PROJECT DELIVERABLE REPORT

Introducing advanced ICT
and Mass Evacuation Vessel design
to ship evacuation and rescue systems

D5.4 PALAEMON AR Glasses component (V2)

A holistic passenger ship evacuation and rescue ecosystem
MG-2-2-2018
Marine Accident Response

"This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 814962"

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2.0	2022/1/15	SIMAVI	The final version (reviewed)

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Abbreviations

AAA	Authentication, Authorization, and Accounting networking
AAD	Azure Active Directory
AC	Alternating current
AD	Active Directory
AR	Augmented Reality
DSS	Decision Support System
EAP	Extensible Authentication Protocol
EMM	enterprise mobility management
FCC	Federal Communications Commission
FIDO2	Fast Identity Online
GCS	Ground Control Station
GPS	Global Positioning System
HEX	Hexadecimal Number String
HMI	Human Machine Interface
HUD	Heads-Up Display
IPv4	Internet Protocol version 4
MAC	Media Access Control address
MDM	Mobile Device Management
MR	Mixed Reality
MSA	Microsoft Service Accounts
NTLM	Network LAN Manager
NUI	Natural User Interface
OOBE	Out of the box experience
PaMEAS	Passenger Mustering and Evacuation process Automation System
RF	Radio Frequency
SRAP	Smart Risk Assessment Platform
SSID	Service Set IDentifier
SSS	Ship Stability toolkit
URL	Uniform Resource Locator
WCD	Windows Configuration Designer
WU	Windows Update

1 Introduction

Augmented Reality (AR) Smart Glasses are defined as wearable Augmented Reality devices that are worn like regular glasses and merge virtual information with physical information in a user's view field. They are usually worn like regular glasses; as an alternative, they can be mounted on regular glasses, as illustrated in Figure 1-1.

a) Standalone AR Smart Glasses (https://www.microsoft.com/en-us/hololens)

b) AR Glasses over regular ones (https://us.dynabook.com/smartglasses/)

Figure 1-1. Augmented Reality Smart Glasses illustrative examples

Several technologies (e.g., camera, GPS, microphones etc.) capture physical information and augment them with virtual information that can be gathered from the internet and/or stored on the smart glasses' memory, primarily accomplished through location, object, facial, and image-based recognition technologies. This virtual information is then displayed in real-time on a display, which, in brief, is a plastic screen in front of a user's eye(s). A user can see both the offline and the virtual and the real world through these displays.

Augmented reality (AR) technologies are consistently proving their benefits in various industries and applications. Within the PALAEMON ecosystem, HoloLens Augmented Reality headset (https://www.microsoft.com/en-us/hololens/) will support a host of applications and uses that will enable users (i.e., crew members) and stakeholders to further assess and train various skills and aspects concerned to passengers, ships and transfer and boarding infrastructure overall safety. However, AR has its challenges, and the users must understand the implications and technical requirements to fully exploit such technology.

The overall objective of Task 5.2 is to provide the technical description and the development of the Augmented Reality (AR) Glasses Component, considering the users' needs and requirements.

Within the last chapters, users will have the chance to understand the prerequisites of the AR technology but also the updates mechanism for such devices.

The guide will conclude with an overview of the HMI and AR implementation within the PALAEMON project.

2 Integration of AR components as part of the PALAEMON Ecosystem

Augmented Reality (AR) components will have a crucial role in supporting the implementation of evacuation scenarios. As mentioned in the introduction, within the PALAEMON Project, the

headset used for AR components will be HoloLens 2 device from Microsoft. During the simulations, Augmented Reality will support two critical features. Firstly, Augmented Reality will be able to provide for crew members and participants real-time assistance and guidance during the bespoke scenarios, and secondly, Augmented Reality will be able to supply the crew members with vital information on ship status, changes, or updates on the evacuation strategy but also passenger and environment information.

As we can see in Figure 2-1, the AR ecosystem connects with several components and modules within the PALAEMON Reference Architecture. Within a green frame, we represent all the components that shape the AR ecosystem: the googles (as physical devices), the Messaging Server, responsible for the audio communication among crew members, the applications itself that are executed on the googles' hardware and, finally, the Heads-Up Display (HUD) that is projected on the glasses.

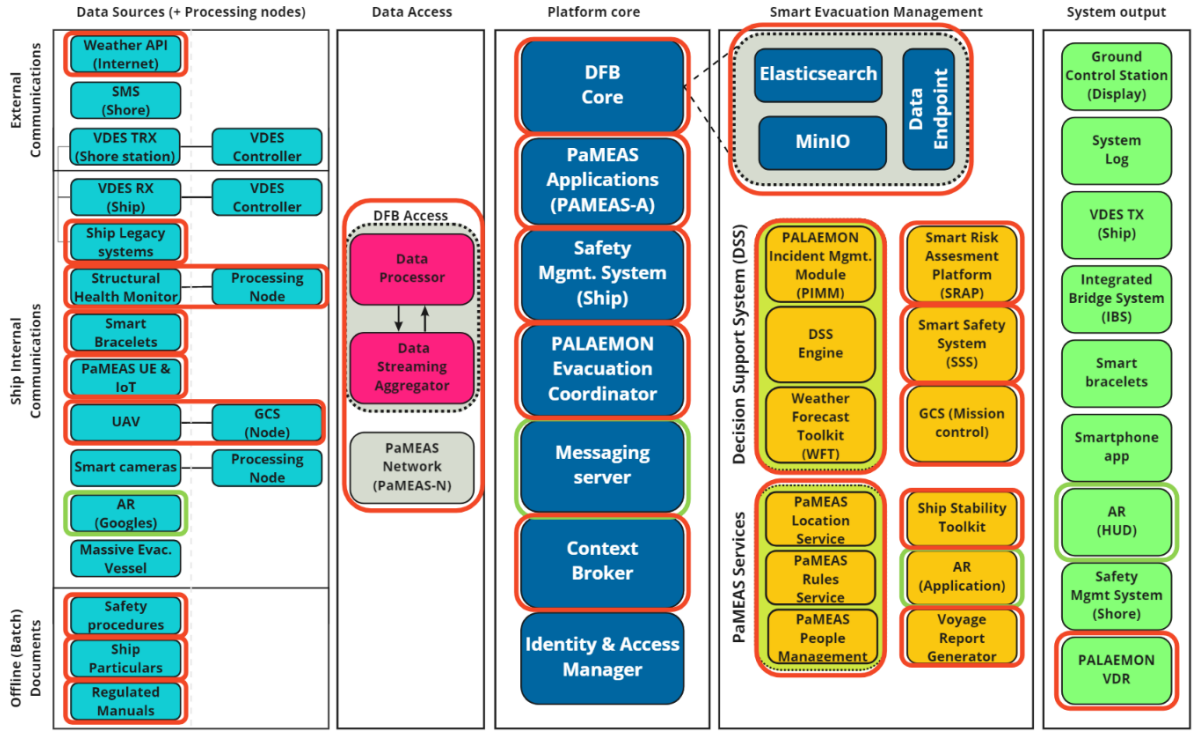

Figure 2-1. PALAEMON Reference Architecture v2, showing the components that interact with the AR ecosystem

Moreover, in red (frames), we represent all the components that have a direct or direct interplay with the AR ecosystem. In the rest of the document, we will proceed to individually address these interactions, either in the form of an information source (such as the elements that are on the left side in the figure), or the services that generate the data that is consumed by the AR app. But before that, it is worth anticipating the main connection point between AR and the PALAEMON platform: Data Fusion Bus. Basically, the AR solution will get all the information from this Bus, which works at the same time as the database (i.e., for persistence) and data endpoint, where services can query the data they want.

2.1 AR User Interface

Unlike other AR devices, Hololens 2 headsets are a more seamless way of experiencing mixed reality environments since it locks the content to the user's peripheral. Headsets allow crew members to freely move their hands and enable special gestures. By using gestures, new interactions are enabled, and Natural User Interface (NUI) designers have already started to explore their potential. This subchapter describes the technology associated with AR to understand the context for both the implemented GUI elements and the hardware used.

HoloLens offer a completely egocentric augmentation of the environment that the crewmember is viewing. Here we will present GUI Widgets for the AR headsets.

2.1.1 Gestures

Unlike any other software program, AR hand Gestures are used for performing tasks and interactions within the application.

Virtual touch gestures have been used in a similar manner as traditional touch for grabbing and touching holograms. We kept this interaction since it's the easiest and most intuitive.

Air tap was used for performing clicks. You can perform an air tap by holding your hand straight out in front of you then pointing you index finger straight up towards the sky then tapping it down and raising it back again.

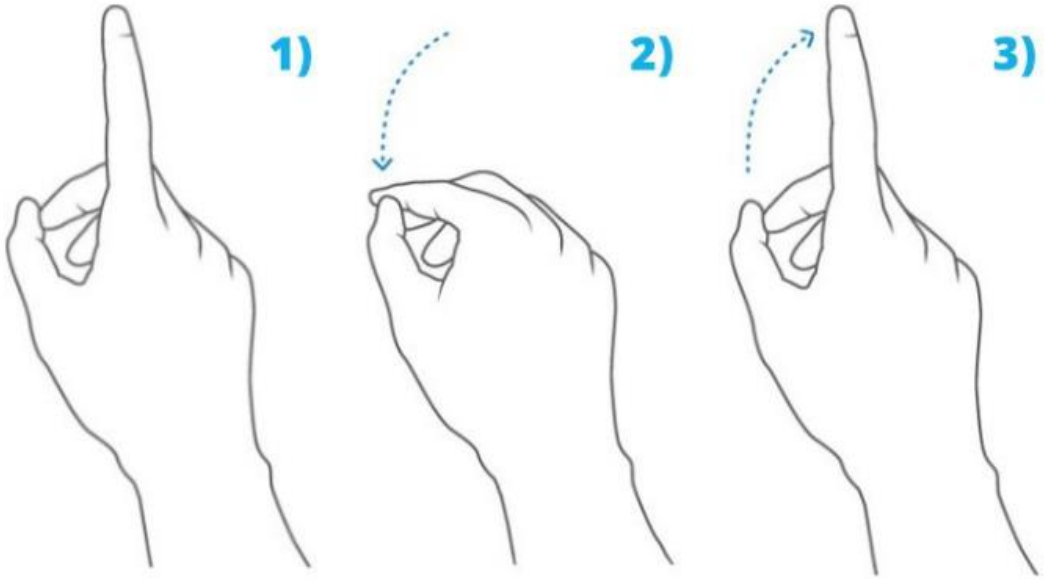

Figure 2-1 Air Tap gesture *(https://docs.microsoft.com/en-us/windows/mixed-reality/design/interaction-fundamentals)*

Home gesture also known as "Bloom" gesture is done by holding out the hand with the palm up, then merge the fingertips together and the Home command is performed.

