ARESIBO

HORIZON 2020

D3.3 Sensing infrastructure and collaborative optimized visual sensing

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Sensing infrastructure and collaborative optimized visual sensing
ARESIBO – GA 833805

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Abstract: This document summarizes the research carried out on the specifications of the ARESIBO system, in order to describe the characteristics, functionalities and the exchange of information between the sensors used in ARESIBO.

Document History

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Acronyms	Meaning
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List of Acronyms

Acronyms	Meaning
3D	Three dimensions
B&W	Black & White (camera)
C2	Command and Control
CS	Control Station
EO	Electro-Optical
GCS	Ground Control Station
GDT	Ground Data Terminal
GPS	Global Positioning System
IR	Infra-Red
RC	Radio Control
RF	Radio Frequency
RGB	Red-Green-Blue (camera)
RLOS	Radio Line of Sight
UAV	Unmanned Aerial Vehicle
UGV	Unmanned Ground Vehicle
USV	Unmanned Surface Vehicle
UUV	Unmanned Underwater Vehicle

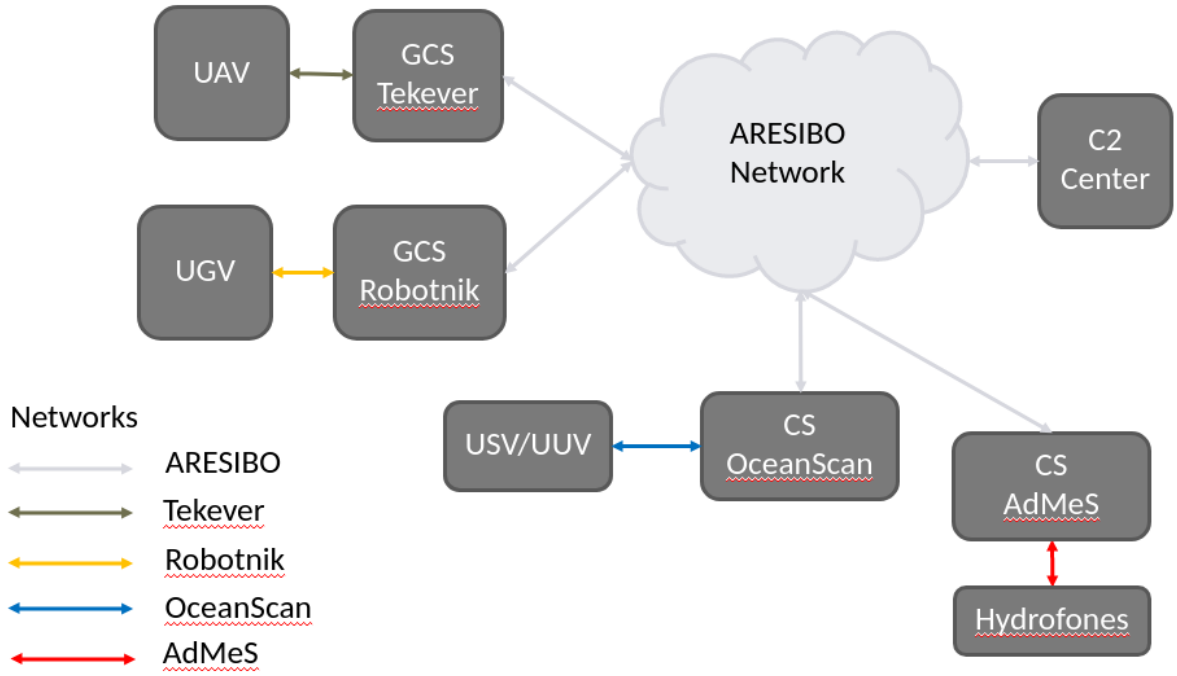
1 Executive summary

The goal of Work Package 3 (WP3) is the development of the second technological pillar of ARESIBO project - Augmented Intelligence for integrated situation awareness. In this way, this document represents the deliverable D3.3 which aims to present the results from task 3.2 the Sensor infrastructure and wearables for field operations.

This task will be responsible for the development of a decision support tool for C2 operators targeting border security missions. Thus, a full description of the vehicles, sensors and wearables, that will be used in the project, is presented. In addition, a description of the sensors required for each of the four Project Use-Cases (PUC) is also introduced.

