reelektronika

International Loran Association

Implementation of a UTC Service on the NELS Eurofix Transmitters

ILA – 34th Convention and Technical Symposium
Santa Barbara, Oct 17-19 2005

Loran-C as a timing source

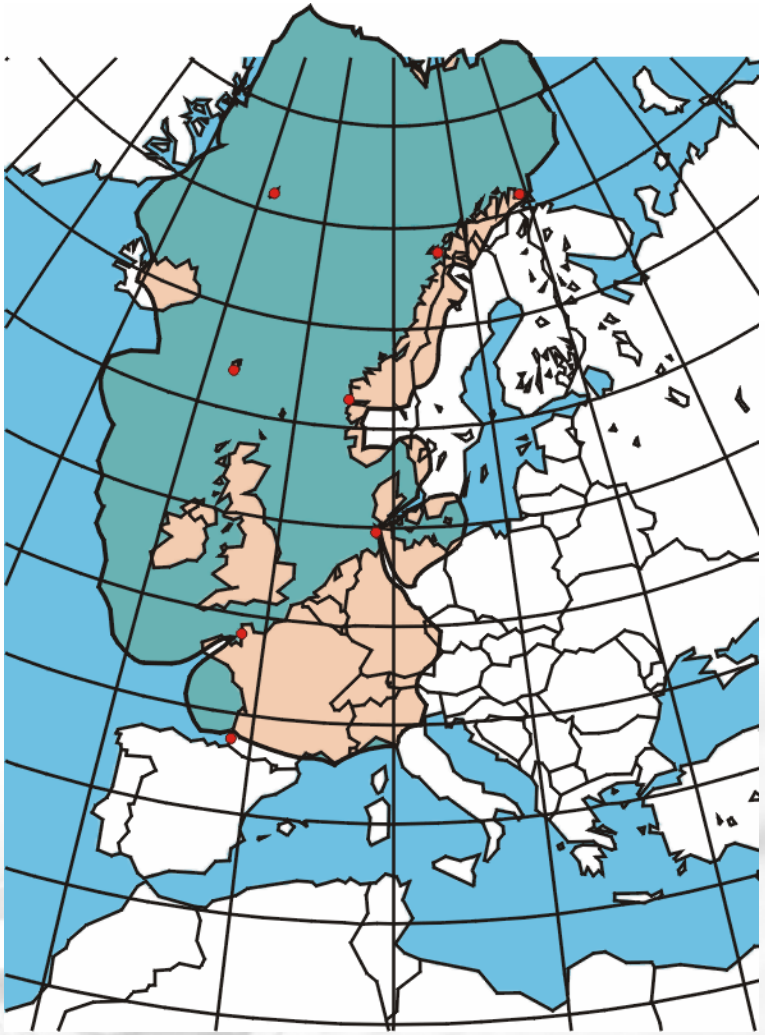
- Loran is widely recognized for its timing capabilities
  - Identified by Volpe report
  - Identified by Helios study
  - Confirmed by numerous papers
  - Meets Stratum-1 specifications, provides an independent timing source
- Timing:
  - Frequency recovery
  - UTC recovery

Loran Timing Control in USA

- New Timing and Frequency Equipment (TFE) in USA
  - Uses precise frequency steering rather than LPA's
  - UTC recovery at site, currently via GPS
    - Can currently cope with weeks of GPS unavailability
    - Anticipates the possibility of 2-way time transfers, thereby completely removing the GPS dependency

Loran Timing Control in Europe

- NELS transmitters are Time-of-Transmission controlled
- Master timing control in Brest
- Secondaries are synchronized using round-trip measurements
- Transmitters are steered via LPA’s



NELS UTC contract

NELS has tasked Reelektronika for:

- Design and documentation of a new Eurofix message format for the transmission of precise UTC time from a Loran-C/Eurofix station
- Design and implementation of the UTC Provider equipment based on the existing Eurofix Reference Station installation
- Installation of the UTC Provider equipment at the Loran-C station Sylt
- Implementation of a prototype UTC receiver which can verify the installation at Sylt
- Design and implementation of the Loran-C Timing receiving equipment, which facilitates a 1-µs UTC timing accuracy – under development
- Delivery of 5 Loran-C Timing receivers

Remaining timing errors

Limiting factors on UTC recovery at receiver:

- Transmitter timing errors (<20 ns with new TFE)
- Propagation effects (ASF)
  - One-time calibration
  - Temporal stability?
- Antenna- and cable-delays at receiver
  - Factory calibration
  - Variations (temperature effects) can be compensated by continuous calibration

