ANALYSIS OF NAVIGATION OPERATIONS AND ELECTRONIC TOOLS IN INLAND WATERWAYS TO SUPPORT THEM

AVIS

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1.0	22/04/2024	15	Initial version prepared for Inception Meeting delivery
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TABLE OF CONTENTS

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LIST OF TABLES AND FIGURES

1. INTRODUCTION

1.1. PURPOSE

The present document is the "Analysis of navigation operations and electronic tools in inland waterways to support them" for the AVIS project. The main purpose of this document is to demonstrate the potential of EU Space data to support shipping on inland waterways in different navigation operations.

In detail, the potential of EGNSS and Copernicus in terms of operation for shipping will be explained in this document. In a further step, an assessment of the navigation operations, which have been identified and described in document D1.1 (REPORT ON THE STATE OF THE ART INCLUDING EU FUNDED PROJECTS), will be carried out. The focus on the analyse is with regard to the potential use of EU space data.

In addition, the objective is to select the most promising IWW navigation operation scenarios where EGNSS and Copernicus can potentially provide a high added value. The output of this task will be a clear description (including navigation phases, use of electronic devices, navigation parameters, expected performance, safety/security need, etc.) of AVIS IWW Navigation operational scenarios.

Furthermore, the objective is to describe how EU Space Data/services can be provided to stakeholders.

1.2. SCOPE

The present document has been organized as follows:

- Chapter 1. gives an introduction to the document, including purpose and scope of the plan.
- Chapter 2. provides the list of project applicable and reference documents.
- Chapter 3. provides the list of terms, definitions and acronyms used throughout the plan.
- Chapter 4. describes the methodology used for this document.
- Chapter 5. provides detailed information about the performance of EU Space data.
- Chapter 6. provides information about how EU space data/services can be provided to stakeholders.
- Chapter 7. selects the IWW navigation operation applicable to the project.
- Chapter 8. provides the conclusions to the document.

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2. REFERENCES

2.1. APPLICABLE DOCUMENTS

The following documents, of the exact issue shown, form part of this document to the extent specified herein. Applicable documents are those referenced in the Contract or approved by the Approval Authority. They are referenced in this document in the form [AD.X]:

Table 2-1: Applicable documents.

Ref.	Title	Code	Version	Date
[AD.1]	SERVICE CONTRACT CONTRACT NUMBER – MOVE/D3/2022-501 – MOVE/2022/OP/0029 for "Study with pilot projects on EU Space Data for automated vessels on European inland waterways"	Contract number: MOVE/D3/2022-501 – MOVE/2022/OP/0029	-	10 May 2023
[AD.2]	Study with pilot projects on EU Space Data for automated vessels on European inland waterways Tender Specifications	Call for tenders MOVE/OP/2022/0029 MOVE/D3/FV-2022-501	-	10 May 2023
[AD.3]	AVIS Technical Proposal	GMV 11852/23 V1/23	1.0	13 July 2023

2.2. REFERENCE DOCUMENTS

The following documents, although not part of this document, amplify or clarify its contents. Reference documents are those not applicable and referenced within this document. They are referenced in this document in the form [RD.X].

Table 2-2: Reference documents.

Ref.	Title	Code	Version	Date
[RD.1.]	IALA Guideline G1129 The retransmission of SBAS corrections using MF-Radio beacon and AIS		2.0	06/2022
[RD.2.]	REPORT ON THE STATE OF THE ART INCLUDING EU FUNDED PROJECTS		1.1	05/2024
[RD.3.]	Galileo - Open Service - Signal In Space Interface Control Document	Galileo OS SIS ICD	2.1	11/2023
[RD.4.]	Galileo Open Service Navigation Message Authentication - Signal In Space Interface Control Document	Galileo OSNMA SIS ICD	1.1	10/2023
[RD.5.]	Galileo High Accuracy Service Signal-In-Space Interface Control Document	Galileo HAS SIS ICD	1.0	05/2022
[RD.6.]	EGNOS - Open Service - Service Definition Document	EGNOS OS SDD	2.3	10/2017

3. TERMS, DEFINITIONS AND ABBREVIATED TERMS

3.1. DEFINITIONS

Concepts and terms used in this document and needing a definition are included in the following table:

Table 3-1 Definitions

Concept / Term	Definition

3.2. ACRONYMS

Acronyms used in this document and needing a definition are included in the following table:

Table 3-2 Acronyms

Acronym	Definition
AIS	Automatic Identification System
AVIS	Automated Vessels on European Inland Waterways
C3S	Copernicus Climate Change Service
CAMS	Copernicus Atmosphere Monitoring Service
CAS	Commercial Authentication Service
CEMS	Copernicus emergency managing services
CLMS	Copernicus Land Monitoring Service
CMEMS	Copernicus Marine Environment Monitoring Service
CSS	Copernicus Security Service
EC	European Commission
ECDIS	Electronic Chart Display and Information System
ECMWF	European Centre for Medium-Range Weather Forecasts
EDAS	EGNOS Data Access Service
EFAS	European Flood Awareness System
EGNOS	European Geostationary Navigation Overlay Service
EGNSS	European GNSS
EMSA	European Maritime Safety Agency
ESMAS	EGNOS Safety of Life Assisted Service for Maritime Users
EU	European Union
FRONTEX	European Border and Coast Guard Agency
GEO	Geostationary
GloFAS	Global Flood Awareness System
GMV	Grupo Mecánica de Vuelo
GNSS	Global Navigation Satellite System
HAS	High Accuracy Service
IALA	International Association of Lighthouse Authorities

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Acronym	Definition
IMO	International Maritime Organization
IWW	Inland Waterways
MF	Medium Frequency
OS	Open Service
OSNMA	Open Service Navigation Message Authentication
PNT	Position, Navigation und Timing
PPP	Precise Point Positioning
PRS	Public Regulated Service
RRA	Rapid risk assessment
SatCen	European Union Satellite Centre
SBAS	Space Based Augmentation System
SBAS	Satellite Based Augmentation System
SIS	Signal In Space
SoL	Safety of Life
VDES	VHF Data Exchange System
WP	Work Package

4. CONTEXT AND METHODOLOGY

4.1. INTRODUCTION

The objective of this activity will be to describe the potential of EU space data and do an assessment of the different navigation operations identified in D1.1. This assessment will show how EU space data will support the navigation on inland waterways.

4.2. METHODOLOGY

In order to do a systematic assessment of "Navigation Operations" for IWW, a stepwise methodology is used as described below and covers the time period T0 to T0+6m of the project.

4.2.1.FIRST STEP

- Describes the potential of EU space data (EGNSS, Copernicus).

4.2.2.SECOND STEP

- Defines how EU space data/services can be provided to the stakeholders.

4.2.3.THIRD STEP

- Performs an assessment on how can EU space data support the identified navigation operations and electronic tools.

4.2.4.FINAL STEP

- Select those navigation operation which a relevant for the project.

