Input paper: [[1]](#footnote-1) ENAV20-13.16

Input paper for the following Committee(s): check as appropriate Purpose of paper:

**□** ARM **□** ENG **□** PAP **⌧** Input

**⌧** ENAV **□** VTS **□** Information

Agenda item [[2]](#footnote-2) 13

Technical Domain / Task Number 2 …………………………………

Author(s) / Submitter(s) Manuel López (GSA), Virginia Antón (ESSP), Sofía Cilla (ESSP)

Generic Cost Analysis focused on relevant architectures for the transmission of SBAS corrections over IALA beacon and AIS

# Summary

The present document provides the results of a generic Cost-Benefit Analysis focused on the most relevant potential architectures that could be used to broadcast DGNSS corrections generated from the EGNOS (SBAS) message (obtained from SIS and/or EDAS) over IALA beacons or AIS. The description of the architectures which are the starting point for this cost analysis can be found in the ENAV19-13.13 input paper [1].

## Purpose of the document

The purpose of this document is to provide the Committee members with a costs’ comparison between EGNOS-based alternate and reference scenarios. Committee members are invited to provide comments and those interested in a customised cost analysis can contact GSA/ESSP (mailto: EGNOS-adoption@essp-sas.eu).

# References

1. ENAV19-13.13 Relevant architectures for the transmission of SBAS corrections over existing maritime AtoN - two cases studies: IALA beacon and AIS
2. ENAV18-13.16 Transmission of SBAS corrections over AIS
3. ENAV18-13.20 Transmission of SBAS corrections over IALA beacons
4. IMO Resolution A.1046 (27), November 2011.
5. RTCM 10402.3 Recommended Standards For Differential GNSS services, August 20, 2001
6. IALA Guideline 1112, Performance and Monitoring of DGNSS Services in the Frequency Band 283.5 – 325 kHz, Edition 1, May 2015
7. IALA Recommendation A-124 Appendix 16 – DGNSS Broadcasts from an AIS Service
8. IALA Guidelines On Ship-Borne Automatic Identification System (AIS) Volume I Part Ii: Technical Aspects Of AIS, Edition 1.1, December 2002

# Action requested of the Committee

The Committee is invited to consider the information provided in the Annex.

1. ANNEX 1: Generic COst analysis focused on relevant architectures for the transmission of SBAS corrections over IALA beacon and AIS

The present document provides the results of a generic cost analysis focused on the most relevant potential architectures that could be used to broadcast DGNSS corrections generated from the EGNOS (SBAS) message (obtained from SIS and/or EDAS) over IALA beacons or AIS.

This paper is organised as follows:

* Section 1: Description of the methodology and main assumptions to implement the generic costs assessment for an AtoN provider.
* Section 2: Overview of the most relevant outcomes of the generic cost assessment for the transmission of SBAS corrections over IALA beacons.
* Section 3: Overview of the most relevant outcomes of the generic cost assessment for the transmission of SBAS corrections over AIS stations.
* Section 4: Conclusions.

The typical IALA DGNSS and AIS architectures, based on current deployments and recommendations, are referred to as “Reference scenario”. The EGNOS-based architectures are referred to as “Alternate scenarios” along the document. The ENAV19-13.13 input paper [1] has to be taken as reference material and should be consulted for further information on these architectures.

It is important to note that the costs of the different infrastructures, used to obtain the results shown in this generic analysis, are based on ESSP research information and assumptions; they have to be considered as an example to get the costs differences between different alternatives. To be also noted that procurement and running costs vary from one country to another and even from one network to another. Therefore, it is essential not to take this information as “absolute” estimations, those interested in having a particular estimation are recommended to validate the costs with the concerned stakeholders and to particularise them to specific situations through customised costs analysis. In this sense, GSA/ESSP offers the maritime authorities the possibility to perform such a bespoke analysis for free.

As an overall summary of the preliminary assessment done in this document, there are some cases where EGNOS-based alternatives could be introduced in IALA DGNSS and AIS systems in a cost-effective way and transparent to the final users (as the signal transmitted by those new proposed architectures are absolutely compatible with the user equipment already installed onboard the vessels).

As described through this document, there are several possibilities and configurations which could bring cost savings in the short term, mainly due to the rationalization of part of the current infrastructure and the subsequent reduction in the operational expenditures. At the same time, these alternatives could respond to potential obsolescence issues. Obviously, it is recommended to assess which specific parts of the infrastructure could be reused, potential benefits of each proposal and other issues related with the architecture, prior to choose an alternative based only on potential savings.

1. Methodology Description

The methodology to implement this generic costs assessment for an AtoN provider consisted of the following steps:

1. Identify the “reference” (current) and “alternate” (EGNOS-based proposal) scenarios.
2. Set the hypotheses for the assessment.
3. Identify the costs applicable in both reference and alternate scenarios, focussing on the difference.
4. Make an economic analysis of the different proposals.
5. Draft conclusions.
   1. Common assumptions and definitions

Reference scenario:

* Both, centralized elements and the ones located at the station sites are considered. The number of units of each of them is based on a full-redundant architecture.
* **CAPEX-C:** Capital Expenditures which represent the value of the assets of the **C**omplete infrastructure. It is calculated for five different placements, according to the number of stations (1, 5, 10, 15 and 20). CAPEX of the overall architecture is useful to have an estimation of the cost of installing a new infrastructure according to the traditional concept, but also to calculate part of the yearly operating expenditures (OPEX).
* **OPEX-C:** Considered as yearly Operating Expenditures associated to the **C**omplete infrastructure, which include maintenance and communication lines. OPEX is highly dependable on specific contracts and difficult to estimate on a generic basis. The approach for estimating annual operating expenditures has been the sum of two addends:
  + A fixed percentage of the capital expenditure. In our analysis, this addend has been estimated in a 12% of the CAPEX.
  + Communications’ costs, according to the rationale explained in section 1.1.1.