Eurofix UTC msg # 6, sub 1

Item	Bits	# bits	Unit	Range
Message type (0110)	1-4	4	1	16
Message sub-type (01)	5-6	2	1	4
Time at Master/Secondary in hour *	7-35	29	10 µs	5,368 sec (> 1 hour)
Hour of year	36-49	14	1 hour	16,384 hours (> 1 year)
Year	50-55	6	1	64 years (2000-2063)
Spare	56	1		
Cyclic Redundancy Check	57-70	14		
Total:		70		

* Indicates the UTC time of the standard zero-crossing of the first pulse of the next Eurofix message

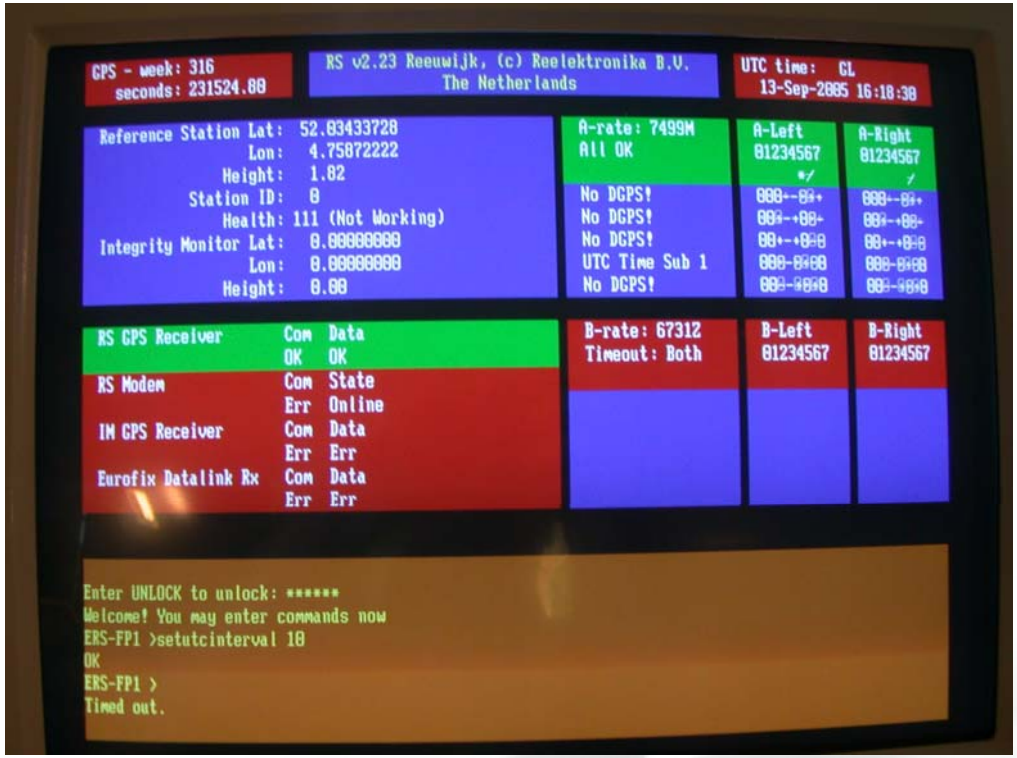
Eurofix UTC msg # 6, sub 2

Item	Bits	# bits	Unit	Range
Message type (0110)	1-4	4	1	16
Message sub-type (10)	5-6	2	1	4
Time at Master/Secondary *	7-35	29	10 µs	5,368 sec (> 1 hour)
Precise Time	36-45	10	10 ns	10.24 µs (> 10 µs)
Leap seconds ** (TAI-UTC)	46-54	9	1 s	-256 – 255 s
Leap second change ***	55-56	2	1 s	-1 – 1 s
Cyclic Redundancy Check	57-70	14		
Total:		70		

- Time within the hour (10 us resolution) is transmitted both in Sub 1 and Sub 2 messages
- Like GPS, provides announcement for leap seconds

