R-Mode in the Baltic Sea region

DLR: Stefan Gewies, Lars Grundhöfer, Markus Wirsing, Ronald Raulefs
NIT: Krzysztof Bronk, Patryk Koncicki, Rafał Niski
WSV: Michael Hoppe
SMA: Jesper Bäckstedt
RISE: Carsten Rieck

9th September 2019, Saint-Germain-en-Laye, France

Outline

- Challenges and preconditions of the Baltic Sea region
- R-Mode Baltic – A testbed for the Southern Baltic Sea
- Results of measurements, theoretical analysis and developments (MF)
- Conclusions

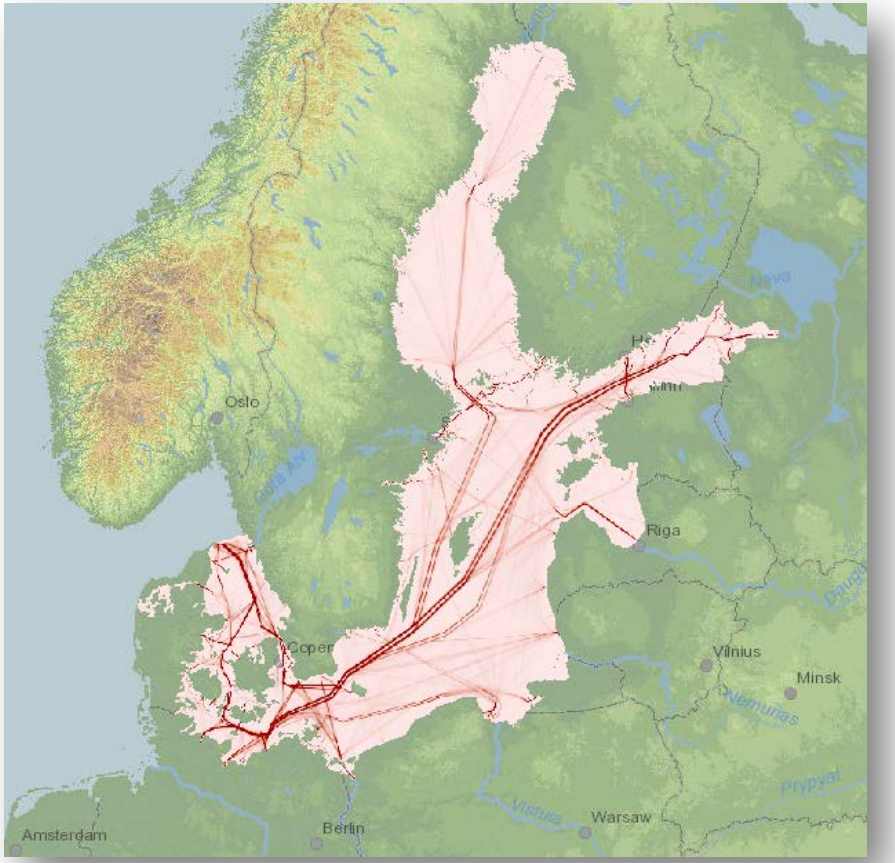
Baltic Sea

- Marginal sea surrounded by 9 states
- Important for transport of goods and persons

- Challenging conditions for maritime traffic
  - Shallow waters, narrow straights, many small island
  - High traffic density
  - Crossing traffic routes

- Challenge: coordinate activities of all Baltic Sea states
- EU strategy for thee Baltic Sea region => increase maritime safety

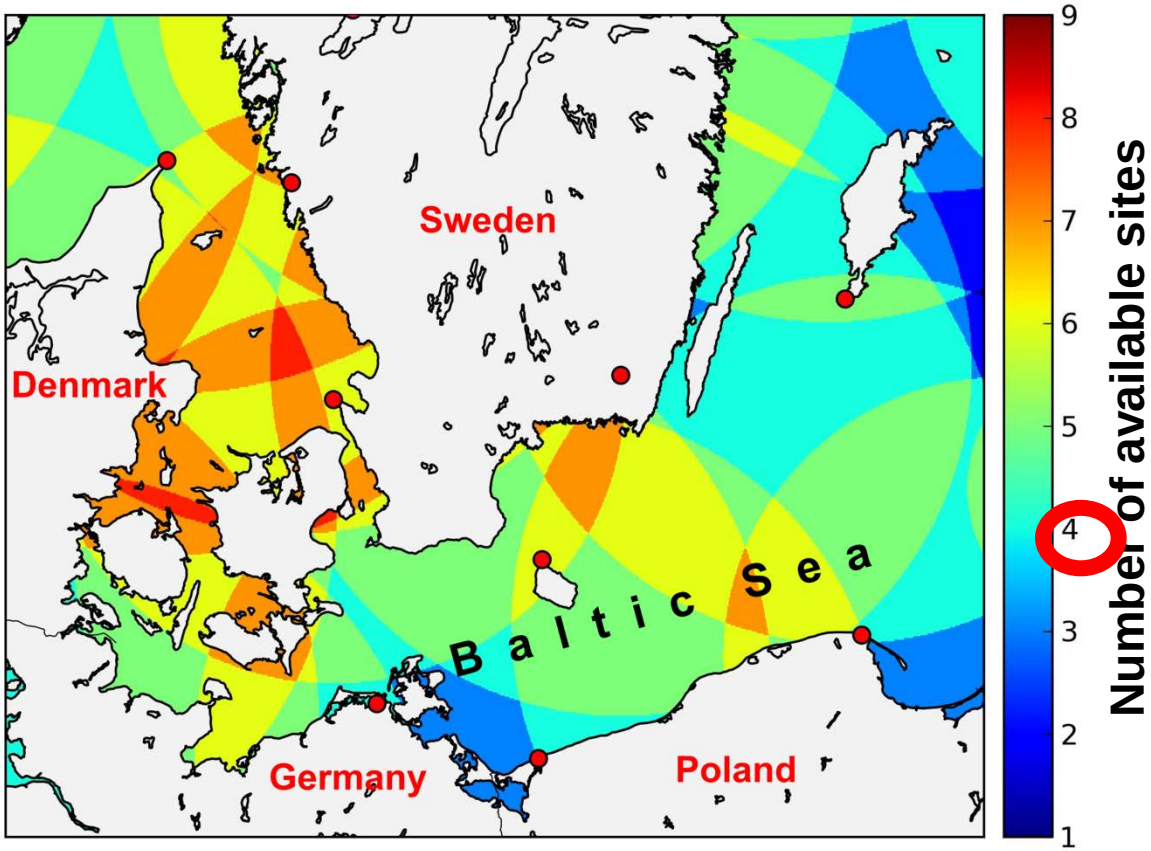
Baltic Sea shipping traffic



Source: HELCOM

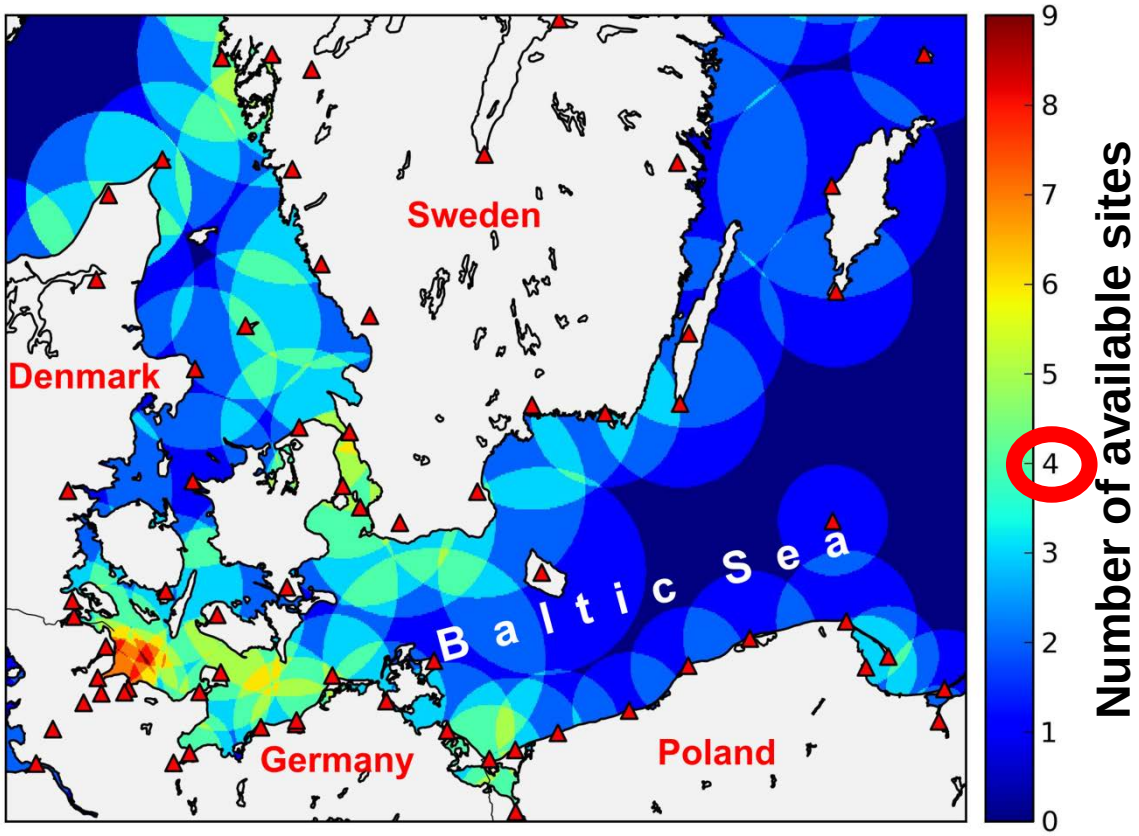
Coverage of the Baltic Sea with MF radio beacon signals