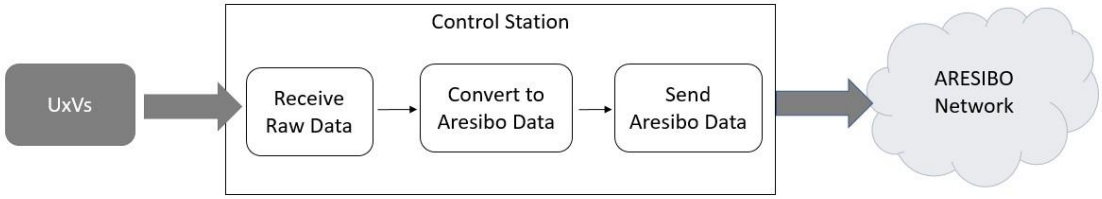
2 Introduction

The vehicles used in the ARESIBO project have their own communication networks between the vehicle and the controller. Therefore, it is necessary to integrate the ARESIBO network with the control station where the control station functions as a communication bridge between the proprietary network and the ARESIBO network. Allowing the vehicle to be viewed and controlled by C2.



2.1 Data Conversion

The various CS of the technical partners will have the responsibility to translate their information that is in a proprietary format to the format used in ARESIBO and send it to the Kafka server.



Each technical partner is responsible for converting their data to the ARESIBO format and sending it to the Kafka server whenever possible.

3 Vehicles

3.1 UAV

3.1.1 AR3 Net Ray

The AR3 Net Ray is a small Unmanned Aerial System (UAS) with medium endurance (up to 10 hours), specially designed for maritime and coastal surveillance missions, but also supporting different types of land-based operations. Due to its communications range of up to 80 Km, as well as its reduced logistics footprint (short set up time and easily installable launch and recovery system), the AR3 platform meets all the requirements to support vessel-based operations. In fact, this platform is launched using a highly mobile catapult system and can be recovered by parachute and airbags (standard recovery option for land-based operations) or with a net system (specifically designed for maritime operations), making it extremely easy to assemble, operate and store.

Property	Value
Dimensions	3.4 x 1.7 m
Maximum Take-off Weight (MTOW)	21.7 Kg
Standard empty weight	16.7 Kg
Maximum payload capacity	5 Kg
Service ceiling	3600 m
Absolute ceiling	4500 m
Maximum endurance	10 h
Maximum communications range	80 Km
Cruise speed	100 Km/h
Maximum speed	110 Km/h
Communications	RF Data Link
Navigation	GPS

3.1.2 AR4

The TEKEVER AR4 system includes the unmanned aerial vehicle (UAV), the GCS and the GDT for providing the data link between the UAV and the GCS. The air vehicle is driven by a push propeller. It is hand launched and has the option of landing using its belly or a parachute. It consists of a fixed-wing UAV that is controlled by a GCS via RLOS communications and delivers video and/or telemetry information from EO/IR image sensors in real time. The UAV can be controlled by the Autopilot or in Manual mode by the Safety Pilot using a RC transmitter (when the last one is available in the system).
The GCS consists of a single rugged laptop that provides all features for operating the system. It is connected to the GDT through either wireless or wired connection.

Property	Value
Dimensions	2.1 x 1.35 m
Maximum Take-off Weight (MTOW)	4 Kg
Maximum payload capacity	1 Kg
Maximum endurance	2 h
Maximum communications range	80 Km
Cruise speed	54 Km/h
Maximum speed	54 Km/h
Communications	RLOS
Navigation	GPS

3.2 UGV

3.2.1 RB-Car

RB-Car is the automation of an all-purpose vehicle, with Robotnik's own technology for autonomous outdoor navigation, which can include the required sensors and hardware for the project. It can carry two people.

Property	Value
Dimensions	2.79x1.47x1.85 m
Weight	800 Kg
Payload	453 Kg
Speed	12 m/s, 40 Km/h
Enclosure class	IP54/65
Traction system	2WD or AWD with Ackermann steering
Autonomy (standard without load)	10 h
Batteries	8x12V@60A
Traction motors	30 Hp
Maximum slope	80%
Applications	Surveillance and Remote monitoring Military

	Access to hazardous areas R&D
Communications	4G/ Long Range Wi-Fi
Navigation	GPS

3.2.2 Summit XL

Robotnik Summit XL is a small outdoors robot that has skid-steering kinematics based on 4 fight power motor-wheels. Each wheel integrates a hub brush-less motor with gearbox and encoder. Different mechanical configurations can be mounted that increase the robot clearance and the shock absorption by the suspension. Several sensor payloads can be mounted on the robot.

Property	Value
Dimensions	0.722x0.613x0.416 m
Weight	45 Kg
Payload	20 Kg
Speed	3 m/s, 10 Km/h
Enclosure class	IP54/65
Traction system	Skid steering/Omni
Autonomy (standard without load)	5h
Batteries	LiFePO4 / 15Ah@24V
Traction motors	4x250W
Maximum slope	80%
Applications	Surveillance and Remote monitoring Military Access to hazardous areas R&D
Communications	4G/ Long Range Wi-Fi
Navigation	GPS

3.3 USV/UUV

3.3.1 USV – Durius-1

DURIUS is a small, compact Autonomous Surface Vessel designed to operate in protected waters, such as harbours and lakes. DURIUS low visual signature is possible because the torpedo-shape floats are almost totally underwater when the DURIUS is deployed.