UTC recovery at Sylt

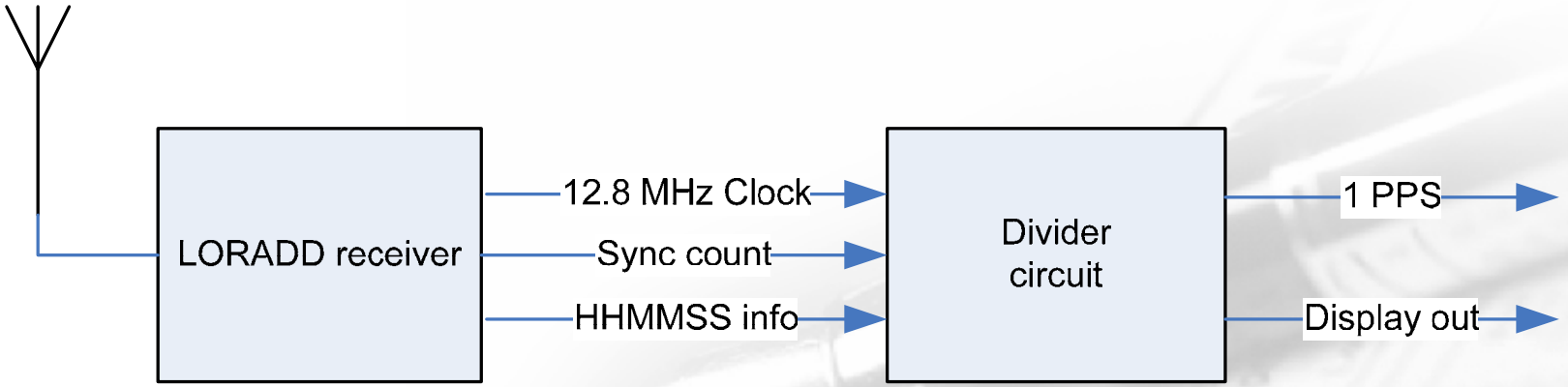
- Transmitter timing is accurately controlled by Control Station Brest
- UTC messages every 2 minutes
- UTC time is calculated by:



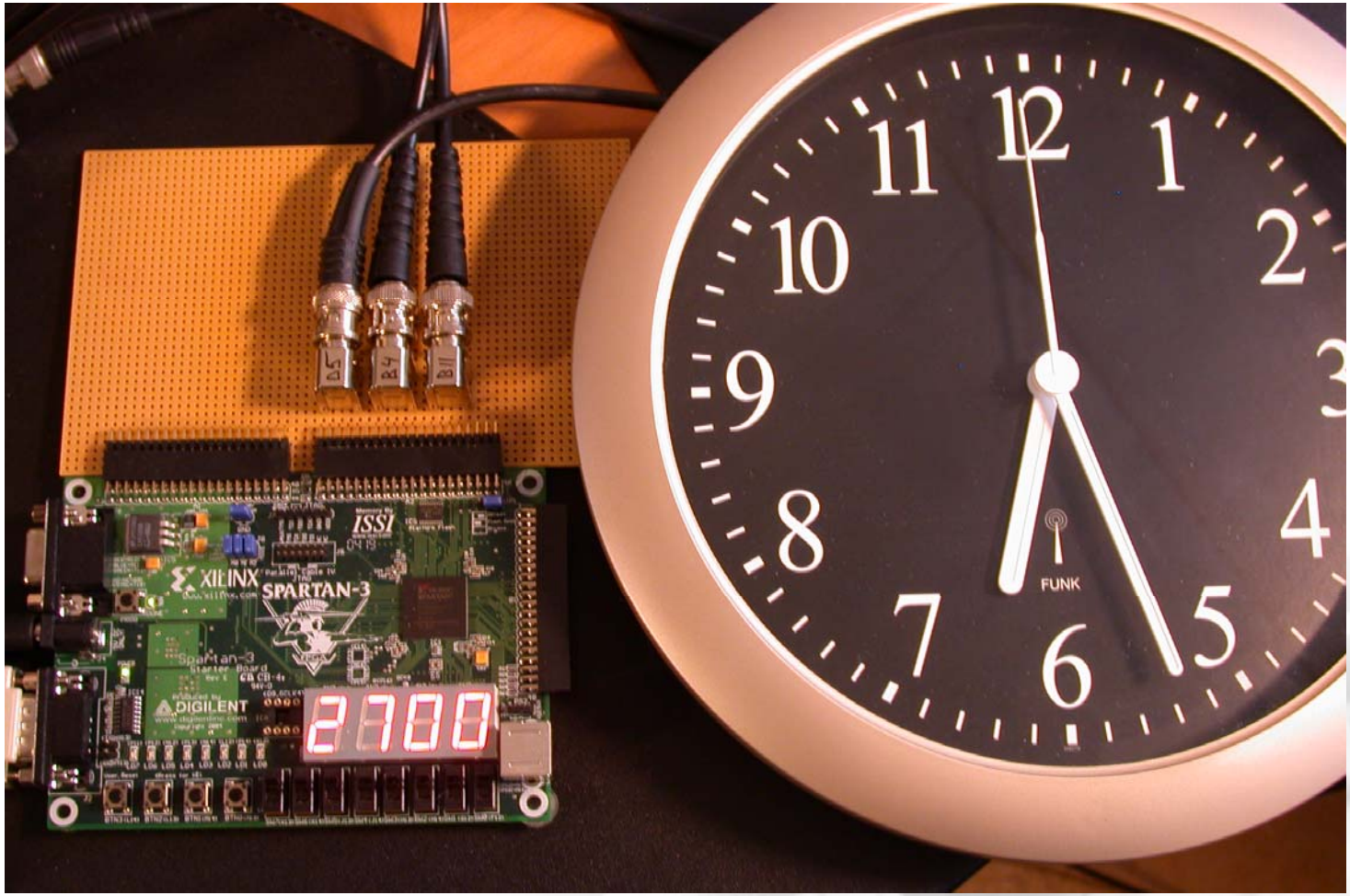
- T_{rough} = GPStimetag(GRI trigger) (in seconds since 1-1-1958)
- 9 seconds between GPS and Loran time, so:
- $T_{fine} = T_{rough} - \mathrm{mod}(T_{rough} * 10^5 + 9, GRI) / 10^5$

