

# reelektronika



## LORADD series

Integrated GPS/eLoran receiver

Installation and operational manual

Version 1.2

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## Table of Contents

1	Introduction .....	1
1.1	Functional description of the LORADD integrated GPS/eLoran core receiver	1
1.2	Supported augmentation systems .....	5
2	Installation .....	7
2.1	Getting started.....	8
2.2	SmallPack .....	9
2.3	OEM boards .....	12
2.4	19" casing .....	12
2.5	Comport interface .....	13
2.6	H-field eLoran and GPS patch antenna .....	13
2.7	Firmware updates .....	14
3	Operation.....	15
3.1	Positioning modes.....	15
3.2	GPS positioning modes .....	16
3.3	eLoran positioning modes.....	16
4	Command and log interface .....	19
4.1	General interface description .....	19
4.2	NMEA 0183 supported logs .....	19
	\$GPGGA - Global Positioning System Fix Data .....	20
	\$GPVTG – Course over ground/speed .....	20
	\$GPZDA - UTC and local date/time data .....	21
	\$GPGSA - GPS DOP and active satellites .....	21
	\$GPGST - GNSS Pseudorange noise statistics .....	21
	\$GPGLL - GPS Geographic position, Latitude and Longitude .....	22
	\$GPGSV – GNSS Satellites in view .....	22
	\$LCGLC - Loran-C Geographic position, Time differences .....	23
	\$LCHDT - Loran-C Heading .....	23
	\$LCGLL – Loran-C .....	23
	\$INDTM – Integrated Position Fix Datum .....	24
	\$INRMC – Integrated Position Recommended Minimum Navigation Information .....	24
	\$INGGA – Integrated Position Fix Data (in GPGGA format) .....	25
4.3	reelektronika Proprietary logs .....	26
	LCPOSA - Loran-C calculated position .....	26
	GPPOSA - GPS calculated position .....	27
	INPOSA - Integrated position fix using GPS and/or Loran-C .....	28
	LCRSDA - Loran-C range residuals .....	29
	TOAA – Loran-C Time of Arrival measurements .....	30
	HDGA – Heading measurement.....	31
	DASFA – Differential ASF measurements.....	31
	RMSGa – Eurofix decoded messages .....	32
	RTCMB – Binary output of RTCM SC104 DGPS data .....	32
	FFTA – Frequency spectrum data .....	32
	NOTCHA– Notch frequency and bandwidth information .....	33
	SYNCA– Loran to UTC Synchronisation information .....	33
	REFSTAA & ASFMAPA - Reference Station Almanac and ASF Map format .....	34
4.4	Commands.....	36
	Command HELP .....	36
	Command VERSION .....	37
	Command SHOWSEARCH .....	37
	Command RESET .....	37
	Command LOG .....	38
	Command UNLOG .....	39

---

Command SETSPEED .....	39
Command READCONFIG .....	40
Command SAVECONFIG .....	40
Command RESETCONFIG .....	40
Command SETPOSITION .....	40
Command LOADREFSTA .....	41
Command LOADASFMAP .....	41
Command AUTH .....	41
Command NOTCH .....	42
Command SETTINGS .....	43
5 LERXAnalyser user interface .....	45
References .....	48
Annex A Technical specifications .....	49

## 1 Introduction

reelektronika's LORADD integrated GPS/eLoran receiver is the first product that can combine GPS and eLoran for various modes of applications. This receiver merges the two navigation systems and their augmentation systems to improve accuracy, integrity, availability and continuity of the navigation function. This section provides the functional description of the receiver and explains the added functionality of eLoran. Information on the working of GPS and its augmentation systems can be found in public literature and is not copied here. This manual does not describe the functionality of the included u-blox GPS receiver in great detail, further information about the u-blox receiver can be found in [u-blox-04].

The user manual helps the user to install and operate LORADD receivers without problems. Specialised and large-volume users are invited to contact reelektronika to set up maintenance contracts.

### 1.1 Functional description of the LORADD integrated GPS/eLoran core receiver

Integrated navigation offers a number of advantages over traditional single-source navigation. Figure 1-1 shows a high-level diagram of such a receiver.

The LORADD integrates GPS, eLoran, and their augmentation systems SBAS and eLoran communications (e.g. Eurofix and/or 9<sup>th</sup> pulse communications). The LORADD is a specific implementation of the general diagram shown in Figure 1-1. Currently, the receiver demodulates the Tri-state Pulse Position Modulation as is used in Eurofix and is standardised by ITU and RTCM [ITU-01][RTCM-01]. At the moment of publishing this manual, there are no standards for 9<sup>th</sup> pulse communications via eLoran. Please visit

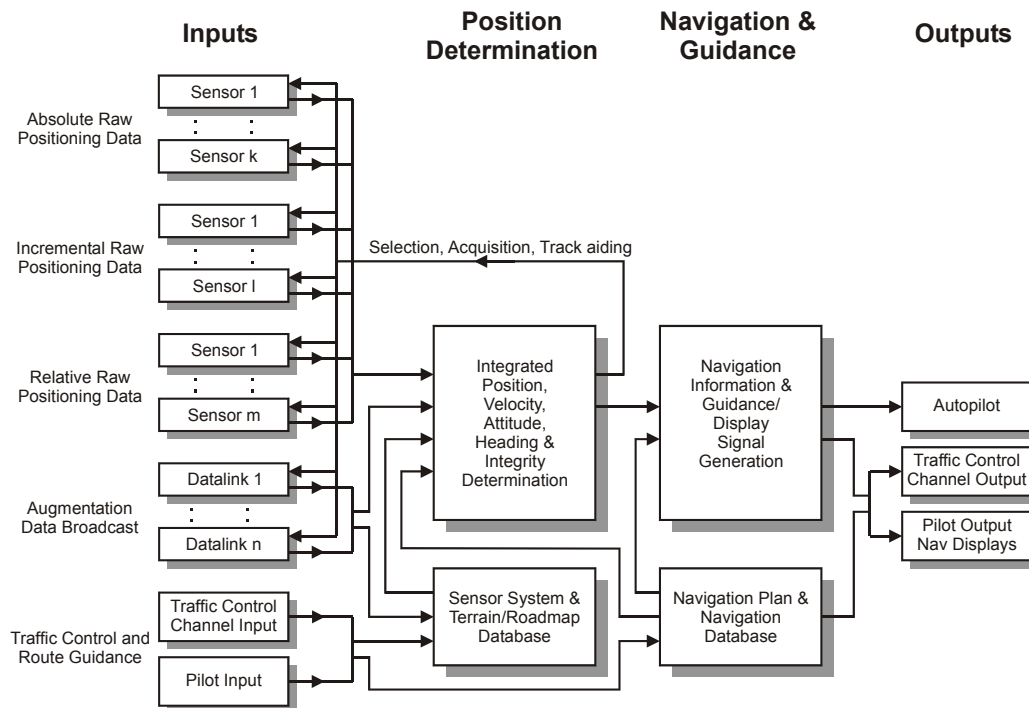


Figure 1-1 Functional block diagram of the Integrated Navigation concept

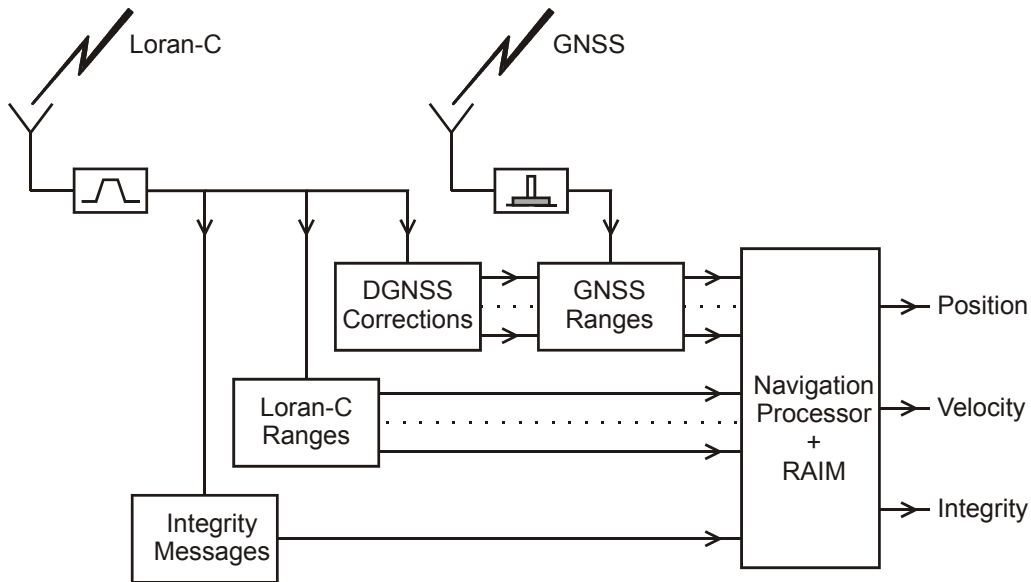


Figure 1-2 Integrated Eurofix receiver structure

reelektronika's website for information on firmware and manual updates to include this functionality too ([www.reelektronika.nl](http://www.reelektronika.nl)).

The benefit of the integrated eLoran/GPS system over conventional services is the availability of two independent navigation systems. As both systems are completely different in nature, their characteristics and failure modes are largely dissimilar and complementary. The complementary system characteristics virtually eliminate the single point failure risk for the integrated navigation user, thereby increasing the availability and continuity of the navigation function.

While the absolute accuracy of stand-alone GPS is already quite good, its accuracy and integrity can be further improved by employing differential corrections. eLoran on the other hand, has a good repeatable accuracy, but its absolute accuracy is less than that of GPS. In the combined system, the influence of the error sources is strongly reduced in the following ways:

- The differential corrections broadcast from a Eurofix reference station or SBAS compensate for any satellite timing error. This clock error is a scalar and is the same across the coverage area.
- If correction data from multiple reference stations is used to calculate a Regional Area differential correction (RAAS), the effects of different ionospheric delays experienced at user and reference station are reduced.
- The resulting (accurate) DGPS position solution (when available) can be used to calibrate the measured user eLoran ranges. In this way, the unknown propagation delay due to the limited ground conductivity can be estimated, or the ASF correction model can be refined. Once calibrated the receiver may benefit fully of the repeatable accuracy characteristics of eLoran.

Figure 1-2 shows the integrated receiver concept. The user has the following measurements available:

- Range and range-rate measurements from the GPS and SBAS satellites

- eLoran range and range-rate measurements
- Differential correction data via the Eurofix datalink and SBAS
- Integrity information on GPS and eLoran

Prior to the calculation of the position, the receiver checks the consistency and quality of the GPS and eLoran measurements through RASIM (Receiver Autonomous Signal Integrity Monitoring). Then the navigation processor selects the best possible combination of measurements and calculates position, velocity and integrity information through RAIM (Receiver Autonomous Integrity Monitoring). The selection will not only be based on the quality of the received signals and data but also on the type of operation performed with its associated Required Navigation Performance parameters.