Property	Value
Endurance	12 hours @ 2 knots 7.5 hours @ 3 knots
Speed	5 knots
Size	150x48x96cm (LxWxH) without antennas
Weight	41kg
Navigation	GPS
Communications	GSM/ Wi-Fi/ Acoustic Modem

3.3.2 UUV - LAUV

LAUV® – Light Autonomous Underwater Vehicle is a lightweight (one-person-portable) and cost effective Autonomous Underwater Vehicle designed to be rugged and simple to deploy, operate and recover by a single person.

Property	Value
Depth rating	100m
Endurance	4.5 hours @ 2 knots 3.5 hours @ 3 knots
Speed	5 knots
Hull diameter	15cm
Length / Weight	185cm / 27kg
Navigation	GPS
Communications	GSM/ Wi-Fi/ Acoustic Modem
Side-Scan Sonar	Deep Vision Dual freq 340/680kHz
RGB Camera	1936x1216 pixels underwater resolution 2.56mm/pixel @5m from target

4 Sensors

4.1 Camera

Camera are cameras that generate and transmit frames of RGB images, in their multiple possible formats. It can be color or black and white cameras, because the determining factor is the format of the communication data and not the colors of the image.

4.1.1 B&W UUV

Black and white camera that aims to capture images of the seabed. It has characteristics aimed at a better capture of light that allows the capture of better photos even in non-ideal conditions. The quality factor of water and solar lighting must always be considered, in low-crystalline waters or on cloudy days the image quality will be impaired.

general specifications	
RGB imager	GenieNano M1920
Image size	1936 x 1216
Lens	12mm
FOV (h x v)	35º x 23º
Target	5m
Resolution	2.56mm/pixel
FPS	Maximum 7 frames per second

4.1.2 EO UAV

The AR3 EO camera provides imagery (high-resolution optical images and/or video streams) better suited for operations carried out during daytime. However, this sensor is also used during night-time operations, as useful information can be collected with it, if there is enough illumination covering the area of interest or suitable laser illuminators are installed on the aircraft. The EO sensor is ideal for surveillance operations, enhancing situational awareness and helping the detection of suspicious behaviour or the coordination of field teams. This is most valid in maritime domain missions, since the operational area is usually open and obstacle-free, with a clean field of view, allowing for the detection of target from greater distances.

AR3 EO sensor general specifications	
Image size	HD 720p (1280 x 720)
Lens	30x optical zoom f=4.3mm (wide) to 129.0mm (tele) F1.6 to F4.7
Horizontal viewing angle	3.7º (wide end) to 2.3º (tele end)

4.1.3 Camera UGV

The camera captures an image of the environment around the vehicle, allowing a better analysis and setting of the operator in the situation of the terrain that the vehicle is on.

general specifications	
RGB imager	Axis M1552
Image size	1920 x 1080
Lens	4.7–47mm, F1.6–3.0
FOV (h x v)	62º x 37º to 7º x 4º

4.1.4 Camera Wearable

As there are several wearable devices, there are also several RGB cameras used. The descriptions of each camera are in the equipment descriptions. But all cemeteries follow the same characteristics of quality 1080p and 30FPS, in addition to sending images over wireless networks.

4.2 *Thermal Camera*

4.2.1 IR Sensor UAV

The IR camera that is typically installed on the AR3 UAV is ideally suited for surveillance and target detection operations carried out both during the day and at night. Being a thermal camera, this sensor provides a sensitive detection of humans, metallic objects, fire outbreaks and other targets or incidents on land or at sea, even in dense environments. The main specifications of the IR sensor typically used with the AR3 are presented in table below:

AR3 IR sensor specifications	
Thermal imager	Uncooled LWIR VOx Microbolometer
Spectral band	7.5 – 13.5 µm
Image size	640x480
Lens	19 mm f/1.25 (wide view)
FOV (h x v)	32º x 26º
Sensitivity	<50mK @ f/1.0

Scene range	-40.0ºC to 550ºC

AR4 IR sensor specifications	
Thermal imager	LWIR
Image size	640x512
Lens	25 mm
FOV (h x v)	25º
Scene range	40.0ºC to 550ºC

4.2.2 Thermal Camera UGV

Thermal cameras are cameras that measure light in the infrared wavelength, thus allowing to measure the heat emitted by an object. They are used in border surveillance to measure heat emitting bodies, as they can operate in conditions of low ambient light conditions.

