Eurofix
Status and Future Developments

Arthur Helwig,
Delft University of Technology
Gerard Offermans, Durk van Willigen,
Reelektronika bv

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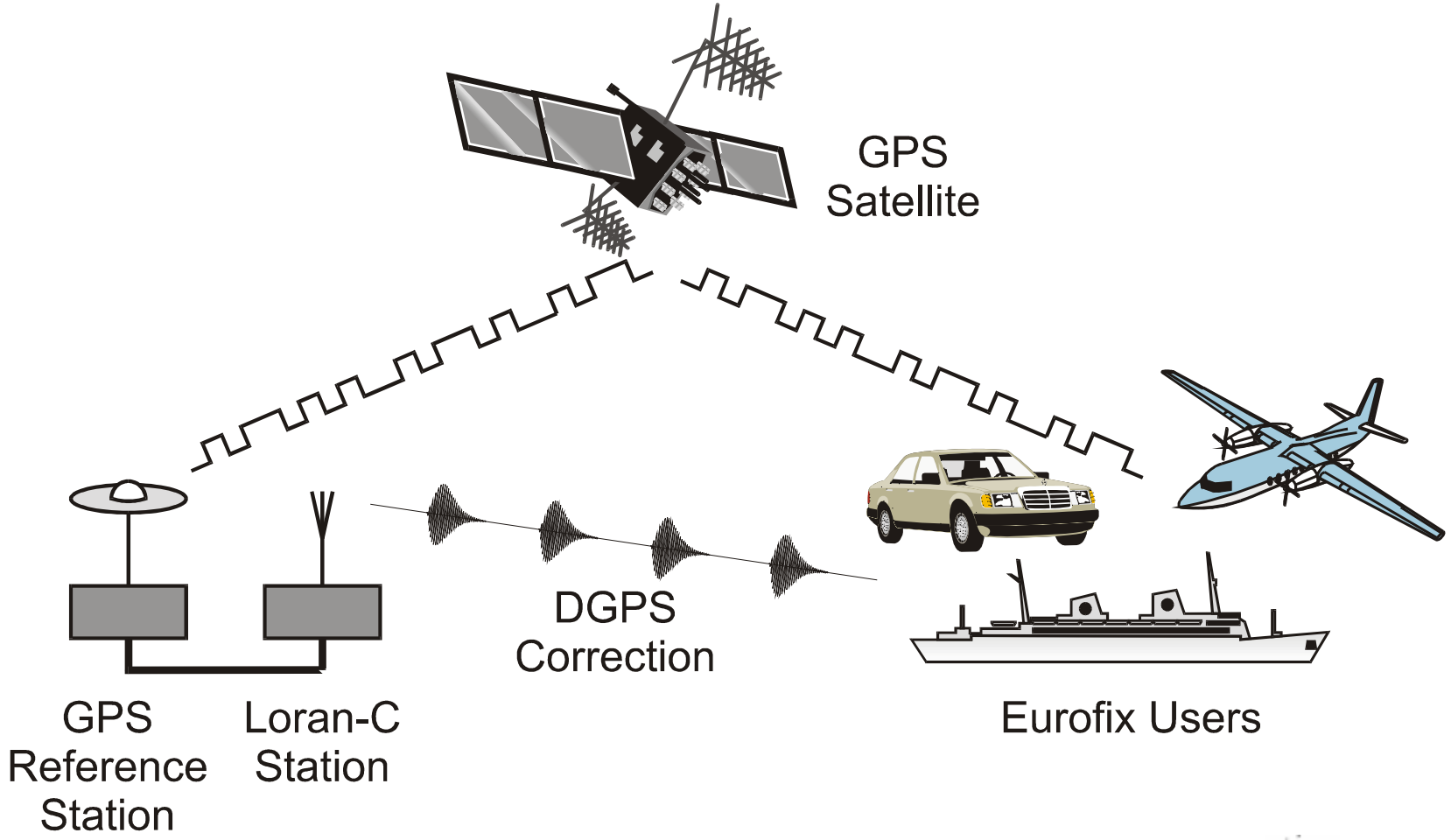
Overview

- Eurofix system overview and datalink concept
- Integrating Loran/Eurofix/GPS
- Recent developments in Eurofix
  - Installation of DGPS equipment on 4 stations
  - Installation of Integrity Monitoring on 4 stations
  - Development of receivers
- European projects underway
- Conclusions

System Overview



Eurofix service

- 3 m (95%) Local Area DGPS service
  - L1 code corrections
- GPS integrity service
- Large coverage area (1,000 km per station)
- Uses existing Loran-C infrastructure
- Cost-effective implementation
- Multi-station DGPS improves accuracy, availability and integrity of service