Although calibrated eLoran positioning is still not as accurate as differential GPS, the user experiences a soft degradation in accuracy in case GPS becomes (temporarily) unavailable. Further, programs within the current eLoran operational coverage are initiated to measure and model Additional Secondary Factor (ASF), the main cause for eLoran positioning biases if not taken into account properly.

GPS receivers that are suitable for deployment in such an integrated navigation receiver are well available on the market. However, the eLoran receiver engine within the integrated LORADD receiver is the first of a new generation eLoran receivers taking full benefit of modern signal processors and new eLoran processing algorithms.

Some key performance requirements for the new receiver are:

- **Small size, low power**  
Especially given the size of the GPS receivers that are available today, this is what is demanded and expected by users for other navigation sensors too.
- **Integration of navigation sensors**  
As described before, many GPS sensors exist that will output raw measurements. This is also what the eLoran sensor provides. The GPS and eLoran measurements are combined by a navigation processor, which calculates an integrated position solution. Rather than having an external unit to perform this task, the navigation processor is included on the same hardware platform as the eLoran engine. This will yield a unit that can either operate as a stand-alone GPS or eLoran receiver, or produce an integrated position solution.
- **All-in-view capability**  
Traditionally, Loran-C is organized in 'chains' of transmitters. However, the upgraded eLoran transmitters apply a Time of Emission control (TOE) where every transmitter is synchronised with respect to an absolute time standard (Universal Time Coordinated, or UTC). Using modern signal processing algorithms, the receiver can combine eLoran range measurements from different chains in a single solution. The receiver makes Time of Arrival measurements (TOA) to every transmitter broadcasting eLoran signals. Note that this also poses an operational requirement on the eLoran operators, who must monitor and maintain the correct timing relationships between the transmitters and UTC. In Europe, this is done for every transmitter individually (TOE-control), which is the preferred method. In the USA, the new eLoran implementation also synchronises each transmitter with respect to UTC. This implementation is underway at the moment. The receiver is in principle an all-in-view receiver. The number of stations tracked might be limited though.



- **Time-of-Arrival measurements**

Traditionally, Loran-C receivers only measured the difference in timing between the Secondaries and the Master station within a chain (so-called TD measurements). However, especially if integration with GPS is pursued, individual timing measurements per station (referenced to a common clock) give much more flexibility. As mentioned before, the TOE control as operated in Europe and being implemented in the US, facilitates TOA measurements. The LORADD receiver makes use of TOA measurements and calculates positions in a rho-rho fashion (just like GPS) rather than a hyperbolic one.

- **Fast start-up**

The LORADD eLoran engine starts station signal tracking within seconds from a cold start. This facilitates Time-to-First-Fix in the order of seconds, rather than minutes under normal signal conditions. The selected u-blox GPS receiver has also specifically been chosen as partner in the LORADD concept for its fast acquisition and re-acquisition times.

- **ASF and differential eLoran capable**

Measured eLoran ranges are often polluted by a fixed bias due to a zero-order model being used for the propagation speed of the signals over terrain with limited and unknown ground conductivity. However, tables with correction values – so-called ASF tables – exist, and should be employed in the eLoran sensor in order to minimise these effects as much as possible. The LORADD receiver has a means to calculate and output “ASF” measurements, when GPS and eLoran reception are available at the same time. If these corrections are used, eLoran absolute accuracies are highly improved in areas close to the location of earlier data collection.

The use of differential eLoran in certain areas further improves the accuracy and integrity of eLoran absolute positioning. Accuracies better than 10 m are feasible with correctly applied differential corrections under good signal reception conditions. At the time of release of this LORADD receiver a final format for distributing differential eLoran corrections has not been standardised. Please visit [reelektronika's website](#) for information on service implementation and firmware updates for the LORADD receivers.

- **Advanced interference rejection**

A possible source that may limit the eLoran signal reception or reception quality is interference. Be it either due to other transmitters that operate on frequencies close to the Loran-C band, or from locally generated interference (computer monitors, car engines, etc.), or due to the way Loran-C inherently operates (cross-rate interference), the Loran-C signals suffer from (sometimes high) levels of distortion before they reach the receiver's antenna. It is expected that the largest performance increase in eLoran will come from this field. The LORADD eLoran engine employs a number of novel techniques that deal with interference in unprecedented ways. Expect future firmware releases or product ranges to include even better noise and interference cancellation techniques.

- **Modern user interface**

The de facto standard in navigation receivers appears to be an interface via a serial port to the receiver core processor. [reelektronika's](#) LORADD receiver is no exception. Through a number of serial ports, the user can get access to low-level measurements (like TOAs), as well as high-level data (such as stand-alone GPS, eLoran and integrated positions, expressed in latitude and longitude). Each port can be configured individually to output various logs at user-selectable intervals.



The LORADD receiver adheres to the NMEA format. For convenience, a Windows package is developed that can be used to command and control the receiver through a user-friendly interface.

## 1.2 Supported augmentation systems

The LORADD integrated GPS/eLoran receiver supports (or plans to support) the following augmentation services:

- **Eurofix Local Area Augmentation System (ELAAS)**  
Eurofix is broadcast from a number of stations in Europe and Saudi Arabia, and has been tested on other stations in the United States, South-Korea and a Chayka station in Russia. A Eurofix enabled eLoran station broadcasts differential GPS and integrity messages using a Tri-state Pulse Position Modulation [ITU-01][RTCM-01]. The messages are RTCM SC-104 compatible and can be output on a serial port to be fed to any RTCM SC-104 capable GPS receiver. Internally, the Eurofix message stream from the closest Eurofix station is connected to the u-blox GPS receiver, which improves its positioning accuracy and integrity. The use of DGPS from the Eurofix stations can be enabled or disabled by commands.

The application of Eurofix LAAS data with the u-blox receiver is enabled by default. In case both Eurofix and SBAS data are available, the Eurofix data takes precedence.

- **Eurofix Regional Area Augmentation System (ERAAS)**  
If Eurofix data from more than one station can be received at the same time, a user may apply a weighted average of the received correction streams to better resemble the correction data valid for the user's current position. This so-called Regional Area Augmentation System reduces the spatial decorrelation experienced with long baseline differential correction services.

The application of RAAS data is available as an option.

- **Satellite Based Augmentation System (SBAS)**  
The SBAS systems as implemented following the RTCA standards [RTCA-99] are supported by the u-blox GPS engine in the LORADD receiver. Currently, the US Wide Area Augmentation System (WAAS) and the European Geostationary Navigation Overlay System (EGNOS) adhere to this standard.

The application of SBAS data with the u-blox receiver is enabled. In case both Eurofix and SBAS data are available, the Eurofix data takes precedence. If a user wants SBAS data rather than Eurofix data, the Eurofix corrections need to be disabled using the SETTINGS command.

- **Radiobeacon differential corrections**  
IALA radiobeacons broadcast differential GPS corrections and integrity information at low frequencies [RTCM-01]. Although the reception of the radiobeacon signals directly is currently not supported, the LORADD receiver can optionally receive the RTCM SC104 data stream coming from any radiobeacon receiver.

The application of radiobeacon differential corrections is available as an option.

- **Differential eLoran or ASF data**

Differential eLoran and accurate ASF measurement or modelled data significantly enhances the absolute accuracy of the LORADD eLoran engine in independent positioning mode. As formats and standards are currently under development by various eLoran system providers, the application of differential eLoran and ASF data will be introduced in the LORADD series product line as standards become available. Differential eLoran or ASF data may be distributed through the standardised Tri-state Pulse Position Modulation (Eurofix) or the 9<sup>th</sup> pulse modulation currently under development.

Only the Differential eLoran service provided through Eurofix is currently supported.

- **UTC broadcast service**

Messages to determine accurate UTC synchronisation with eLoran are implemented in Europe, where four Eurofix equipped Loran stations are upgraded with a UTC broadcast facility. From this the user has access to a sub 1- $\mu$ s class UTC service. Also, the accurate UTC timing through Loran allows for a tighter integration with GPS. The receiver outputs the timing relation between Loran and UTC in a SYNCA message for further processing by the user.

The whole LORADD series line of receivers will be able to output UTC timing information as received through Eurofix. However, in order to make use of the highest accuracy UTC output, including 1pps, a LORADD-UTC Timing receiver is needed.

**reelektronika** currently provides UTC timing receivers for the UTC services in Europe.

## 2 Installation

The LORADD receivers come in three different hardware versions:

- SmallPack  
A small sturdy aluminium casing with connectors for power, antennas and serial communication.
- OEM board set  
The simplest hardware version consists of two stacked credit-card size PCBs for integration in the user's application box.
- 19" case  
Various products based on LORADD technology are available. Each product comes with its own installation and operational manual with reference to this manual. At this moment **reelektronika** provides five different 19" based receivers for different applications:
  - LORADD-UTC  
An integrated eLoran/GPS timing receiver with timing grade oscillator for improved performance. The UTC receiver outputs various reference frequencies and 1 PPS outputs. The receiver provides synchronisation with UTC through the eLoran signals and UTC data from the eLoran data channel.
  - LORADD-TMS  
The LORADD TOA Measurement System is a scientific receiver with a Rubidium oscillator that can be disciplined with an external 1 PPS source (e.g. GPS). The TMS allows scientific users to measure eLoran against UTC (derived from GPS) and provides additional settings and logs. The TMS uses a hardware simulator to continuously calibrate the antenna and processing delays.
  - LORADD-LMS  
The LORADD-LMS is an eLoran Monitor System. It consists of a LORADD-OEM and a PC platform with Windows based monitoring and data collection software.
  - LORADD-ASF  
The LORADD-ASF is **reelektronika**'s Additional Secondary Factor measurement system. It consists of a LORADD-TMS with an integrated NovAtel GPS receiver and a PC platform with Windows based monitoring and data collection software. The LORADD-ASF can both be a dynamic ASF data collector and a static Differential eLoran Reference Station.
  - Differential eLoran Reference Station  
The Differential eLoran Reference Station is installed at a fixed location close to a harbour where a differential eLoran service is provided. The Differential eLoran Reference Station monitors the reception of the eLoran signals needed for the service in the area and provides real-time differential eLoran corrections. The corrections are broadcast through the eLoran data channel to users of the service.

## 2.1 Getting started...

If you have purchased a SmallPack receiver, this “Getting started” section will guide you through the typical first time use.

