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Differential eLoran Reference Station for Maritime and Precise Time Applications

Gerard Offermans, Arthur Helwig,
Reelektronika NL

International Loran Association
36th Annual Convention and Technical Symposium
October 14-17, Orlando

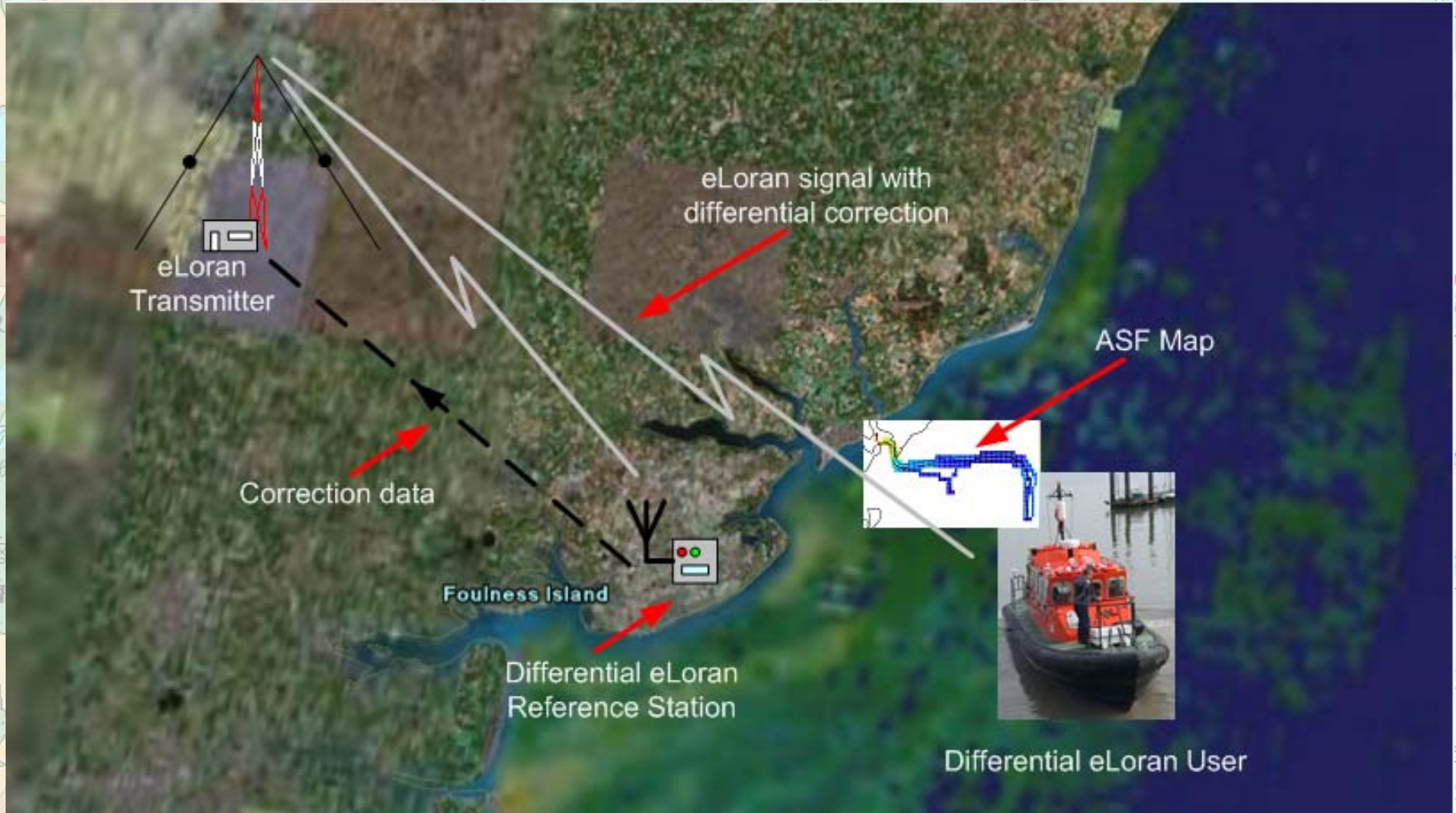
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Real-time Differential eLoran trials in Harwich Harbour – Harwich II