Alternate scenarios:

* **CAPEX-C**: This is calculated in the same way as the reference scenario. CAPEX of the **C**omplete architecture from scratch is useful to have an estimation of the cost of installing a new infrastructure according to the EGNOS-based concept, but also to calculate part of the yearly operating expenditures.
* **CAPEX-U:** CAPEX related to an infrastructure **U**pgrade. This cost accounts for the investment in new components required in the EGNOS-based architectures.
* **OPEX-C**: It is calculated in the same way as the reference scenario. The approach for estimating annual operating expenditures of the **C**omplete architecture has been the sum of two addends:
  + A fixed percentage of the capital expenditure. In our analysis, this addend has been estimated in a 12% of the CAPEX.
  + Communications’ costs, taking into account the necessary upgrades in centralised and/or EDAS based architectures, according to the rationale explained in section 1.1.1.

Costs comparison:

* **CAPEX-D**: This is the **D**ifference between the CAPEX-C in an alternative scenario and the CAPEX-C in the reference scenario.
* **OPEX-D**: This is the **D**ifference between the OPEX-C in an alternative scenario and the OPEX-C in the reference scenario.
* **Delta-C**: This cost represents the cumulative difference in costs along the yearsfor **C**ompletely new infrastructures, comparing the deployment of a traditional architecture (reference scenario) with the deployment of an EGNOS-based architecture (alternate scenario) from scratch. The same calculus is made for different years (1, 2, 3, 4, 5 and 20) to have an overview of savings or increases in costs.

It has been calculated the difference in CAPEX plus OPEX between the deployment of a reference scenario and the deployment of an alternate scenario with the same number of broadcasting stations.

Green cells represent a cost reduction, while red cells mean a cost increase.

* **Delta-U:** This cost represents the cumulative difference in costs along the yearsfor infrastructure **U**pgrades, comparing the operational costs in a traditional architecture (reference scenario) with the investment in upgrading an existing infrastructure to become an EGNOS-based architecture (alternate scenario), including also the operational costs. The same calculus is made for different years (1, 2, 3, 4, 5 and 20) to have an overview of savings or increases in costs.

The first year includes the investment in CAPEX due to the provision of new components and the OPEX associated to the first year of operation. The second year accumulates the expenditures in the first year plus the OPEX associated to the second year of operation (investment in new elements is only considered in the first year). The same rationale is followed for the rest of the years.

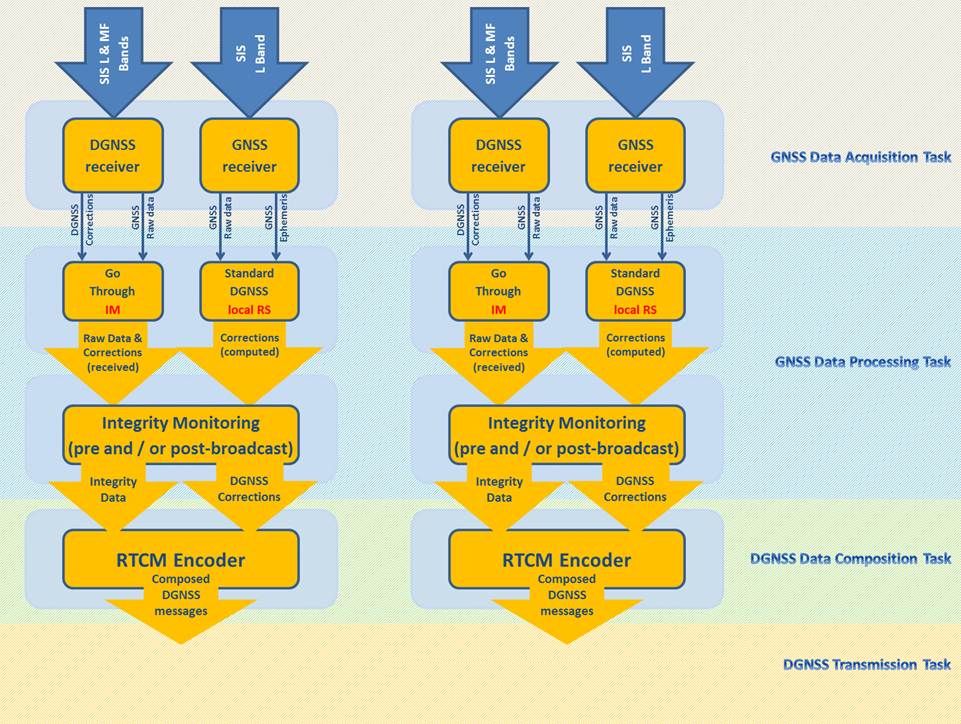
Green cells represent a cost reduction, while red cells mean a cost increase.

