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# Differential eLoran trials in Harwich harbour

Gerard Offermans, Arthur Helwig, Reelektronika NL  
 Paul Williams, Trinity House UK  
 Wouter Pelgrum, NL

35<sup>th</sup> ILA Convention, Groton October 23-25, 2006

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# Differential eLoran Performance Evaluation

- **Contract:** Trials conducted by the General Lighthouse Authorities of the United Kingdom and Ireland
- **Purpose:** Assessing the performance potential of eLoran, using ASF maps and Differential Loran
- **Targets:**
  - Harbour Entrance and Approach accuracy requirements (8-20 m)
  - IMO A915 accuracy requirements for future GNSS (10 m)
- **Measurements:** 3 days of measurements, 19-21 April 2006
- **Location:** Harwich, 67 miles east of London
- **Results input to:**
  - GLA's "case for eLoran"
  - Manchester ENC conferenc





# Differential eLoran trial logic

- Two measurement set-ups acting as
  - differential eLoran station
  - mobile ASF measurement unit
- Two measurement days
  - Data collection for ASF map generation
  - Data collection for differential eLoran show-case using ASF map of day before and current differential eLoran corrections from reference station

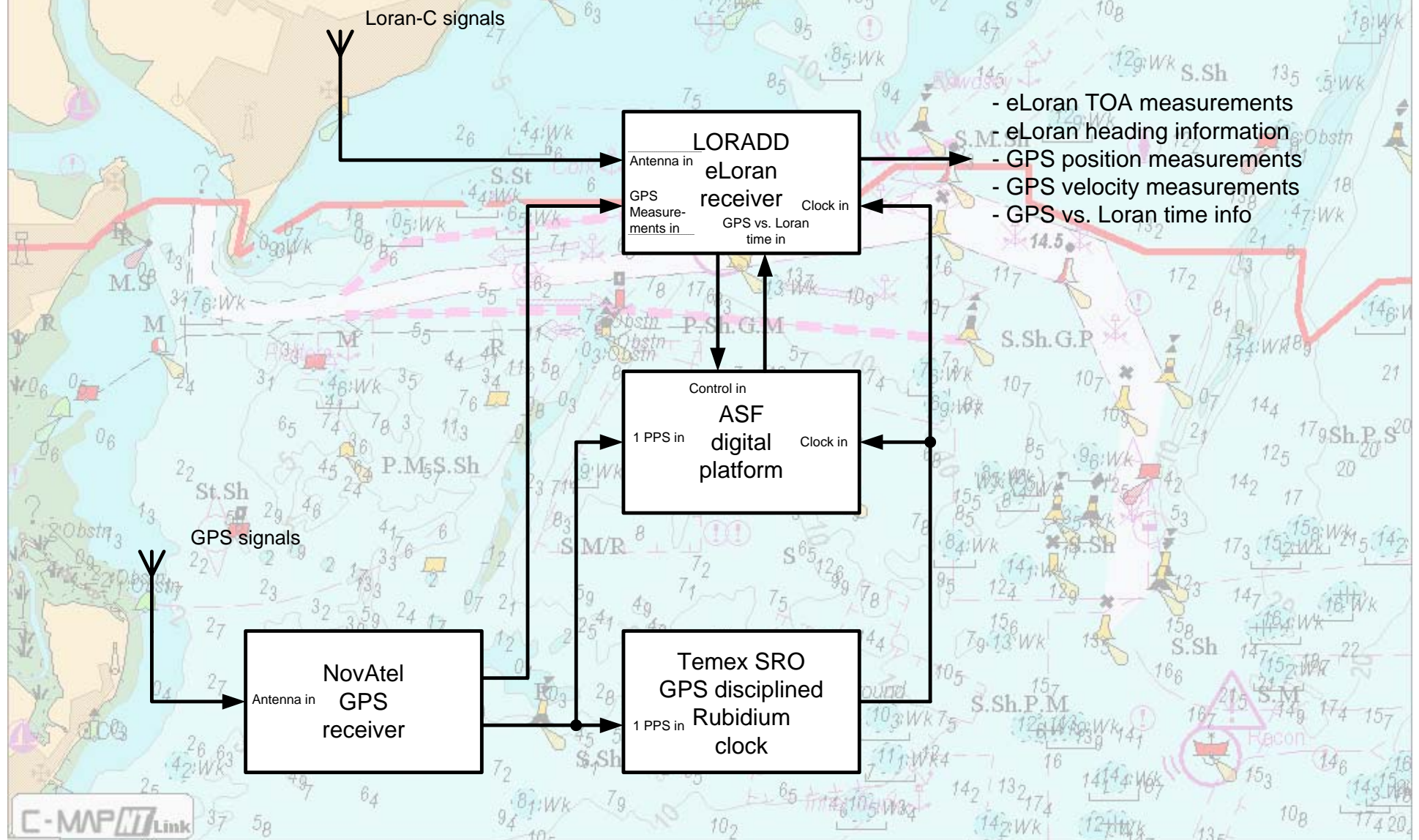


## Differential eLoran trial logic -2

- Wednesday was used for equipment installation and calibration
- Thursday was used to measure the Additional Secondary Factors (ASFs) and create an ASF map of the Harwich area
- Friday a **stand-alone** eLoran measurement run was done, using the ASF map created the day before. dLoran corrections were applied in post-processing
- Data collection of eLoran TOAs, eLoran Heading, (D)GPS position and velocity information, timing relation between eLoran and GPS



# Differential eLoran set-up



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# Differential eLoran hardware