5. EU SPACE DATA

5.1. EU SPACE DATA RELEVANT FOR IWW

The European Union (EU) has made significant strides in utilizing space-based data for a wide range of applications, from navigation and positioning to environmental monitoring and disaster management. This chapter aims to provide an overview of two key components of EU space data initiatives: the European Global Navigation Satellite Systems (EGNSS) and the Copernicus program.

From a general point of view, the main mandate for the evolution of the European PNT systems is to maximize the socio-economic benefits of these systems. One of the key issues to ensure a favorable reception from the user communities of the PNT technology and its evolutions is to provide a clear added value.

On the other hand, Copernicus is the European system for monitoring the Earth. Copernicus delivers useful data and information for EU policies for agriculture, environment, development and humanitarian aid, energy or coastal surveillance, smart cities, climate change adaptation, transport, border security and many other fields, including the IT sector, culture, and education. A key issue is then to identify Copernicus services that can provide added value to IWW.

5.1.1. EGNSS

EGNSS is the European Union's satellite navigation program, designed to provide accurate positioning, navigation, and timing (PNT) services to users in Europe and beyond. At the core of EGNSS are two systems: Galileo and EGNOS (European Geostationary Navigation Overlay Service).

- Galileo

  The Galileo programme is aiming at developing and operating the first global satellite navigation and positioning infrastructure specifically designed for civilian purposes. The Galileo system, once fully operational, will offer six high-performance services worldwide:

  - Open Service (OS): Galileo open and free of charge service set up for positioning and timing services. In the future, the Galileo Open Service will also provide Navigation Message Authentication, which will allow the computation of the user position using authenticated data extracted from the navigation message.
  - Open Service Navigation Message Authentication (OSNMA): Free access service complementing the OS by delivering authenticated data, assuring users that the received Galileo navigation message is coming from the system itself and has not been modified.
  - High Accuracy Service (HAS): A service complementing the OS by providing an additional navigation signal and added-value services in a different frequency band. The HAS signal can be encrypted in order to control the access to the Galileo HAS services.
  - Public Regulated Service (PRS): Service restricted to government-authorised users, for sensitive applications that require a high level of service continuity.
  - Commercial Authentication Service (CAS): A service complementing the OS, providing a controlled access and authentication function to users.

- EGNOS

  EGNOS system is aiming at improving the quality of signals from existing global navigation satellite systems over a service area which covers all the EU. The European Geostationary Navigation Overlay Service (EGNOS) consists of three core services:

  - Open Service: free and open to the public, the Open Service is used by mass-market receivers and common user applications.
  - EGNOS Data Access Service (EDAS): The EGNOS Data Access Service (EDAS) offers ground-based access to EGNOS data through the Internet on a controlled access basis.

- Safety of Life Service (SoL): for safety-critical transport applications, including civil aviation, which require enhanced and guaranteed performance and an integrity warning system.

A new maritime service based on SBAS L1 with integrity provided by EGNOS in line with IMO 1046(27) is recently launched called EGNOS Safety of Life Assisted Service for Maritime Users (ESMAS).

5.1.2.COPERNICUS

Copernicus is the EU's Earth observation program, aimed at providing timely and reliable information for environmental monitoring, climate change analysis, emergency management, and other societal benefits. It consists of a constellation of satellites, as well as ground-based and airborne sensors, data processing facilities, and services.

The Copernicus program is a component of the EU Space program providing information and services from satellite and in-situ data, offering inter-country comparable data for regulatory monitoring and reporting, which can be further explored in the environmental policy field. It is one of the world largest satellite Earth Observation systems and in 2016 Copernicus was already identified as a tool that could provide data for the purpose of environmental policy, and consequently reducing the burden of reporting. At the core of Copernicus program is the Sentinel satellites, namely,

Sentinel-1: This mission consists of two satellites, Sentinel-1A and Sentinel-1B (currently non-operational), equipped with radar imaging capabilities. They provide all-weather, day-and-night radar imagery for land and ocean services, supporting applications such as monitoring sea ice, oil spills, and land surface movements.

Sentinel-2: This mission includes Sentinel-2A and Sentinel-2B, which carry high-resolution optical imaging instruments. They are designed for land monitoring, providing data on vegetation, soil, water cover, inland waterways, and coastal areas. The satellites offer a high revisit frequency, capturing images every five days at the equator

Sentinel-3: This mission focuses on marine and land services, providing high-accuracy optical, radar, and altimetry data. It measures variables such as sea-surface topography, sea- and land-surface temperature, and ocean and land color with high-end accuracy and reliability

Sentinel-5: This mission focuses on atmospheric composition monitoring but operates in a low Earth orbit. It provides data on air pollution, including ozone, nitrogen dioxide, and other trace gases.

Additionally, Copernicus services also includes an in-situ component which collects data acquired by a multitude of sensors at air-, sea- and ground-level. At the moment there are six different Copernicus services as described below,

- The Copernicus Atmosphere Monitoring Service (CAMS) continuously monitors the composition of the Earth’s atmosphere at global and regional scales and delivers accurate and reliable information related to air pollution and health, solar energy, greenhouse gases and climate forcing. ECMWF implements CAMS Under the Delegation Agreement with the European Commission.
- The Copernicus Marine Environment Monitoring Service (CMEMS) provides regular and systematic reference information on the physical and biogeochemical state, variability and dynamics of the ocean and marine ecosystems for the global ocean and the European regional seas. Mercator Ocean International was selected by the European Commission to implement CMEMS.
- The Copernicus Land Monitoring Service (CLMS) delivers geographical and environmental information on land cover which includes land cover characteristics and changes, land use, vegetation state, water cycle and earth surface energy variables. The CLMS has been jointly implemented by the European Commission and the European Environment Agency.

- The Copernicus Climate Change Service (C3S) provides authoritative information about the past, present and future climate, as well as tools to enable climate change mitigation and adaptation strategies by policy makers and businesses. C3S is being implemented by the European Centre for Medium-range Weather Forecasts on behalf of the European Commission.
- The Copernicus Emergency Management Service (CEMS) delivers on-demand geospatial information for emergency situations that arise from natural or man-made disasters anywhere in the world, and provides early warning information for floods, wildfires and droughts. The CEMS has been implemented by the European Commission.
- The Copernicus Security Service (CSS) delivers information which helps the European Union to improve crisis prevention, preparedness and response and to face the security related challenges in the areas of maritime surveillance, border surveillance and support to EU external action. The European Commission has entrusted European Maritime Safety Agency (EMSA), European Border and Coast Guard Agency (FRONTEX) and EU SatCen with the different components of the CSS.

5.1.3.SUMMARY

Both EGNSS and Copernicus play crucial roles in various sectors, offering synergies and complementing each other's capabilities:

- Navigation and Positioning: EGNSS provides precise positioning and timing information for navigation and transportation applications, while Copernicus contributes to route optimization, maritime safety, and infrastructure monitoring through its Earth observation data.
- Emergency Management: Copernicus enables rapid response to natural disasters, providing real-time imagery and situational awareness, while EGNSS supports search and rescue operations with accurate location information.
- Environmental Monitoring: Copernicus offers comprehensive data on environmental parameters, supporting ecosystem management, climate change mitigation, and pollution monitoring, while EGNSS facilitates field data collection and monitoring activities through precise geolocation.

