



European  
Global Navigation  
Satellite Systems  
Agency

# GSA/OP/07/13/SC24 “Support to Maritime Service Providers for the transmission of EGNOS corrections via IALA beacons and AIS/VDES Stations ”

**Eighth Session of the IALA AtoN Engineering and Sustainability Committee (ENG8)**

15-19 October 2018  
IALA Headquarters, France



**ALG** by Indra



We certify you're there.

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## GSA has an active long-term trajectory working to foster EGNOS adoption in maritime for SOLAS vessels, beyond leisure applications

- Use of EGNOS in Maritime enabled in more than 80% of receiver models for both SOLAS and non-SOLAS vessels.
- The EGNOS Programme aims at fostering the **adoption of EGNOS V2 in maritime**, with the following active lines of action for general navigation:

**GSA/OP/07/13/SC24**

### 2. Direct use of EGNOS v2 SIS by maritime receivers

- Analysis of EGNOS v2 performances for its use in maritime using **SBAS integrity**
- Guidelines for the implementation of **SBAS** in **shipborne receivers**

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# The project aims at demonstrating that EGNOS can provide multiple benefits to the maritime and IWW service providers

- The contract will allow the maritime and IWW service providers to have a clear understanding about the **technical and economic feasibility** of the transmission of EGNOS corrections via IALA beacons and AIS/VDES.
- EGNOS data is provided to the mariner over an **existing marine radio service** currently used for a recognized Aid to Navigation. This approach would take **benefit of EGNOS data** with **no impact at user level** (who will use the same receiver).
- **Four pilot projects will be developed** in different sites and countries **implementing preferred service provision schemes**, which will be evaluated in long-term real scenarios and validated both from operational and economic points of view.
- The **key drivers of this project** include
  1. **Close involvement of the maritime and IWW authorities**
  2. **Practical implementation of the architectures** to verify operational requirements, carry out extensive analysis and identify the best value for investment options

In case that this feasibility is confirmed, the project will constitute a **Success Case** and a **Catalyst for implementation** of the service provision schemes in other sites and countries

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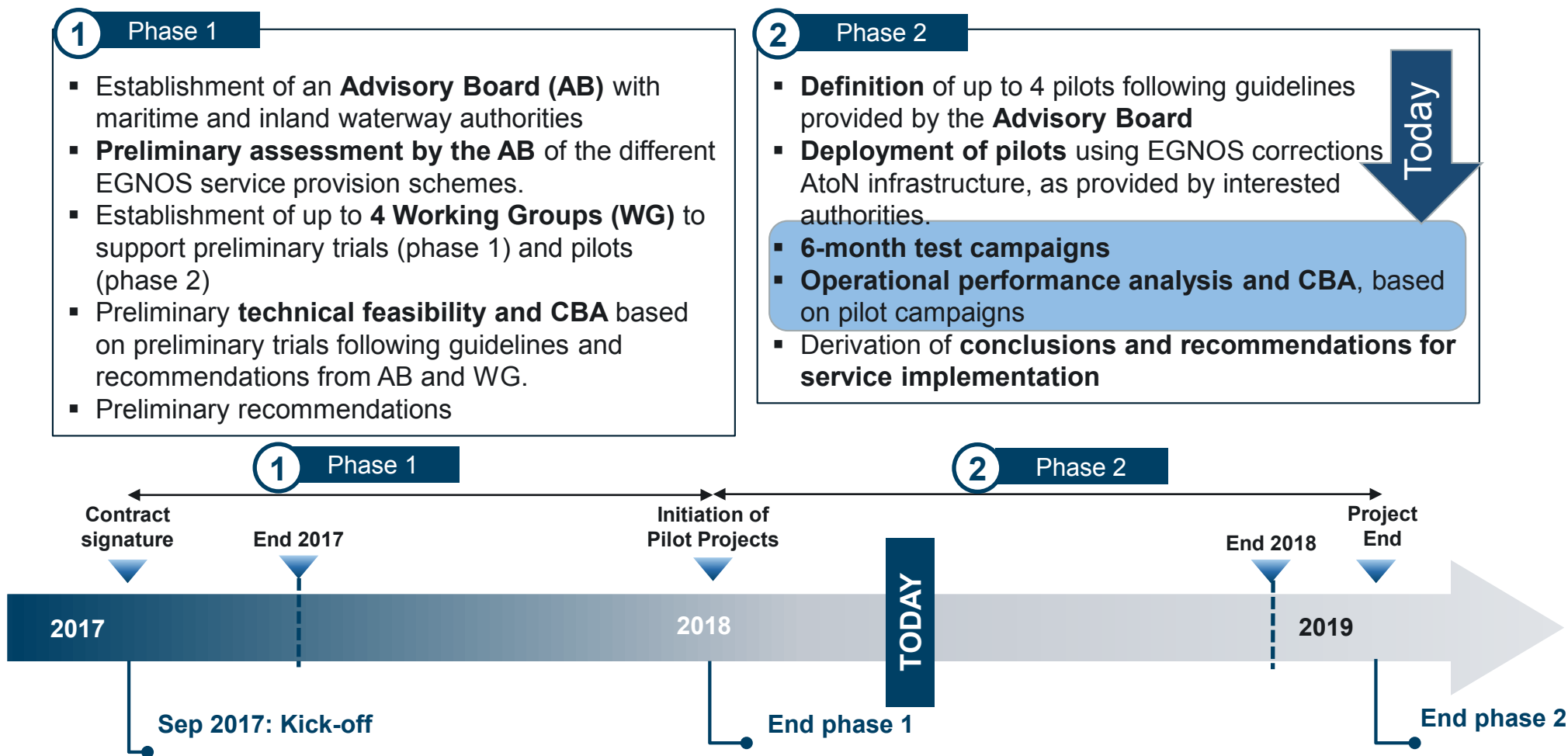
# Project organisation





# The Project aims to address technical, operation and economical feasibility of using EGNOS as a source for the Differential GNSS (DGNSS) corrections to be transmitted via IALA beacons and AIS stations

## Structure and Implementation Timeline



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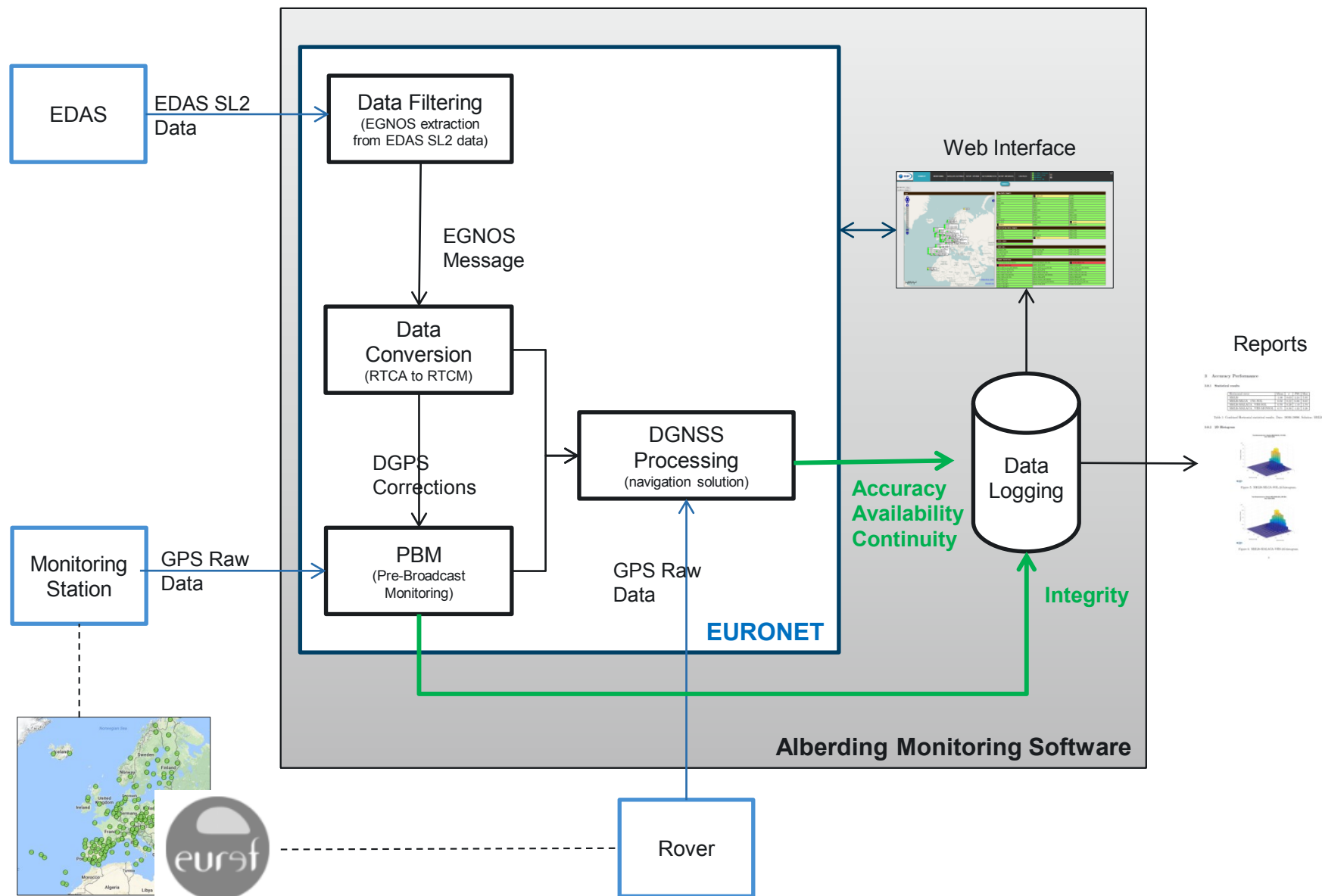
Pilot Projects

