MARGOT Project

User Consultation Platform 2020 – Maritime and Ocean Monitoring Session

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Multipath & Interference Error Mitigation Techniques for Future Maritime e-NAV Services

ESA NAVISP Element I

Objectives:
• Determine over-bounding multipath and interference error models for the maritime environment
• Determine mitigation methodologies for multipath and interference
• Determine L-band channel models for the maritime environment
Project overview

Prime

Subcontractors

Third party

Support

Experts Advisory Board
Data collection campaigns

Piggyback and dedicated data collection campaigns were conducted on three vessels, from May 2018 until June 2019.

**Istros**
- Length: 32 m
- **Navigation types:** fluvial navigation on the Danube river, coastal navigation in the Black Sea, port navigation
- **Collected data:** 651 hours

**Mare Nigrum**
- Length: 82 m
- **Navigation types:** coastal navigation, open sea navigation and port navigation in the Black Sea
- **Collected data:** 1666 hours

**Cpt. Cdor. Alexandru Catuneanu**
- Length: 64.7 m
- **Navigation types:** port navigation, open sea navigation and coastal navigation in the Black Sea and Aegean Sea
- **Collected data:** 531 hours

Sources: geoecomar.ro & dhmf.b.ro
Data collection equipment
Multipath over-bounding models methodology

**Estimate absolute multipath**
- GPS L1-L2, L1-L5
- Galileo E1-E5a, E1-E5b, E1-E5
- Raw data and 100 s smoothed data

**Estimate standard deviation**
- Group multipath values in 1 degree elevation bins and compute standard deviation ($\sigma_x$) values

**Data classification**
- Classify multipath data based on navigation type, vessel type, antenna type and location, antenna height, receiver type, sea state

**Multipath modelling**
- Determine multipath over-bounding error models for each classification, using the standard deviation for each satellite elevation bin

**Over-bounding process**
- Compute exponential fit as a function of elevation for each frequency

\[ a \cdot e^{bx} + c \]

Based on: **Blanch, Juan, Walter, Todd, Enge, Per**, "A MATLAB Toolset to Determine Strict Gaussian Bounding Distributions of a Sample Distribution", Proceedings of the 30th International Technical Meeting of The Satellite Division of the Institute of Navigation (ION GNSS+ 2017), Portland, Oregon, September 2017, pp. 4236-4247
Proposed multipath models

1. **Port navigation model** - all vessels
2. **Cluttered antenna environment in open navigation model** - coastal navigation, open sea navigation and port approach with Mare Nigrum and Catuneanu
3. **Open antenna environment in open navigation model** - coastal navigation, fluvial navigation and port approach with Istros

The chosen frequencies are L1/E1 and L5/E5, disregarding the constellation differences.
Conclusions of the multipath analysis

• There is a very small difference between coastal navigation, open sea navigation and port approach.
• Port environment has very similar multipath effects on all three types of ships.
• The antenna environment has the highest impact.
• Methods for reducing the impact of multipath, such as choke ring antennas and smoothing, may be used with very good results.
• Antenna height has a small impact on multipath.
• The receiver type does not have a significant impact on multipath.
• Ship movement has a small impact on multipath. Multipath models should be determined for calm weather and low ship movement.
• Differences between GPS and Galileo are small.
Recommendations regarding multipath for maritime

- Navigation phases can be grouped in **open navigation** (open sea, coastal, fluvial, port approach) and **port navigation**.
- Ships should be classified based on the amount of cluttering around the GNSS antenna. A mapping of the masking surfaces should be considered.
- The ICAO multipath model used in aviation is not suitable for maritime and fluvial navigation.
- Fluvial navigation should be divided into **open fluvial navigation** (wide navigation lanes, no bridges) and **port fluvial navigation** (high buildings on both shores, bridges).
- A **minimum 20° elevation mask** is recommended.
- Multipath models should be built based on measurements recorded in calm weather.
- The requirements on positioning accuracy should depend also on ship movement.
- At least **100 s smoothing** is recommended.
- **Additional integrity methods** should be used at receiver level.
THANK YOU!

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Linking space to user needs

How to get in touch:

www.GSA.europa.eu

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