PROTOTYPE EQUIPMENT SET – RELEASE 1. DESIGN DOCUMENT

AVIS

Prepared by: AVIS team

Approved by: Marcos López (GMV)

Authorized by: Marta Cueto (GMV)

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DOCUMENT STATUS SHEET

Version	Date	Pages	Changes
1.0	30/06/2025	32	Initial version prepared for T0+17 delivery
1.1	31/10/2025	31	Second version prepared for IRM2 closeout
1.2	18/12/2025	29	Updated version with the following changes after EC review: ▪ Applicable Documents´ section removed (included in a separate document) Terms. Definitions and abbreviated terms´ section removed (included in a separate document)

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LIST OF TABLES AND FIGURES

1. INTRODUCTION

1.1. PURPOSE

The present document is the "Prototype equipment set – release 1. Design document" document for the AVIS project. The main purpose of this document is to develop the AVIS prototype equipment design to be used for the pilots.

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 reference documents.
- Chapter 3. describes the methodology used for this document.
- Chapter 4. describes the architecture at a high level view.
- Chapter 5. provides details on the EGNSS part of the prototype.
- Chapter 6. provides details on the Copernicus part of the prototype.
- Chapter 7. provides details on the ECDIS part of the prototype.
- Chapter 8. includes the AVIS prototype design.
- Chapter 9. gives the pre-existing Industrial Property Rights.

2. REFERENCES

2.1. 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 2-1 Reference documents.

Ref.	Title	Code	Version	Date
[RD.1.]	Galileo - Open Service - Signal In Space Interface Control Document	OS SIS ICD	2.1	November 2023

3. CONTEXT AND METHODOLOGY

In this document produced in AVIS WP5000 “Prototype development and design of the pilot projects”, the high-level methodology for the work performed in this document is:

- Step 1: to define the architecture of the prototype at a high level point of view following the work performed in previous deliverables (Section 4.)
- Step 2: to define in detail what the different parts of the prototype will include and provide the specific details that are relevant (Section 5. , Section 6. and Section 7.)
- Step 3: to define all the components that could interact with the prototype and to provide the final design (Section 8.)

4. ARCHITECTURE HIGH LEVEL VIEW

The prototype to be used in the project pilots is conceptually made up of different layers. This section describes the different layers that form the prototype. Figure 4-1 shows the prototype architecture from a high-level point of view.

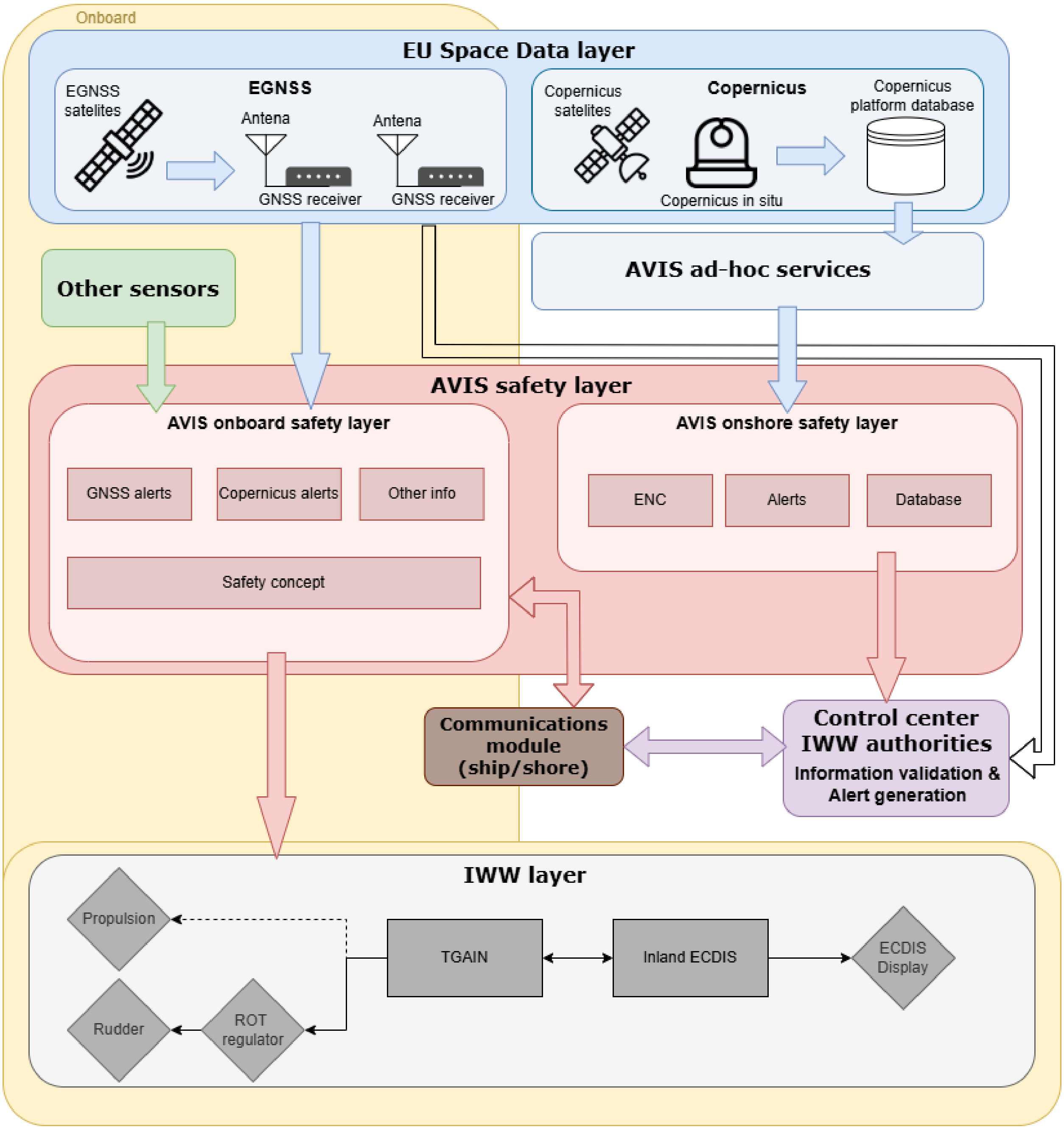

Figure 4-1: AVIS high level view prototype architecture

Following are more details on each of the layers:

- **EU Space Data layer**. This layer is made up of all those elements of the prototype that make up all the information currently provided by the EU services. Therefore, this layer collects all the information coming from EU Space data that is accessible to all users. In other words, this is where the information is located before it is used and added value.