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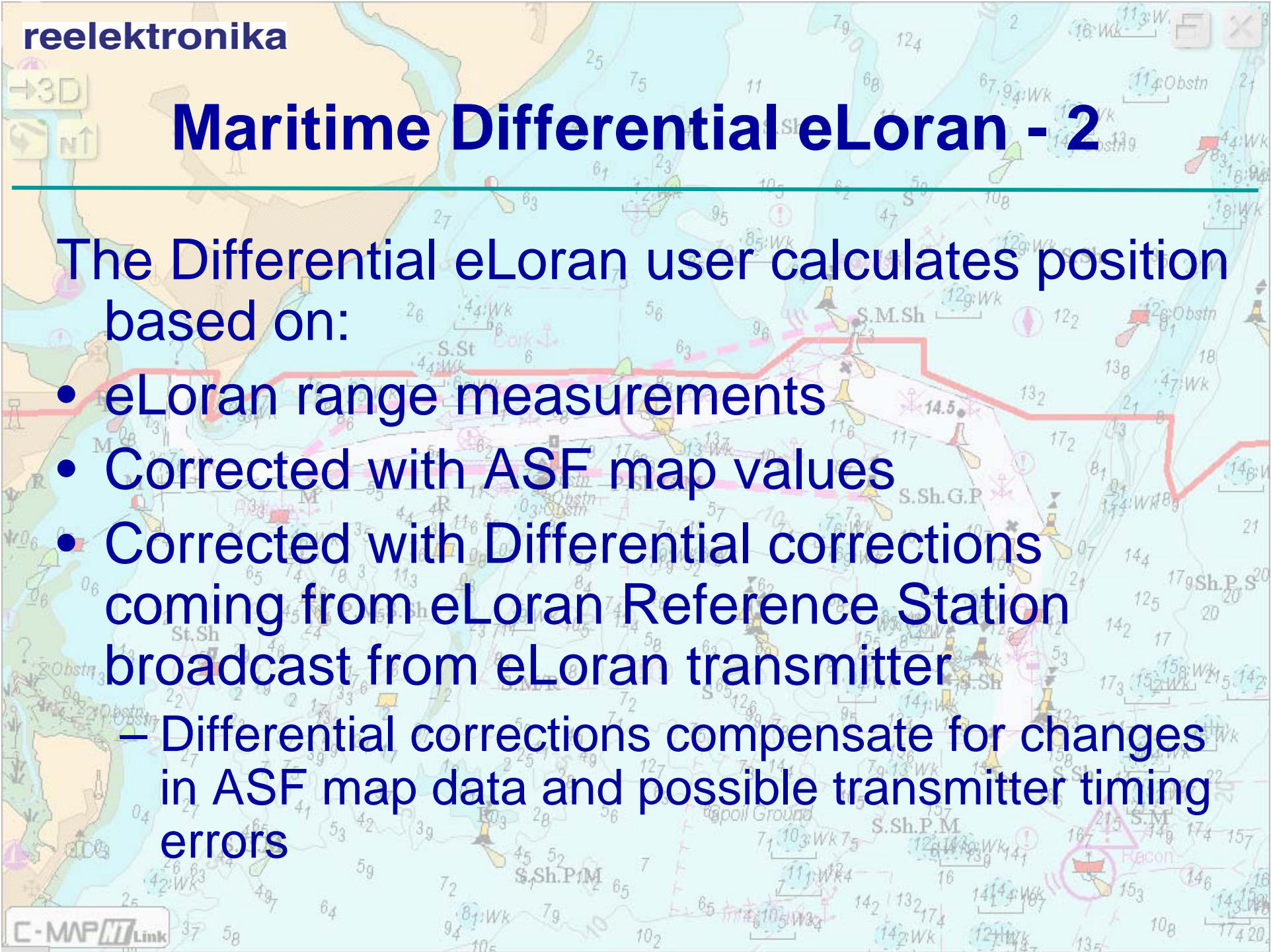
Maritime Differential eLoran