Based on given nominal range



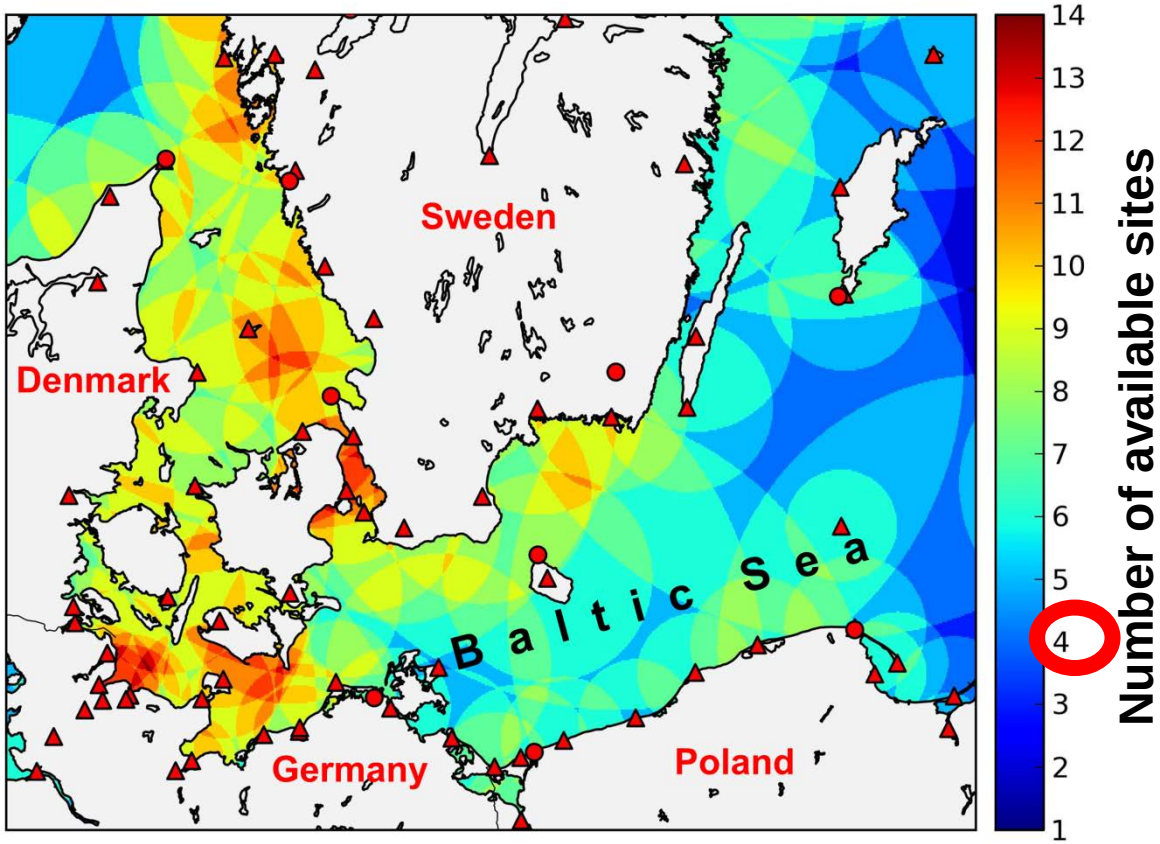
Coverage of the Baltic Sea with VHF AIS signals

Based on geometrical range (vessel: 10 m antenna height)



Coverage of the Baltic Sea with VHF and MF signals

Considers not disturbances of signal propagation



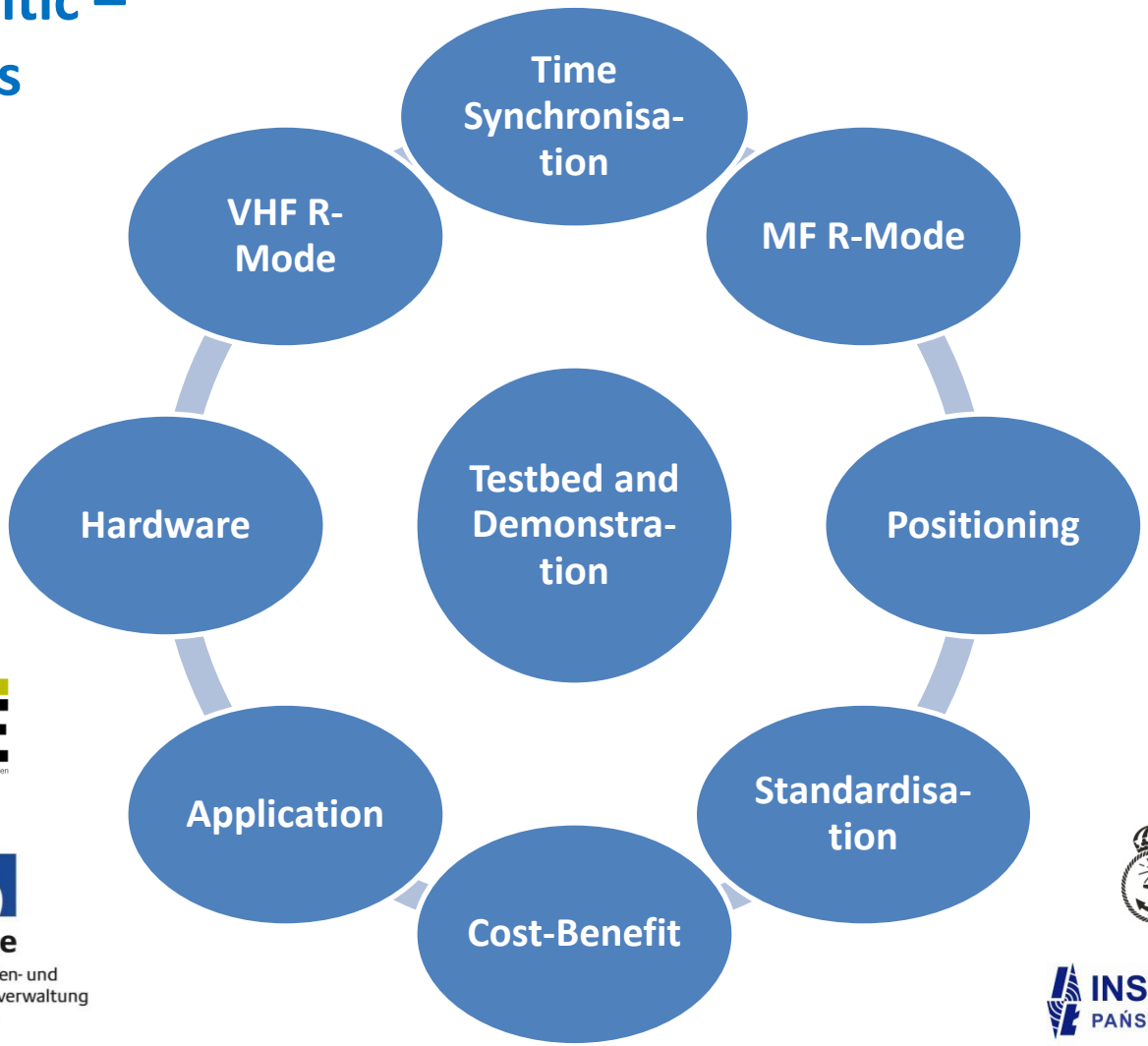
Sufficient number of available signals (>3) for positioning in the Southern Baltic Sea – R-Mode based positioning requires both signals-of-opportunity

Project R-Mode Baltic 2017 - 2020

Aims

- Build a R-Mode testbed in the Baltic Sea until 2020 that utilises maritime radio beacons and AIS/VDES base stations
- Show R-Mode is able to meet maritime user requirements for a backup system.

