



EGNOS, it's there. Use it.

# SBAS Guidelines for Shipborne Receiver based on IMO Res. A.1046 (27): EGNOS performance assessment in Norwegian coast

ITSNT 2018



European  
Global Navigation  
Satellite Systems  
Agency



Precise navigation,  
powered by Europe



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- Introduction
- EGNOS architecture
- SBAS Guidelines for Shipborne Receiver
- Maritime GNSS campaign in Norway coast
- Conclusions

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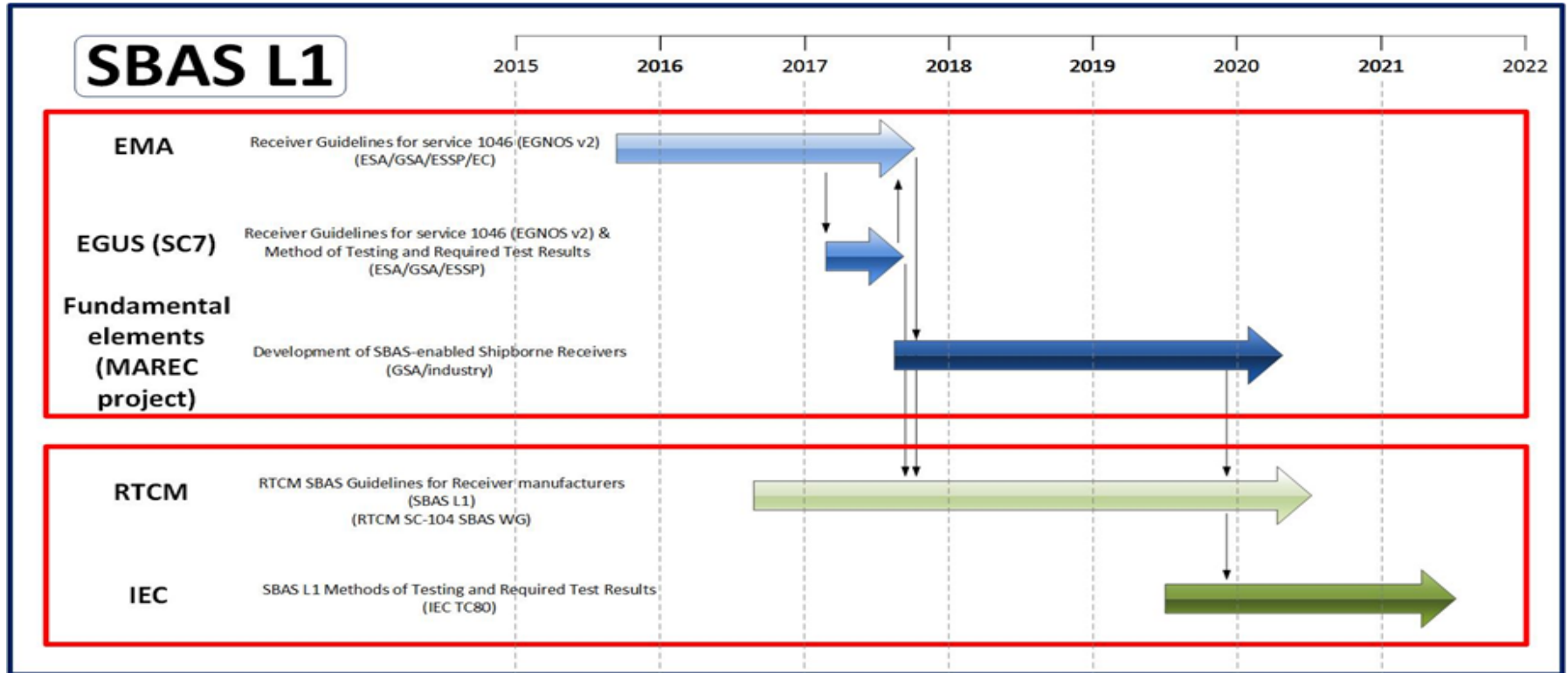
# Introduction

- EC/GSA is assessing to put in place **a maritime SBAS L1 service** in Europe.
- A shipborne receiver standard shall be developed to ensure a safe use of SBAS by the maritime community.
- EC/GSA, ESA and ESSP have drafted the guidelines in support of this process:  
*“ Draft Guidelines for manufacturers for the implementation of SBAS in Shipborne Receivers”*
- EGNOS SW application was developed in line to these guidelines, which was used for testing the proposed tests and methods.
- A maritime GNSS campaign was performed in Norway. Performance results are presented here to demonstrate the feasibility of EGNOS for some maritime applications.

## Next steps:

- In MAREC project funded by GSA, Kongsberg is developing a receiver in line with these guidelines.
- Support the standardization process for the integration of SBAS L1 in maritime navigation IEC 61108.

