.000,532034.13,1,3,4,5,5,5,5,5,4,4,
  16.3,111.1507,111.0966,111.0569,111.0275,111.0065,110.9915,110.9811,110.9739,
  110.9679,110.9618,1.4070,1.2542,1.1521,1.0804,1.0293,0.9937,0.9702,0.9549,
  0.9438,0.9325,0.00,0.00,0.00,0.00,0.00*49
```

PRLK,	RLK identifier
MTOAA,	Log identifier
1.0,	MTOAA Log version
532045.00,	Time since receiver start (seconds)
5,	Update interval (seconds)
5,	Integration time (seconds)
FINESTEERING,	Clock steering mode (NOCLOCK, INITIALISING, COARSESTEERING, FINESTEERING)
4.30e-06,	Measured clock error
-13.02,	Noise loop 0
-13.12,	Noise loop 1
1,	Number of channels output
10,	Number of zero-crossing tracked
1,	Number of stations output
7823M,	Station identifier
0.0,	Station heading
574,	Number of pulses
0.93,	Batch quality
-4.351,	Measured ECD
0.000,	Cycle-ident quality
0,	Cycle-ident alarm
8001,	Hexadecimal Flag
0.000,	Doppler
532034.13,	Locktime (seconds)
1,3,4,5,5,5,5,5,4,4,	Signal strength (one value per zero-crossing)
16.3,	SNR
111.1507,111.0966,111.0569,111.0275,111.0065,110.9915,110.9811,110.9739,110.9679,110.9618,	TOA values (one value per zero-crossing)
1.4070,1.2542,1.1521,1.0804,1.0293,0.9937,0.9702,0.9549,0.9438,0.9325,	Ratios (one value per zero-crossing)
0.00,0.00,0.00,0.00,0.00	
*49	Checksum

Trigger: ONNEW

HDGLA – Station Heading measurements

Sample log:

```
$PRLK,HDGLA,1.0,116.00,1,1,1,3.49,0.00,1,0,L,146.711,0.00,0.975,6,6731M,102.08
   9,281.825,2978.43,248.800,411.96,1.000,...,7499Y,213.476,28.679,483.87,0.186
   ,20.59,0.000*00
```

PRLK,	RLK identifier
HDGLA,	Log identifier
1.0,	HDGLA Log version
116.00,	Log timestamp (seconds since receiver power-on)
1,	Update Time in seconds
1,	Integration Time in seconds
1,	Position valid (1=true, 0=false)
3.49,	Cycle Ident Pos (5 μs Cycle Ident values)
0.00,	Cycle Ident Neg (5 μs Cycle Ident values)
1,	Ambiguity solved (1=true, 0=false)
0,	Beam Flipped (1=true, 0=false)
L,	Mode (L=Loran)
146.711,	Heading in degrees
0.00,	Heading Std
0.975,	Quality
6,	Num Stations
6731M,	Station identifier
102.089,	Beam Orientation
281.825,	Measured Heading
2978.43,	Measured Quality
248.800,	Calculated Heading
411.96,	Beam over Null Ratio
1.000,	Weight
*00	Checksum

Trigger: ONNEW

TIMETAGA – Timetag information

Sample log:

```
$PRLK,TIMETAGA,1.0,1,532042.997760,1424,518392,532043.692979590036*32
```

PRLK,	RLK identifier
TIMETAGA,	Log identifier
1.0,	TIMETAGA Log version
1,	Timetag source (1 or 2)
532042.997760,	Log timestamp (seconds since receiver power-on)
1424,	GPS week
518392,	GPS seconds
532043.692979590036	Event occurrence in receiver time (in seconds)

Trigger: ONNEW

LCPOSA - eLoran calculated position

Header	Logheader	Interface version	UTC time of fix [1]	UTC Date	UTC Mode [2]	LC Mode [3]	Latitude	Longitude	Velocity (m/s)	Heading	Compass heading [4]	Num eLoran	HDOP	Quality [5]	Checksum

`$PRLK,LCPOSA,c--c,hhmmss.ss,ddmmyy,a,a,x.x,x.x,x.x,x.x,x.x,x,x.x,x.x*CC`

[1] If UTC time is not available, the internal receiver time since boot is reported
[2] UTC Mode is:
G = GPS derived UTC
L = eLoran derived UTC
N = No UTC synchronisation
[3] LC Mode is:
C = Coarse position (no cycle identification necessary)
A = Uncorrected eLoran
D = Differential eLoran
G = GPS Calibrated eLoran
S = ASF Corrected eLoran
N = No position fix
[4] Compass heading currently not available in this log, use HDGA instead
[5] Quality indicator TBD

Sample log:
`$PRLK,LCPOSA,1.0,1934.00,,N,G,50.8727050,4.6262118,0.2,161.2,,5,2.0,*29`

Trigger: ONTIME

LCRSDA - eLoran range residuals

Header	Logheader	Interface version	UTC time of fix [1]	UTC Date	UTC Mode [2]	LC Mode [3]	Num eLoran	eLoran Station ID 1	Residual LC 1 (m)	Weight factor LC 1	eLoran Station ID n	Residual LC n (m)	Weight factor LC n	Checksum

`$PRLK,LCRSDA,c--c,hhmmss.ss,ddmmyy,a,a,x,xa,x.x,x.x,.....,xa,x.x,x.x*CC`

[1] If UTC time is not available, the internal receiver time since boot is reported
[2] UTC Mode is:
G = GPS derived UTC
L = eLoran derived UTC
N = No UTC synchronization
[3] LC Mode is:
A = Uncorrected eLoran
D = Differential eLoran
G = GPS Calibrated eLoran
S = ASF Corrected eLoran
N = No position fix

Sample log:

```
$PRLK,LCRSDA,1.0,1274.00,,N,S,5,6731M,-0.4,1.00,6731X,0.0,0.14,6731Z,
   -1.0,0.49,7499M,0.9,0.49,7499X,0.3,0.99*75
```

Trigger: ONTIME

TOAA – eLoran Time of Arrival measurements

Header	$PRLK
Logheader	TOAA
Interface version	c--c
Receiver time [1]	x.x
Update interval	x
Integration time	x
Clock steering	c--c
Clock error (s/s)	x.x
Noise Loop 1 (dB)	x.x
Noise Loop 2 (dB)	x.x
Num Stations	x
eLoran Station ID 1	xa
Signal Strength (dB)	x.x
SNR (dB)	x.x
Batch Quality [2]	x.x
ECD (µs)	x.x
Cycle Ident Quality [2]	x.x
Status [3]	XXXX
Time of Arrival (µs)	x.x
Doppler (s/s)	x.x
Locktime (s)	x.x
	...

```
$PRLK,TOAA,c--c,x.x,x,x,c--c,x.x,x.x,x.x,x,xa,x.x,x.x,x.x,x.x,x.x,XXXX,x.x,x.x,x.x,...
```

eLoran Station ID n	xa
Signal Strength (dB)	x.x
SNR (dB)	x.x
Batch Quality [2]	x.x
ECD (µs)	x.x
Cycle Ident Quality [2]	x.x
Status [3]	XXXX
Time of Arrival (µs)	x.x
Doppler (s/s)	x.x
Locktime (s)	x.x
Checksum	*CC