Test receiver setup

- Based on standard Loradd receiver
- Currently using standard onboard Xtal



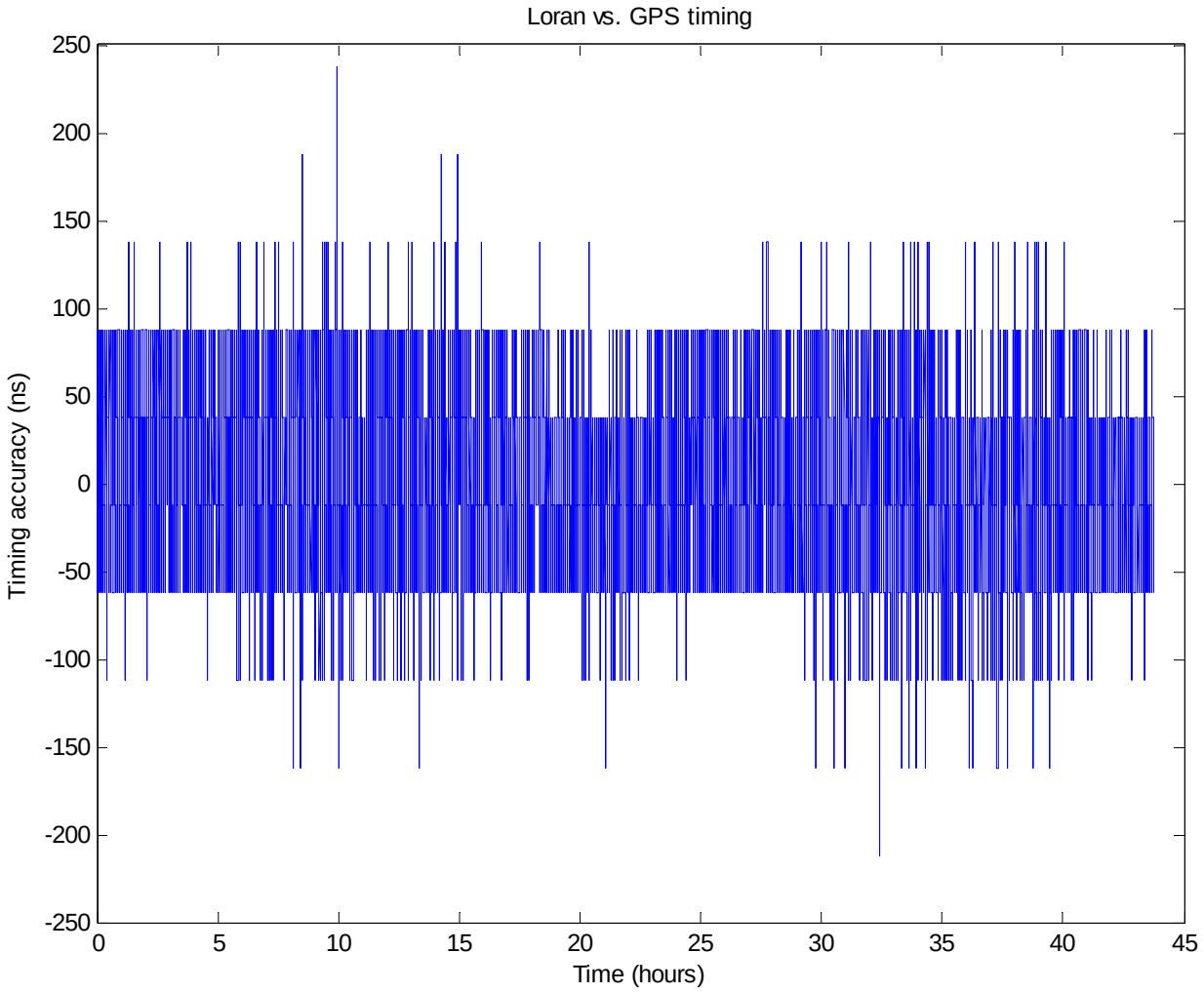
Breadboard set-up



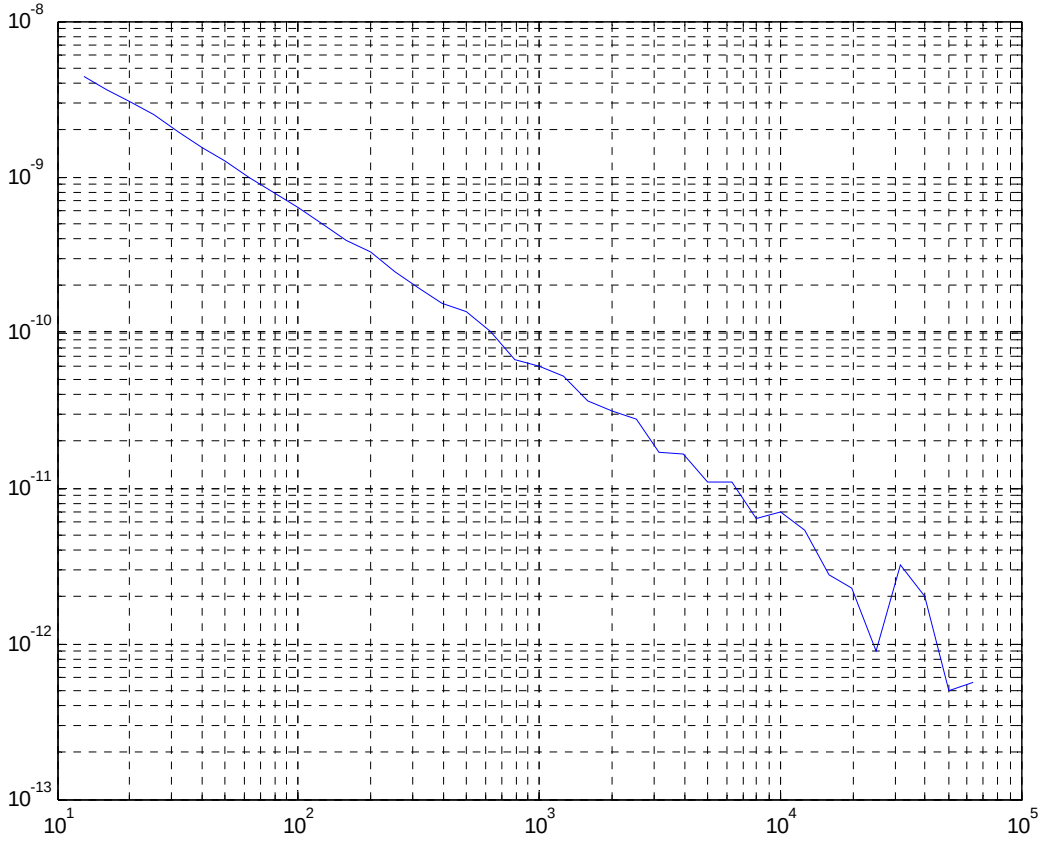
Measurements

- UTC 1 PPS output at the moment (proof-of-concept) controlled in 78 ns steps
  - Currently using on-board Xtal
  - Possible to do frequency steering rather than stepping with firmware upgrade only
  - Product version will contain OCXO which will be frequency steered → approx. 15 ns
- Using Novatel OEM4 with 50 ns timetagging resolution

44 hours of Loran-timing



Allan deviation



Upcoming product

- Single-box Loran/GPS timing solution
- Automatic ASF-calibration of Loran using GPS
  - One-time calibration
  - Continuously
- Frequency output (1 MHz, 10 MHz)
- 1 PPS output
- Precise (< 5 ns) time tagging input capability
- Independent from source of UTC information (Eurofix, Loran Data Channel)

Conclusions

NELS contract almost fulfilled:

- UTC service has been embedded in Sylt Eurofix transmissions
- UTC prototype receiver successfully demonstrated
- UTC recovery (1 PPS signal) within 100 ns possible with low-cost equipment
- Currently on-air
- First timing receivers to be delivered shortly