



ENG8-6.7



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# R-Mode Baltic – R-Mode testbed in the Baltic Sea

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R-Mode Baltic project team

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# Outline



- Introduction
- An R-Mode testbed for the Baltic Sea
- Signal-of-opportunity coverage prediction for the Baltic Sea
- R-Mode user requirements on a backup system
- Conclusion

# Introduction: GNSS in the maritime domain today

Safe navigation requires a backup system

- GNSS has become the primary source for maritime positioning and timing
- GNSS data is used in many ship systems e.g. AIS, ECDIS, INS
- GNSS is vulnerable to unintentional and intentional interferences
- IMO: maritime user requires a backup systems for GNSS (MSC 85/26, Annex 20)

## ECDIS



[www.glasgowmaritimeacademy.com](http://www.glasgowmaritimeacademy.com)

## AIS

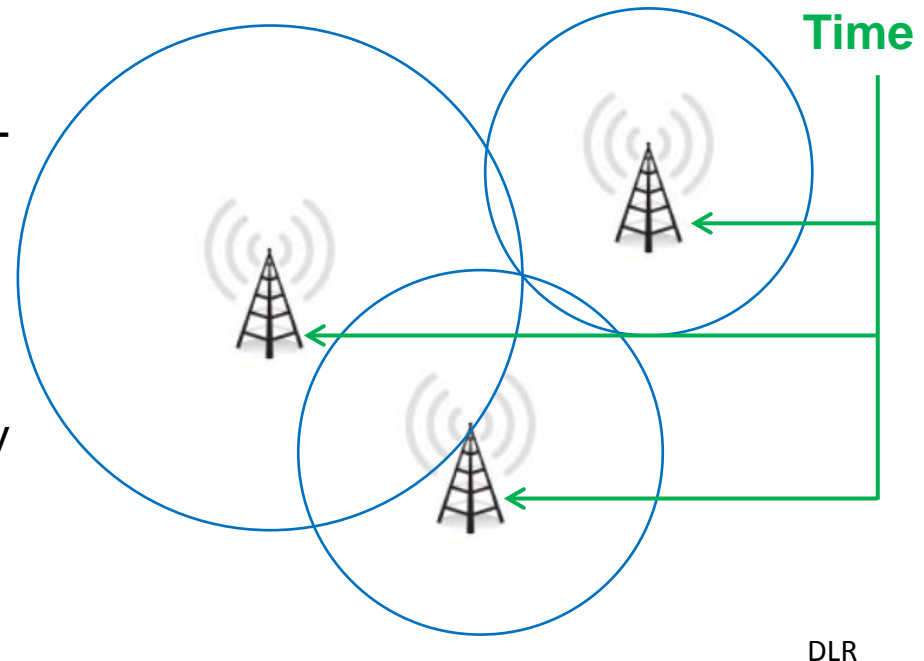


[www.raymarine.com](http://www.raymarine.com)

## Introduction: R-Mode

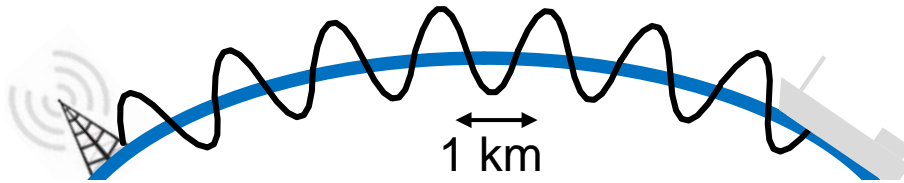
### A terrestrial maritime backup system for GNSS

- R(anging)-Mode is a positioning system that
  - transmits timely synchronised ranging signals
  - using the communication channel of existing maritime radio infrastructure
- Recent studies show the potential of R-Mode implemented on maritime radio beacons and AIS base stations
- A testbed is needed for
  - Further development of technology
  - Validation and long term studies
  - Development and test of user equipment and applications
  - Development of guidelines and standards