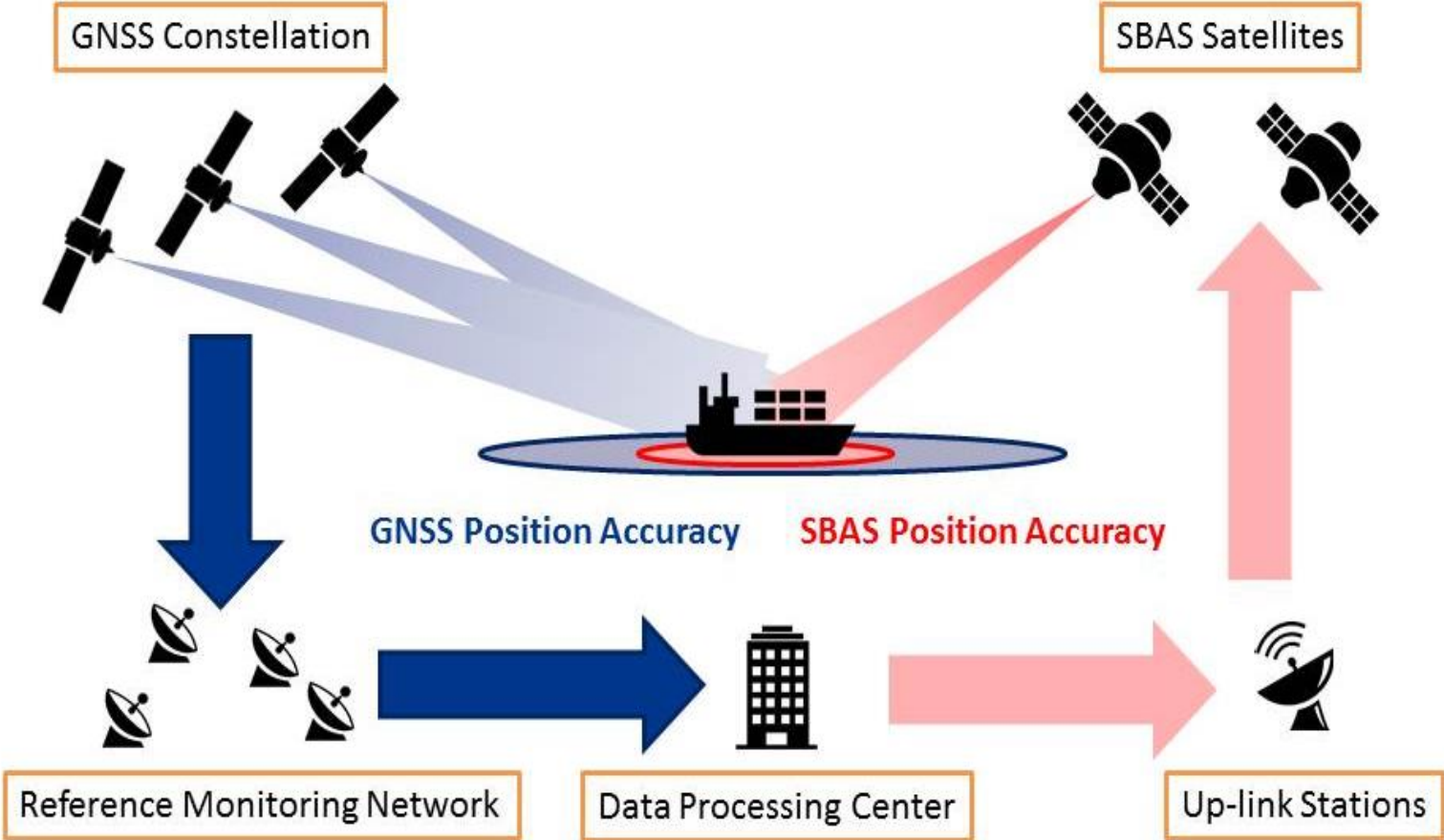
# Plan



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# EGNOS architecture



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# SBAS Guidelines ToC

## 1. Introduction

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- 1.2. Document Overview
- 1.3. Associated Documents
  - 1.3.1. Reference Document
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## 2. SBAS Overview

- 2.1. SBAS System Architecture
- 2.2. SiS Interface Characteristics

## 3. Key Definitions and Assumptions

- 3.1. IMO Resolution A.1046 concepts/definitions

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- 4.1. General Requirements
  - 4.1.1. GPS Signal Processing Requirements
  - 4.1.2. SBAS Signal Processing Requirements
- 4.2. Guidelines for PVT SBAS Solution Computation
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- 4.2.2. Integrity Monitoring: System Integrity Messages
- 4.2.3. SBAS Message Processing
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## 5. SBAS Signal and Data Specification

- 5.1. Introduction
- 5.2. Signal-in-Space RF Characteristics
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- 5.4. SBAS Data Formats
- 5.5. Messages and Relationships between Message types
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## 6. Method of Testing and Required Test Results

APPENDIX A – Error Models

APPENDIX B – Messages Processing Flow Diagrams

APPENDIX C – SBAS Signal in Space Messages

APPENDIX D – Baseline Navigation Solution

# SBAS Receiver Guidelines

- SBAS Guidelines proposes the use of the following Message Types to fulfil IMO Res A.1046 performance requirements:
  - **Accuracy-related messages:**
    - Decode and apply fast corrections information broadcast through **MT 2 to 5** and **24** corresponding to satellites selected by **MT 1**.
    - Decode and apply long-term satellite error corrections broadcast through **MT24** and **25**.
    - Decode and apply ionospheric corrections if available broadcast through **MT 26** for ionospheric grid points defined by **MT 18**.
    - Apply **tropospheric error** corrections.
    - Use the SBAS satellite ranging function if available broadcast through **MT 9**.

# SBAS Receiver Guidelines

- **Consider major warnings broadcast by the system (Integrity-related messages):**
  - Information on the availability of the service by the system through **MT 0**.
  - Satellite alerts in **MT 2 to 6** and **24**.
  - Ionospheric alerts in **MT 26**.
- **Other recommended messages:**
  - Time-out intervals for the validity of the messages from **MT 7**.
  - Almanac data from SBAS satellites broadcast through **MT 17**.
- **Optional messages:**
  - Degradation factors provided in **MT 10**.
  - **MT 27** and **28** to compute satellites' sigma values.