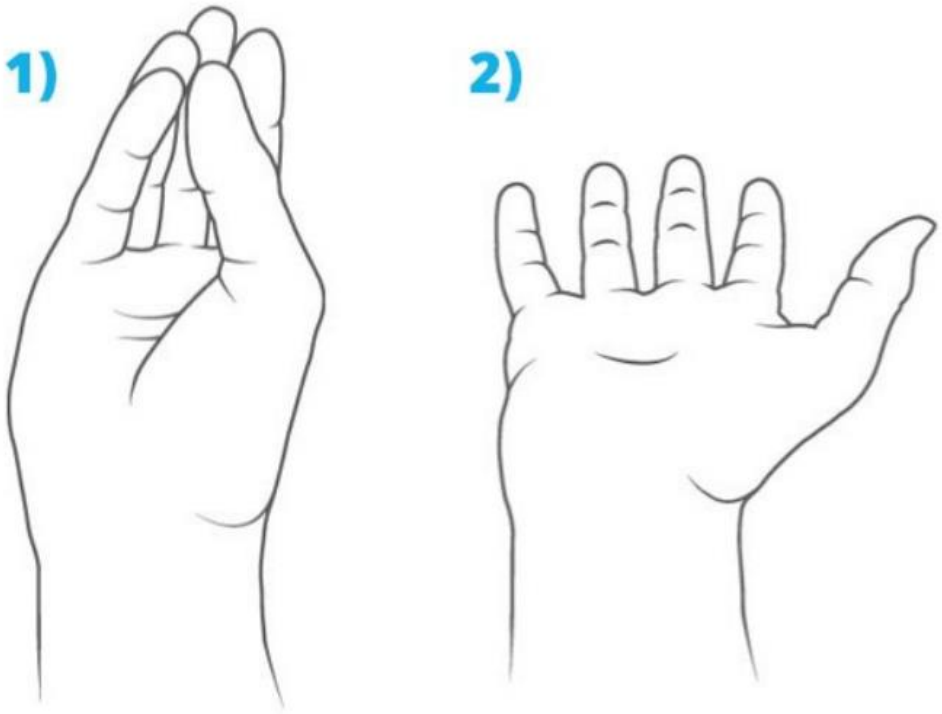

Figure 2-2 Bloom/Home gesture *(https://docs.microsoft.com/en-us/windows/mixed-reality/design/interaction-fundamentals)*

Additionally, if the user must quit the application, they can put their palm up, then touch the tip of their pointer and thumb. A window icon will appear on their wrist. If the crewmember presses the window icon with the pointer of their other's hand, the application will exit.

Figure 2-3 Home gesture *(https://docs.microsoft.com/en-us/windows/mixed-reality/design/interaction-fundamentals)*

2.1.2 Application's menu

Like any other software program, the PALAEMON AR application will load the application using a personalized loading screen. The loading screen will be displayed until the application will be loaded.

After the application is loaded, the main menu will be presented.

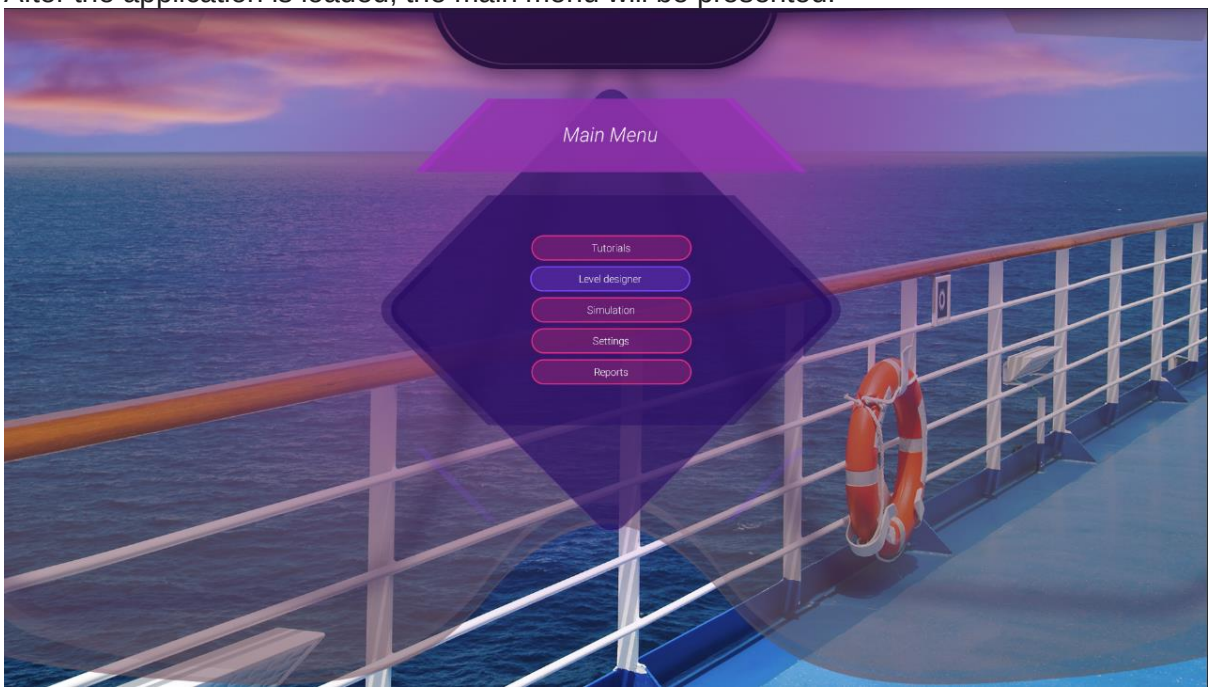

Figure 2-2 Main Menu

Within the main menu, we have:

2.1.3 Tutorials

This section allows the user to perform several short tutorials to get used to the headset navigation and controls. The tutorials will be progressive and will present all the application interactions and modules. The tutorials will present all the widgets and their functions along with the gestures used to access them.

The main role of the tutorial section is to allow the crewmembers to get familiar with the AR Headset within minutes.

2.1.4 Level designer

The level designer is built as a backup solution for running the app within a generic environment in case of a lack of a real environment. From the beginning of the project, we had the risk of accessing actual ship data. The data is mandatory for 3D mapping the entire ship to let the system know where the evacuation routes are, safe zones, etc. To overcome this risk, we decided to implement a simplified authoring tool for placing virtual objects, zone markers, simple objectives, hazards to create a mixed reality environment. Within this environment, we allow the users to experience the application. The Editor mode will be available for designated users. This functionality will not be available for the actual crew members. For the sake of illustration, the Editor provides a simplified GUI, shown in Figure 2-3.

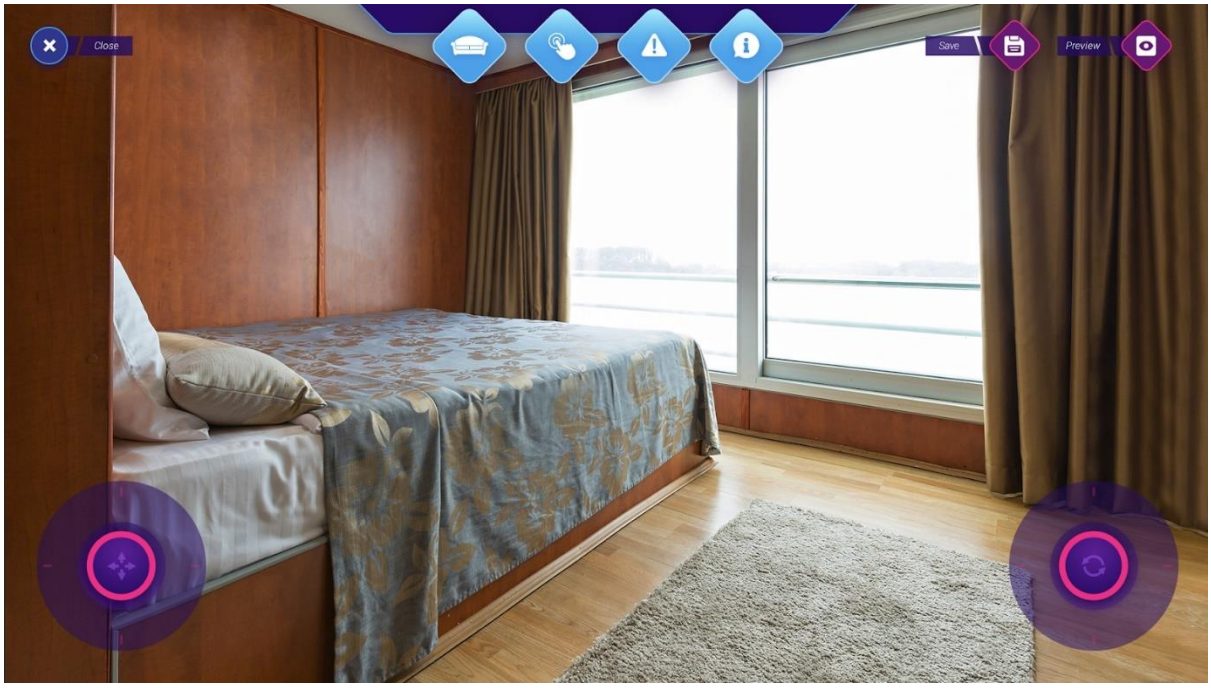

Figure 2-3 Editor GUI

On the top left, there will be the close button to get back to the main menu. On the middle top of the screen, there will be a special menu to add the interactive and static elements to the actual screen.

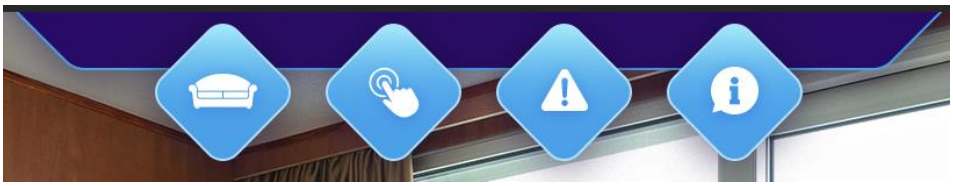

Figure 2-4 Editor Menu - Categories

Those buttons will open a horizontal scrollbar from which the editor can choose several object types:

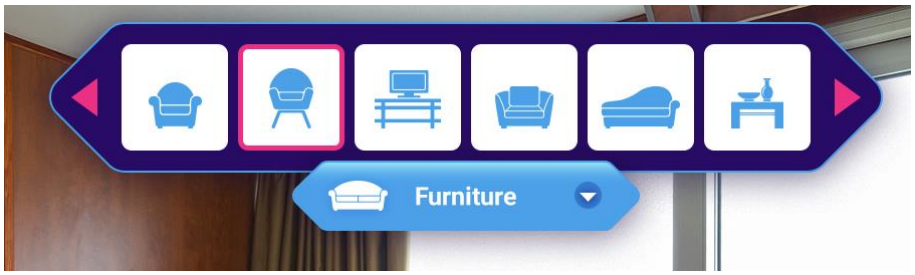

Figure 2-5 Editor Menu - Items within categories

Once the category is selected, the user is able to select one of the objects within the scroll or to change the category by pressing the drop-down menu below the scroll:

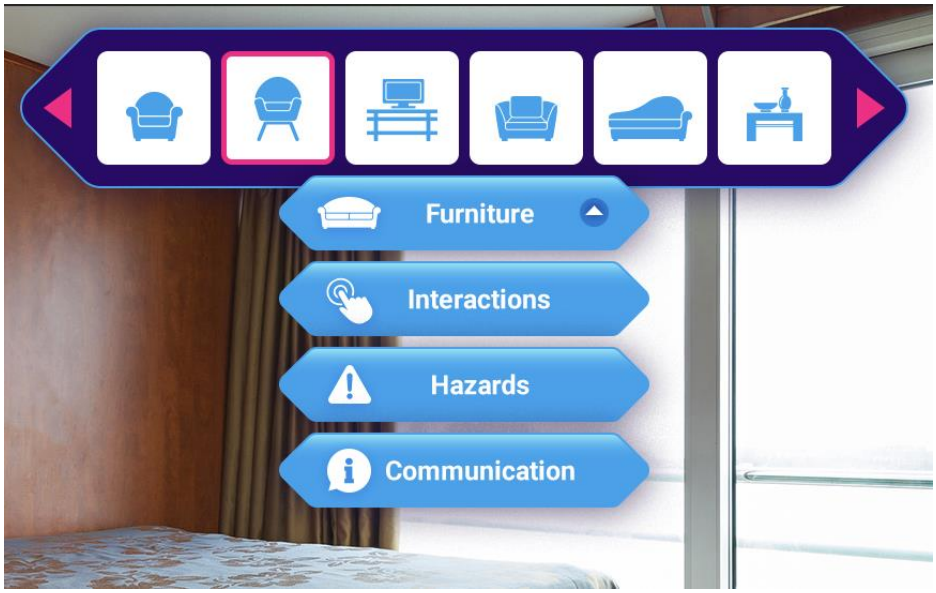

Figure 2-6 Editor Drop-down menu for categories

The interactive elements are grouped in several categories:
Furniture- allows you to place furniture items:

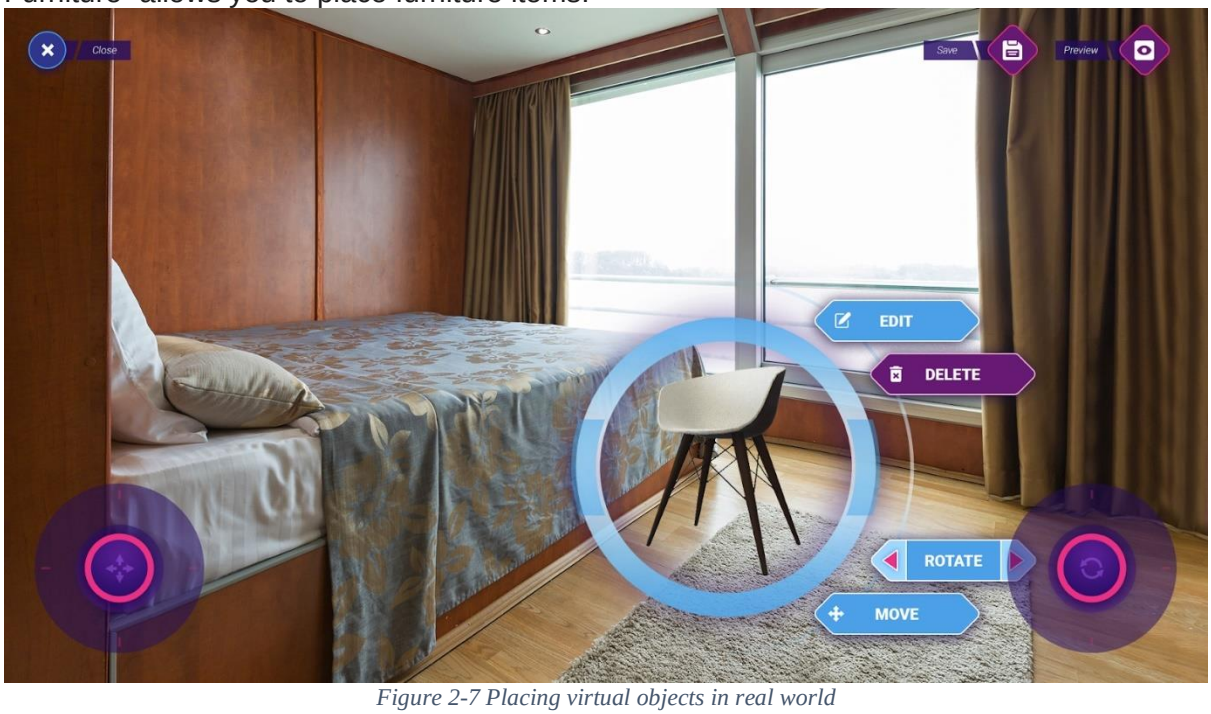

Figure 2-7 Placing virtual objects in real world

The placing menu allows the user to edit the description of the object, delete the object, rotate it and move it once it is pressed.
The edit window allows the editor will look similar to the below image:

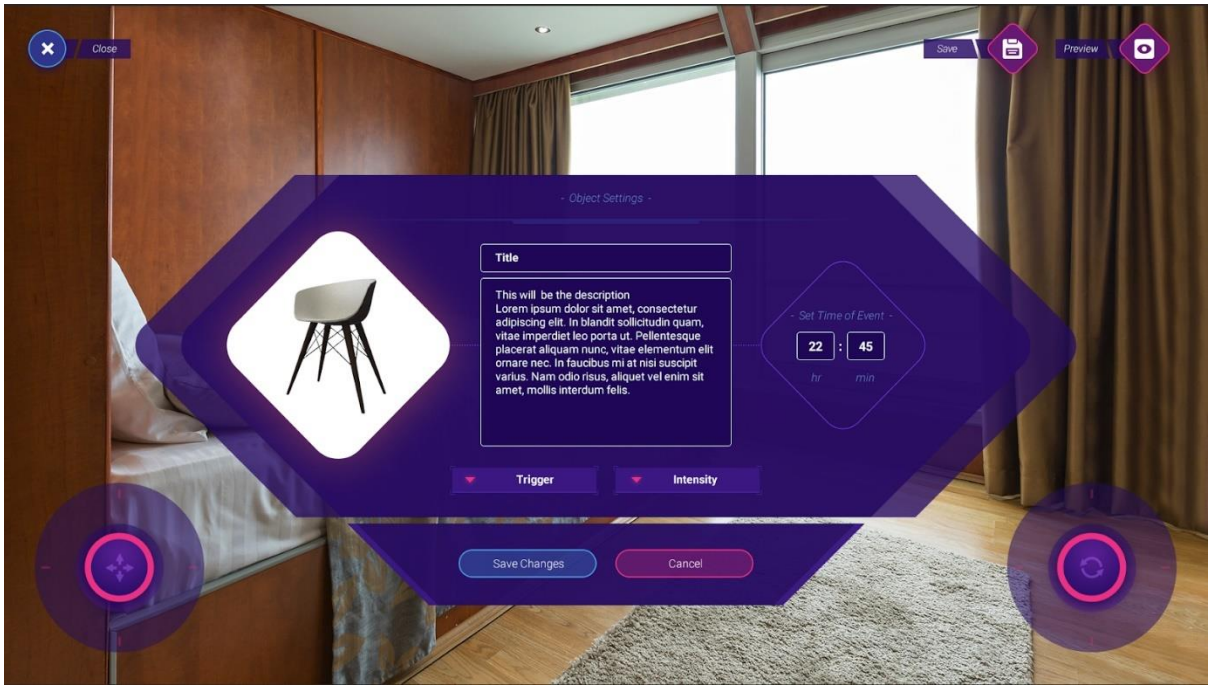

Figure 2-8 Adding descriptions to virtual objects

It allows the editor to add a description to the object, to add an interactive trigger group (perform a predefined action) and to select the intensity level of that trigger. Certain triggers will have several intensity levels.

Also, the editor can plan action by using the time menu on the right if a certain element, animation or hazard must be triggered at a certain point by planning the time

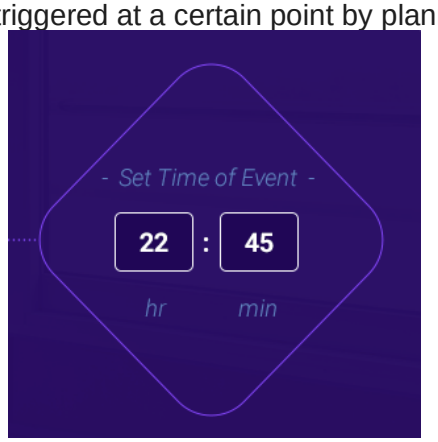

Figure 2-9 Setting time depending triggers

Once the editor is happy with the description and the triggers, he must save the changes by pressing the designated button to persist the data within the scenario.

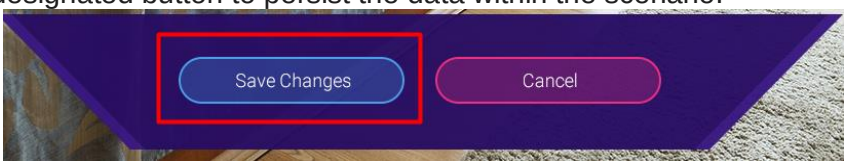

Figure 2-10 Saving a scenario

Other interactive objects planned to be developed are:

- Hazards such as fires, smoke, flood,
- interactive objects such as extinguishers, blocked doors, first aid kits
- Interactions - such as placing jammed doors, blown fuse boxes, burnt wires

- Communication - virtual messages that will appear once they perform an action or they reach a milestone.

The level designer allows crewmembers with elevated rights to place virtual messages and markers as well.

During evacuation procedures, crewmembers can mark the doors as checked (passengers have been evacuated from that area). The checkable doors can be defined before launching the MR mode within the application's main menu.

2.1.5 MR Mode

Mixed reality mode represents the main function of the application. Once users access this section, the app will try to connect to the PALAEMON System to retrieve the actual ship's data. Before the simulation, the user must log in first to use the system.

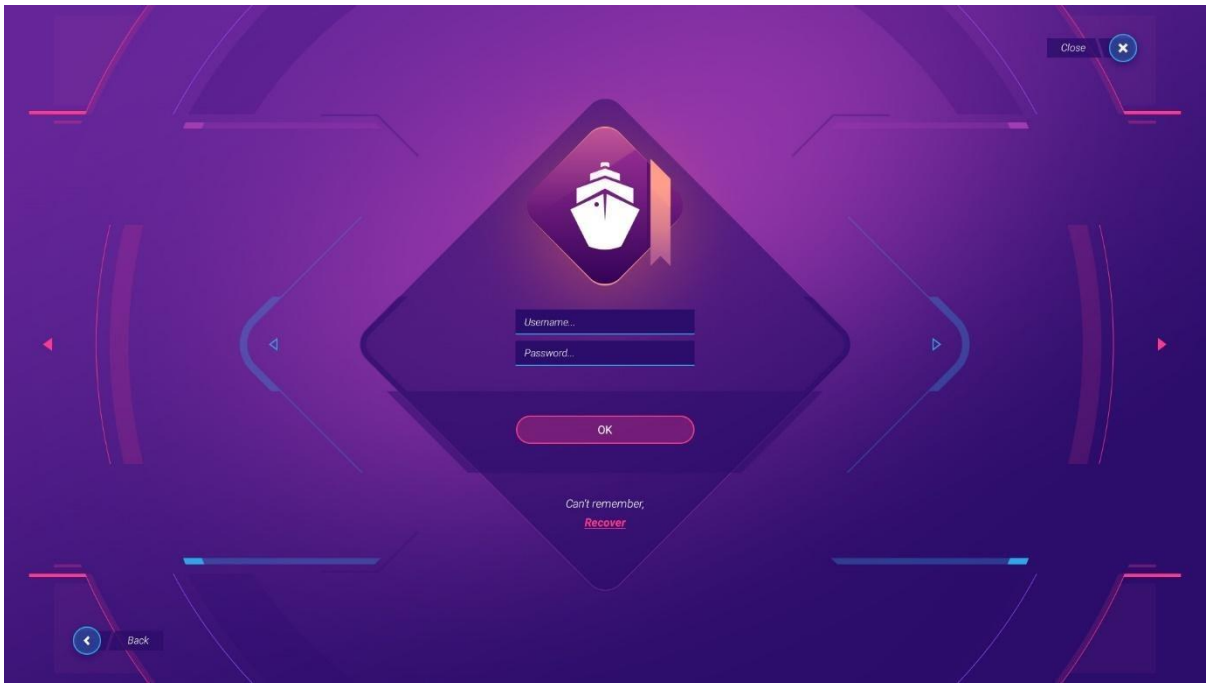

Figure 2-11 Login interface

The AR Headset application enables the connection with the server (i.e., PALAEMON system) just after the Login screen is displayed. The module (data module) handling the communication with the data server will automatically establish a connection based on basic authentication(user/password) to a specific URL.
The data module and the data server will communicate with each other by sending and receiving *.json files. This exchange of data will be done in a specific time frame that can be set within the data module. The first message to be read is the current status. For this, a JSON-based body will be sent to the data server using the topic 'evacuation-coordinator'. The communication with Data Fusion Bus is done using a Scorpio Broker *(https://scorpio.readthedocs.io/en/latest)*