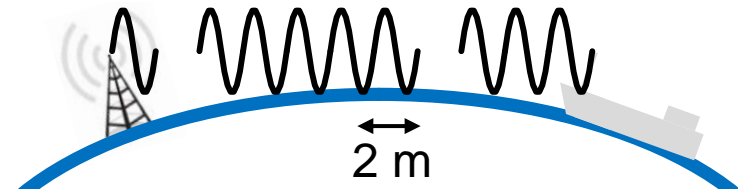
# R-Mode Signals-of-Opportunities

## Maritime Radio Beacon



- Continuous stream of DGNSS corrections
- MF: 283.5 – 325 kHz
- Neighboring stations differ in transmitting frequency
- Ground wave propagation (day)
- Service area: up to 500 km
- ITU-R M.823-3, RTCM SC104

## AIS



- Packed based digital communication system
- VHF: 162 MHz
- Ships and shore share two channels (each 2250 slots/min)
- Line of sight propagation
- Service area base station: up to 80 km
- ITU-R M-1371

# Signals of Opportunities as source for R-Mode ranging

## Maritime Radio Beacon

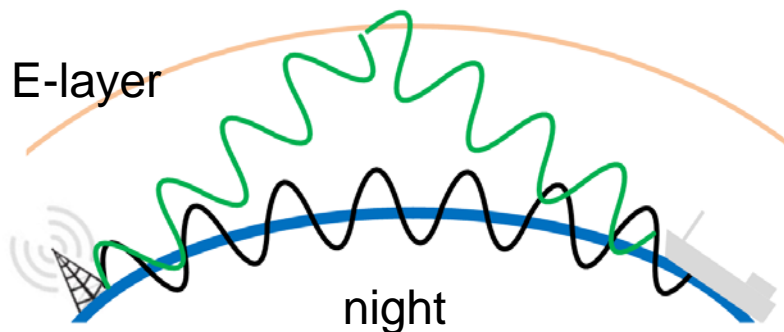
**Approach:** add two 2 continuous wave (CW) signals 225 Hz beside carrier of legacy signal

### First results (measured)

- Range : <10 m day ; <50 m night

### Challenges

- Mitigate skywave induced fading
- Accurate estimation of beat signal

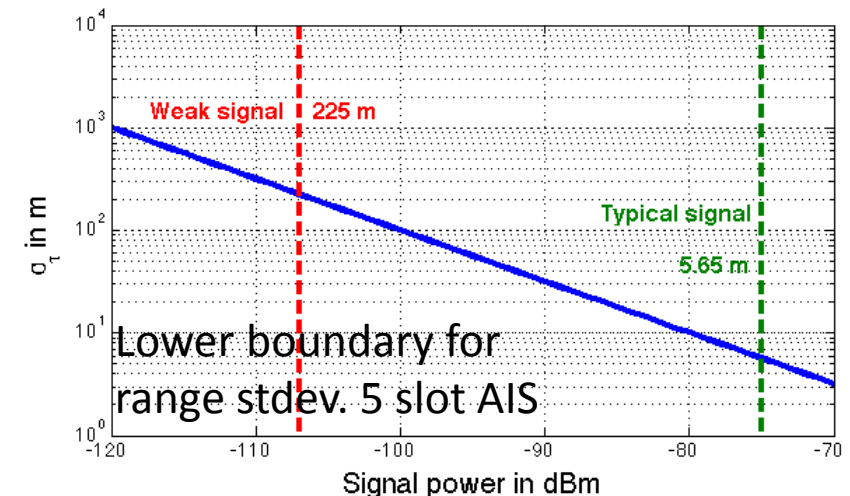


## AIS

**Approach:** Range estimation using bit edge of AIS message transmitted from base station

### Challenges

- Design AIS message with sufficient length and low autocorrelation
- Minimized additional channel load