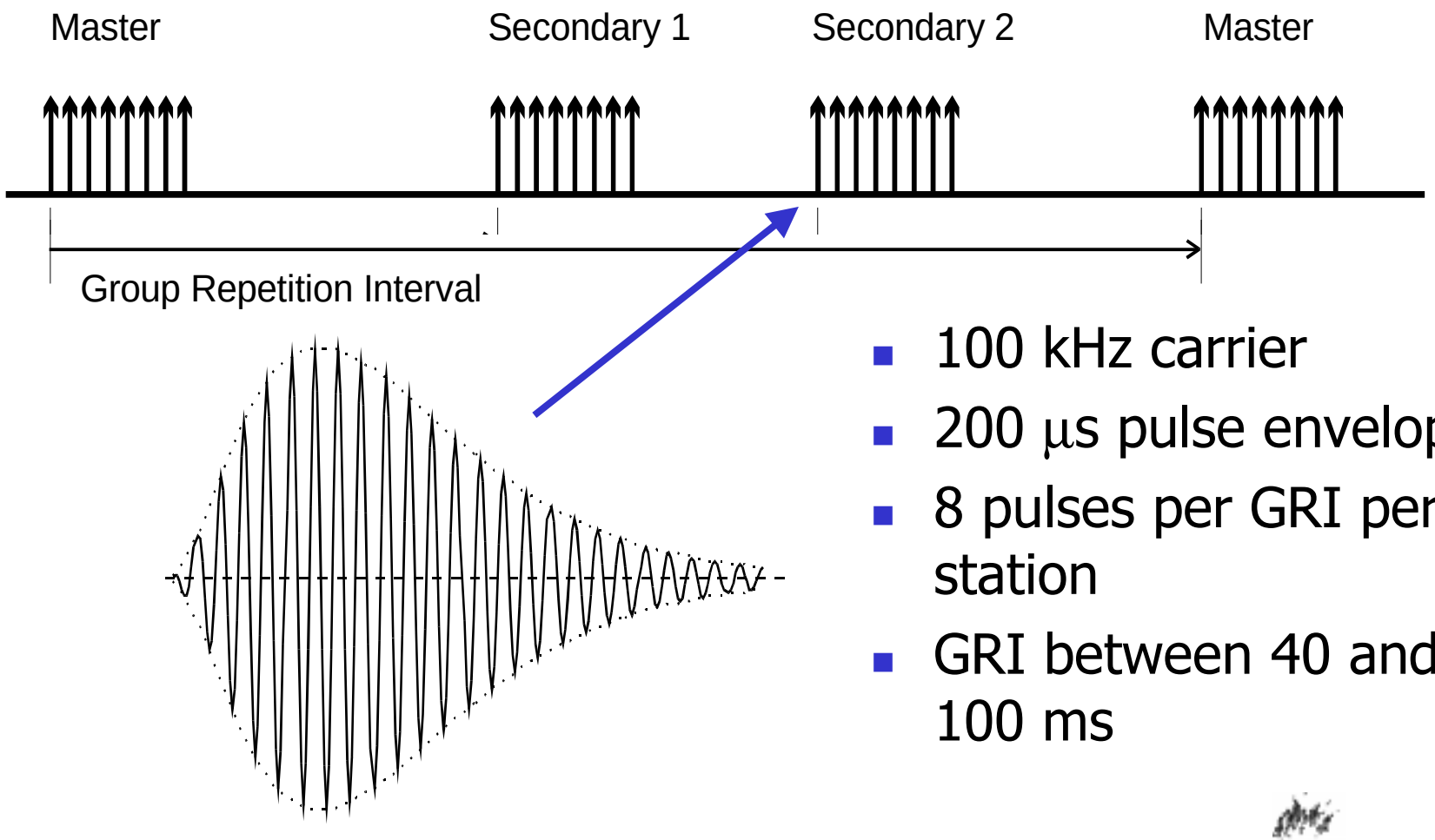
Eurofix Loran-C datachannel

- Additional modulation shall not deteriorate Loran-C navigation
- Eurofix messages have to be fully RTCM compatible

Chosen datalink:

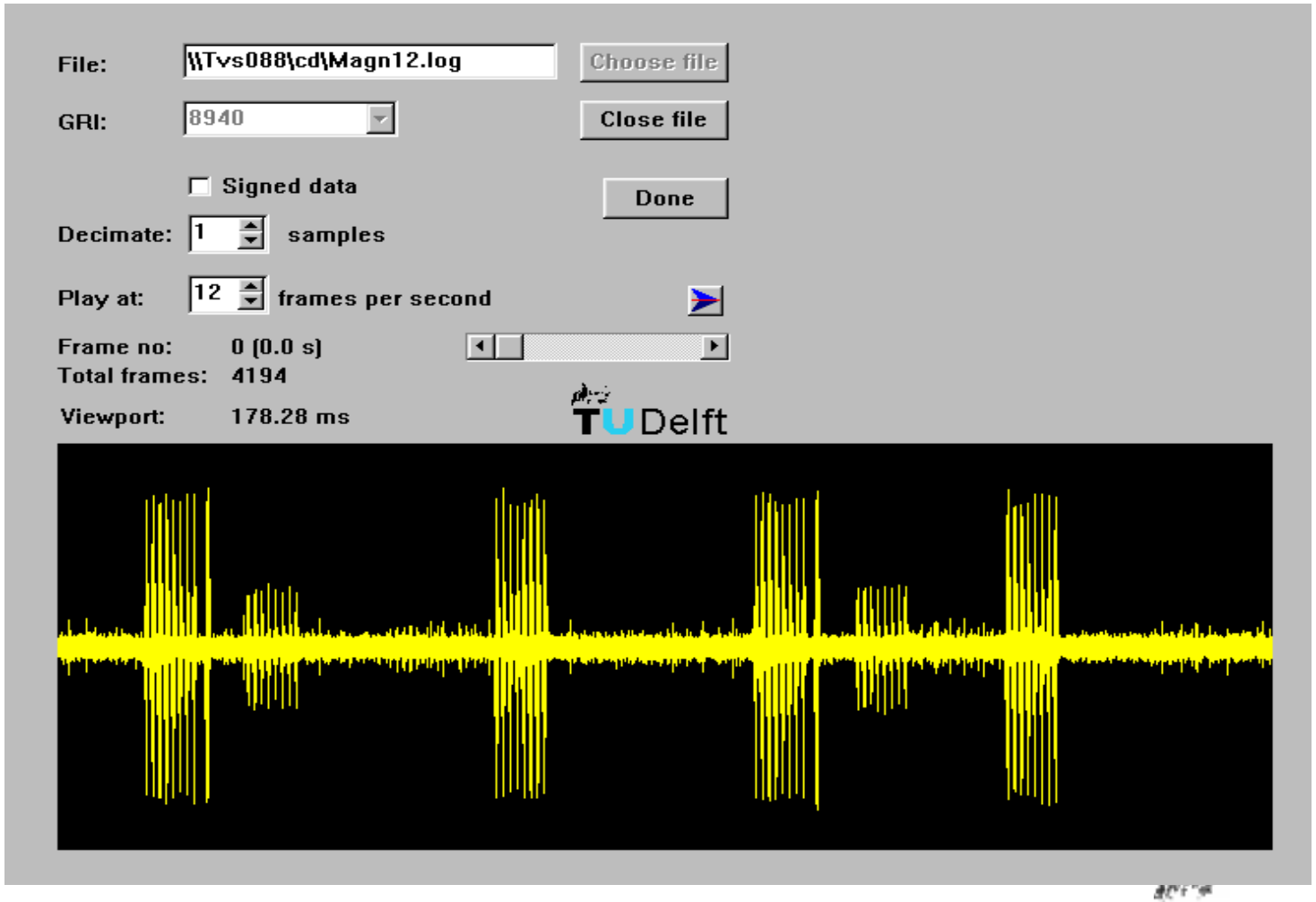
- Loran Pulse Position Modulation results in 30 bps datalink
- Strong Forward Error Correction ensures robustness of datalink service