R-Mode Baltic – Work topics



DLR

KONGSBERG

URZĄD MORSKI W GDYNI

RI.SE Research Institutes of Sweden

BSH BUNDESAMT FÜR SEESCHIFFFAHRT UND HYDROGRAPHIE

WSV.de Wasserstraßen- und Schifffahrtsverwaltung des Bundes

R MODE BALTIC

Gutec AB

NavSim POLAND TECHNOLOGY

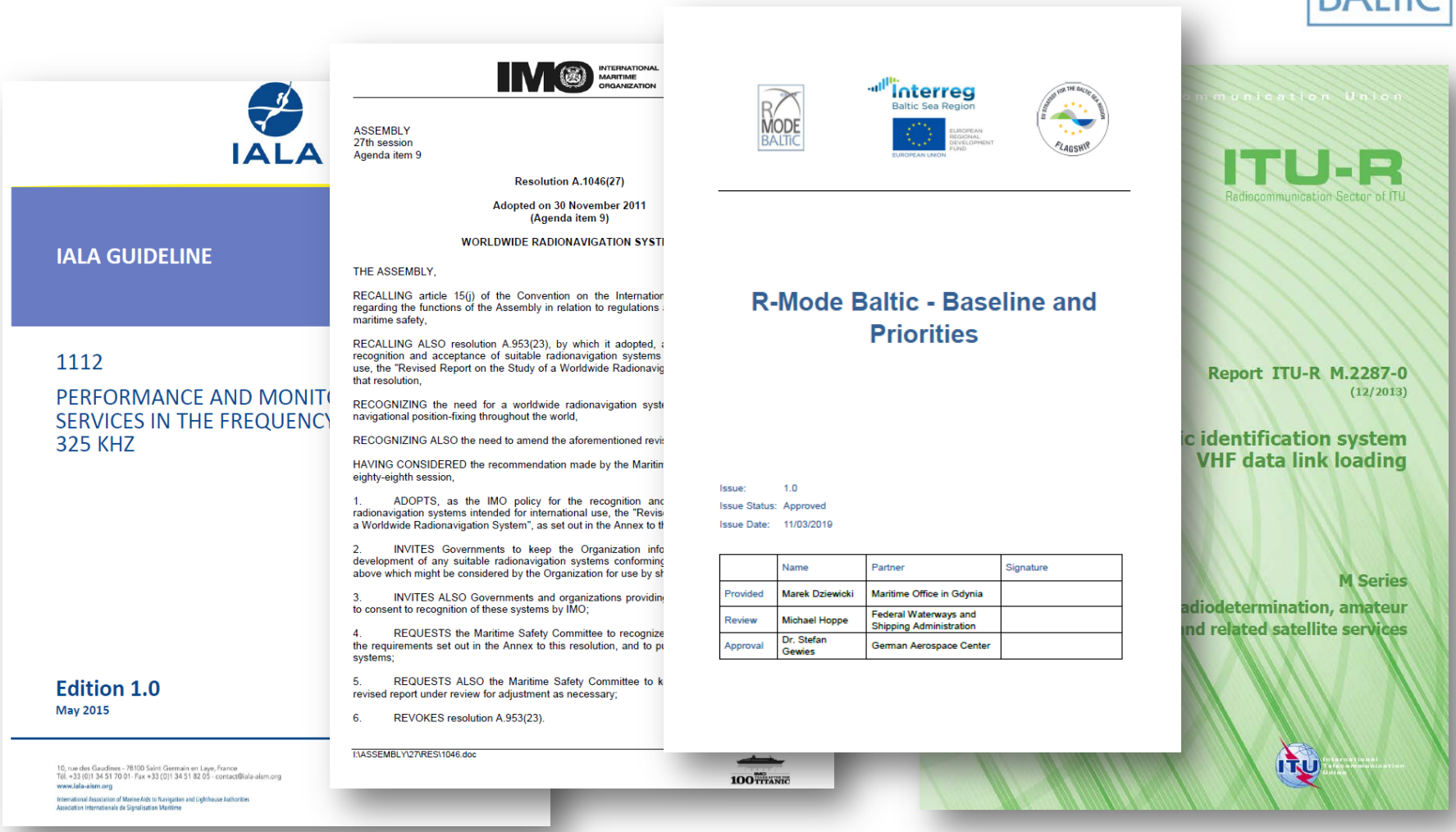
navXperience

SAAB TECHNOLOGIES SAAB

SWEDISH MARITIME ADMINISTRATION

INSTYTUT ŁĄCZNOŚCI PAŃSTWOWY INSTYTUT BADAWCZY

R-Mode system frame work



IALA

IALA GUIDELINE

1112

PERFORMANCE AND MONIT
SERVICES IN THE FREQUENCY
325 KHZ

Edition 1.0
May 2015

10, rue des Gaudines - 78100 Saint Germain en Laye, France
Tél. +33 (0)1 34 51 70 01 - Fax +33 (0)1 34 51 82 05 - contact@iala-aism.org
www.iala-aism.org

International Association of Marine Aids to Navigation and Lighthouse Authorities
Association Internationale de Signalisation Maritime

IMO INTERNATIONAL MARITIME ORGANIZATION

ASSEMBLY
27th session
Agenda item 9

Resolution A.1046(27)

Adopted on 30 November 2011
(Agenda item 9)

WORLDWIDE RADIONAVIGATION SYST

THE ASSEMBLY,

RECALLING article 15(j) of the Convention on the Internatio
regarding the functions of the Assembly in relation to regulations
maritime safety,

RECALLING ALSO resolution A.953(23), by which it adopted,
recognition and acceptance of suitable radionavigation systems
use, the "Revised Report on the Study of a Worldwide Radionavig
that resolution,

RECOGNIZING the need for a worldwide radionavigation syst
navigational position-fixing throughout the world,

RECOGNIZING ALSO the need to amend the aforementioned revis

HAVING CONSIDERED the recommendation made by the Maritin
eighty-eighth session,

1. ADOPTS, as the IMO policy for the recognition anc
radionavigation systems intended for international use, the "Revis
a Worldwide Radionavigation System", as set out in the Annex to t

2. INVITES Governments to keep the Organization info
development of any suitable radionavigation systems conforming
above which might be considered by the Organization for use by s

3. INVITES ALSO Governments and organizations providin
to consent to recognition of these systems by IMO;

4. REQUESTS the Maritime Safety Committee to recognize
the requirements set out in the Annex to this resolution, and to p
systems;

5. REQUESTS ALSO the Maritime Safety Committee to k
revised report under review for adjustment as necessary;

6. REVOKES resolution A.953(23).

I:\ASSEMBLY\27\RES\1046.doc

Interreg Baltic Sea Region
EUROPEAN REGIONAL DEVELOPMENT FUND
EUROPEAN UNION

R-Mode Baltic - Baseline and Priorities

Issue: 1.0
Issue Status: Approved
Issue Date: 11/03/2019

	Name	Partner	Signature
Provided	Marek Dziewicki	Maritime Office in Gdynia	
Review	Michael Hoppe	Federal Waterways and Shipping Administration	
Approval	Dr. Stefan Gewies	German Aerospace Center	

ITU-R
Radiocommunication Sector of ITU

Report ITU-R M.2287-0
(12/2013)

c identification system
VHF data link loading

M Series
adiodetermination, amateur
nd related satellite services

User requirement used in the project R-Mode Baltic

The project team will setup a **contingency system** for GNSS, which in case of unavailability of GNSS should allow positioning for at least **2 hours** with:

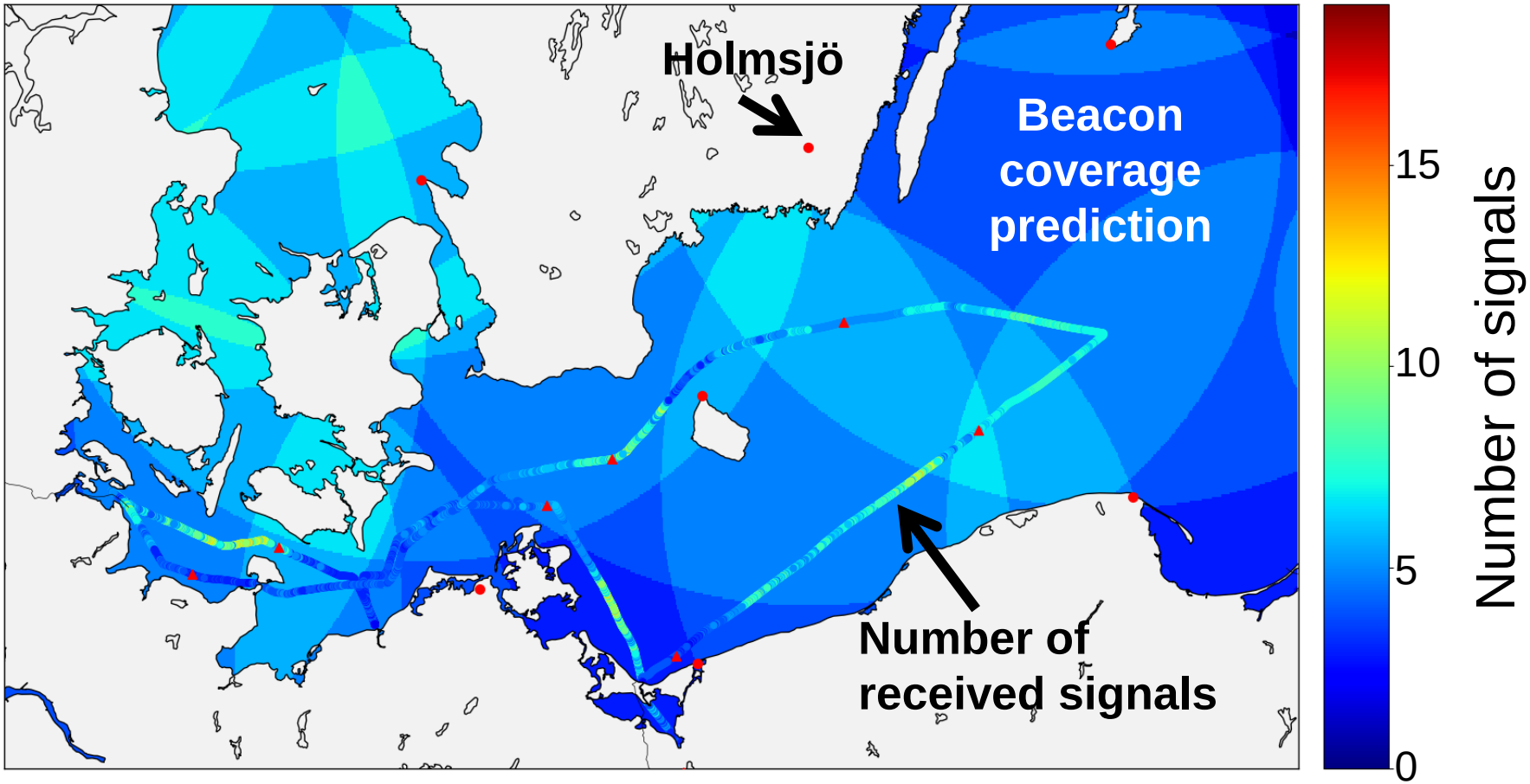
	System level parameters				Service level parameters			
Maritime region	Absolute Accuracy	Integrity			Availability % per 30 days	Continuity % over 15 minutes	Coverage	Fix interval (seconds)
	Horizontal (meters)	Alert limit (meters)	Time to Alarm (seconds)	Integrity Risk (per 3 hours)				
Coastal	100	250	30	10^{-4}	99	N/A²	Regional	15
Port approach and restricted waters	10	25	10	10^{-4}	99	99,97	Regional	2
Inland Waterways	10	25	10	10^{-4}	99	99,97	Regional	2