# Project R-Mode Baltic 2017 - 2020

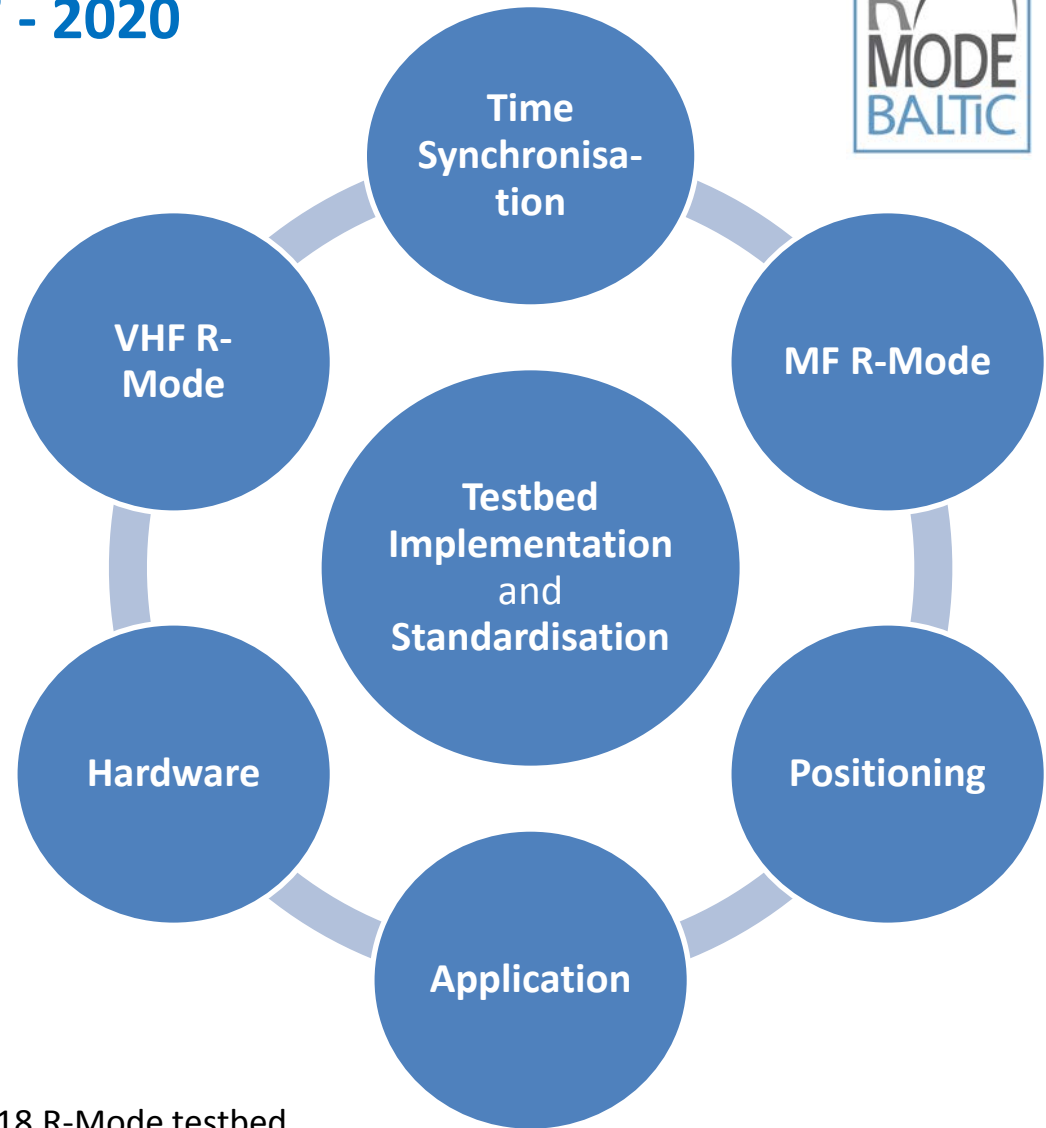
## Aims

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

## Constraint

- No disturbance of legacy service and equipment

## Project considers R-Mode roadmap of IALA



More details: Gewies et al. IALA Conference 2018 R-Mode testbed