Maritime Differential eLoran - 2

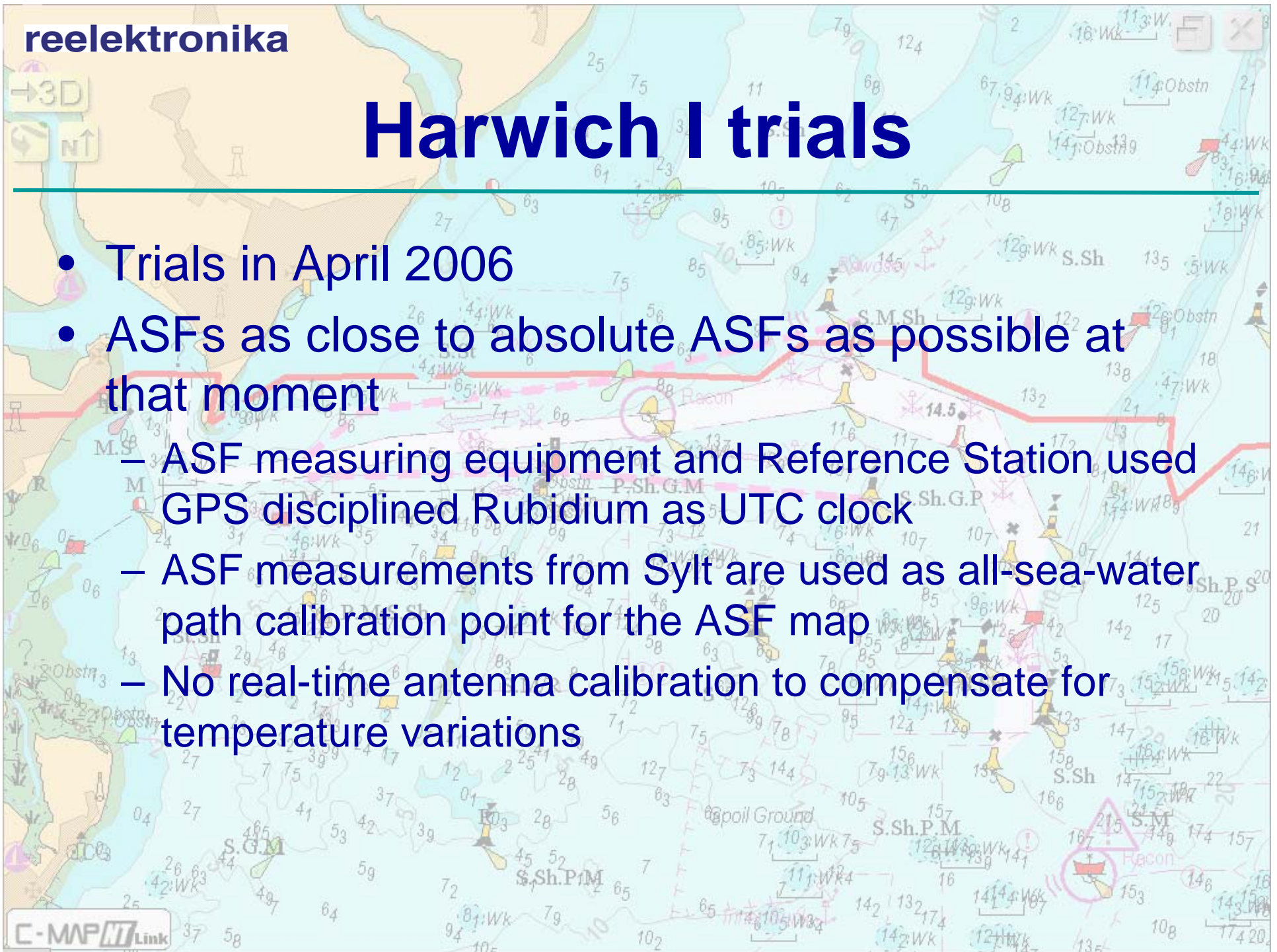
The Differential eLoran user calculates position based on:

- eLoran range measurements
- Corrected with ASF map values
- Corrected with Differential corrections coming from eLoran Reference Station
 - Differential corrections compensate for changes in ASF map data and possible transmitter timing errors

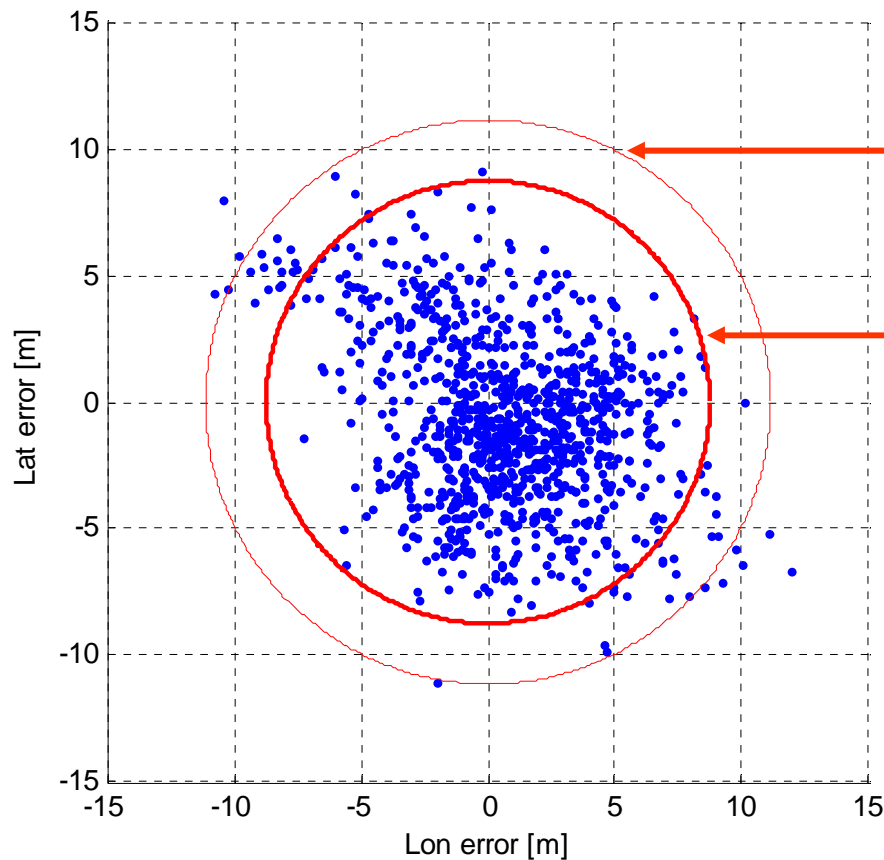


Harwich I trials

- Trials in April 2006
- ASFs as close to absolute ASFs as possible at that moment
 - ASF measuring equipment and Reference Station used GPS disciplined Rubidium as UTC clock
 - ASF measurements from Sylt are used as all-sea-water path calibration point for the ASF map
 - No real-time antenna calibration to compensate for temperature variations