6. EU SPACE DATA/SERVICES PROVIDED TO STAKEHOLDERS

The objective of this activity is to define the way in which the EU Space data/services related to Galileo, EGNOS & Copernicus could be provided to authorities and skippers (Figure 6-1), including the electronic equipment to receive and display the above-mentioned information. As part of the task, the operational concept for data exchanges will be defined in this chapter.

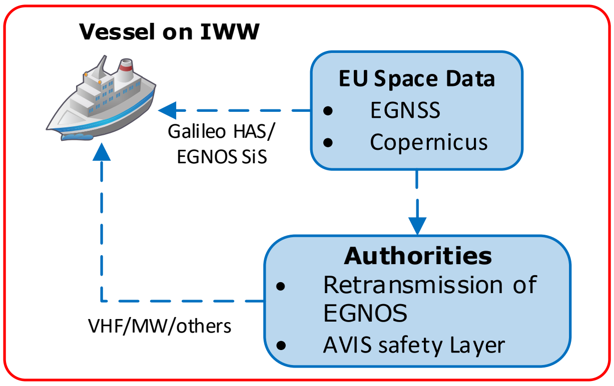

Figure 6-1 Schematic overview transmission of EU Space data

6.1. DATA PROVIDERS IDENTIFICATION

In order to implement the AVIS solution it will be necessary for all data and services to reach all stakeholders involved in inland waterways navigation. To properly assess this need, it is first necessary to identify who the data and service providers are. In a first analysis, two main sources of data and services provision can be identified. On the one hand we have the EU Space data that are provided directly through the signal in space, or the frameworks provided by EU. On the other hand, EU Space data can also be provided through the various inland waterway authorities.

Continuing with the analysis, two types of recipients of EU Space data are also identified, the skippers and the authorities. At the same time, skippers can receive data both from the signal in space, that reaches them directly, and from the authorities, through an infrastructure set up to communicate with them. In the case of authorities, they are expected to receive data and services directly from the signal in space or from the platforms provided by the EU.

These data and services can be from both EGNSS and Copernicus. In Annex I there are more details about the type of information and characteristics of this data.

All of these concepts are summarized and listed in Table 6-1. In the table you can see that EGNSS and Copernicus data that comes directly to skippers and authorities. You can also see the data provided by the authorities to the skippers.

Table 6-1 Data providers schema

		EU Space data provided directly	EU Space data provided through Authorities
Skippers	EGNSS	• Galileo OS • Galileo OSNMA • Galileo HAS E6 • EGNOS SiS / ESMAS	• Differential corrections based on EGNOS / ESMAS • Inputs for NtS
	Copernicus	• Not expected	• Alarms/Alerts[1] • Safety layer maps[1]
Authorities	EGNSS	• Galileo OS • Galileo OSNMA • Galileo HAS E6 • EGNOS SiS / ESMAS	• N/A
	Copernicus	• Datasets[1]	• N/A

[1] in case the AVIS solution is based on Authorities responsibility, point to be reviewed at a later stage in the WP1400

6.2. DATA PROVISON DETAILS

Once the data providers and recipients have been identified, the details of the communications are analyzed. The most particular details will be developed to be aligned with the developments of the CONOPS studied in WP 1400. However, at this stage, a first analysis of important aspects can be carried out such as:

- How the EU Space data is provided. Examples could be Signal in space, MF AIS/VDES type communications, access through the internet in the cloud, etc.
- Where the responsibility and control of data provision lies.
- Technical aspects of data and communications. Aspects such as interfaces/format (for example the ICD), access control/security, access frequency, etc. are covered here.

Table 6-2 shows a summary of all these aspects for each of the EGNSS and Copernicus data typologies identified.

Table 6-2 Summary of data provision details

		How is provided?		Responsibility and Control	Technical aspects
		To Skippers	To authorities		
EGNSS	Galileo OS	SiS	SiS	EUSPA	As specified in Galileo OS ICD [RD.3.]
	Galileo OSNMA	SiS	SiS	EUSPA	As specified in Galileo OSNMA ICD [RD.4.]
	Galileo HAS E6[3]	SiS	SiS	EUSPA	As specified in Galileo HAS ICD [RD.5.]
	EGNOS SiS /ESMAS	SiS	SiS	EUSPA	As specified in EGNOS OS SDD [RD.6.]
	Differential corrections based on EGNOS / ESMAS	• MF[2] • AIS/VDES[2] • others	N/A (Provided by authorities)	Authorities	Details are provided in Annex I[2]
Copernicus	Datasets	N/A	Internet/Cloud	EUSPA	Defined in Copernicus.eu
	Alarms/Alerts	As will be defined in AVIS solution[1]	N/A (Provided by authorities[1])	Authorities[1]	As will be defined in AVIS solution[1]
	Safety layer maps	As will be defined in AVIS solution[1]	N/A (Provided by authorities[1])	Authorities[1]	As will be defined in AVIS solution[1]

[1] in case the AVIS solution is based on Authorities responsibility, point to be reviewed at a later stage in the WP1400

[2] Appendix I describes the retransmission of SBAS data.

[3] IALA is currently developing a guideline that addresses the topic: GNSS SATELLITE-BASED PRECISE POINT POSITIONING (PPP) MARITIME SERVICE. The guideline provides the description of all the elements of GNSS satellite-based PPP service relevant to the maritime administrations (direct reception of GNSS satellite-based PPP service Signal in Space (SiS) onboard the vessels. The Guideline to be developed is mainly based on the already published Guideline G1127 SYSTEMS AND SERVICES FOR HIGH-ACCURACY POSITIONING AND RANGING.

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7. SELECTION OF IWW OPERATIONAL NAVIGATION

7.1. ASSESSMENT OF RELEVANT AVIS NAVIGATION OPERATIONS REGARDING THE USE OF EU SPACE DATA

Next step is to identify from the IWW Navigation Operational scenarios identified in D1.1., the potential uses of EGNSS and Copernicus (EU Space data) to enhance the operations.

All navigation operations identified in deliverable D1.1 have been analyzed from the point of view of the potential that EGNSS and Copernicus services can provide. This analysis focuses on both the characteristics of the operation and the safety parameters reflected in D1.1. Please Note that the key parameters have been used in the assessment and therefore used for the selection of navigation IWW operations.

7.1.1. EGNSS ASSESSMENT

7.1.1.1. GALILEO OS

Regarding the potential analysis, Galileo OS is considered to have potential in all operations. Currently, GNSS is a primary technology for navigation and is expected to remain essential in the future of inland waterways operations.

7.1.1.2. GALILEO OSNMA AND CAS

In order to face the challenges that cyberattacks imply, it is considered the Galileo OSNMA service and the future Galileo CAS. OSNMA allows the navigation message to be authenticated to ensure that it is the one provided by the Galileo system without having been modified. CAS will complement OSNMA by providing a service with range authentication capabilities. With this, we see that with OSNMA a first level of resilience is achieved and by adding CAS a higher level of protection against cyber-attacks can be reached.

