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**□** ARM **✓**ENG **□** PAP **□** Input

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Agenda item [[2]](#footnote-2) (from agenda) 11

Workplan Task Number / Technical Domain 2 Radionavigation services

Working Group WG3

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Support to Maritime and Inland Waterways Service Providers for the transmission of EGNOS corrections via IALA beacons and AIS/VDES stations

# Summary

The use of SBAS corrections for navigation, in both coastal waters and inland waterways, has already brought the attention of many European authorities, which are interested in its potential to complement/replace their DGPS radio beacon networks.

The European GNSS Agency (GSA) has an active long-term trajectory working to **foster the EGNOS adoption in maritime** through the launch of several actions whose results will pave the way for the provision of maritime EGNOS services. In this line, GSA has awarded the consortium ALG-Indra, ESSP and Alberding with the Specific Contract GSA/OP/07/13/SC24 ‘**Support to Maritime Service Providers for the transmission of EGNOS corrections via IALA beacons and AIS/VDES stations**’.

The main objective of this Specific Contract is to demonstrate the **operational performance** of the **transmission of EGNOS corrections converted to Differential GPS corrections** over the **existing transmission infrastructure** (AIS base stations/IALA beacons) in the Maritime and Inland Waterways (IWW) domains, while providing a detailed cost benefit analysis of the solutions proposed. This service may complement the current GNSS augmentation services exploiting synergies and benefiting from the current infrastructure and standards, facilitating the adoption of EGNOS by maritime and inland waterways authorities. Furthermore, the service has no impact at user level since the DGNSS corrections are transmitted over the existing infrastructure, in the same format and implementing the same integrity mechanisms required for traditional IALA beacons (i.e. RTCM 10401.2, Standard for Differential Navstar GPS Reference Stations and Integrity Monitors (RSIM), December 18, 2006).

This project will allow the maritime and IWW service providers to have a clear understanding about the **technical, operational and economic feasibility of the transmission of EGNOS corrections via IALA beacons and AIS/VDES stations.**

The project is currently ongoing and 2 months of pilot projects data has been collected and analysed so far. The results of the execution up to that point of the Specific Contract are presented in this paper.

## Purpose of the document

This paper is for information purposes.

## Related documents

[Guidelines G-1129 on the Retransmission of SBAS Corrections using MF-Radiobeacon and AIS](http://www.iala-aism.org/product/g1129-retransmission-sbas-corrections-using-mf-radio-beacon-ais/).

# Background

The European Geostationary Navigation Overlay Service (EGNOS) is Europe's regional satellite-based augmentation system (SBAS). Today it improves the performance of GPS and from 2025 will augment Galileo as well. Since 2009 it is providing benefits in different maritime applications such as general navigation, especially in terms of increased accuracy.

EGNOS can provide multiple benefits to the maritime and IWW service providers. The most relevant ones are associated to the fact that access to EGNOS is free of charge, the redundancy of signal sources (Signal-in-Space (SiS) and EGNOS Data Access Service (EDAS)), and the possibility of making use of the **Virtual Reference Station (VRS)** concept. The main advantage of a DGPS solution based on VRS (using EGNOS messages as input, that is, EGNOS-based VRS) with respect to traditional DGPS is that corrections can be remotely generated for a specific location without the need of having a physical reference station at that location. Also, there are a number of EGNOS-based solutions that can be set-up to complement and/or replace traditional DGNSS networks, depending on the specific operational scenario.

# Discussion

## Project structure

The organisations involved in the project are: GSA (customer), ALG (prime contractor), Indra, ESSP, and Alberding GmbH.

The project tasks are distributed in two phases:

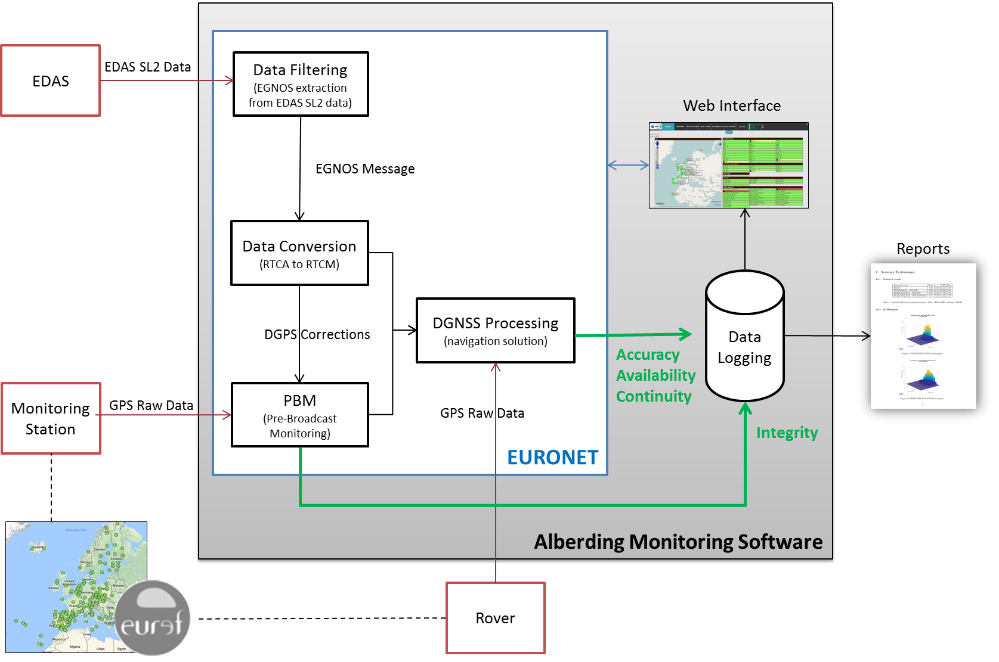
* **First phase** – **preliminary tests** - (which lasted for 7 months and ended in April 2018) was aimed at verifying the **feasibility of using EGNOS as a source for the Differential GNSS (DGNSS) corrections** to be transmitted via IALA beacons and AIS/VDES stations. This was achieved by a set of preliminary tests performed using simulation and without signal broadcast, but focused on the locations where pilot projects are implemented in the second phase of the project and with a configuration as close as possible to the operational one. Also, the same SW solution (provided by Alberding GmbH) to be used for the real tests –pilot projects- was used for the generation of the EGNOS-based DGPS corrections (conversion from RTCA to RTCM format) and the required integrity verifications, ensuring the representativeness of the preliminary tests.
* **Second phase** – **pilot projects** - (lasting 10 months and ending in January 2019) is aimed at **deploying and testing via four (4) pilot projects the EGNOS-based solutions in various European locations** re-using as much as possible the currently available infrastructure. Cost Benefit Analysis will also be developed customized (with the support of the corresponding authorities) for the countries hosting a pilot project. Additionally, a liability analysis will be performed in order to understand the regulatory constraints that may apply to the proposed solutions with the objective to achieve a harmonised approach to be followed by Maritime and Inland Waterways authorities.

A total of **seven (7) European Maritime and Inland Waterways** (IWW) authorities have shown interest in participating in the project, namely: CEREMA (France), GLA (United Kingdom), Kystverket (Norway), MRCC (Latvia), Puertos del Estado (Spain), RSOE (Hungary), and WSV (Germany). Some of these authorities (**MRCC, Puertos del Estado, RSOE and WSV**) are also providing their infrastructure to **host a pilot project** to demonstrate the operational performance of the transmission of the EGNOS corrections. They are also supporting the project by providing information to generate realistic cost benefit analysis and reviewing their outcomes afterwards.

## Phase 1: preliminary tests

For the preliminary tests, the **Alberding Monitoring SW** and the **EuroNet** module (developed by Alberding GmbH) have been used. As shown in Figure 1, the EuroNet module implements the protocol to connect to the EDAS SL2 data stream, extract the EGNOS messages and convert them from RTCA to RTCM for a user-defined location. This location is the Reference Station (RS), which, in the case of EGNOS, can be Virtual (VRS) since it is not required to physically place a receiver at that location. It also implements the integrity monitoring functionality, supporting the Pre-Broadcast Monitoring (PBM) concept in line with the IALA Guideline 1112.

The EGNOS-based corrections generated by EuroNet can then be applied to the raw data collected by a GNSS receiver (used as rover). For the preliminary tests, no radio broadcast has been done; the corrections generated by EuroNet have been internally applied to the raw data provided (via NTRIP) by a remote receiver (i.e. rover).



1. Alberding Monitoring SW Architecture

As depicted in Figure 1, at least two GNSS receivers are needed in the vicinity of the configured reference stations:

* one receiver is used as **monitoring station**, to check the integrity of the EGNOS-based DGPS corrections,
* the other receiver is used as **rover** to assess the accuracy, availability and continuity performance obtained when the differential corrections are applied.

The monitoring stations are used for the integrity check, which is based on the **Pre-Broadcast Monitoring** concept (applied both at the pseudorange and position domain):

* **Pseudorange domain:** Pseudorange (or signal) domain analysis will be carried out in two steps. First the PRC and RRC values are checked during correction generation phase at the reference station side.