Harwich I Measurement results



Outer red circle: 99% measured accuracy – 11.1 m

Inner red circle: 95% measured accuracy – 8.7 m

The scatter plot represents the difference between DGPS and differential eLoran positioning (position fix based on 5-sec integrated independent eLoran measurements)

Harwich II trials

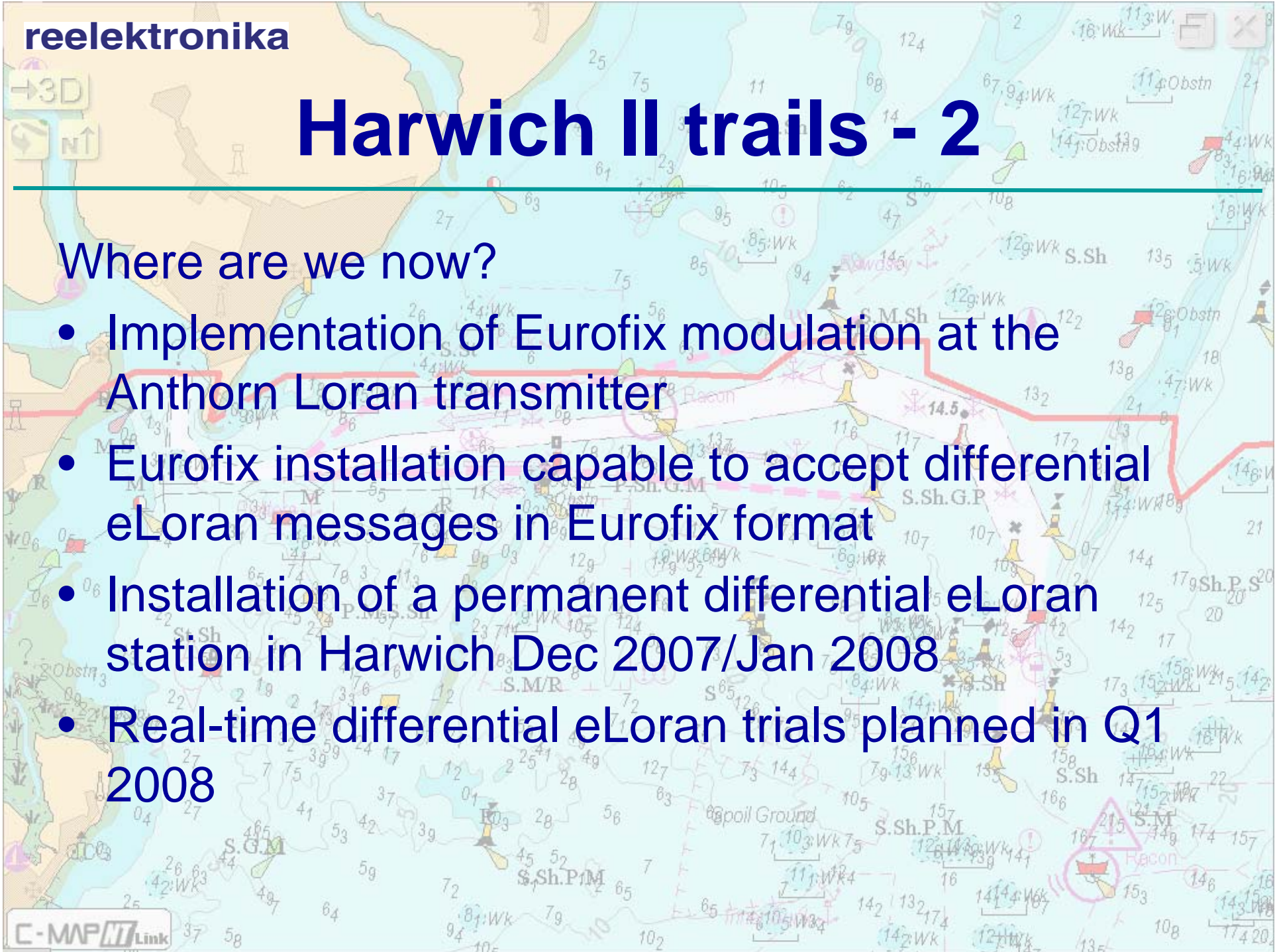
- June 2007 – preparations underway to repeat Harwich I trials
 - Real-time calibration of antenna, front-end and processing path by simulator signal injection
 - Real-time differential corrections via GSM Modem
- July 2007 constraints
 - 4 July Rugby transmitter permanently turned off for replacement to Anthorn
 - Unfortunately, Sylt station went off-air for maintenance 2 weeks before Ruby transmitter was taken off-line
- Now trials are postponed until Anthorn transmitter is operating stable in its designated time slot