* **Payback**: As the first year after an infrastructure upgrade when the investment is recovered and a positive return occurs.
  + 1. Communications costs assumptions

**Communications’ costs** are considered as part of the OPEX and the following assumptions have been taken in this analysis:

* In the IALA DGNSS case, an Internet connection is assumed to be available at the beacon sites and at the Central Monitoring Centre based on access to public networks. Since dedicated lines are not deployed, there are not a CAPEX associated to communications but an OPEX to account for the Internet access. In the AIS architecture, the AIS Base Stations are connected through an IP based communication network with the Central Segment.
* Availability of communications is essential in case of EDAS based architectures and/or centralised proposals. In such cases it has been assumed a cost increment in the OPEX, due to the upgrade of the contract with the ISP (Internet Service Provider), to reinforce reliability of the connection and increased data volume.
* To be noted that prices can differ up to 400% among European countries, according to EC studies[[3]](#footnote-3). These differences make it difficult to establish a common price for a generic costs analysis.
* Current estimated prices (OPEX):
  + At each beacon: “Basic Internet connection”.
  + At Central Monitoring Centre: “Broadband Internet connection”.
* Estimated prices for the upgrade in case of full-EDAS based architectures and/or full-centralised proposals (OPEX):
  + At each beacon: High availability Internet connection, with a cost 5 times higher than “Basic Internet connection”.
  + At Central Monitoring Centre: Broadband Internet connection with improved availability and bandwidth, with a cost 2 times higher than just “Broadband Internet connection”.

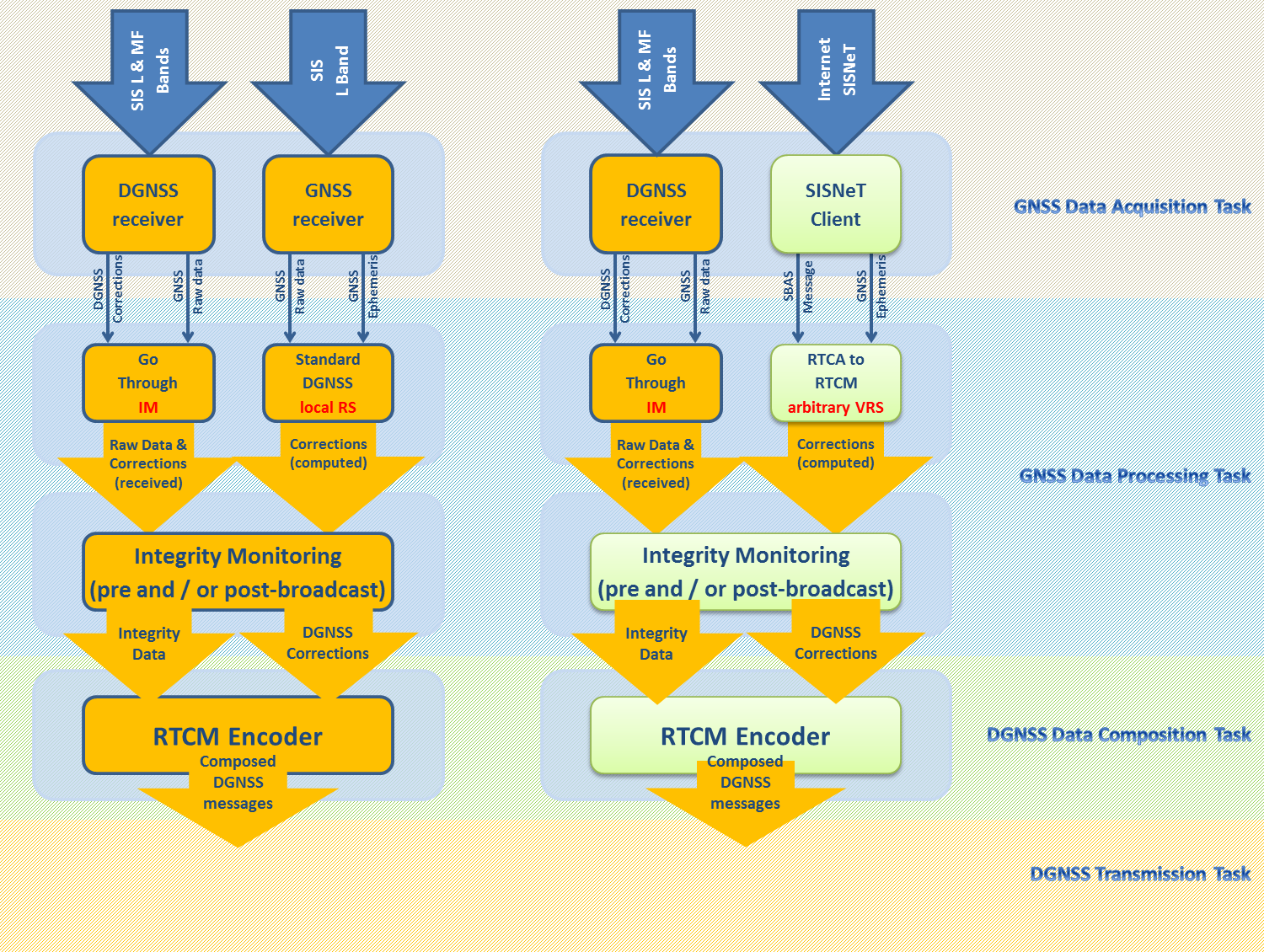
1. EGNOS OVER IALA BEACONS: Generic Cost Assessment
   1. Reference scenario: baseline IALA DGNSS infrastructure



1. Baseline/current IALA Architecture
   1. Alternate scenarios: Cost analysis of the EGNOS over IALA DGNSS options

This section provides qualitative costs analysis results that the proposed modifications to use EGNOS over IALA DGNSS implies with respect to the current scenario. The alternate scenarios are the ones proposed in the ENAV19-13.13 input paper [1]. It is highly recommended to follow the architectures description in such document for a better understanding.