MF R-Mode

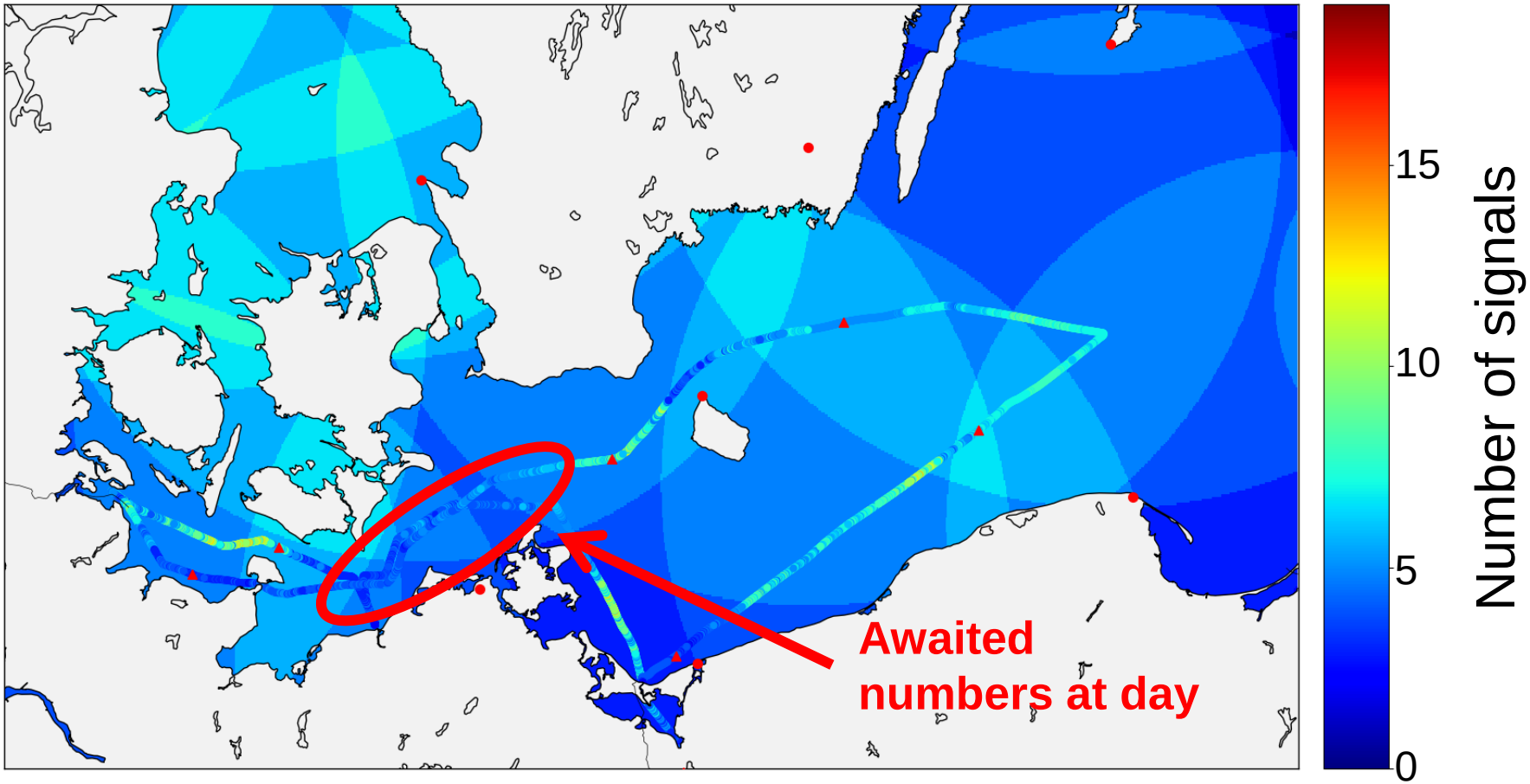
Signal availability measurement campaign