With this, based on the security levels required in the navigation operations, it is identified that those navigation operations that require medium security OSNMA would have the potential to contribute to that security. In the event that there is a high security requirement, it is considered that CAS can provide that extra potential to pursue high levels of security.

Taking this criterion into account, for each of the navigation operations, we identify whether OSNMA or CAS have the potential to contribute to the navigation operation. Table 7-1 shows all IWW operations along with OSNMA and CAS potential. An “X” is marked with those navigation operations where a potential added value of using the services is identified. In any case, there are other navigation operations in which a potential differential is not identified but which, nevertheless, could be used. In these cases where it could be used but no potential improvement is introduced for the operation it is identified in the table as “.”, leaving the blanks for those operations where it would not be able to provide added value.

In this case, we see how in all navigation operations it can always be interesting to use measures that increase security. If the measures do not imply an additional cost or consideration, it is preferable to use them as far as possible.

Table 7-1 Potential added value of Galileo OSNMA and CAS for IWW operations

	Identified Security need [RD.2.]	Galileo Services	
		OSNMA	CAS
AIS Navigation, short term ahead	H	X	X
AIS Navigation, medium term ahead	H	X	X
ECDIS Navigation, Information Modus	L	.	.
ECDIS Navigation, Navigation Modus	H	X	X
Track Guidance Assistants in Inland Navigation	H	X	X
Remote shipping	H	X	X
General navigation on free-flowing rivers	H	X	X
Navigation on small narrow channels	H	X	X
Congestion controlled rivers and canals	H	X	X
Bridge passing	M	X	.
Mooring/berthing	M	X	.
Lock manoeuvre	M	X	.
Urban areas with a high number of bridges, …	M	X	.
Environmental consideration dif. weather con., …	M	X	.
Overtaking	L	.	.
Turning	L	.	.
Stopping	L	.	.
Harbor manoeuvre	L	.	.

7.1.1.3. GALILEO HAS SPP AND PPP

The Galileo High Accuracy Service (HAS) is designed to provide a high-precision PPP service globally and directly through the signal in space. However, the corrections provided by the system can also be applied to a simpler positioning algorithm such as Single Point Positioning (SPP), also improving the performance of the receiver. Therefore, in terms of using the Galileo HAS service, there are two options identified at user level:

- HAS SPP, which improves the accuracy performance compared to using the receiver without any correction. With this technique, it is expected that the accuracy obtained will be slightly less than 1m in the multi-frequency multi-constellation case.
- HAS PPP, which allows to obtain the maximum accuracy offered by HAS Service. In this case, the maximum expected accuracy levels would be in the order of decimetres.

Taking this into account, the navigation operations can be analyzed in terms of accuracy needs to assess where this Galileo service has the potential to add value. It must be taken into account that the service could be applied to any operation, since corrections are provided in real time through the signal in space. However, for operations that do not have a need for high accuracy, it would not be interesting to devote more effort to applying these techniques when the receiver itself already easily meets these accuracy needs, maximizing the “value for money”.

Table 7-2 shows those navigation operations where the potential use of HAS SPP and HAS PPP is identified. It is marked with an "X" where it is considered that there is potential for use and with "." where it could be applied but would not provide more added value.

Note: Accuracy requirements will be discussed in more detail in WP2000. This first identification has been made to facilitate GNSS and Copernicus assessment.

Table 7-2 Potential added value of Galileo HAS SPP and HAS PPP for IWW operations

	Identified position accuracy [RD.2.]		Galileo Services	
	Horizontal	Vertical	HAS SPP	HAS PPP
AIS Navigation, short term ahead	B	-	.	.
AIS Navigation, medium term ahead	A	-	.	.
ECDIS Navigation, Information Modus	A	-	.	.
ECDIS Navigation, Navigation Modus	B-C	-	X	.
Track Guidance Assistants in Inland Navigation	B-C	-	X	.
Remote shipping	B-C	-	X	.
General navigation on free-flowing rivers	B-C	-	X	.
Navigation on small narrow channels	C	-	X	.
Congestion controlled rivers and canals	B-C	-	X	.
Bridge passing	D	D		X
Mooring/berthing	D	-		X
Lock manoeuvre	D	-		X
Urban areas with a high number of bridges, …	B-C	-	X	.
Environmental consideration dif. weather con., …	B-C	-	X	.
Overtaking	D	-		X
Turning	B-C	-	X	.
Stopping	B-C-D	-	X	.
Harbor manoeuvre	B-C-D	D	X	.

From this analysis it is seen that for many navigation operations, the range of accuracy needed may vary. Therefore, there are many navigation operations in which HAS can provide potential for improvement when these operations require the greatest accuracy. Following the accuracy levels criterion in Table 7-3, the HAS service begins to have potential for use when the accuracy level of the operation is B.3 - B.4. or more demanding. We see how the approach of using HAS SPP can already provide potential to a large number of inland navigation operations, and for those where it is not possible, HAS PPP can contribute to improving operations.

Table 7-3 Accuracy levels definition from MSC.1575

Acc.	A	A.1	A.2	A.3	A.4	B	B.1	B.2	B.3	B.4	C	C.1	C.2	C.3	C.4	D	D.1
m.	100	50	35	25	15	10	5	3.5	2.5	1.5	1	0.5	0.35	0.25	0.15	0.1	0.05

7.1.1.4. EGNOS / ESMAS / USER INTEGRITY

There are a variety of EGNOS services that provide augmentation services to improve the accuracy and integrity of operations. At the level of this analysis, we include these services in:

- EGNOS OS, as EGNOS services in general provided by satellites,
- EDAS, to highlight the differential element of being a ground-based service and,

- ESMAS, since being a service adapted to maritime it is interesting assess in more detail whether it may also have interest in inland navigation operations.

Furthermore, another trend in the use of SBAS systems is to combine them with some integrity solution at the receiver level to improve overall integrity performance.

At the level of integrity needs, it is seen that all navigation operations have a high need for integrity. In that sense, having EGNOS services in general and EGNOS + integrity at the receiver level is always interesting.

Combining this analysis with the analysis of accuracy needed in navigation operations, the identification of potential expressed in Table 7-4 is obtained.