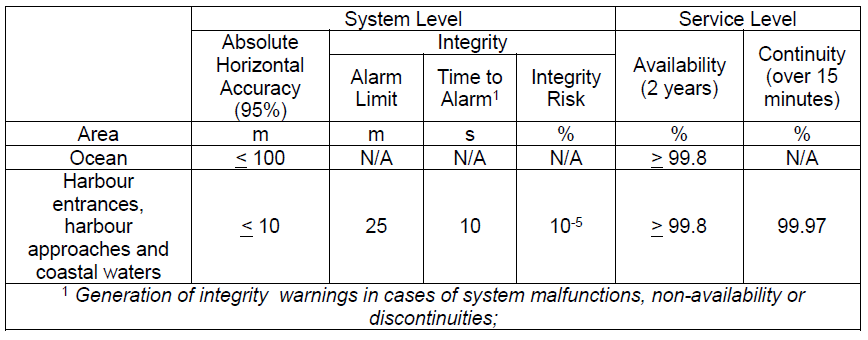
In a second step the quality of the corrections is assessed at the monitoring station side. Based on the known antenna coordinates, the PRC and RRC residual values are computed as the difference between the geometric (physical distance between the antenna and the satellite position) and corrected pseudoranges. If the correction values for a given satellite exceed the user-defined thresholds, the corresponding satellite is marked as “do not use”.

* **Position domain**: a real-time DGNSS position solution is computed using raw data input from the monitoring station and the monitored differential corrections. The resulting position output is compared to the pre-surveyed coordinates of the monitoring station antenna. If the calculated difference (horizontal position error) exceeds a pre-defined threshold (for more than a pre-set period of time) the reference station is marked “not working”. On the other hand, if the monitoring station is not available, the reference station is flagged as “not monitored” and the differential corrections are discarded.

It is noted that the EGNOS-based corrections have been applied to the rover raw data in two simultaneous computations: first with no integrity checks, second with the PBM algorithms applied. This allows comparing the performance of the EGNOS-based corrections with and without pre-broadcast monitoring.

### **Minimum user requirements**

In order to assess the compliance with the minimum maritime user requirements for coastal and inland waterways navigation defined by IMO [4], a detailed analysis of the accuracy, availability, continuity and integrity performance has been performed for each preliminary test. According to [2], the following table summarises the requirements specified in [3], augmented by those described in [4]:



1. Maritime requirements based on IMO Recommendations

### **Test scenarios**

In order to assess the potential benefits of the EGNOS-based VRS concept for maritime navigation, a performance analysis campaign has been conducted (1 month duration -from January 26th to February 25th-) at six (6) different European locations.

1. Preliminary tests scenarios

| Country | VRS https://s20.postimg.org/l3b5ji9gd/antenna-green.png | Rover https://maps.gstatic.com/mapfiles/ms2/micons/ferry.png | | Monitoring Stations https://s20.postimg.org/f5r5l1yzh/mon4_small.png | | Type | PBM  Settings |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Location | Baseline (km) | Location | Baseline (km) |
| Spain | Rota | TARI0 | 100 | HUEL0 | 85 | IALA | Maritime |
| Spain | Sevilla | TARI0 | 159 | HUEL0 | 85 | AIS | Inland |
| Germany | Koblenz | DILL1 | 126 | FFMJ1 | 81 | AIS | Inland |
| Hungary | Budapest | BUTE0 | 5 | PENC0 | 34 | AIS | Inland |
| Norway | Utsira | OSLS0 | 313 | STAS0 | 56 | IALA | Maritime |
| Latvia | Riga | TOR20 | 200 | KURE0 | 169 | AIS | Maritime |

The distances detailed in the previous table show that there is a great diversity of scenarios, combining IALA, AIS, Inland and Maritime, in the configurations proposed. Also, the range of baselines defined helped identifying the impact of the distance between the VRS and the rover on the performance results obtained, and also, how the distance between the VRS and the monitoring station affects the integrity check.

In this sense, it is noted that the monitoring station is normally located at the same place as the reference station. For the preliminary tests, different distances between the reference (VRS) and monitoring station have been configured, up to 169 km (Riga scenario). This configuration could imply discarding Lines of Sight (LoS) when a corrected satellite is not in view by the monitoring station and could eventually trigger the generation of additional integrity events. This approach is therefore more conservative than the traditional one. It is also noted that the performance observed by the monitoring station will be more aligned with the actual performance observed by the users.

However, based on the results obtained (see below), it is concluded that the location of the monitoring stations, not co-located with the reference station, has neither caused the rejection of satellites nor the generation of additional integrity events.

### **Tests results**

The following table summarises the performance results obtained in the six scenarios:

1. Preliminary tests performance results

| Scenario | Non-Integrity Checked Solution | | | Integrity Checked Solution | | | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Availability | Continuity | Accuracy (95%, m) | Availability | Continuity | Accuracy (95%, m) | Integrity |
| Rota | 100% | 100% | 0.8 | 99.84% | 98.75% | 0.8 | No integrity events |
| Koblenz | 100% | 100% | 1.08 | 97.3% | 99.34% | 1.08 | No integrity events |
| Budapest | 99.99% | 99.97% | 1.25 | 98.18% | 98.33% | 1.25 | One short event at the position domain – TTA met |
| Sevilla | 99.99% | 99.97% | 0.8 | 99.84% | 98.75% | 0.8 | No integrity events |
| Utsira | 100% | 100% | 1.24 | 99.98% | 99.3% | 1.24 | No integrity events |
| Riga | 100% | 100% | 1.35 | 83.31% | 86.45% | 1.35 | One short event at the position domain – TTA met |

Cells are painted in green when IMO requirements are met. Results demonstrate that the quality of the EGNOS-based differential corrections is sufficient to meet the availability, continuity, accuracy and integrity requirements defined by IMO in the A.1046 resolution.