Harwich II trails - 2

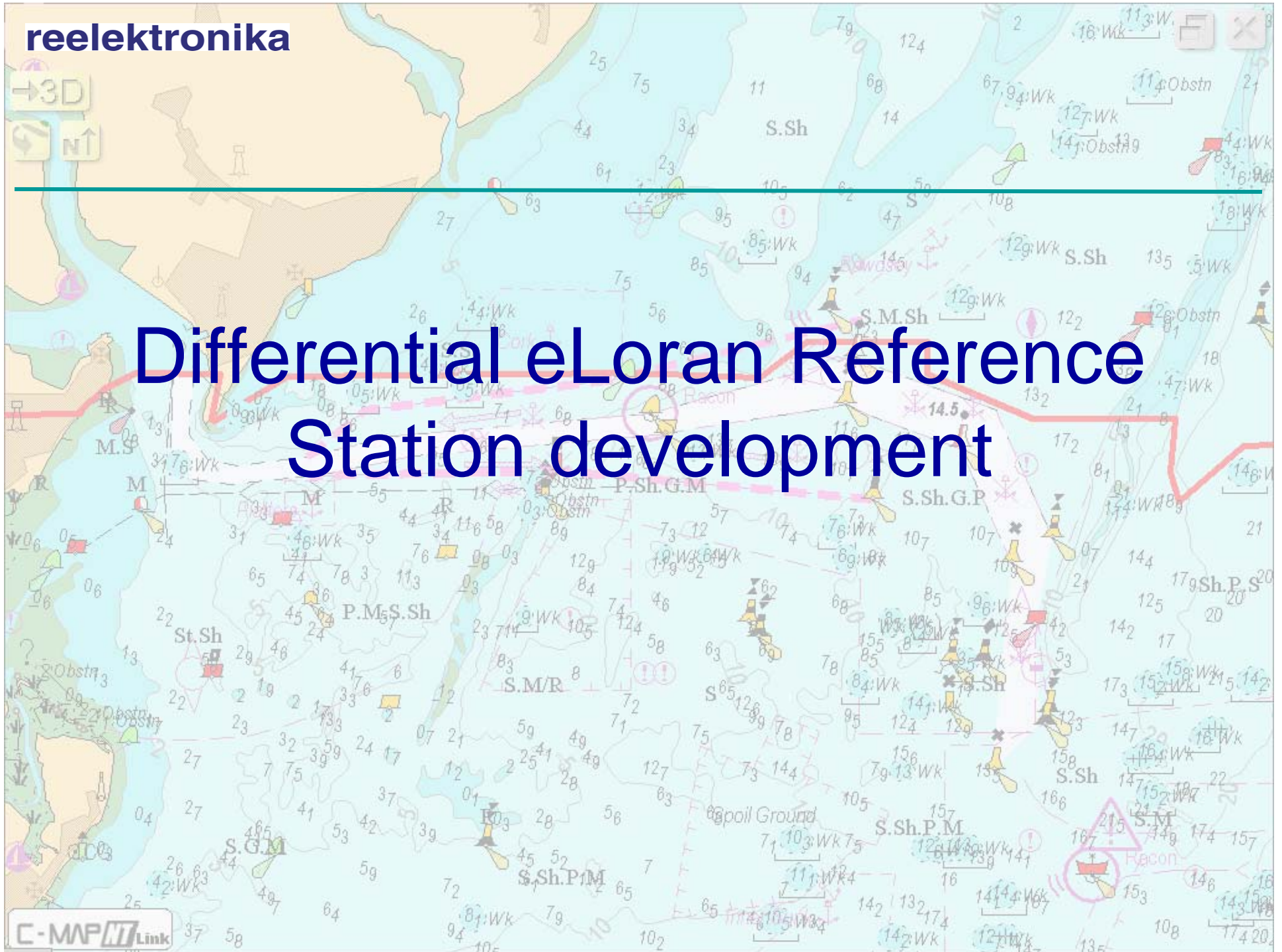
Where are we now?

- Implementation of Eurofix modulation at the Anthorn Loran transmitter
- Eurofix installation capable to accept differential eLoran messages in Eurofix format
- Installation of a permanent differential eLoran station in Harwich Dec 2007/Jan 2008
- Real-time differential eLoran trials planned in Q1 2008



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Differential eLoran Reference Station development



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LORADD TOA Measurement System