- Unpack the receiver, antenna and antenna cables.
- Install the antenna at a location free of interference for GPS and eLoran. The antenna should have a clear view at the sky and should not be close to any large metal objects for best performance.
- Connect the antenna to the receiver using the 8-wire H-field eLoran antenna cable and the coaxial GPS cable.
- Connect the receiver comport COM1 to a PC or laptop comport using the RJ10-DB9 converter.
- Connect the power cable to the receiver and a 9-36V DC power supply.
- Install the LERXAnalyser software on the PC or laptop. You can always download the latest version of the LERXAnalyser from [www.reelektronika.nl](http://www.reelektronika.nl).
- Start the LERXAnalyser software.
- Click on “File” – “Data Source” and select the PC comport you have connected the receiver to. The default settings for communication are: Bitrate: 115200, Parity: None, Databits: 8, Stopbits 1. Press the “Connect” button on the Data Source window.
- Verify that the receiver communicates with the LERXAnalyser software by looking at the “Monitor” window on the screen. You should be able to see logs scrolling by.
- Close the “Data Connect” window and select “Show Default Logs” on the “View” menu.
- Now you will be able to see the logs in a more readable form. The TOAA window gives information on the number of eLoran stations tracked, the TOA measurements and their quality. Verify that you track stations. If three stations in a chain are tracked and the last character in the “State” column reads “0” for three stations in a chain you should be able to see a calculated eLoran position. GPS positions are reported through the GPPOSA or GPGGA logs.
- Open the “TOA/TD Plot” window on the “View” menu.
- Select “All Stations” on the “Select Stations” menu of the “Time difference – Time of Arrival Plots” window. This will allow you to monitor the TOAs coming out of the receiver.
- Select “Position Plot” from the “View” menu on the main window to see a scatter plot of the calculated positions.
- In case you encounter any difficulties with GPS and/or eLoran reception, **reelektronika** has a troubleshooting guide available to help you find the



*Figure 2-1 SmallPack housing and front plate*

source of the problems. Please visit [www.reelektronika.nl](http://www.reelektronika.nl) to see if the latest troubleshooting guide is available.

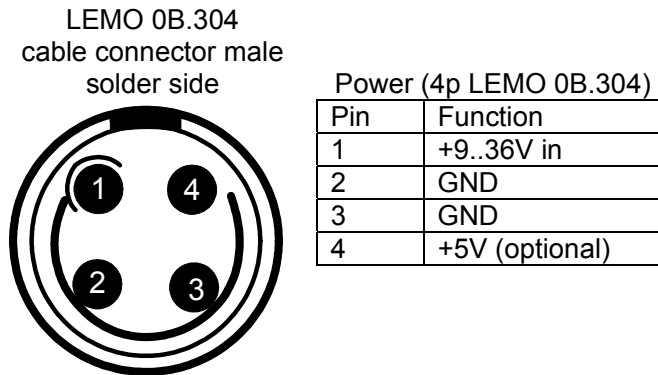
- Enjoy using your integrated GPS/eLoran receiver!

## 2.2 SmallPack

Figure 2-1 shows the SmallPack housing and its front plate. The following connectors are available (from left to right):

- 4-pin LEMO 0B.304 power connector
- 4-pin RJ10 comport COM1
- 4-pin RJ10 comport COM2
- 8-pin LEMO 1B.308 eLoran H-field antenna connector
- SMA GPS antenna connector
- Red GPS status LED
- Green eLoran status LED

The pin layout of the different connectors is as follows:



The pin layout as described above is for the SmallPack front plate as shown in Figure 2-1.

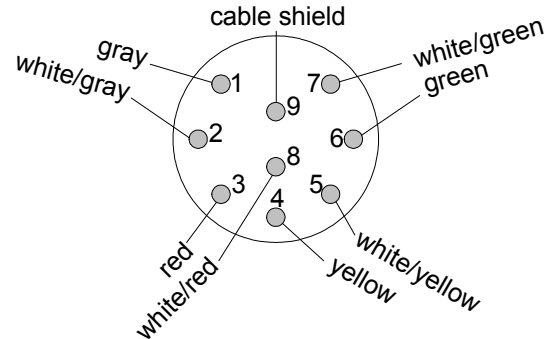
The receiver operates from a +9..36V DC input. Optionally, the receiver's internal power supply can be bypassed and the receiver can run of an external +5V DC input. Please contact **reelektronika** for enabling this option.

Comports (4p RJ10)	
Pin	Function
1	GND
2	RxD
3	TxD
4	GND

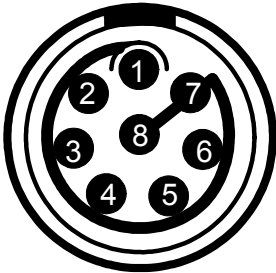
The pin layout as described above is for the SmallPack front plate as shown in Figure 2-1. Pins are assigned from left to right. Serial communication up to 400 kbps will be done on three wire interfaces (no flow control signals).

The H-field antenna is connected using an 8-wire Tasker C185 cable. On the receiver end, the cable is connected using a LEMO 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 colour codes:

CONXall Multi-Con 282-9SG-3XX  
cable connector female  
solder side  
(TASKER C185 colour code)



LEMO 1B.308  
cable connector male  
solder side



Connector @ antenna	Cable color	connector @ receiver
<b>(CONXall Multi-Con-X 282-9SG-3XX)</b>	<b>(TASKER C185)</b>	<b>(LEMO 308: FGG.1B.308.CLCD72)</b>
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 (200mA)	red	3 +5V (200mA)
8 GND	white/red	8 GND
6 Reserved	green	6 Reserved
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.

The SmallPack receiver package comes with power, serial communications and antenna cables.



## 2.3 OEM boards

The OEM board version of the receiver consists of two stacked printed circuit boards. The upper board is the DSP processing platform; the lower board is the MotherBoard which contains the analogue and digital hardware for eLoran signal reception and the u-blox GPS receiver. This board also contains all connectors and headers for signal input and output.

Figure 2-2 shows the OEM board interface layout and input/output connections. Note that the SMA connector can also come as a straight connector facing upwards.

## 2.4 19" casing

The 19" casing includes power, antenna connectors and serial communication

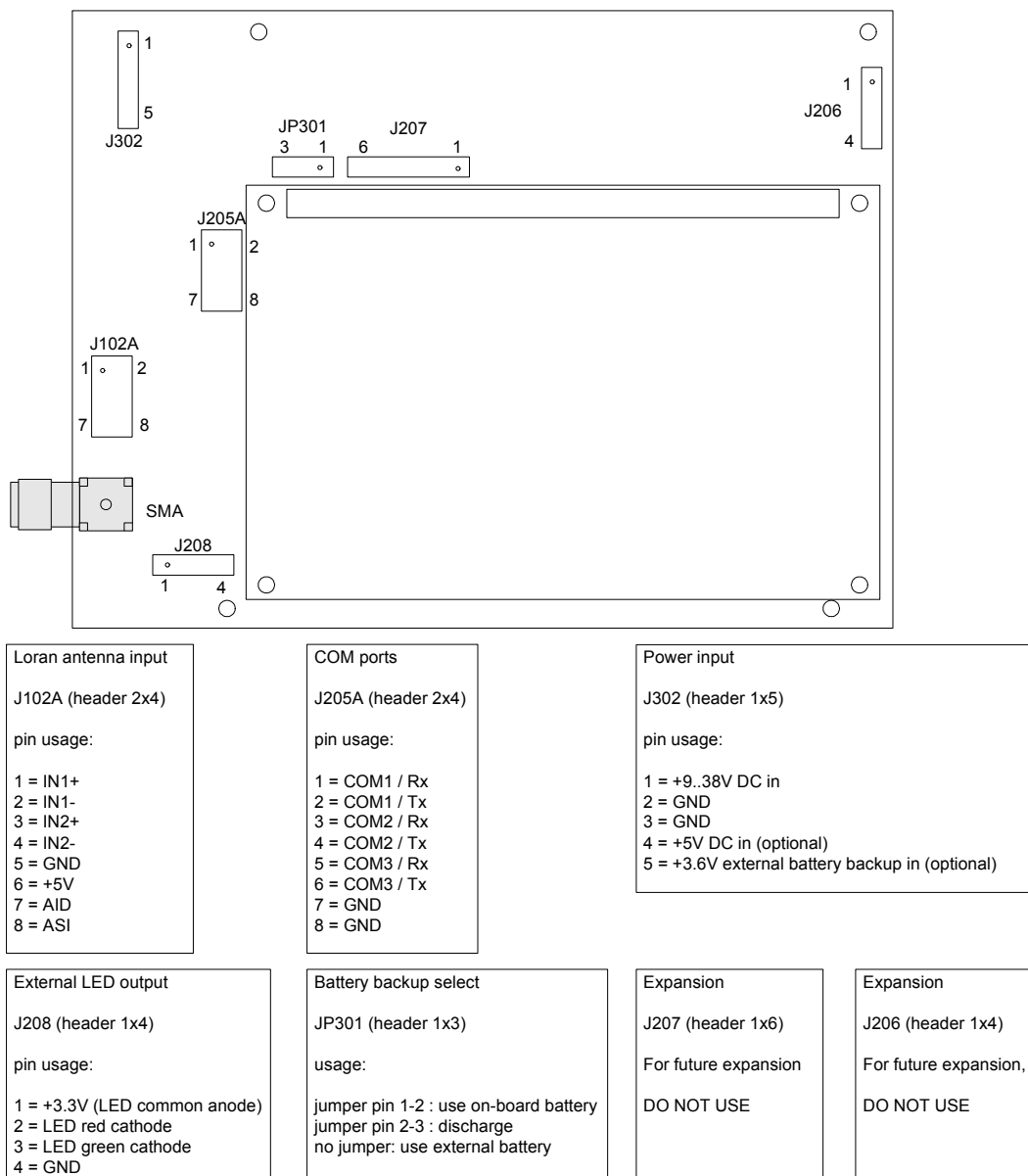


Figure 2-2 OEM board interface layout and description

connectors. Optionally, the 19" unit can have additional connectors for timing and frequency output, external clock input etc. Detailed specifications on the 19" casing will be provided separately.

## 2.5 Comport interface

The comport interfaces on the LORADD receiver for either of the versions is a three wire serial interface (RXD, TXD and GND, no handshaking). Comport speeds up to 400 kbps can be selected using the command SETSPEED (see Section 4).

## 2.6 H-field eLoran and GPS patch antenna

Every LORADD receiver comes with its own H-field eLoran antenna. The receiver and antenna should be considered as one. Changing antennas from one receiver to another is not recommended and may produce sub-optimal results. Please contact **reelektronika** in case you need to change the antenna – LORADD receiver combination.

The eLoran antenna is integrated with a GPS antenna. If the antenna is used in a location where GPS reception is not optimal a separate GPS antenna can be connected. For installation of the antennas 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 performance of eLoran in your receiver. Further, antenna installation close to large metal objects might have a negative influence on the accuracy of reception of eLoran signals.
- The GPS antenna needs to be installed with a clear and unobstructed view at the sky, free from any objects which may reflect satellite signals to the antenna.



*Figure 2-3 H-field antenna with GPS patch included*

Also, the antenna should not be installed close to equipment which may cause interference in the 1 GHz frequency range, such as TV and radio receiving and broadcasting antennas as well as radar equipment.

In case the antenna is an integrated eLoran/GPS patch antenna the installation has to be performed taking both guidelines into account.

The arrow of the antenna housing should be pointed in the direction of movement for dynamic applications, which will allow true vehicle heading information based on eLoran. The H-field antenna can be mounted upside down if needed. In order to produce accurate measurement results the receiver needs to be told that the antenna is upside down through a SETTINGS command. Obviously, with the antenna upside down the GPS patch antenna is performing sub-optimal. The use of an external GPS antenna is then recommended.