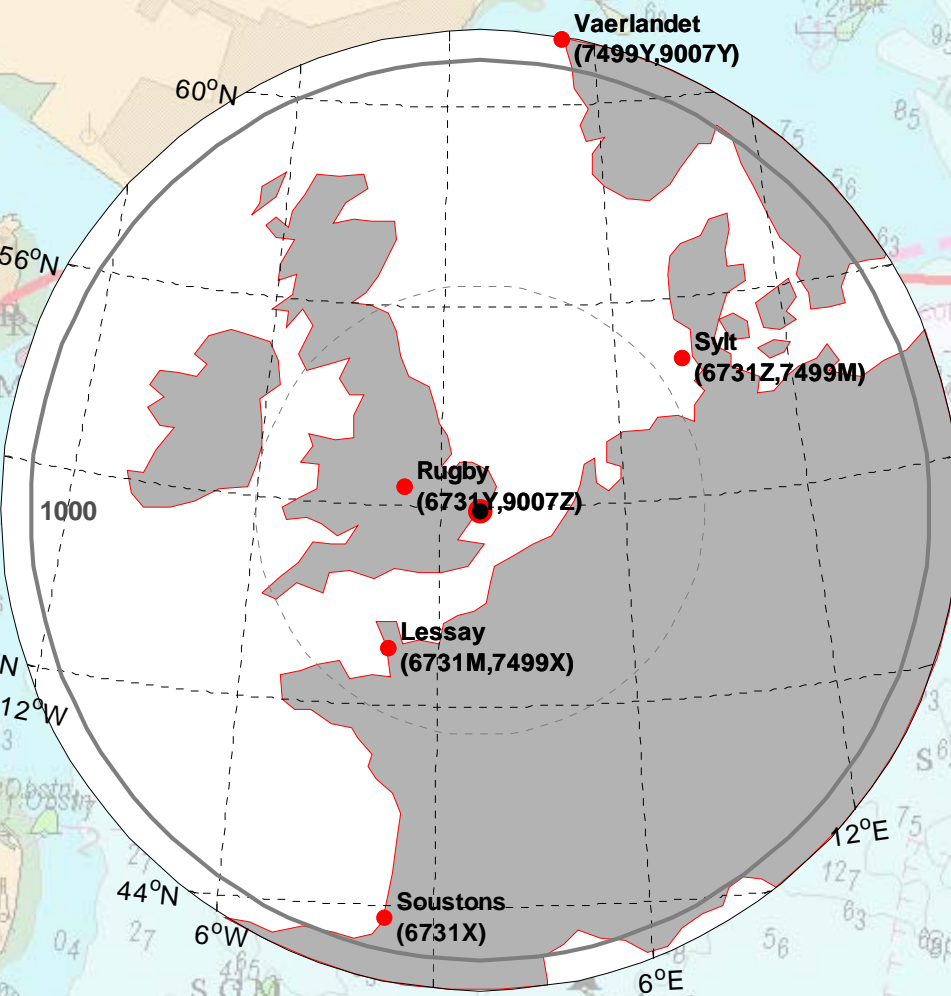
- LORADD ASF Measurement receiver
- NovAtel OEM-4 GPS receiver (DGPS)





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# eLoran constellation at Harwich



Distances of eLoran transmitters:

Rugby	176 km
Lessay	368 km
Sylt	564 km
Soustons	933 km
Vaerlandet	1062 km

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# Measurement vessel

Vessel used for trials:  
Trinity House "Ready"

- eLoran antenna
- GPS antenna (reference)