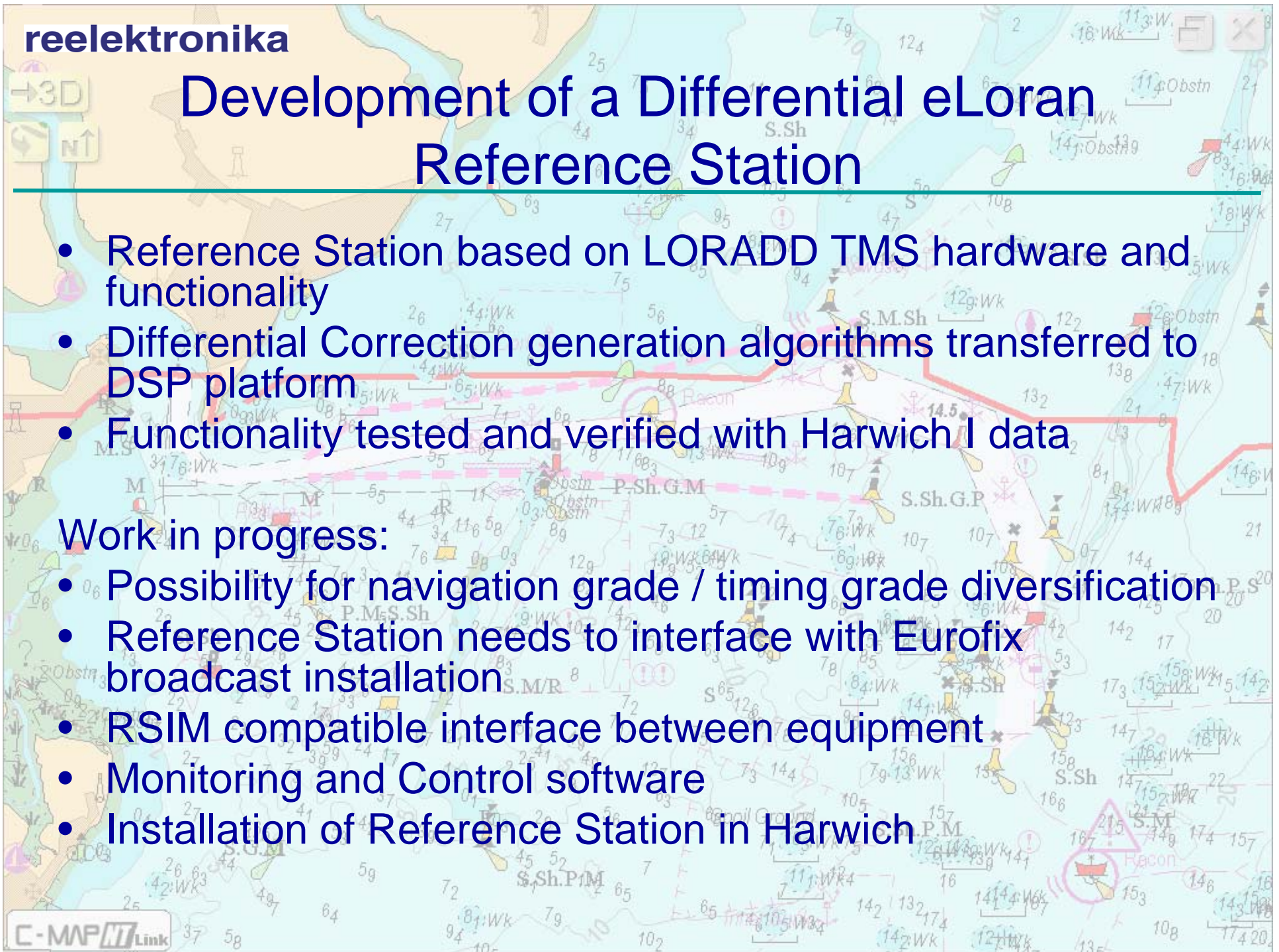
- Includes accurately timed eLoran simulator signal for continuous antenna calibration
- Additional measurement output capabilities
- Various hardware inputs/outputs for time tagging and synchronized data collection
- Turnkey solution for ASF measurements and Differential eLoran Reference Stations
- Functionality and performance presented in Wouter's presentation
- To be used as basis for ASF measurement equipment and Differential eLoran Reference Station

Development of a Differential eLoran Reference Station

- Reference Station based on LORADD TMS hardware and functionality
- Differential Correction generation algorithms transferred to DSP platform
- Functionality tested and verified with Harwich I data

