Assessment of EGNOS potential in the maritime and inland waterways transport sector
A Project for the European Commission by Valdani Vicari & Associati S.r.l. and DKE Aerospace Germany GmbH

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Table of content

- Introduction to the project
- Test results per site
  - Inland waterways
  - Maritime
- Conclusion
Overview/Purpose of this project

- Get views from **maritime** and **inland waterways** national authorities on **EGNOS and DGPS** usage
- Perform tests to **compare EGNOS and DGPS** in different European maritime and inland waterway areas. Assess the benefits of the EGNOS services compared to maritime DGPS (283.5 – 325.0 kHz) by performing in-the-field tests
- Create a **roadmap towards the certification of EGNOS** receivers for maritime use
- The tests were carried out on **nine different sites** in Europe
- Different boat on each site
- Same test setup and similar test routes (depending on the local conditions)

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A few words about the methodology ...

- Equipment covers a wide price range
  - to reflect the scenarios from the private ship owner to the “expensive” receiver required to use the DGPS L-band frequency services used as reference position
  - Absolute high-end equipment in the price range of >10T EUR is not covered by this test
  - Three antennas: High-end, medium-end and DPGS
  - Six receivers

<table>
<thead>
<tr>
<th>Receiver usage</th>
<th>Receiver name</th>
<th>Receiver ID</th>
<th>Price [EUR]</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPS receiver</td>
<td>uBlox EVK-6T</td>
<td>RX1</td>
<td>~ 300</td>
</tr>
<tr>
<td>EGNOS low-end receiver</td>
<td>uBlox EVK-6T</td>
<td>RX2</td>
<td>~ 300</td>
</tr>
<tr>
<td>EGNOS mid-end receiver</td>
<td>Furuno GP-150</td>
<td>RX3</td>
<td>~ 1.500</td>
</tr>
<tr>
<td>EGNOS high-end receiver</td>
<td>Septentrio AsteRx2eL</td>
<td>RX4</td>
<td>~ 7.000</td>
</tr>
<tr>
<td>IALA (MSK) beacon receiver</td>
<td>Trimble SPS 351</td>
<td>RX5</td>
<td>~ 2.400</td>
</tr>
<tr>
<td>Reference receiver (Veripos service)</td>
<td>Septentrio AsteRx2eL</td>
<td>RX6</td>
<td>~ 7.000</td>
</tr>
</tbody>
</table>

- “Static” tests in the harbors to check equipment and signals received additional to the dynamic tests
- Raw data recorded for post processing; done by French CNES (double-check measured data)
- Great supported by ESSP - EGNOS performance check over test duration on each site
- Test route good trade-off between speed of boat, time available and distance to be covered
- $k_H=5.612^*$ chosen to check EGNOS HPL against the values of (future) IMO A.915(22)

*EGNOS Terrestrial Regional Augmentation Networks Based on AIS for River Information Services by M. Jandrisits, J.C. de Mateo and G. Abwerzger*
Table of content

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Overall performance, given that the Cologne site is an inland-waterway, of EGNOS compared to GPS and DGPS was good.

No IMO performance standard currently available for EGNOS.

Requirements as defined by IMO A.915(22) (knowing it is for future GNSS) and IMO A.1046(27) were taken as a basis for the analysis.

IMO requirements met all the time up to coastal navigation (HAL<25m).
EGNOS can fulfill the requirements except for the port zone.

EGNOS and the IALA beacon system could co-exist.

use IALA beacon system in the difficult navigation zones

 corrections are better when the receiver is close to the station.
Table of content

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  - Maritime
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Integrity assessment HPL vs. HAL

- **Brest – all scenarios** max. HPL < HAL
- **Venice – 99.8%** max. HPL < HAL
  - scenario inside the lagoon (additional test)
  - HPL peak - 0.2% of the time
- **Cannes – all scenarios** max. HPL < HAL
  - HPL spike 0.4% of the time
- **Belfast – 99.9%** max. HPL < HAL
  - One scenario single peak (also recorded by ESSP)
  - Medium-end antenna single HPL spikes
- **Bergen – 99.95%** max. HPL < HAL
  - Single HPL peak, sudden drop of #SV
  - Additional test inside fjord - 99.95% of the time HPL < 25m
- **Lisbon**
  - Single peak one scenario, sudden drop of #SV
  - Higher HPL at end of last scenario

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Accuracy assessment

- Brest
- Venice
- Cannes
- Klaipeda all scenarios max. HPE < 10m
- Belfast
- Bergen
- Lisbon

- The accuracy requirement
  - of HPE < 10m was fulfilled all the time for EGNOS
  - sometimes even for HPE < 1m (even with the low-end EGNOS receiver)

- Accuracy and Integrity of EGNOS support the maritime user
Table of content

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The availability of the IALA beacon signal was good

The overall performance of the Beacon signal was according to the expectations

- The closer the station is the better the performance

<table>
<thead>
<tr>
<th>Test site</th>
<th>Station ID</th>
<th>Frequency [kHz]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kehl</td>
<td>Iffezheim</td>
<td>494</td>
</tr>
<tr>
<td>Brest</td>
<td>Point de Buis</td>
<td>462</td>
</tr>
<tr>
<td>Venice</td>
<td>No IALA beacon signal</td>
<td></td>
</tr>
<tr>
<td>Cannes</td>
<td>Porquerolles</td>
<td>469</td>
</tr>
<tr>
<td>Klaipeda</td>
<td>Klaipeda</td>
<td>535</td>
</tr>
<tr>
<td>Belfast</td>
<td>No IALA beacon signal</td>
<td></td>
</tr>
<tr>
<td>Bergen</td>
<td>Utvaer</td>
<td>507</td>
</tr>
<tr>
<td>Lisbon</td>
<td>Cape Carvoeiro</td>
<td>480</td>
</tr>
</tbody>
</table>

*DGPS Genauigkeitsverlauf - Entfernungsabhängigkeit -* 

1 "Installation eines Testpiloten zur Aussendung von GNSS-Korrekturdien über MW und AIS auf der Basis der Virtuellen Referenzstationstechnik (VRS)™, Wasser- und Schifffahrtsverwaltung des Bundes, Fachstelle der WSV für Verkehrstechniken, Koblenz, November 2011"
Conclusion on EGNOS

- Over all the tests conducted the performance of EGNOS was recognized as being very good.
- EGNOS meets IMO requirements up to coastal navigation in terms of accuracy at all cases, sometimes even meeting the requirements for port navigation.
- In terms of meeting the requirement for the horizontal alert limit EGNOS also fulfilled the requirement for the navigation zones outside the port.
- The peaks encountered during the tests were in most cases of very short duration and therefore thought neither to nor putting safety at risk.

The combination of EGNOS and IALA beacon would support to get the benefits of both systems where they perform best.
Recommendations

- The marine community should consider to come-up with some specifics with respect to EGNOS such as its proper philosophy of integrity from which in particular a really tailor-made k-factor would be derived.
- Also a different multipath model should be something of interest.
- Overall there are certain aspects to EGNOS where the marine community could provide an input to the operator of EGNOS in order to enhance the overall already very good experience a user has with EGNOS in the maritime.
- Also the ongoing discussion about EGNOS v3 which will represent a new version of the EGNOS system by 2020 should be considered relevant by the maritime community for the tailoring of the EGNOS system to maritime needs.
THANK YOU FOR YOUR ATTENTION

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