  This layer is composed of two sub-layers:

  - **EGNSS sub-layer**. The signal from the EGNSS satellites (Galileo and EGNOS) is received here. In order to receive these signals, it is necessary to have a GNSS antenna and a GNSS receiver that is capable of processing these signals. Specifically, for the AVIS prototype, two antennas are identified, each with a different GNSS receiver. With this, it is possible to obtain all the navigation parameters coming from GNSS services.
  - **Copernicus sub-layer**. Copernicus services information can come from two different sources. On the one hand, information can come from Earth observation satellites (i.e. Sentinel-1 and Sentinel-2). On the other hand, information can come from some land-based sensors (i.e. buoys) called Copernicus in-situ. All this information is stored in a database on the Copernicus platform which is accessible to the AVIS prototype via API.

    Currently, at the time of developing this deliverable, it is observed that the Copernicus service is capable of providing interesting data although, in some cases, not directly applicable to navigation in inland waterways. For this reason, some ad-hoc services were identified which, based on Copernicus data, are given a processing layer so that they can be used for navigation in inland waterways. These services include, for example, the identification of river width, water depth or object detection. These services would not formally form part of the EU Space Data layer, although it would be reasonable to think that in the future the service itself would provide this information.

  Note that GNSS information is mainly used onboard, in GNSS receivers installed on the vessel. However, from the onshore side, authorities can also make use of EGNSS services to monitor the status of the service and/or provide differential corrections obtained by other communication channels. On the other hand, Copernicus information is intended to be used directly onshore. It is considered that this information shall be validated and verified before being used, therefore, it is proposed that the authorities must validate the information and provide ships with the information or alerts they consider relevant.

- **AVIS safety layer**. This layer is responsible for obtaining all relevant data, whether from the EU Space Data layer or from other sensors and processing it to give it added value that allows decision-making for safe navigation. This layer is made up of two sub-layers.

  - **AVIS onshore safety layer**. This sub-layer uses the capabilities of Copernicus ad-hoc services to generate chart updates and alerts derived from Copernicus. In addition, this information could be stored in a database that can be consulted by any user who needs it. In this sense, the idea is to be able to use the capabilities that can be used with Copernicus data to obtain relevant information. For example, having the ability to compare the current state of the river with historical data to generate an alarm in the event that there is a deviation from the historical data.

    All information provided by this sub-layer is consulted directly by the IWW authorities, so that they can validate it and decide which to use and transmit to the vessels. In order to transmit alerts and relevant information to vessels, authorities rely on various means of communication that communicate with the elements of the ship's communication module to send them the information. With this, it is possible to take advantage of the added value of the sub-layer AVIS onshore safety layer from the vessel, having passed a prior validation process.
  - **AVIS onboard safety layer**. This sublayer is the one present on the vessel and takes advantage of all the inputs relevant to navigation. That is, it uses data from GNSS receivers, data provided by other sensors and Copernicus data and alerts. This sublayer contains the logical processing of the safety concept developments.

- **IWW layer**. This is the execution layer. Once the situation has been analyzed in the AVIS safety layer, it is transmitted to the vessel's components capable of following, in an automated way, the route. This is done using the TGAIN, which is connected to the rudder via the autopilot. At the same time, there is a bidirectional communication with the inland ECDIS, which displays the results on the screen. It should be noted that there is no standardized, commercial interface available between TGAIN and the motor panel(s) on board of the demo vessels. For the moment, connecting and controlling a motor depends heavily on the motor brand and even the different motor types for each brand/motor-manufacturer. So, currently it would be technically feasible to develop that interface. However, it is to be custom-made for each vessel under consideration. We had a survey among the demonstration vessels about the different motor types. The end result is that there is no easy way to do motor control on any of the four demo vessels.

This architecture allows flexibility, so that it can be applied to different automation levels, depending on the environmental situation and the vessel's equipment. In addition, if remote control navigation has to be applied, it would also be possible, as instructions would be sent from the remote control center to the vessel via the vessel's communications system.

4.1. PILOT SETUP CONSIDERATIONS

The purpose of the AVIS pilots is to showcase the added value of EU Space Data and services for automated vessels on European inland waterways. To show this correctly, it is considered that the best approach is to perform the AVIS pilots, recording as much data as possible to be able to analyze them later in post-processing, as well as to allow performing more significant statistical analysis. Therefore, the prototype design will be based on facilitating this approach.

The idea of the prototype setup is to configure it so that it can record as much navigation data as possible over a long period of time. This data would come from each part of the prototype, i.e. the EGNSS part, the Copernicus part and the IWW layer part. It is also planned to be able to record data from other sensors to provide more information (see section 9). In this way, the performance that the pilots operations would have had can be analyzed and contrasted with the requirements set. For example, during a real time operation, it is not possible to have the reference that is considered the actual trajectory and to compare it with the position provided by the EGNSS receiver, while in post-processing this comparison is feasible.

The aim of this setup is to carry out a statistical study that can show the added value of EU Space Data services. For this, ideally the vessel should operate normally, as it is important to have an example of the prototype's performance in as many real situations as possible.

At the time of the execution pilots, real-time information on the added value of the EU Space Data will be available on inland ECDIS, for example including the Copernicus information layers (maps and alerts) or the protection level display obtained with the GNSS receiver.

The aim of the AVIS pilots is not to develop technology that would allow live testing of automation, so the prototype does not consider elements, outside EU Space data, that are necessary for automated navigation. When possible, due to the characteristics of the vessels identified for the pilots, the prototype would allow the use of Track Guidance Assistance with the tool developed by TRESCO. As of today, there is no commercially available product to deploy an AL2 or higher.

This means that the maximum level of automation expected to be achieved in the AVIS pilots is AL1, however, the data collected will allow us to evaluate performances and cases for higher levels of automation. Thus, the focus will be on analyzing the capabilities of EU Space Data for safe automated navigation.

5. EU SPACE DATA: EGNSS PROTOTYPE

EGNSS prototype is defined as any part of the prototype that is directly related to EGNSS services. Although from a conceptual point of view, the authorities can make use of these services, for the design of the pilot prototype we will focus only on those elements that are onboard.

The following figure shows the part of the high-level architecture representing the EGNSS prototype part.