UGV Thermal Camera specifications	
Thermal imager	Axis Q1942
Spectral band	8 – 14 µm
Image size	640x480
Lens	19 mm f/1.25 (wide view)
FOV (h x v)	31º x 23º
Sensitivity	NETD < 50 mK

4.3 Side-scan

Side-scan sonar is a category of sonar system that is used to efficiently create an image of large areas of the sea floor.
The side-scan sonar can provide an understanding of the differences in the type of material and texture of the seabed. Side-scan sonar images are also a tool commonly used to detect items and other obstructions under the sea.

Side-scan specifications	
Model	DeepVision
Frequency	Dual freq 340/680kHz

4.4 *Acoustic Modem*

Acoustic modem for communication with the UUV while submerged. It allows a vehicle status report and sending commands in case of emergency. Due to the low transfer rate, it is not possible to transmit the data collected by the vehicle's sensors.

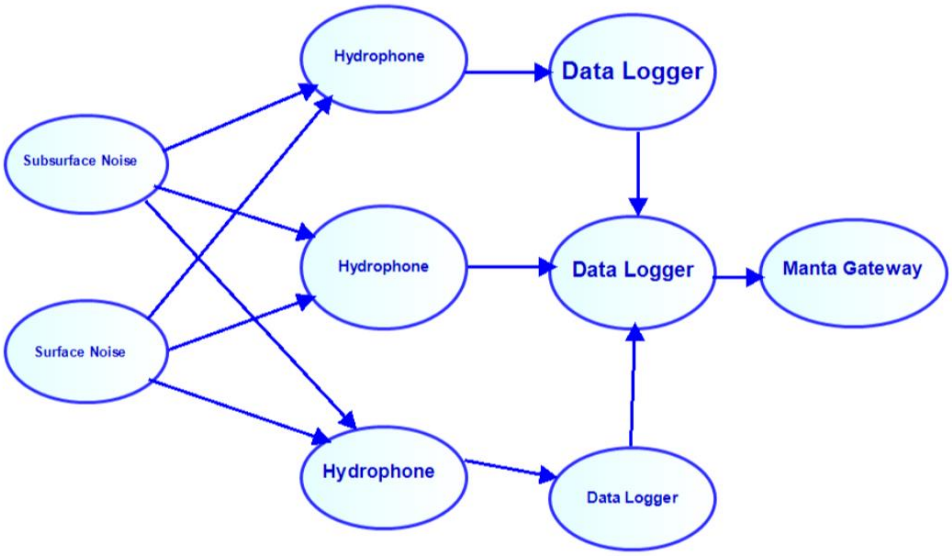
Acoustic Modem specifications	
Model	WHOI Micro-modem
Bandwidth	80bps
Range	2km
Frequency	20-30kHz

4.5 Hydrophones

The installation of hydrophones will provide monitoring of underwater and surface noise. The system will be capable of recording data from surface ships that travel at very low speed (approx. 10kts) and from underwater vehicles inside a 2 nautical mile diameter.

The hydrophones will be installed on buoys and will operate independently. They will provide data to Manta Gateway for further transmission or analysis to a control room. It will be designed for long term operation with solar panels and Batteries.

The installation will provide data in frequencies from 1 to 60kHz on maximum depth of 900m. The noise of surface and subsurface vessels will be captured (in a range of 2 nautical miles) and sent wirelessly to a data logger.



5 Communication

5.1 OceanScan Network

Manta Communications Gateway works as a plug-and-play communication hub, supporting seamlessly wireless and acoustic communication between the operator and the LAUV, enabling extended connection range. It allows multiple operators to control and monitor multiple vehicles in a networked environment.
Due to media limitations, it is not possible to access the data collected by the sensors in real time. These data are accessed at the end of the mission.

5.2 Tekever Network

Tekever has two distinct communication networks, RF Datalink for AR3 and RLOS for AR4. Both networks allow full control and access to real-time data collected by the sensors.

5.3 Robotnik Network

The network can be operated via Wi-fi Long Range or 4G. Even if both networks allow full control and access to real-time data collected by the sensors, the manufacturer advises the use of 4G whenever coverage is available.

6 Wearables

Wearables are technologies that are presented in the form of devices that are the same or similar to pieces of clothing or wearable equipment, such as watches, bracelets or even virtual reality glasses.
At ARESIBO, they will be used to communicate and monitor the action of field officers. Allowing the exchange of information by audio and video and following the C2 of the progress of the mission.