```
xa,x.x,x.x,x.x,x.x,x.x,XXXX,x.x,x.x,x.x,*CC
```

1 The internal receiver time since boot is reported

2 Quality indicator between 0 and 1, 1 is highest quality

3 Status is a hexadecimal number which indicates the tracking of the station. Each bit in the number corresponds to a signal flag:

0x0001	Cycle Ident not valid
0x0002	Reserved
0x0004	Reserved
0x0008	Reserved
0x0010	Reserved
0x0020	Reserved
0x0040	TOA invalid (TOA set to -1)
0x0080	Doppler invalid
0x0100	Reserved
0x0200	Reserved
0x0400	Reserved
0x0800	Reserved
0x1000	Reserved
0x2000	Data modulation detected
0x4000	Reserved
0x8000	Simulator indicator

Sample log:
```
$PRLK,TOAA,1.0,1129.00,5,5,FINESTEERING,7.86e-07,,,6,
   6731M,50.98,16.66,0.777,-0.369,0.780,0000,6750.6586,1.8025e-09,1063.97,
   6731X,38.94,-0.58,0.377,-0.003,0.351,0000,21201.4204,4.0613e-10,1064.98,
   6731Z,50.14,10.28,0.860,-0.895,0.653,0000,48928.8892,1.3639e-09,1064.98,
   7499M,50.32,10.45,0.816,-0.817,0.682,0000,7238.8968,-1.4135e-09,1064.03,
   7499X,51.01,16.68,0.866,-0.421,0.774,0000,21260.6690,1.479e-09,1063.96,
   7499Y,34.07,-6.82,0.312,-0.858,0.346,0000,38935.0639,3.7997e-09,1063.96*79
```

Trigger: ONNEW

HDGA – Heading measurement

Header
Logheader
Interface version
Receiver time [1]
Update time
Mode [2]
Heading
Heading Std
Quality
Checksum

```
$PRLK,HDGA,c--c,x.x,x,a,x.x,x.x,x.x*CC
```

[1] The internal receiver time since boot is reported
[2] Mode is:
G = GPS derived heading
L = eLoran derived heading
I = Inertial derived heading

Sample log:
```
$PRLK,HDGA,1.0,1216.00,1,L,65.47,0.0,1.0*58
```

Trigger: ONNEW

RMSGA – Eurofix decoded messages

Header
Logheader
Interface version
Receiver time [1]
eLoran Station ID
Eurofix message [2]
Num GRI Errors
Num GRI Erasures
Checksum

```
$PRLK,RMSG,c--c,x.x,xa,X--X,x,x*CC
```

[1] The internal receiver time since boot is reported
[2] The Eurofix message of 10 7-bit words is represented as 10 hexadecimal numbers of two characters, description of the message content can be found in “Eurofix Message Format, Reel-EMF”

Sample log:
```
$PRLK,RMSGA,1.0,1605.66,7499Y,61574307711F000C2A63,0,12*78
```

Trigger: ONNEW

FFTA – Frequency spectrum data

Header
Logheader
Interface version
FFT points
Start bin [1]
Num bins [1]
Integration count
Profile count [2]
Gain setting
Number of FFT channels
FFT value
Next FFT value
Checksum

```
$PRLK,FFTA,c--c,x,x,x,x,x,x,x,x,x.x,...*CC
```

[1] Bins are counted in units of 400 kHz/(FFT Points)
[2] Profile count is TBD

Sample log:

```
$PRLK,FFTA,1.1,4096,615,820,24,0,127,1,20.9,13.5,-2.0,...*29
```

Trigger: ONNEW

NOTCHA– Notch frequency and bandwidth information

Header
Logheader
Interface version
Receiver time[1]
Number of notches in log
Number of active notches
Frequency Notch 0 (kHz)
Bandwidth Notch 0 (kHz)
Next notch
Checksum

```
$PRLK,NOTCHA,c--c,x.x,x,x,x.x,x.x...*CC
```

[1] The internal receiver time since boot is reported

Sample log:

```
$PRLK,NOTCHA,1.0,171130.81,30,13,128.92,0.6867,77.47,0.6338,75.03,0.6457,77.47
   ,0.6338,127.27,0.5483,80.99,0.5649,80.99,0.5649,118.28,0.5122,128.92,0.6867,
   94.67,0.2946,75.03,0.6457,70.92,0.3092,-1,-1,82.74,0.6709,-1,-1,-1,-1,-1,-
   1,-1,-1,-1,-1,-1,-1,-1,-1,-1,-1,-1,-1,-1,-1,-1,-1,-1,-1,-1,-1,-1,-1,-1,-1,-
   1,-1*07
```

Trigger: ONNEW

SYNCA– eLoran to UTC Synchronisation information

Header, Logheader, Interface version, Receiver time[1], Synchronisation source[2], Year, Month, Day, Hours, Minutes, Seconds, Receiver Samplecount[3], UTC Flag[4], Applied Leapseconds[5], Applied Offset[6], Loran UTC Station ID[7], Checksum