Pilot Projects

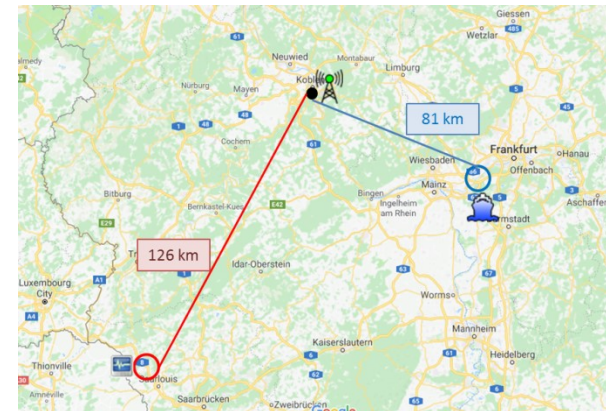
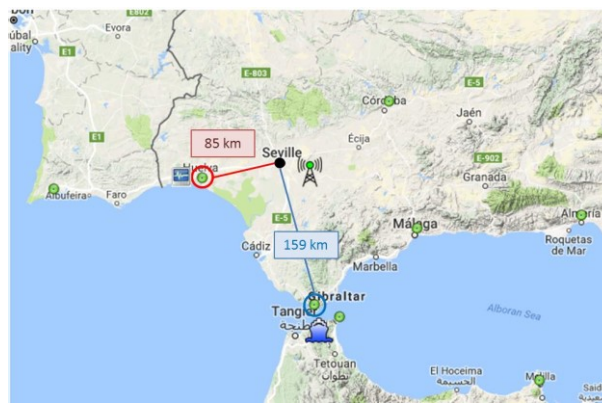
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


# Preliminary Tests Platform – Alberding Monitoring SW

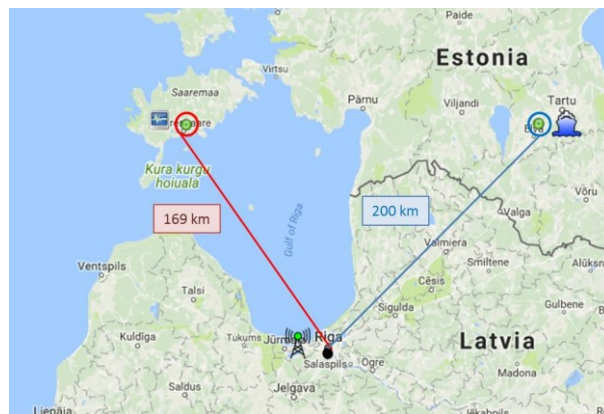
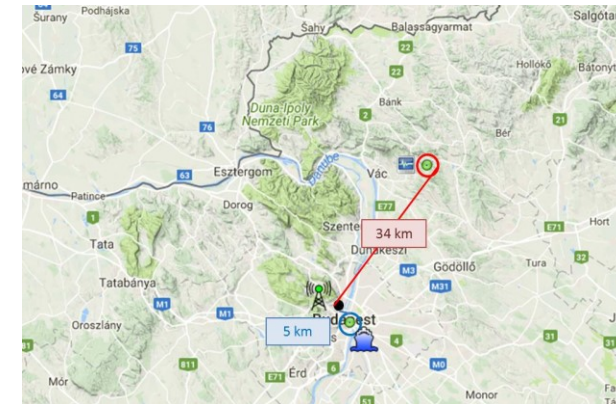


# Scenarios



1 month duration - from January 26<sup>th</sup> to February 25<sup>th</sup> - 2018

Country	VRS 	Rover 		Monitoring Stations 	
		Location	Baseline	Location	Baseline
Spain	Rota	TARIO	100	HUEL0	85
Spain	Sevilla	TARIO	159	HUEL0	85
Germany	Koblenz	DILL1	126	FFMJ1	81
Hungary	Budapest	BUTE0	5	PENC0	34
Norway	Utsira	OSLS0	313	STAS0	56
Latvia	Riga	TOR20	200	KURE0	169



# Conclusions

- The EGNOS SIS combined availability was 100% and the EDAS SL2 was 99.99%
- EDAS-based DGPS availability and continuity performance above 99.9999% and 99.97% (without the integrity check)
- All the availability and continuity events detected in the integrity-checked solutions were caused by failures on the monitoring station. There is a need to look for reliable stations that can be used as monitoring stations.
- EDAS-based DGPS accuracy clearly below the 10 meters IMO requirement
- No single satellite correction discarded due to high PRC, RRC or their corresponding residual values → This illustrates the corrections quality
- Two single integrity events on the position domain (linked with the quality of the measurements and/or GPS navigation data collected by the monitoring station) → TTA met in both cases (user protection ensured)

Scenario	Non-Integrity Checked Solution				Integrity Checked Solution			
	Availability	Continuity	Accuracy (95%, m)	Integrity	Availability	Continuity	Accuracy (95%, m)	Integrity
Rota	100%	100%	0.8	NA	99.94%	99.75%	0.8	No integrity events
Koblentz	<div> <p>The quality of EGNOS-based differential corrections is sufficient to meet the availability, continuity, accuracy and integrity requirements defined by IMO in resolution A.1046, and IALA Guidelines 1112 and 1129.</p> <p>position domain – TTA met</p> </div>							
Budapest								
Sevilla	99.99%	99.97%	0.8	NA	99.84%	98.75%	0.8	No integrity events
Utsira	100%	100%					1.24	No integrity events
Riga	100%	100%	1.35	NA	83.31%	86.45%	1.35	One short event at the position domain – TTA met

**Continuation to Phase 2 accepted**

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# Operational requirements

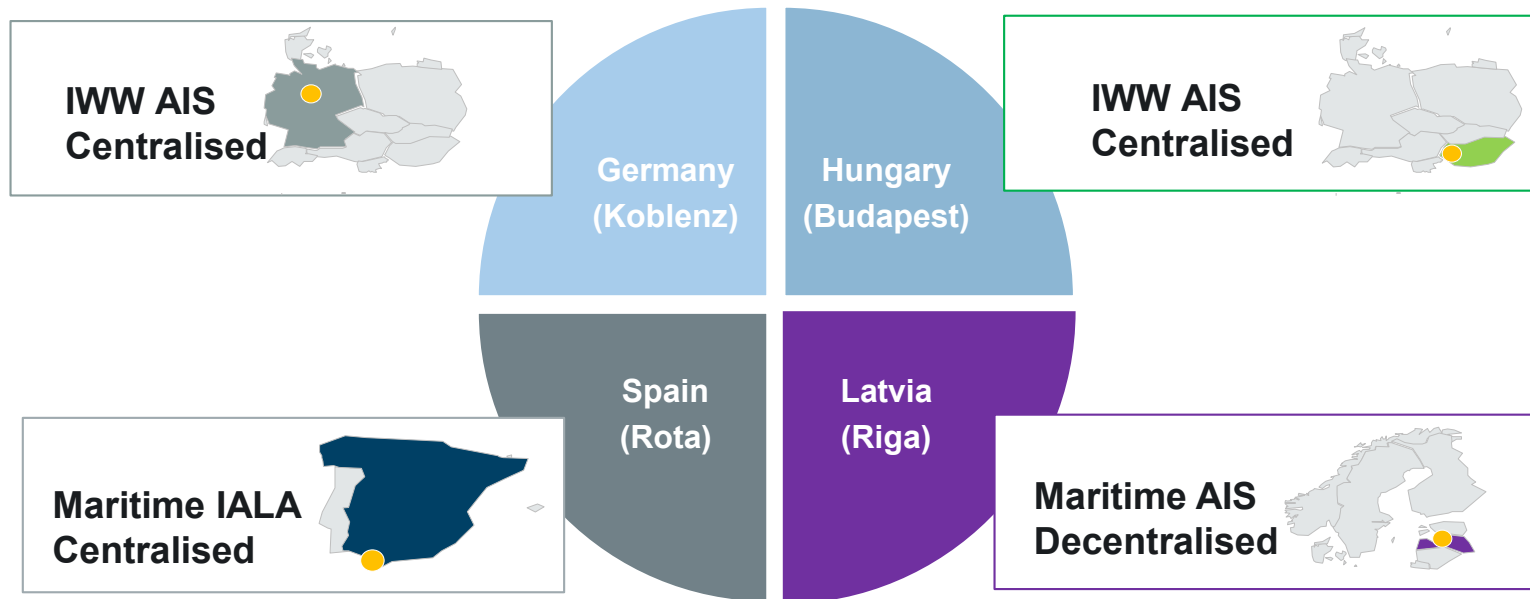
## Maritime domain

<b>Horizontal Accuracy (95%):</b>	<b>10 m</b>
<b>Availability (per 2 years):</b>	<b>99.8 %</b>
<b>Continuity (over 15 minutes):</b>	<b>99.97 %</b>
<b>Integrity Time to Alarm:</b>	<b>10 s</b>