For eLoran signal environment analyses the receiver is capable of outputting received spectrum plots, through the FFT log, which can be made visible through the LERXAnalyser software tool. See Section 4 for more information on this log.

The eLoran antenna and GPS antenna are active antennas. Therefore, the LORADD receiver outputs +5 V DC on pin 6 of the eLoran antenna connector and +3.3 V on the GPS SMA connector. Figure 2-3 shows the integrated eLoran/GPS patch antenna.

## 2.7 Firmware updates

The LORADD receivers are designed to accept software updates and **reelektronika** continues to update the firmware for the LORADD receivers. New firmware can be downloaded from [www.reelektronika.nl](http://www.reelektronika.nl). View the “readme.txt” file to see what changes are incorporated in the new firmware and how to upgrade the receiver.

Further, with every firmware update the LERXAnalyser software and manual are updated accordingly if needed. Please find the latest version of both on the website too.

### 3 Operation

The LORADD receiver operates automatically. When all connections are made (eLoran + GPS antenna and power) and the receiver is powered on, the GPS and eLoran engines will automatically start searching for GPS satellites and eLoran stations. The receiver will maintain its latest position and GPS almanac prior to the previous power down to facilitate a fast warm acquisition. In case no last position is available the receiver starts looking for any GPS satellite or eLoran station in the world.

The receiver automatically starts outputting information on the position as it becomes available. Further, the receiver can also be controlled by user commands and output raw measurements for user processing or post-processing.

#### 3.1 Positioning modes

The LORADD receiver integrates two independent radionavigation systems eLoran and GPS. The receiver operates automatically, selecting the best measurements for positioning and reporting a position to the user at regular intervals. The receiver can output GPS positions and eLoran positions simultaneously. Further, it outputs an integrated position fix based on GPS calibrated eLoran ranges.

The GPS position is reported from the following list of precedence:

1. GPS + Radiobeacon
2. GPS + Eurofix
3. GPS + SBAS
4. GPS (stand alone)

Differential corrections using a radiobeacon receiver can be applied to the internal GPS receiver as an option. If enabled this mode takes precedence over Eurofix and SBAS DGPS.

If a user wants to receive DGPS from SBAS rather than Eurofix, the Eurofix pass through to the internal GPS receiver needs to be disabled through a SETTINGS command.

GPS positions are reported in NMEA format as well as in a **reelektronika** proprietary format (Section 4).

The following eLoran positioning modes are output simultaneously:

1. GPS calibrated eLoran position
2. Differentially or ASF corrected eLoran position
3. Autonomous eLoran position
4. Coarse eLoran position

eLoran positions are reported in NMEA format as well as a **reelektronika** proprietary format (Section 4).

The integrated position reported is the same as the GPS calibrated eLoran positioning, and is available in a **reelektronika** proprietary format (Section 4).

When a GPS position is available the GPS LED is lit continuously. When the GPS receiver is searching for satellites and no position is available, the LED flashes.

When an eLoran position is available the eLoran LED is lit continuously. When the receiver is acquiring eLoran signals and no position is available, the LED flashes.

### 3.2 GPS positioning modes

GPS positioning is widely described in open literature. A well-known augmentation to GPS is the use of differential corrections and integrity information. The LORADD receiver has the capability to use three different types of augmentation data together with the internal u-blox GPS receiver.

1. GPS + Eurofix

On eLoran stations which are upgraded with Eurofix technology, differential corrections and integrity information is broadcast using the Loran-C signals. The LORADD receiver automatically demodulates and decodes the Eurofix messages and feeds the corrections to the GPS receiver. Corrections from the closest Eurofix station are used. Further, Eurofix messages can be output in a **reelektronika** proprietary format for further processing. Optionally, the differential corrections of multiple Eurofix sites can be combined. This so-called Regional Area Augmentation System (RAAS) further improves accuracy and integrity of the differential GPS service. Please contact **reelektronika** if this option is needed to upgrade your receiver.

2. GPS + Radiobeacon

Optionally, the LORADD receiver can accept an RTCM SC104 binary data stream coming from a radiobeacon (or any other device outputting RTCM data). When the data stream is present the RTCM corrections are used for improving the GPS positioning accuracy. Please contact **reelektronika** if this option is needed to upgrade your receiver.

3. GPS + SBAS

The u-blox receiver is SBAS capable and will use WAAS, EGNOS or MSAS corrections when available. If the user wants to use SBAS at all times, the pass through of Eurofix data needs to be disabled.

4. GPS stand alone

If no augmentation data through Eurofix, radiobeacon or SBAS is present, the GPS receiver reverts back to standard GPS SPS positioning.

### 3.3 eLoran positioning modes

eLoran positioning is done in a similar way as GPS positioning. Station's signals are acquired, identified and tracked. On regular intervals the receiver produces pseudo range measurements which are fed to the positioning algorithms. From these measurements the LORADD receiver calculates a number of eLoran position solutions.

In order to understand the different positioning mode, the reader has to be familiar with the eLoran signal structure and propagation phenomena. Each transmitter broadcasts a group of eight eLoran pulses with a strictly defined pulse shape on a 100-kHz carrier frequency. The reported pseudo range measurements are related to the Time of Arrival of the third cycle of the first pulse in the group of eight. The right cycle is identified based on the leading edge of the received pulse.

The eLoran signals travel from transmitter to the antenna of the user receiver over the earth. Due to the low frequency the signals bend with the earth's curvature and bend around objects that are small compared to the wavelength of the eLoran signal (3 km). Due to the fact that the signals travel through the atmosphere and over the earth rather than through vacuum the signals travel with a speed slightly lower than the speed of light, which is experienced as a small delay in Time of Arrival (TOA) measurements. To get from a TOA measurement to a pseudo range, the travel time is multiplied by the travel speed of the signals over sea water. However, if the signals travel (partially) over land or over elevated terrain rather than over sea, the signals experience additional delays, known as Additional Secondary Factors (ASFs). If these ASFs are not modelled, measured or calibrated properly, the absolute accuracy of eLoran will be offset from the real position. These offsets can be as large as a few kilometres if signals from stations have to travel long distances over land or elevated terrain. Luckily, these ASFs remain constant over large periods of time, and experience only slight diurnal and seasonal variations.

Within the eLoran concept ASFs can be taken into account in four different ways:

1. ASF modelling

By using models of the earth's elevation and ground conductivity, the receiver can estimate the ASF value for each station based on the estimated user location. Currently, a lot of research has been put into ASF modelling; however, ASF models for all Loran coverage areas are not available yet.

2. ASF measuring

Using accurate GPS positions and eLoran TOA measurements at regular time and position intervals, the receiver can build up its own ASF database. A user travelling along the same trajectory can make use of this ASF database and improve the absolute eLoran positioning accuracy tremendously. The LORADD receiver allows a user to measure ASFs using the DASFA logs. An ASF database with measured values can be combined with modelled data to expand the usable range of the measured data. **reelektronika** can provide software to convert DASFA measurements into an ASF database, which can be uploaded to any LORADD receiver. Please note that the quality of the resulting ASF corrected position fix depend on the quality of the DASFA measurements.

In some specific areas (especially if a differential eLoran service is available) the service provider will publish an ASF map of the area. This map can be loaded into the LORADD receiver. The LORADD will automatically use the map if it detects that it is in the coverage area of the ASF map.

3. Differential eLoran

In parallel to differential GPS, an Differential eLoran Reference station can make measurements and calculate differential eLoran corrections for use in a defined area of operation (e.g Harbour area). These differential corrections will not only provide corrections for ASF but also for any transmitter clock bias, diurnal or seasonal variation etc. The applicability of differential corrections from one location depends on the spatial decorrelation of the corrections. In combination with measured (or modelled) ASFs (published by the service provider), the differential corrections will provide the highest possible autonomous eLoran accuracy. Currently, the LORADD receiver supports the differential eLoran service through Eurofix as provided for example by the General Lighthouse Authorities of the UK and Ireland for Harwich harbour.

#### 4. GPS Calibrated eLoran

In the LORADD integrated eLoran/GPS receiver this mode of eLoran operation will provide the highest possible eLoran accuracy. Whenever an accurate GPS position fix is available (with or without augmentation data), the eLoran pseudo range measurements are continuously calibrated. All possible error sources and unknown biases within the eLoran measurements, including ASFs, transmitter clock biases, system timing offsets (e.g. between Chayka and Loran-C) etc. will be calibrated out. In case of loss of GPS due to interference or shadowing, the LORADD receiver continues positioning with accurately calibrated eLoran position fixes. The calibration values remain valid for longer periods of time, but degrade with distance from the last calibration location. It should be noted that this is an integrated positioning mode which requires GPS and eLoran to be present at least during a certain period of the journey. For the most accurate independent eLoran position solution the user is referred to mode 2 and 3 with measured ASFs and differential eLoran corrections.

The LORADD receiver outputs four different eLoran position solutions. Next to the GPS calibrated and ASF corrected, two other modes are available.

#### 5. Autonomous eLoran

The stand-alone eLoran mode calculates a position based on TOA measurements without any ASF corrections or calibration applied. In this mode, the absolute position offsets with respect to the true position can be as large as a few kilometres. Typically, however, position offsets are within 450 m (a quarter nautical mile).

#### 6. Coarse eLoran

For applications that require the highest possible eLoran positioning availability the receiver is capable of outputting an eLoran coarse position, based on the measurements of three stations in one chain, where cycle identification is not strictly necessary. It should be noted that this position solution could be inaccurate and give position biases in the order of several kilometres. If position integrity is important this positioning mode should better not be used.

Positioning mode 4 is used as the integrated position output (INPOSA).

For certain areas of operation where accurate ASF databases are necessary, such as for instance Harbour Entrance and Approach (HEA), system providers and users are encouraged to contact **reelektronika** to set-up an ASF measurement campaign.



## 4 Command and log interface

### 4.1 General 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 LORADD receiver. Comports can be set at speeds up to 400 kbps.

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** sensor 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 on. More information on the commands will be given below. To enable the logs, an example is given using LORADD COM1. Replace COM1 with COM2 or COM3 if appropriate.