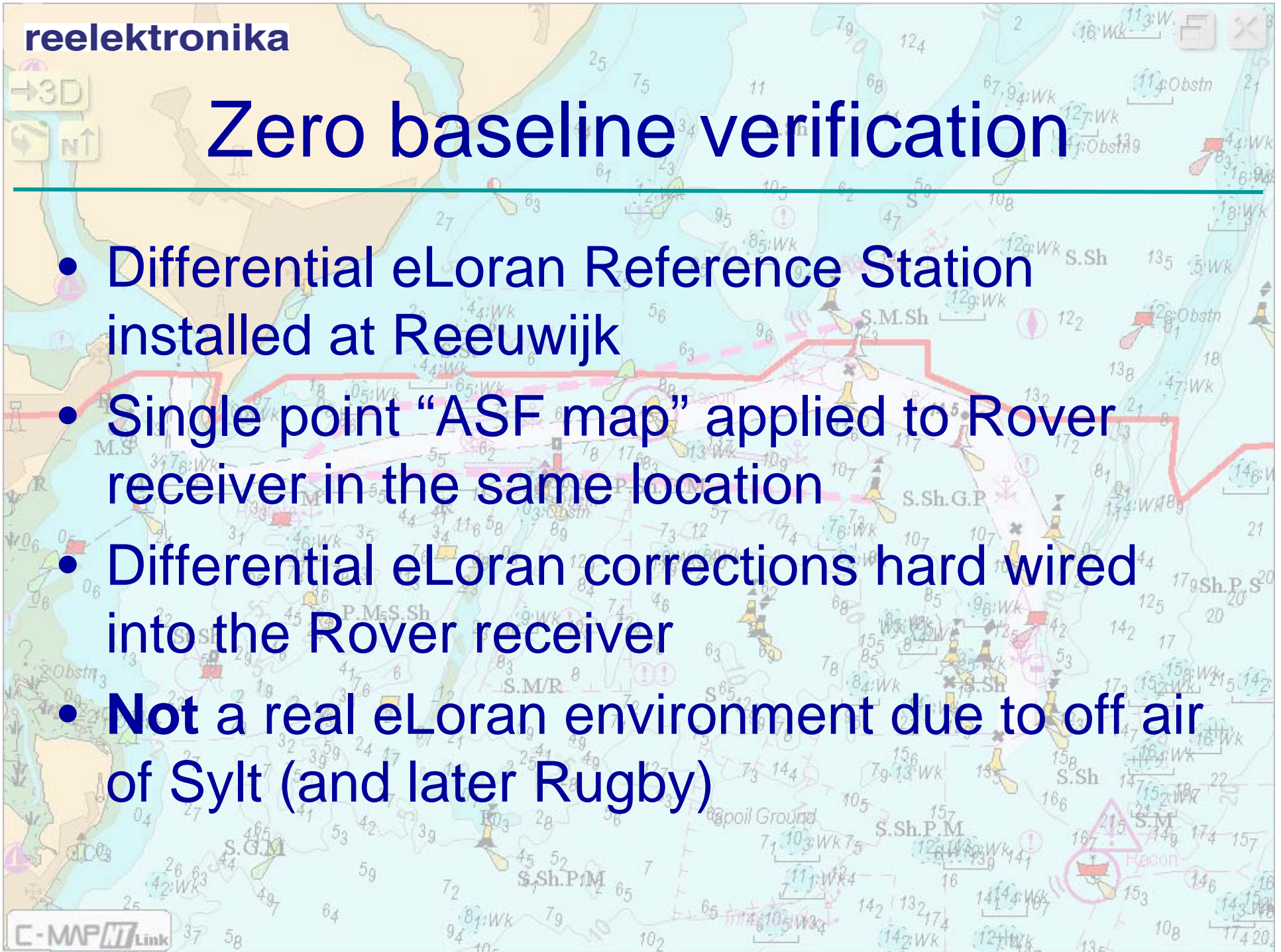
Work in progress:

- Possibility for navigation grade / timing grade diversification
- Reference Station needs to interface with Eurofix broadcast installation
- RSIM compatible interface between equipment
- Monitoring and Control software
- Installation of Reference Station in Harwich