Table 7-4 Potential added value of EGNOS and EGNOS + user Integrity for IWW operations

	Identified Integrity Level [RD.2.]	EGNOS V2 Services			Combination
		EGNOS OS	EDAS	ESMAS	Protection level (user Integrity Alg. + SBAS)
AIS Navigation, short term ahead	H	.		X	X
AIS Navigation, medium term ahead	-	.		X	X
ECDIS Navigation, Information Modus	-	.		X	
ECDIS Navigation, Navigation Modus	H	X	~	X	X
Track Guidance Assistants in Inland Navigation	H	X	~	X	X
Remote shipping	H	X	~	X	X
General navigation on free-flowing rivers	H	X	~	X	X
Navigation on small narrow channels	H				X
Congestion controlled rivers and canals	H	X	~	X	X
Bridge passing	H				X
Mooring/berthing	H				X
Lock manoeuvre	H				X
Urban areas with a high number of bridges, …	H		X		X
Environmental consideration dif. weather con., …	H	X	~	X	X
Overtaking	H				X
Turning	H	X	~	X	X
Stopping	H			X	X
Harbor manoeuvre	H				X

At the accuracy perspective, it is seen that the augmentation with EGNOS does not allow us to achieve accuracy values as high as those obtained with HAS SPP. One of the characteristics of EGNOS OS is that there are few satellites, so in areas where visibility is compromised, these services could not provide great potential. To overcome this problem, it can be count on infrastructure on ground. For example, it is seen how in urban areas with many bridges and buildings, EDAS would play a differential role. Regarding other operations, EDAS could provide potential, but only in those areas where the necessary infrastructure is in place. Therefore, in the Table 7-4, the symbol "~" has been used to indicate that it has partial potential in the areas where there would be coverage.

As we see, at the integrity level, the solution that combines EGNOS with a user-level algorithm provides potential in practically all navigation operations, since they all have a high demand for integrity. However, in some navigation operations that demand a lot of integrity, such as locks or moorings, this solution would not be sufficient to meet the needs and would have to be combined with other sensors.

7.1.1.5. FINAL ASSESSMENT

Putting together all the analyses made in the previous sections, the overall potential offered by EGNSS services for each IWW navigation operation is assessed. Table 7-5 shows the result where "H" stands for high potential, "M" for medium potential and "L" for low potential.

Table 7-5 Potential added value of EGNSS for IWW operations

	Total Score (H, M & L)
AIS Navigation, short term ahead	M
AIS Navigation, medium term ahead	M
ECDIS Navigation, Information Modus	L
ECDIS Navigation, Navigation Modus	H
Track Guidance Assistants in Inland Navigation	H
Remote shipping	H
General navigation on free-flowing rivers	H
Navigation on small narrow channels	H
Congestion controlled rivers and canals	H
Bridge passing	M
Mooring/berthing	M
Lock manoeuvre	M
Urban areas with a high number of bridges, …	H
Environmental consideration dif. weather con., …	M
Overtaking	L
Turning	M
Stopping	L
Harbor manoeuvre	L

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7.1.2.COPERNICUS ASSESSMENT

Regarding the potential analysis, Copernicus is considered to have potential support in some navigation operations. Currently, Copernicus is a new technology for navigation and is expected to play an important role in the future of inland waterways navigation operations.

In the next sections, potential services that could support the identified navigation operations will be presented. It has been divided into two main components. The services already available from the Copernicus platform, mentioned in section 5.1.2, and the ad hoc services, the latter personalized services.

The first are services already developed on the Copernicus platform. The advantages to highlight of these services would be the easy access to the dataset, many of them as open datasets, and the readiness of a valuable data. On the other hand, many of these services do not fit at all for AVIS objectives, either due to the domain in which have been developed or because the internal characteristics of these datasets escape the performance required to support autonomous navigation.

The ad hoc services are referred to particular solutions to be developed based on inputs from Sentinel1 and Sentinel2 satellites from Sentinel hub and Google Earth engine. Those solutions are customizable to the end user aiming to support automated navigation operations. Most of the ad hoc services are presented as auxiliary information that can be valuable in supporting IWW navigation operations.

Below, the services that can potentially add value are listed, presented along with a description of each service and the possible potential use for each operation.

- Copernicus Platform Services: In particular, CMEMS, CLMS, C3S, CEMS.
- Ad Hoc Services:
  - River Edge
  - River depth
  - Quality indicators for ad hoc services

7.1.2.1. COPERNICUS PLATFORM SERVICES

Below are some of the candidate services that could be interesting for supporting identified navigation operations. A short description of each associated service and the idea of how it might be of interest is presented.

7.1.2.1.1. THE COPERNICUS MARINE ENVIRONMENT MONITORING SERVICE (CMEMS)

In particular, Copernicus Marine Service In-situ Ocean TAC is the component of Copernicus Marine Environment Monitoring Service which ensures a consistent and reliable access to a range of in situ data for the purpose of service production and validation.

The CMEMS in situ data are considered in terms of buoys availability in the existing CMEMS dataset. The following dataset has been identified as potentially interesting for AVIS based on analysis and interpretation of the available data:

- Provision of tidal data, river outflow data. https://marineinsitu.eu/dashboard/

Products in the current CMEMS catalogue are organized in terms of both multi-year and near real time model and observation (including satellite) products.

7.1.2.1.2. COPERNICUS LAND MONITORING SERVICES (CLMS)

For this particular case, a set of interesting data have been identified as potentially interesting for AVIS relating to the extraction of water bodies present in inland, lakes and rivers. Among others, there are global datasets following the next description:

- The Water product group provides information about the surface extent covered by water on a permanent basis, lake water quality, the water level of lakes and rivers and ice occurrences in the hydrographic network. The products at global scale are as continuous time series available in low to medium resolution and at pan-European level they are provided at high resolution. https://land.copernicus.eu/en/products/water-bodies
- Defined as the height, in meters above the geoid, of the reflecting surface of continental water bodies. It is observed by space radar altimeters that measure the time it takes for radar pulses to reach the ground targets, directly below the spacecraft (nadir position), and return (Sentinel3 – Sentinel6). The data at global scale are available in near real time in vector format and with the temporal extent from 2002 to present. https://land.copernicus.eu/api/en/products/water-bodies/water-level-rivers-near-real-time-v2.0

7.1.2.1.3. COPERNICUS CLIMATE CHANGE SERVICE (C3S)

Historical and forecasted of river discharge data can be found in the Copernicus Climate Data Hub. Next datasets were identified as potentially interesting for AVIS:

- River discharge and related forecasted data by the Global Flood Awareness System. This dataset provides an ensemble of forecast time series of gridded hydrological data. The data set is a product of the Global Flood Awareness System (GloFAS) and offers a consistent representation of key hydrological variables across the global domain including:
  - River discharge
  - Soil wetness index (root zone)
  - Snow water equivalent
  - Runoff water equivalent (surface plus subsurface)

  https://cds.climate.copernicus.eu/cdsapp#!/dataset/cems-glofas-forecast?tab=overview

- River discharge and related forecasted data by the European Flood Awareness System. This dataset provides gridded modelled hydrological time series forced with medium-range meteorological forecasts. The data is a consistent representation of the most important hydrological variables across the European Flood Awareness System (EFAS) domain. The temporal resolution is sub-daily high-resolution and ensemble forecasts of:
  - River discharge
  - Snow water equivalent
  - Volumetric soil moisture for three soil layers

  https://cds.climate.copernicus.eu/cdsapp#!/dataset/efas-forecast?tab=overview

7.1.2.1.4. COPERNICUS EMERGENCY MANAGING SERVICES (CEMS)

EFAS/GloFAS contains floods real time forecasts data and it is identified as potentially interesting for AVIS. The EFAS archive contains the operational output of EFAS as well as the historical simulations. The real-time EFAS forecasts are restricted to the EFAS partners, all data that is older than 30 days is open access.