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# Antenna installation

eLoran antenna

GPS antenna





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# dLoran reference station

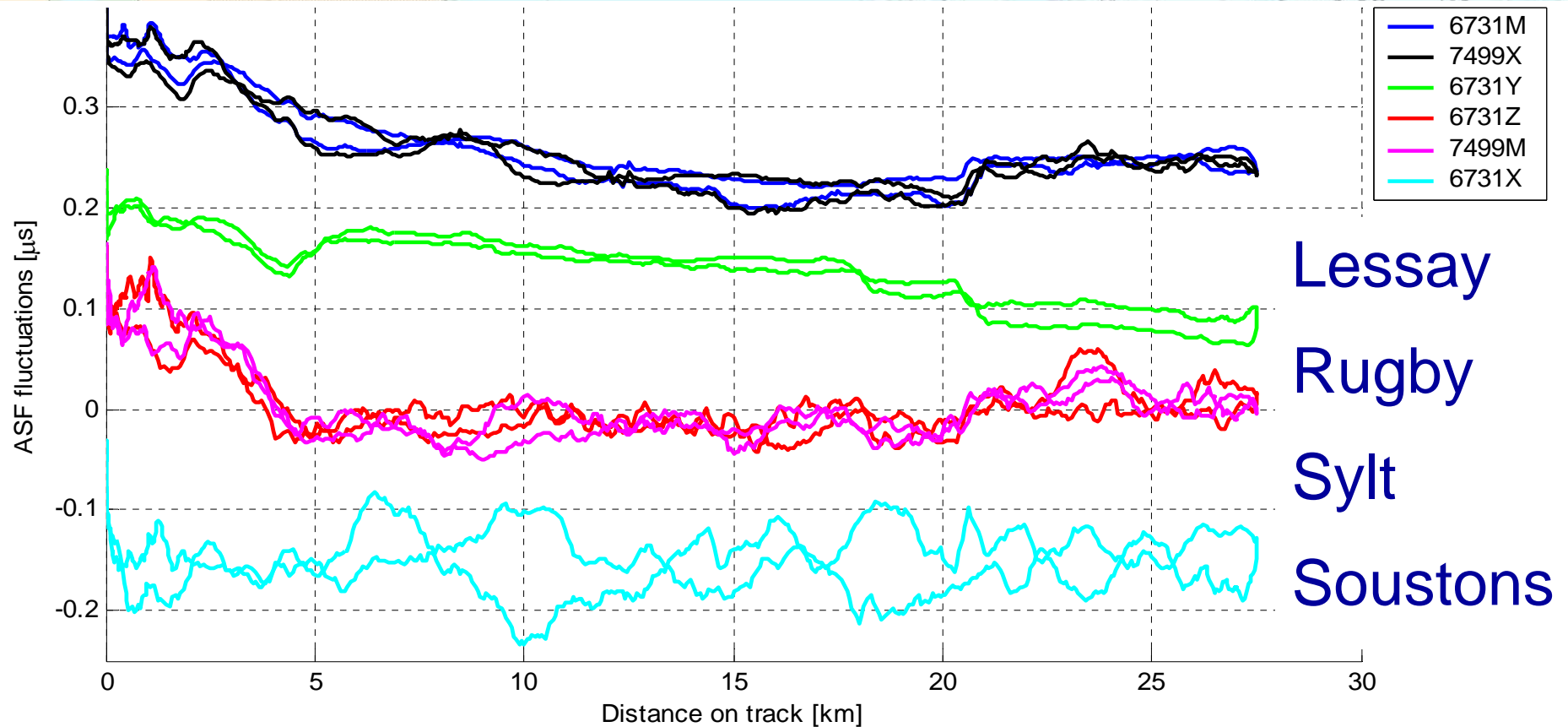


Reference station installed  
at Trinity House



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# ASF variations along the track