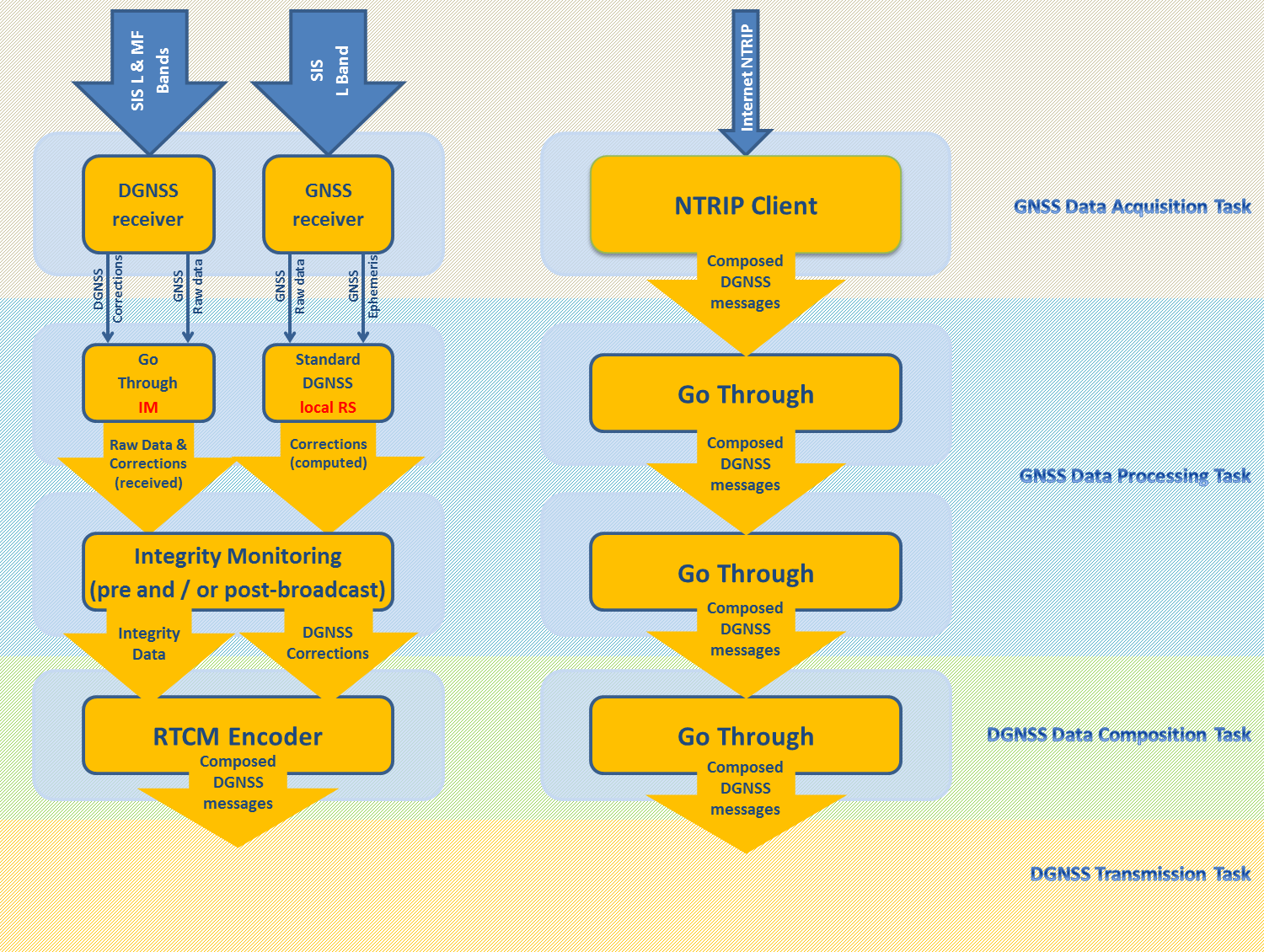
* + 1. Hybrid Decentralised Architecture: Traditional DGNSS + SISNeT Based



1. Hybrid Decentralised Architecture: Traditional DGNSS + SISNeT Based

Qualitative costs analysis results:

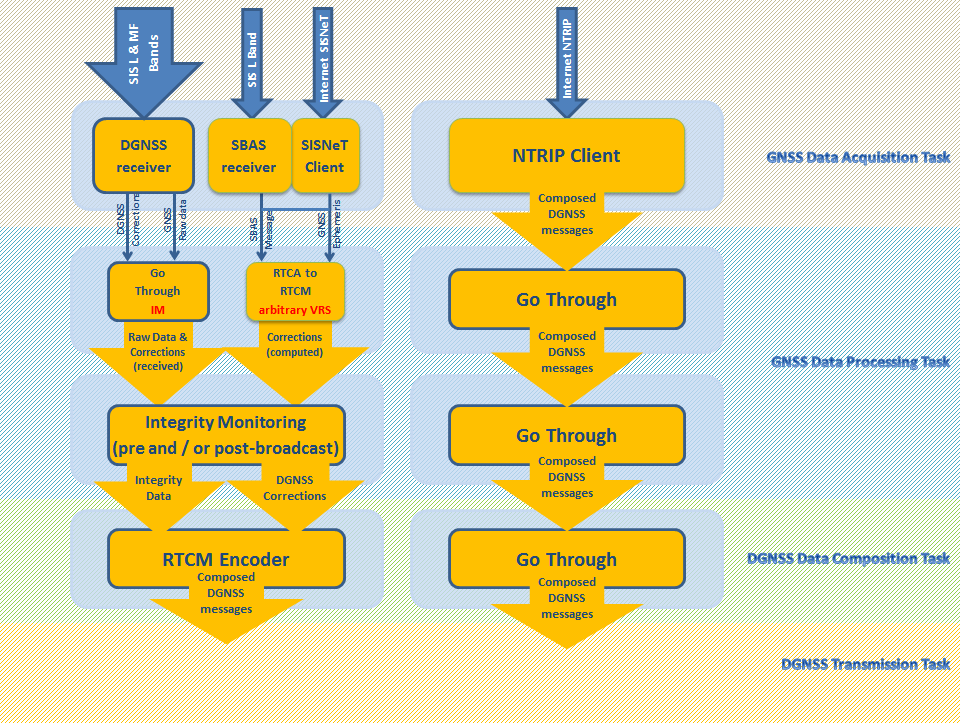
* CAPEX in a completely new infrastructure based on EGNOS is slightly lower compared to CAPEX in the reference scenario.
* The removal of components on site entails a reduction in the maintenance costs. Standard communication lines remains unchanged at each beacon. Therefore, OPEX decreases in the EGNOS-based option.
* The payback due to the savings in OPEX happens as of the 5th year since the infrastructure upgrade in all the study cases (1, 5, 10, 15 and 20 stations).
  + 1. Hybrid Centralised Architecture: Traditional DGNSS + EGNOS Based VRS



1. Hybrid Centralised Architecture: Traditional DGNSS + EGNOS Based VRS[[4]](#footnote-4)

Qualitative costs analysis results:

* CAPEX in a completely new infrastructure based on EGNOS is lower compared to CAPEX in the reference scenario, except in the case that there is only one station (a centralized architecture does not have sense in this situation).
* The removal of components on site entails a reduction in the maintenance costs, which balances out the OPEX increase due to the upgrade of the contract with the communications provider. This upgrade is needed since this is a centralized architecture.
* In an infrastructure with 5 broadcast sites, the payback due to the savings in OPEX happens as of the 7th year since the infrastructure upgrade. The same happens as of the 3rd year if there are 10 broadcast sites; or as of the 2nd year if there are 15 or 20 broadcast sites.
  + 1. Redundant Fully EGNOS Based Solution



1. Fully EGNOS Based Solution

Qualitative costs analysis results:

* CAPEX in a completely new infrastructure based on EGNOS is lower compared to CAPEX in the reference scenario, except in the case that there is only one station (a centralized architecture does not have sense in this situation).
* The removal of components on site entails a reduction in the maintenance costs, which balances out the OPEX increase due to the upgrade of the contract with the communications provider. This upgrade is needed since this is a centralized architecture.
* In an infrastructure with 10 broadcast sites, the payback due to the savings in OPEX happens as of the 6th year since the infrastructure upgrade. The same happens as of the 5th year if there are 15 or 20 broadcast sites.
  1. Costs comparison and conclusions

The performed analysis has taken into account the modifications to be made in the reference scenario in order to implement 3 different alternatives, according to the trade-off analysis in the ENAV19-13.13 input paper [1].

As commented before, CAPEX is directly related with the number of IALA beacons, either in the reference scenario or in the proposed alternatives, being worth implementing a centralised architecture only when there are more than one broadcast stations.

In terms of CAPEX, the “Redundant Fully EGNOS Based Solution” is the alternative requiring the highest upgrade investments. In addition, the “Hybrid Decentralised Architecture: Traditional DGNSS + SISNeT Based” requires lower investment than the “Hybrid Centralised Architecture: Traditional DGNSS + EGNOS Based VRS” when the number of stations to be upgraded is less than 15.

In regards to the evolution of the operational expenditures in the alternate scenarios compared with the reference scenario, they are clearly reduced as the number of onsite equipment decreases; even taking into account the upgrades of the contract with the ISP in the Central Facility.

* + 1. Infrastructure upgrade

Table 1 shows the relative investment in terms of CAPEX of each EGNOS-based alternative, the variation in percentage of OPEX with regard to the reference scenario and the payback period. All this values apply to the 10 stations case when an infrastructure upgrade is done:

1. Costs variation – 10 stations – infrastructure upgrade

|  |  |  |  |
| --- | --- | --- | --- |
| **10 stations**  **Infrastructure upgrade** | **Hybrid Decentralised** | **Hybrid Centralised** | **Redundant fully EGNOS** |
| **CAPEX-U** | 3% | 4% | 11% |
| **OPEX-D** | ▼5,3% | ▼13,7% | ▼15,8% |
| **Payback** | 5th year | 3rd year | 6th year |

In summary:

* CAPEX-U: CAPEX investment is shown as a percentage of the CAPEX for the reference scenario. The lowest investment is required by the “Hybrid Decentralised” architecture, while the highest corresponds to the “Redundant fully EGNOS”.
* The three EGNOS-based alternatives entail a yearly reduction in OPEX from 5% to almost 16% with regard to the OPEX of the reference scenario.
* Accrued savings after 5 years of operation are positive in the “Hybrid Decentralised” and “Hybrid Centralised” alternatives. Due to the higher yearly decrease in OPEX and the similar CAPEX investment, the accrued savings after 5 years in the “Hybrid Centralised” alternative are 32 times higher than in the “Hybrid Decentralised”.
* It is not possible to obtain any accrued saving after 5 years of operation in the “Redundant fully EGNOS” since the payback period is 6 years.