In particular, the rapid risk assessment (RRA) product aims to provide emergency response actors daily updates of predicted flood impacts on population, sensitive infrastructures and urban areas. The procedure combines GloFAS flood forecasts with event-based rapid flood mapping, translating the predicted river flows into explicit flood maps.

https://global-flood.emergency.copernicus.eu/technical-information/glousers-feedbackas-impact-forecasts/

7.1.2.1.5. POTENTIAL ADDED VALUE OF COPERNICUS PLATFORM SERVICES AND IWW NAVIGATION OPERATIONS

In order to face the challenges that autonomous driven vessels imply, it is considered the Copernicus platform services.

With this, based on the supporting levels required in navigation operations, it is identified as potentially interesting for AVIS that those Copernicus platform services as CMEMS, CLMS, C3S, CEMS could have the potential to contribute to that support.

Taking this criterion into account, for each of the navigation operations, we identify particularly whether CMEMS, CLMS, C3S, or CEMS have the potential to contribute to the operations. Next Table shows all vessel operations considered along with the Copernicus platform services that can be a potential candidates to support those navigation operations. An "X" is marked with those navigation operations where a potential added value of using the services is identified. Then, leaving the blanks for those operations where it would not be able to provide added value.

In general, Copernicus data will serve as a support measure for the activities mentioned below. All operations related to ship maneuvers require an immediate response in the short and medium terms. For this reason, it is considered that Copernicus information and the final results derivate from those services mentioned should be treated as complementary information, such as support measures. It is important to highlight that **the analytics and the results would not meet the user need for a rapid response (since the river dynamics usually changes faster than the dataset update rate), and as it is mentioned, the information should be considered as complementary data**, but still data will be valuable in the sense of planning. Furthermore, most of these mentioned products of the Copernicus product are global products, where the service or product has been resampled to a much lower spatial resolution, so they should contain a greater amount of uncertainty.

In the case of CMEMS, where in situ data will be available, estimates of changes in tide level and river current flow can be made. Measurements of anomalies can be established or changes can be measured from some threshold. This service can provide a measure of support for the maneuvers indicated in the next table. In situ data could be as well used to evaluate ad-hoc services output proposed in the coming phases.

CLMS contains an interesting product about the surface extent covered by water, in particular it can extract bodies of water where possible increases or decreases in the water level can be derived from this mask. The precision offered still needs to be estimated, since it is a product derived from the analysis of multiple temporal images, and it is denoted as "surface extent covered by water on a permanent basis" and perhaps it can serve as a reference to subsequently create a water level change detection capability.

On the other hand, it also contains a product that, thanks to Sentinel 6 sensors, is capable of measuring the height of the water with respect to the geoid from radar pulses. It is also worth mentioning that these data are only available for small areas of interest, and the availability, frequency and spatial resolution of this product should be assessed.

The interesting product about C3S service is that it offers historical and future information on the discharge of the river flow, which is in particular, the forecasted data the one that could be very

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interesting for the future maneuver plan. Data should be reviewed in the same line than the rest of the services.

Finally, CEMS services provides flood real-time forecast. Floods services could help to determine and condition the planned activities for the autonomous vessel operations.

Table 7-6 Potential added value of Copernicus platform services and IWW navigation operations

	CMEMS	CLMS	C3S	CEMS
AIS Navigation, short term ahead				
AIS Navigation, medium term ahead				
ECDIS Navigation, Information Modus			X	X
ECDIS Navigation, Navigation Modus				
Track Guidance Assistants in Inland Navigation	X	X	X	X
Remote shipping	X	X	X	X
General navigation on free-flowing rivers	X	X		
Navigation on small narrow channels	X	X		
Congestion controlled rivers and canals	X	X		
Bridge passing	X	X		
Mooring/berthing	X	X		
Lock manoeuvre	X	X		
Urban areas with a high number of bridges, …				
Environmental consideration dif. weather con., …	X	X	X	X
Overtaking				
Turning				
Stopping				
Harbor manoeuvre				

7.1.2.2. AD HOC SERVICES

The ad hoc services are referred to particular solutions to be developed based on inputs from Sentinel1-Sentinel2 satellites.

This section is divided into two types of products proposed for development. With the aim on the one hand of resolving lacks of the existing data sets on the Copernicus platform services, either because there is not sufficient spatial or temporal resolution to support autonomous navigation. And with the objective of assessing new possible capabilities derived from Copernicus data.

The main strategy is to use sentinel 1 and 2 data to increase the frequency of data available in the areas of interest, with the spatial resolution originally provided by satellite sensors (https://scihub.copernicus.eu/). Next services are proposed:

Main services, which will be the derived layers of information that could provide more support:

- River Edge
- River Depth/Bathymetry
- Water speed
- Object detection

Quality measurements, measures that will determine the degree of feasibility of obtaining the main services mentioned above:

- Measure of turbidity/sedimentation process.
- Cloud coverage.

The main services are defined in the table below.

Table 7-7 Main ad hoc services definition

Service	Definition
River Edge and River Depth	These ad hoc services are estimates derived from a detailed analysis of the mask that will be extracted from the detection of the water bodies. With river edge detection the main idea is to extract the possible rises and falls of the river flow (depending on the contours that make up the river basin). Moreover, in the case of being able to obtain high resolution bathymetries, an attempt, in form of a proof of concept, could be made to derive the depth through a multispectral analysis and observing the penetration level of each wavelength. For the detection of contours, sentinel2 and sentinel1 will be used with the intention of improving the frequency of obtaining images of the areas of interest. In the case of the possibility of deriving the depth, the sentinel 2 multispectral sensor would have to be used.
Water speed	The water speed can be extracted directly from the corresponding in situ data from the CMEMS service, discussed above. In case of obtaining multiple points along the river transect, a possible interpolated estimations will be made, although these results should be considered as auxiliary information, since due to the peculiarities and physical characteristics of the rivers these data could not be reliable, since they have a high dependence on the shape of the river, its channels, and reliefs.
Object detection	Objects that do not belong to water bodies could be detected; their identification will be complicated due to the low spatial resolution, and the low appearance of the types of objects in the images.

All these main services do not really cover the needs of offering a rapid response to the type of navigation operations that are proposed, but it has been identified which of them could in some way offer valuable auxiliary information, and also consider them as variables to be taken into account for the autonomous navigation planning.

Table 7-8 quality measurements ad hoc services definition

Service	Definition
Measure of turbidity / sedimentation process	Turbidity provides a quantitative measure of the transparency of water, which can vary with different levels of suspended particles (solid, organic, etc.). These are often used to monitor sea coastal water because the turbidity and level of suspended matter influence light penetration, water composition, and have impacts on marine ecosystems in the area. Multispectral colors from Sentinel-2 satellites will be used.
Cloud coverage	The majority of all optical observations collected via space borne satellites are affected by haze or clouds. Consequently, persistent cloud coverage affects the remote sensing practitioner's capabilities of a continuous and seamless monitoring of our planet. Cloud coverage areas will be detected by using Sentinel-2 satellites. Moreover Sentinel 1 satellites will be used in order to increase data frequency. It is worth mentioning that the data from radar is less affected by cloud cover, since it is capable of penetrating these layers.