Loran-C signal format

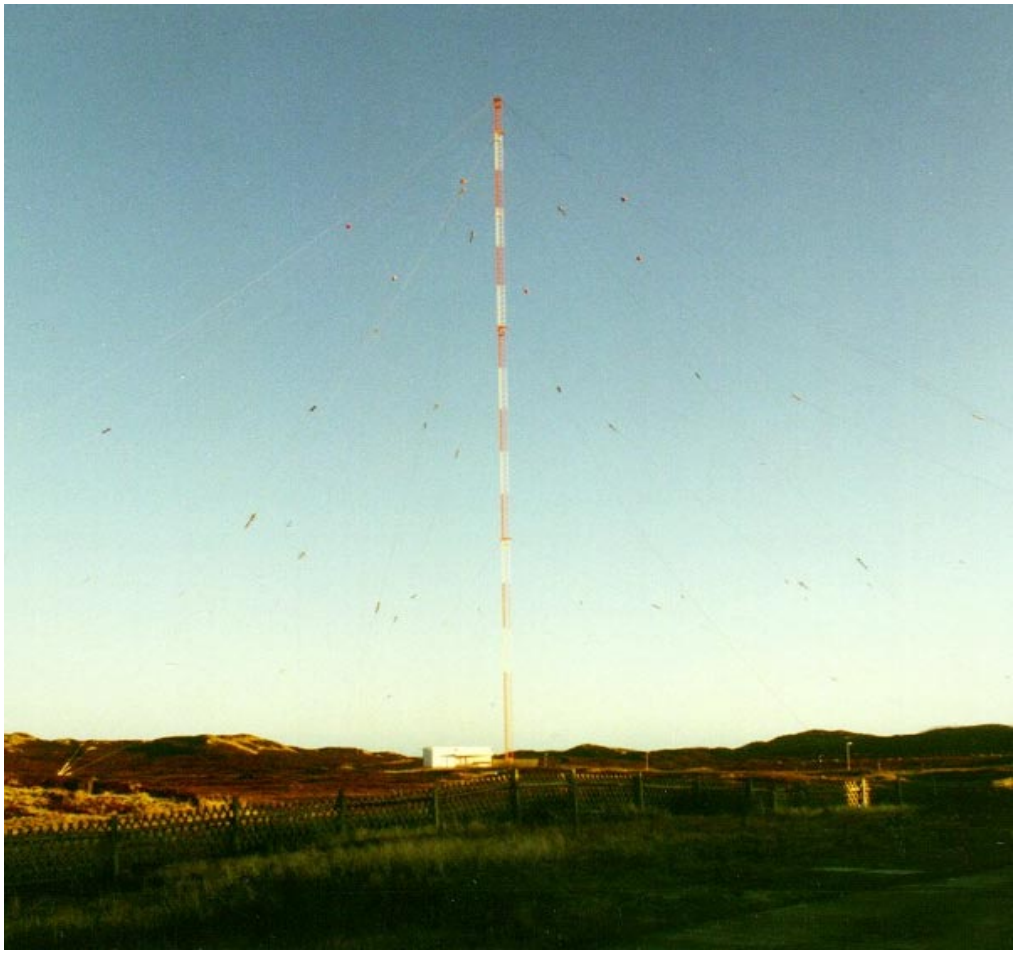


- 100 kHz carrier
- 200 μs pulse envelopes
- 8 pulses per GRI per station
- GRI between 40 and 100 ms

Digitized RF; mobile recording

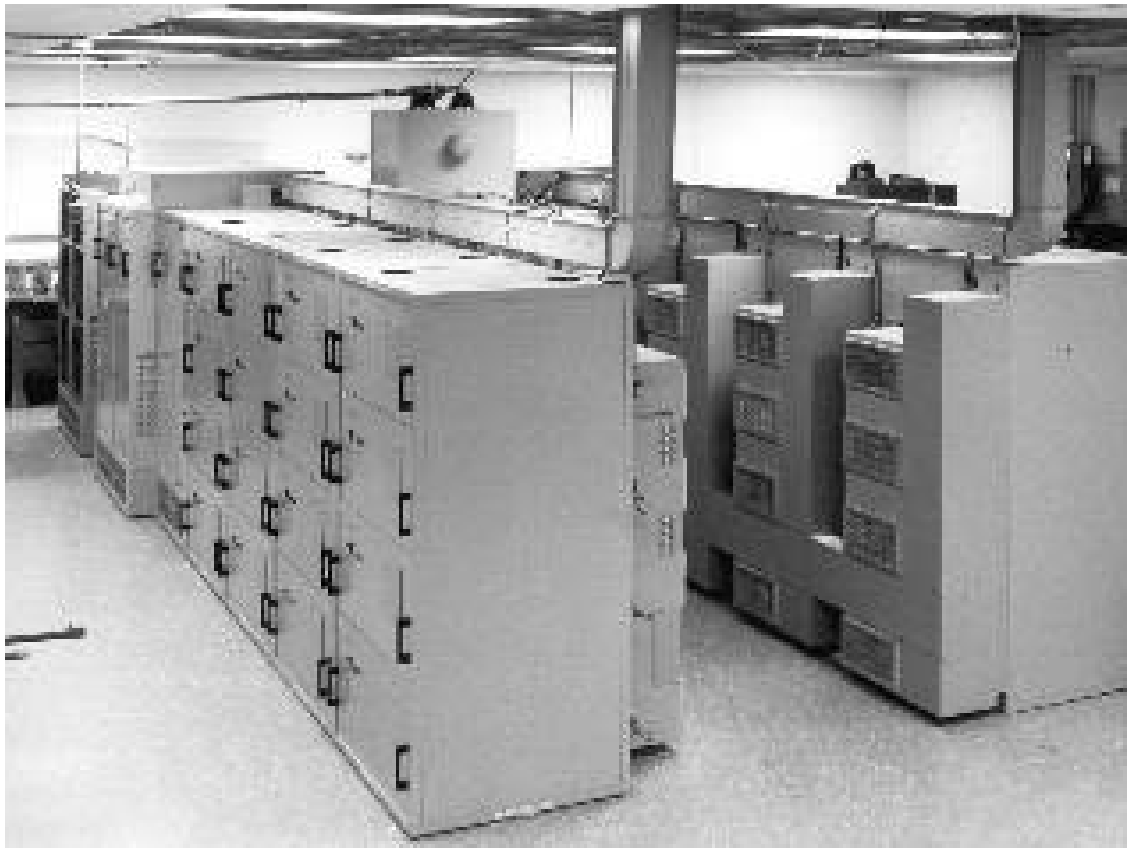


Loran-C transmitter



- 100 kHz Loran-C signal
- Antenna mast 200 m
- Approximately 1,000 km range
- Automatic stations with back-up power