# SBAS Receiver Guidelines

- **Proposed Test for manufacturers:**
  - Static accuracy
  - Static accuracy with angular movement of the antenna
  - Dynamic accuracy
  - Static availability
  - Static continuity
  - SBAS Navigation warnings and status indications
  - Use of SBAS messages
  - SBAS data input
  - Sensitivity and dynamic range
  - SBAS GEO switching

# Integrity concept in the maritime domain using EGNOS

- The integrity concept in IMO Res A1046 is defined at system level:
  - GPS system failures
  - not consider local sources (multipath, shadowing, interferences, ...)
- EGNOS integrity concept at system level in the maritime domain has to consider at least the following:
  - Satellite alert or not monitored:
    - Satellite not used when  $UDREI \geq 14$
  - Ionosphere alert or not monitored:
    - Ionospheric grid not used when  $GIVEI=15$  or  $GIVD=63.875m$ )
  - EGNOS system alerts or test
    - SBAS corrections not used when  $MT0$

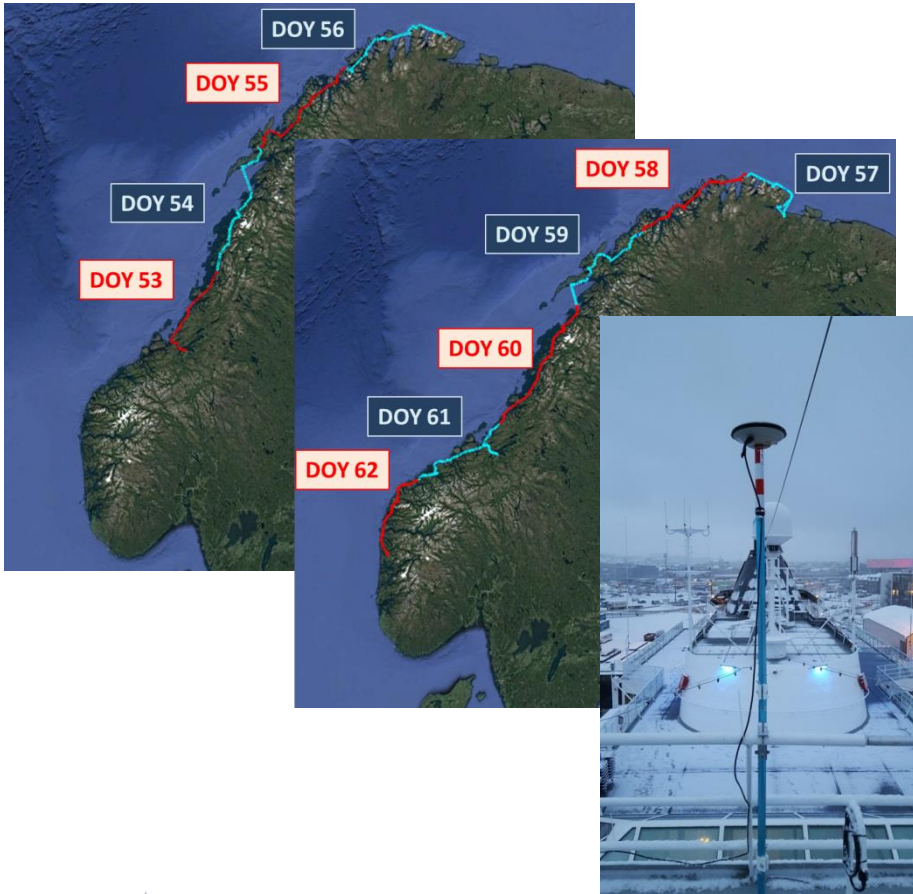
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# Maritime GNSS campaign in Norway coast

- Route:
  - In the northbound, the vessel departed from Trondheim to Kirkenes.
  - The southbound was from Kirkenes to Bergen.
- Dates:
  - Departure from Trondheim: 22/02/2018
  - Arrival to and departure from Kirkenes: 26/02/2018
  - Arrival to Bergen: 03/03/2018
- Vessel: MS Finnmarken (more information in <https://www.hurtigruten.co.uk/our-ships/ms-finnmarken/>)

# Maritime GNSS campaign in Norway coast



- GNSS multi-frequency Receiver with the following capability:
  - GPS L1/L2/L5
  - SBAS
- GNSS Antenna L1/L2/L5
- L1 RF Recorder





# Maritime GNSS campaign in Norway coast



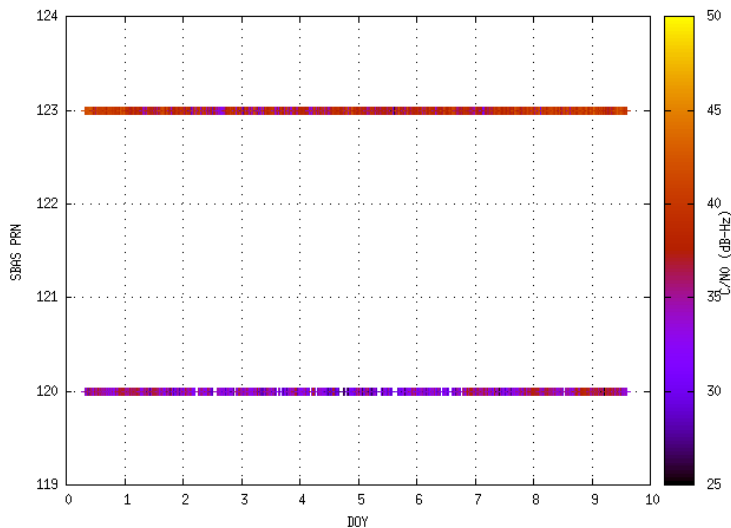
Signal is recorded and available for reproduction for receiver manufactures.