More information can be found within deliverable D7.1 PALAEMON Communication Platform and D7.3 Uniform Data Exchange Modules – Interoperability Layer, where the particular details of the communication will be addressed. These documents will be published in M32 (January 2022).

```
{
    "topic": "evacuation-coordinator-*",
    "size": 1,
    "sort": [
```

```
            {"field": "timestamp", "order": "DESC"}
        ]
}
```


Figure 2-12 Login JSON data for evacuation coordinator

The PALAEMON server's response will have the following structure, where the AR application fetches the current evacuation status of the ship:


```
{
    "took": 1,
    "timed_out": false,
    "_shards": {
        "total": 4,
        "successful": 4,
        "skipped": 0,
        "failed": 0
    },
    "hits": {
        "total": {
            "value": 65,
            "relation": "eq"
        },
        "max_score": null,
        "hits": [
            {
                "_index": "evacuation-coordinator-2021.02.08",
                "_type": "_doc",
                "_id": "DtI1gXcBCVeu6s5VKaji",
                "_score": null,
                "_source": {
                    "current": 0,
                    "previous": 1,
                    "timestamp": "2021-02-08T10:34:40.732739+00:00"
                },
                "sort": [
                    1612780480732
                ]
            }
        ]
    }
}
```


Figure 2-13 PALAEMON login server's response structure

As for the actual MR layout users can see through the glasses, the HUD looks like we display in Figure 2-14.

Figure 2-14 Main MR GUI

The interface is configurable, and it's comprised of 4 main zones:

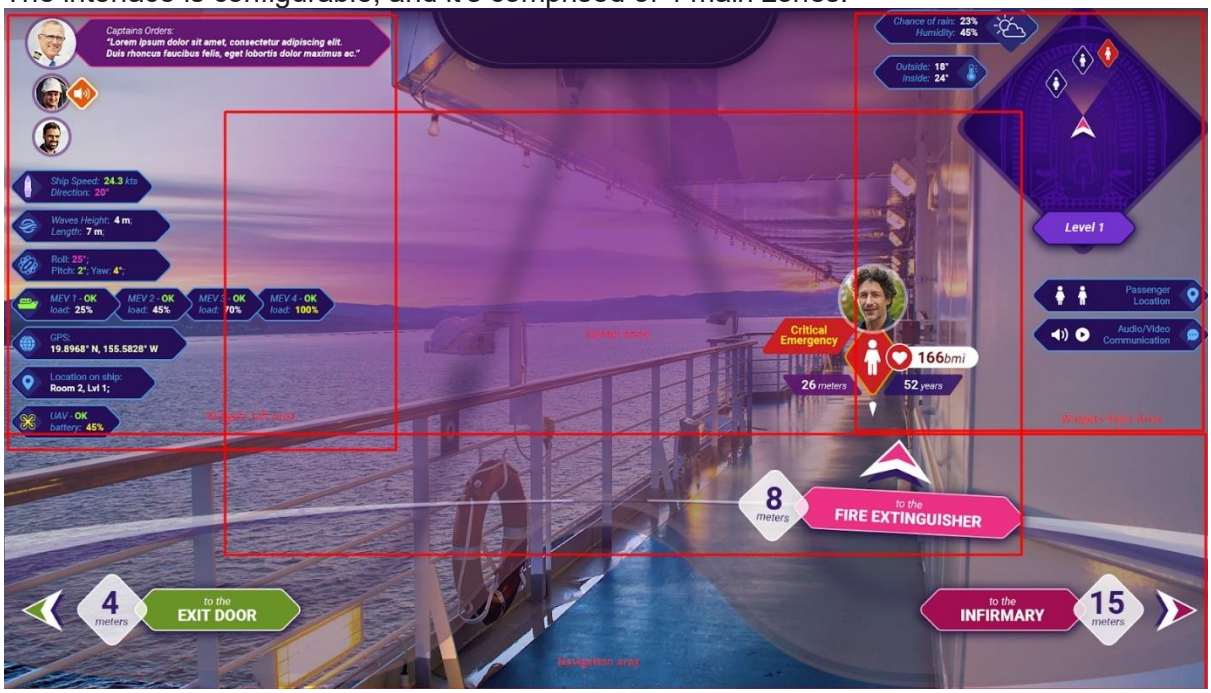

Figure 2-15 Main GUI Regions

The Left and Right zones are reserved for the widgets. They can be activated/deactivated or repositioned.
The Center Area - this area is reserved for displaying critical information, waypoints to passengers with emergencies
The bottom area which is reserved for providing guidance to the main POIs (points of interest)

2.1.6 Settings section

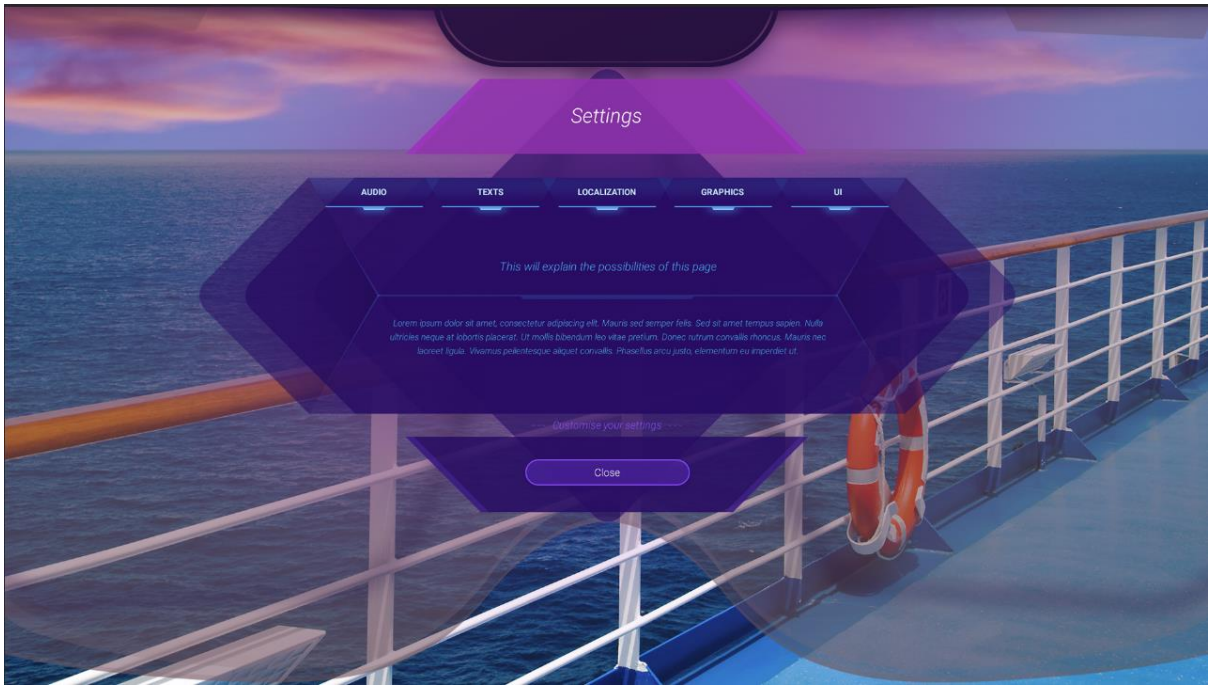

Figure 2-16 Settings Menu

This section will allow the user to change the Audio settings:

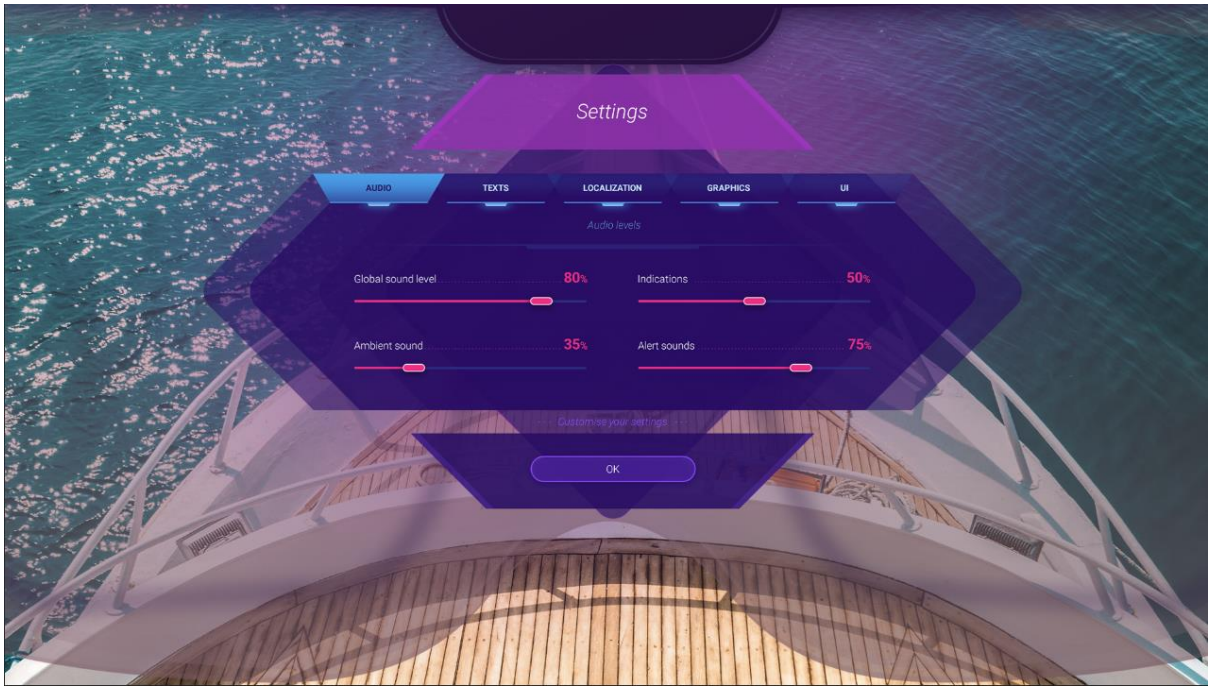

Figure 2-17 Audio Settings menu

The user will be able to customize the sound level for the alerts, for the indications, the global app sound level and ambient sounds (within rooms). The settings will be stored within the device.