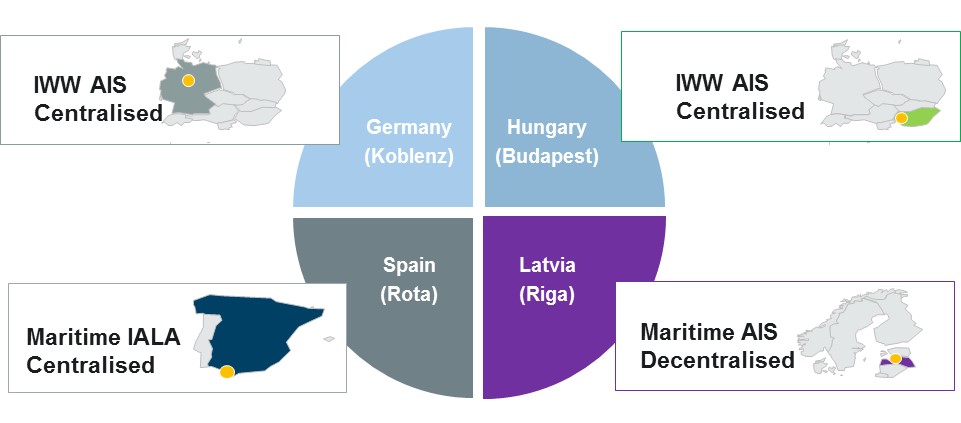
Regarding the availability and continuity performance measured for the integrity checked solution, it is noted that all the events were caused by data gaps or issues related with the data quality of the measurements collected by the receiver (monitoring station). It is also noted that the integrity concept, and therefore the monitoring station itself, does not depend on the kind of solution implemented: EGNOS-based VRS or traditional DGPS meaning that the same impact would have been observed in a traditional DGNSS station that used the same rover receivers as integrity monitors.

For the preliminary tests data campaign, EUREF receivers have been used as monitoring stations, without any kind of Service Level Agreement (SLA) or Memorandum of Understanding (MOU) with this organization. In view of the results obtained, it could be already advanced that the use of these receivers would not be acceptable for an operational configuration.

It is therefore highly recommended to use reliable receivers for the integrity check and eventually implementing a switching algorithm to use the data collected by a backup receiver for the integrity module. For instance, the monitoring receivers from a neighbouring station can be used as backup. Doing so, the system availability will not be impacted by a failure on the receiver, and also, in the event of a jamming attack near the monitoring station receiver, the service will not be affected, since the corrections generated in the central server can be integrity checked by a receiver from a nearby station.

## Phase 2: pilot projects

Four (4) European scenarios are currently being analysed and the most suitable architectures to transmit the EGNOS-based VRS differential corrections have been selected, which can be either centralised or de-centralised. A fair combination of both IALA beacons and AIS/VDES stations as well as maritime and IWW domains have been chosen. The duration of the pilot projects will be **six** (**6) months**. Data will be collected from both static and dynamic receivers. During this period, in the scenarios where at present DGNSS corrections are being generated and broadcasted to users, the current solution will be deactivated in favour of the EGNOS-based solution. However, current infrastructure will remain as a backup.



1. Pilot project locations and architectures/domains

### **EGNOS-based architectures implemented in the pilot projects**

From the recommended EGNOS-based architectures detailed in [1], the following have been implemented in the pilot projects:

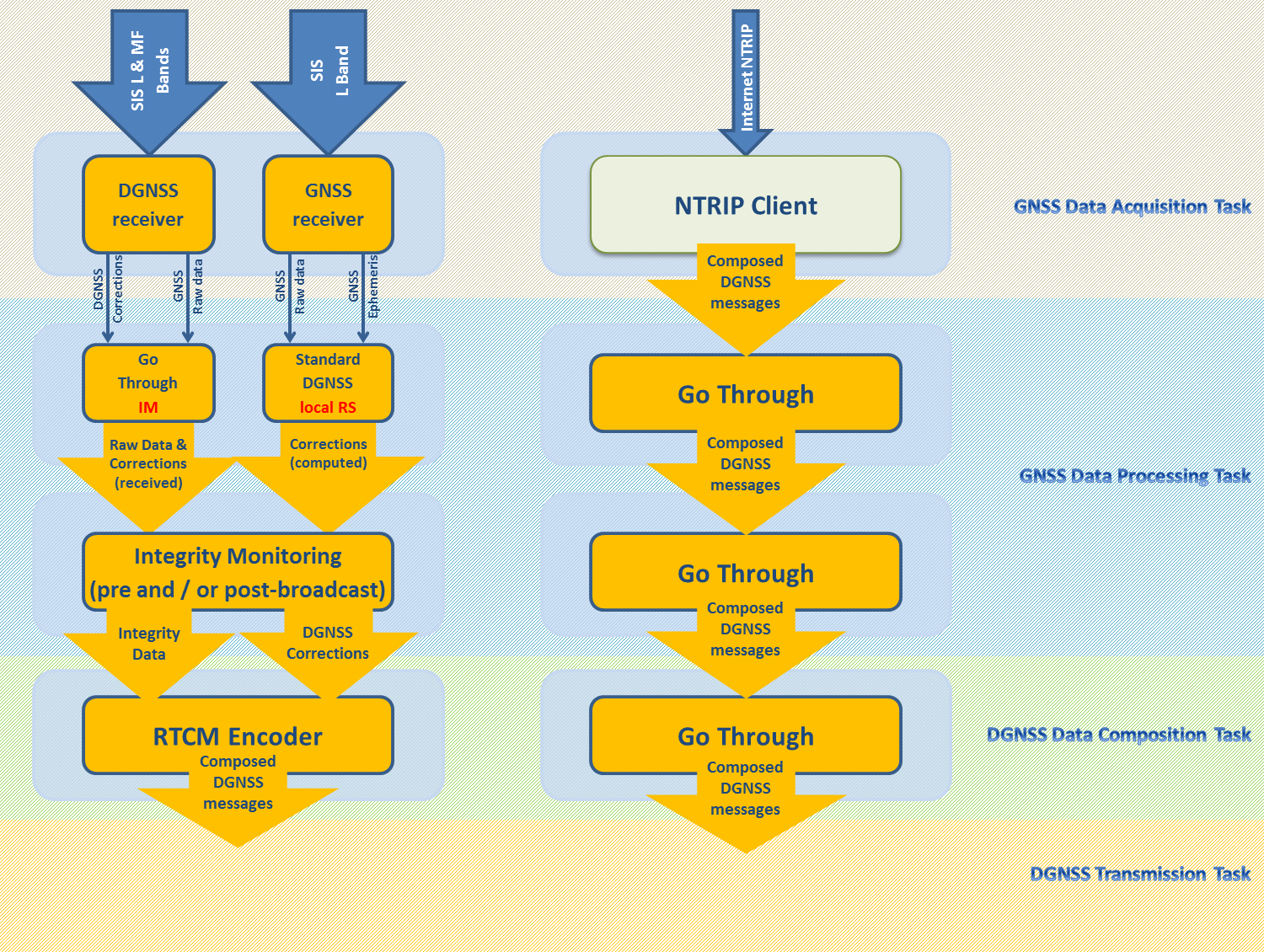
1. Pilot projects domains and architectures

|  |  |  |
| --- | --- | --- |
| Scenario | Domain | Architecture implemented |
| Rota | IALA maritime | Hybrid centralised |
| Koblenz | AIS inland | AIS centralised |
| Budapest | AIS inland | AIS centralised |
| Riga | AIS maritime | AIS decentralised – external source |

**Hybrid centralised architecture (IALA beacon in Spain)**

This solution combines a classical DGNSS station deployed at each beacon site with a centralised EGNOS based VRS solution. For the EGNOS-based VRS solution (right chain), both the RS and the IM stations are centralised in the “Central Facility”, and therefore, the only infrastructure needed at each beacon site is the communication lines and the transmission equipment. On the other hand, it is noted that the network approach results in high requirements concerning the availability and quality of the communication links.

Even though the only infrastructure needed at each beacon site is the communication lines and the transmission equipment, a network of GNSS receivers is needed for the integrity check. At least one receiver located within the coverage range of each beacon transmitter and able to transmit the GNSS raw data collected to the central server shall be available.



1. Hybrid Centralised Architecture: classical DGNSS + SBAS Based VRS (functional view)

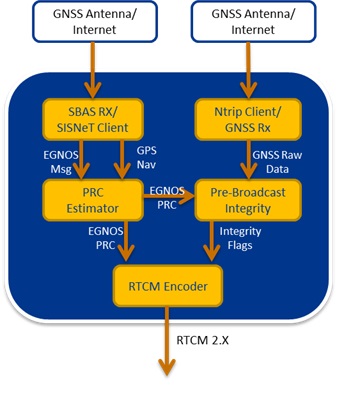
As agreed with the Spanish Ports authority (PdE), one of the GNSS receivers in the classical DGNSS architecture (left chain in Figure 4) is also used to monitor the signal and corrections transmitted by the EGNOS based solution (right chain in Figure 4). Data collected by this receiver is sent to the central server for the integrity check.

**AIS decentralised architecture – external source (AIS station in Latvia)**

In those AIS Base Stations where there is no access (either via radio or serial connection) to the DGPS messages provided by a IALA beacon, the pseudorange corrections can be generated locally using the EGNOS message (either obtained from the EGNOS SIS or from the EDAS service).