If interested, contact [resev@essp-sas.eu](mailto:resev@essp-sas.eu)



# Maritime GNSS campaign in Norway coast

- EGNOS SIS availability
  - Broadcast at least one EGNOS GEO satellite: **100%**
  - At receiver level → % time SBAS PRN is tracked by the receiver

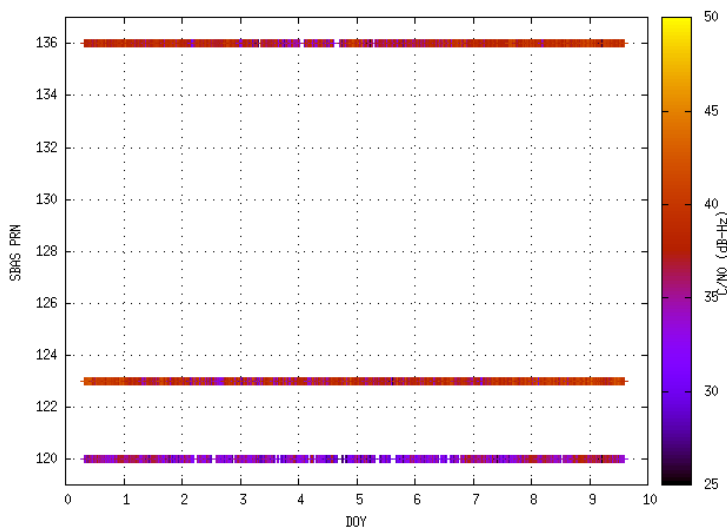


PRN123 tracked: 96.78%

PRN120 tracked: 73.34%

# Maritime GNSS campaign in Norway coast

- EGNOS SIS availability
  - Broadcast at least one EGNOS GEO satellite: **100%**
  - At receiver level → % time SBAS PRN is tracked by the receiver



PRN136 tracked: 93.02% (TEST)  
-> **OPERATIONAL from 23rd August 2018**

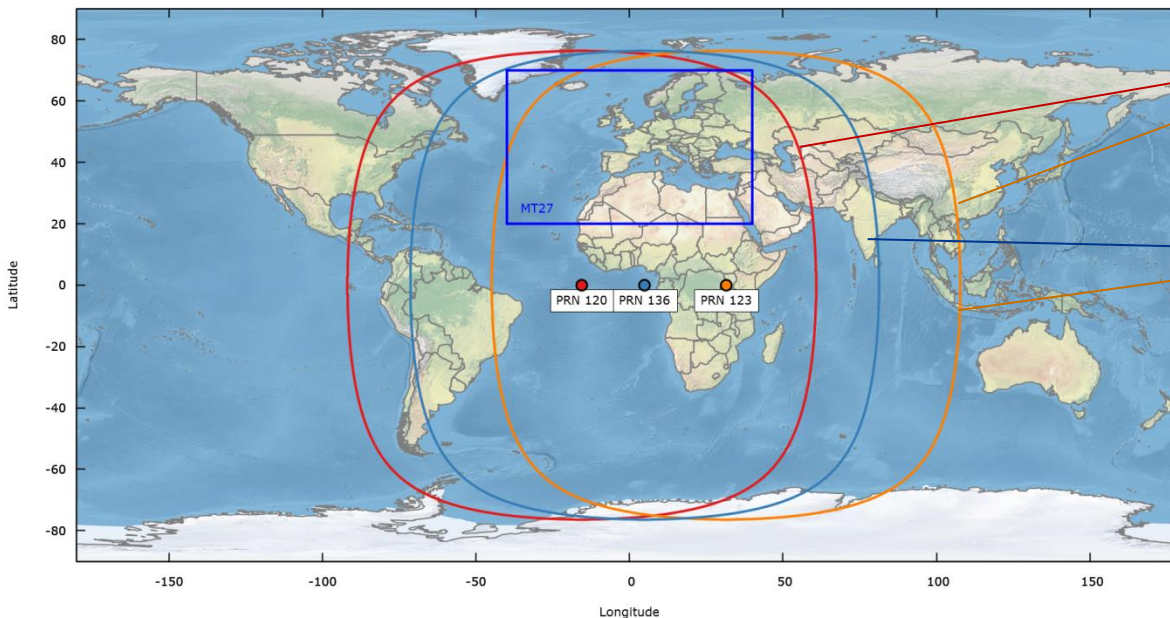
**GEO swap 120 -> 136 in OPERATIONAL**

PRN123 tracked: 96.78% (OPERATIONAL)

PRN120 tracked: 73.34% (OPERATIONAL)  
-> **Test from 30th August 2018**

# Maritime GNSS campaign in Norway coast

- EGNOS SIS availability
  - Broadcast at least one EGNOS GEO satellite: **100%**
  - At receiver level → % time SBAS PRN is tracked by the receiver