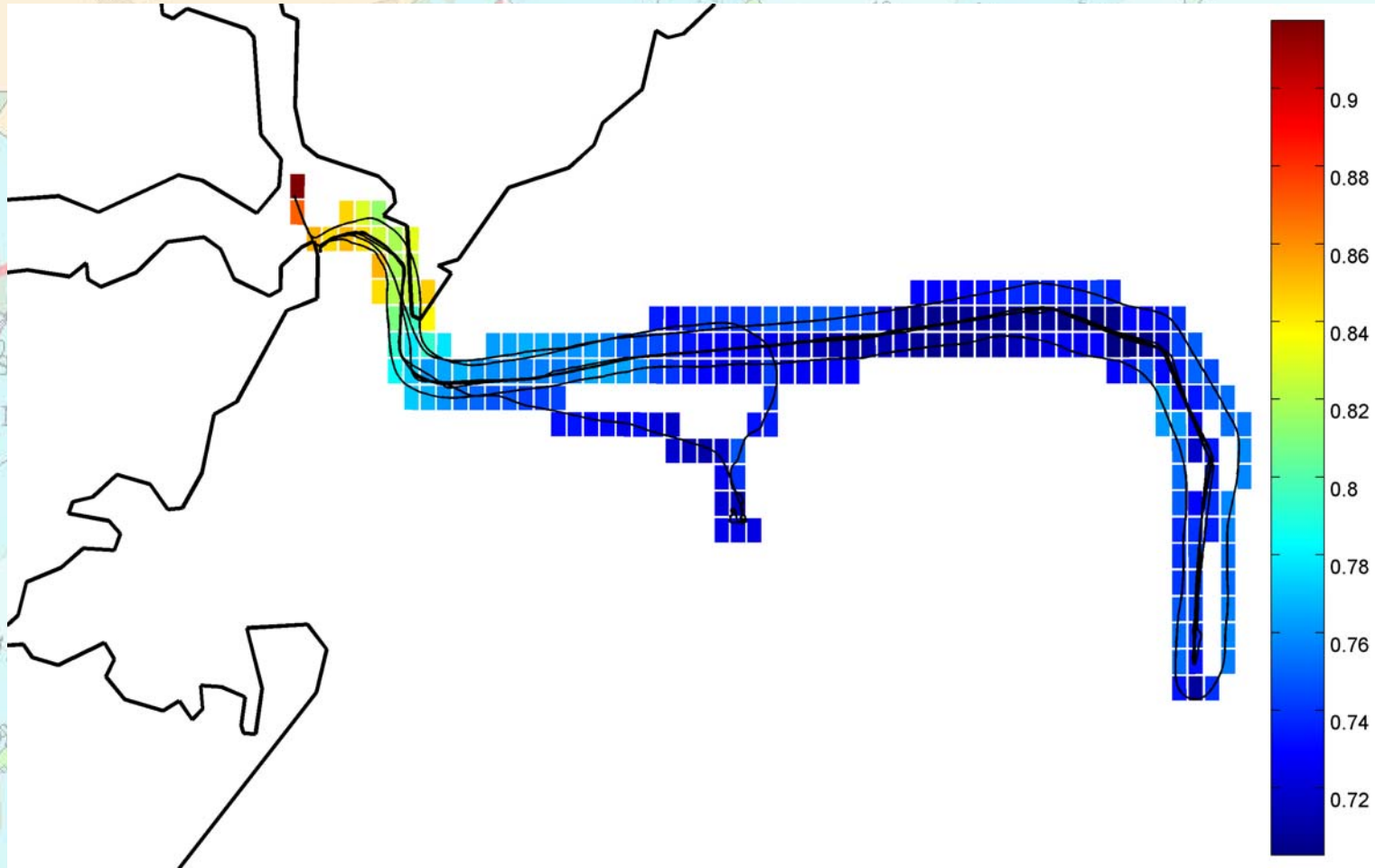
Lessay  
Rugby  
Sylt  
Soustons





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# Creating the ASF maps

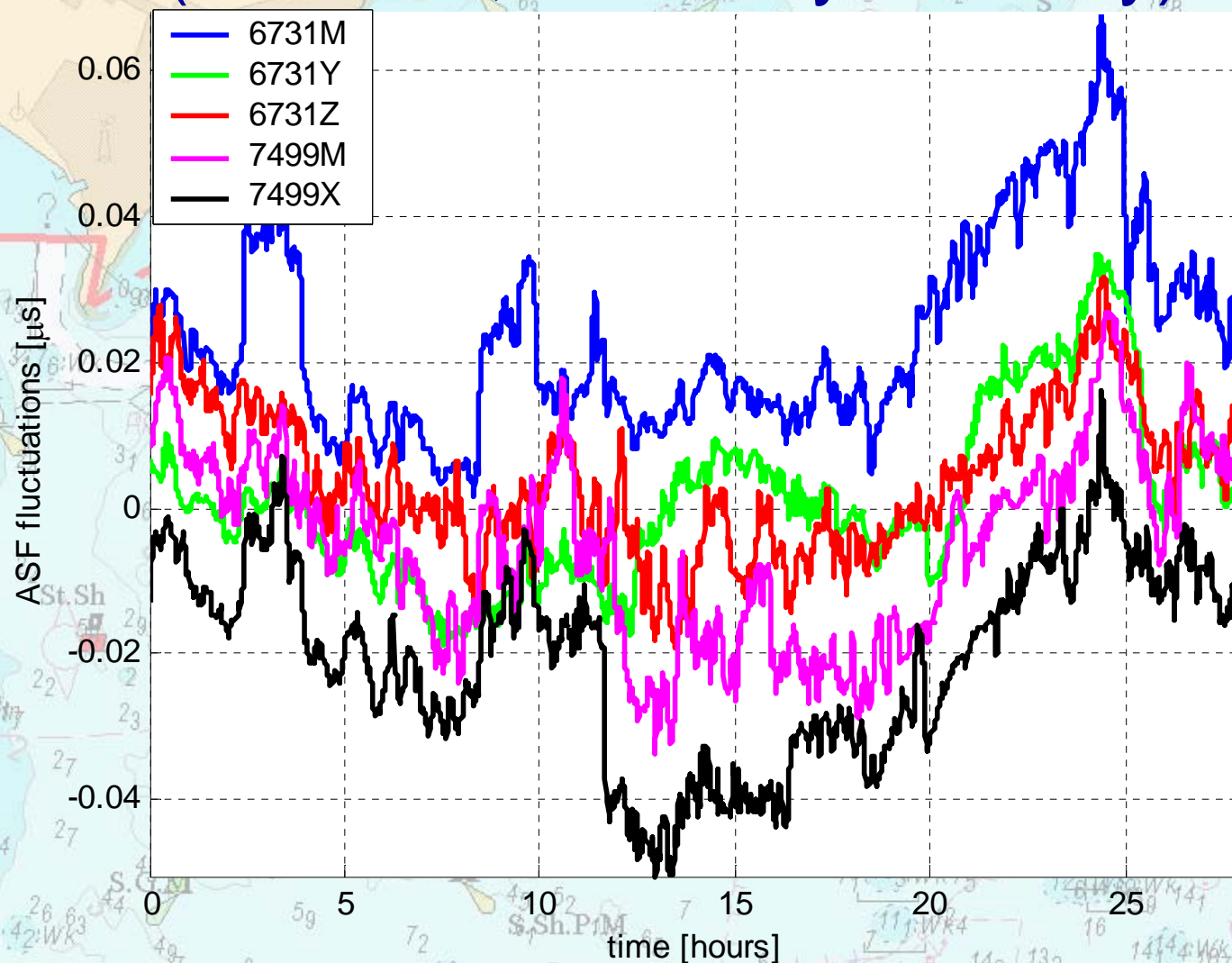


ASF map for Lessay

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# Reference Station measurements

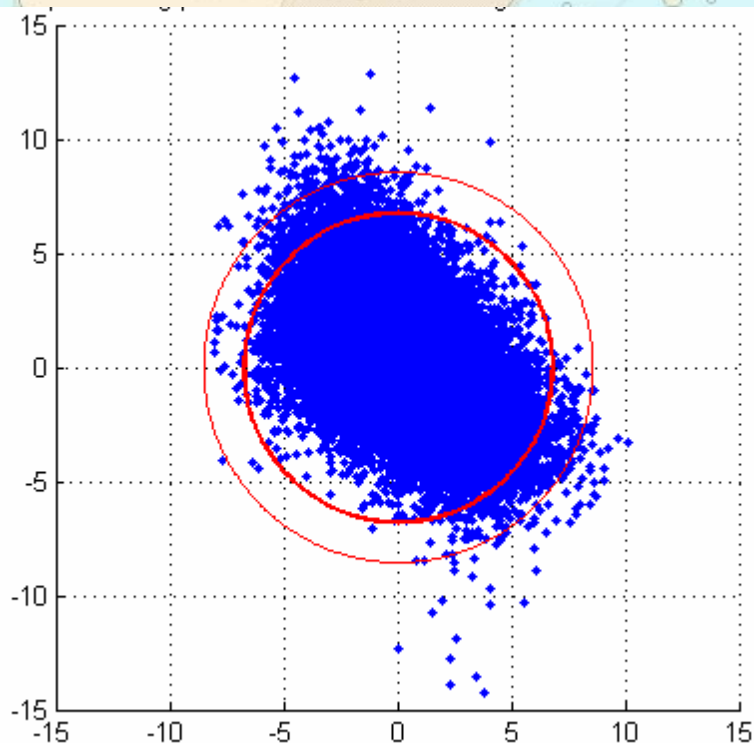
(26 hours, Thursday & Friday)