DGNSS corrections are provided as input (via a dedicated port – see Figure 5) to the AIS Base Station, therefore, whether these corrections are received from a traditional DGNSS stations or generated based on EGNOS is completely transparent for the AIS Base Station.

Taking this into account, it is not necessary to do any change on the AIS Base Station, but just implementing an external component that converts the EGNOS wide area corrections in RTCA format into local area corrections in RTCM. It is to be noted that the SBAS message and the GPS ephemeris can be obtained from an SBAS enabled receiver or from the EDAS SISNeT service over the internet.



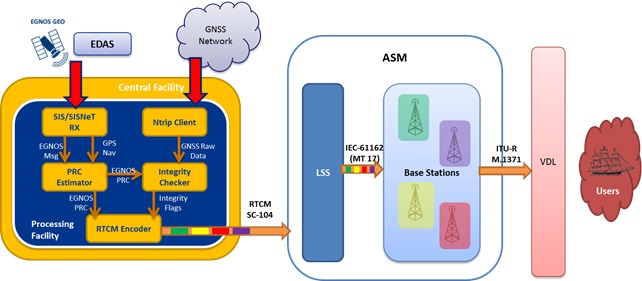
1. EGNOS-based AIS station: RS & IM block diagram

In the Riga pilot, an SBAS enabled receiver is used to obtain the EGNOS message. Hence, GNSS observations collected by this receiver are used to check the integrity of the data (note that the observations are not used to generate the differential corrections).

The corrections generated by the RTCA to RTCM converter are provided to the AIS Controller Unit in Message Type 17 format (via the dedicated input port).

**AIS centralised architecture (AIS station in Germany and Hungary)**

This solution consists on generating the EGNOS-based VRS streams in a central facility. Through the AIS Service Manager (ASM), these corrections are then routed and sent to each AIS base station. At very high level, the architecture of this solution is depicted in the following diagram:



1. EGNOS-based AIS centralised architecture

A more detailed description of each of these components is provided below:

* **Central Facility:** it is the main component of a centralised SBAS based DGNSS service. The primary function of the Central Facility is to compute the Pseudorange Corrections for all the satellites above the elevation mask. PRCs and ancillary information (e.g. antenna location) are encoded into RTCM 10402.3 and transmitted to each beacon transmitter site. The source for the generation of the DGPS corrections to be broadcast by the transmitter could be the SBAS Signal in Space or the SBAS messages received from EDAS.
* **AIS Service Manager (ASM):** The RTCM corrections generated by the central facility are transmitted to the AIS Service Manager which converts them in an IEC 61162 VDM sentence (discarding the preamble and parity fields) to be then distributed to the final users by the AIS base stations using the VDL channel. Considering that the corrections are generated and integrity checked in the central server, the communication links and the protocol for the data transmission between the central server and the ASM shall be designed to ensure the **integrity** of the corrections provided. In case of using the NTRIP protocol for the data transmission, the TLS option could be selected to ensure communication privacy and data integrity.

Internally to the AIS service each correction set will be routed to the target AIS Base Station (AIS-PCU) by the AIS-LSS.

* **Monitoring Network:** For the integrity monitoring check, the Central Facility needs to have access to GPS measurements collected from a receiver located within the validity area of each set of DGNSS corrections. How this data is fed in the central facility would depend on each particular implementation. For instance, the NTRIP protocol designed to disseminate GNSS raw data and differential corrections over internet could be used to transmit the raw data from the receiver location to the central facility. In the case of the Koblenz and Budapest pilot projects, since a single monitoring receiver is used, standard TCP/IP connections are used.

### **Performance assessment: definitions and assumptions**

* **Availability:** percentage of time EGNOS-based corrections are available to the user. This means that the following failures have not been included in this computation:
  + HW and SW failures related to pilot project setup and not representative of an operational set-up.
  + Malfunctions detected in the rover receiver.
* **Continuity:** Probability that a signal failure incident will start during the Continuity Time Interval (CTI).

𝐶𝑜𝑛𝑡𝑖𝑛𝑢𝑖𝑡𝑦 = 1 − 𝐶𝑇𝐼/𝑀𝑇𝐵𝐹

Where CTI is **15 minutes** as stated in [3] and MTBF is the Mean Time Between Failures measured over **two years**.

For the present analysis, a failure will be considered an event when the EGNOS-based DGPS corrections are not available for the user (after being integrity-checked) and therefore, it is not possible to compute a differential solution.

* **Accuracy:** it is based only on the DGPS epochs using EGNOS-VRS corrections marked healthy (standalone epochs, “not-monitored” and “not-working” epochs are excluded from the accuracy statistics).
* **Integrity analysis:** integrity approach is based on the Pre-Broadcast Monitoring concept. Corrections are checked both in the pseudorange and position domains as already explained for the preliminary tests.