- 4 day measurement campaign in the Southern Baltic Sea in September 2017

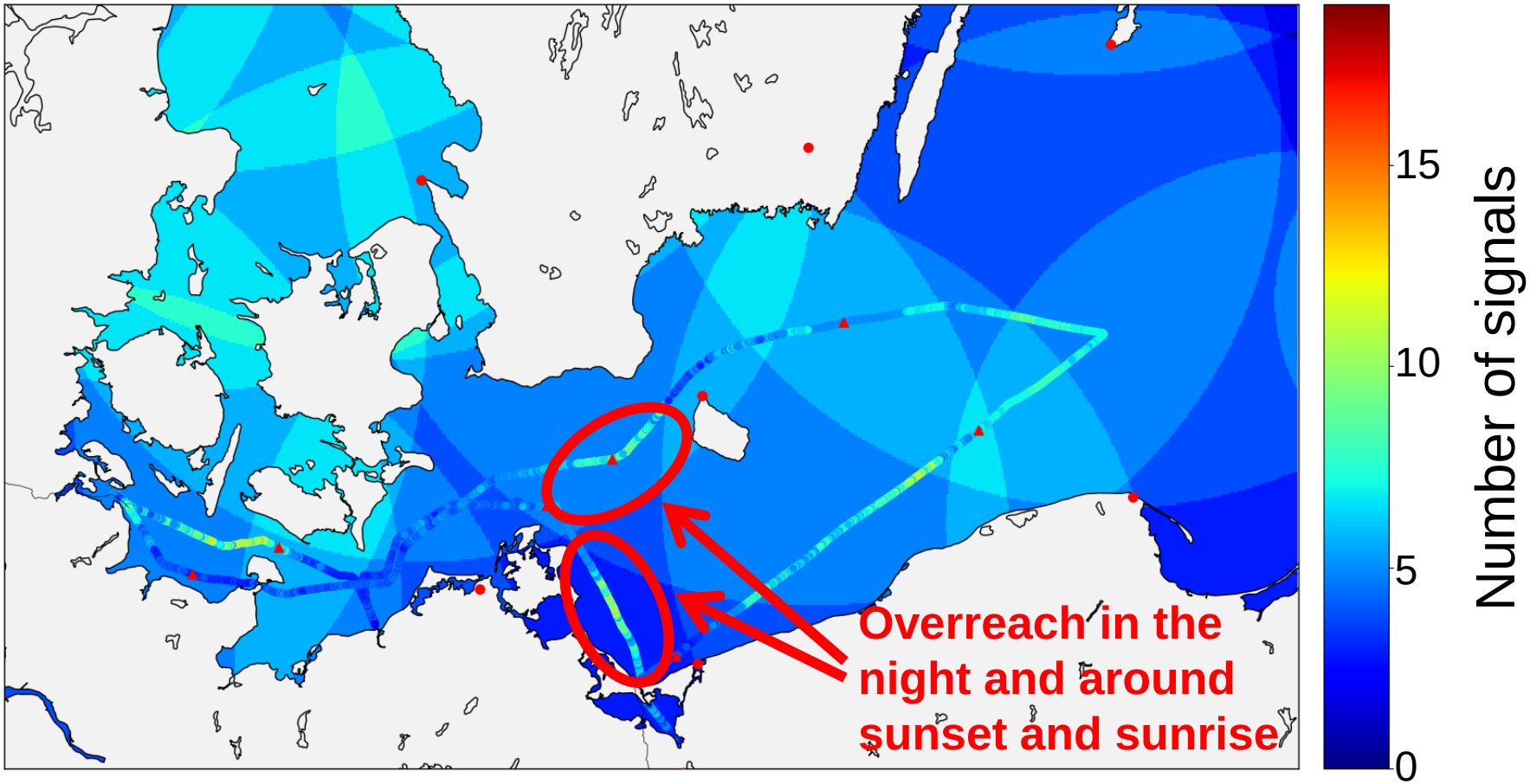
Available signals



Available signals

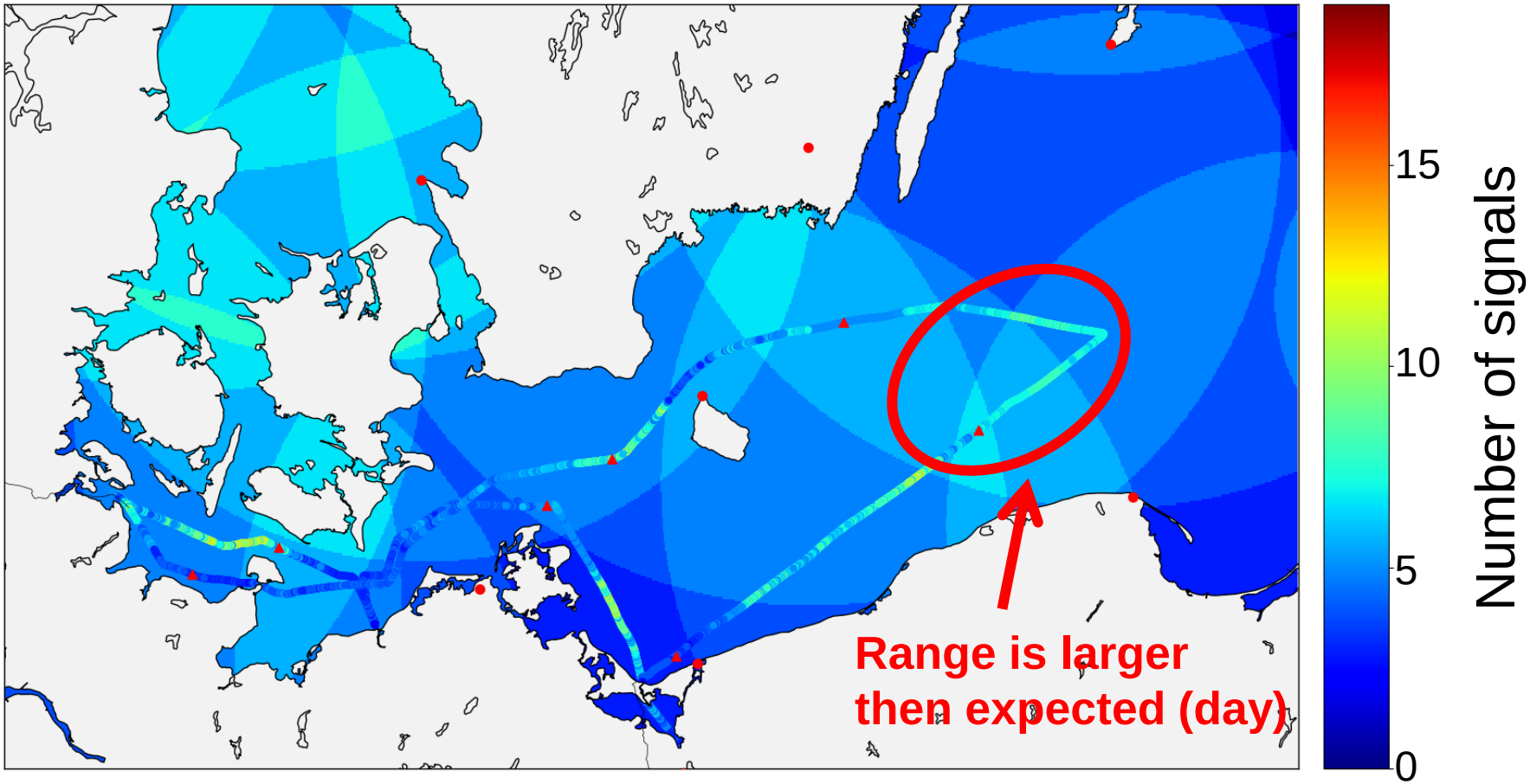


Available signals

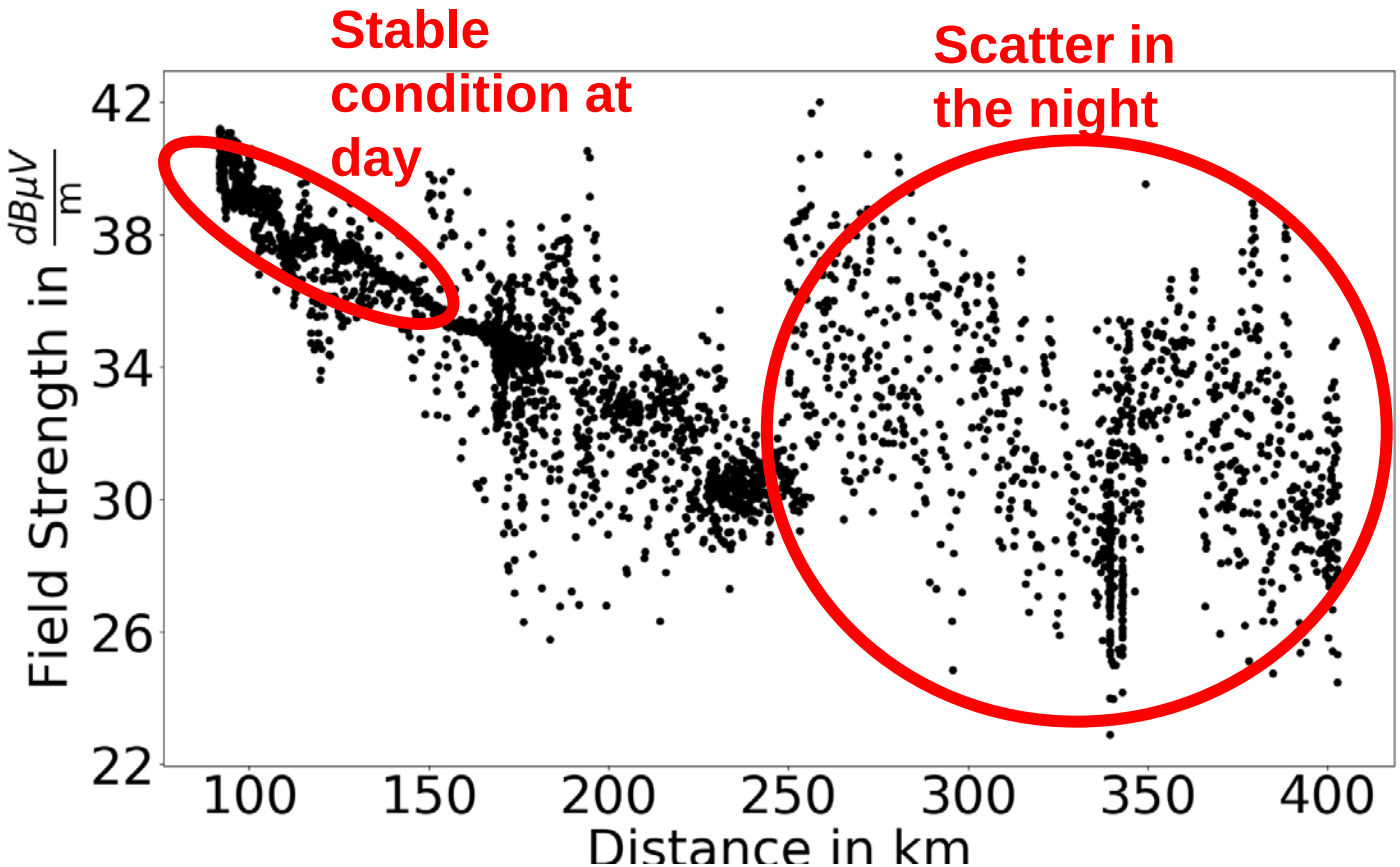


DLR

Available signals



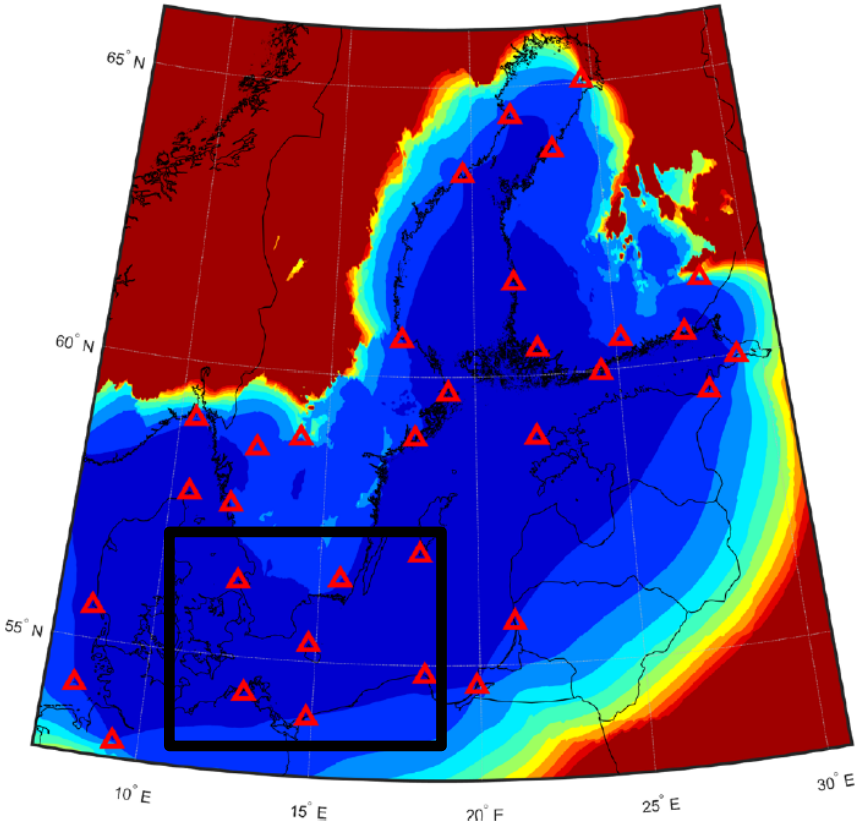
Measured filed strength Holmsjö



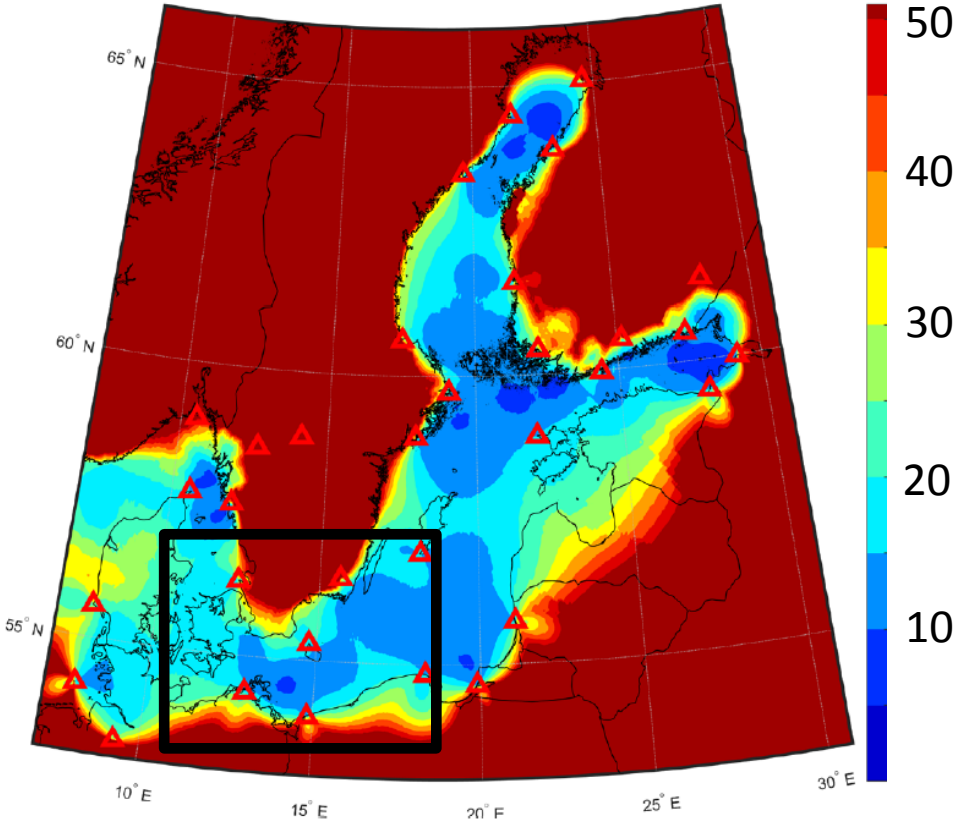
MF prediction based on propagation and interference models (GLA)