In case that an infrastructure’s upgrade is possible, by reusing some parts of the current architecture, this analysis concludes that the most promising architecture in terms of costs is the “Hybrid Centralised”. The payback would happen after three years of operation and the cumulative savings after 5 years of operation are higher than in the other alternatives.

* + 1. New infrastructure

The following table summarises the variation in percentage with regard to the CAPEX and OPEX of the reference scenario in the 10 stations case, assuming that the reference and the alternate scenarios are built from scratch:

1. Costs variation – 10 stations – new infrastructure

|  |  |  |  |
| --- | --- | --- | --- |
| **10 stations**  **New infrastructure** | **Hybrid Decentralised** | **Hybrid Centralised** | **Redundant fully EGNOS** |
| **CAPEX-D** | ▼5,3% | ▼14,8% | ▼16,9% |
| **OPEX-D** | ▼5,3% | ▼13,7% | ▼15,8% |

In summary:

* The three EGNOS-based alternatives entail a reduction in CAPEX from 5% to almost 17% with regard to the CAPEX of the reference scenario.
* The three EGNOS-based alternatives entail a yearly reduction in OPEX from 5% to almost 16% with regard to the OPEX of the reference scenario (there is no difference with regard to the “infrastructure upgrade” case).
* Accrued savings after 5 years of operation are 2,75 times higher in the “Hybrid Centralised” than in the “Hybrid Decentralised”.
* Accrued savings after 5 years of operation are 3,14 times higher in the “Redundant fully EGNOS” than in the “Hybrid Decentralised”.

Taking as example the deployment based on 10 stations, this analysis concludes that the “Redundant fully EGNOS” alternative is the most cost-effective if compared with the deployment of the reference scenario, both of them built from scratch.

1. EGNOS OVER AIS: Generic Cost Assessment

The EGNOS-based alternatives follow the high level architectures described in [1] in two different situations:

* AIS #1 – Infrastructure upgrade:
  + The reference scenario is an AIS network (implementing MT17) associated to an existing IALA DGNSS deployment. Corrections from the IALA DGNSS stations are used to feed the AIS Base Stations. As an assumption, one IALA beacon feeds five AIS Base Stations[[5]](#footnote-5). Costs of the reference scenario include the AIS network and also the IALA DGNSS infrastructure.
  + The alternate scenarios analysed are decentralised (EGNOS SIS and EDAS) and centralised (EGNOS SIS and EDAS) assuming that the modifications are implemented in the IALA beacons.
* AIS #2 – New infrastructure:
  + The reference scenario is an AIS network (implementing MT17) associated to an IALA DGNSS infrastructure (to be deployed). Corrections from the IALA DGNSS stations are used to feed the AIS Base Stations. One IALA beacon feeds five AIS Base Stations.
  + The alternate scenario analysed is centralised (EGNOS SIS and EDAS) assuming that there is no IALA DGNSS infrastructure, hence a centralised computation of corrections is performed in the Central Segment.
  1. Reference scenario: baseline AIS infrastructure

**Assumptions:**

* The reference scenario is an AIS network (maritime or inland) with computation of DGPS corrections, hence message 17 is implemented.
* It is assumed that the AIS Base Stations are ready to receive DGNSS corrections provided as input via a dedicated port.
* An external RS (with its corresponding IM) is in place and could be used to provide DGNSS corrections to the AIS Base Stations. It is not necessary to do any change on the AIS Base Station to obtain an EGNOS-based alternative but only on the external reference station (RS). (See ENAV19-13.13 ref.[1]).
  1. Alternate scenarios: Cost analysis of the EGNOS over AIS options

**Assumptions:**

* In the decentralised options, the EGNOS-based alternatives imply the modification of the DGNSS station which feeds the AIS base station and this AIS base station remains unchanged.
* In the centralised options, the EGNOS-based alternatives imply the modification of the Central Segment in order to include the Processing Facility to generate the DGNSS corrections. AIS base stations remain unchanged.
  + 1. Decentralised – EGNOS SIS

Qualitative costs analysis results:

* CAPEX and OPEX in the reference scenario include not only the AIS network related costs but also the DGNSS reference stations costs which are needed to provide the corrections.
* CAPEX in a completely new infrastructure based on EGNOS is lower compared to CAPEX in the reference scenario.
* OPEX decreases in the EGNOS-based option, however this decrease does not allow to recover the required investment.
  + 1. Decentralised – EDAS

Qualitative costs analysis results:

* CAPEX and OPEX in the reference scenario include not only the AIS network related costs but also the DGNSS reference stations costs which are needed to provide the corrections.
* CAPEX in a completely new infrastructure based on EGNOS is lower compared to CAPEX in the reference scenario.
* Despite of removing some elements on site, which entails a reduction in the maintenance costs, OPEX increases in the EGNOS-based option due to the upgrade of the contract with the communications provider, since this is an architecture based on EDAS.
  + 1. Centralised – EGNOS SIS

Qualitative costs analysis results:

Situation AIS #1 (Infrastructure upgrade):

* CAPEX in a completely new infrastructure based on EGNOS is lower compared to CAPEX in the reference scenario, except in the case that there are only one or two IALA DGNSS stations (a centralized architecture does not have sense in this situation).
* The removal of components in the IALA beacons entails a reduction in the maintenance costs, which balances out the OPEX increase due to the upgrade of the contract with the communications provider. This upgrade is needed since this is a centralized architecture.
* In an infrastructure with 20 AIS Base Stations attached to 4 IALA beacons, the payback due to the savings in OPEX happens as of the 13th year since the infrastructure upgrade.