## Inland Waterways domain

Targets set by European inland waterway navigation experts in the frame of the IRIS Europe II project:

<b>Horizontal Accuracy (95%):</b>	<b>3 m</b>
<b>Availability (per 2 years):</b>	<b>99.8 %</b>
<b>Continuity (over 15 minutes):</b>	<b>99.97 %</b>
<b>Integrity Time to Alarm:</b>	<b>10 s</b>



# Pilot Projects

## Performance results (2 months of data: June and July 2018)

Pilot Project	Availability		Continuity		Accuracy (95%, m)		Integrity	
	June	July	June	July	June	July	June	July
HU (RSOE, Budapest)	100%	99.98%	100%	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							

Availability/continuity requirements not met due to issues related to communication aspects intrinsic to the infrastructure and **not related to the quality/availability of the EGNOS corrections.**



## Pilot Projects

### Performance results: main conclusions

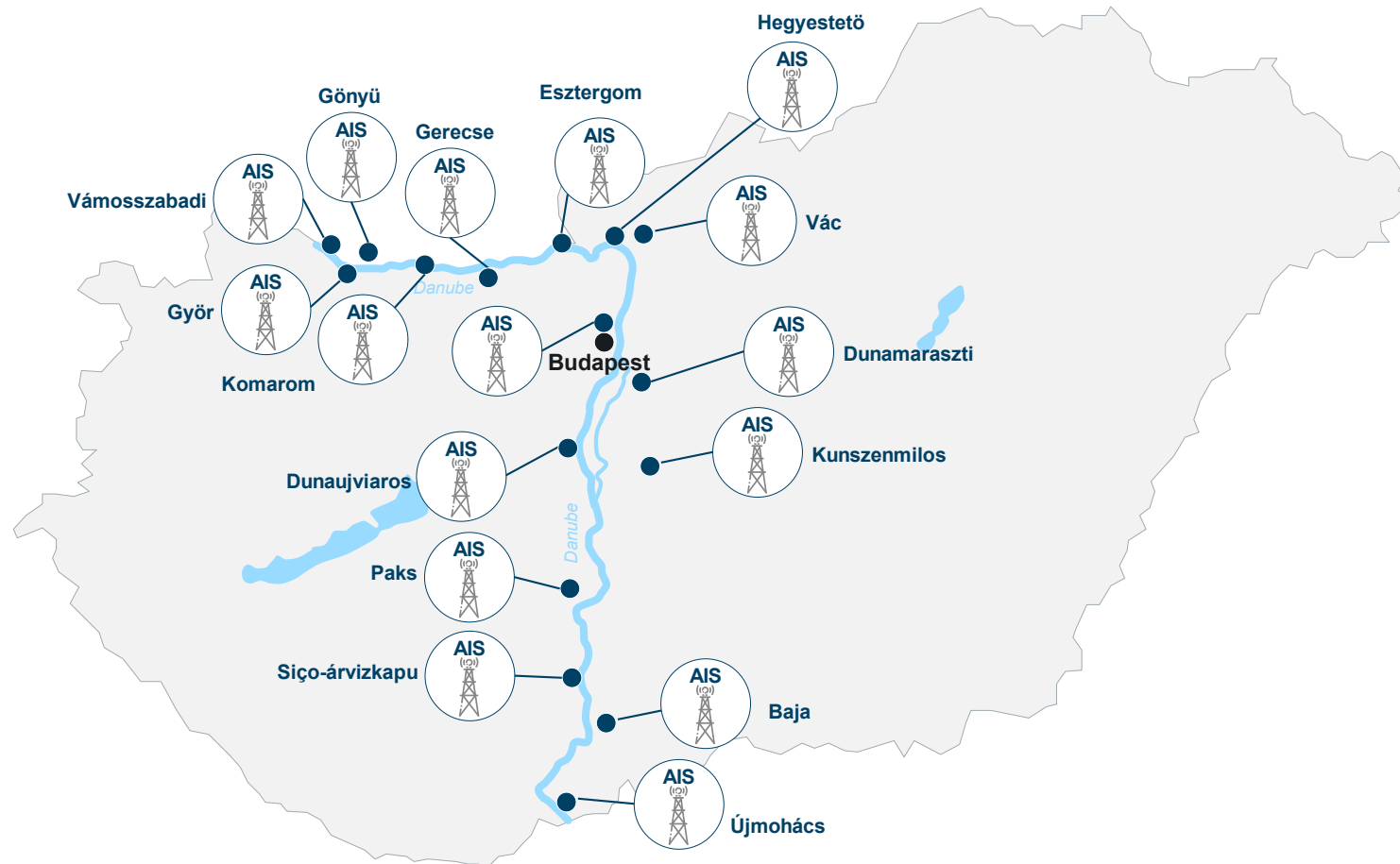
**2 months of data campaign executed and analysed so far**

**A fine-tuning of the system is still under execution to improve performance results**

**Overall, pilot projects have demonstrated the high availability of the EGNOS-based differential corrections as well as their very good quality.**

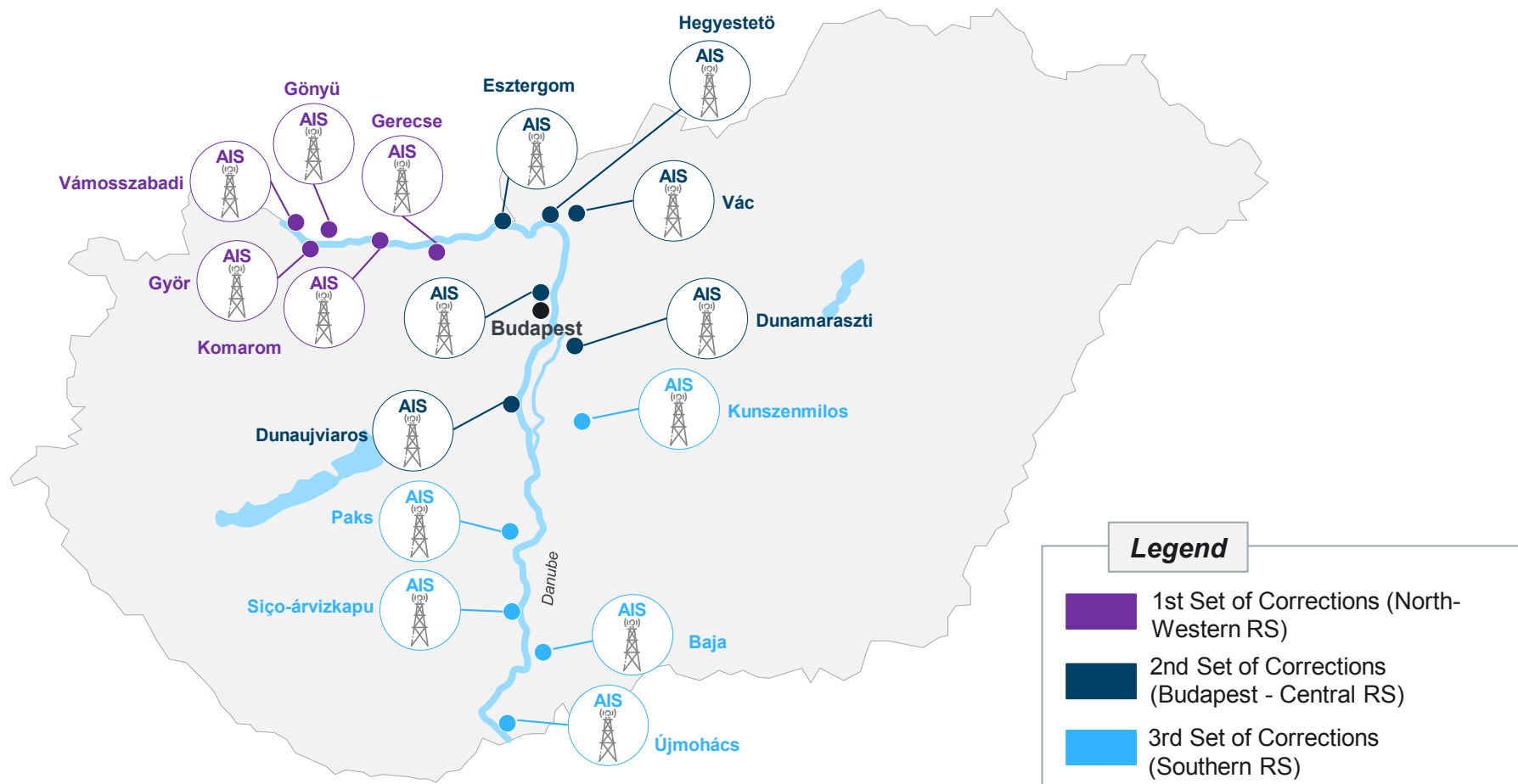
**Final results to be presented in next IALA ENG8 Session in 2019**