This means that:

* EGNOS SiS/EDAS data gaps are taken into account for the availability and continuity results.
* Monitoring station data gaps are taken into account for the availability and continuity results.
* Transmission failures are taken into account for the availability and continuity results.
* User receiver data gaps are NOT taken into account for the availability and continuity results.

### **Performance results**

The following table summarizes the results obtained during the first batch of the test campaign:

1. Pilot projects performance results

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Pilot Project** | **Availability** | | **Continuity** | | **Accuracy (95%, m)** | | **Integrity** | |
| **June** | **July** | **June** | **July** | **June** | **July** | **June** | **July** |
| **HU (RSOE, Budapest)** | 100% | 99.99% | 100.00% | 99.87% | 1.95 | 1.94 | No integrity events | No integrity events in the pseudorange domain  4 short events in the position domain (all not-monitored) |
| **DE (WSV, Koblenz)** | 99.43% | 96.06% | Not Available | | 1.29 | 1.08 | No integrity events in the pseudorange domain  Short events in the position domain | No integrity events in the pseudorange domain  3 events in the position domain (horizontal error above threshold) |
| **LV (MRCC, Riga)** | Not Available | | | | 3.22 | 3.21 | No integrity events in the pseudorange domain  Short events in the position domain | No integrity events in the pseudorange domain  Very few events in the position domain (horizontal error above threshold) |
| **SP (PdE, Rota)** | Not Available | | | | | | | |

**Budapest pilot project results**

This pilot is running smoothly so far. All continuity and integrity events are related to the availability or latency of the monitoring station data (due to short network outages).

**Koblenz pilot project results**

Various installation/setup issues not related with EGNOS prevented the generation of continuity statistics during the period of analysis. These issues have now been solved, which shall allow generating adequate statistics for the remaining of the test campaign.

On 23-24 July a general internet connection outage in the WSV/FVT WAN had an influence on the availability statistics due to missing data from the monitoring station. Other shorter monitoring data gaps also occurred during the period of analysis.

**Riga pilot project results**

Due to some disturbances in the area (this is a harbour area with lots of traffic), there were occasions when the rover did not receive corrections in time. The reason for these transmission failures has to be further analysed. Once identified (and solved), adequate statistics will be generated. These problems have caused that the availability and continuity figures could not be computed for the period of analysis. Once this issue is solved, it is expected to generate adequate statistics for the remaining of the test campaign.

Accuracy values are slightly worse than in other pilot projects, probably due to local interferences. It is suspected that rover in Riga is affected by multipath since it is installed in a metal tower. Further analysis is underway.

**Rota pilot project results**

Several issues with the installation, failures on the transmitter (allegedly due to drops in the line voltage) and problems with the rover receiver have led to the situation where no clean statistics can be derived for the period of analysis. All installation issues have now been solved and a new rover receiver is currently being installed. This shall allow generating adequate statistics for the remaining of the test campaign.

**Pilot projects results summary**

For all cases where adequate data was available and statistics could be computed, EGNOS-based corrections have proved to achieve performance levels above or closely below the requirements set by the IMO. This is mainly due to:

* the high availability of the EGNOS SiS (100% in the period of analysis when using combined SiS), and EDAS (only minor outages detected), and
* the high quality of the corrections generated.

Red cells in the table above for continuity (July, Budapest) and availability (June & July, Koblenz) are due to missing monitoring data for the Pre-Broadcast Monitoring (PBM) check. These delays (sometimes outages) are due to the fact that pilot projects use conventional communication lines (i.e. not dedicated) to transmit data from the monitoring receiver to the central facility. This is enough for the purpose of the pilot. However, in an operational system, it would be required to contract dedicated communication lines where Service Level Agreements (SLA) with the communications provider should be arranged. This is of course out of the scope of this project.

Furthermore, on top of the accuracy computed at the rover, in all pilot projects cross-checks have also been implemented. These cross-checks are aimed at computing the accuracy when corrections are applied to the raw data from the monitoring station, which is always a geodetic receiver (i.e. of higher quality than the rover receiver). In all cases the accuracy obtained was around 1 meter or below.

It can be concluded that so far the pilot projects have demonstrated the suitability of EGNOS-based differential corrections to meet IMO requirements and hence complement/replace a system where differential corrections are computed using a classical approach.

## Cost Benefit Analysis

The goal of the CBA is to translate the proposed technical architecture (DGNSS and EGNOS-based) of all the considered scenarios into an effective evaluation of costs and benefits. With this aim in mind, a five-step methodology has been developed:



1. CBA methodology

The CBA builds upon a comparison (or Delta) of costs and benefits between a reference scenario, using traditional DGNSS infrastructure, and an EGNOS-based scenario. These costs and benefits are mainly originated by the difference in CAPEX and OPEX between reference and EGNOS scenario, deriving from different infrastructure deployment and maintenance requirements.