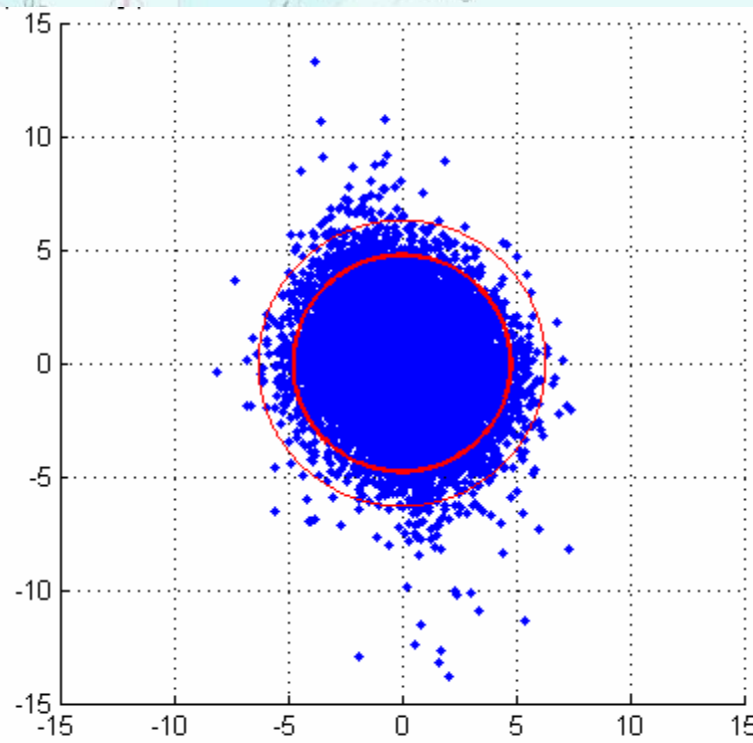
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# Reference Station measurements



Single ASF for 26-hour period

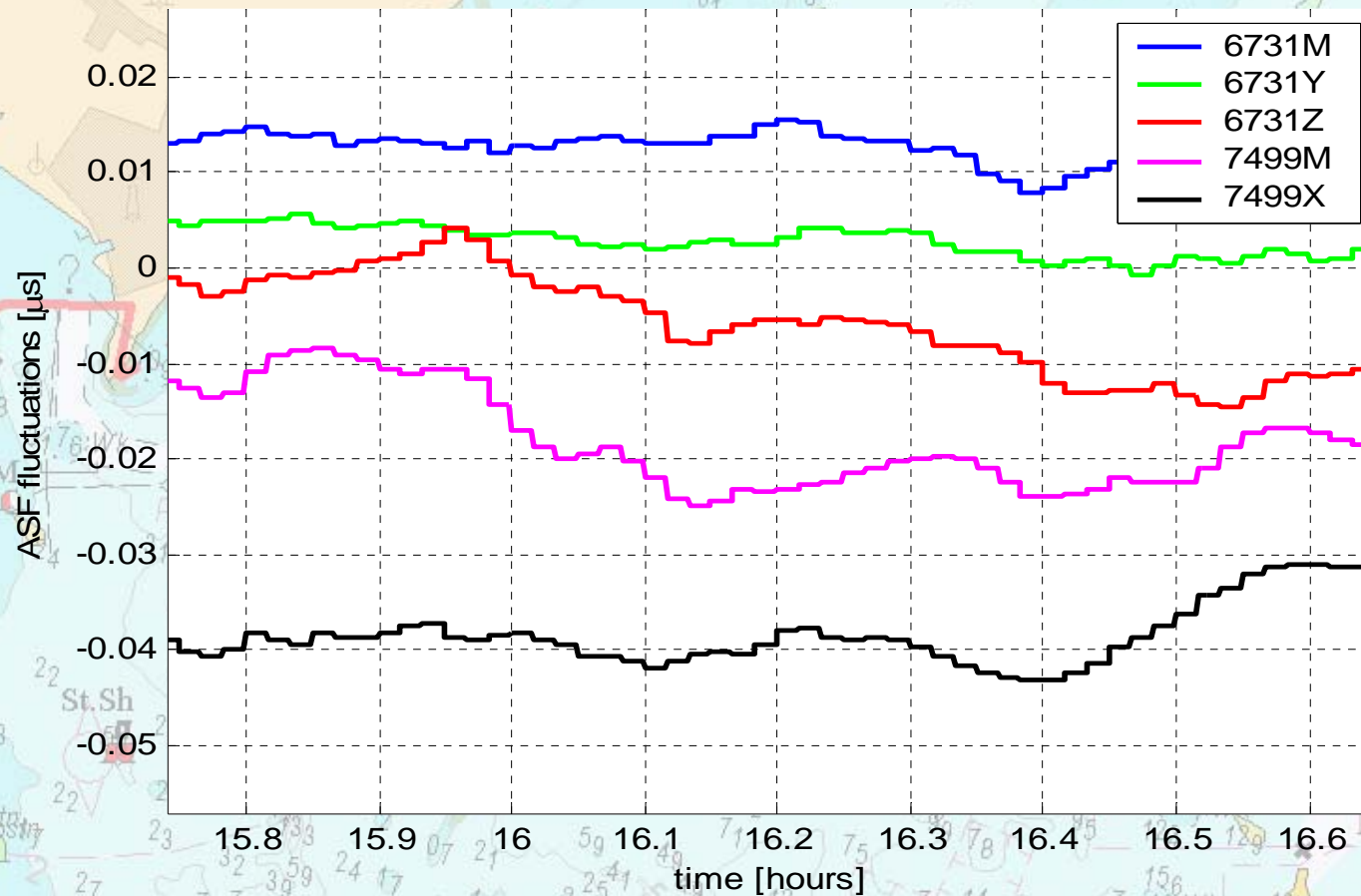
Accuracy: 6.8 m (95%)



1-minute correction update based on  
10-minutes observation time

Accuracy: 4.8 m (95%)