Loran-C transmitter



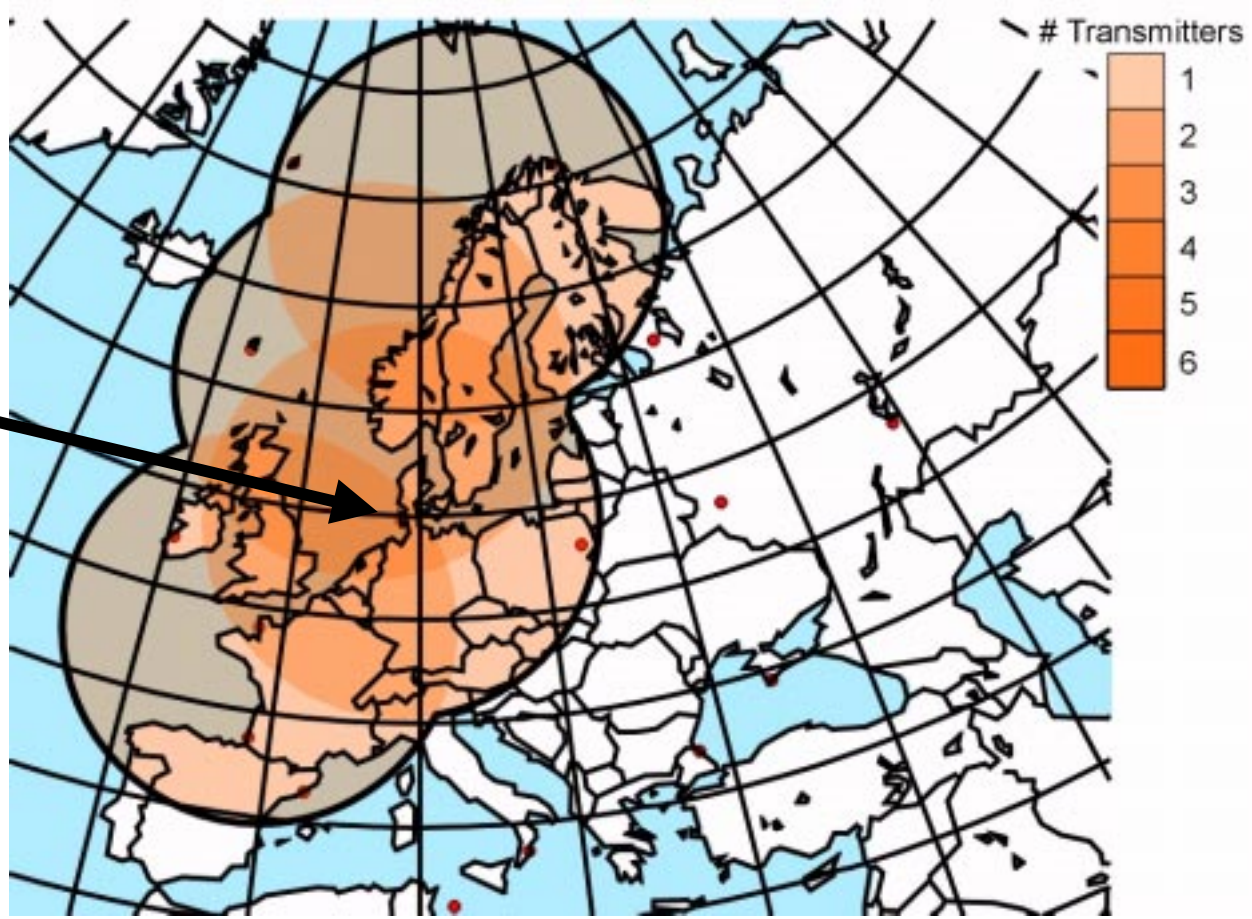
- 250 kW transmitters
- UTC controlled Loran-C transmissions