PRN120 or PRN123: 98.89%



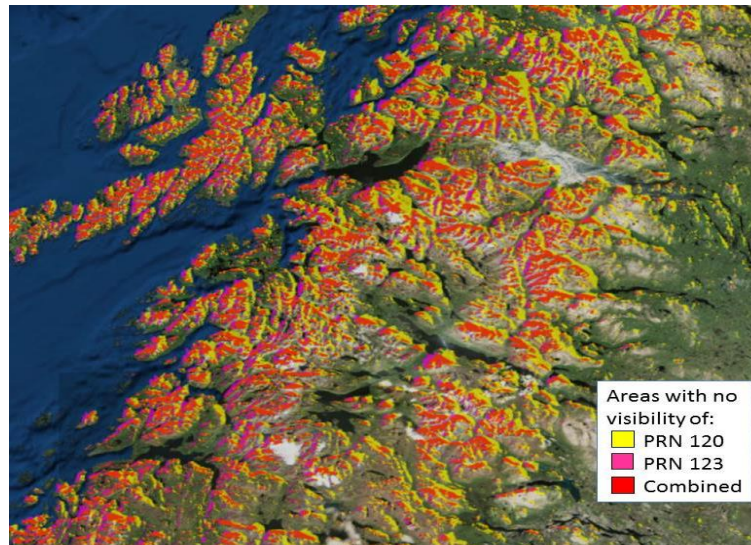
PRN136 or PRN123: 99.34%  
From 23<sup>rd</sup> August 2018



**New Operational EGNOS GEO satellite PRN136 improves the EGNOS SiS visibility in the Northeast of Europe.**

# Maritime GNSS campaign in Norway coast

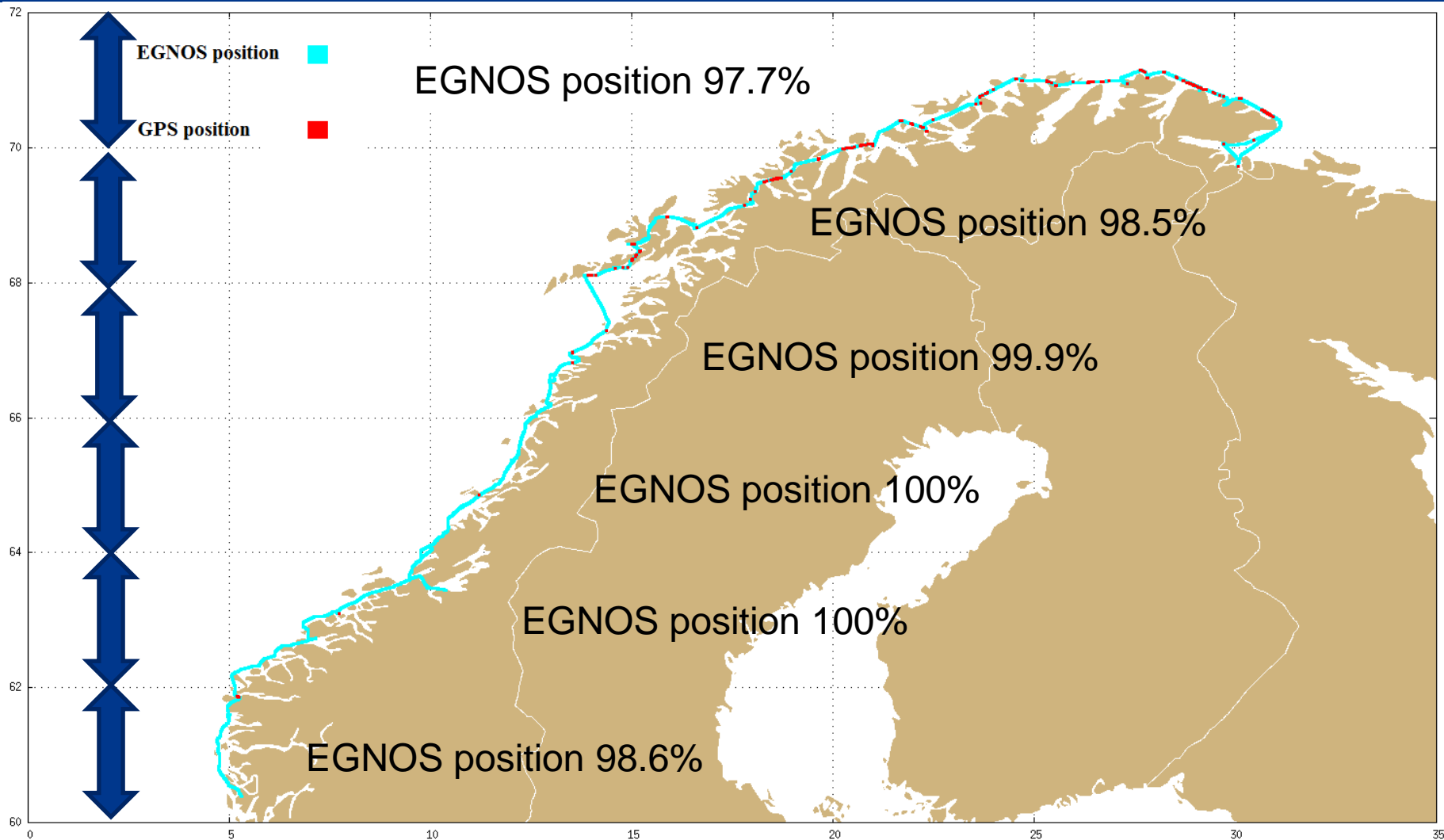
- EGNOS SIS availability
  - Broadcast at least one EGNOS GEO satellite: **100%**
  - The lack of EGNOS signal at the receiver → the orography