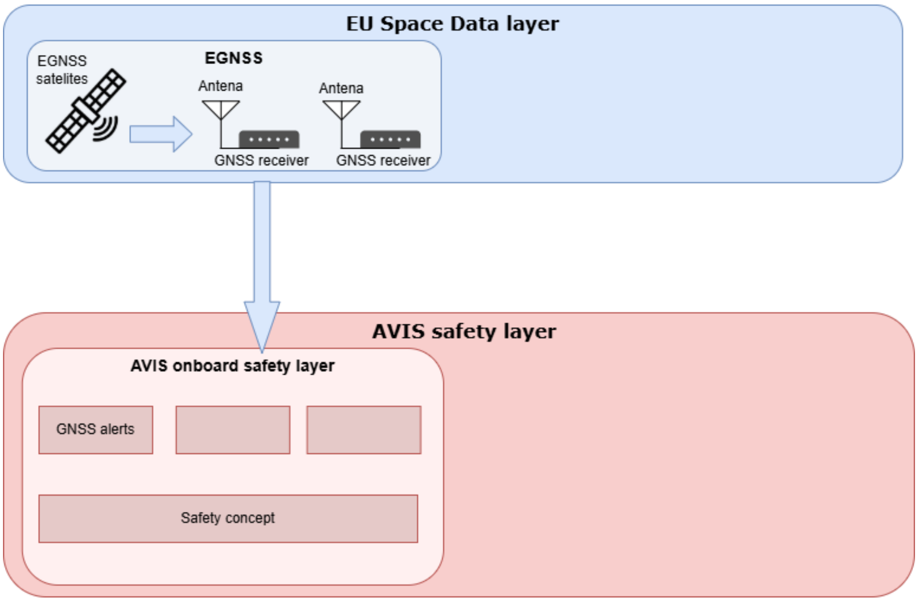

Figure 5-1: EGNSS prototype high-level architecture

There are several elements that conform the EGNSS prototype, each of the elements that are included are detailed below.

5.1. GNSS ANTENNAS

A GNSS antenna is a critical component of a GNSS receiver. It is designed to receive signals transmitted by GNSS satellites. These signals are electromagnetic waves in the L-band frequency range (1.2 to 1.6 GHz). There are some aspects to take into account with antennas:

- Installation: the antenna shall be placed in a location with a clear view of the sky to ensure it can receive signals from as many satellites as possible. For optimal performance, the antenna should be mount on a stable, metallic surface. This helps improve signal strength and reduce multipath errors.
- Processed signals: antennas can process different signals, there are antennas that only process one band, and others that can process various bands. Therefore, it is important to ensure that the antenna used can receive the signals to be received. In the case of the AVIS project, the aim is to cover the E1, E5 and E6 bands (as shown in Figure 5-2).

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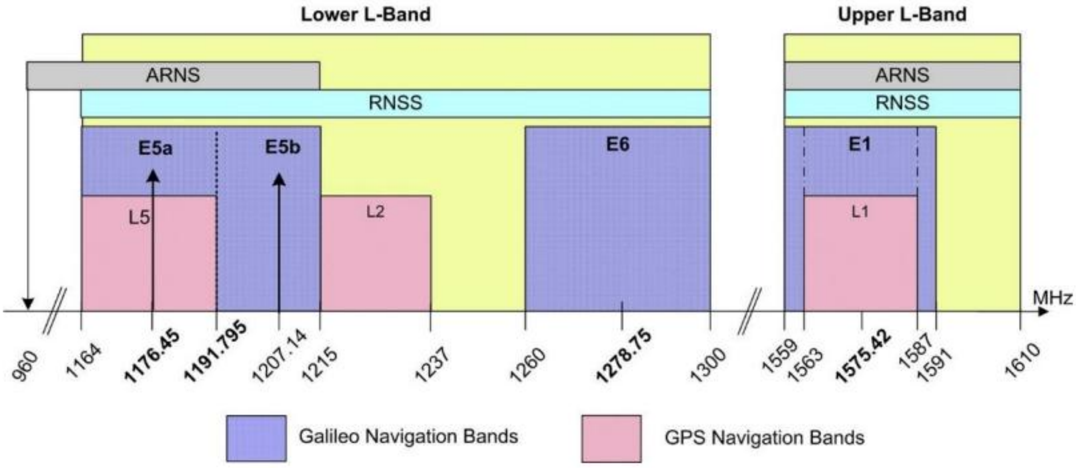

Figure 5-2: Galileo Frequency plan [RD.1.]

- Signal strength: Antenna cables and connectors cause signal loss. On the other hand, antennas can use Low Noise Amplifiers (LNA) that produces a signal gain. When calculating the required signal for the equipment, it is important to keep in mind the loss due to the cables and connectors, and the gain due to the LNA amplification.

The EGNSS prototype has two GNSS antennas. At least one antenna of both antennas should be able to process the E6 band, since HAS services are provided through that band. The other antenna does not need to contain E6, so it is decided to use only a dual frequency antenna, in order to have a wider range of antenna options and reduce the potential cost of the equipment.

Having two antennas makes it possible to calculate the heading of the vessel. The farther apart the antennas are, the better the accuracy of the heading calculation. However, the physical characteristics of vessels make it not always easy to place the antennas far apart. Ideally, the antennas should be mounted at the same height, along the vessel's centerline (if possible), or parallel to it. This helps keep heading computations straightforward.

The antennas preliminarily identified for use in the pilots are listed below, although the exact model may change depending on availability at the time of conducting the pilots.

E1/E5 Antenna: Hemisphere A45

The A45 GNSS antenna is designed to support millimeter-level accuracy on land and marine applications. The A45 GNSS antenna offers support for present and future GNSS signals, including GPS, GLONASS, BeiDou, and Galileo.

Figure 5-3: Hemisphere A45 antenna

Its technical characteristics are:

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- GNSS Reception: GPS L1/L2/L5, GLONASS G1/G2, BeiDou B1/B2/B3, SBAS, L-band and Galileo E1/E5a and b
- GNSS Frequency: 1.165 to 1.278 GHz and 1.525 to 1.615 GHz
- LNA Gain: 30 dB
- LNA Noise: 2.0 dB, typical
- Input Voltage: 3.3 to 15 VDC
- Input Current: 25 mA, typical

E1/E5/E6 Antenna: Taoglas Colosseum XAHP.50

The Taoglas Colosseum X XAHP.50 is an active multi-band GNSS antenna has been carefully designed to work well on the full GNSS spectrum. The LNA used in the XAHP.50 ensures excellent out of band rejection and provides excellent positioning stability and reliability of GNSS signals.

Figure 5-4: Taoglas Colosseum XAHP.50 antenna

Its technical characteristics are:

- GNSS Reception: GPS/QZSS L1/L2/L5, GLONASS G1/G2/G3, Galileo E1/E5a/E5b/E6, BeiDou B1/B2a/B2b/B3, QZSS L6, NAVIC L5, as well as SBAS (WAAS/EGNOS/GAGAN/SDCM/SNAS)
- GNSS Frequency: 1.164 to 1.3 GHz and 1.559 to 1.61 GHz.
- LNA Gain: 22 - 28 dB
- LNA Noise: 2.6 – 4.5 dB, typical
- Input Voltage: 1.8 to 5 VDC
- Input Current: 20 mA, typical

5.2. GNSS RECEIVERS

A GNSS receiver is a device that receives signals from satellites to determine its location on Earth. It works by capturing signals from multiple satellites in orbit, which contain information about the satellite's position and the exact time the signal was transmitted. By calculating the time delay between the transmission and reception of these signals, the receiver can compute its position.