2.1.6.1 Texts tab

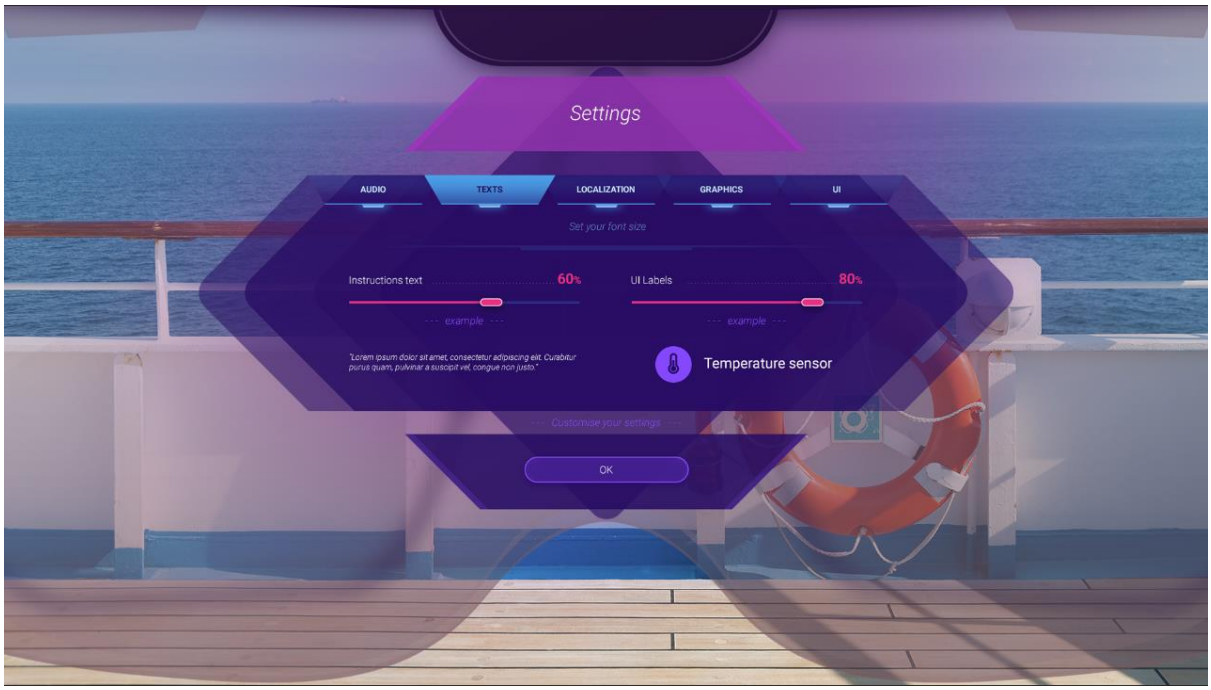

Figure 2-18 Text settings menu

This “Text” tab (Figure 2-18) within the screen will provide support for changing the text size within the interface. The texts will have preview areas and the users will be able to see the modifications in real-time:

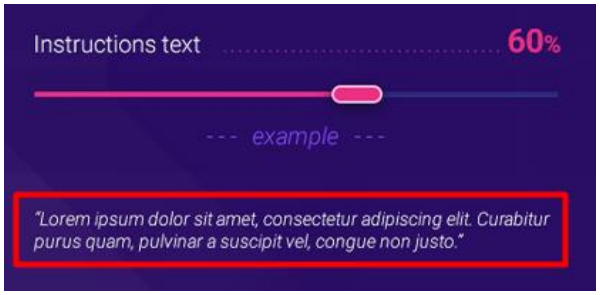

Figure 2-19 Text size preview area

The same will be for the widgets and alert texts (Figure 2-19). The users will be able to customize and view in real-time the text dimensions:

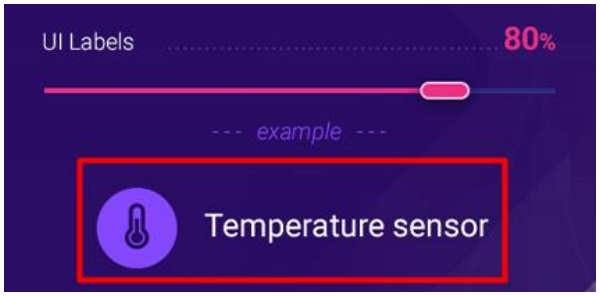

Figure 2-20 Icon size preview area

To persist in the settings, the users must click the confirmation button at the bottom.

2.1.6.2 Location tab

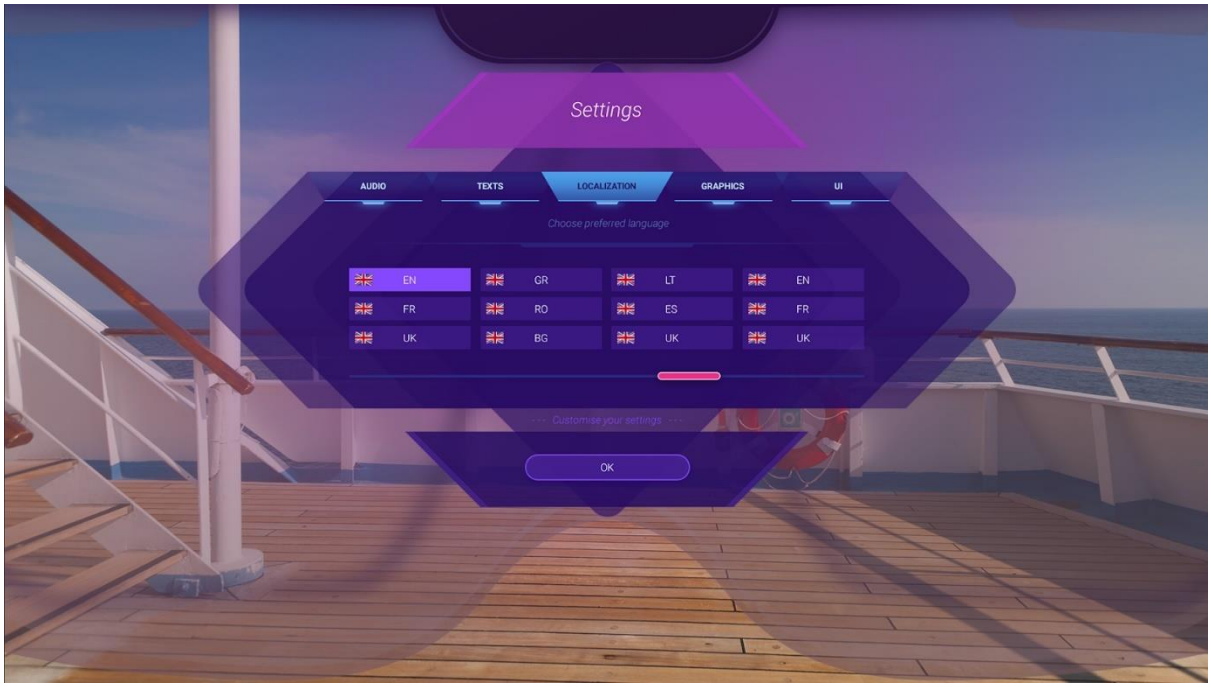

Figure 2-21 Localization menu

Within the localization tab, the user will be able to change the content UI language by simply clicking the desired language button. To persist the data, the confirmation button below the language selector will be pressed.

2.1.6.3 Graphics settings tab

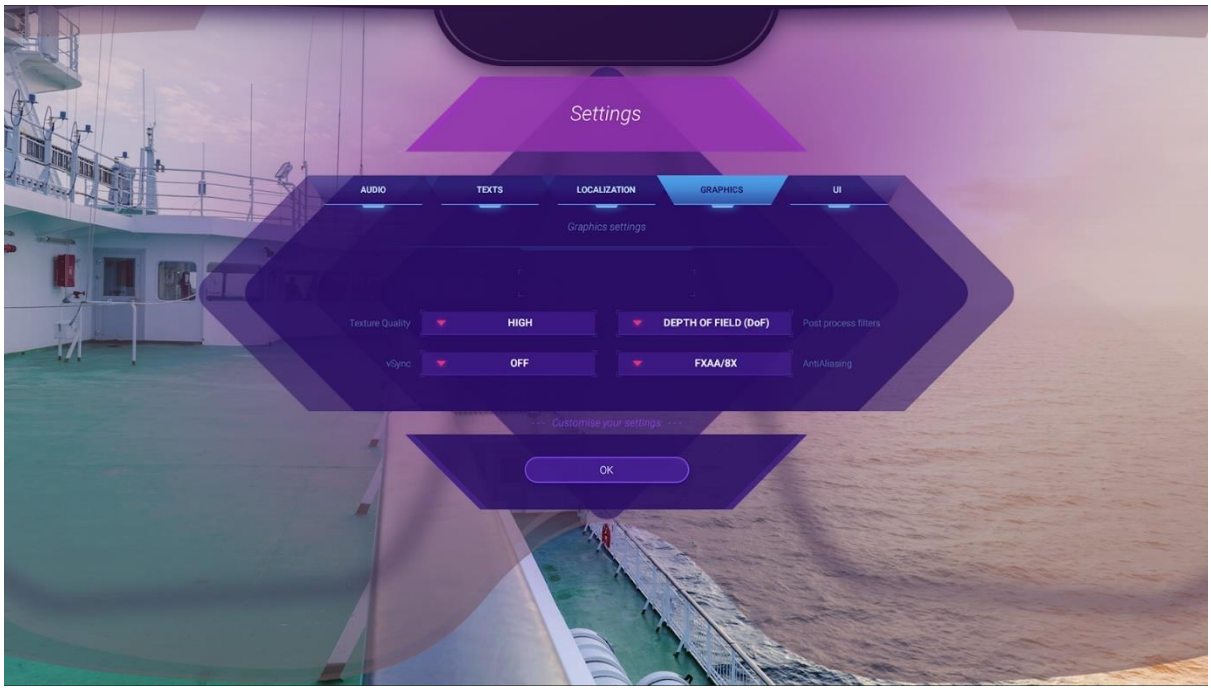

Figure 2-22 Visual settings menu

The graphics tab will allow the user to customize the quality of the overlaid 3D objects, processing filters, and will be able to activate vertical sync and the antialiasing level. Some of the settings might change within the final version of the app due to hardware limitations.