Estimated position accuracy based on coverage and HDOP predictions for the Baltic Sea

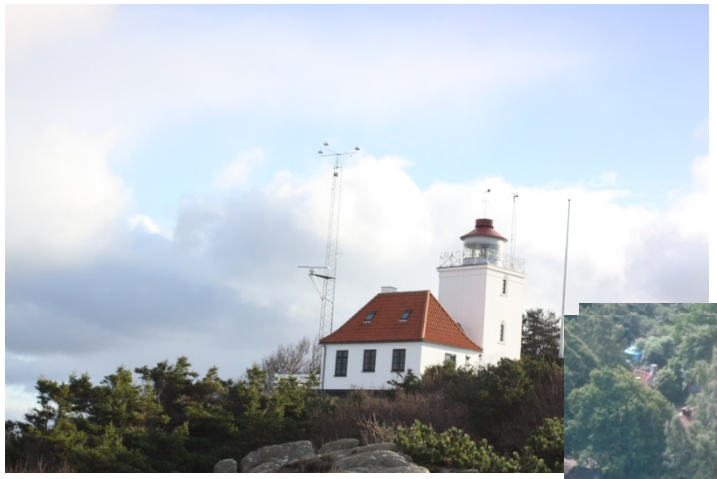
Day-time hours, 95% accuracy [m]



Night-time hours, 95% accuracy [m]



Radio beacon side inspection

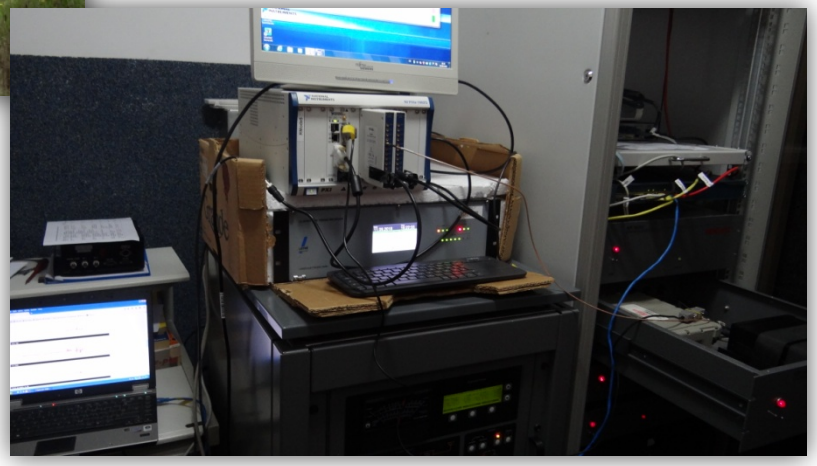


Hammerode

Rozwie

Holmsjö

Tests performed



- Approach: replace modulator

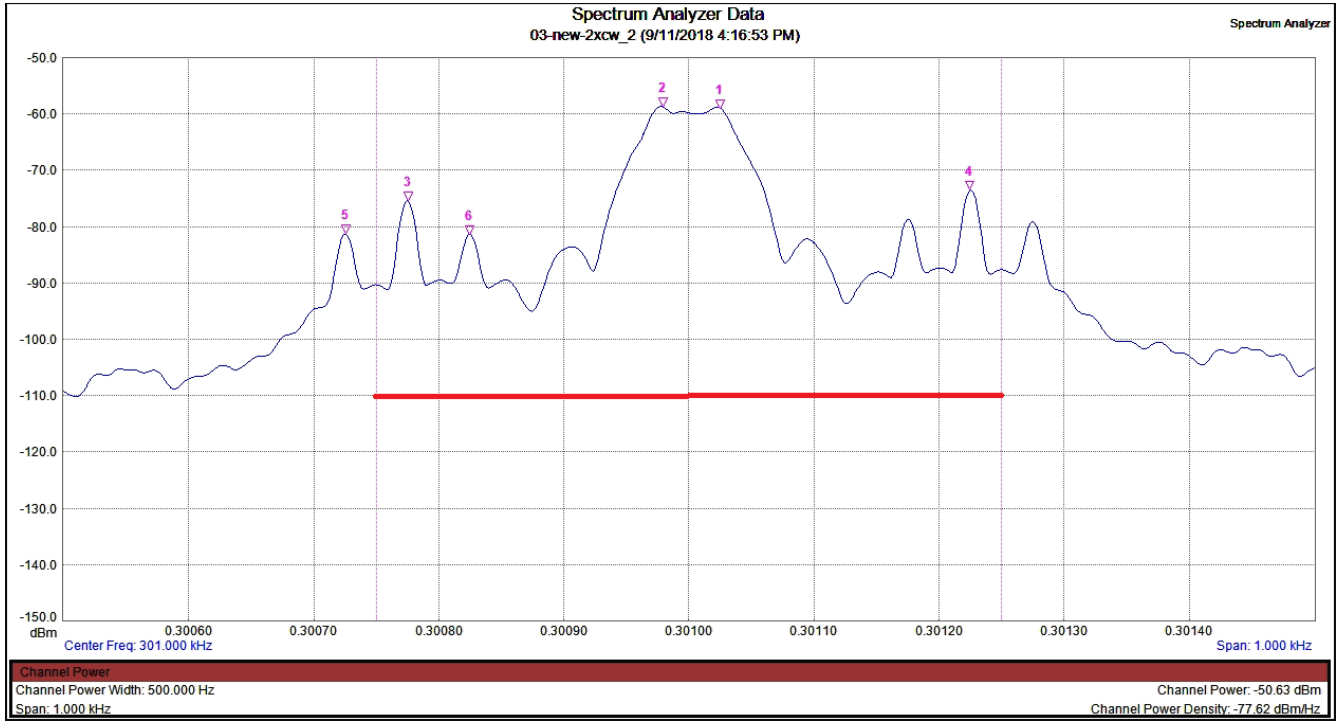
- Measure spectra in near field
- Observe influence on monitor station
- Antenna impedance measurement