6.1 Realwear HMT-1

Figure 5: Realwear HMT-1

HMT-1 is a rugged device optimized for heavy industry and outdoor environments. It can be easily mounted and can be used in combination with own glasses or helmet. It is a good option when moving between different temperature zones that include a frozen zone of -20 degrees Celsius. The battery can last up to 8 hours in use. The technical specification can be found on Table 1.

Table 1: Realwear HMT-1 Datasheet

Property	Value
OS	Android 8
CPU	2GH
RAM	2GB
Internal Storage	16GB
Wifi	802.11a/b/g/n/ac, Ht20/40 (2.4/5GHz)
Display	854 x 480px
Camera	1080p;30fps Auto Focus
Audio	4 Digital mini microphones
Internal Battery	3240mAh
Weight	380g

6.2 iPad Pro

Figure 6: Fourth-generation 11" iPad Pro – Field Commander AR device

Technical details (see Table 2) on the Fourth-generation 11" iPad Pro upon which the ARESIBO Field Commander will use:

Table 2: iPad Pro Datasheet

Property	Value
Developer	Apple Inc
Manufacturer	Foxconn
Product Family	iPad
OS	IOS (2015-2019) IPadOS (2019-present)
Storage	32,64,128,256,512 GB or 1 TB
Display	11-inch: 2388 x 1668 px

Graphics	12-core PowerVR Series 7XT
Sound	Four speakers, adjusting sound to device orientation
Camera	4K 11-inch: 7 megapixels 1080p front-facing TrueDepth and 12 megapixels 4K rear-facing, Digital Image Stabilization
Connectivity	Wi-Fi and Wi-Fi + Cellular: Wi-Fi 802.11 a/b/g/n/ac; dual channel (2.4 GHz and 5 GHz); HT80 with MIMO Bluetooth 4.2[3] Wi-Fi + Cellular: GPS & GLONASS GSM UMTS/HSDPA 850, 900, 1700, 1900, 2100 MHz GSM/EDGE 850, 900, 1800, 1900 MHz CDMA CDMA/EV-DO Rev. A and B. 800, 1900 MHz 12.9-inch Wi-Fi + Cellular: LTE Multiple bands 1, 2, 3, 4, 5, 7, 8, 13, 17, 18, 19, 20, 25, 26, 28, 29 and TD-LTE 38, 39, 40, 41

6.3 Microsoft HoloLens 2

Figure 7: HoloLens 2 – C2 Operators AR device

Technical details (see Table 3) on the latest release of Microsoft HoloLens 2 upon which the ARESIBO C2 operator will use:

Table 3: Microsoft HoloLens 2 Datasheet

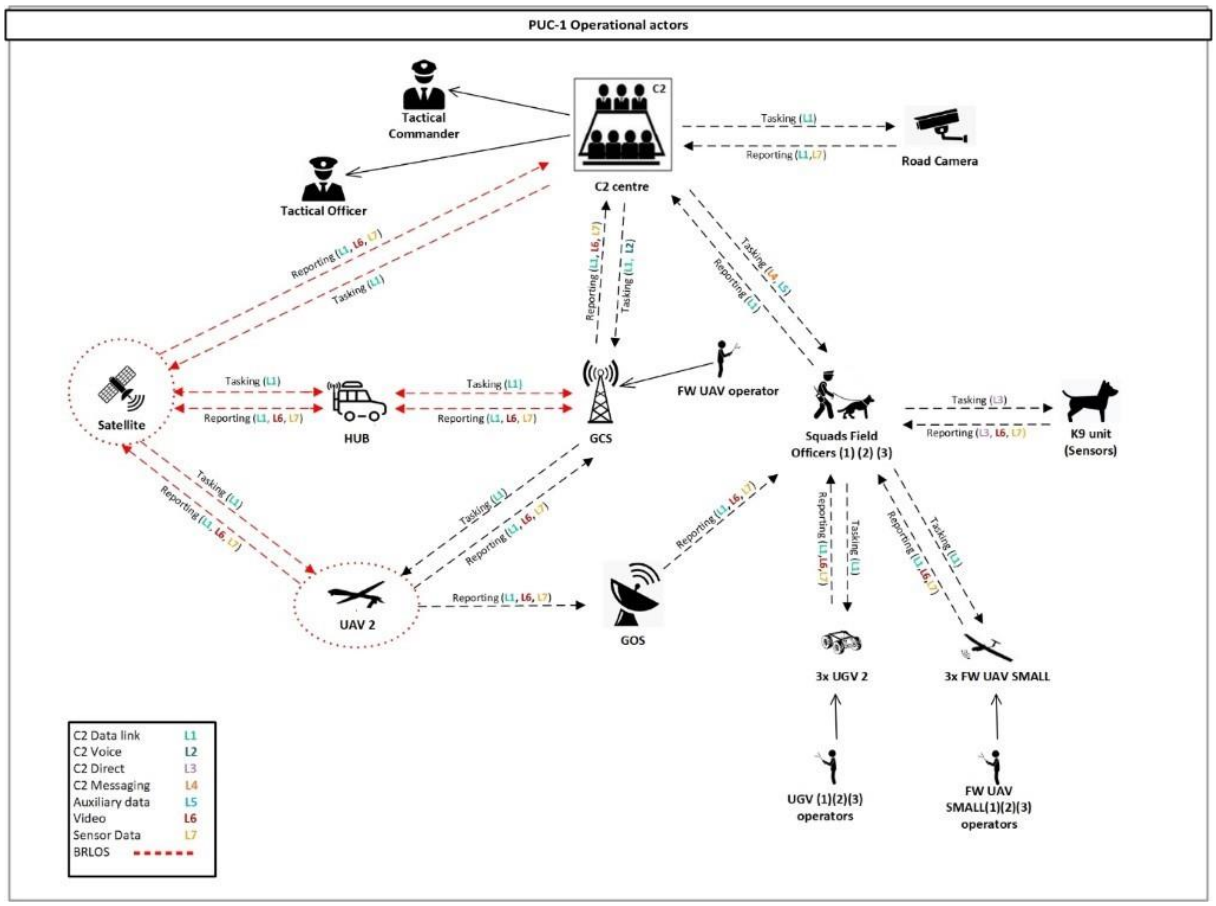
Display	
Optics	See-through holographic lenses
Resolution	2k 3:2 light engines
Holographic density	>2.5k radiant
Eye-based rendering	Display optimization for 3D eye position
Sensors	
Head tracking	4 visible light cameras
Eye tracking	2 IR cameras
Depth	1-MP time-of-flight (ToF) depth sensor
IMU	Accelerometer, gyroscope, magnetometer
Camera	8-MP stills, 1080p30 video
Audio and Speech	
Microphone array	5 channels
Speakers	Built-in spatial sound
Human understanding	
Hand tracking	Two-handed fully articulated model, direct manipulation
Eye tracking	Real-time tracking
Voice	Command and control on-device; natural language with internet connectivity
Windows Hello	Enterprise-grade security with iris recognition
Environment understanding	
6DoF tracking	World-scale positional tracking
Spatial Mapping	Real-time environment mesh
Mixed Reality Capture	Mixed hologram and physical environment photos and videos
Compute and Connectivity	
SoC	Qualcomm Snapdragon 850 Compute Platform
HPU	Second-generation custom-built holographic processing unit
Memory	4-GB LPDDR4x system DRAM
Storage	64-GB UFS 2.1
Wi-Fi	Wi-Fi: Wi-Fi 5 (802.11ac 2x2
Bluetooth	5

For more details, consult the D5.1 delivery, which contains all the complete information on the equipment and methods of integration in the ARESIBO network.

7 Tests and Uses case

If you do not know the PUCs or want more details about the characteristics of the PUCs, it is advisable to read the delivery document D2.8 which contains all the information relevant to the test scenarios. In this chapter, the use of sensors in each specific PUC will be limited.