2.1.6.4 UI and Widget area

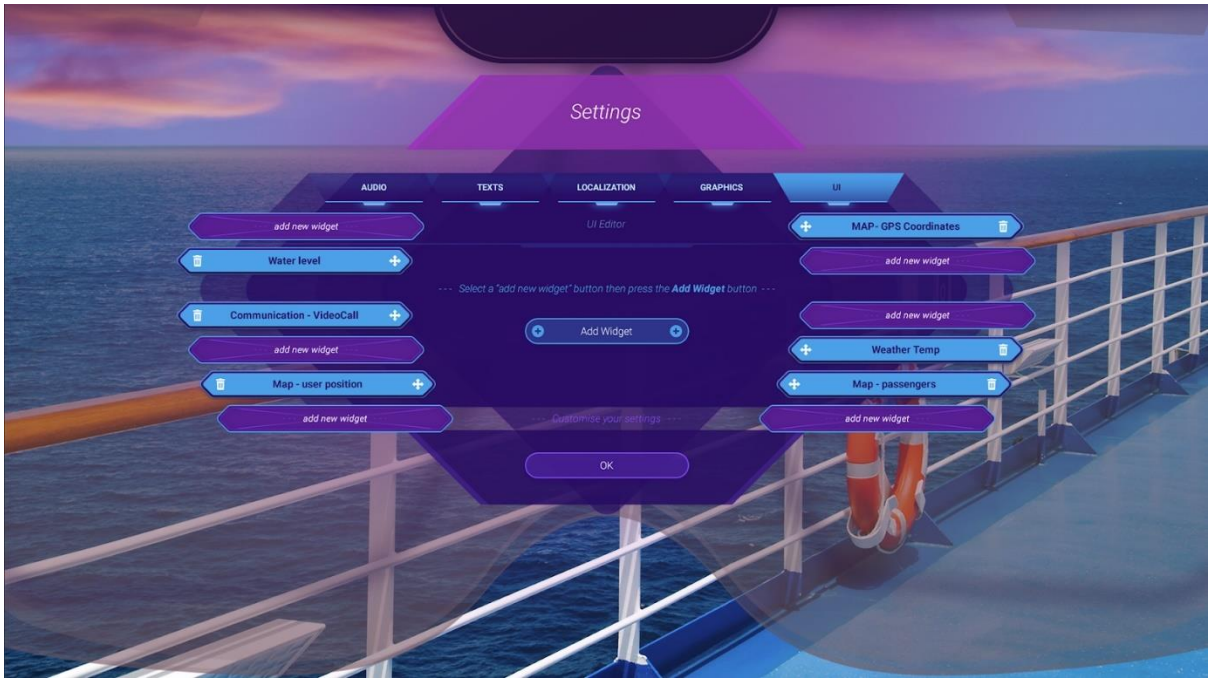

Figure 2-23 Widget editor menu

Within this tab, the users will be able to customize the widgets they see within the headset.

Figure 2-24 Widget placement areas

They will need to select a zone for the widget (where they will be displayed no.1) then press the Add Widget button (no2.) to open the widget selection window:

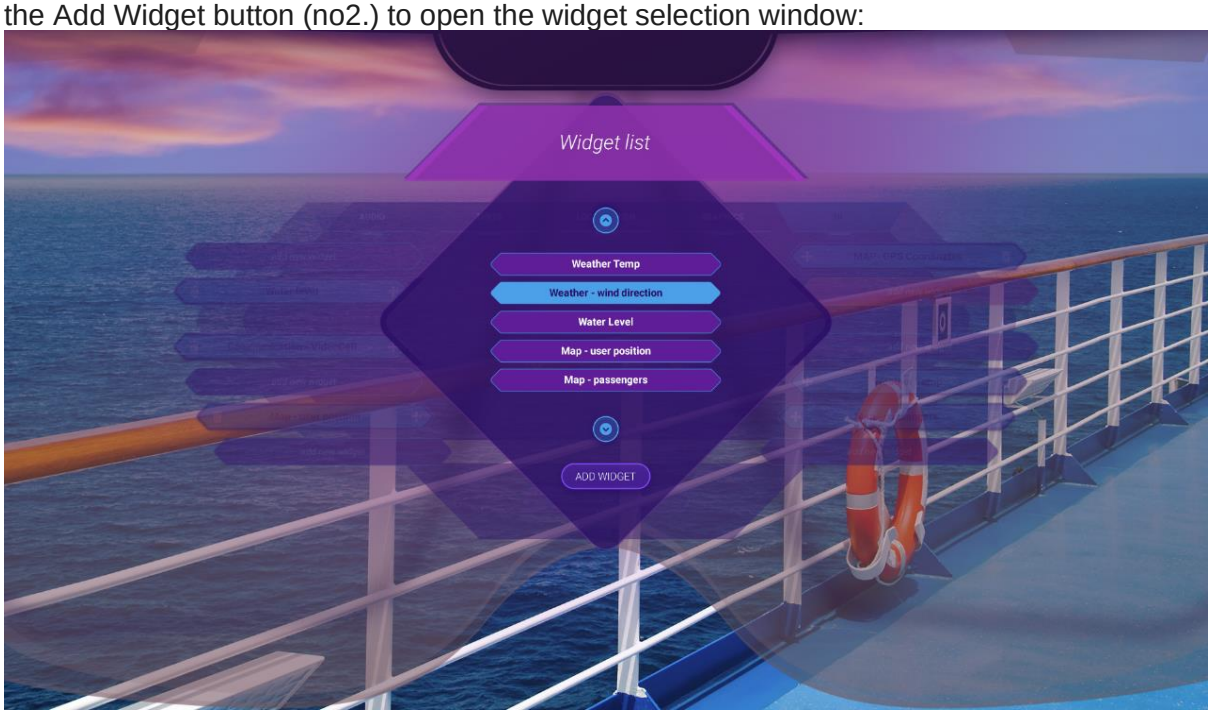

Figure 2-25 Widget list

Within the popup above, you will be able to select the desired widget. A customized GUI might look similar to Figure 2-26.

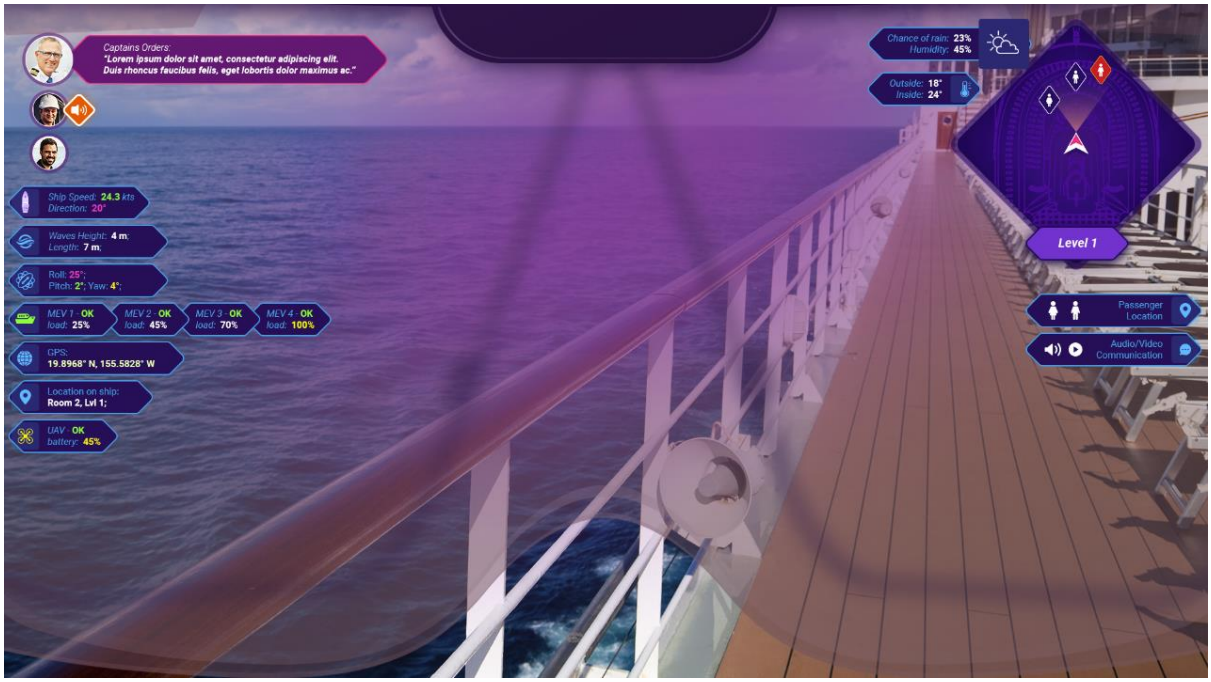

Figure 2-26 Custom edited GUI

2.1.7 Configurable Widgets list

This section presents all the widgets that will be usable during the execution of the evacuation scenarios.

2.1.7.1 Communication module

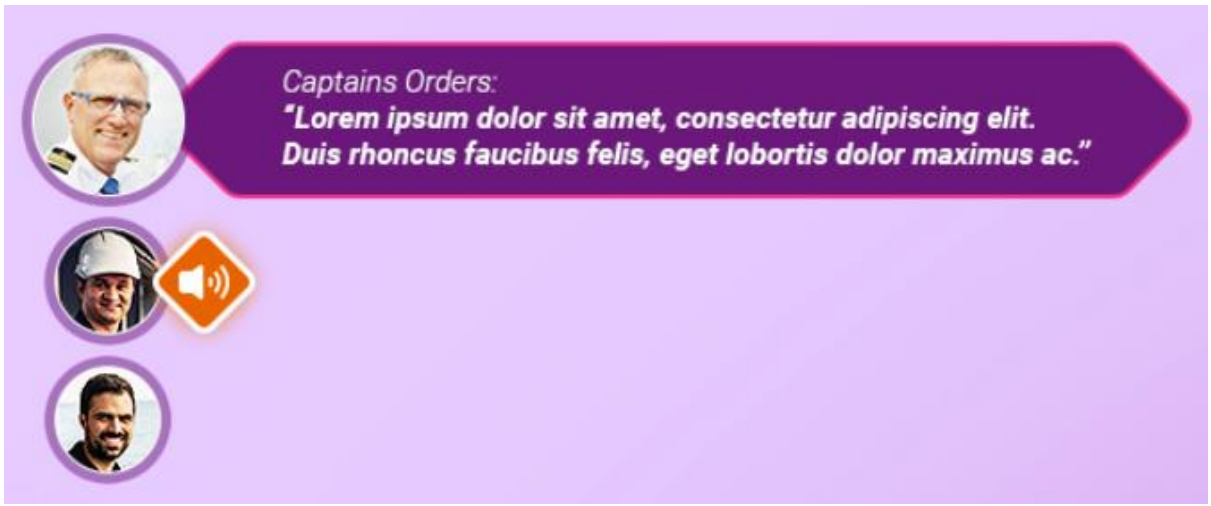

Figure 2-27 Communication module

The communication module will allow the crewmembers to freely communicate with each other without making use of other devices that may prevent them from freely using their hands. The interface will display the crewmember profile image. A speaker icon will be displayed when a crew member speaks. The text communication module will be integrated within this module also to display directives or messages from the crewmembers or the captain. The user can turn off the audio communication and rely only on messages. The interface will allow the crewmember to send predefined messages or to write their own. The reader will find more technical details on how this works in Section 3.5.

2.1.7.2 Ship speed/direction

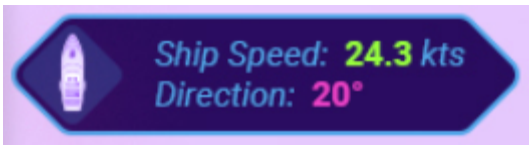

Figure 2-28 Ship speed/direction

This module will get information from the Data Fusion Bus about the actual ship speed and direction. Originally, the information comes from the Shipboard Legacy Systems. Technically speaking, the Automatic Identification System (AIS) transmits this (and other key positioning elements) to shore, where e.g., Port Authorities can track the overall ship positioning over the sea. The widget is important mostly for the Captain. The first responders will also have the possibility to activate this widget.