Each receiver has specific processing capabilities, so not all receivers are capable of taking advantage of all GNSS services. Generally, depending on the application and budget, there is a range of specific receivers on which to trade off the most needed features.

Depending on the characteristics of the receiver and how it is configured, the receiver can provide different features such as update rate, integrity features, EGNSS services to be used.

For the AVIS prototype it is proposed to use two GNSS receivers. This has the advantage of having greater redundancy in case of failure, being able to perform consistency checks, and even use different receivers to have a wider range of features. For this, it is important that both receivers are time synchronized, so that the time stamp they apply to the output is the same and they can be processed directly. The outputs shall be provided in NMEA format, to facilitate interpretation of the outputs by other on-board equipment.

In addition, it is proposed to have other receivers in parallel whose only function is to save the observations in RINEX format. In this way, it is possible to carry out a post-processing study, applying different techniques. Thus, it is proposed to use a high precision technique, called PPP, in order to obtain an accurate trajectory to be used as a reference line. So, to obtain accuracy, the position provided by the receivers will be compared with the position of the reference line.

The receivers preliminarily identified for use are described below.

GNSS receiver: ASGARD

The ASGARD receiver is a dual-frequency shipborne multi-constellation receiver that complies with various maritime regulations such as IEC 61108-1, IEC 61108-3. Developed by GMV, this receiver has dual-frequency Galileo and GPS processing capability. In addition, it includes the ability to use OSNMA as a spoofing detection measure.

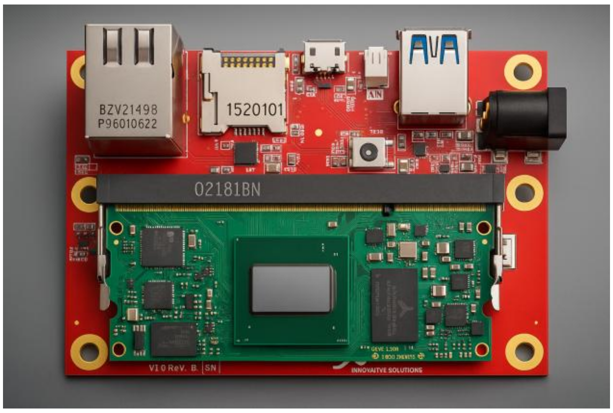

Figure 5-5: ASGARD GNSS receiver chipset

Figure 5-6: ASGARD GNSS receiver box

Key technical details are shown below:

- Supported bands: GPS L1C/A, GPS L5, Galileo E1, Galileo E5a.
- Operational modes: Single frequency, Single frequency with differential corrections, double frequency for Galileo and GPS.
- Outputs: Interface aligned with IEC 61162-1.
- Power supply: 3V3 DC; 12/24V DC (Optional).
- Connections: MicroUSB, RJ45 (Ethernet), USB-C, USB 3.0.
- Features: IBPL integrated, differential corrections, OSNMA.
- Standards: IEC 61108-1, IEC 61108-3 Type approval.

5.3. GNSS ANTENNA SIGNAL SPLITTER

A GNSS antenna signal splitter is a device that allows a single GNSS antenna to be shared among multiple GNSS receivers. It works by taking the signal received from the antenna and distributing it to several outputs, each connected to a different receiver.

The splitter typically has one input port for the antenna and multiple output ports for the receivers. It can be passive, requiring no external power, or active, where it may need power to amplify the signal to compensate for any loss during splitting. This setup is ideal for applications requiring redundancy, testing, or comparative analysis of different GNSS receivers using the same antenna signal.

When using a GNSS antenna signal splitter, it's important to consider the DC block to ensure proper operation and avoid potential issues. Therefore, it has to be checked that the splitter correctly manages the power supply to the antenna. Typically, one port will pass DC power to the antenna (DC pass-through), while other ports will block DC power (DC block) to prevent interference or damage.

6. EU SPACE DATA: COPERNICUS PROTOTYPE

The following figure shows the part of the high-level architecture representing the Copernicus prototype part.

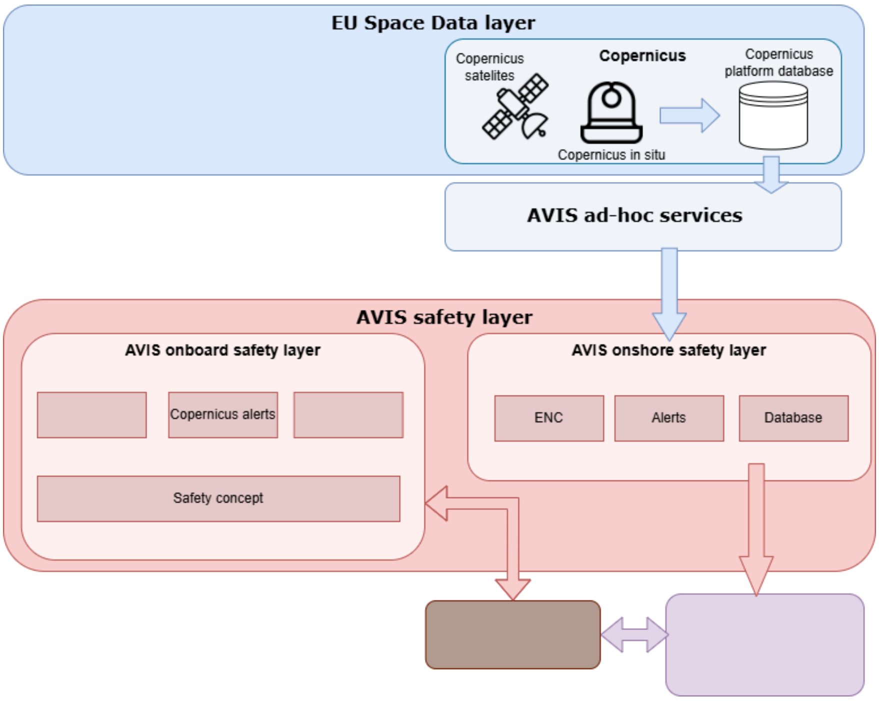

Figure 6-1: Copernicus prototype high-level architecture

In this section we show in detail the components for the modular design of the Copernicus prototypes which constitutes the AVIS ad-hoc services. An overview of the ad-hoc services with its constituent modules are shown in Figure 7-2.