# Project consortium



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- Research institutions



- National maritime administrations



- Industry

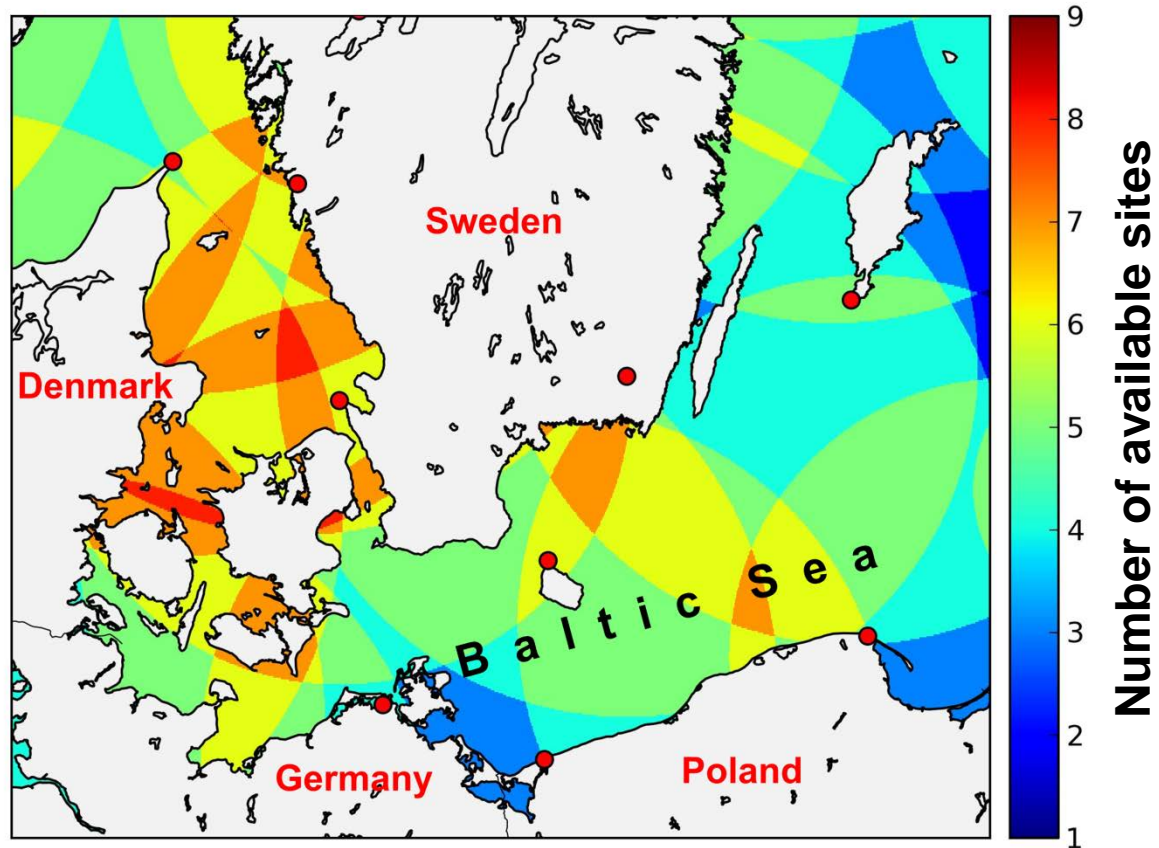


\* Lead partner



# Coverage of the Baltic Sea with MF radio beacon signals

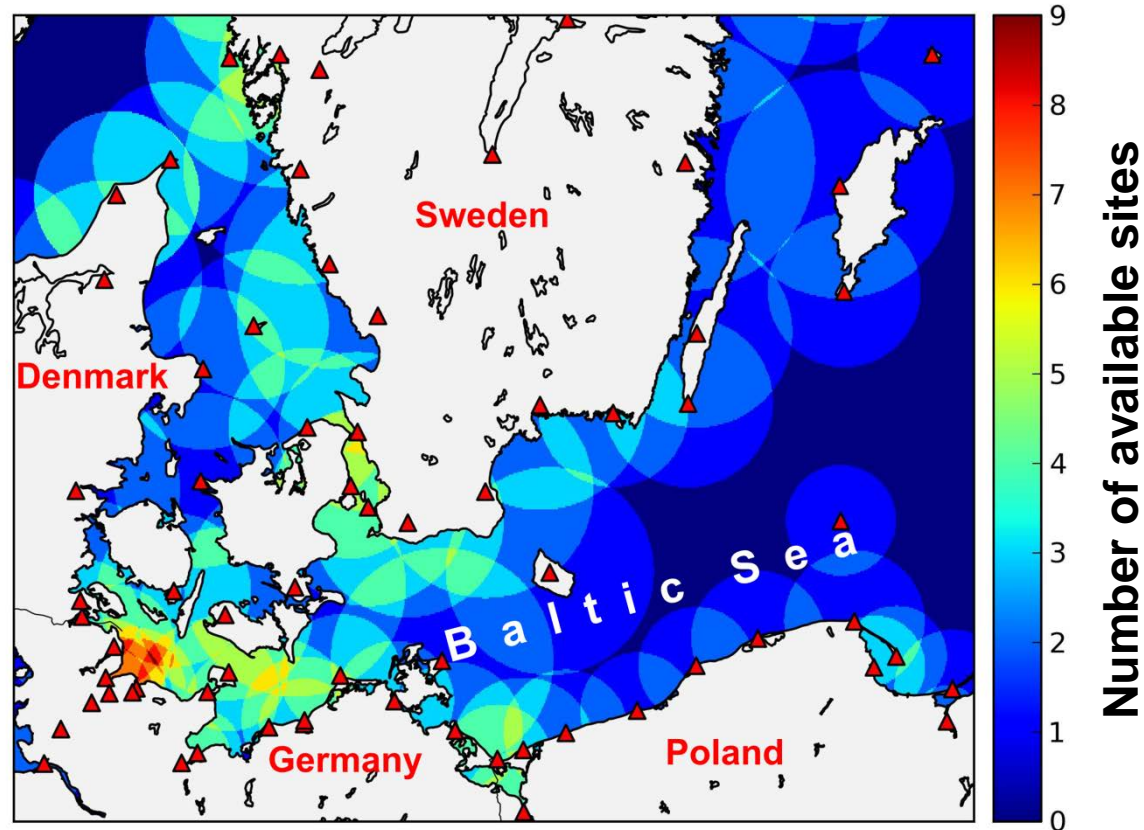