```
$PRLK,SYNCA,c--c,x.x,c—c,x ,x ,x .x ,x ,x ,x.x,x,x ,x.x,xa*CC
```

1 The internal receiver time since boot is reported
2 Synchronisation source can be
LORANUTC = sync information derived from received Eurofix UTC message (depending if the service is available in the area of operation)
GPSPPS = sync information is derived from an external GPS 1 PPS signal fed into the receiver (only available on UTC and ASF measurement equipment)
3 Receiver samplecount (with fraction) in units of 2.5 μs of the exact UTC second
4 Indicates of the date and time are represented in UTC time (1=UTC, 0=No UTC)
5 Number of leap seconds between the UTC source and UTC time. At the moment of printing of this manual GPS is 14 seconds ahead of UTC, Loran is 23 seconds ahead of UTC. Note that the leap seconds are already applied in the UTC date and time presented
6 Applied offset to compensate for propagation time from transmitter to user, also already used in the reported UTC time.
7 Loran station ID of the station of which the UTC information is derived

Sample log:

```
$PRLK,SYNCA,1.0,1676.97,LORANUTC,2006,06,01,08,57,24,671653990.473579,1,
   23,0.0,7499M*30
```

Trigger: ONNEW

REFSTAA & ASFMAPA - Reference Station Almanac and ASF Map format

In the US format [LDCC-06], a differential eLoran user also needs to receive eLoran Almanac messages. These messages contain information such as the transmission order (assignment of correction number to a Loran rate), the Reference Station position and the nominal ASF values for all corrected Loran rates. For the time being, within the Differential eLoran implementation using Eurofix it is chosen to provide the transmission almanac together with the ASF Corrections map to the users, instead of implementing a broadcast almanac. The user needs to upload the Reference Station almanac configuration together with the "published" ASF map to its receiver. The receiver will then correct its measured eLoran ranges with the ASF value corresponding to its position for each Loran station, corrected with the most recently received differential eLoran correction.

The `REFSTAA` log contains the following information:

Header, Logheader, Interface version, Reference Station Name, Reference Station ID, Reference Station Latitude, Reference Station Longitude, Correction 1 Loran Station ID, Correction 1 Nominal ASF (µs), Correction n Loran Station ID, Correction n Nominal ASF (µs), Checksum

```
$PRLK,REFSTAA,1.0,Harwich,100,51.94575504,1.28561571,6731M,0.5900,...,7499M,0.0800*35
```

The `ASFMAPA` log contains the following information:

Header, Logheader, Interface version, Map Name, Map Line Number, Total Map Lines, Map Generation Date, Map Description, Reference Station Name

```
$PRLK,ASFMAPA,1.0,Harwich08,1,12,19-03-08,Harwich_ASFMap_19_March_2008,Harwich,
```

Start Latitude (degrees), Start Longitude (degrees), Step Latitude (degrees), Step Longitude (degrees), Number of Latitude cells, Number of Longitude cells, Number of Loran Stations, Station 1 Loran ID, Station 1 Dualrate ID, Station 1 Mean ASF first rate (ns), Station 1 Mean ASF dualrate (ns), Station n Loran ID, Station n Dualrate ID, Station n Mean ASF first rate (ns), Station n Mean ASF dualrate (ns), Checksum

```
51.8550,1.2300,0.0100,0.0100,11,36,5,6731M,7499X,569,567,...,7499Y,9007Y,-5,4*13
```

Header, Logheader, Interface version, Map Name, Map Line Number, Total Map Lines, Binary map data, Checksum