Quality measures refer to those measures that determine the degree of feasibility of obtaining the main products briefly described above. For this reason when these types of events arise, such as cloud cover or sedimentation or turbidity processes in the river, they will negatively affect the results obtained from the main products.

7.1.2.2.1. POTENTIAL ADDED VALUE OF AD-HOC SERVICES AND IWW NAVIGATION OPERATIONS

The following table shows the possible services that could potentially support the operations identified.

The majority of proposed services aim to offer information close to the position of the ship. Valuable data surrounding the presence of the ship can offer an additional level of support. For this reason, it is identified the need to have solutions that can offer high temporal frequency and spatial resolution data. For example, the main point of the "main services" group (Table 7-7) is to observe changes in the water surface over time, in such a way that if the flow of the river has increased or decreased, it will be possible to observe whether a channel has narrowed or, on the contrary, has widened, or if a sand bar appears or disappears...

Based on these premises, and analyzing the proposed services, the operations that could have a degree of support have been identified, although perhaps not based on solutions/services able to offer immediate responses, many of them offer high value in the sense of route or maneuver planning.

Table 7-9 Potential added value of ad-hoc services and IWW navigation operations

	River Edge	River depth + bathymetry	Object detection	Turbidity/ Sedimentation	Clouds presence	Water speed (optical + insitu)
AIS Navigation, short term ahead	X	X	X	X	X	X
AIS Navigation, medium term ahead	X	X	X	X	X	X
ECDIS Navigation, Information Modus	X	X	X	X	X	X
ECDIS Navigation, Navigation Modus	X	X	X	X	X	X
Track Guidance Assistants in Inland Navigation	X	X	X	X	X	X
Remote shipping	X	X	X	X	X	X
General navigation on free-flowing rivers	X	X	X	X	X	X
Navigation on small narrow channels	X	X	X	X	X	X
Congestion controlled rivers and canals	X	X	X	X	X	
Bridge passing	X	X	X	X	X	
Mooring/berthing	X	X		X	X	
Lock manoeuvre	X	X		X	X	
Urban areas with a high number of bridges, …						
Environmental consideration dif. weather con., …						
Overtaking						
Turning				X	X	X
Stopping				X	X	X
Harbor manoeuvre						

7.1.2.3. FINAL ASSESMENT

Putting together all the analyses made in the previous sections, the overall potential offered by Copernicus services for each IWW navigation operation is assessed. Table 7-10 shows the result where "H" stands for high potential, "M" for medium potential and "L" for low potential.

Table 7-10 Potential added value of Copernicus for IWW operations

	Total Score (H, M & L)
AIS Navigation, short term ahead	M
AIS Navigation, medium term ahead	M
ECDIS Navigation, Information Modus	H
ECDIS Navigation, Navigation Modus	M
Track Guidance Assistants in Inland Navigation	H
Remote shipping	H
General navigation on free-flowing rivers	M
Navigation on small narrow channels	M
Congestion controlled rivers and canals	M
Bridge passing	M
Mooring/berthing	M
Lock manoeuvre	M
Urban areas with a high number of bridges, …	L
Environmental consideration dif. weather con., …	M
Overtaking	L
Turning	L
Stopping	L
Harbor manoeuvre	L

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7.2. SELECTION OF NAVIGATION OPERATIONS ON IWW

The next step will be to **select those IWW operational scenarios** along with the use of electronic tools, which can be applicable to this project. Those AVIS IWW navigation operations will be the ones where the EU Space Data have more potential added value to provide.

Table 7-11 Selection of navigation operations

	Total Score		Operation selection
	EGNSS	Copernicus	
AIS Navigation, short term ahead	M	M	-
AIS Navigation, medium term ahead	M	M	-
ECDIS Navigation, Information Modus	**L**	**H**	**X**
ECDIS Navigation, Navigation Modus	**H**	**M**	**X**
Track Guidance Assistants in Inland Navigation	**H**	**H**	**X**
Remote shipping	**H**	**H**	**X**
General navigation on free-flowing rivers	**H**	**M**	**X**
Navigation on small narrow channels	**H**	**M**	**X**
Congestion controlled rivers and canals	**H**	**M**	**X**
Bridge passing	**M**	**M**	**X**
Mooring/berthing	M	M	-
Lock manoeuvre	M	M	-
Urban areas with a high number of bridges, …	H	L	-
Environmental consideration dif. weather con., …	M	M	-
Overtaking	L	L	-
Turning	M	L	-
Stopping	L	L	-
Harbor manoeuvre	L	L	-

Having in mind that the main objective of the AVIS project is to assess the potential added value of the use of EGNSS and Copernicus, we base the decision for selecting the operations on the total scores derived from the previous assessments. In order to ensure that both, EGNSS and Copernicus, can contribute to the operations, we consider, as a first approach, that we need to choose a criterion in which both technologies can provide at least medium potential. For the final decision in the selection, we also consider the need to focus in a manageable list of operations, to be able to deeply analyze them in the next phases of the project and taking into account the available efforts. Hence, we propose to select those operation in which we have at least "High" potential in one technology and at least "Medium" potential in the other technology. Additionally, and even if it does not fit with the criterion, we have also selected the "bridge passing" operation, since it has the vertical component in place, which is not found

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in any other operation. Also, this is a quite common operation that skippers face in their daily operations. Finally, the operation of ECDIS Navigation, Information Modus is the most common operation performed in Inland Waterways, therefore, we decide to select that operation as well considering that the final users would have interest on it. Hence, the final list of selected operations remains as:

- ECDIS Navigation, Information Modus
- ECDIS Navigation, Navigation Modus
- Track Guidance Assistants in Inland Navigation
- Remote shipping
- General navigation on free-flowing rivers
- Navigation on small narrow channels
- Congestion controlled rivers and canals
- Bridge passing

Note that in this selection there are operations that may have similar needs. For future analysis of the project, these operations could be grouped according to needs to facilitate the understanding and analysis of them.

8. CONCLUSIONS

The combination of EGNSS and Copernicus is a mutually beneficial combination that increases the effectiveness and efficiency of various areas. In the area of inland waterway navigation and positioning, EGNSS provides the basis for accurate location information, while Copernicus enriches this data with detailed environmental information, enabling optimized route planning and improved safety measures.

Together, these initiatives underline the EU's commitment to the use of space-based technologies for the benefit of society and highlight the invaluable synergies between navigation, Earth observation and data analysis in addressing today's challenges.

Through a comprehensive analysis and assessment of the performance and benefits of EGNSS and Copernicus, the value of the two systems in supporting various navigation operations has been identified. On the basis of an assessment, the navigation operations with the greatest potential benefit from EGNSS and Copernicus were then finally determined.