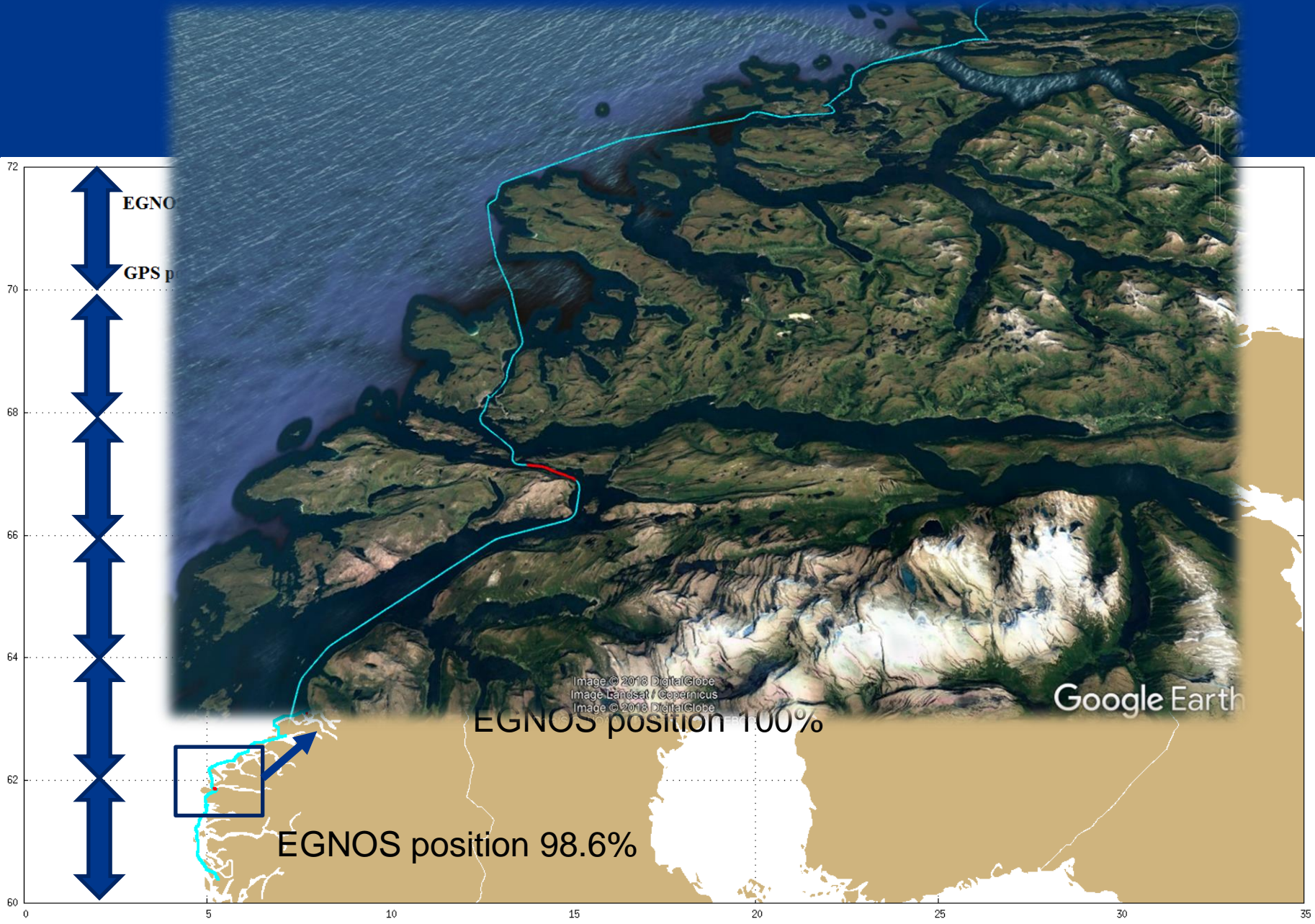
EGNOS visibility maps in  
EGNOS user support website

[https://egnos-user-support.essp-sas.eu/new\\_egnos\\_ops/resources-tools/egnos-visibility-maps](https://egnos-user-support.essp-sas.eu/new_egnos_ops/resources-tools/egnos-visibility-maps)