In close cooperation with the participating authorities, the consortium has developed a complete cost-benefit model that allows to quantify potential savings brought by EGNOS introduction in all the scenarios and to assess the optimal deployment strategy for maximising benefits of this transition. More specifically, for all the scenarios analysed the results have been the following:

1. Phase 2 CBA results

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Port Authority /State** | **Domain** | **Reference Scenario**  **Architecture** | **EGNOS Option Architecture** | **Total Savings** | **Savings percentage**  **(EGNOS Option vs**  **Reference Scenario)** |
| MRCC/Latvia | Maritime | AIS decentralised | AIS centralised | 0,19 Mln Eur | 52% |
| Puertos del Estado/Spain | Maritime | IALA decentralised | IALA centralised | 2,1 Mln Eur (Hybrid Centralised) | 33% |
| 2,5 Mln Eur (Fully EGNOS) | 39% |
| RSOE/Hungary | IWW | AIS centralised | AIS centralised | 0,80 Mln Eur | 19% |
| WSV/Germany | IWW | AIS centralised | AIS centralised | 0,36 Mln Eur | 5% |

In Latvia, EGNOS could bring considerable added value in the transmission of corrections over the AIS Network; through centralisation, the EGNOS-based centralised option allows a notable amount of savings in comparison to the Reference Scenario. This happens since the CAPEX and OPEX for the central server and IM Stations in the EGNOS option are lower than the purchase costs of the required beacon stations to generate corrections in the reference scenario (no IALA beacons are available in Latvia).

EGNOS could also provide benefits to the rationalisation and modernisation of the IALA Network in Spain. The adoption of EGNOS allows benefits both in CAPEX and in OPEX. This happens since the setup costs for the central server and the purchase costs of IM stations in the EGNOS option are lower than the purchase costs of redundant traditional IALA beacons in the reference scenario, even taking into account that the proposed EGNOS based options are not fully centralised and maintain some decentralised components (especially for remote broadcast sites where reliable communications may not be available).

In Hungary, EGNOS could provide sensitive benefits in the transmission of corrections over the AIS Network. Specifically, the CAPEX and OPEX for the central server and the additional IM Stations needed in the EGNOS option are lower than the purchase costs of DRS and IMS in the reference scenario. Besides cost advantages, the EGNOS solution foresees the generation of more localized sets of corrections for the AIS Base Stations (one set for a group of 3 stations with EGNOS versus one set for a group of 5 stations with DGNSS), providing additional operational benefits (performance improvement).

Finally, in Germany, the introduction of EGNOS could provide some benefits as well, since the purchase costs of IM Stations in the EGNOS option are lower than the purchase costs of RS in the reference scenario. It should be noted that in this case economic benefits are more limited. This is mainly due to the fact that the primary German system is already based on centralised approach (not EGNOS based), being already quite optimized from a cost/infrastructure point of view. In this case, the inclusion of EGNOS is expected to bring significant benefits in terms of robustness/redundancy.

## Conclusions

As shown in this analysis, an EGNOS-based system generating differential corrections can bring important economic benefits while keeping adequate performance levels for the user. On the other hand, there are also operational benefits that this kind of solution can provide, such as increased robustness against jamming and spoofing (for centralized architecture), robustness of the solution (redundancy of the source of corrections via EDAS and SiS), geographical separation between correction generation and transmission, independence of the generated corrections from local issues (e.g. multipath) and some others yet under discussion in the project’s Advisory Board (AB). At present, most problems related with installation/setup have been solved, which should bring the required stability to analyse the next months of test campaign data. The Consortium, together with the AB, have agreed on the importance that all lessons learned during installation/setup are addressed to IALA as an input paper, in order to be used as input to update the existing Guidelines [1] if deemed appropriate. A similar approach could be followed at inland level (via the RIS expert groups). These recommendations to maritime and IWW service providers for the use of EGNOS over IALA beacons and AIS/VDES shall facilitate the consolidation of the EGNOS service in the maritime/IWW domains.

It is expected that the results of the project will **increase the EGNOS awareness** among the **maritime** and the **IWW** communities, as well as acting as a **catalyst for the adoption of EGNOS** in other sites and countries.

# References

1. IALA Guideline G1129 “The retransmission of SBAS corrections using MF RB and AIS” – Edition 1 - December 2017
2. Performance and Monitoring of DGNSS Services in the Frequency Band 283.5 – 325 kHz, IALA Guideline 1112
3. IMO Resolution A.1046, Worldwide Radionavigation system
4. IMO Resolution A.915 (22) “Revised maritime policy and requirements for a future global navigation satellite system (GNSS)”.

# Action requested of the Committee

The Committee is requested to:

1. Note the information provided in this paper, and
2. Assess the convenience to update the existing IALA Guideline G1129 taking into account the lessons learned during this project.

1. Input document number, to be assigned by the Committee Secretary [↑](#footnote-ref-1)
2. Input papers should be assigned to a work task as listed in the Committee work plan which is available in input papers. Leave open if uncertain but consider how the paper is to be processed if not relevant to a work task [↑](#footnote-ref-2)