Eurofix Coverage - Feasibility Phase

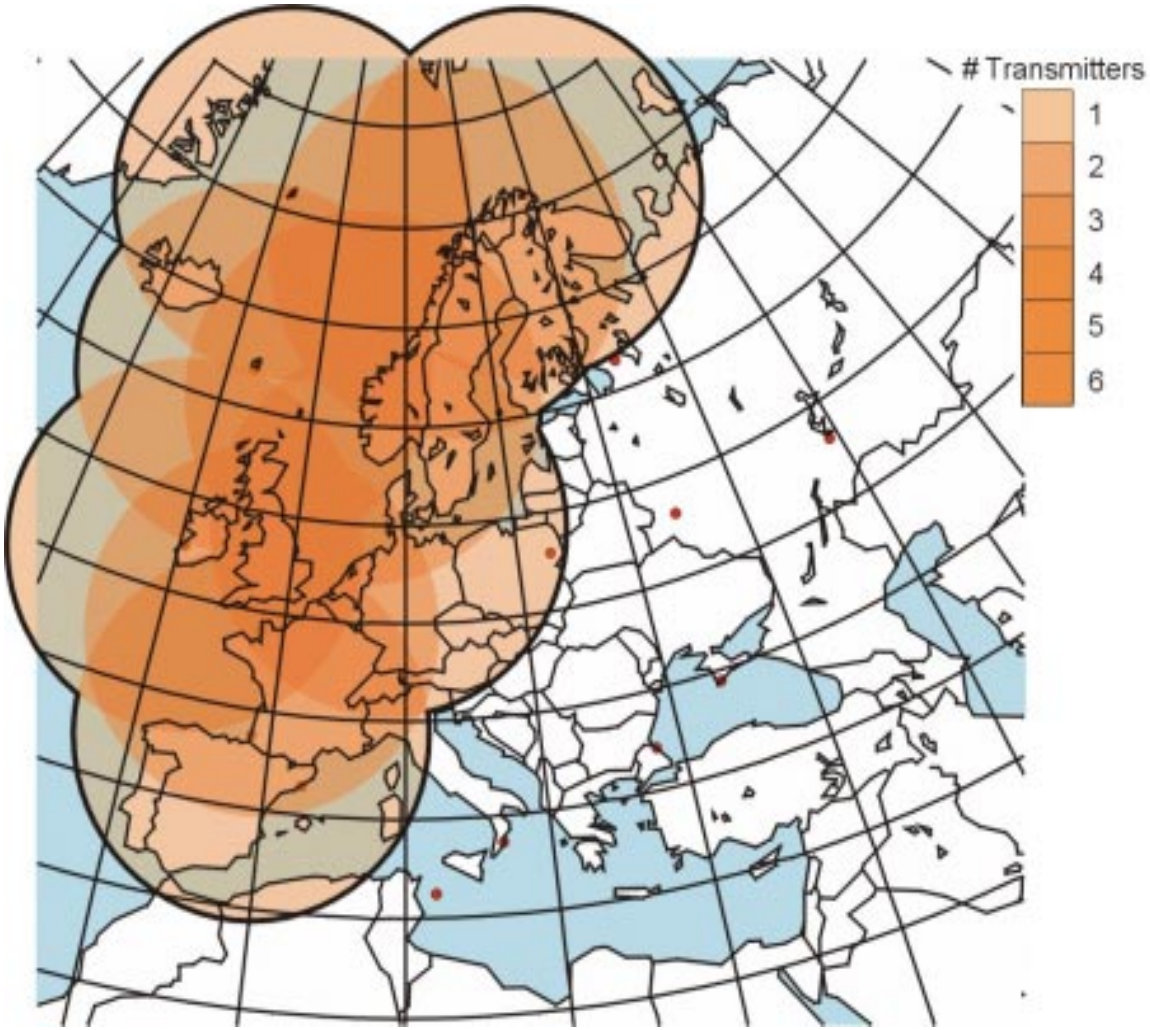
Bø, Værlandet, Sylt & Lessay

Sylt

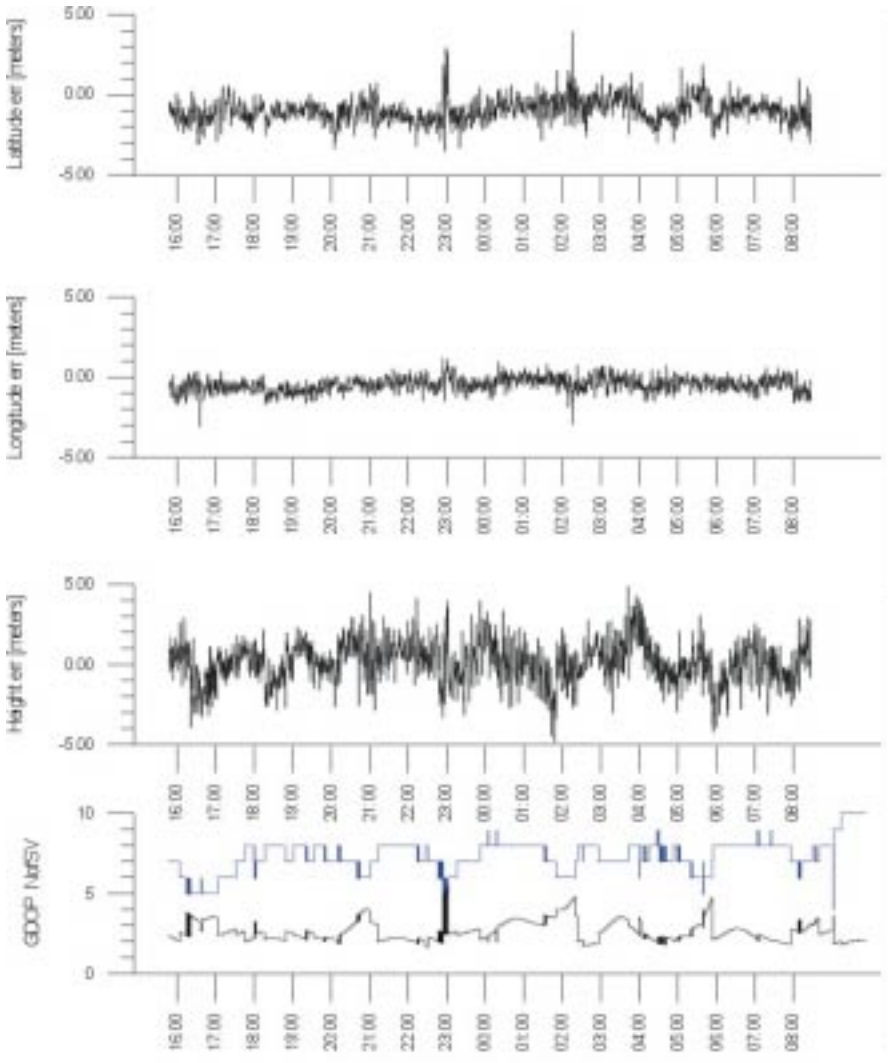
Coverage range:
appr. 1,000 km

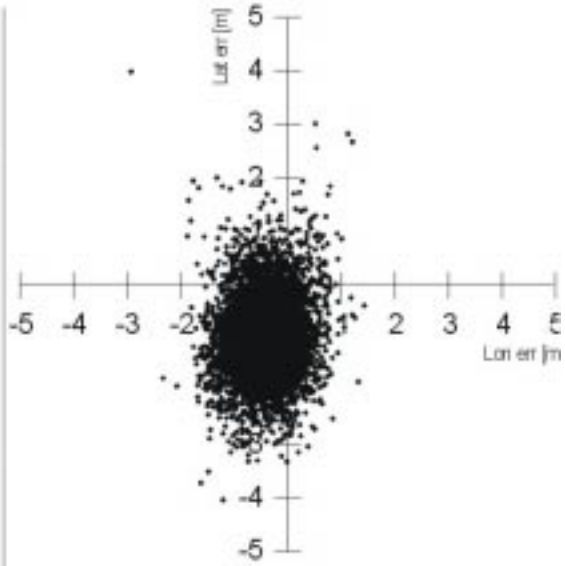


Projected NELS coverage



Eurofix LADGPS performance





Date		:	6-apr-1998
Starttime		:	15:47
Endtime		:	08:27
CEP	(50 %)	:	1.19 m
dRMS	(68 %)	:	1.47 m
2dRMS	(95 %)	:	2.22 m
=< 2.5 m		:	97.8 %
=< 5.0 m		:	100.0 %
=< 7.5 m		:	100.0 %
> 7.5 m		:	0.0 %

Eurofix

TU Delft

GNSS and Loran-C system characteristics

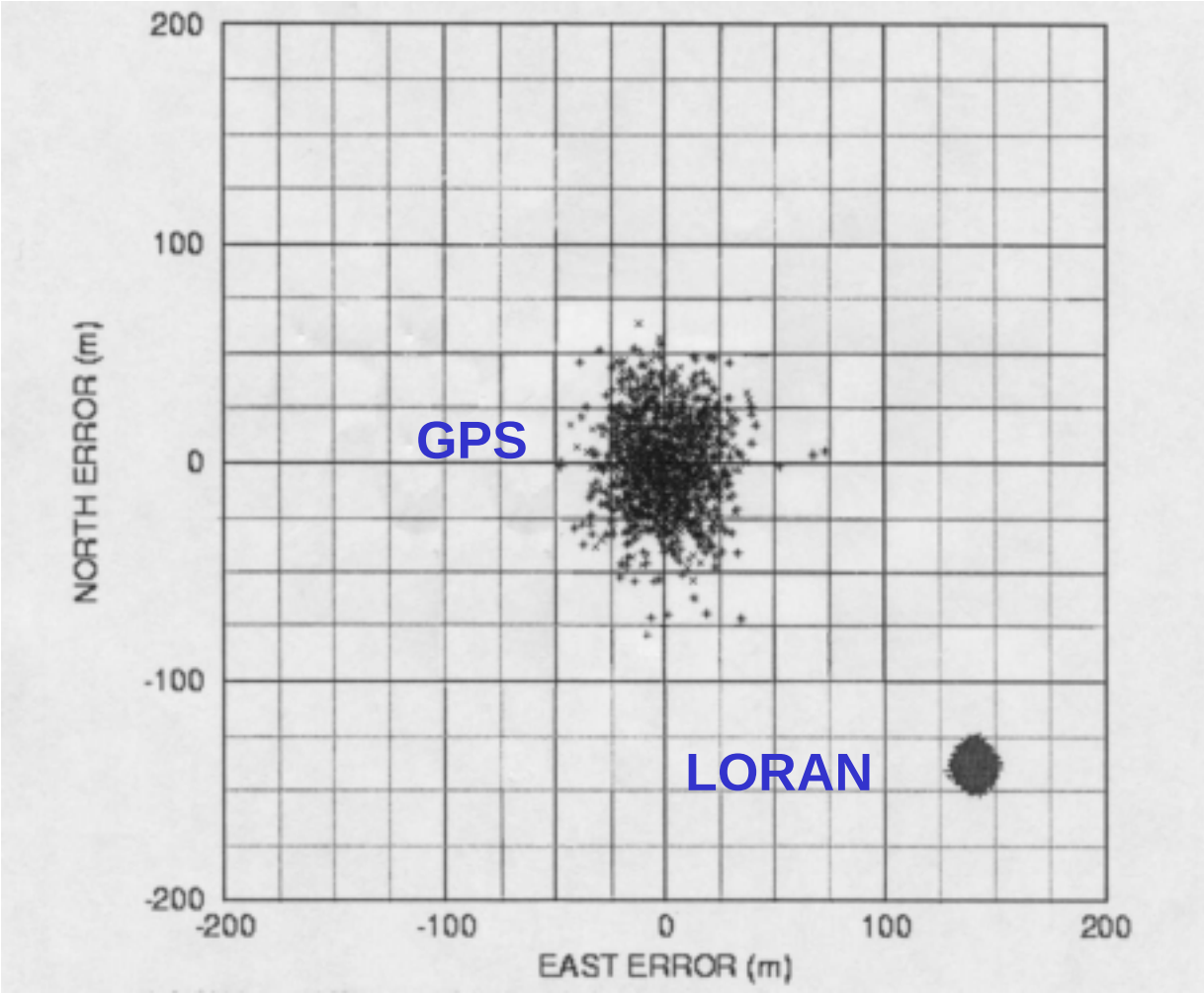
GNSS

- Ultra-High Frequency, low power
- Satellite based
- Line of sight propagation (multipath, shadowing)
- Global coverage