## Hungarian AIS Network includes 16 AIS Base Stations plus a series of VHF and Microwave repeaters (with no AIS capabilities)



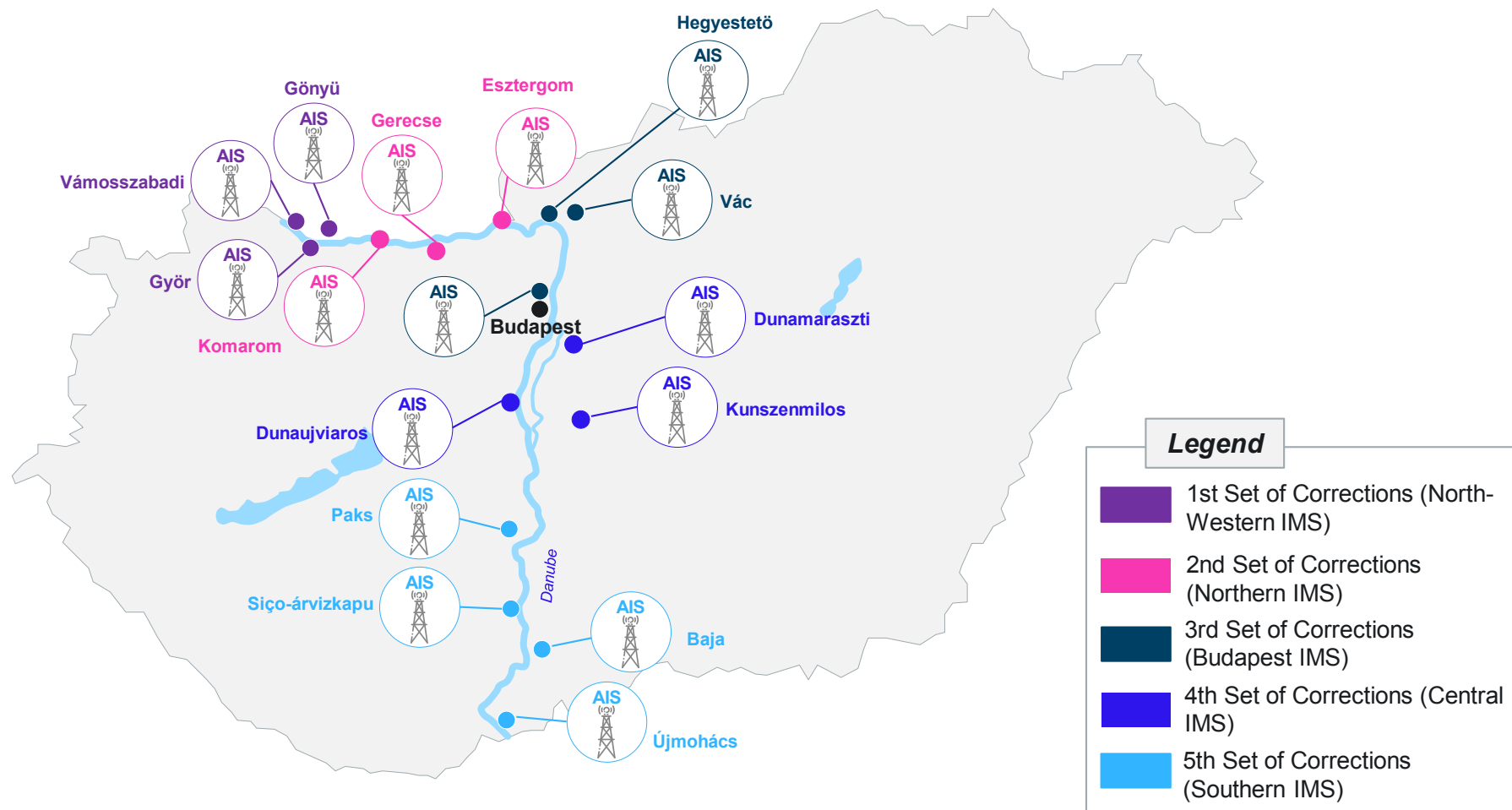
AIS Network is fully centralised and includes one central VRS Server; currently only one set of corrections is generated and transmitted to all the 16 AIS Base Stations

# In case of traditional DGNSS, additional RS and IM Stations should be deployed, for providing additional sets of corrections



As validated with RSOE, the deployment of 2 additional RS would allow customized corrections for Southern and North-Western area

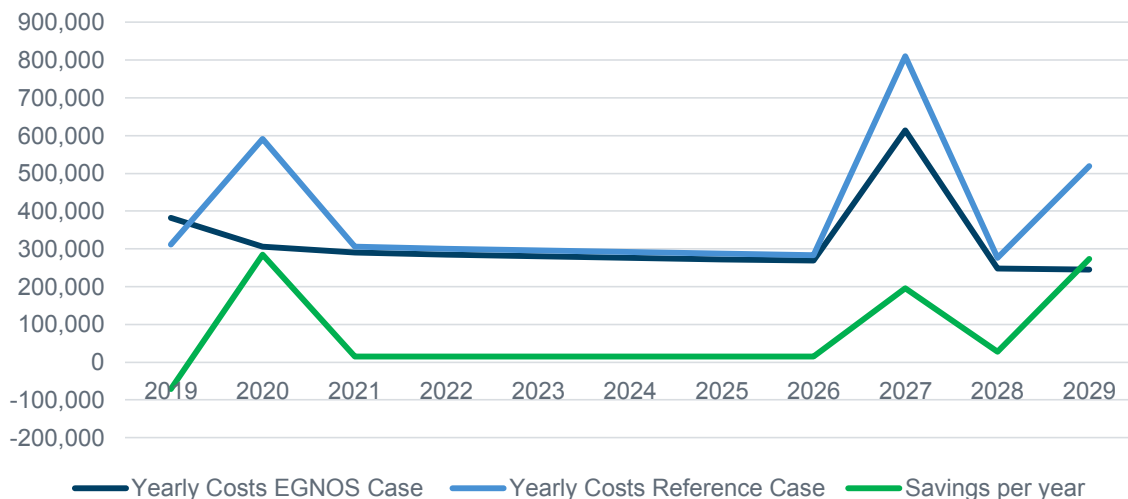
# In case of EGNOS, additional IM Stations could be deployed, in order to provide a total of 5 sets of corrections throughout the whole country



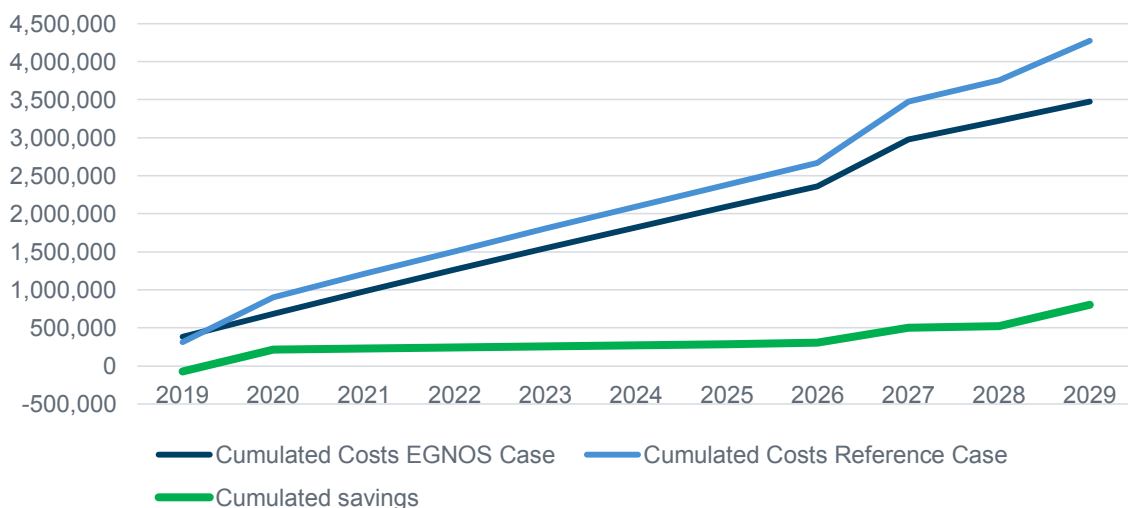
As validated with Alberding, 5 sets of correction would provide an optimal cost-quality trade-off and allow sufficiently customized corrections for the whole Hungary