### 4.2 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
GPGBA	Global Positioning System Fix Data
GPVTG	Course over ground/speed
GPZDA	UTC and local date/time data
GPGBA	GPS DOP and active satellites
GPGST	GNSS Pseudorange noise statistics
GPGLL	GPS Geographic position, Latitude and Longitude
GPGSV	GNSS Satellites in view
LCGLC	Loran-C Geographic position, Time differences
LCHDT	Loran-C Heading
LCGLL	Loran-C Geographic position, Latitude and Longitude
INDTM	Integrated Position Datum reference
INRMC	Integrated Position Recommended Minimum Navigation Information
INGGA	Integrated Position Fix Data

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:

## \$GPGGA - Global Positioning System Fix Data

Header	UTC time of fix	Latitude	N/S	Longitude	E/W	GPS Quality	Num satellites used	HDOP	Height above MSL	Meters	Geoidal separation	Meters	Age of DGPS data	DGPS reference ID	Checksum
\$GPGGA	hhmmss.ss	ddmm.mm	a	dddmm.mm	a	x,xx	x.x,x.x,M	x.x,M	x.x,M	x.x,xxxx	*CC				

Sample log:

\$GPGGA,104545.00,5052.3562,N,00437.5650,E,2,06,2.5,61.3,M,47.4,M,5.7,0548\*7F

To enable this log type: LOG COM1 GPGGA ONNEW

## \$GPVTG – Course over ground/speed

Header	Course in degrees	True course	Course in degrees	Magnetic course	Speed	Knots	Speed	km/h	Checksum
\$GPVTG	x.x,T	x.x,M	x.x,N	x.x,K	*CC				

Sample log:

\$GPVTG,352.39,T,,M,0.005,N,0.010,K,D\*32

To enable this log type: LOG COM1 GPVTG ONNEW

## \$GPZDA - UTC and local date/time data

Header	UTC time	UTC Day	UTC Month	UTC Year	Local Zone Hours	Local Zone Minutes	Checksum
\$GPZDA	hhmmss.ss	xx	xx	xxxx	xx	xx	*CC

Sample log:

\$GPZDA,092803.00,01,06,2006,00,00\*65

To enable this log type: LOG COM1 GPZDA ONNEW

## \$GPGSA - GPS DOP and active satellites

Header	Mode 1	Mode 2	12 Satellite IDs	PDOP	HDOP	VDOP	Checksum
\$GPGSA	a	x	xx,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx	x.x	x.x	x.x	*CC

<sup>1</sup> Mode is M for manual forced 2D/3D, A for automatic

<sup>2</sup> Mode is:

1 = fix not available

2 = 2D

3 = 3D

Sample log:

\$GPGSA,A,3,03,22,11,18,15,19,,,,,,,,,3.3,2.5,2.0\*31

To enable this log type: LOG COM1 GPGSA ONNEW

## \$GPGST - GNSS Pseudorange noise statistics

Header	UTC Time	RMS Deviation	Semi-major deviation	Semi-minor deviation	Semi-major orientation	Latitude error	Longitude error	Altitude error	Checksum
\$GPGST	hhmmss.ss	x.x	x.x	x.x	x.x	x.x	x.x	x.x	*CC

Sample log:

\$GPGST,104815.00,2.4,3.2,2.1,0.0,3.2,2.1,3.9\*52

To enable this log type: LOG COM1 GPGST ONNEW

## \$GPGLL - GPS Geographic position, Latitude and Longitude

Header	Latitude	N/S	Longitude	E/W	UTC time of fix	Status <sup>1</sup>	Mode Indicator <sup>2</sup>	Checksum
\$GPGLL	ddmm.mm	a	dddmm.mm	a	hhmmss.ss	a	a	*CC

<sup>1</sup> Status is A for normal operation, V for invalid position

<sup>2</sup> Mode Indicator is:  
 A = Autonomous  
 D = Differential  
 E = Estimated  
 M = Manual mode  
 S = Simulator mode  
 N = No fix data

Sample log:

\$GPGLL,5052.35,N,00437.56,E,104835.00,A,D\*60

To enable this log type: LOG COM1 GPGLL ONNEW

## \$GPGSV – GNSS Satellites in view

Header	Total messages	Message number	Number of Satellites	Satellite ID	Elevation	Azimuth	SNR	Checksum <sup>1</sup>
\$GPGSV	x	x	xx	xx,xx,xxx,xx	...			*CC

<sup>1</sup> Logs come in groups of three satellites each

Sample log:

\$GPGSV,3,1,12,20,85,302,39,11,49,142,42,24,55,297,41,31,43,251,39\*76

\$GPGSV,3,2,12,01,39,055,41,23,39,188,40,25,24,077,36,04,12,301,\*7A

\$GPGSV,3,3,12,13,11,201,,14,04,037,30,33,29,205,34,05,0,354,\*70

To enable this log type: LOG COM1 GPGSV ONNEW

## \$LCGLC - Loran-C Geographic position, Time differences

Header	
GRI	
Master TOA	
Signal Quality M	<sup>1</sup>
TD1	
Signal Quality 1	<sup>1</sup>
TD2	
Signal Quality 2	<sup>1</sup>
TD3	
Signal Quality 3	<sup>1</sup>
TD4	
Signal Quality 4	<sup>1</sup>
TD5	
Signal Quality 5	<sup>1</sup>
Checksum	

```
$LCGLC,xxxx,x.x,a,x.x,a,x.x,a,x.x,a,x.x,a,x.x,a*CC
```

- <sup>1</sup> 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
```

To enable this log type: LOG COM1 LCGLC ONNEW

## \$LCHDT - Loran-C Heading

Header	
Heading	
True heading	
Checksum	

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

Sample log:

```
$LCHDT,65.9,T*17
```

To enable this log type: LOG COM1 LCHDT ONNEW

## \$LCGLL – Loran-C

Header	
Latitude	
N/S	
Longitude	
E/W	
UTC time of fix	
Status <sup>1</sup>	
Mode Indicator <sup>2</sup>	
Checksum	

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

- <sup>1</sup> Status is A for normal operation, V for invalid position  
<sup>2</sup> 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
```

To enable this log type: LOG COM1 LCGLL ONTIME 5

Replace “5” with the interval you would like to receive logs. At the moment 5 is the minimum interval. If a smaller interval is chosen the data content will only change every 5 seconds.

## \$INDTM – Integrated Position Fix Datum

Header	Local Datum ID	Local Datum Subcode	Latitude offset in minutes N/S	Longitude offset in minutes E/W	Altitude offset in m	Datum name	Checksum
\$INDTM,	c--c,	x,	m.m,	a,m.m,	a,	x.x,	c--c*CC

Sample log:

```
$INDTM,W84,,00.0000,N,00.0000,E,,W84*51
```

Note that the ID of the Integrated position logs (here IN) can be changed using the SETTINGS SET INTID <AA>.

## \$INRMC – Integrated Position Recommended Minimum Navigation Information

Header	UTC time of fix	Status <sup>1</sup>	Latitude	N/S	Longitude	E/W	Speed over ground in knots	Track made good, degrees true	Date	Magnetic Variation in degrees E/W	Checksum
\$INRMC,	hhmmss.ss,	a,	ddmm.mm,	a,	dddmm.mm,	a,	x.x,x.x,	ddmmyy,	x.x,	a,	*CC

<sup>1</sup> Status is A for normal operation, V for invalid position

Sample log:

\$INRMC,,A,5202.07346,N,00445.57040,E,0.717,248.35,,,E\*5D

Note that the ID of the Integrated position logs (here IN) can be changed using the SETTINGS SET INTID <AA>.

## \$INGGA – Integrated Position Fix Data (in GPGGA format)

Header	UTC time of fix	Latitude	N/S	Longitude	E/W	Quality	Num observations used	HDOP	Height above MSL	Meters	Geoidal separation	Meters	Age of DGPS data	DGPS reference ID	Checksum
\$INGGA	hhmmss.ss	ddmm.mm	a	dddmm.mm	a	x	xx	x.x	x.x	M	x.x	M	x.x	xxxx	*CC

- <sup>1</sup> Status indicates fix mode:
- 1: GPS Stand alone
  - 2: GPS Differential
  - 4: eLoran

Sample log:

\$INGGA,104545.00,5052.3562,N,00437.5650,E,2,06,2.5,61.3,M,47.4,M,5.7,0548\*7F

Note that the ID of the Integrated position logs (here IN) can be changed using the SETTINGS SET INTID <AA>.



### 4.3 reelektronika Proprietary logs

Besides the supported NMEA logs for GPS and Loran-C 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.

The following logs are currently supported:

Log	Description
LCPOSA	Loran-C calculated position
GPPOSA	GPS calculated position
INPOSA	Integrated position fix using GPS and/or Loran-C
LCRSDA	Loran-C range residuals
TOAA	Loran-C Time of Arrival measurements
HDGA	Heading measurement
DASFA	Differential ASF measurements
RMSGA	Eurofix decoded messages
RTCMB	Binary output of RTCM SC104 DGPS data received through Eurofix
FFTA	Frequency spectrum data
NOTCHA	Notch frequency and bandwidth information
SYNCA	Loran to UTC Synchronisation information
REFSTAA & ASFMAPA	Reference Station Almanac and ASF Map format

### LCPOSA - Loran-C calculated position

Header	Logheader	Interface version	UTC time of fix <sup>1</sup>	UTC Date	UTC Mode <sup>2</sup>	LC Mode <sup>3</sup>	Latitude	Longitude	Velocity (m/s)	Course	Future use <sup>4</sup>	Num Loran-C	HDOP	Quality <sup>5</sup>	Checksum
--------	-----------	-------------------	------------------------------	----------	-----------------------	----------------------	----------	-----------	----------------	--------	-------------------------	-------------	------	----------------------	----------

\$PRLK,LCPOSA,c--c,hmmss.ss,ddmmyy,a,a,x.x,x.x,x.x,x.x,x.x,x.x,x.x,x.x\*CC

<sup>1</sup> If UTC time is not available, the internal receiver time since boot is reported

<sup>2</sup> UTC Mode is:

G = GPS derived UTC

L = Loran-C derived UTC

N = No UTC synchronisation

<sup>3</sup> LC Mode is:

C = Coarse position (no cycle identification necessary)

A = Uncorrected Loran-C

D = Differential Loran-C

G = GPS Calibrated Loran-C

S = ASF Corrected Loran-C

N = No position fix

<sup>4</sup> Currently, this field is empty, reserved for future use



## INPOSA - Integrated position fix using GPS and/or Loran-C

Header	Logheader	Interface version	UTC time of fix <sup>1</sup>	UTC Date	UTC Mode <sup>2</sup>	Position Mode <sup>3</sup>	Latitude	Longitude	Height above MSL	Undulation <sup>4</sup>	Velocity (m/s)	Course	Future use <sup>5</sup>
--------	-----------	-------------------	------------------------------	----------	-----------------------	----------------------------	----------	-----------	------------------	-------------------------	----------------	--------	-------------------------

```
$PRLK,INPOSA,c--c,hmmss.ss,ddmmyy,a,aa,x.x,x.x,x.x,x.x,x.x,x.x,x.x,
```

Num Satellites	Num Loran-C	HDOP	Quality <sup>6</sup>	Checksum
----------------	-------------	------	----------------------	----------

```
x,x,x.x,x.x*CC
```

- <sup>1</sup> If UTC time is not available, the internal receiver time since boot is reported
- <sup>2</sup> UTC Mode is:  
G = GPS derived UTC  
L = Loran-C derived UTC  
N = No UTC synchronisation
- <sup>3</sup> Position Mode has two characters, first indicating the GPS mode:  
A = Uncorrected GPS  
W = Differential WAAS/EGNOS  
R = Differential RTCM Radiobeacons  
E = Differential Eurofix  
N = No GPS included  
The second character indicates the Loran-C mode:  
A = Uncorrected Loran-C  
D = Differential Loran-C  
G = GPS Calibrated Loran-C  
S = ASF Corrected Loran-C  
N = No Loran-C included
- <sup>4</sup> Undulation is difference between Mean Sea Level (MSL) and geoid height, “-“ = mean sea level is below WGS-84 geoid. If height is not available the field will be left blank
- <sup>5</sup> Currently, this field is empty, reserved for future use
- <sup>6</sup> Quality indicator TBD

Sample log:

```
$PRLK,INPOSA,1.0,141646.00,110405,G,EG,50.8727703,4.6260831,69.3,47.4,1.4,33  
1.5,,6,5,0.00,*46
```

To enable this log type: LOG COM1 INPOSA ONTIME 5

Replace “5” with the interval you would like to receive logs. At the moment 5 is the minimum interval. If a smaller interval is chosen the data content will only change every 5 seconds.