Based on given nominal range



Sufficient ( $>3$ ) number of beacons for positioning in wide areas of the Southern Baltic Sea

# Coverage of the Baltic Sea with VHF AIS signals

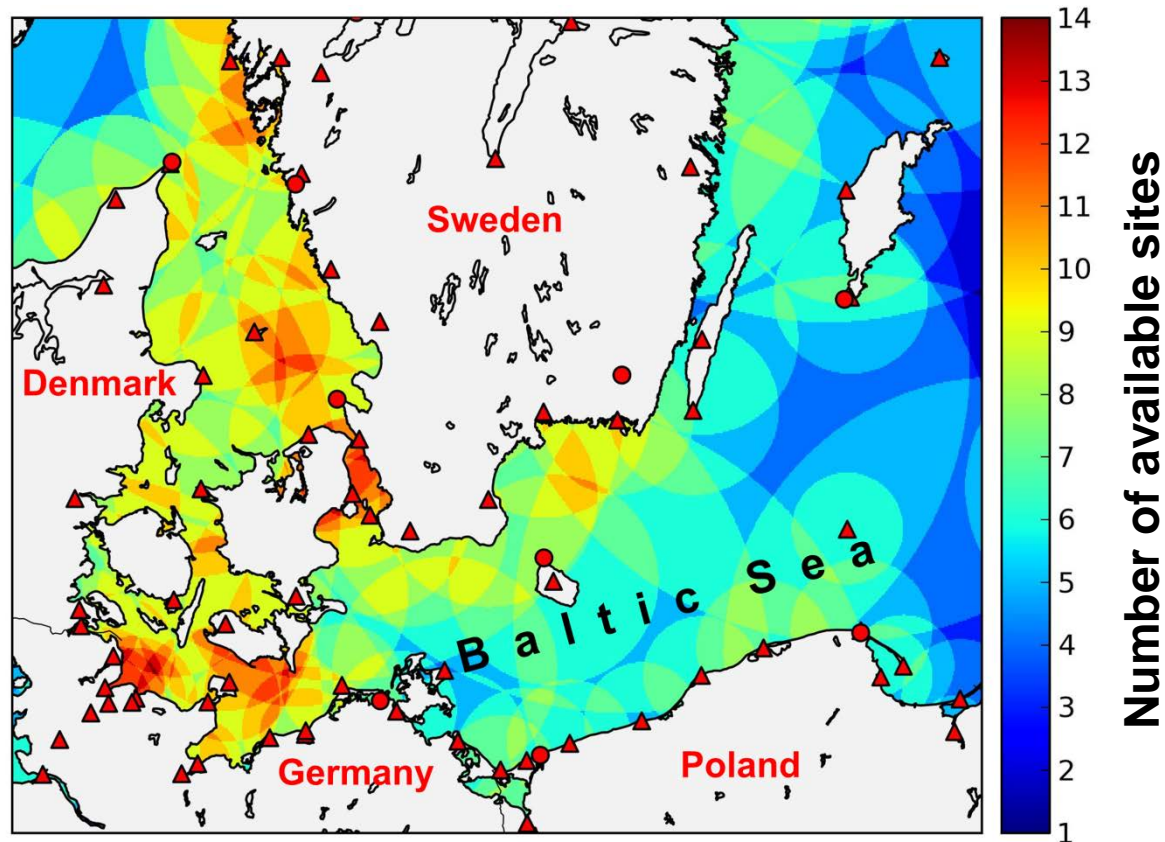
Based on geometrical range (vessel: 10 m antenna height)