# Reference Station corrections

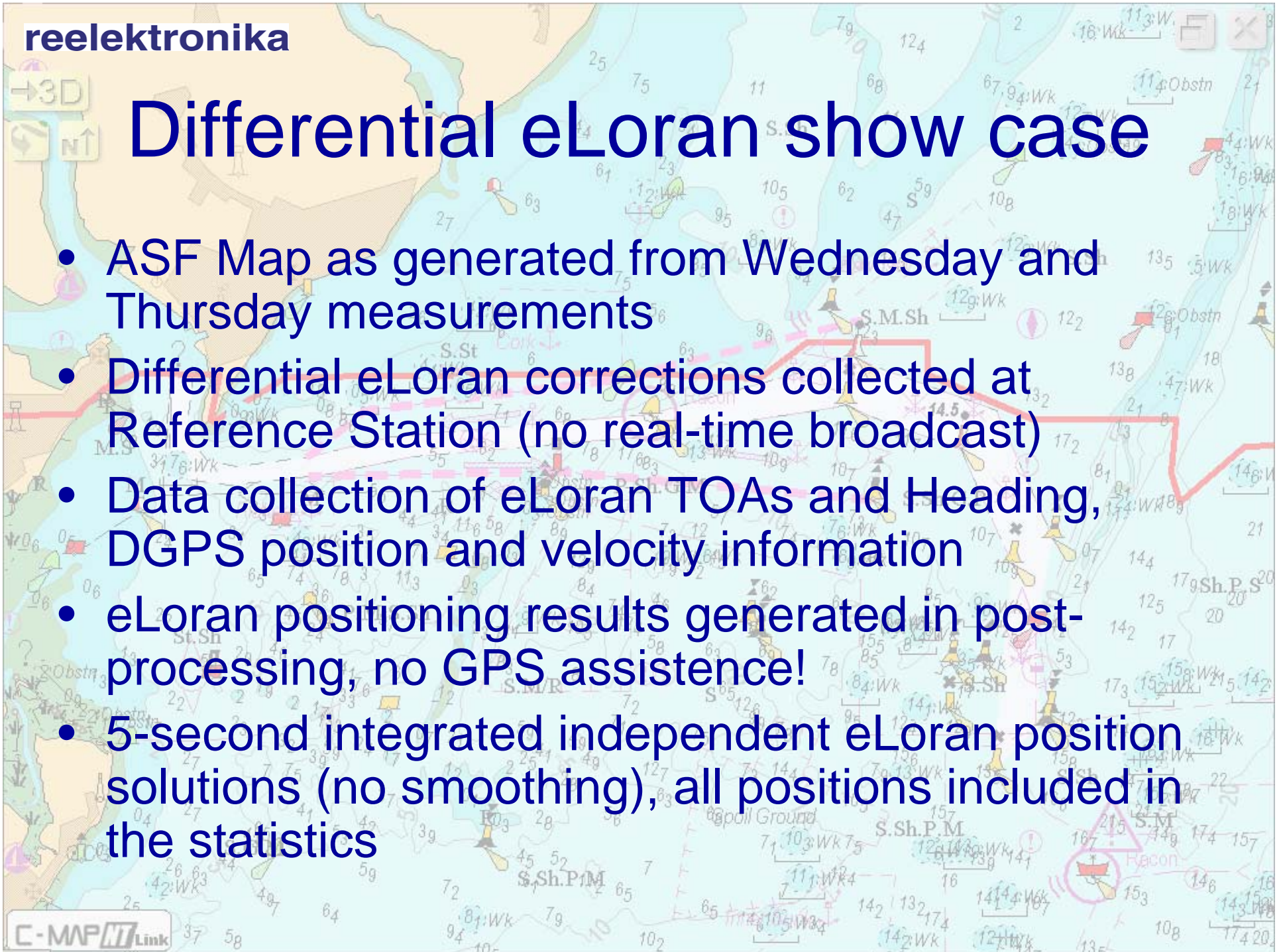


- Reference Station correction generation (1 hour)
- 10-minute observation interval, 1-minute correction update

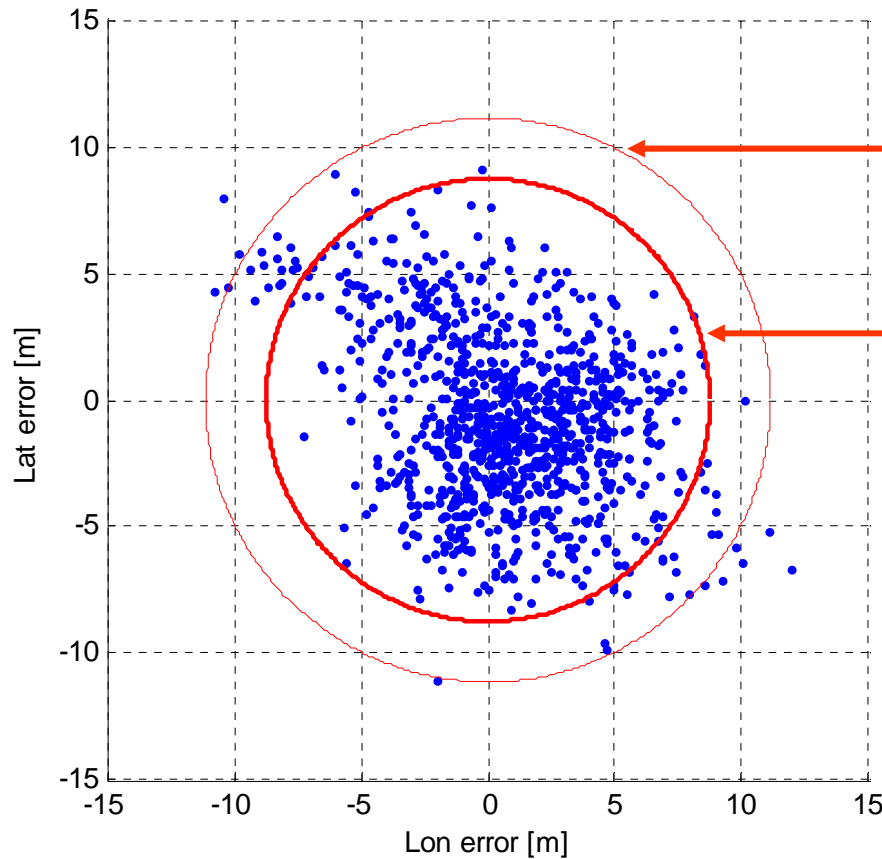


# Differential eLoran show case

- ASF Map as generated from Wednesday and Thursday measurements
- Differential eLoran corrections collected at Reference Station (no real-time broadcast)
- Data collection of eLoran TOAs and Heading, DGPS position and velocity information
- eLoran positioning results generated in post-processing, no GPS assistance!
- 5-second integrated independent eLoran position solutions (no smoothing), all positions included in the statistics