## LCRSDA - Loran-C range residuals

Header	Logheader	Interface version	UTC time of fix <sup>1</sup>	UTC Date	UTC Mode <sup>2</sup>	LC Mode <sup>3</sup>	Num Loran-C	Loran-C Station ID <sup>1</sup>	Residual LC 1 (m)	Weight factor LC 1	Loran-C Station ID <sup>n</sup>	Residual LC <sup>n</sup> (m)	Weight factor LC <sup>n</sup>	Checksum
\$PRLK,LCRSDA,c--c,hhmmss.ss,ddmmyy,a,a,x,xa,x.x,x.x,.....,xa,x.x,x.x*CC														

<sup>1</sup> If UTC time is not available, the internal receiver time since boot is reported

<sup>2</sup> UTC Mode is:

G = GPS derived UTC

L = Loran-C derived UTC

N = No UTC synchronization

<sup>3</sup> LC Mode is:

A = Uncorrected Loran-C

D = Differential Loran-C

G = GPS Calibrated Loran-C

S = ASF Corrected Loran-C

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
```

To enable this log type: LOG COM1 LCRSDA ONTIME 5

This log is generated together with the LCPOSA log. It is advised to take the same ONTIME interval as the LCPOSA log. Replace "5" with the interval you would like to receive logs. At the moment 5 is the minimum interval. If a smaller interval is chosen the data content will only change every 5 seconds.

## TOAA – Loran-C Time of Arrival measurements

Header	Logheader	Interface version	Receiver time <sup>1</sup>	Update interval	Integration time	Clock steering	Clock error (s/s)	Noise Loop 1 (dB)	Noise Loop 2 (dB)	Num Stations	Loran-C Station ID 1	Signal Strength (dB)	SNR (dB)	Batch Quality <sup>2</sup>	ECD (μs)	Cycle Ident Quality <sup>2</sup>	Status <sup>3</sup>	Time of Arrival (μs)	Doppler (s/s)	Locktime (s)
--------	-----------	-------------------	----------------------------	-----------------	------------------	----------------	-------------------	-------------------	-------------------	--------------	----------------------	----------------------	----------	----------------------------	----------	----------------------------------	---------------------	----------------------	---------------	--------------

\$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,XXXX,x.x,x.x,x.x,...

Loran-C Station ID n	Signal Strength (dB)	SNR (dB)	Batch Quality <sup>2</sup>	ECD (μs)	Cycle Ident Quality <sup>2</sup>	Status <sup>3</sup>	Time of Arrival (μs)	Doppler (s/s)	Locktime (s)	Checksum
----------------------	----------------------	----------	----------------------------	----------	----------------------------------	---------------------	----------------------	---------------	--------------	----------

xa,x.x,x.x,x.x,x.x,x.x,XXXX,x.x,x.x,x.x,\*CC

<sup>1</sup> The internal receiver time since boot is reported

<sup>2</sup> Quality indicator between 0 and 1, 1 is highest quality

<sup>3</sup> 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	Reserved

Sample log:

```
$PRLK,TOAA,1.0,1129.00,5,5,FINESTEERING,7.86e-07,35.34,33.23,6,
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
```

To enable this log type: LOG COM1 TOAA ONNEW

## HDGA – Heading measurement

Header	Interface version	Receiver time <sup>1</sup>	Update time	Mode <sup>2</sup>	True heading	Heading Std	Quality	Checksum
Logheader								

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

<sup>1</sup> The internal receiver time since boot is reported

<sup>2</sup> Mode is:

G = GPS derived heading

L = Loran-C derived heading

I = Inertial derived heading

Sample log:

\$PRLK,HDGA,1.0,1216.00,1,L,65.47,0.0,1.0\*58

To enable this log type: LOG COM1 HDGA ONNEW

## DASFA – Differential ASF measurements

Header	Interface version	UTC time of fix	UTC Date	UTC Mode <sup>1</sup>	GPS Pos Lat	GPS Pos Lon	Num stations	Loran-C Station ID 1	Differential ASF	Quality	Loran-C Station ID n	Differential ASF	Quality	Checksum
Logheader														

\$PRLK,DASF,c--c,hmmss.ss,ddmmyy,a,x.x,x.x,x,xa,x.x,x.x,...,xa,x.x,x.x\*CC

<sup>1</sup> UTC Mode is:

G = GPS derived UTC

L = Loran-C derived UTC

N = No UTC synchronisation

Sample log:

\$PRLK,DASFA,1.0,1464.00,,N,50.8726202,4.6260773,6,6731M,0.000,0.0001,  
6731X,2.084,0.0043,6731Z,-0.068,0.0030,7499M,-0.069,0.0030,  
7499X,0.002,0.0024,7499Y,-0.710,0.0053\*32

To enable this log type: LOG COM1 DASFA ONTIME 5

Replace "5" with the interval you would like to receive logs. At the moment 5 is the minimum interval. If a smaller interval is chosen the data content will only change every 5 seconds.

## RMSGA – Eurofix decoded messages

Header	Logheader	Interface version	Receiver time <sup>1</sup>	Loran-C Station ID <sup>2</sup>	Eurofix message	Num GRI Errors	Num GRI Erasures	Checksum
\$PRLK,RMSG,C--C,x,x,x,x,X--X,x,x*^C								

- <sup>1</sup> The internal receiver time since boot is reported  
<sup>2</sup> 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,RMSG,1.0,1605.66,7499Y,61574307711F000C2A63,0,12\*78

To enable this log type: LOG COM1 RMSGA ONNEW

## RTCMB – Binary output of RTCM SC104 DGPS data

RTCM data is binary RTCM SC 104 Version 2.2 data that can be fed to any standard GPS receiver. It is recommended that this log is activated on a separate comport than ASCII logs. The RTCM data is extracted from the received Eurofix messages from the closest Loran Station outputting Eurofix.

Sample log:

fQFIA^AAB{w~oTS@tO@kYnYvH^aHBO@ cV@ZF@zYnyv~an}vw|Ome Gy nY  
nYvH^Q

To enable this log type: LOG COM1 RTCMB ONNEW

## FFTA – Frequency spectrum data

\$PRLK, FFTA, C-I-C,	x,x,x,x,x,x,x,x,x,x
Header	
Logheader	
Interface version	
FFT points	
Start bin <sup>1</sup>	
Num bins <sup>1</sup>	
Integration count	
Profile count <sup>2</sup>	
Gain setting	
Number of FFT channels	
FFT value	
Next FFT value	
Checksum	
\$CPRKL, FFTA, C-I-C,	x,x,x,x,x,x,x,x,x,x

- <sup>1</sup> Bins are counted in units of 400 kHz/(FFT Points)  
<sup>2</sup> Profile count is TBD

Sample log:

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



## NOTCHA– Notch frequency and bandwidth information

<sup>1</sup> The internal receiver time since boot is reported

To enable this log type: LOG COM1 NOTCHA ONNEW

## SYNCA- Loran to UTC Synchronisation information

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  $\mu$ s 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 this manual GPS is 14 seconds ahead of UTC, and Loran is 23 seconds  
ahead of UTC. Note that the leap seconds are already applied in the UTC date and  
time presented

- <sup>6</sup> Applied offset to compensate for propagation time from transmitter to user, also already used in the reported UTC time.
- <sup>7</sup> 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

To enable this log type: LOG COM1 SYNCA ONNEW

**REFSTAA & ASFMAPA - Reference Station Almanac and ASF Map format**

In an area where a differential eLoran service is present the user needs to upload the Reference Station almanac configuration together with the “published” ASF map to its receiver to make use of the service. 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											

	Header
Start Latitude (degrees)	Logheader
Start Longitude (degrees)	Interface version
Step Latitude (degrees)	Map Name
Step Longitude (degrees)	Map Line Number
Number of Latitude cells	Total Map Lines
Number of Longitude cells	Map Generation Date
Number of Loran Stations	Map Description
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)	Reference Station Name
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	\$PRLK,ASFMAPA,1.0,Harwich08,1,12,19-03-08,Harwich_ASFMap_19_March_2008,Harwich,

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	

---

35

## 4.4 Commands

Commands are entered as space separated commands terminated by a Carriage Return <CR>. Commands can be entered on all serial ports. Commands are not case sensitive.

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 search list
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
LOADREFSTA	Loads the Reference Station almanac
LOADASFMAP	Loads the ASF Map
AUTH	Enters an authentication code into the receiver
NOTCH	Activates or deactivates notch filters
SETTINGS	Manages various receiver settings

## Command HELP

Syntax:    HELP

Response: HELP                   Prints help for all supported commands  
           VERSION               Prints version information  
           SHOWSEARCH          Shows the current search list  
           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  
           LOADREFSTA          Loads Loran reference station almanac data

LOADASFMAP	Loads an ASF map
AUTH	Enters an authentication code into the receiver
NOTCH	Activates or deactivates a notch
SETTINGS	Manages various Settings

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

Response: Detailed help on the command

## Command VERSION

Syntax: `VERSION`

Response: `LORADD - High performance integrated eLoran/GPS/Eurofix receiver  
Firmware version: 2.0, May 24 2006  
Copyright (C) 2005 by Reelelektronika B.V., The Netherlands  
For information, contact support@reelektronika.nl`

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

## Command SHOWSEARCH

Syntax: `SHOWSEARCH`

Response: Current Search List:

```
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:

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. Note that the GPS receiver is not reset but continues tracking of satellites. In order to reset the GPS the receiver needs to be power cycled.

## 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: Generation of output logs

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

<b>NMEA logs</b>			
Log	Description	Triggers	
GPGBGA	Global Positioning System Fix Data		ONNEW
GPVGTG	Course over ground/speed		ONNEW
GPZDA	UTC and local date/time data		ONNEW
GPGBSA	GPS DOP and active satellites		ONNEW
GPGBST	GNSS Pseudorange noise statistics		ONNEW
GPGLLL	GPS Geographic position, Latitude and Longitude		ONNEW
GPGBSV	GNSS Satellites in view		ONNEW
LCGLC	Loran-C Geographic position, Time differences		ONNEW
LCHDT	Loran-C Heading		ONNEW
LCGLL	Loran-C Geographic position, Latitude and Longitude	ONTIME	
INDTM	Integrated Position Fix Datum	ONTIME	
INRMC	Integrated Position Recommended Minimum Navigation Information		ONNEW
INGGA	Integrated Position Fix Data		ONNEW

<b>reelektronika proprietary logs</b>			
Log	Description	Triggers	
LCPOSA	Loran-C calculated position	ONTIME	
GPPOSA	GPS calculated position	ONTIME	
INPOSA	Integrated position fix using GPS and/or Loran-C	ONTIME	
LCRSDA	Loran-C range residuals	ONTIME	
TOAA	Loran-C Time of Arrival measurements		ONNEW
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	Loran-C 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: None

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: None

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 in bps of a port. Supported 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 search list 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 search list.