# Hungarian AIS scenario generates an high NPV and an high percentage of savings

## Yearly Cash Flows



## Cumulated Savings (with EGNOS Option)



- EGNOS Option foresees high savings in CAPEX (mainly IM/DRS/FFM Stations)
- EGNOS Options generates some savings in OPEX (mainly IM/DRS Maintenance and warranty)

	Reference Scenario	EGNOS Option	EGNOS Option Savings
<b>Total CAPEX</b>	1.075.406	461.676	57%
<b>Total OPEX</b>	3.196.683	3.008.934	6%

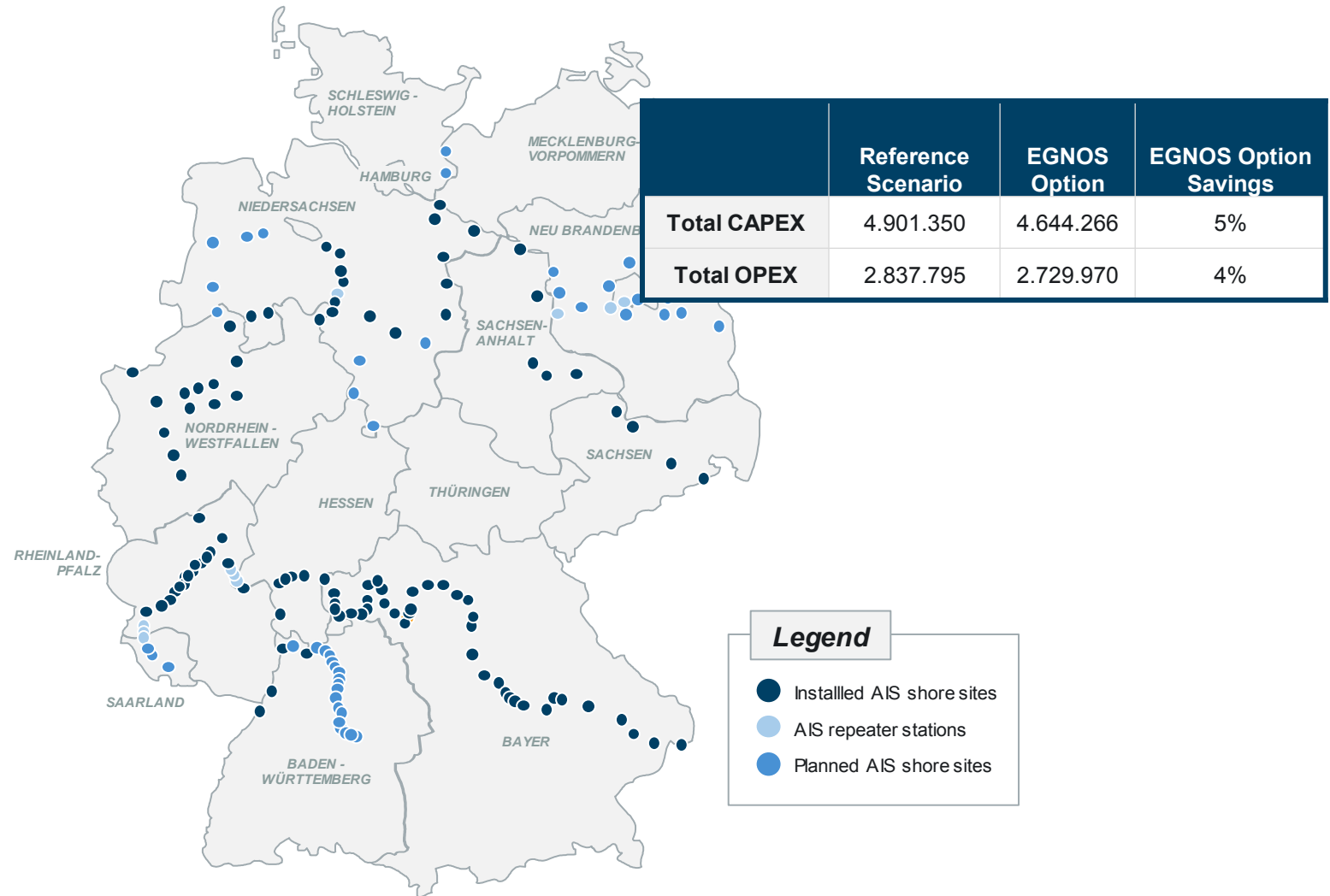
- Overall results of Hungarian scenario are promising in terms of costs savings
- Hungary shows good potential for the implementation of an EGNOS-based AIS centralised Architecture:

## Spanish AIS CBA – Global Results of EGNOS-Based AIS Centralised architecture

<b>NPV</b>	0,8 Mln €
<b>Savings percentage EGNOS Option vs Reference Scenario</b>	19 %*

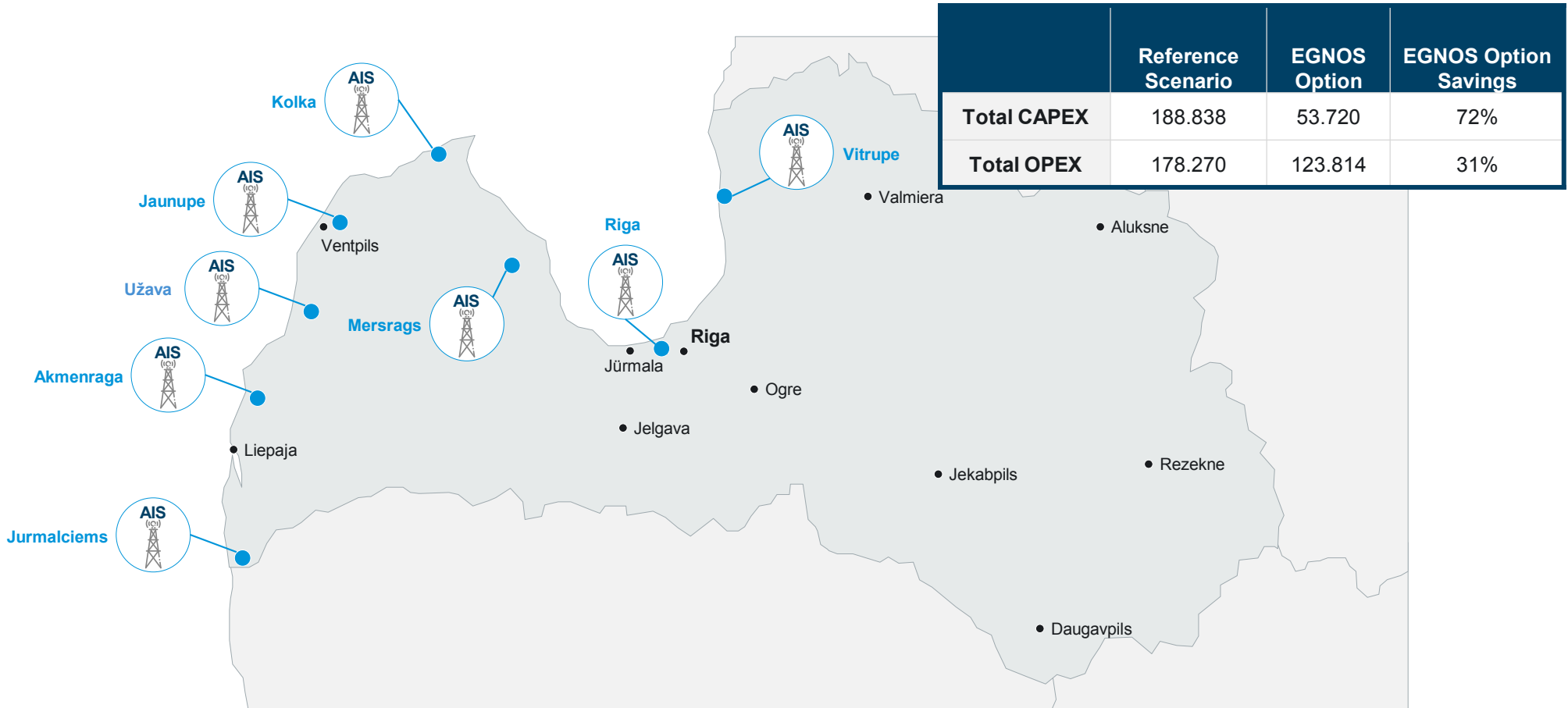
\* Communications OPEX data to be further investigated