# eLoran 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.



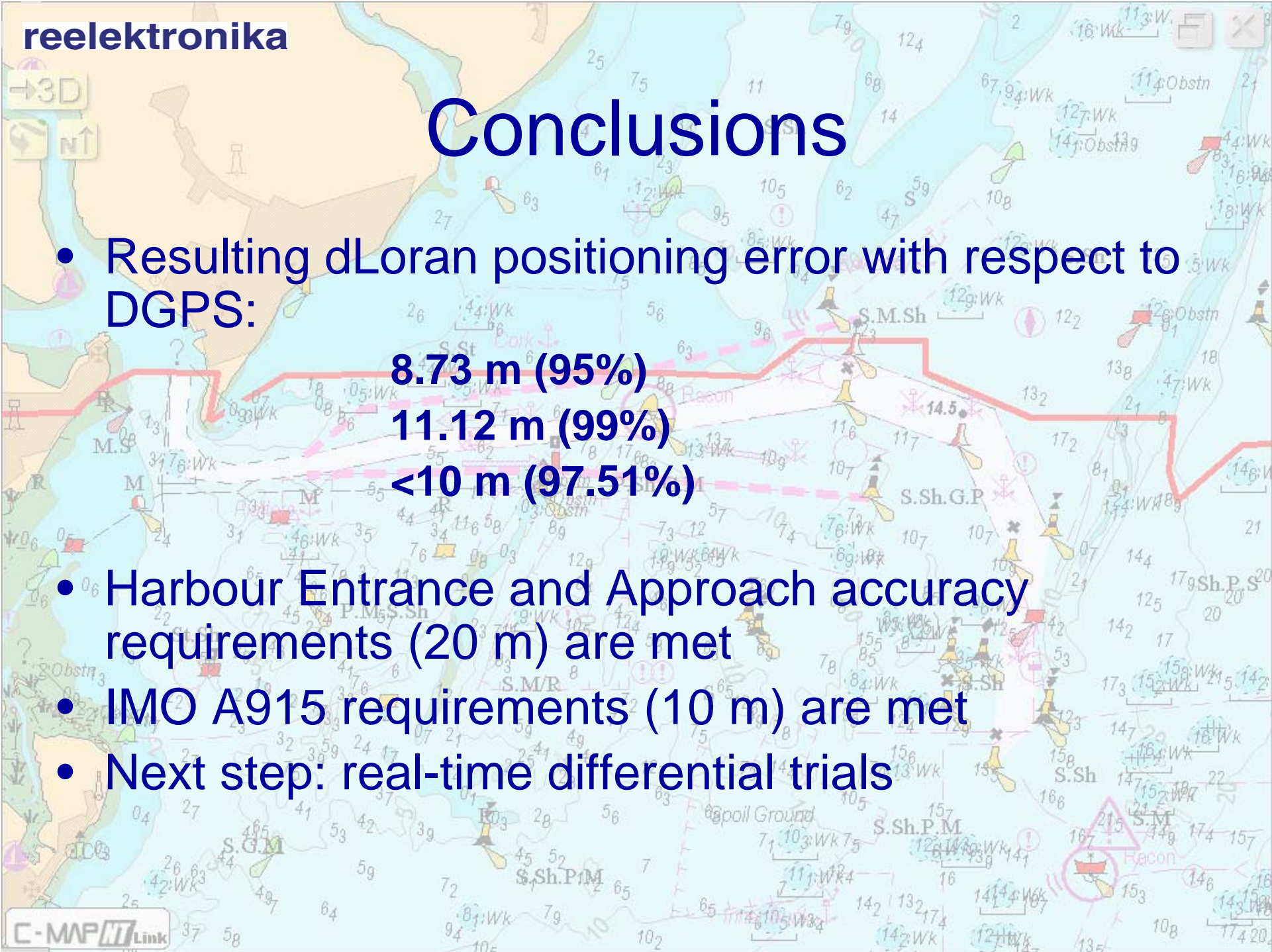
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# eLoran accuracy results presented in Google Earth



Yellow line is difference between  
eLoran and DGPS positioning  
Scale is 10 m/div