## Command LOADREFSTA

Syntax: `LOADREFSTA <$PRLK,REFSTAA ,...*CC>`

Response: REFSTAA data accepted

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

A Reference Station almanac will be published by the differential eLoran service provider and provided to the user. Once this data is published, **reelektronika** will make the almanac and/or ASF map data available in **reelektronika** format for use with the receiver.

## Command LOADASFMAP

Syntax: `LOADASFMAP <$PRLK,ASFMAPA ,...*CC>`

Response: ASFMAP data accepted  
ASFMAP complete

Loads lines of an ASF map.

An ASF map will be published by an eLoran service provider and provided to the user. Once this data is published, **reelektronika** will make the almanac and/or ASF map data available in **reelektronika** format for use with the receiver.

## 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 hexadecimal 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**.

Note: It is very important that the correct authorisation code for each receiver and firmware combination is entered correctly. If the receiver does not respond with `Auth code accepted` or if no valid authorisation code is entered the behaviour of the receiver is unpredictable and unstable. Generally a receiver which comes directly from **reelektronika** is properly authenticated. A new authentication code may only need to be entered if the user changes firmware. In case a new authorisation code is needed, 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  
          INTID                : IN

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 SET INTID <AA>

Response: SETTINGS: Setting applied

Sets the ID for the Integrated Position logs INDTM, INRMC and INGGGA to <AA>. Using <AA> = GP the receiver can mimic a GPS receiver with an integrated position as source. This enables the LORADD receiver to interface with existing display systems accepting NMEA GP log lines.

**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.

## 5 LERXAnalyser user interface

The LORADD receiver comes with a Windows software program to view and monitor the output of the receiver, LERXAnalyser. The software allows communicating to the receiver via serial communications or replaying of recorded logs from file.

Before the LERXAnalyser is able to display information, the user should select a data source from a comport, TCP/IP connection or file, using the “Data source” menu under “File”. Once a connection to the receiver is made, a command script (for instance to upload a previously stored DASFA database) can be uploaded. Also, a file can be opened in which the incoming data is stored.

Views of different logs can be opened or closed using the menu “View”. By selecting the “Serial Monitor” view the user may enter commands. The two windows show the incoming data. The left window shows all data passing by, the right window all data which have the Select string included or excluded. If for instance the Select string is “\$” and the radiobutton “Exclude” is selected, the right window will show responses on commands only. The data views display the different logs in a tabulated structure for easy viewing. The Loran-C derived heading information is displayed as an arrow. Offsets can be entered to calibrate the true north heading, which may be biased during to antenna installation. The user has a number of tools at his disposal; most of which are self-explanatory. Figure 5-1 shows a screen capture of the main window.

Besides data views the LERXAnalyser has more sophisticated screens available. The software allows monitoring of eLoran TOA measurements for a longer period in a

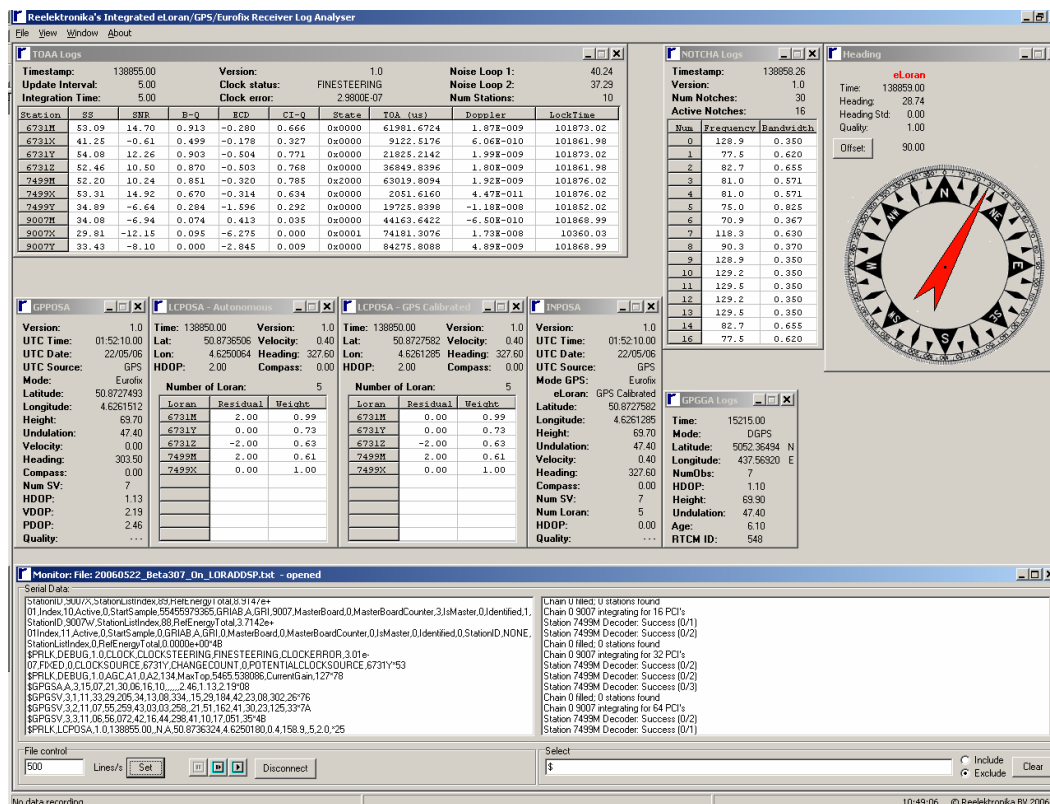


Figure 5-1 Screen capture of the main view of the LERXAnalyser software

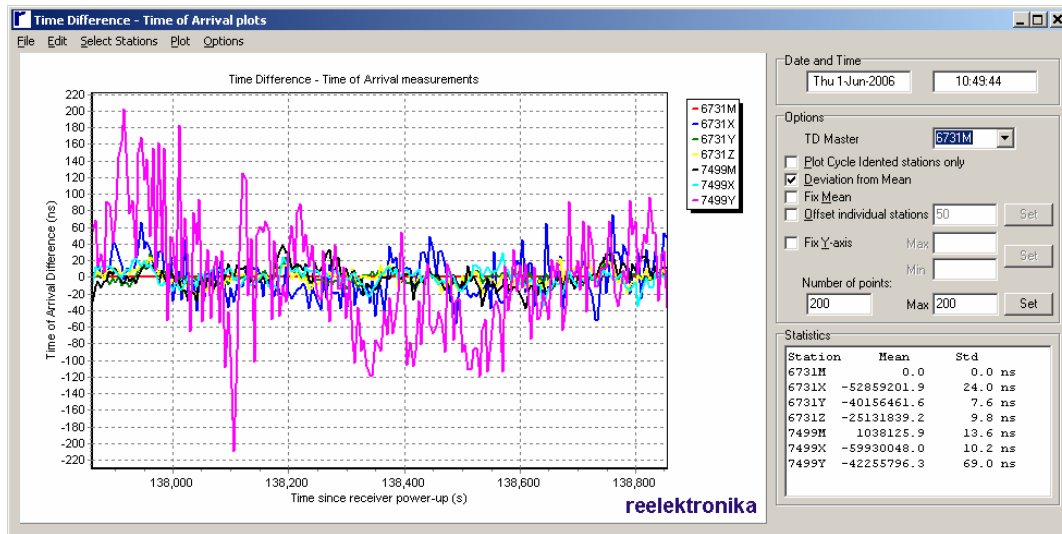


Figure 5-2 Screen capture of the TOA monitoring plots

graphical representation, Figure 5-2. To reduce the effects of receiver clock error, the user may select any station to be a “master”. All TOAs will be plotted with respect to the timing of the “master” station. This window also allows displaying of DASFA data, use “File” – “Source”. Individual stations or whole chains can be selected and deselected using the “Select Stations” menu. On the right side, different settings can be chosen to display the data. Also, statistical data for all stations displayed is presented.

The reception of Eurofix messages can be monitored using the Eurofix Data screen, Figure 5-3, which will be shown through “View” – “Eurofix Data”. Select the tab “DGPS” to view the reception of DGPS messages of the different eLoran stations.

The LERXAnalyser further allows monitoring position outputs of the different modes of operation in a scatter plot, Figure 5-4. Positions can be selected to be displayed using the “Plot” menu. Further, statistical information on the performance is displayed for 5 position outputs. This will only make sense for static measurements obviously.