# German AIS Network includes 117 deployed and 48 planned AIS Base Stations



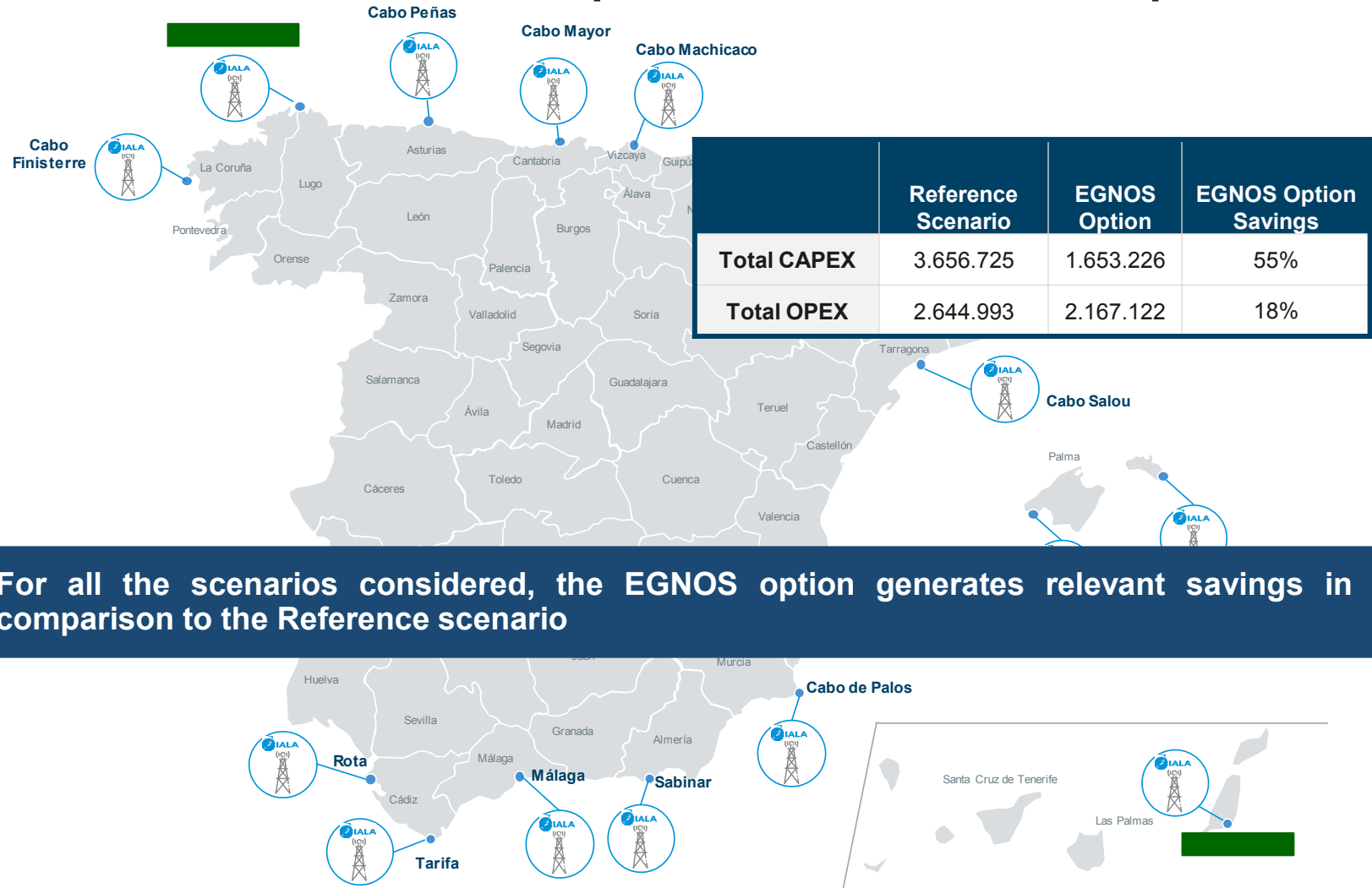
AIS Network is fully centralised and includes one central VRS Server and six AIS Service Managers

# Latvian AIS Network includes 8 AIS Base Stations plus a microwave backbone LAN connecting the MRCC with all the AIS BS



Currently a DGNSS corrections service over AIS is not implemented. There are no IALA beacons in Latvia or any other source to get the RTCM messages required to transmit the MT17.

# Spanish IALA Network includes 18 operational Beacons and 1 planned Beacon



**For all the scenarios considered, the EGNOS option generates relevant savings in comparison to the Reference scenario**

IALA Network in Spain is currently fully decentralised. Excessive overlapping is in some locations, so Puertos del Estado is interested in a rationalization of stations. Mobile communications coverage analysis.



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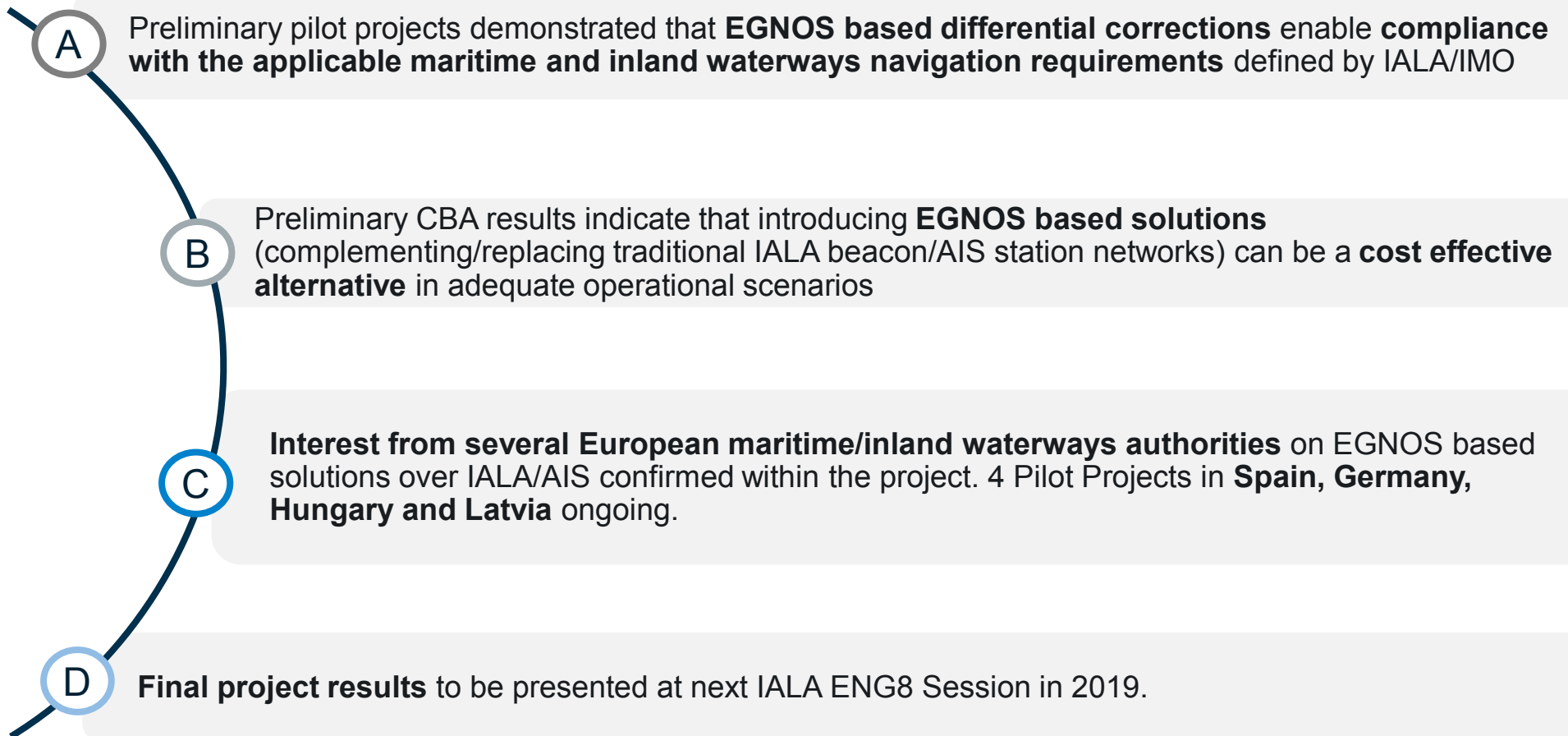
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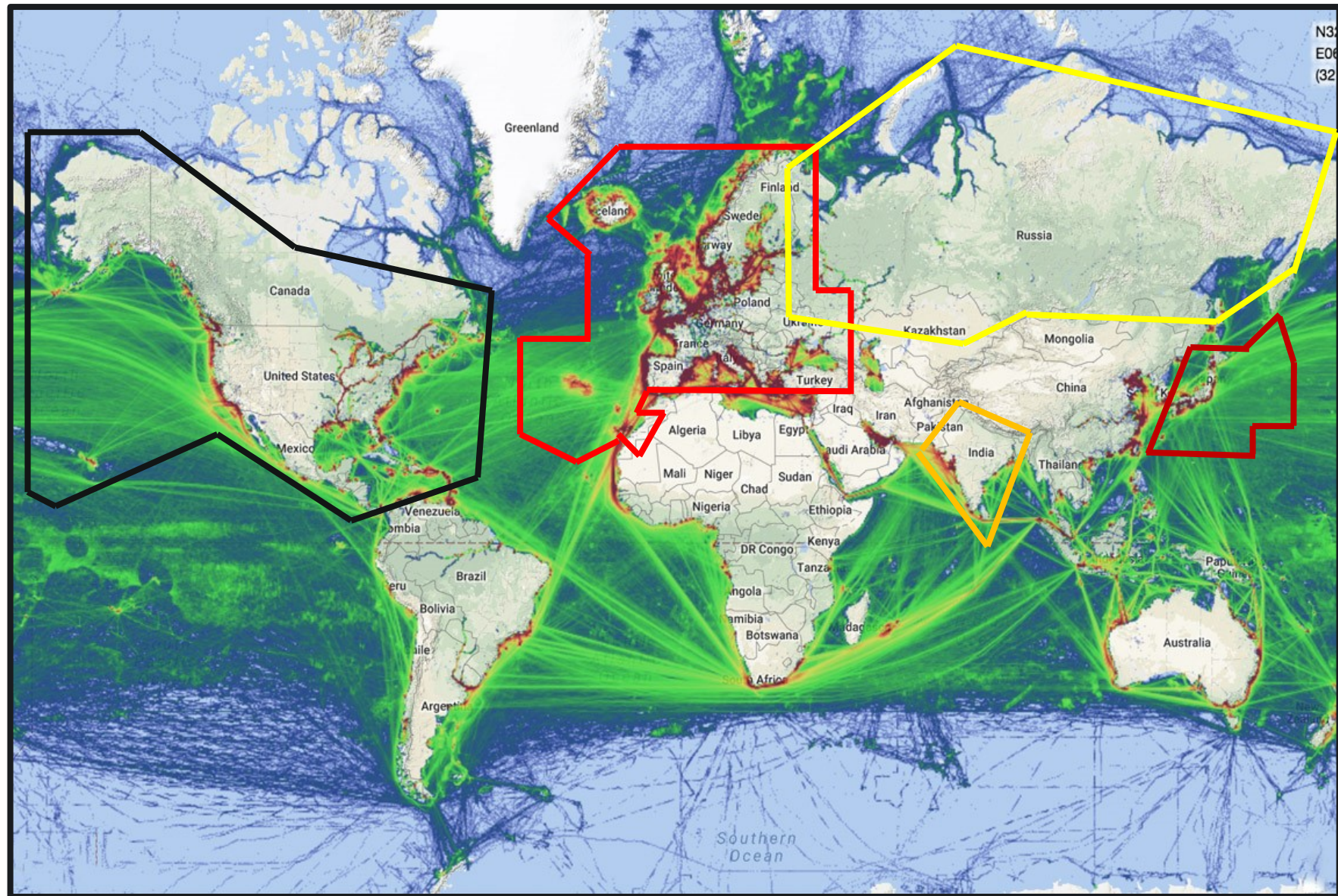
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## Preliminary conclusions (to be validated/complemented at the end of the project)