2.1.7.3 PALAEMON System status widget

This module will get information from the Data Fusion Bus about the current ship evacuation status. This information is taken from the so-called PALAEMON Evacuation Coordinator, which has been previously introduced in D2.6 (PALAEMON Architecture v1. (https://freedcamp.com/EFB_DK5/Palaemon_Oce/files/view/9199969)
The widget is important al the crewmembers since it announces the current threat level for a specific scenario.

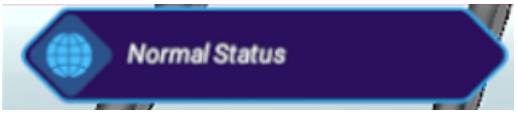

Figure 2-29 Ship current status

The default value from the Data service bus is "current": 0
This informs the widget that the status is ‘Normal’. The possible values for the status are compiled in Table 2-1:

Table 2-1. Ship evacuation status

Code	Status
0	Normal status
1	Situation Assessment
2	Passenger Mustering
3	Boarding to MEVs
4	MEV Launching
5	Clearing from Ship & Rescue

The next request once the status is updated is about the incident types (e.g., Fall – if someone fell; Fire – if a fire took place; Grounding – if the ship got into trouble)
The query has the following structure:

```
{
    "topic": "smart-safety-system-*",
    "sort": [
        { "field" : "timestamp", "order": "ASC"}
    ]
}
```

Figure 2-30 Status request JSON structure

The server’s response should have the following structure (this is an arbitrary sample):

```
{
    "took": 3,
    "timed_out": false,
    "_shards": {
```

```
        "total": 2,
        "successful": 2,
        "skipped": 0,
        "failed": 0
    },
    "hits": {
        "total": {
            "value": 4,
            "relation": "eq"
        },
        "max_score": null,
        "hits": [
            {
                "_index": "smart-safety-system-2021.01.26",
                "_type": "_doc",
                "_id": "nssVP3cBCVeu6s5VDLnj",
                "_score": null,
                "_source": {
                    "type": "Fall",
                    "timestamp": "2021-01-26T14:24:39+00:00",
                    "deck": "6",
                    "position_x": 131.53,
                    "position_y": 8.36
                },
                "sort": [
                    1611671079000
                ]
            },
            {
                "_index": "smart-safety-system-2021.01.26",
                "_type": "_doc",
                "_id": "DssVP3cBCVeu6s5ViLqq",
                "_score": null,
                "_source": {
                    "type": "Fall",
                    "timestamp": "2021-01-26T14:25:11+00:00",
                    "deck": "6",
                    "position_x": 132.9,
                    "position_y": 7.67
                },
                "sort": [
                    1611671111000
                ]
            },
            {
                "_index": "smart-safety-system-2021.11.15",
                "_type": "_doc",
                "_id": "5XLzIn0BBqNGxey_CS0M",
                "_score": null,
                "_source": {
                    "type": "Fire",
                    "timestamp": "2021-11-15T09:34:51+00:00",
                    "deck": "6",
                    "position_x": 599.45,
                    "position_y": -3.47
                },
                "sort": [
                    1636968891000
                ]
            },
            {
                "_index": "smart-safety-system-2021.11.15",
                "_type": "_doc",
                "_id": "aXIMI30BBqNGxey_mzBH",
                "_score": null,
                "_source": {
                    "type": "Fire",
                    "timestamp": "2021-11-15T10:02:47+00:00",
                    "deck": "6",
                    "position_x": 671.8,
                    "position_y": 36.48
                },
                "sort": [
                    1636970567000
                ]
            }
        ]
    }
}
```

Figure 2-31 Server status response JSON structure

We can identify a *Fall* incident type that took place at a specific time shown by the ("timestamp": "2021-01-26T14:24:39+00:00"). We also know the exact deck within the ship where the incident occurred ("deck": "6") and the exact position of the incident by reading the information ("position_x": 131.53, "position_y": 8.36).
Also, we can identify also *Fire* incident that took place at this time ("timestamp": "2021-11-15T10:02:47+00:00"), at this deck ("deck": "6") and the exact location can be read here ("position_x": 671.8,"position_y": 36.48). With this information, we can pinpoint the exact place where the incident occurred.
Now that the system is aware of the type of incident, we can proceed to query a list with the recommended actions to be taken. These steps have been properly mapped from International Safety Management (ISM) *(www.imo.org/en/OurWork/HumanElement/Pages/ISMCode.aspx)* code and/or the company's Contingency Plan. The reader should refer to D3.7 (Modelling of Safety Procedures) to have a deep dive into how this works.

This widget is directly linked with the Task list window below:

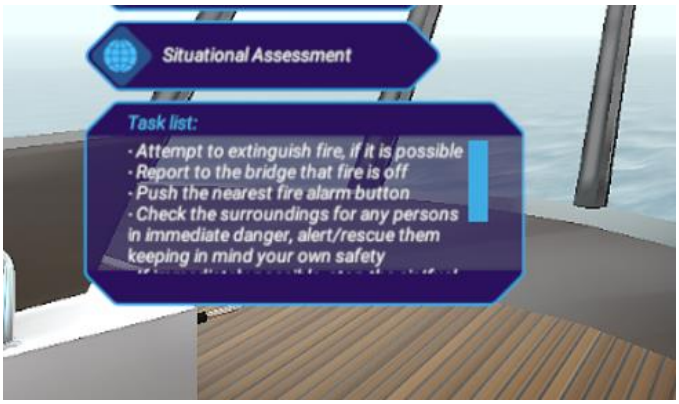

Figure 2-32 Task list windows

2.1.7.4 Waves height/length

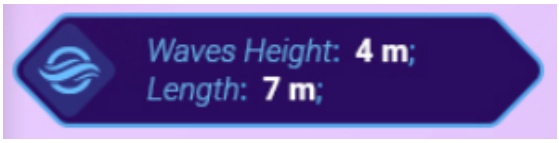

Figure 2-33 Waves height/length

This module will be downloaded from the Data Fusion Bus. It shows information about the waves' length and height. In this case, the information comes from a dedicated API, courtesy of DANAOS. Aside from the information on waves, we receive, every three hours, a complete weather forecast that embraces some physical phenomena: temperature, relative humidity, wind speed and direction, ice cover, swell period, comb period, etc. More information about this weather service can be found in D3.6 (Development of PALAEMON Weather Forecast Tool v2). The widget is important mostly for the Captain. The first responders will also have the possibility to activate this widget.
The JSON information we get from the Data service bus has the following structure:


```
{
	"took": 1,
	"timed_out": false,
	"_shards": {
		"total": 4,
```

```
                "successful": 4,
                "skipped": 0,
                "failed": 0
        },
        "hits": {
                "total": {
                        "value": 65,
                        "relation": "eq"
                },
                "max_score": null,
                "hits": [
                        {
                                "_index": "waves",
                                "_type": "_doc",
                                "_id": "DtI1gXcBCVeu6s5VKaji",
                                "_score": null,
                                "_source": {
                                        "timestamp": "2021-02-08T10:34:40.732739+00:00",
                                        "height": 4,
                                        "length": 7
                                },
                                "sort": [
                                        1612780480732
                                ]
                        }
                ]
        }
}
```


Figure 2-34 Json structure for Waves height and length

2.1.7.5 Ship roll/pitch/yaw

Figure 2-35 Ship roll/pitch/yaw

The widget shows information about the ship's roll, pitch and yaw. This information is updated via the Data Service Bus. Technically speaking, the data comes from the so-called Ship Health Monitoring component, which deploys a handful of motion sensors (e.g., accelerometer + gyroscope) throughout the vessel to measure the stability and overall structural response of the ship. The reader can find additional information in D6.1 (Ship Structural Monitoring Ecosystem). The widget is important mostly for the Captain. The first responders will also have the possibility to activate this widget.
The JSON information we get from the Data service bus has the following structure:


```
{
        "took": 1,
        "timed_out": false,
        "_shards": {
                "total": 4,
                "successful": 4,
```

```
            "skipped": 0,
            "failed": 0
        },
        "hits": {
            "total": {
                "value": 65,
                "relation": "eq"
            },
            "max_score": null,
            "hits": [
                {
                    "_index": "ship",
                    "_type": "_doc",
                    "_id": "DtI1gXcBCVeu6s5VKaji",
                    "_score": null,
                    "_source": {
                        "timestamp": "2021-02-08T10:34:40.732739+00:00",
                        "roll": 25,
                        "pitch": 2,
                        "yaw": 4,
                        "speed": 24.3,
                        "direction": 20
                    },
                    "sort": [
                        1612780480732
                    ]
                }
            ]
        }
}
```


Figure 2-36 Json structure for ship parameters (Roll, Pitch, Speed, Direction)

More information can be found within deliverable D7.1 PALAEMON Communication Platform (v1).

2.1.7.6 MEV status

Figure 2-37 MEVs status

This widget is configurable. It allows the display of the MEV load and technical status. The widget can be added several times, one for each MEV. For the sake of illustration, in Figure 2-37 we display the layout in the case of 4 MEVs. The widget can be displayed also vertically. The status and loading of MEVs are downloaded from the Data service Bus. It shows crucial information and allows the captain a clear view of the technical availability of the evacuation vessels. As for the data source that provides this information, Passenger Mustering and Evacuation process Automation System (PaMEAS) framework provides the means to locate people (indoors & outdoors), hence we can calculate the ratio of occupancy of the MEVs,

knowing beforehand its nominal capacity (the calculation is trivial). More information about this is available in D5.14 (PaMEAS Suite Deployment – v2). The first responders will also have the possibility to activate the widgets.
The data structure we get from the Message bus has the following structure:

Send:

```
{
    "topic": "mevs"
}
```

Receive:


```
{
        "took": 3,
        "timed_out": false,
        "_shards": {
                "total": 2,
                "successful": 2,
                "skipped": 0,
                "failed": 0
        },
        "hits": {
                "total": {
                        "value": 2,
                        "relation": "eq"
                },
                "max_score": null,
                "hits": [
                        {
                                "_index": "mevs",
                                "_type": "_doc",
                                "_id": "nssVP3cBCVeu6s5VDLnj",
                                "_score": null,
                                "_source": {
                                        "type": "mev1",
                                        "timestamp": "2021-01-26T14:24:39+00:00",
                                        "status": "ok",
                                        "load": 11
                                },
                                "sort": [
                                        1611671079000
                                ]
                        },
                        {
                                "_index": "mevs",
                                "_type": "_doc",
                                "_id": "aXIMI30BBqNGxey_mzBH",
                                "_score": null,
                                "_source": {
                                        "type": "mev2",
                                        "timestamp": "2021-11-15T10:02:47+00:00",
                                        "status": "ok",
                                        "load": 22
```

```
                                },
                                "sort": [
                                        1636970567000
                                ]
                        }
                ]
        }
}
```


Figure 2-38 MEV Status JSON structure

More information can be found within deliverable D7.1 PALAEMON Communication Platform (v1).

2.1.7.7 GPS coordinates

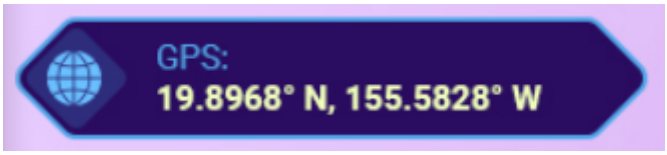

Figure 2-39 GPS coordinates

This widget will display the Actual GPS coordinates of the ship. This information is taken from the ship's AIS. The information can be displayed in DD (Decimal Degrees), DMS (degrees, minutes, seconds), DDM (Degrees, Decimal, Minutes). This information is updated by the SST (Ship Stability Toolkit). The widget is available for the Captain and the crew members.