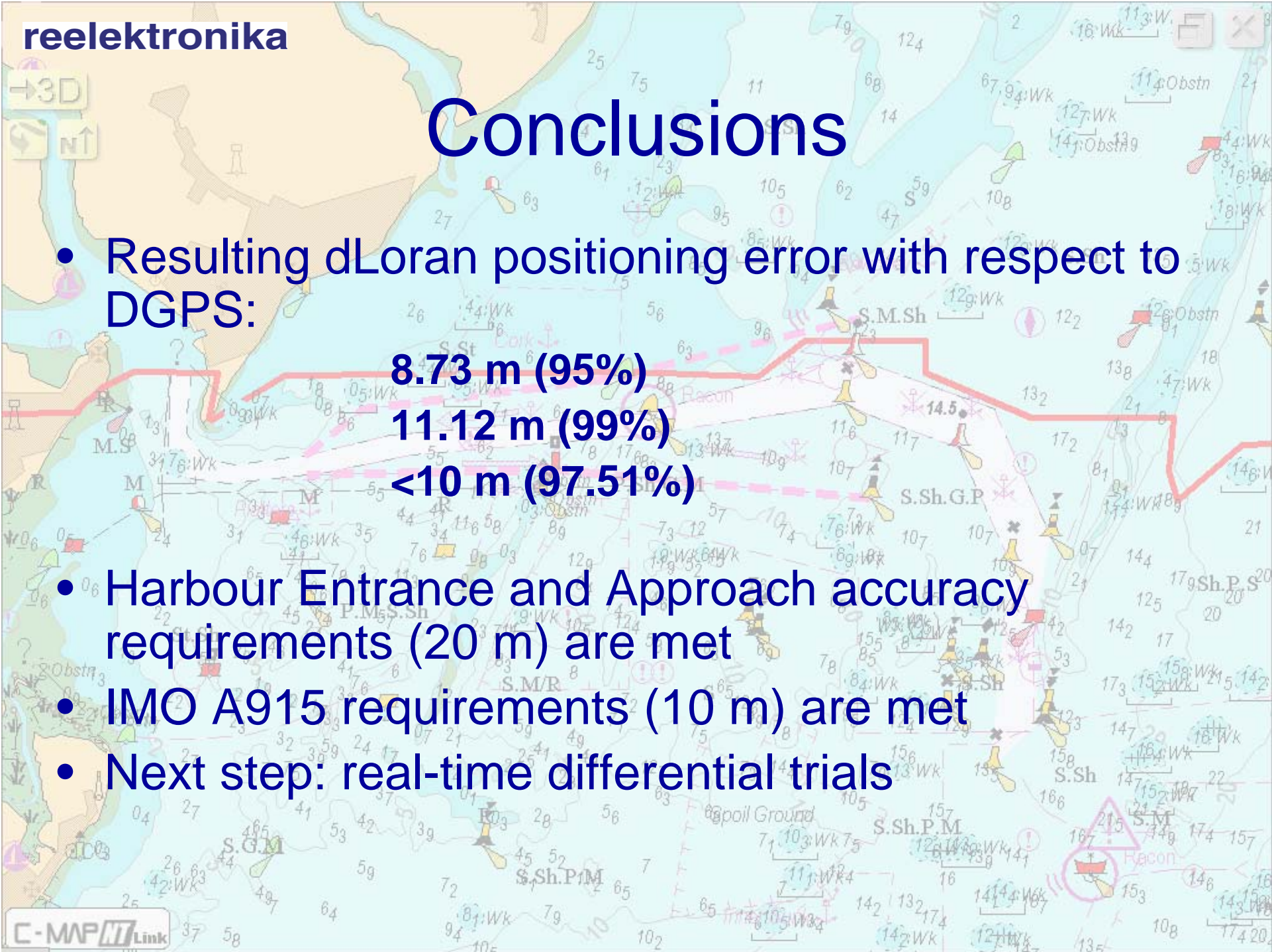




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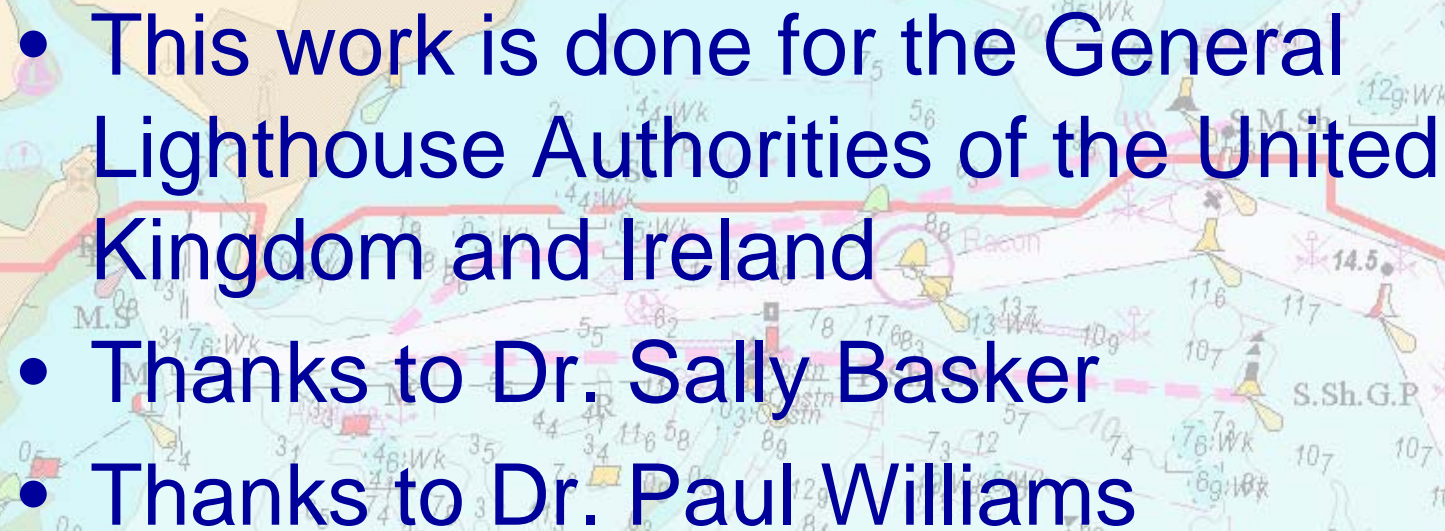
## Conclusions

- Resulting dLoran positioning error with respect to DGPS:
  - 8.73 m (95%)
  - 11.12 m (99%)
  - <10 m (97.51%)
- Harbour Entrance and Approach accuracy requirements (20 m) are met
- IMO A915 requirements (10 m) are met
- Next step: real-time differential trials

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- # reelektronika
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# Acknowledgements

- 
- This work is done for the General Lighthouse Authorities of the United Kingdom and Ireland
  - Thanks to Dr. Sally Basker
  - Thanks to Dr. Paul Williams



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The End

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