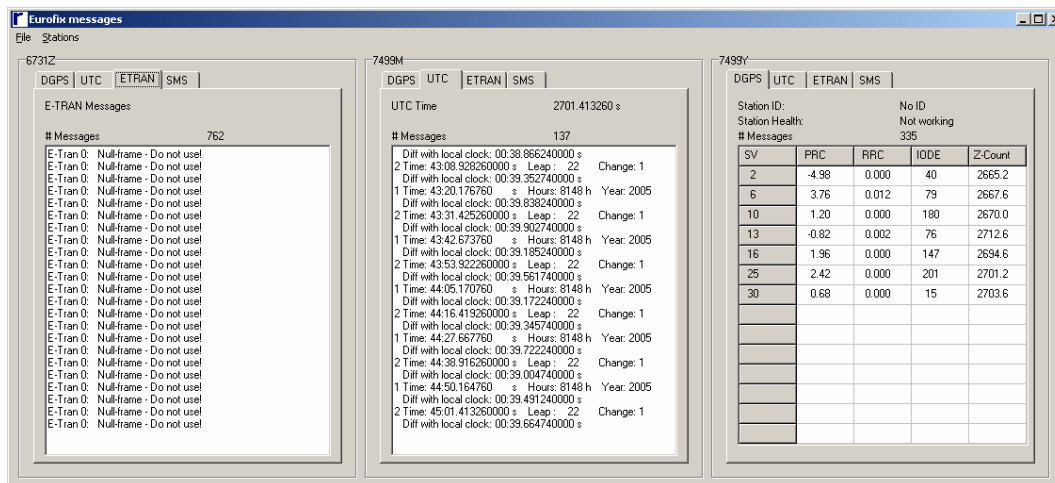


Figure 5-3 Screen capture of the Eurofix message decoding

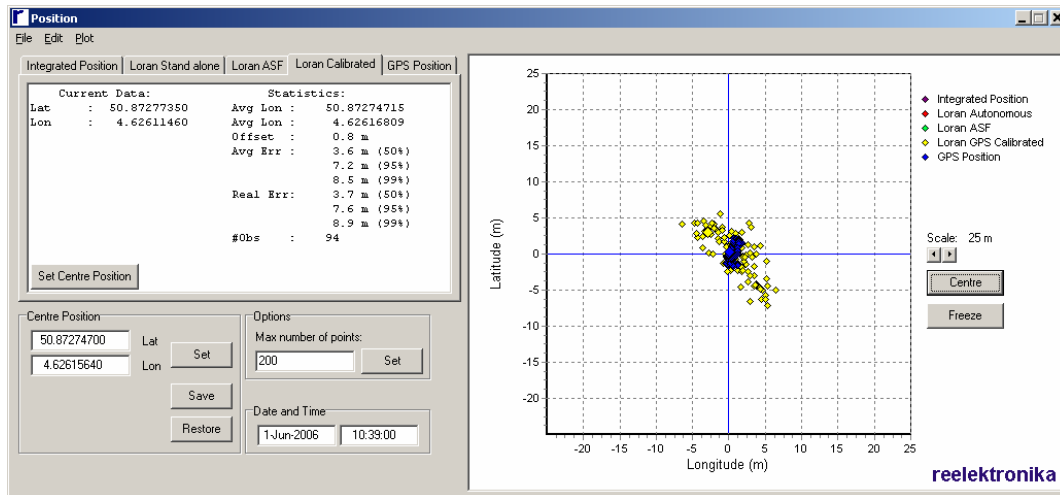


Figure 5-4 Screen capture of the position scatter plots

The last screen shows a spectrum plot of the received Loran and in-band/out-of-band interferers, Figure 5-5. The mouse pointer will show frequency and relative strength of the interferer pointed at. Make sure you enabled the FFTA log by sending the command "LOG COM1 FFTA ONNEW" (if your PC is connected to LORADD com1). If the NOTCHA logs are enabled too (LOG COM1 NOTCHA ONNEW), the location and width of the notches is shown in the same figure. If multiple notches overlap, the color will be more intense.

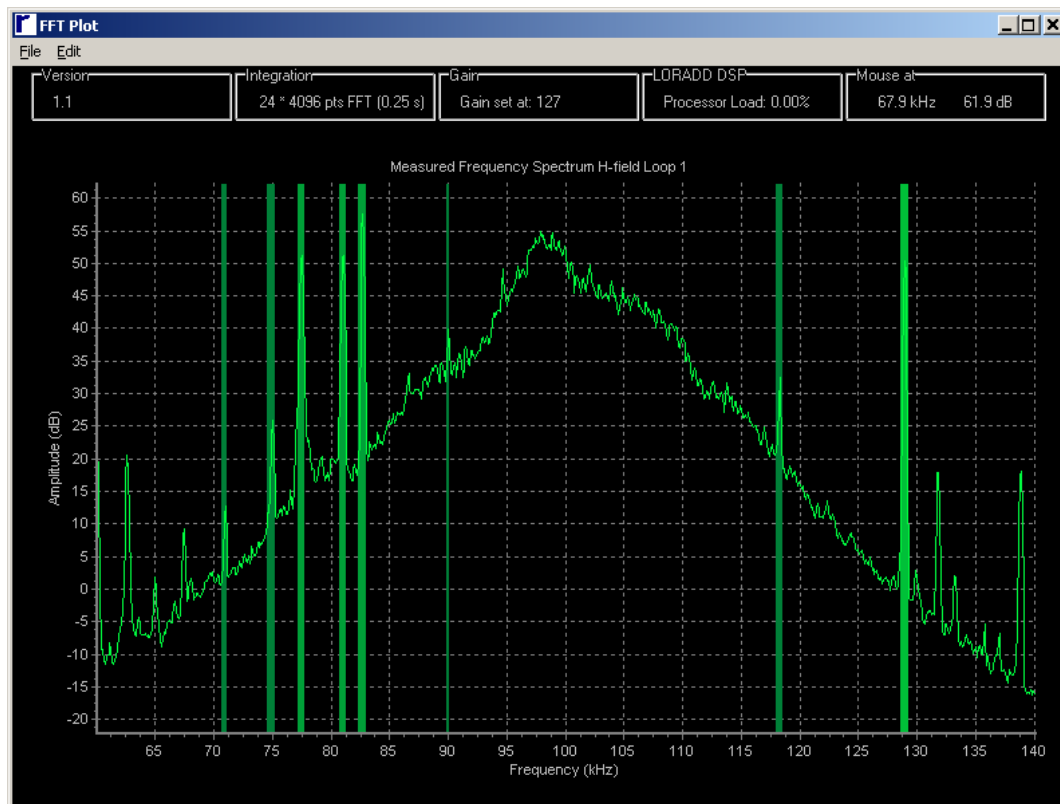


Figure 5-5 Screen capture of FFT screen

## References

- [u-blox-04] "TIM-LC, TIM-LF, TIM-LP System Integration Manual", "TIM-LC-LF-LP\_Sys\_Integr\_Manual(GPS.G3-MS3-01001).pdf", [www.u-blox.com](http://www.u-blox.com).
- [ITU-01] Recommendation ITU-R M.589-3, "Technical characteristics of methods of data transmission and interference protection for radionavigation services in the frequency bands between 70 and 130 kHz", International Telecommunication Union, August, 2001.
- [RTCM-01] "RTCM Recommended Standards for Differential GPS (Global Navigation Satellite Systems) Service", Version 2.3, RTCM Special Committee no. 104, Alexandria, VA, USA, 2001.
- [RTCA-99] "Minimum operational performance standards for Global Positioning System / Wide Area Augmentation System airborne equipment", RTCA DO-229B, RTCA SC-159, October 6, 1999.



## Annex A Technical specifications

reelektronika

### LORADD series Integrated GPS / eLoran Receiver



reelektronika's new generation of LORADD receivers marks the start of a new era in eLoran receiver technology. Drawing from its long history of experience in the field of Loran, reelektronika successfully implemented unprecedented digital signal processing algorithms on a newly designed, compact yet powerful DSP platform.

#### Navigation

LORADD receivers can output independent eLoran positions, enhanced by the use of ASF maps where available. However, LORADD technology can also take full advantage of an integrated or optionally externally connected GPS receiver. In this case, the GPS receiver provides additional raw measurements to the LORADD. The LORADD then combines its own eLoran measurements with the GPS measurements, and outputs a so-called 'integrated position solution', taking full advantage of the strong points of both navigation systems.

#### Measurements

Designed for high performance, the LORADD is capable of outputting independent measurements at user selectable intervals. Measurements on eLoran time-of arrival, ECD and signal quality are output. Also, accurate true-North heading info based on eLoran is available even if the receiver is stationary.

#### Interfacing

Through the serial ports, the receiver is fully customizable to output all required measurements on any of the serial ports. A Windows® software package is supplied for easy interfacing. The receiver's interface is according to NMEA standards. Relevant NMEA messages and proprietary messages in NMEA format can be used in parallel for flexible receiver operation and easy connection to other navigation equipment.

#### Key features

- All-in-View eLoran receiver
- Small size
- Integrated GPS receiver
- Built-in eLoran data channel capability
- ASF-map ready
- Differential eLoran ready
- Firmware upgradeable

#### Performance characteristics

Frequency	90-110 kHz
Signal strength	30-120 dBμV/m
Dynamic range	90 dB
Loran data channel	Eurofix decoding 9° pulse prepared
Interference suppression	30 dual-channel notch filters
Measurement output	TOA, TD, position (eLoran/GPS/ integrated), Heading, SNR, ECD and Eurofix data

#### Physical characteristics

Receiver	
Power consumption	4 W
Voltage	9-36 V DC
Operating temperature	0° to +50° C
Humidity	90% (non-condensing)
Antenna	
eLoran H-field	Active dual-loop eLoran H-field antenna with GPS patch antenna, 19 x 19 x 8 cm
eLoran E-field	Active eLoran E-field antenna with high dynamic range, 30 x 3 (diameter) cm
Cable length	Up to 50 meters
Interfacing	
Serial ports	3 RS232
Speed	Up to 115.2 kbps
Connector type	3 x header-connection on OEM 2 x RJ10 in SmallPack 1 x DB-9 on Single Housing

#### Configurations

OEM board	Option LORADD-D1-OE-x 10 x 7.5 x 2 cm
SmallPack	Option LORADD-D1-SP-x 11 x 8.5 x 3 cm
SingleHouse	Option LORADD-D1-SH-x 20.3 cm diameter 8.3 cm height
Integrated GPS receiver	Option LORADD-D1-xx-G
External GPS receiver	Option LORADD-D1-xx-E
RTCM SC104 input	Option LORADD-D1-xx-R
UTC Timing receiver	Option LORADD-D1-19-U

Specifications are subject to change without prior notice

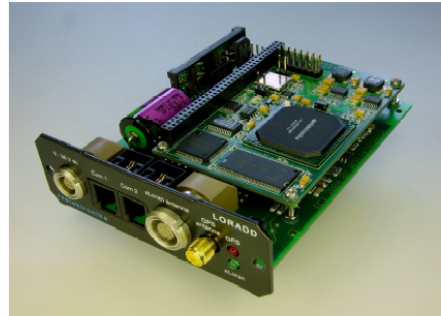
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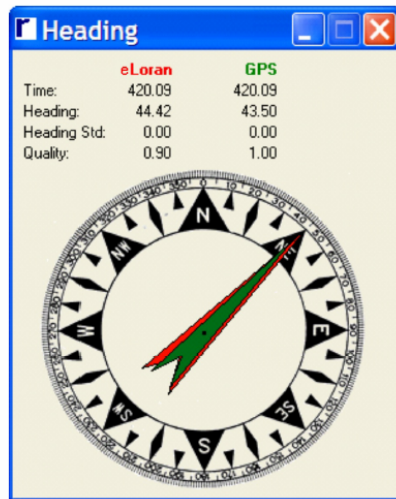
Right: Internal view of the SmallPack LORADD receiver. The upper credit card size PCB contains the DSP. The lower PCB contains the front end with the dual channel high-dynamic range A/D converters. On the left the power supply circuitry including power line RFI filters, and backup battery



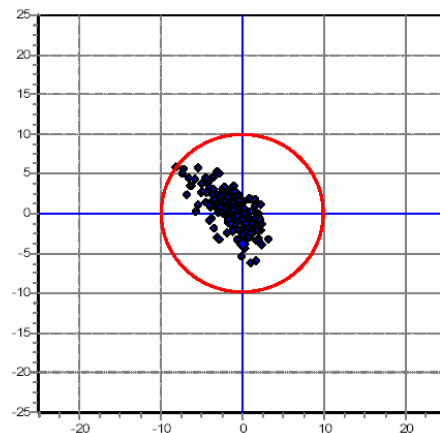
Above: eLoran E-field antenna (left) and H-field antenna (right) with integrated GPS patch antenna



Above: LORADD SingleHouse GPS/eLoran receiver



Above: Comparison of GPS and eLoran based compass performances. eLoran antenna heading output is typically better than 1 degree under normal conditions



Above: Differential eLoran position error scatter plot with respect to GPS reference. Red circle is 10-m target accuracy

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