# Thank you for your attention



# Backup slides

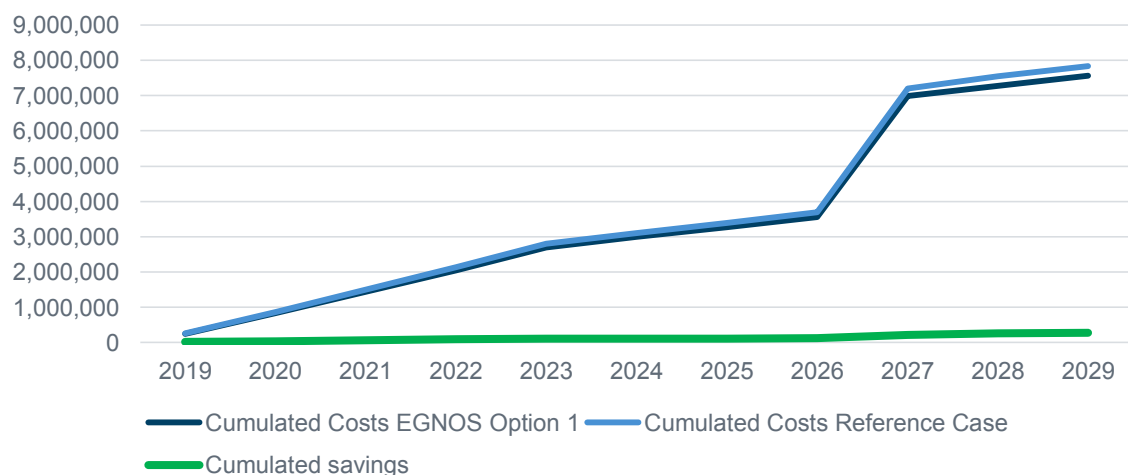


# German AIS scenario yields a reasonable NPV and a reasonable percentage of savings

## Yearly Savings (with EGNOS Option)



## Cumulated Savings (with EGNOS Option)



- EGNOS Option foresees higher savings in CAPEX (mainly IM/DRS Stations) and OPEX than the Reference Scenario

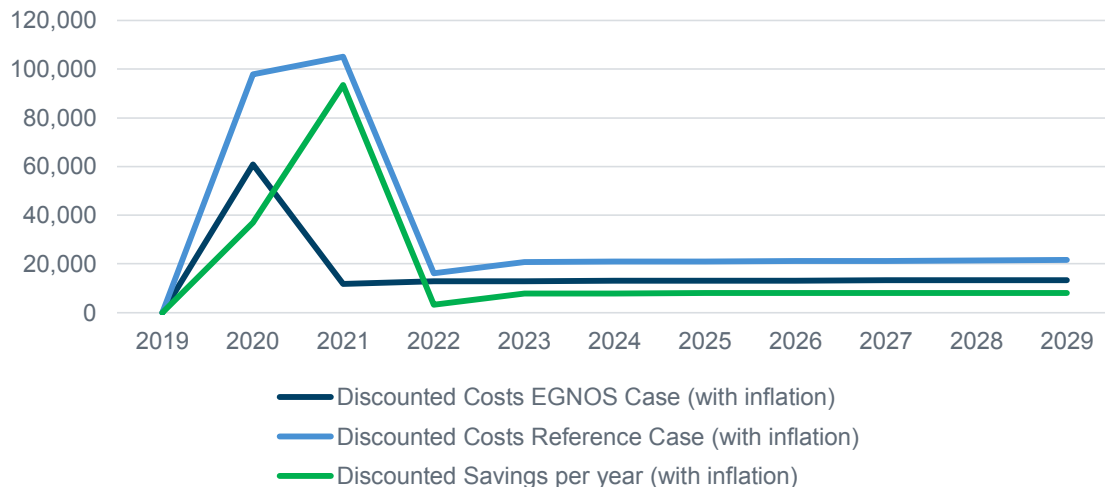
	Reference Scenario	EGNOS Option	EGNOS Option Savings
<b>Total CAPEX</b>	4.901.350	4.644.266	5%
<b>Total OPEX</b>	2.837.795	2.729.970	4%

Germany AIS CBA – Global Results of EGNOS-Based Option (Centralised)	
<b>NPV</b>	0,36 Mln €
<b>Savings percentage EGNOS Option 1 vs Reference Scenario</b>	5 %