Situation AIS #2 (New infrastructure):

* CAPEX and OPEX in the reference scenario include not only the AIS related costs but also the DGNSS reference stations costs which are needed to provide the corrections.
* This analysis is focused in the cost comparison between the deployment of a decentralised infrastructure of IALA DGNSS stations to feed the AIS Base Stations (1 IALA beacon each 5 AIS base stations) and the deployment of a centralised alternative based on EGNOS, without IALA DGNSS stations.
* CAPEX in a completely new infrastructure based on EGNOS is lower compared to CAPEX in the reference scenario.
* The decrease of components on site entails a reduction in the maintenance costs, however OPEX increases due to the upgrade of the contract with the communications provider. This upgrade is needed since this is a centralized architecture. As of 15 AIS Base Stations OPEX decreases in the alternative scenario with regards to the reference one.
* According to the “Deltas for completely new infrastructure (cumulative)” a centralised option deployed for 5 AIS Base Stations is cheaper than the deployment of the reference scenario; however the increase in OPEX leads to a non-profitable result as of the 5th year of operation.
* According to the “Deltas for completely new infrastructure (cumulative)” a centralised option deployed for 15 (or more) AIS Base Stations is cheaper than the deployment of the reference scenario; besides the decrease in OPEX leads to a growing profit result along the years.
  + 1. Centralised – EGNOS EDAS

Qualitative costs analysis results:

Situation AIS #1 (Infrastructure upgrade):

* CAPEX and OPEX in the reference scenario include not only the AIS related costs but also the DGNSS reference stations costs which are needed to provide the corrections.
* CAPEX in a completely new infrastructure based on EGNOS is lower compared to CAPEX in the reference scenario, except in the case that there are only one or two IALA DGNSS stations (a centralized architecture does not have sense in this situation).
* The removal of components in the IALA beacons entails a reduction in the maintenance costs, which balances out the OPEX increase due to the upgrade of the contract with the communications provider.
* In an infrastructure with 20 AIS Base Stations attached to 4 IALA beacons, the payback due to the savings in OPEX happens as of the 11th year since the infrastructure upgrade.

Situation AIS #2 (New infrastructure):

* CAPEX and OPEX in the reference scenario include not only the AIS related costs but also the DGNSS reference stations costs which are needed to provide the corrections.
* This analysis is focused in the cost comparison between the deployment of a decentralised infrastructure of IALA DGNSS stations to feed the AIS Base Stations (1 IALA beacon each 5 AIS base stations) and the deployment of a centralised alternative based on EDAS, without IALA DGNSS stations.
* CAPEX in a completely new infrastructure based on EDAS is lower compared to CAPEX in the reference scenario.
* The decrease of components on site entails a reduction in the maintenance costs, however OPEX increases due to the upgrade of the contract with the communications provider. This upgrade is needed since this is a centralized architecture based on EDAS. As of 15 AIS Base Stations OPEX decreases in the alternative scenario with regards to the reference one.
* According to the “Deltas for completely new infrastructure (cumulative)” a centralised option deployed for 5 AIS Base Stations is cheaper than the deployment of the reference scenario; however the increase in OPEX leads to a non-profitable result as of the 7th year of operation.
* According to the “Deltas for completely new infrastructure (cumulative)” a centralised option deployed for 15 (or more) AIS Base Stations is cheaper than the deployment of the reference scenario; besides the decrease in OPEX leads to a growing profit result along the years.
  1. Costs comparison and conclusions
     1. Infrastructure upgrade – AIS #1

The reference scenario is already deployed and the connected DGNSS beacons are upgraded following a decentralised or centralised EGNOS-based alternative.

In the decentralised options, CAPEX investment is directly related with the number of IALA beacons feeding the AIS network. Besides, the centralised alternatives are the ones requiring the highest upgrade investments in terms of CAPEX.

Regarding the evolution of the operational expenditures in the alternate scenarios compared with the reference scenario, they are clearly reduced as the number of onsite equipment decreases; that is in the centralised architectures, even taking into account the upgrades of the contract with the ISP.

The following table summarises the costs results in a large size deployment, if referred to inland waters, or a medium-small size deployment, if referred to coastal AIS. This case analyses an infrastructure upgrade in a network with 20 AIS base stations.

1. Costs variation – 20 stations – infrastructure upgrade

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **20 stations**  **Infrastructure upgrade** | **Decentralised**  **EGNOS-SIS** | **Decentralised**  **EDAS** | **Centralised**  **EGNOS-SIS** | **Centralised**  **EDAS** |
| **CAPEX-U** | 5,2% | 2,5% | 9,6% | 8,9% |
| **OPEX-D** | = | ▲0,8% | ▼5,9% | ▼6,8% |
| **Payback** | NA | NA | 13th year | 11th year |

In summary:

* CAPEX-U: CAPEX investment is shown as a percentage of the CAPEX for the reference scenario. The lowest investment is required by the “Decentralised EDAS” architecture, while the highest corresponds to the “Centralised EGNOS-SIS”.
* OPEX-D: OPEX remains almost unchanged in the decentralised options. As a consequence, the decentralised alternate scenarios entail an increase in the cumulative costs or a very slight decrease and a return of the investment is not possible in these alternatives (payback period Not Applicable).
* The centralised alternatives entail a yearly reduction in OPEX from 6% to almost 7% with regard to the OPEX of the reference scenario. As a consequence, the centralised alternate scenarios entail a decrease in the cumulative costs and in both of them a return of the investment will happen. The lowest payback period happens in the “Centralised - EDAS” alternative, after 11 years of operation.