Loran-C

- Low Frequency, high power
- Ground based
- Groundwave and Skywave propagation
- No global coverage
- Good urban penetration

GPS vs. Loran positioning



- **GPS (SA) 100 m**
- **GPS (No SA) 10 m**
- **DGPS 3 m**
- **Loran-C 450 m**
- **Calibrated Loran-C 10-30 m**

From:
"The Case for Loran"
July- September edition of Journal of Air Traffic Control

Loran-C as a Back-up for GPS Positioning

- Loran-C is a fully independent, terrestrial positioning system
- New receiver technology (Locus) shows that a Loran-C Repeatable Accuracy of 5 meters is possible
- When Loran-C ranges are calibrated using DGPS while still available, Loran-C's *repeatable* accuracy becomes the *absolute accuracy*
- Loran-C/Eurofix enables accurate positioning in moments when GPS not available

GNSS and Loran-C integrated positioning

Number of Loran-C Transmitters	GPS / Loran-C	Number of Satellites: 0	1	2	3	4	5+
	0	-	-	-	2D	3D [2]	3D Integrity
	1	-	-	-	2D	3D [2]	3D Integrity
	2	-	-	2D	3D [2]	3D Integrity	3D Integrity
	3	2D	2D	3D [2]	3D Integrity	3D Integrity	3D Integrity
	4+	2D [1] Integrity	2D [1] Integrity	3D Integrity	3D Integrity	3D Integrity	3D Integrity

[1] Loran-C is not suitable for altitude determination.
[2] 3D or 2D + Integrity.

From “The Potential of Hybrid GPS/LORAN-C Receivers”, dr. D. Kügler, ILA ’97

Recent developments
Installation at 4 stations

- Reference station
  - PC
  - Novatel GPS Rx
  - Connection to Loran Timer
  - Modem for remote monitoring/maintenance
- Integrity Monitor
  - PC
  - Novatel GPS Rx
  - Eurofix datalink RX
  - Integrity feedback to Reference Station

NELS Gauss Initiative

- ITU standard, describing Eurofix modulation and coding scheme, is ready for approval
  - ITU-R M.589-3
  - Co-ordination with RTCM Eurofix subgroup
  - 16 possible message types, 3 currently used
    - DGPS
    - DGLONASS
    - Short Text message
  - New messages … ?
- IEC and IMO standardisation is underway

Receiver development

Companies developing Eurofix datalink receivers

Available:

- Reelektronika BV (Netherlands) ERX104-D1
- Locus Inc. (USA) SatMate

Under development:

- ViCon Engineering (Germany) Miniature receiver
- Diginext (France)

ERX104-D1 receiver

10 cm

ERX104-D1 with H-field antenna

European Navigation projects

- Loran-C/Eurofix related
  - EFP — **E**urofix **F**easibility **P**hase, installation of Eurofix on 4 NELS Loran-C transmitters
    http://www.nels.org
    http://www.reelektronika.nl
  - Disc-II — Loran-C/Eurofix receiver concept development
  - EUROLOG — Miniaturisation of Loran-C/Eurofix receivers
  - TACIS — Technical **A**ssistance for **CIS** countries - Establishment of a joint Loran-C/Chayka navigation system in southern Europe

European Navigation projects

- Integrated Navigation
  - LOREG — **LOR**AN/Eurofix/**EG**NOS Test & Validation Programme
    http://www.telematica.de/loreg/
    Started May 2000
  - GLORIA — **G**NSS & **LO**ran-C for **R**oad and Ra**I**l **A**pplications
    http://www.eu-gloria.org/
    Started September 2000

Conclusions

- Eurofix developed by TU Delft is currently being deployed in Europe (NELS)
- European Commission supports projects for integrated navigation in which Loran/Eurofix is a component
- Eurofix receivers are commercially available
- Eurofix data modulation and transmission format is being standardised by ITU and RTCM; IEC and IMO underway
- Number of projects are going to evaluate integrated GNSS/Loran/Eurofix performance

More information

Arthur Helwig
TU Delft - Elektrotechniek
+31-15-2785844
A.Helwig@ITS.TUDelft.nl

A.Helwig@reelektronika.nl

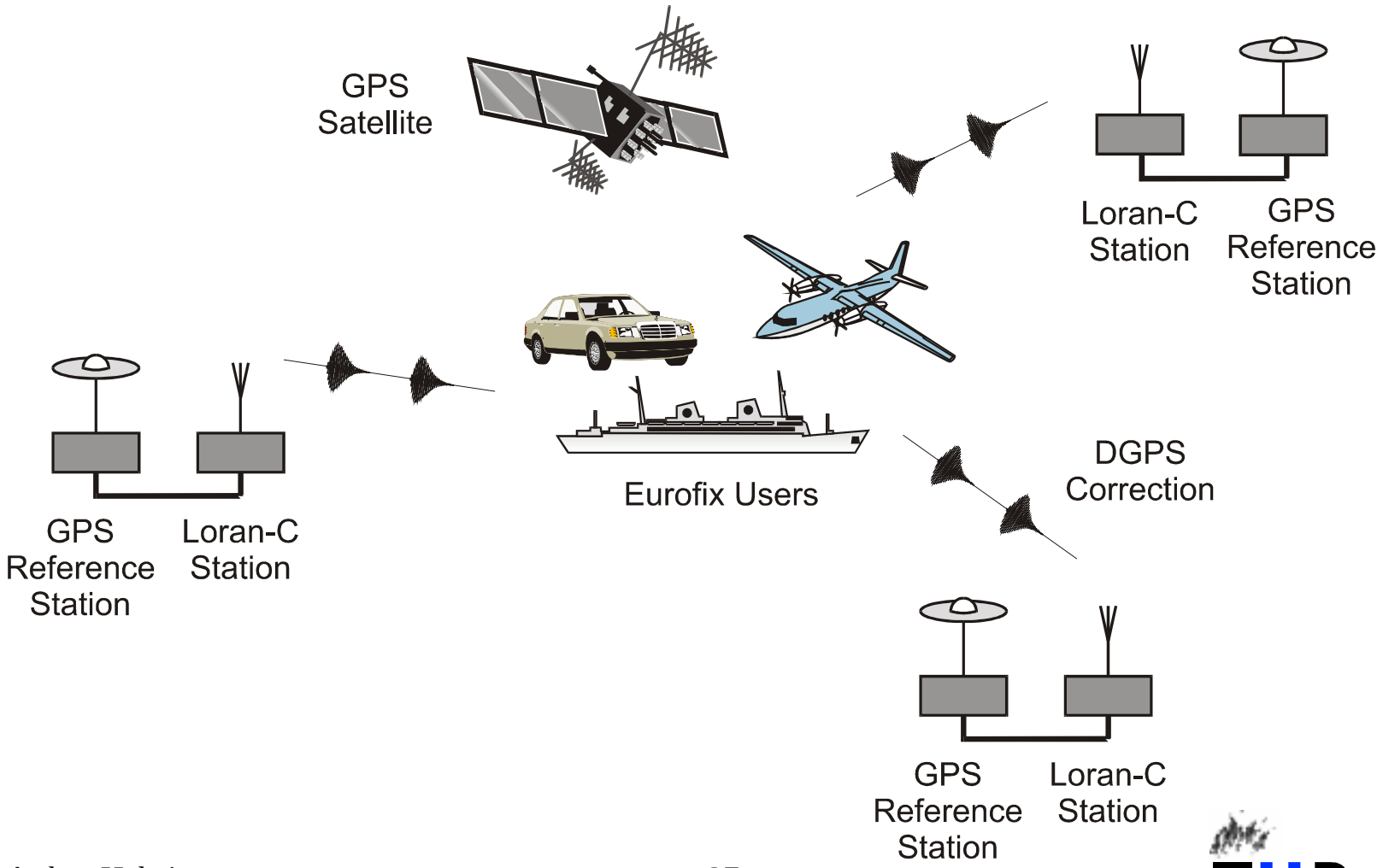
Gerard Offermans
Reelektronika bv
+32-16-482707
G.Offermans@reelektronika.nl