Insufficient ( $<4$ ) number of stations for positioning in wide areas of the Southern Baltic Sea

# 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

# Maritime user requirements on a backup system?

## IMO documents

- IMO Resolution A.915 (22) – user requirements for future GNSS
- IMO Resolution A.1046 (27) – service requirements for Worldwide Radio Navigation Systems
- IMO the SAR Convention and reports of NAV-Committee meetings – need for alternative navigation system to increase robustness, reliability and availability
- IMO MSR performance standard and PNT guideline – use of terrestrial services would improve redundancy and introduce new integrity concepts

### R-Mode Baltic - Baseline and Priorities





Issue: 1  
Issue Status:  
Issue Date:

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

# Maritime user requirements on a backup system?

## IALA documents

- IALA R-115 – DGNSS Services: recommends the use of proper radio frequency bands
- IALA R-150 - future of IALA DGNSS: NMA asked to consider the implementation of new services
- IALA Recommendation A-123 – encourages administrations to provide an AIS shore infrastructure in terms of navigation safety
- IALA R-124 – management and prevention of AIS data channel overload
- IALA World Wide Radio Navigation Plan
- IALA R-129 - GNSS Vulnerability and Mitigation Measures – Minimum user requirements for a backup navigation system proposed

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Approval	Dr. Stefan Gewies	German Aerospace Center	



# Minimum user requirement on a backup system

IALA R-129 based on IMO Resolution A.915(22)

	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)				
Ocean	1000	2500	Not covered by MF or VHF transmitter sites				60	
Coastal	100	250	30	$10^{-4}$	99	N/A <sup>2</sup>	Regional	15
Port approach and restricted waters	10	25	10	$10^{-4}$	99	99,97	Regional	2
Port	1	2.5	Not reachable		99	99,97	Local	1
Inland Waterways	10	25	10	$10^{-4}$	99	99,97	Regional	2

## Types of alternative system

### Definitions in IALA Recommendation R-129

- A **redundant system** provides the same functionality as the primary system, allowing a seamless transition with no change in procedures.

- A **backup system** ensures continuation of the navigation application, but not necessarily with the full functionality of the primary system and may necessitate some change in procedures by the user.

### R-Mode

**GNSS independent time  
synchronisation**

- A **contingency system** allows safe completion of a manoeuvre, but may not be adequate for long-term use.

**GNSS dependent time  
synchronisation**

## 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)
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Coastal	100	250	30	$10^{-4}$	99	N/A <sup>2</sup>	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



## Conclusion

- R-Mode has the potential to support navigation in coastal regions, port approaches and inland waterways
- Both, MF and VHF, station upgrade to R-Mode stations seems to be necessary to enable positioning in the Southern Baltic Sea
- Project R-Mode Baltic team will perform fundamental developments and build up a first testbed that utilises both signals-of-opportunity
- IALA R-129 provides user requirements for R-Mode system development
- VDES can help to overcome AIS channel load limitations



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## Project partner



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