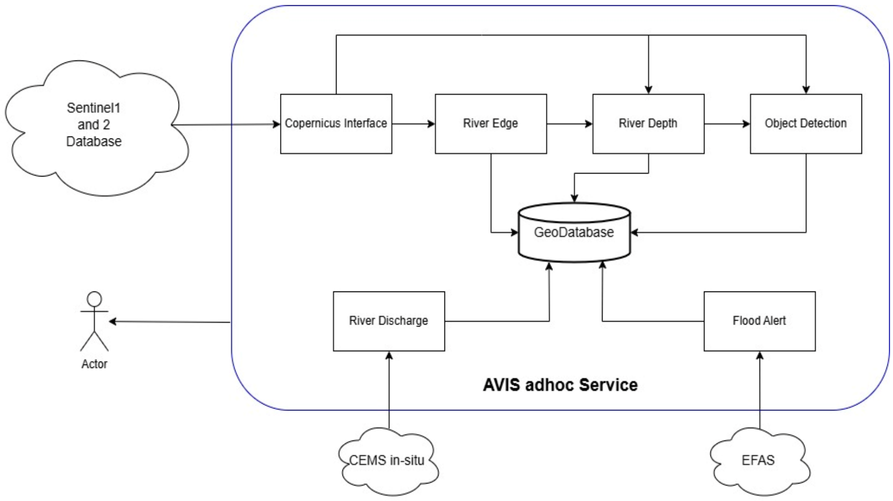

Figure 6-2: The prototype design for AVIS adhoc service is shows here. The components of the prototype are shown within the blue outline.

The prototype ad-hoc service consists of several modules, each with specific functionalities:

- **Copernicus Interface**
    - **Functionality**: Queries Sentinel 1 and 2 databases periodically to gather satellite data for the Area of Interest (AOI).
- **River Edge Module**
    - **Functionality**: Segments and detects river edges, generates alerts based on changes in river boundaries, and stores the results.
- **River Depth Module**
    - **Functionality**: Maps river depth using satellite imagery and river edge data, and generates alerts based on depth changes, and stores the results.
- **Object Detection Module**
    - **Functionality**: Detects objects (mainly vessels) within the river extent, generates alerts based on detected objects, and stores the results.
- **River Discharge Module**
    - **Functionality**: Ingests in-situ observation data to calculate river discharge values, generates alerts based on significant changes, and stores the results.
- **Flood Forecast Module**
    - **Functionality**: Ingests flood forecast data from EFAS and GLOFAS, generates flood alert maps, and stores the results.
- **Geodatabase Module**
    - **Functionality**: Stores the output of each sub-module in GeoTIFF and Shapefile formats, updates periodically, and serves georeferenced raster and vector data to third parties via API.

Overview of each of these modules are described in detail below,

6.1. COPERNICUS INTERFACE

The role of this Interface is to query the Sentinel 1 and 2 database periodically for each of the input Area of Interest (AOI) and gather the data whenever they are available. This interface runs continuously.

Table 6-1 Summary of Copernicus Interface

	Description
Functionality	Queries the Sentinel 1 and 2 Database periodically for each Area of Interest (AOI) and gathers available data continuously.
Details	The Copernicus Interface acts as a bridge between the Sentinel database and the processing modules. It ensures that the latest satellite data is fetched and made available for analysis. This interface runs continuously to keep the data updated and relevant for the AOI.
Input	Area of Interest (AOI) corresponding to the pilot sites.
Output	Sentinel 1 and 2 georeferenced images

6.2. RIVER EDGE

The River Edge module is designed to segment and detect river edges, generate alerts based on the segmented data, and store the results locally. It consists of three sub-modules: River Edge Segmentation, River Edge Alert Generator, and Local Storage.

6.2.1. RIVER EDGE SEGMENTATION SUB-MODULE

This sub-module takes data from the Copernicus Interface and implements algorithms to segment and detect river edges. It processes satellite imagery to identify the boundaries of rivers and segment the extent of water in the river. It generates a georeferenced raster map of the river extent.

Table 6-2 Summary of River edge segmentation sub-module

	Description
Functionality	Takes data from the Copernicus Interface and implements algorithms to segment and detect river edges.
Details	Processes satellite imagery to identify the boundaries of rivers by creating a segmentation of water bodies within the AOI. Generates a georeferenced raster map of the water extent in the river.
Input	Data From Copernicus Interface
Output	Georeferenced raster map to local storage

6.2.2.RIVER EDGE ALERT GENERATOR SUB-MODULE

Uses the segmented map from the River Edge Segmentation sub-module to create an alert map in geo-referenced raster format. It analyzes the segmented river edge data to identify changes in the river boundaries. When the change is significant compared to historical data, it generates alerts in a geo-referenced raster format.

Table 6-3 Summary of River edge alert generator sub-module

	Description
Functionality	Uses the segmented map from the River Edge Segmentation sub-module to create an alert map in geo-referenced raster format.
Details	Analyzes the segmented river edge data to identify potential risks or changes in the river boundaries. Generates alerts in a geo-referenced raster format for real-time monitoring and decision-making.
Input	Georeferenced water extent map from River Edge Segmentation Sub-Module

	Description
Output	Georeferenced raster map to local storage

6.2.3. RIVER EDGE LOCAL STORAGE SUB-MODULE

This sub-module stores the segmented map and alert map internally and ensures that the processed data is stored securely and can be accessed for further analysis or reporting. It maintains the integrity and availability of the data for various applications.

Table 6-4 Summary of River Edge local storage sub-module

	Description
Functionality	Stores the segmented map and alert map internally.
Details	Ensures that the processed data is stored securely and can be accessed for further analysis or reporting. Maintains the integrity and availability of the data for various applications.
Input	Georeferenced water extent map from River Edge Segmentation Sub-Module and alert map from River Edge Alert Generator Sub-Module
Output	To GeoDataBase for serving

6.3. RIVER DEPTH

The River Depth module is designed to map river depth, generate alerts based on the depth data, and store the results locally. It consists of three sub-modules: River Depth Generator, River Depth Alert Generator, and Local Storage.

6.3.1. RIVER DEPTH GENERATOR SUB-MODULE

It takes data from the Copernicus Interface and the River Edge module to implement algorithms for mapping river depth. This sub-module processes satellite imagery and river edge data to calculate the depth of the river. It generates a detailed raster map denoting the river depth.

Table 6-5 Summary of River Depth Generator sub-module

	Description
Functionality	Takes data from the Copernicus Interface and the River Edge module to implement algorithms for mapping river depth.
Details	Processes satellite imagery and river edge data to calculate the depth of the river at various points. Generates a detailed raster map highlighting the river depth, essential for understanding water flow, sediment transport, and potential flood risks.
Input	Data from Copernicus Interface (Satellite imagery) and River Edge module (River edge data)

	Description
Output	Raster map of river depth (GeoTIFF format)

6.3.2.RIVER DEPTH ALERT GENERATOR SUB-MODULE

This sub-module uses the river depth map from the River Depth Generator to create an alert map in geo-referenced raster format by analyzing the river depth data to identify potential changes in the river depth. It generates alerts in a geo-referenced raster format.