Non Linear Amplifier

MF Signal spectrum in air R Mode MSK +2CW, + intermodulation for CW= 225 Hz

MSK 301,0 kHz + CW1-m3 (300,775 kHz) + CW2-m4 (301,225 kHz)

Channel power: - 50,63 dBm



Conclusion radio beacon side inspection

- All antennas work for R-Mode
- No changes were observed from the monitors
- Non linear amplifiers are not suitable

  - **Upgrade of Danish, Swedish and German stations is possible by modulator exchange**
  - **Polish stations need a linear transmitter**

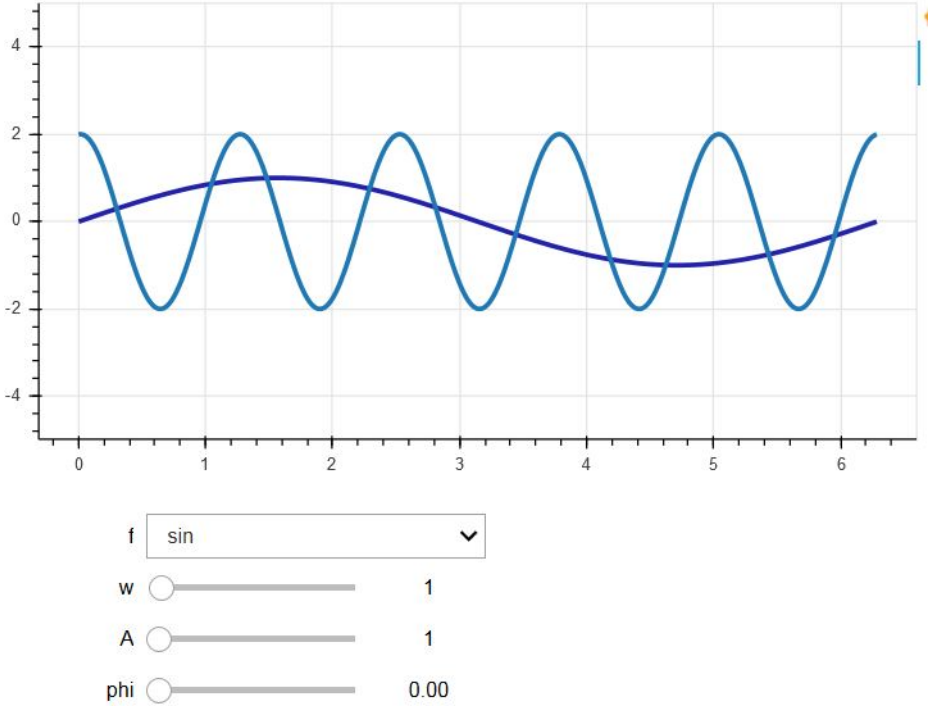
MF phase estimation technique

Parametric estimation

- Parameter:
  - o Phase
  - o Amplitude
  - o Frequency

- Maximum Likelihood estimation:
  - o Choose frequency of interest
  - o Estimate exactly one frequency

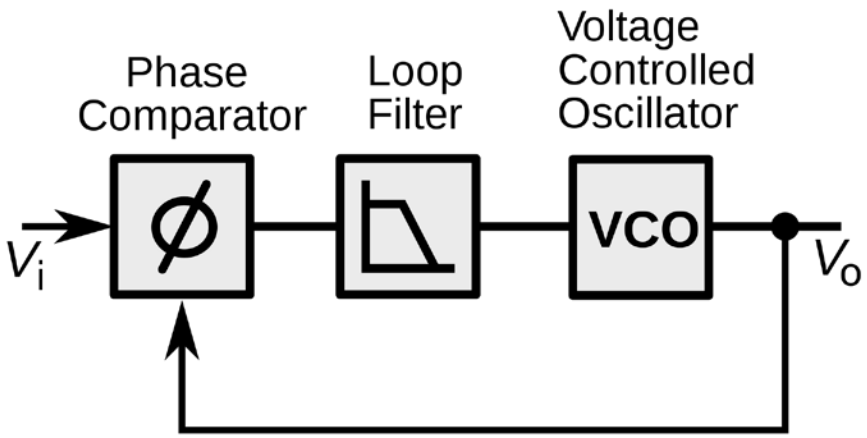
- Discrete Fourier transform estimation:
  - o Frequency on fixed grid
  - o Estimate all frequency on grid



Estimation technique

Phase Locked Loop (PLL)

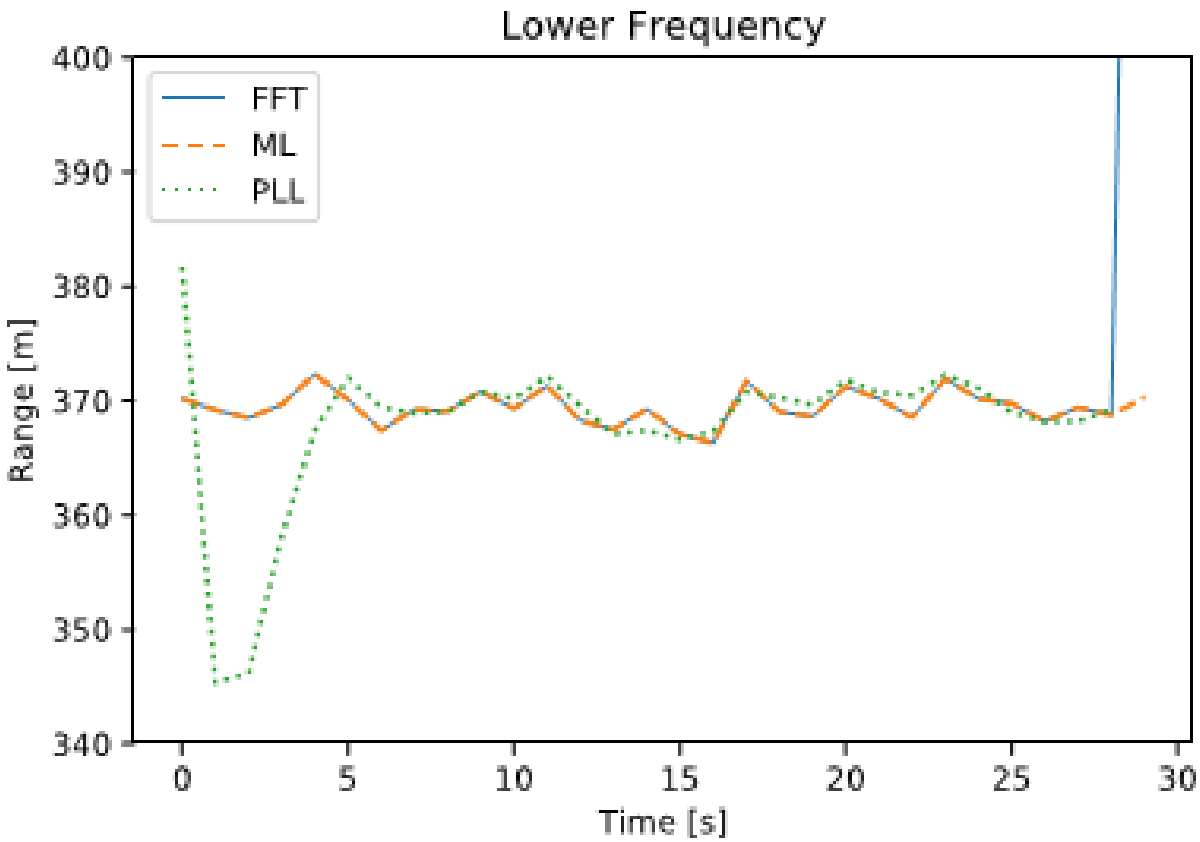
- Control system
  - o Phase comparator
  - o Loop filter
  - o VCO
- No observation time
- No separation of signal components
- Well known implementation