Analysing the evolution of cumulative costs (CAPEX and OPEX) along a timeframe period of 5 years in a network with 20 AIS Base Stations and 4 DGNSS beacons, it can be observed that when an infrastructure upgrade is done to build the decentralised alternate scenarios, a return of the investment is not possible. On the contrary, when an infrastructure upgrade is done to build the centralised alternate scenarios, in both of them a return of the investment will happen. The earliest return of the investment happens in the “Centralised - EDAS” alternative. Hence, this would be the most promising alternative in terms of costs, in this situation (AIS #1).

* + 1. New infrastructure – AIS #2

This analysis is focused in the cost comparison between the deployment of a decentralised infrastructure of IALA DGNSS stations to feed the AIS Base Stations (1 IALA beacon each 5 AIS base stations) and the deployment of a centralised alternative based on EGNOS, without IALA DGNSS stations. In this situation a CAPEX investment is needed to implement MT17 in both, the reference scenario and the EGNOS-based alternatives. The required CAPEX investment is directly related with the number of AIS stations and higher in the reference scenario than in the centralised options.

In regards to the evolution of the operational expenditures in the alternate scenarios compared with the reference scenario, they decrease as the number of onsite equipment is reduced; that is in the centralised architectures, even taking into account the upgrades of the contract with the ISP.

The following table summarises the costs results in a large size deployment, if referred to inland waters, or a medium-small size deployment, if referred to coastal AIS. This case analyses the deployment of a new infrastructure with 20 AIS base stations.

1. Costs variation – 20 stations – New infrastructure

|  |  |  |
| --- | --- | --- |
| **20 stations**  **New infrastructure** | **Centralised**  **EGNOS-SIS** | **Centralised**  **EDAS** |
| **CAPEX-D** | ▼36,9% | ▼37,6% |
| **OPEX-D** | ▼8,9% | ▼9,7% |

In summary:

* The EGNOS-based alternatives entail a reduction in CAPEX from 36,9% to 37,6% with regard to the CAPEX of the reference scenario.
* The EGNOS-based alternatives entail a yearly reduction in OPEX from 9% to almost 10% with regard to the OPEX of the reference scenario.

A completely new centralised option deployed for 20 AIS Base Stations is cheaper than the deployment of the reference scenario. Besides, the decrease in OPEX leads to a growing profit result along the years. Both centralised alternatives yield similar savings, being the “Centralised EDAS” slightly better in terms of costs.

1. Conclusions

The performed analysis has taken into account the modifications to be made in the reference scenario in order to implement different alternatives based on EGNOS, according to the trade-off analysis in the ENAV19-13.13 input paper [1].

**EGNOS over IALA beacons**

In terms of CAPEX, the “Redundant Fully EGNOS Based Solution” is the alternative requiring the highest upgrade investments. In addition, the “Hybrid Decentralised Architecture: Traditional DGNSS + SISNeT Based” requires lower investment than the “Hybrid Centralised Architecture: Traditional DGNSS + EGNOS Based VRS” when the number of stations to be upgraded is less than 15.

Infrastructure upgrade (10 stations):

* In case that an infrastructure’s upgrade is possible, by reusing some parts of the current architecture, this analysis concludes that the most promising architecture in terms of costs is the “Hybrid Centralised”. The payback would happen after three years of operation and the cumulative savings after 5 years of operation are higher than in the other alternatives.

New infrastructure (10 stations):

* Taking as example the deployment based on 10 stations, this analysis concludes that the “Redundant fully EGNOS” alternative is the most cost-effective if compared with the deployment of the reference scenario, both of them built from scratch.

**EGNOS over AIS**

Infrastructure upgrade (20 stations):

* Analysing the evolution of cumulative costs (CAPEX and OPEX) along a timeframe period of 5 years in a network with 20 AIS Base Stations and 4 DGNSS beacons, it can be observed that when an infrastructure upgrade is done to build the decentralised alternate scenarios, a return of the investment is not possible. On the contrary, when an infrastructure upgrade is done to build the centralised alternate scenarios, in both of them a return of the investment will happen. The earliest return of the investment happens in the “Centralised - EDAS” alternative. Hence, this would be the most promising alternative in terms of costs, in this situation.

New infrastructure (20 stations):

* A completely new centralised option deployed for 20 AIS Base Stations is cheaper than the deployment of the reference scenario. Besides, the decrease in OPEX leads to a growing profit result along the years. Both centralised alternatives yield similar savings, being the “Centralised EDAS” slightly better in terms of costs.

1. Input document number, to be assigned by the Committee Secretary [↑](#footnote-ref-1)
2. Leave open if uncertain [↑](#footnote-ref-2)
3. <http://europa.eu/rapid/press-release_IP-14-314_en.htm> [↑](#footnote-ref-3)
4. “Go Through” module: means that no change on the data is done on this layer at the broadcast site. For instance, in the centralised solution, corrections (including integrity) are received at the broadcast site, being only necessary to transmit this data via radio. Hence, no action is done in the "GNSS data processing and composition" tasks. [↑](#footnote-ref-4)
5. The case of locating one RS with IM is located at the same site as each AIS Base Station is highly unlikely and inefficient: considering the short coverage of the AIS base stations (within LoS range) compared to the broadcast range of a DGNSS station (in the order of 200 NM), in a defined area covered by both systems there would be more AIS Base Stations than IALA beacons. [↑](#footnote-ref-5)