Prof. Durk van Willigen
Reelektronika bv
+31-182-393456
D.vanWilligen@reelektronika.nl

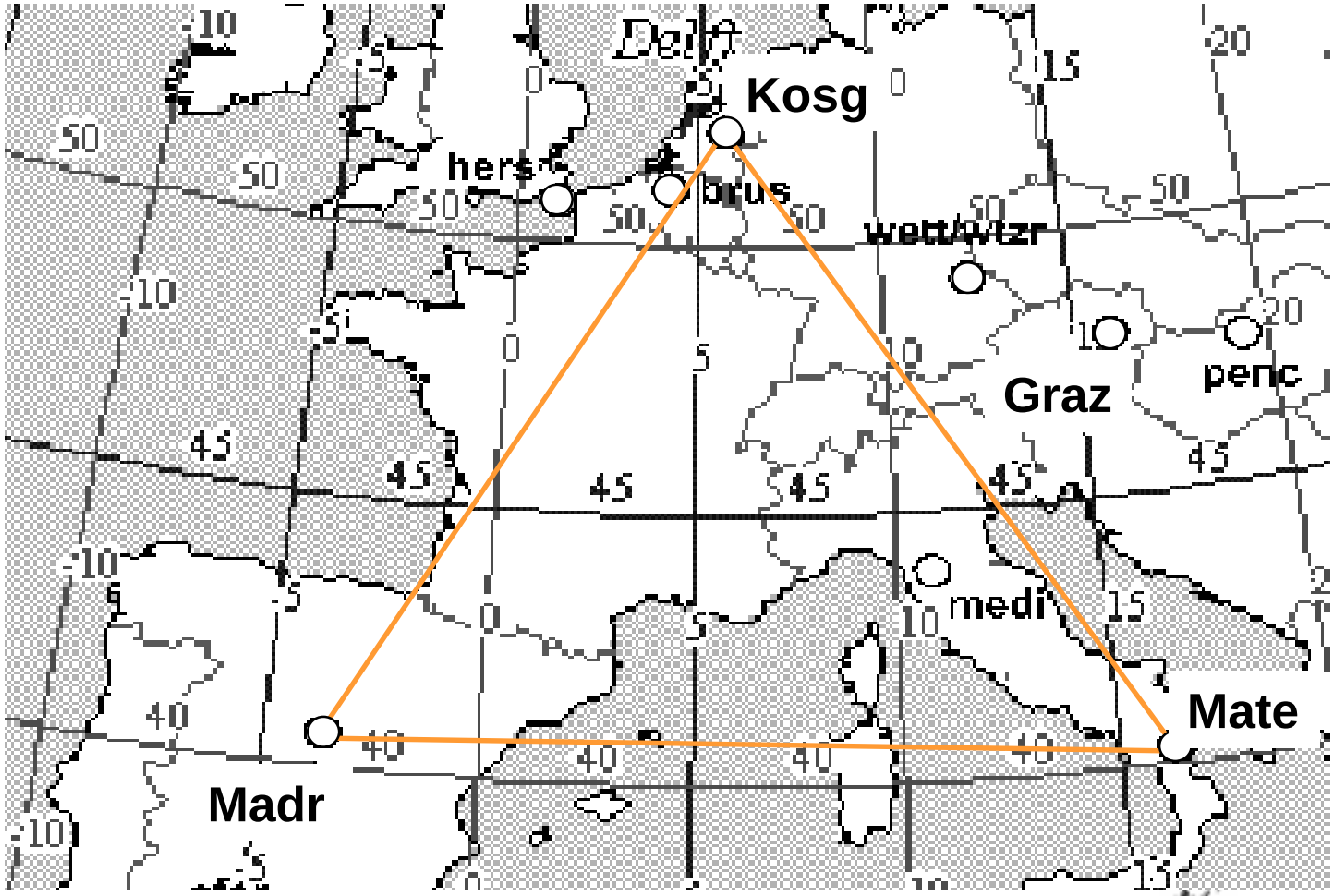
Backup

Backup and Background Slides

RAAS Concept

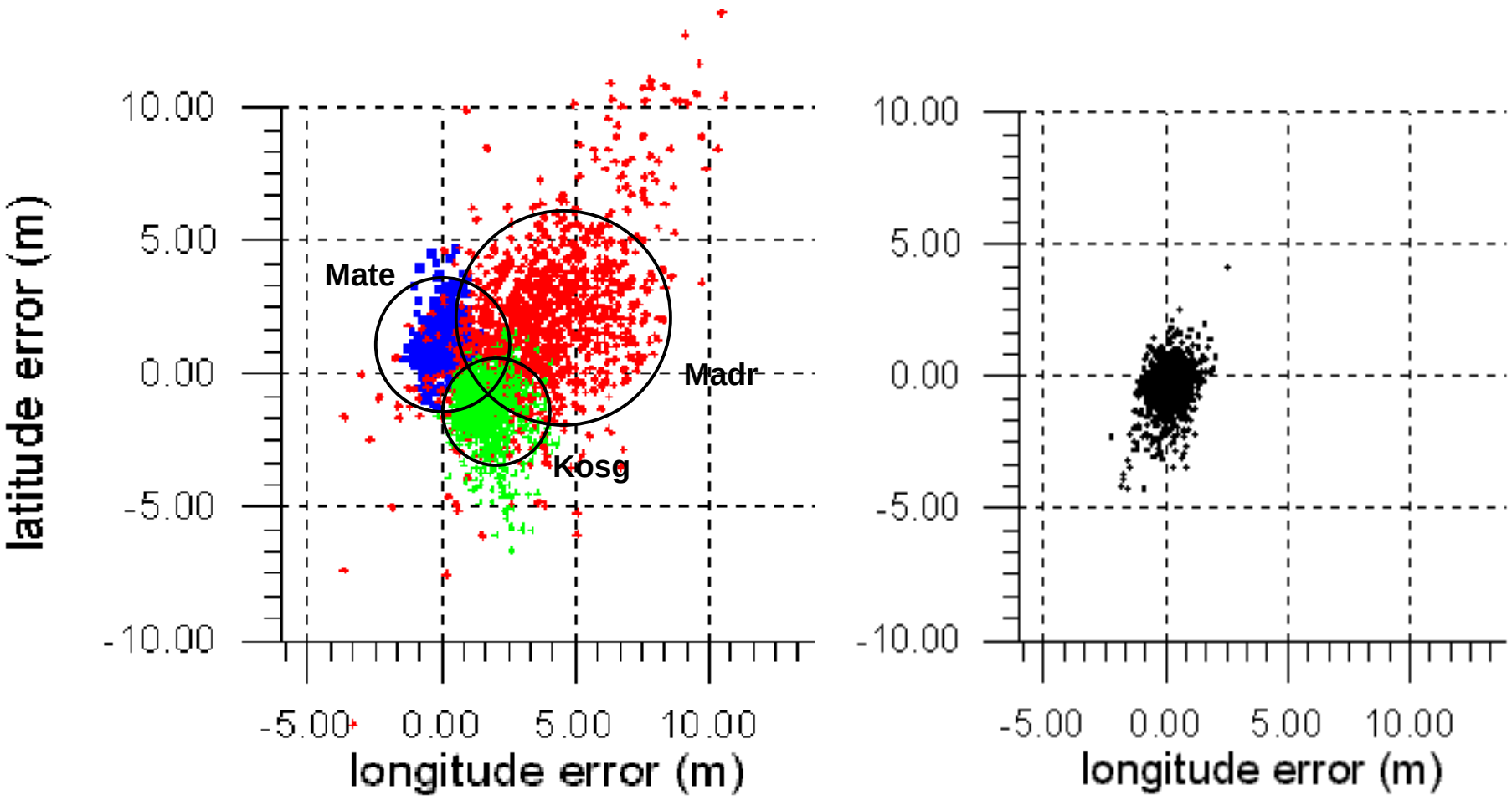


European RAAS Experiment - 1



Baselines approx. 1,500 km

Eurofix RAAS Positioning Results



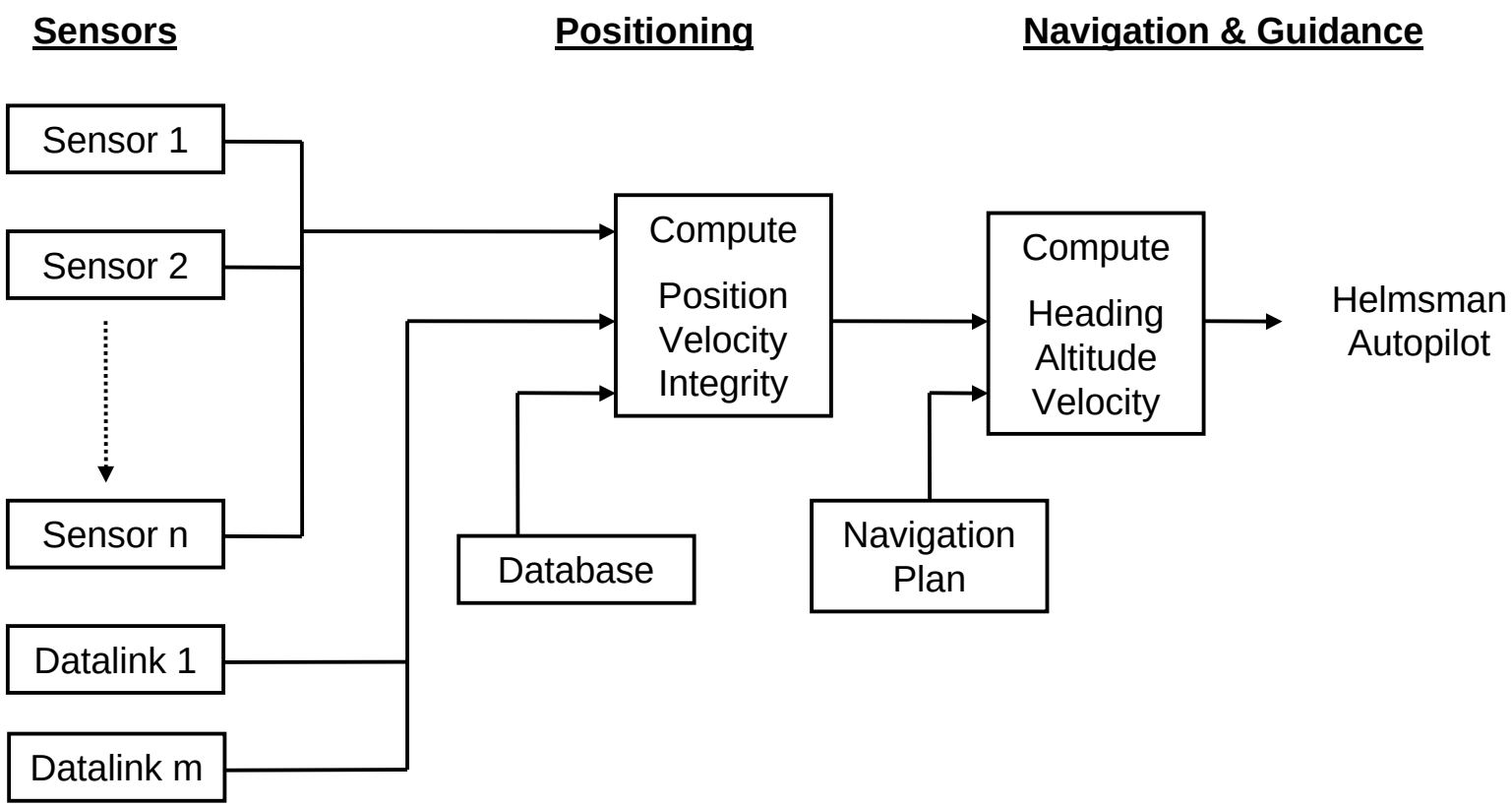
Baselines ± 1,500 km

Eurofix Message Format

Function	Number of bits	Resolution	Range
Message type	3		8 types of messages
Modified Z-count	13	0.6 seconds	0 - 3599.4
Scale factor	1		
UDRE	2		4 states
Satellite ID	5		32 satellites
Pseudo-Range Correction	16	0.02 or 0.32 m	±655.34 or ±10,485.44 m
Range Rate Correction	8	0.002 or 0.032 m/s	±0.254 or 4.064 m/s
Issue of Data	8		
Total:	56		

- Full RTCM SC104 type-9 compatible
- Station ID through Loran-C Station Identification
- RTCM parity replaced by Eurofix FEC

Integrated Navigation concept



NELS Eurofix Feasibility Phase

- NELS has initiated a feasibility phase in which 4 transmitters are upgraded with Eurofix technology
- Reference Stations on-air since last summer
- On-site Integrity Monitoring is currently being added
  - Datalink integrity
  - Pseudorange integrity
  - Position integrity