Comparison of phase estimation approaches

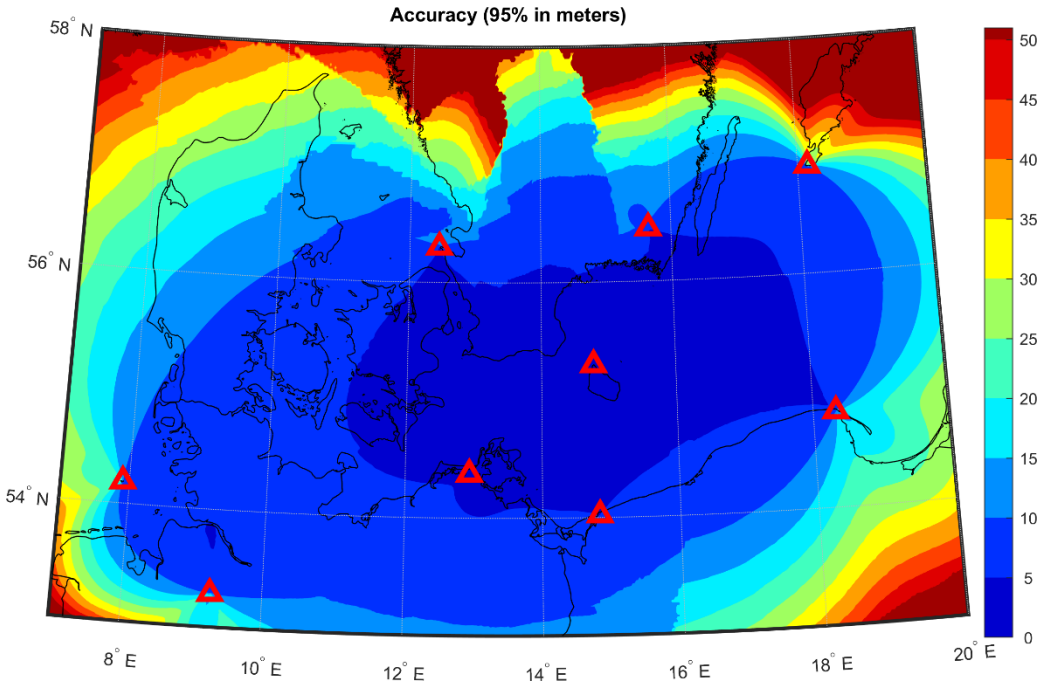
Real measurements

- PLL show phase at the moment
- ML/FFT show the phase delayed
- FFT 10x faster then ML



MF R-Mode testbed

- Swedish and German maritime administration purchase at the moment MF R-Mode modulators and clocks
- First installations are predicted for October 2019
- *In total we expect 9 R-Mode enabled MF transmitters*



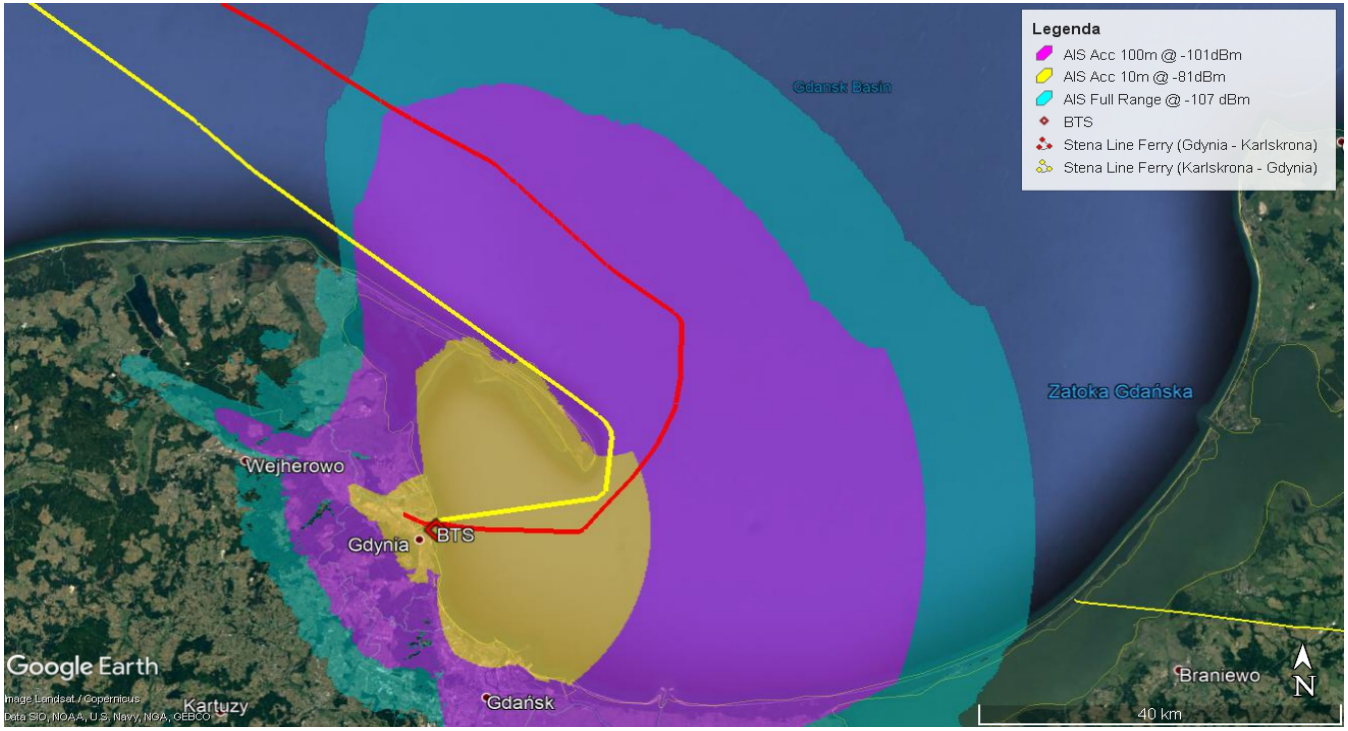
VHF R-Mode

- Theoretical analysis and results of measurements
  - Lower bound for accuracy estimation when using AIS or VDES channels for R-Mode

- More details in a presentation in session 5 BG 1

VHF R-Mode

- Search optimal code for synchronization

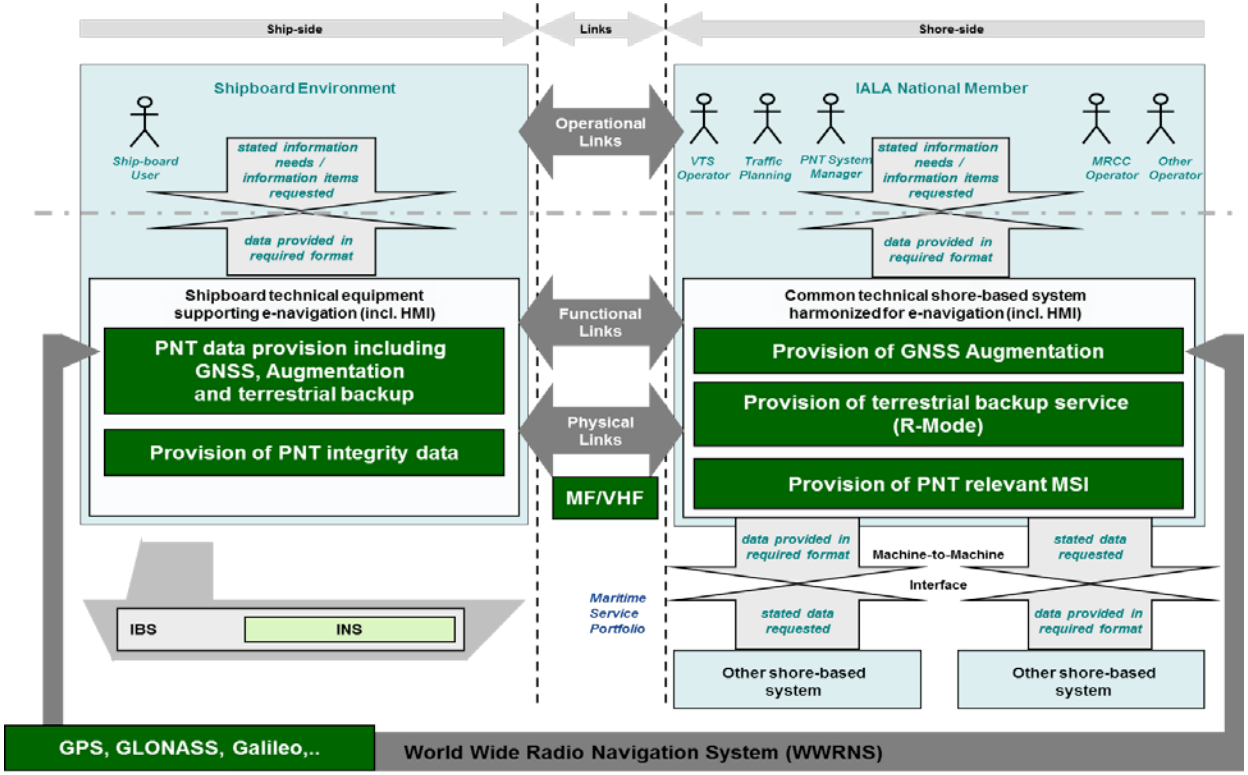


- More details in a presentation in session 5 BG 1

R-Mode testbed system design

Session 5 - BG2: Guidelines on Implementation of R-Mode on MF and VHF

- Presentation: R-Mode implementation in R-Mode Baltic project



Conclusions

- Baltic Sea is a suitable region for a combined MF and VHF R-Mode testbed.
- Theoretical analysis shows, user requirement can be fulfilled at day-time.
- Skywave has to be mitigated to reach user requirement between sunset and sunrise.
- Upgrade of existing radio beacons feasible when the amplifier is linear.
- Different approach to estimate range for MF signals available.

Contact

Stefan Gewies
Project Manager
German Aerospace Center
Institute of Communications and Navigation
Phone: +49 3981 480187
E-mail: Stefan.Gewies@dlr.de
www.r-mode-baltic.eu

Project partner