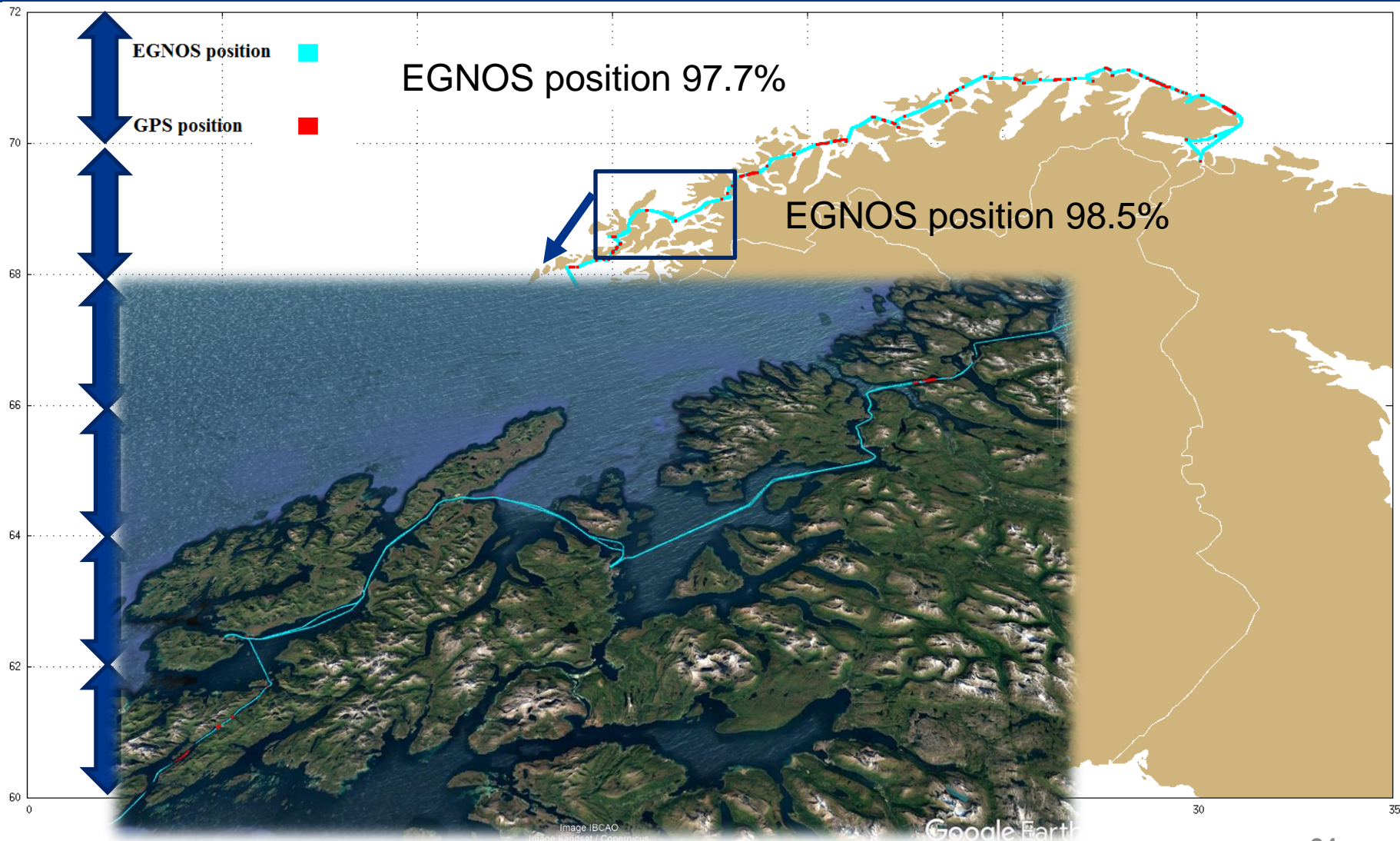
# Maritime GNSS campaign in Norway coast







# Maritime GNSS campaign in Norway coast





# Maritime GNSS campaign in Norway coast

- EGNOS accuracy: Horizontal position error at 95<sup>TH</sup> percentile in meters

DOY	EGNOS Rx		EGNOS SW		GPS	
	HNSE (m)	Used SV Average	HNSE (m)	Used SV Average	HNSE (m)	Used SV Average
53	1.24	9.4	1.14	9.1	2.08	9.4
54	1.21	9.0	0.95	9.0	2.00	9.7
55	1.41	8.1	1.03	8.2	2.09	9.8
56	1.30	7.6	0.92	8.0	1.87	9.8
57	1.23	7.8	0.97	8.0	1.87	9.9
58	1.44	7.8	0.96	8.0	2.00	9.8
59	1.23	8.6	0.89	8.5	2.05	9.7
60	1.18	9.2	0.89	9.1	2.05	9.6
61	1.14	9.3	0.80	9.1	2.36	9.5
62	1.11	9.8	0.76	9.5	1.87	9.4

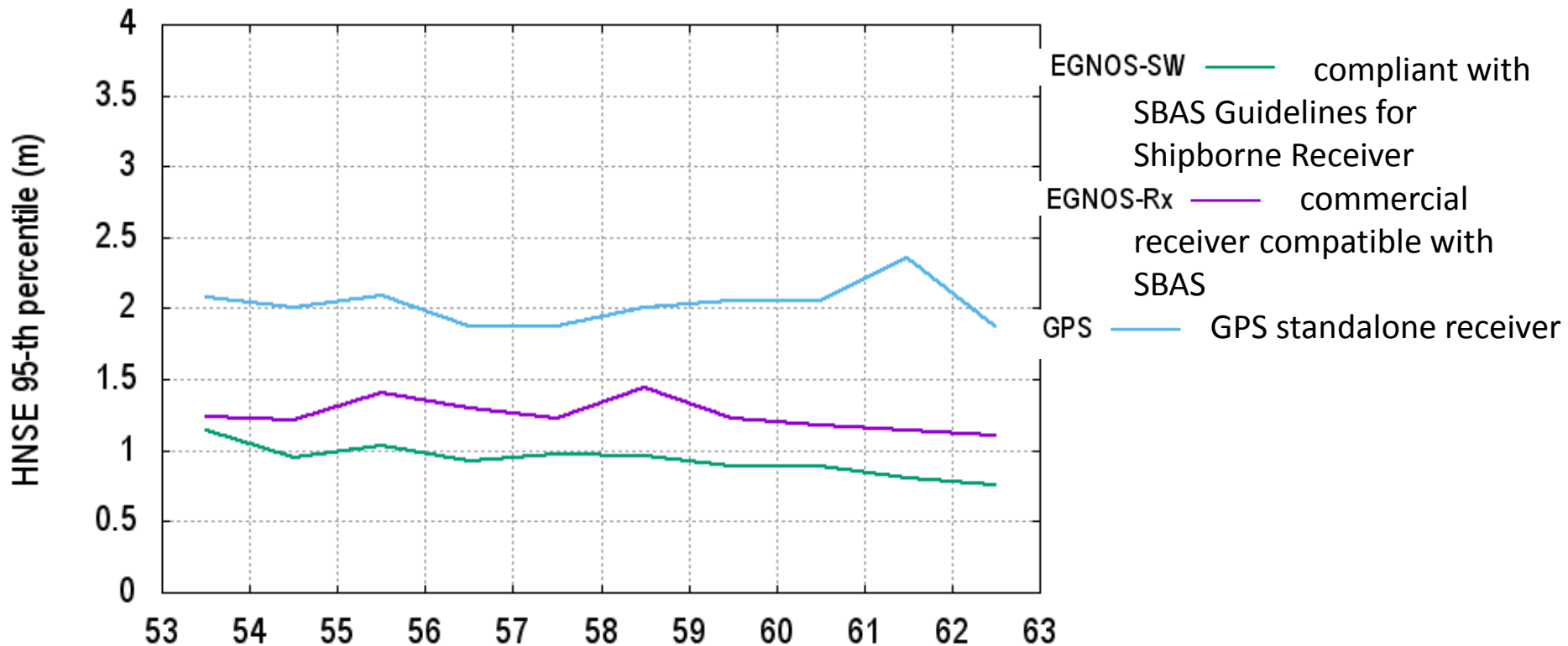
**EGNOS SW:** compliant with SBAS Guidelines for Shipborne Receiver