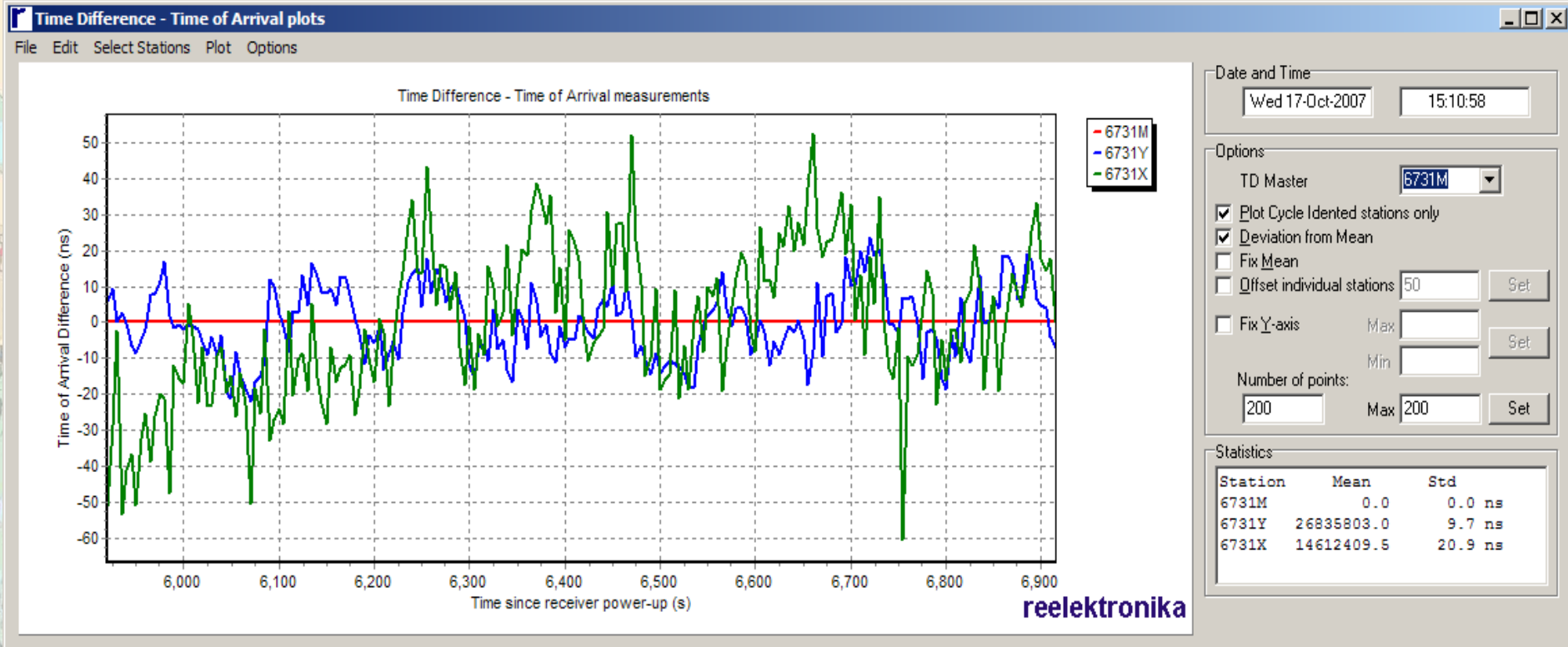


Zero baseline verification

- Differential eLoran Reference Station installed at Reeuwijk
- Single point “ASF map” applied to Rover receiver in the same location
- Differential eLoran corrections hard wired into the Rover receiver
- **Not** a real eLoran environment due to off air of Sylt (and later Rugby)



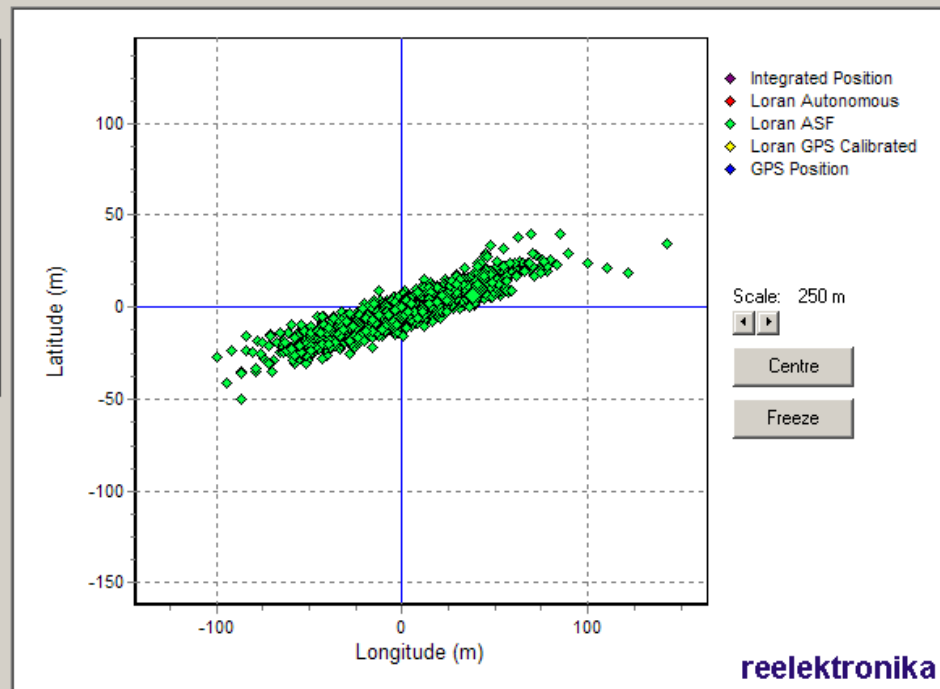
TOA stability zero baseline



- Rugby (6731Y, 400km) and Soustons (6731X, 1000km) wrt Lessay (6731M, 500km)
- More proof of concept than actual accurate measurements

Zero baseline verification

Integrated Position	Loran Stand alone	Loran ASF	Loran Calibrated	GPS Position
Current Data: Lat : 52.03436810 Lon : 4.75912760		Statistics: Avg Lon : 52.03428473 Avg Lon : 4.75854243 Offset : 3.1 m Avg Err : 21.3 m (50%) 60.2 m (95%) 83.7 m (99%) Real Err: 21.1 m (50%) 60.0 m (95%) 85.6 m (99%) #Obs : 2000		
<input type="button" value="Set Centre Position"/>				
Centre Position 52.03430940 Lat <input type="button" value="Set"/> 4.75856320 Lon <input type="button" value="Set"/>		Options Max number of points: <input type="text" value="2000"/> <input type="button" value="Set"/>		
<input type="checkbox"/> Loran vs GPS <input type="button" value="Save"/>		Date and Time 17-Oct-2007 06:27:26 <input type="button" value="Restore"/>		



- Positioning based on TOA measurements, ASF map and differential corrections from Reference Station in same location
- Positioning in Reeuwijk without Sylt

Summary

- Differential eLoran Reference Station development work in progress
- Algorithms successfully ported to Reference Station DSP platform
- Functionality tested and verified with Harwich I data
- Limited on-air testing due to insufficient Loran signal availability
- “Permanent” Reference Station installation will contain Rubidium and real-time antenna calibration
- Discussion on other Nav grade reference stations hardware requirements
- Harwich II trials expected to commence after stable 6731Y signal output (Dec-2007)