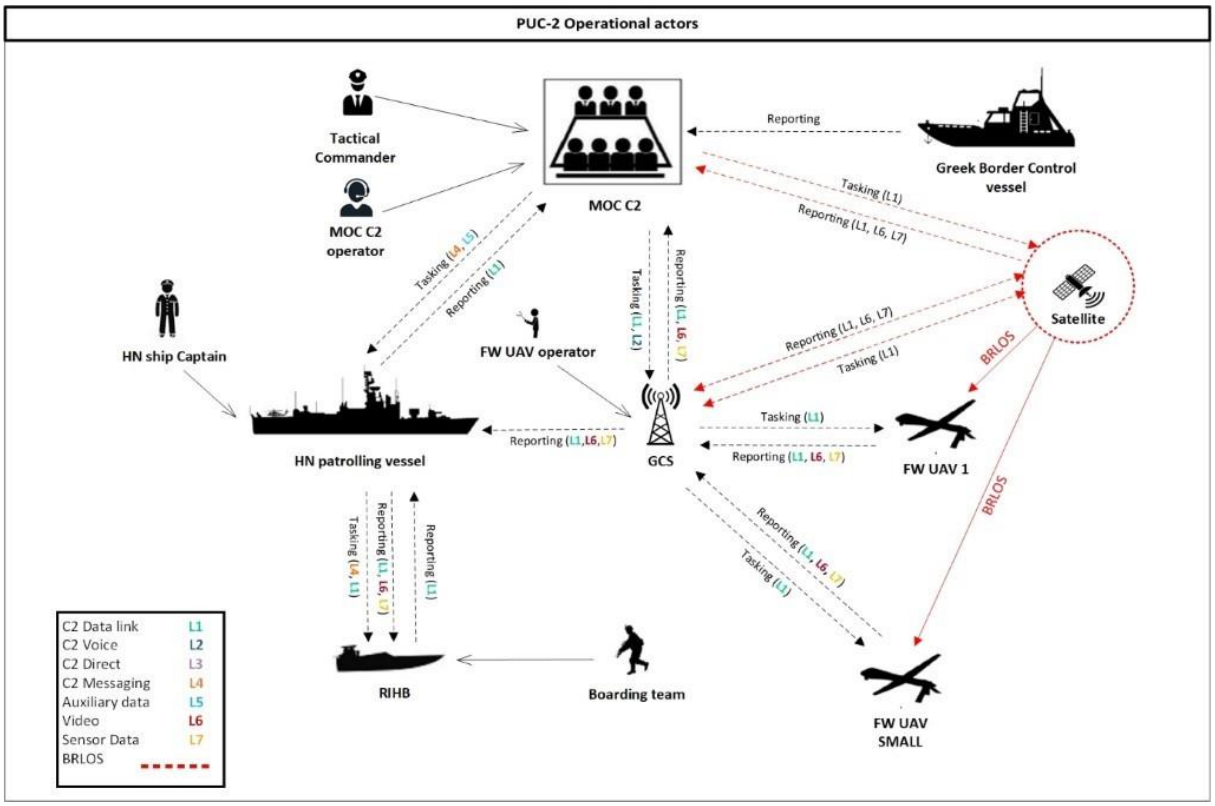
7.1 PUC1



In this first scenario, the main objective is to test the integration and use of the following sensors:

- Wearables
  - Binocular
  - Comms
  - Monocular
  - iPad
- UAV
  - EO Camera
  - IR
  - Comms
- UGV
  - RGB Camera
  - Thermal Camera
  - Comms