**EGNOS Rx:** commercial receiver compatible with SBAS

**GPS:** GPS standalone receiver

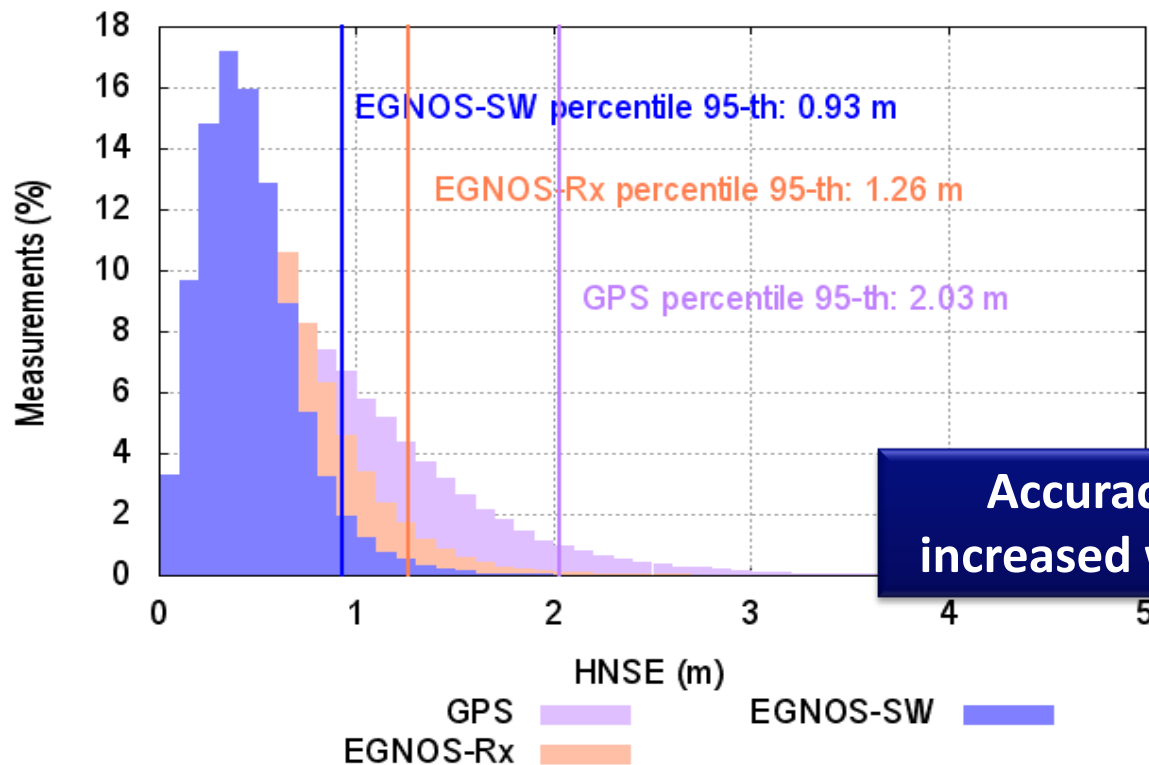
# Maritime GNSS campaign in Norway coast

- EGNOS accuracy: Horizontal position error at 95<sup>TH</sup> percentile in meters



# Maritime GNSS campaign in Norway coast

- EGNOS accuracy



Accuracy with EGNOS is increased with respect to GPS

- EGNOS SW:** compliant with SBAS Guidelines for Shipborne Receiver.
- EGNOS Rx:** commercial receiver compatible with SBAS
- GPS:** GPS standalone receiver

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# Conclusions

- **Guidelines for Manufacturers for the Implementation of SBAS in Shipborne Receivers** including Methods of Testing and Required Test Results was developed.
- **EGNOS provides integrity** information that should be used as explained in the guidelines as added value to the GPS standalone position solution.
- A GNSS campaign was done in Norway coast:
  - The **EGNOS signal in space availability** was 100% during the whole period.
  - EGNOS provides **better accuracy** performance than GPS Standalone.
    - Accuracy figures are degraded between 30% and 50% in GPS standalone.
- The work presented in this paper are intended to support the integration of SBAS in the standardization process for maritime navigation and radiocommunication equipment and systems IEC 61108.



EGNOS, it's there. Use it.



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Corporate Video

**THANK YOU!**