```
$PRLK,ASFMAPA,1.0,Harwich08,2,12,602C60226021 ..... FA7FEB7FEC7FF13FF53FF45FF37FF2*60
```

Note that the nominal ASF values for the ASF map and Reference Station need not necessarily be the same.

References

[Temex] “iSync+™ Smart SRO SynClock+® Manual, Low Cost & Profile GPS/Reference Synchronized Rubidium Oscillator (SRO-100/75)”, www.temextime.com, Temex, 2004-02-25

[Motorola] “Motorola M12+ GPS Receiver User’s Guide”,http://www.synergy-gps.com/images/stories/guides/m12+userguide.pdf

[LDCC-06] “Loran Data Channel Communications using 9th Pulse Modulation, version 1.3 (mod1), Dr. B. Peterson et al., 20-Oct-2006.

[Eurofix-08] “Eurofix Message Format”, Version 2.12, Reelektronika, Gerard Offermans, 10 March 2008.

Annex A. Eurofix Differential eLoran Correction Format

The Eurofix message format allows for 56 bits payload in a 30 GRI message length. 4 bits indicate the message type of which Table 1 gives an overview. Message types 10 and 11 are reserved for differential eLoran operation. Differential eLoran trials in the US use the 9th pulse data channel implementation to broadcast differential corrections. For compatibility reasons, the differential eLoran correction format in Eurofix is based on the bit assignment used in the US trials [LDCC-06]. Table 2 shows the bit assignment used in these trials. As can be seen, the Eurofix payload content is larger than the US 9th pulse payload content and leaves room for one additional correction per message. This may prove important if data channel capacity demand increases with the implementation of a differential eLoran service on multiple harbours in the UK and Europe.

TABLE 1. EUROFIX MESSAGE DESCRIPTION AND STATUS

Message Type	Bits	Description	Status
1	0001	Eurofix DGPS correction (single sat)	Fixed
2	0010	Eurofix DGlonass correction (single sat)	Fixed
3	0011	Reserved	Reserved
4	0100	Eurofix Station ID/Health message	Tentative
5	0101	Short Message Service (SMS)	Fixed
6	0110	Loran UTC Message	Tentative
7	0111	Reserved	Reserved
8	1000	EGNOS TRAN	Tentative
9	1001	Reserved	Reserved
10	1010	Differential eLoran Phase Corrections	Tentative
11	1011	Differential eLoran Almanac data	Tentative
12	1100	Reserved	Reserved
13	1101	Reserved	Reserved
14	1110	Reserved	Reserved
15	1111	Reserved	Reserved
16	0000	Reserved	Reserved

TABLE 2. DIFFERENTIAL ELORAN TYPE 10 – PHASE CORRECTIONS

Field	Bits	# bits	Units	Range	Remark
Eurofix ID	1-4	4		16	1010
Reference Station	5-14	10		0-1023	
Correction Number	15-17	3		0-7	Correction Number Identification Code 000 = Cor 1,2 001 = Cor 3,4 010 = Cor 5,6 011 = Cor 7,8 100 = Cor 9,10 101 = Cor 11,12 110 = Undefined 111 = Undefined
Sky Wave Warning	18	1		0-1	0 = No warning 1 = Warning
Time Base Quality	19-20	2		0-3	Quality of Time Reference at Differential eLoran Station 00 = Level 1: <15 ns (rms) 01 = Level 2: 15-40 ns (rms) 10 = Level 3: 40-200 ns (rms) 11 = Level 4: > 200 ns
Age of Correction	21-23	3		0-7	Time since last correction update 000 = < 6 minutes 001 = 6-20 minutes 010 = 20-60 minutes 011 = 1-3 hours 100 = 3-6 hours 101 = 6-12 hours 110 = 12-24 hours 111 = > 24 hours
Correction 1	24-34	11	2 ns	-2.046 – 2.046 µs	All ones indicates do not use
Correction 2	35-45	11	2 ns	-2.046 – 2.046 µs	All ones indicates do not use
Spare	46-56	11			
CRC	57-70	14			Eurofix CRC
Total:		70			

Message type 10 contains the broadcast of differential eLoran data over the Eurofix datalink. The data content is compatible with the data content of the US Loran Data Channel Communications using 9th Pulse Modulation
[LDCC-06].