An interview conducted with various stakeholders (outputs included in D7.4) regarding the results of document D1.1 with regard to the identified navigation operation and the associated navigation parameters showed that all the needs were largely reflected in the work of D1.1. Hence, the assessment conducted in D1.2 document would be based on a well-funded base of Inland Waterways operations and needs.

ANNEX I TECHNICAL ASPECTS OF RETRANSMISSION OF DIFFERENTIAL CORRECTIONS BASED ON EGNOS

This section describes the technical aspects of Table "6-2 Summary of data provision details" on how DGNSS corrections can be made available to skippers through an authority.

Satellite Based Augmentation Systems (SBAS) improve Global Navigation Satellite Systems (GNSS) by providing correction data and integrity details, improving the accuracy of positioning, navigation and timing. Reference stations, strategically located over a large area, collect precise GNSS measurements. These measurements are then forwarded to a central processing unit, which calculates both the differential corrections and the integrity data for the satellite constellations being monitored. This refined information is then disseminated via the satellites throughout the coverage area. Numerous SBAS services are currently in operation worldwide, providing regional coverage, particularly in the northern hemisphere. These services offer interoperable signals from different satellites [RD.1.].

As already described in chapter 6.2, there are two different methods on how EGNOS data could be used in the IWW sector (**Figure 8-1**).

- **Method a)** EGNOS Data used from Satellites (Signal in Space);
- **Method b)** EGNOS Data used via IWW Service providers' AtoN

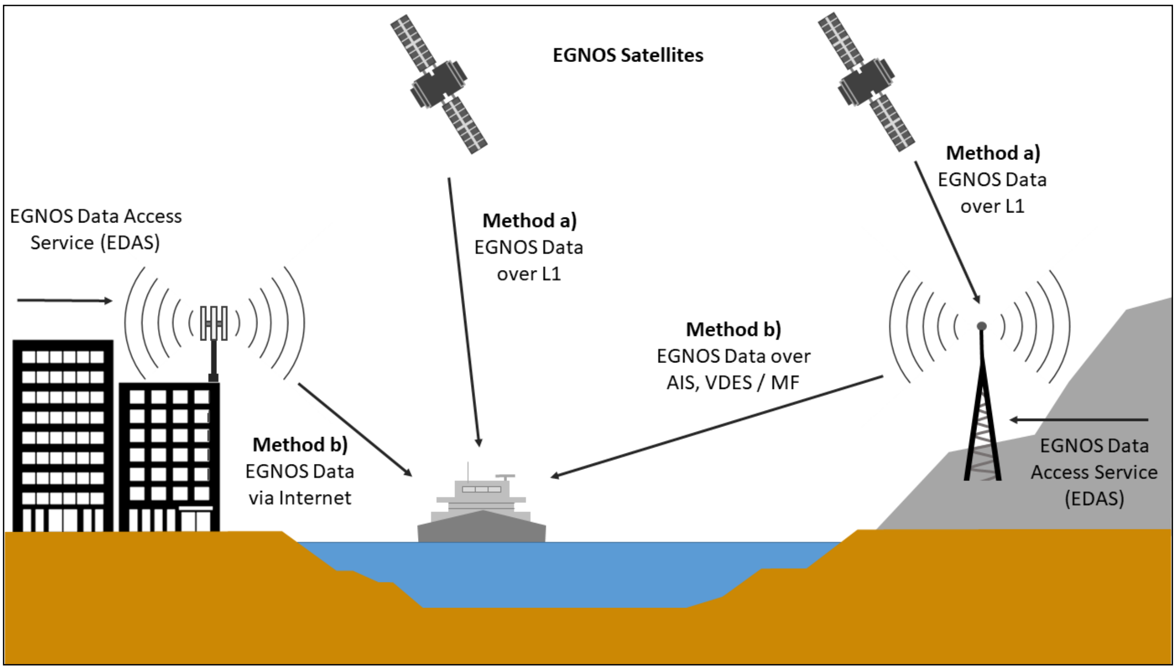

Figure 8-1 Generic view of the EGNOS transmission /reception options in the IWW sector

It is not always possible to receive EGNOS data directly from the satellite. This may be due to topographical conditions such as shading from mountains or waterways running through valleys. To solve this problem, EGNOS data can be distributed via various infrastructures such as AIS or MF stations operated by public authorities.

There are a number of guidelines and recommendations on how this should be done. These works are published by the IALA. IALA is a non-profit, international technical association. Established in 1957, it gathers together Marine Aids to Navigation authorities, manufacturers, consultants, and, scientific and training institutes from all parts of the world and offers them the opportunity to exchange and compare their experiences and achievements.

IALA encourages its members to work together in a common effort to harmonize Marine Aids to Navigation worldwide and to ensure that the movements of vessels are safe, expeditious and cost-effective while protecting the environment.

Taking into account the needs of mariners, developments in technology and the requirements and constraints of aids to navigation authorities, a number of technical committees have been established bringing together experts from around the world.

The work of the committees is aimed at developing common best practices through the publication of IALA Standards, Recommendations, Guidelines and Model courses.

This work ensures that mariners have Marine Aids to Navigation which will meet their needs both now and in the future. Thus IALA contributes to a reduction of marine accidents, increased safety of life and property at sea, as well as the protection of the marine environment.

IALA also encourages cooperation between nations to assist developing nations in establishing aids to navigation networks in accordance with the degree of risk for the waterway concerned (https://www.iala-aism.org/about-iala/).

The following table shows all necessary recommendations and guidelines issued by the IALA concerning the topic: Technical aspects of retransmission of DGNSS corrections based on EGNOS.

Table 8-1 DGNSS and EGNOS IALA recommendations and guidelines

Publication by IALA	Purpose	Download Link
G1129 The retransmission of SBAS corrections using MF-Radio beacon and AIS	This document sets out guidance for Marine Aids to Navigation (AtoN) service providers wishing to understand where SBAS information could be used to support the mariner and then how to employ such data.	G1129 The retransmission of SBAS corrections using MF-Radio beacon and AIS
R0124 Appendix 16 DGNSS Broadcasts from an AIS service	The purpose of Differential GNSS (DGNSS) is to increase accuracy and integrity of position reports from vessel. A base station may transmit DGNSS corrections via AIS VDL if it is connected to a DGNSS reference station. This service can be provided automatically and may be considered a back-up service for the radiobeacon DGNSS service. Unfortunately, the DGNSS corrections are generally not available to a vessel's own EPFS.	R0124 (A-124) APPENDIX 19 SATELLITE AIS CONSIDERATIONS
IALA Guideline G1112 Performance and monitoring of DGNSS services in the frequency band 283.5 – 325 kHz	This Guideline provides the design and implementation principles of IALA Recommendation R0121(R-121) Performance and Monitoring of DGNSS Services in the frequency band 283.5 – 325 kHz.	G1112 PERFORMANCE AND MONITORING OF DGNSS SERVICES IN THE FREQUENCY BAND 283.5 – 325 KHZ