Table 6-6 Summary of River Depth Alert Module

	Description
Functionality	Uses the river depth map from the River Depth Generator sub-module to create an alert map in geo-referenced raster format.
Details	Analyzes the river depth data to identify potential risks or changes in the river depth. Generates alerts in a geo-referenced raster format for real-time monitoring and decision-making.
Input	River depth map from River Depth Generator sub-module (GeoTIFF format)
Output	Alert map in geo-referenced raster format (GeoTIFF format)

6.3.3.RIVER DEPTH LOCAL STORAGE SUB-MODULE

This sub-module stores the river depth map and alert map internally and connects to GeoDataBase.

Table 6-7 Summary of River Depth Local Storage sub-module

	Description
Functionality	Stores the river depth map and alert map internally.
Details	Ensures that the processed data is stored securely and can be accessed for further analysis or reporting. Maintains the integrity and availability of the data for various applications.
Input	River depth map and alert map (GeoTIFF format)
Output	Stored data to be served by GeoDataBase

6.4. OBJECT DETECTION

The Object Detection module is designed to detect objects (mainly vessels) within the river extent, generate alerts based on the detected objects, and store the results locally. It consists of three sub-modules: Object Map Sub-Module, Object Alert Generator, and Local Storage.

6.4.1. OBJECT SEGMENTATION SUB-MODULE

Ingesting data from the Copernicus Input Module and the River Edge Module, this sub-module is responsible for detecting objects—primarily vessels—within the defined river extent. It processes satellite imagery alongside river boundary data to identify and segment objects located within the Area of Interest (AOI). The output is a vector-based map (shapefile) representing the bounding boxes of the detected objects.

Table 6-8 Summary of Object Mapping sub-module

	Description
Functionality	Ingests data from the Copernicus input module and the output of the River Edge module to detect objects within the river extent.
Details	Processes satellite imagery and river edge data to identify and segment objects, primarily vessels, within the AOI. Generates a detailed vector map of the detected objects.
Input	Data from Copernicus input module (Satellite imagery) and River Edge module (River edge data)
Output	Bounding boxes of detected objects (Shapefile format)

6.4.2. OBJECT ALERT GENERATOR SUB-MODULE

Using the objects identified by the Object Segmentation Sub-Module, this component generates vector-based object alerts. An alert is triggered for any detected object that lacks a corresponding AIS entry. The result is a vector file containing only those objects within the Area of Interest that are not broadcasting an AIS signal, enabling further analysis or investigation.

Table 6-9 Summary of Object Alert Generator sub-module

	Description
Functionality	Takes the objects in the segmentation raster and generates an alert map.
Details	Analyzes the segmented object data to generate alerts in a geo-referenced raster format.
Input	Bounding boxes of detected objects (Shapefile format)
Output	Bounding boxes of objects (Shapefile format) corresponding to alarm generation criteria

6.4.3. OBJECT DETECTION LOCAL STORAGE SUB-MODULE

This sub-module stores the object segmentation map and alert map internally and connects to GeoDataBase.

Table 6-10 Summary of Object detection Local Storage sub-module

	Description
Functionality	Stores the vectorized files
Details	Ensures that the processed data is stored securely and can be accessed for further analysis or reporting. Maintains the integrity and availability of the data for various applications.
Input	Object segmentation and alert vector files (shapefiles)
Output	Stored data to be served by GeoDataBase

6.5. RIVER DISCHARGE

The River Discharge Module will ingest data from in-situ observations of Copernicus Marine service and generate a geo-referenced vector file with attributes containing the river discharge value and an alert when there is a considerable change in the river discharge.

Table 6-11 Summary of River Discharge Module

	Description
Functionality	Ingests data from in-situ observations of CMEMS and generates a geo-referenced vector file with attributes containing the river discharge value and an alert when there is a considerable change in the river discharge.
Details	Processes in-situ observation data to extract river discharge values at various points within the AOI. Generates a geo-referenced vector file with the following attributes: river discharge values and alert indicators.
Input	In-situ observation data from CMEMS (CSV or JSON format)
Output	Geo-referenced vector file with river discharge values and alerts (Shapefile)
Remark	**It is possible that the AOI given does not include any in-situ observation station. In that case, in the same river, if there exists Copernicus in-situ observations, then the information will be extracted from the nearest in-situ observation station.**

6.6. FLOOD ALERT

This module stores the flood forecasting map for AOI specific to the pilot after requesting it to EFAS.

Table 6-12 Summary of Flood Alert Module

	Description
Functionality	It ingests flood forecast maps from EFAS
Details	Given an AOI it enquires the availability of the flood forecast map
Input	AOI and Date
Output	Geo-referenced raster image of the alert
Remarks	**The functionality of this service depends on the access to EFAS database. This database is restricted. The freely available dataset (with a delay of a month) does not include the flood forecast map.**

6.7. GEODATABASE

The Geodatabase module is designed to store the output of each sub-module in GeoTIFF and Shapefile formats. It runs periodically to update the stored data and serves georeferenced raster and vector data to third parties. Third parties (actor) can query the database through an API to obtain recent raster and vector maps for a specific Area of Interest (AOI) and date.

6.7.1.GEODATABASE CREATION WITH GEOSERVER

The geodatabase is created using GeoServer[1], a open source server for sharing geospatial data, which implements OGC standards. To streamline deployment and ensure scalability, GeoServer is containerized using Docker, allowing for consistent and portable setup across environments. It is integrated with Nginx, which acts as a reverse proxy to securely expose the GeoServer instance to an external port, enabling access from outside the local network. This setup facilitates efficient publishing of spatial datasets, including vector and raster layers, through standard web services like Web Feature Service and Web Coverage Service. The Geoserver contains workspaces (a workspace is a logical grouping used to organize and manage related geospatial data and services) described in Table 6-13

Table 6-13 Workspace description of the Copernicus Prototype GeoServer

Workspace	Functionality
S12Image	Stores the satellite images available
RiverExtent	Stores raster files for River Edge ad-hoc services
RiverExtentAlert	Stores raster files generating alerts for River Edge ad-hoc services

[1] https://geoserver.org/

Workspace	Functionality
RiverWidth	Stores raster files for River Width ad-hoc services
RiverWidthAlert	Stores alerts for River Width ad-hoc services in raster format.
RiverDischarge	Stores River Discharge data in shapefile format
Vessel	Stores shapefiles for Object Detection ad-hoc services
VesselAlert	Stores the shapefiles for alert service for Object Detection

6.7.2.ACCESSING AND UTILIZING THE GEODATABASE

The Geodatabase created will be running at GMV premises and can be accessed upon request by creating the corresponding username and password. Moreover, a client code will be provided which can be used to access the data. The parameters needed to access the data are workspace name, area of interest and date.