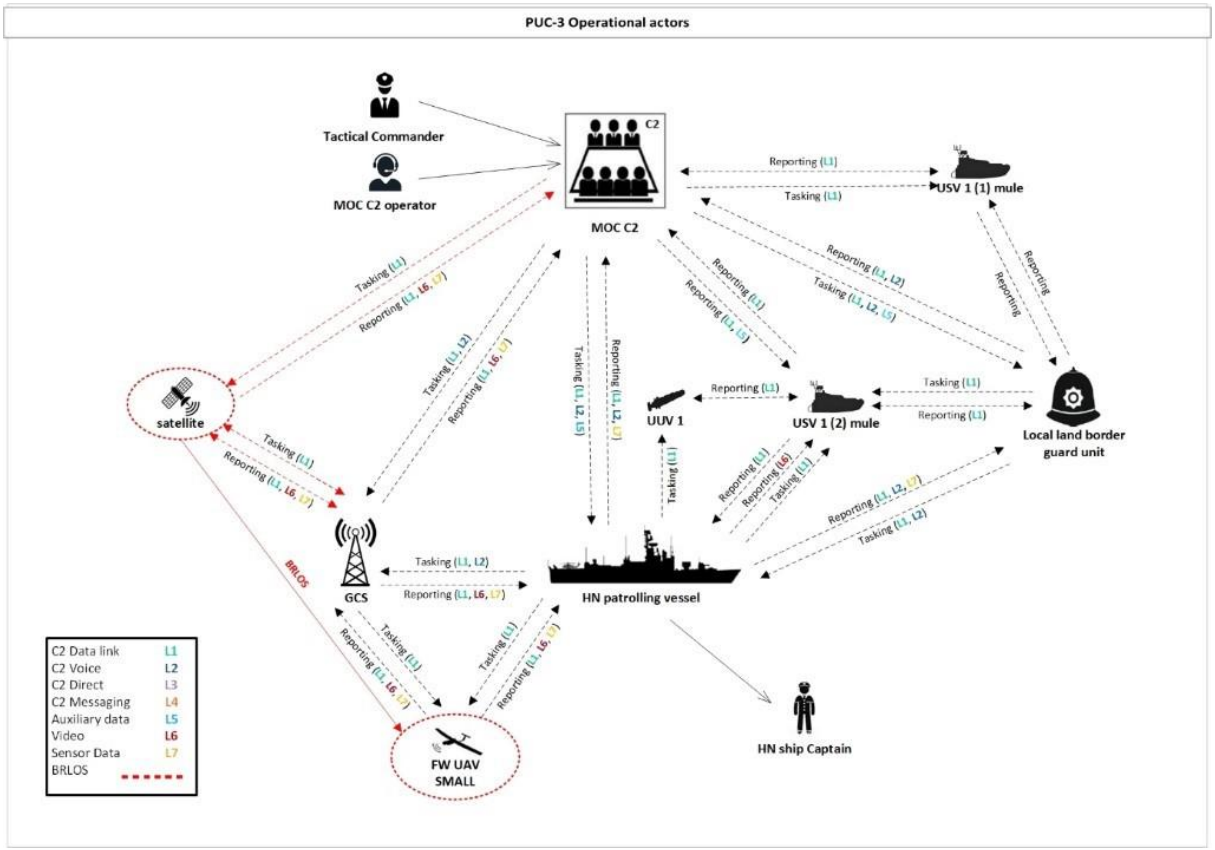
7.2 PUC2



In this second scenario, the main objective is to test the integration and use of the following sensors:

- Wearables
  - Binocular
  - Comms
  - Monocular
  - iPad
- UAV
  - EO Camera
  - IR
  - Comms

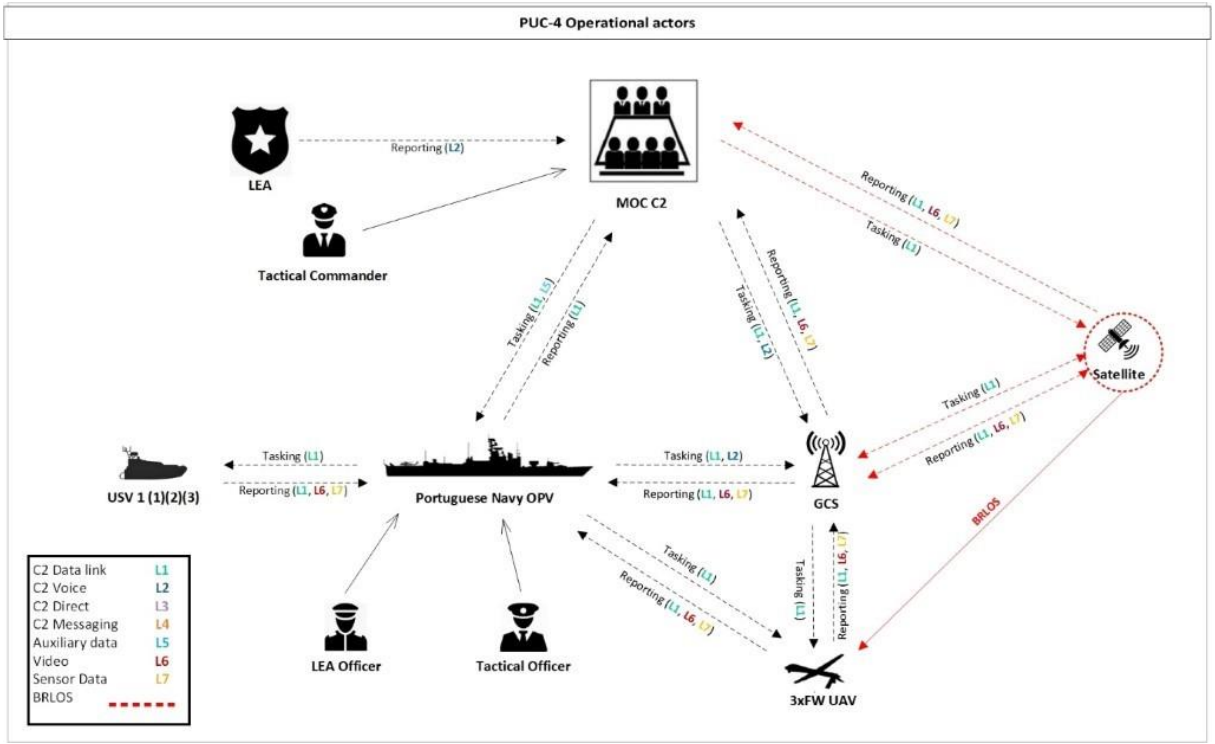
7.3 PUC3



In this third scenario, the main objective is to test the integration and use of the following sensors:

- Wearables
  - Binocular
  - Comms
  - Monocular
  - iPad
- UAV
  - EO Camera
  - IR
  - Comms
- USV
  - Without sensors defined
- UUV
  - RGB Camera
  - Side-Scan
- Underwater Acoustic Surveillance Sensors

7.4 PUC4



In this fourth scenario, the main objective is to test the integration and use of the following sensors:

- Wearables
  - Binocular
  - Comms
  - Monocular
  - iPad
- UAV
  - EO Camera
  - IR
  - Comms
- UUV
  - RGB Camera
  - Side-Scan

8 Acknowledgement

Thanks to all the technical partners and end-user entities who have contributed the necessary information to complete this deliverable.