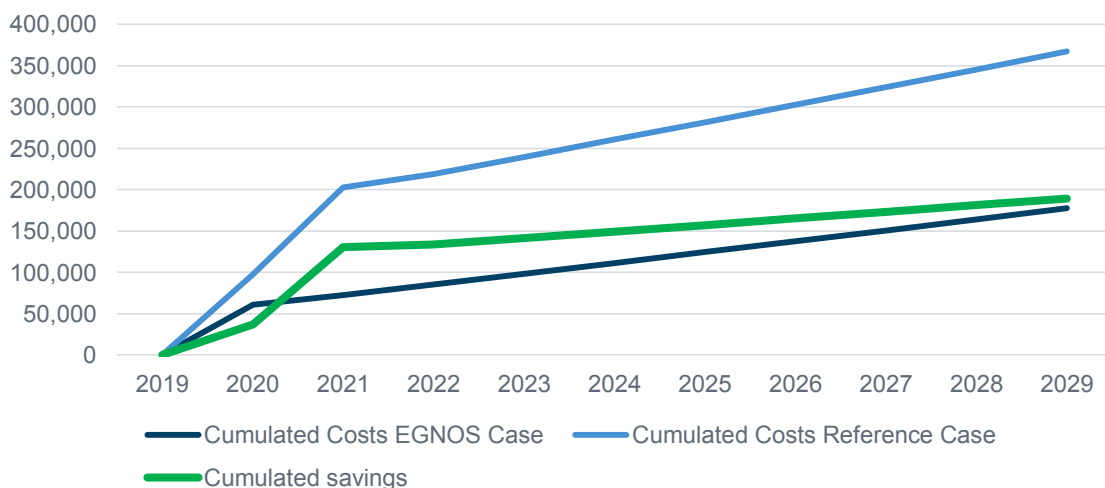
- Overall results of German scenario keeps on being promising in terms of costs savings
- An AIS centralised option could allow interesting savings in infrastructure
- EGNOS allows to reduce the number of output streams

# Latvian AIS scenario yields a high NPV and a very high percentage of savings with EGNOS centralised option

## Yearly Cash Flows



## Cumulated Savings (with EGNOS Option)



- EGNOS Option foresees high savings in CAPEX (mainly due to the evolution from a decentralised reference scenario to an EGNOS-based centralised one)
- EGNOS Option also generates savings in OPEX (mainly in Maintenance and warranty)

	Reference Scenario	EGNOS Option	EGNOS Option Savings
<b>Total CAPEX</b>	188.838	53.720	72%
<b>Total OPEX</b>	178.270	123.814	31%

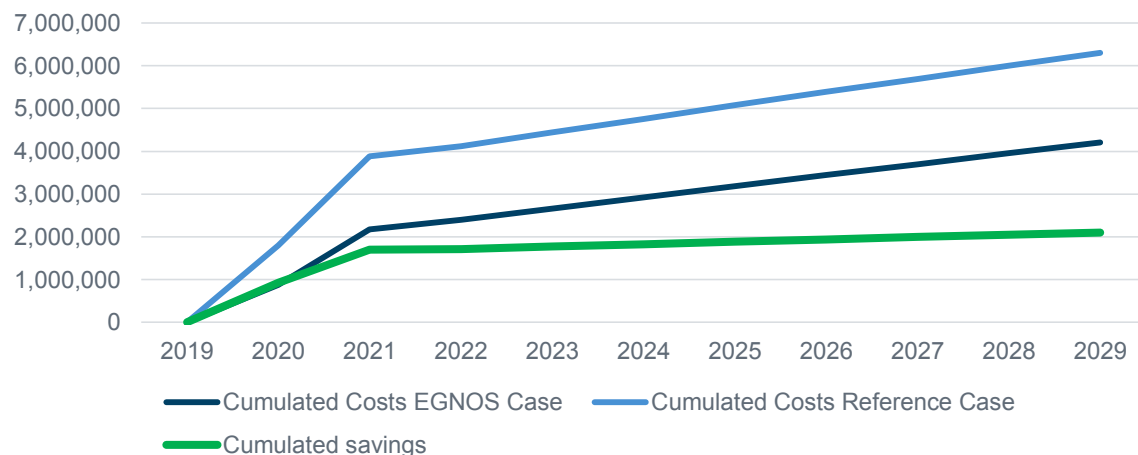
- Overall results of Latvian scenario are promising in terms of costs savings
- Latvia shows good potential for the implementation of an EGNOS-based AIS centralised Architecture:

### Latvia AIS CBA – Global Results of EGNOS-Based AIS Centralised architecture

<b>NPV</b>	190 K€
<b>Savings percentage EGNOS Option vs Reference Scenario</b>	52 %

# Spanish IALA scenario yields high NPV and high percentage of savings with EGNOS Option 1 (local DGNSS) and Option 2 (local EGNOS)

## Cumulated Savings (with EGNOS Option 1)



## Cumulated Savings (with EGNOS Option 2)



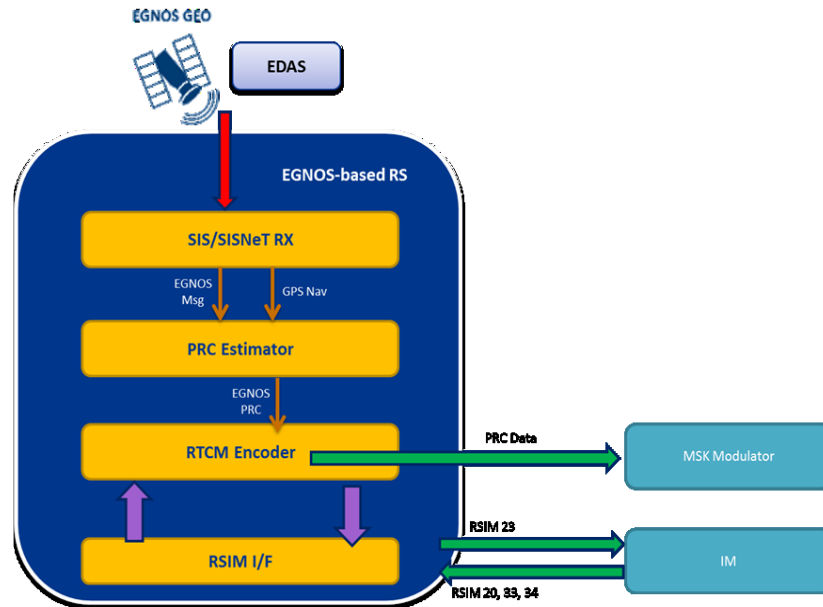
- EGNOS Options foresees high savings in CAPEX (mainly RS/IM Stations) and OPEX in comparison to the Reference Scenario

	Reference Scenario	EGNOS Option 1	EGNOS Option 1 Savings
Total CAPEX	3.656.725	1.931.086	47%
Total OPEX	2.644.993	2.262.825	14%

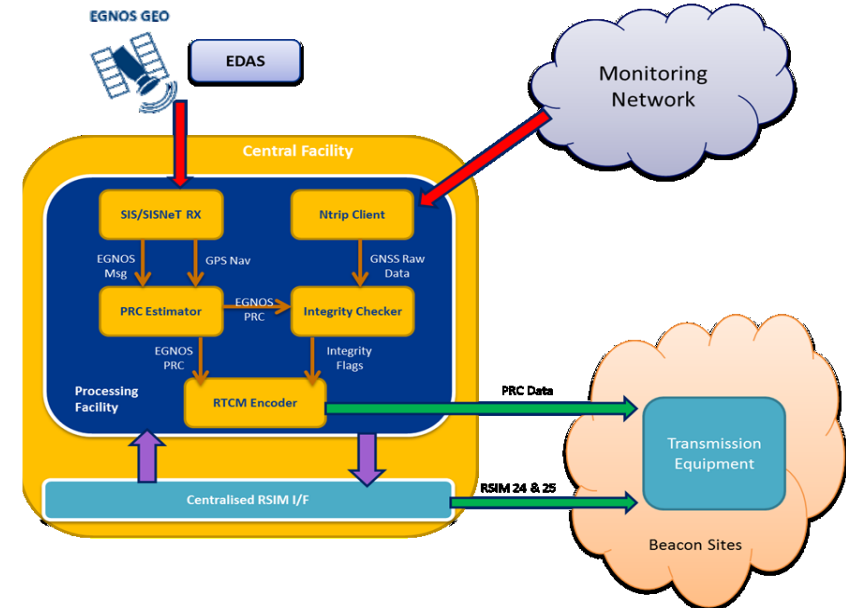
	Reference Scenario	EGNOS Option 2	EGNOS Option 2 Savings
Total CAPEX	3.656.725	1.653.226	55%
Total OPEX	2.644.993	2.167.122	18%

- Overall results of Spanish scenario are promising in terms of costs savings with a centralised solution
- CAPEX in EGNOS centralised options is far lower than in Reference Scenario, and also OPEX is reduced

Spanish IALA CBA – Global Results of EGNOS-Based Option (Hybrid Centralised)	
NPV	2,1 Mln €
Savings percentage EGNOS Option 1 vs Reference Scenario	33 %
Spanish IALA CBA – Global Results of EGNOS-Based Option (Fully EGNOS based)	
NPV	2,5 Mln €
Savings percentage EGNOS Option 2 vs Reference Scenario	39 %



# EGNOS-based RS



## EGNOS-based RS/IM

For more information on the proposed EGNOS based solutions, please refer to the IALA [\*\*Guidelines G-1129 on the Retransmission of SBAS Corrections using MF-Radiobeacon and AIS\*\*](#)



## Pilot Projects

### Performance assessment: definitions and assumptions

- **Availability (system 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 IMO Res A.1046 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.