7. IWW LAYER – IWW ECDIS PROTOTYPE

The following figure shows the part of the high-level architecture representing the IWW ECDIS prototype part.

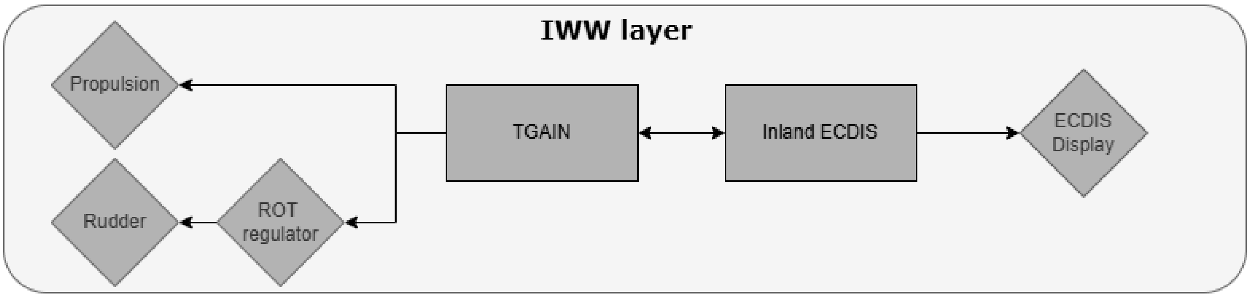

Figure 7-1: IWW ECDIS prototype high-level architecture

The acronym "ECDIS" stands for Electronic Chart Display and Information System. The term is used in the maritime sector as well as in the inland sector ("Inland ECDIS" or "chart viewer"). Besides visualising ENCs to the boatmaster, the (inland) ECDIS has numerous other features:

- Show all sensor info in a user interface (position, time, course, speed, heading, depth and ROT)
- Communicate with external agents (info services like Copernicus)
- Show danger (area)s, alerts, lock statuses, water levels, …
- Offer route planning options (in real time or planned)
- Offer trip preparing options (upfront trip plan)
- Show overlaid information layers (military layer, fishing zones, extra bathymetric layers, …)
- Log as much data (sensor, trip, TGAIN-performance) as possible (= "voyage data recording"-functionality)

Besides these internal features, an ECDIS also offers integration with other systems on the bridge. It can for instance communicate with the (river) radar, the auto pilot, VHF-devices, River Information Systems (RIS), Copernicus. For purposes of this prototype, all connections with other devices and services will use the network, using TCP or UDP.

In our demonstrators we will try to incorporate as much integration as is possible:

- Integrate with EGNSS for more accurate PNT sensor data
- Integrate with Copernicus for extra chart overlays and alerts.
- Integrate with the ROT-regulator (auto pilot) to demonstrate TGAIN together with EGNSS and Copernicus
- (possibly) integrate with the onboard river radar to overlay the radar image on top of the chart and/or do radar target detection

To have an optimal integration, our ECDIS PC will combine the ECDIS- and the TGAIN-functionality in a single process (Tresco *Navigis* license + Tresco *TrackPilot* license).

To have an integration with radar, our demonstrator will use an extra Tresco *RadarLink* license.

All these processes can be run on one or more computers. For the demonstrator we decided on using a single, performant laptop with an optional extra monitor.

8. AVIS PROTOTYPE SOLUTION DESIGN

Once the three fundamental parts of the prototype have been described, the complete prototype design is shown here.

The flow of operation is that the EGNSS and Copernicus parts will work in parallel and provide information in the form of inputs to the main PC. In this main PC will be installed the SW for the ECDIS that will use all the inputs to show the information on the display.

It should be noted that the prototype is composed of the indispensable necessary elements for which the AVIS solution provides added value. The prototype is considered to have the capability to receive inputs from other auxiliary equipment and sensors, but these are not strictly considered part of the prototype. These sensors are considered to be part of the vessel´s equipment and the AVIS prototype can make use of them, but they are not part of the prototype definition.

Therefore, when the prototype is delivered by the end of the project as D5.3 deliverable, it will consist of those element considered to analyze and show the added vale of EU-Space data, i.e. a GNSS antenna, an ASGARD receiver, a laptop PC with connection to the Copernicus server and with the inland ECDIS SW installed including the modifications to integrate the EU Space data.

Two GNSS receivers are planned to be used in parallel for the execution of the AVIS pilot. This idea is based on being able to test different functionalities at the same time. This is intended to have one receiver operating with multi-constellation and multi-frequency and the other receiver having OSNMA connected to provide spoofing alerts or EGNOS.As a note, a solution with two independent receivers would also allow cross-checks to increase the safety of navigation, however, this would imply a higher cost solution.

Auxiliary equipment and sensors that could be used in pilots include:

- COMPASS (GNSS-based)
- AIS receiver
- RADAR

Regarding connectivity, generally ships usually have 4G/5G connection, however, for the prototype we propose to use a dedicated 4G connection to avoid vessel dependencies.

With this, the design for the prototype, using auxiliary equipment and sensors, would be as shown in the following figure:

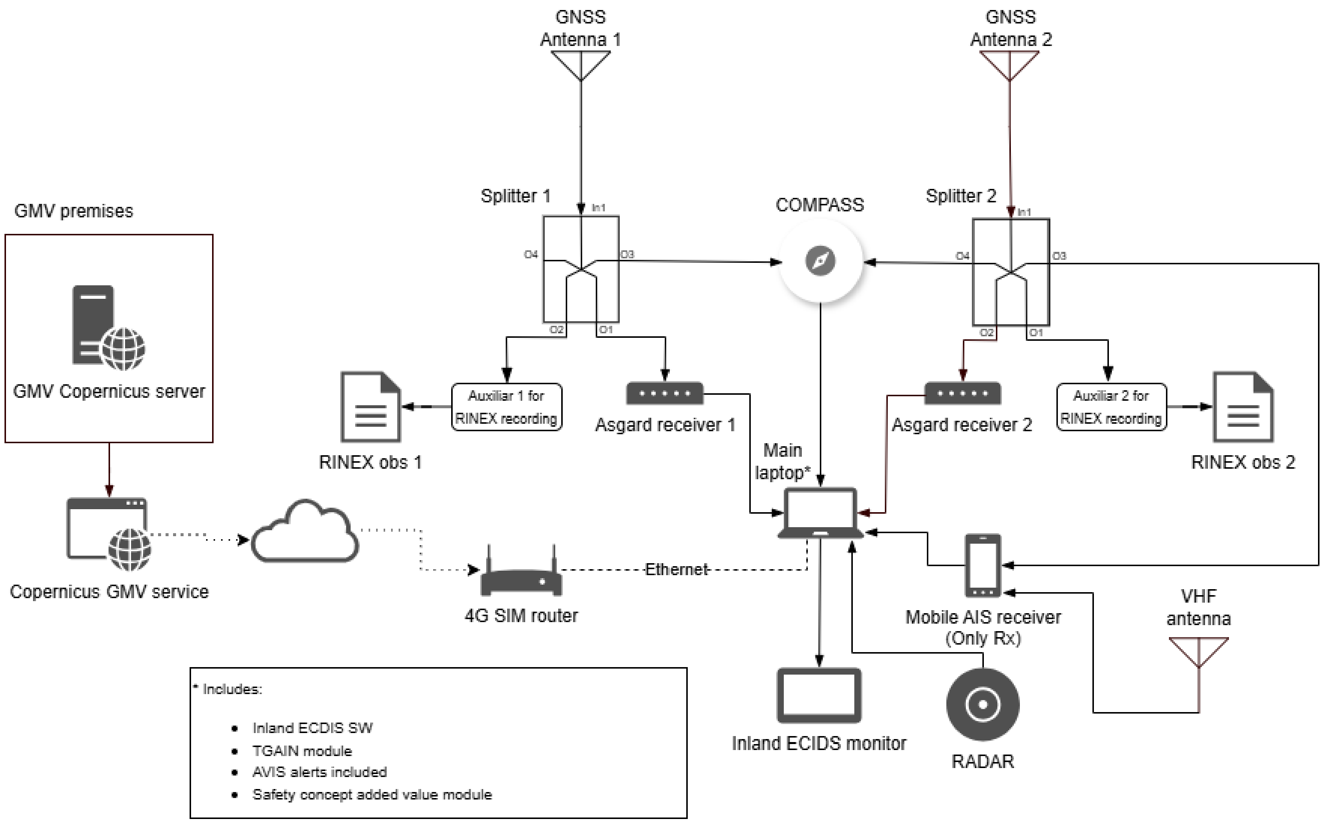

Figure 8-1: AVIS prototype design

AVIS project is funded by the European Commission. Results are property of the European Commission.

9. INDUSTRY PROPERTY RIGHTS

The IPRs for the tools owned by the consortium are shown below.

Table 9-1 List of pre-existing rights

Items	Definition/Description of pre- - existing intellectual property right	Owner	Specific limitations and/or conditions for implementation
GMV tools: magicGNSS, magicPPP, magicSBAS, EETES, elcano & polaris	For a description of GMV tools, please refer to Volume 4, section 4.5 within this proposal. SW elements of GMV's magic Suite are used for performance analysis. The results (deliverables) will not incorporate any of these tools.	GMV	
Patent: IBPL EP Publication: 08380133.2	Autonomous Integrity Algorithm based on the Isotropy Assumption. Patent Title: "Procedimiento para determinación autónoma de niveles de protección para posicionamiento GNSS basado en residuos de navegación y en una relación de confianza isotrópica". Development of the patent was GMV´s fully funded under GMV´s own R&D programme.	GMV	Its use is granted for the development of the system and for demonstration purposes only in the frame of the project during the project duration.
Patent: KIPL Request number: EP 14189240.6	Method for computing and error bound of a Kalman filter based GNSS position solution. Development of the patent was GMV´s fully funded under GMV´s own R&D programme.	GMV	Its use is granted for the development of the system and for demonstration purposes only in the frame of the project during the project duration.
PRESENCE_OS	Current version of GPS/Galileo multifrequency receiver, firmware and SW, for signal processing and PVT navigation with GNSS signals. It is based on the PRESENCE2 GPS SPS, PRESENCE_OS Galileo OS/PRS multi-frequency GMV receiver. The project will make exclusive use of the GPS SPS and Galileo OS functionalities, therefore the process of the PRS signals is not incorporated.	GMV	
THOR	Reconfigurable Multiband RF front end for synchronous processing of M RF chains in different GNSS bands. Thor The version in production is used in GMV the PRESENCE2 PRS Receiver, configured to process the E1, E5 and E6 GNSS bands.	GMV	
Navigis	Navigation software in information mode (basis = an ENC-viewer) shows own vessel and other vessels (AIS) on the river/canal includes a route planning module for Western Europe includes the querying of different real time (web) services like weather, berth availability, water levels, ... auto updates of ENCs, software modules and drivers aerial photography overlay wheater overlay skipper overlay also contains its own webserver to convey navigation info (chart, NMEA, sail status, ...) over the on board LAN	TRESCO	commercially marketed Tresco product - can be used in AVIS after consent of Tresco
RadarLink	Navigation software in navigation mode (certified against radar requirements) shows radar echos on top of ENCs controls the radar from software (range, PRR, tuning, off-center, ...) compatible the two common brands of inland radars connection between Tresco-PC and radar via ethernet link	TRESCO	commercially marketed Tresco product - can be used in AVIS after consent of Tresco
RadarOverlay	Older product like *RadarLink*, but the connection uses a frame grabber card instead of ethernet	TRESCO	commercially marketed Tresco product - can be used in AVIS after consent of Tresco
Fleet	Track&Trace platform for the IWW ship owners FLeet overview Geo fencing auto alarms via email or SMS auto generated reports accross customers' fleet	TRESCO	commercially marketed Tresco product - can be used in AVIS after consent of Tresco

Track Pilot	'lane assist' for inland vessels to be connected to the autopilot (Tresco is compatible with 5 most common brands of inland autopilots) steering code can use SmartTracks, waypoints, past tracks or vessel ahead to follow as guidance	TRESCO	commercially marketed Tresco product - can be used in AVIS after consent of Tresco
Dashboard	This software application shows several vessel parameters on one 'conning' screen	TRESCO	commercially marketed Tresco product - can be used in AVIS after consent of Tresco
radar extractor	New tool to detect polygons from radar images	TRESCO	commercially marketed Tresco product - can be used in AVIS after consent of Tresco
smarttracks	Ideal sailing lines accross Europe (bidirectional: up- and downstream) created from historical vessel data	TRESCO	commercially marketed Tresco product - can be used in AVIS after consent of Tresco
chart kernel	Tresco's chart rendering engine used in all our 'chart-showing' products We can render and combine *uStation* (Bentley Systems) vector charts, ARCS raster charts (UKHO), C-Map CM93, primar and IC-maritime ENCs and Inland S-57 formats	TRESCO	commercially marketed Tresco product - can be used in AVIS after consent of Tresco
smartrack genrator	Automatically generate SmartTracks starting from historic logged vessel data	TRESCO	commercially marketed Tresco product - can be used in AVIS after consent of Tresco