2.1.7.8 Wind speed

Figure 2-40 Wind speed

This widget will display exterior wind direction and Speed. This information is crucial for the Captain in case of an open fire to assess and plan the evacuation process and is (obviously) part of the data we get via DANAOS Weather API (explained in Section 2.1.7.4). This information is downloaded from the Data service bus and updated by the WFT (Weather Forecast Toolkit). The widget is available for the Captain and the crew members.

2.1.7.9 Location within ship

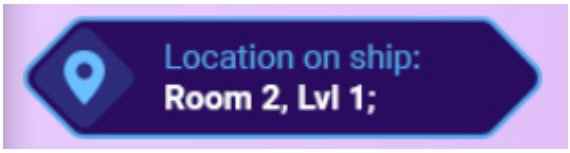

Figure 2-41 Location within the ship

This widget will display the location of the crew member within the ship. This information is downloaded from the Data service bus. The widget is available for the crew members. PaMEAS is the location service responsible for calculating (in a close to the real-time manner) the positioning of passengers and crew members.

2.1.7.10 UAV status

Figure 2-42 UAV status

The widget will allow the Captain to view technical data related to the UAVs (whose number may vary). The information sent by these drones is gathered by a so-called Ground Control Station (GCS), which forwards the information to the Data Fusion, where it is made accessible to the AR application. The reader might refer to D5.7 (UAV Platform v1) to get further details about this standalone system.

2.1.7.11 Weather report

Figure 2-43 Weather report

Again, DANAOS Weather API generates weather predictions every three hours, which are sent to the Data Fusion Bus. As of this point, the AR application can query the data and display it as another widget. The weather data will be displayed to assess the context in which an evacuation scenario will take place.

2.1.7.12 Outside/inside ship temperature

Figure 2-44 Outside/inside ship temperature

This information is downloaded from the Data Fusion Bus and provides information related to the outside and inside of the ship temperature. The widget is accessible for both the captain and the crew members.

2.1.7.13 Passenger location

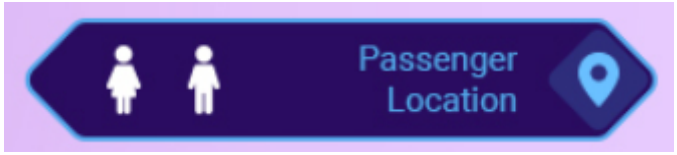

Figure 2-45 Passenger location

One of the most important widgets, this widget is working related to the map widget. It will display the nearest passengers within the ship and will highlight the ones that might have problems based on medical parameters, based on the information generated by PaMEAS and the Smart Bracelets (whose owners can use to generate alarms, e.g., notify an accidental fall). Crew members will use this widget as a toggle, that is, they will have the possibility to activate or hide the passenger location on the screen. The passenger location and vital signs will be downloaded from the Data Fusion Bus. The widget is available for both crew members and captains. Thanks to this widget, the Master can have a holistic view of where are all people aboard, thus saving much time on the mustering phase.

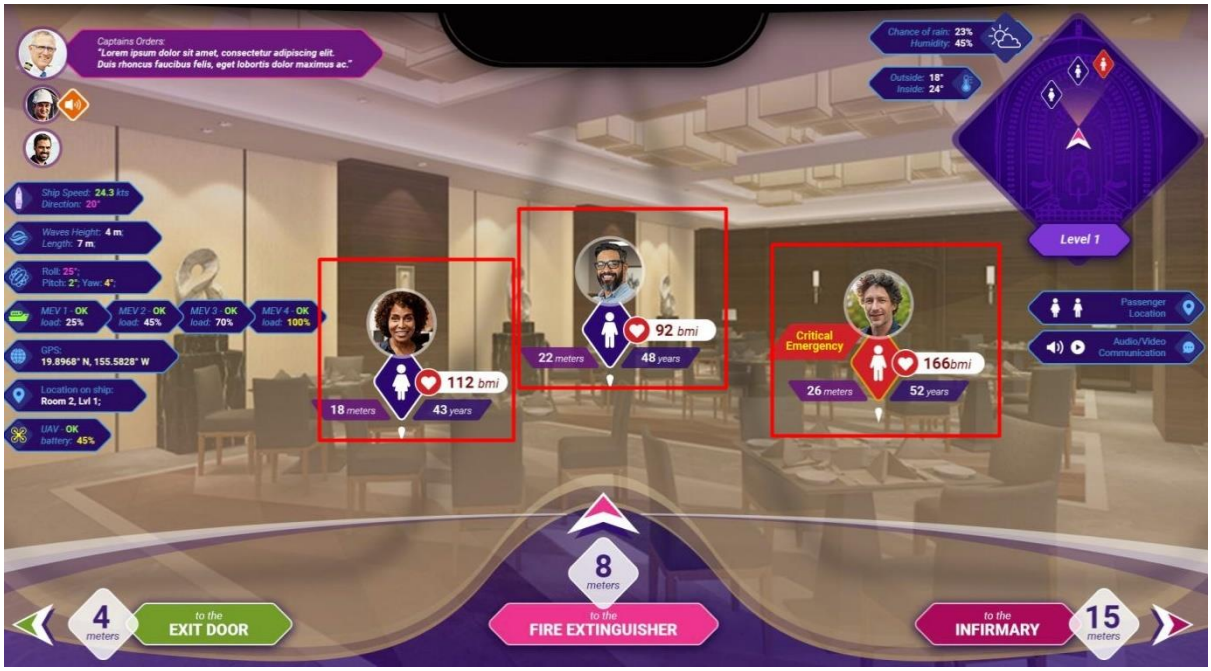

Figure 2-46 Nearest passengers

2.1.7.14 Map

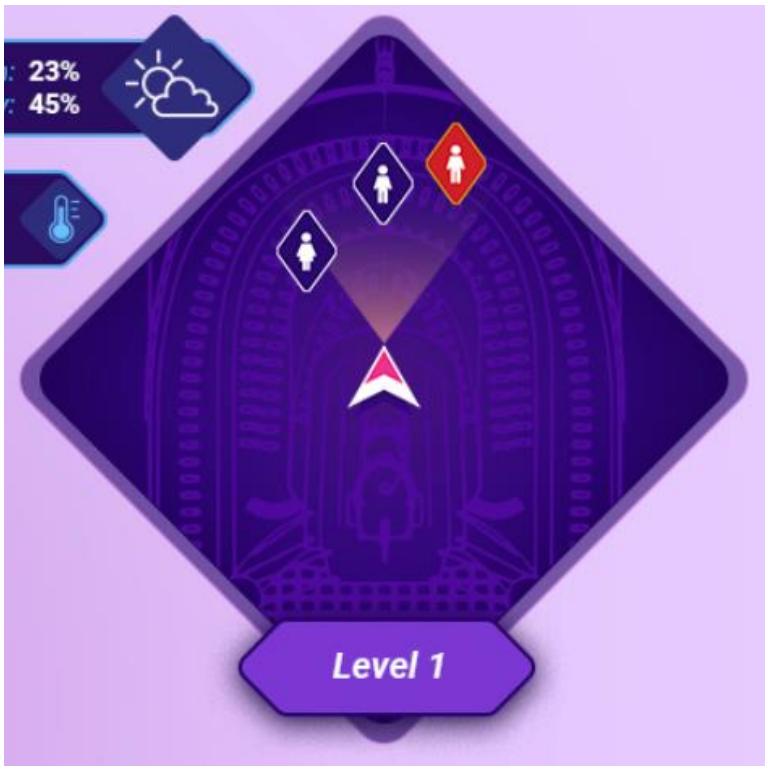

Figure 2-47 Map

The map module allows the crewmember to better view the passenger location within the map. The zoom level can be tweaked. The map information will be embedded within the app but the passenger location will be downloaded from the Data Fusion Bus. The map will be available for both the captain and the crew members.

2.1.7.15 Audio communication module

Figure 2-48 Audio communication module

This module will allow the crew members to activate/deactivate the audio function of the headset. In emergencies, they must have the possibility to deactivate the audio communication for focus purposes and rely only on messages coming from the captain or PALAEMON system. As a matter of fact, in case an incident happens and the evacuation process is unleashed, all audio conversations will be recorded and registered as part of the so-called PALAEMON Voyage Report Generator (which was introduced in D2.7 – PALAEMON Architecture v2). A deeper explanation about the communications module will be carried out in Section 3.5.

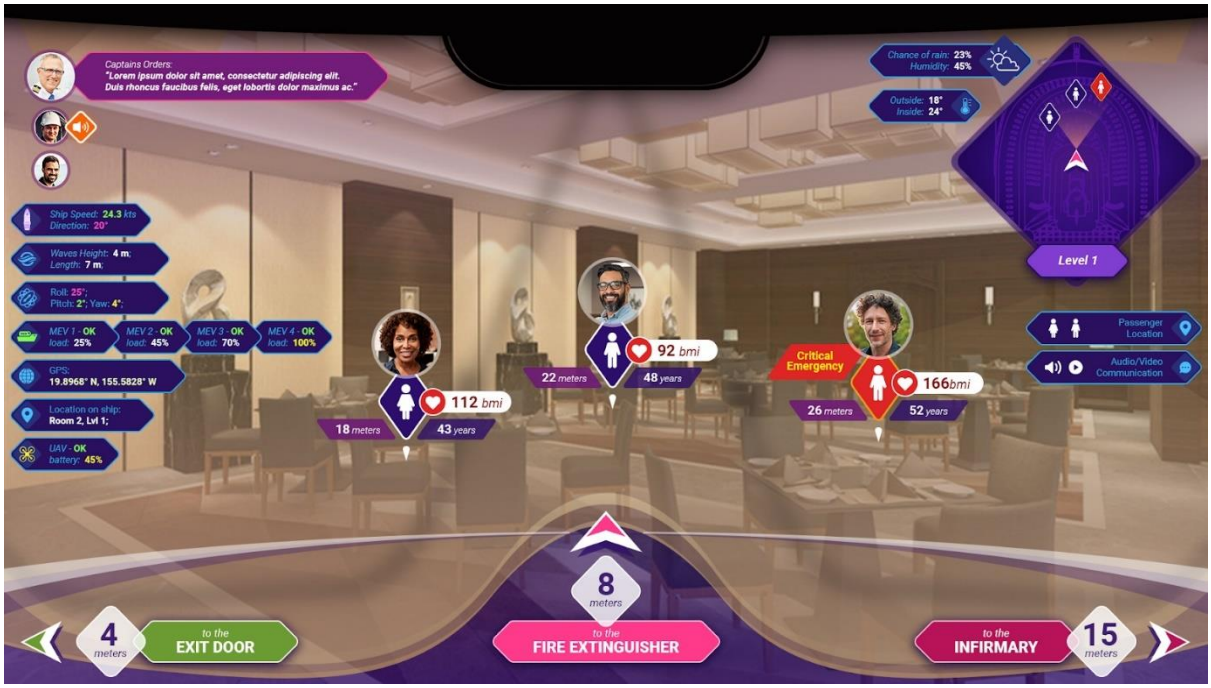

Figure 2-49 AR GUI

2.1.7.16 Reports module

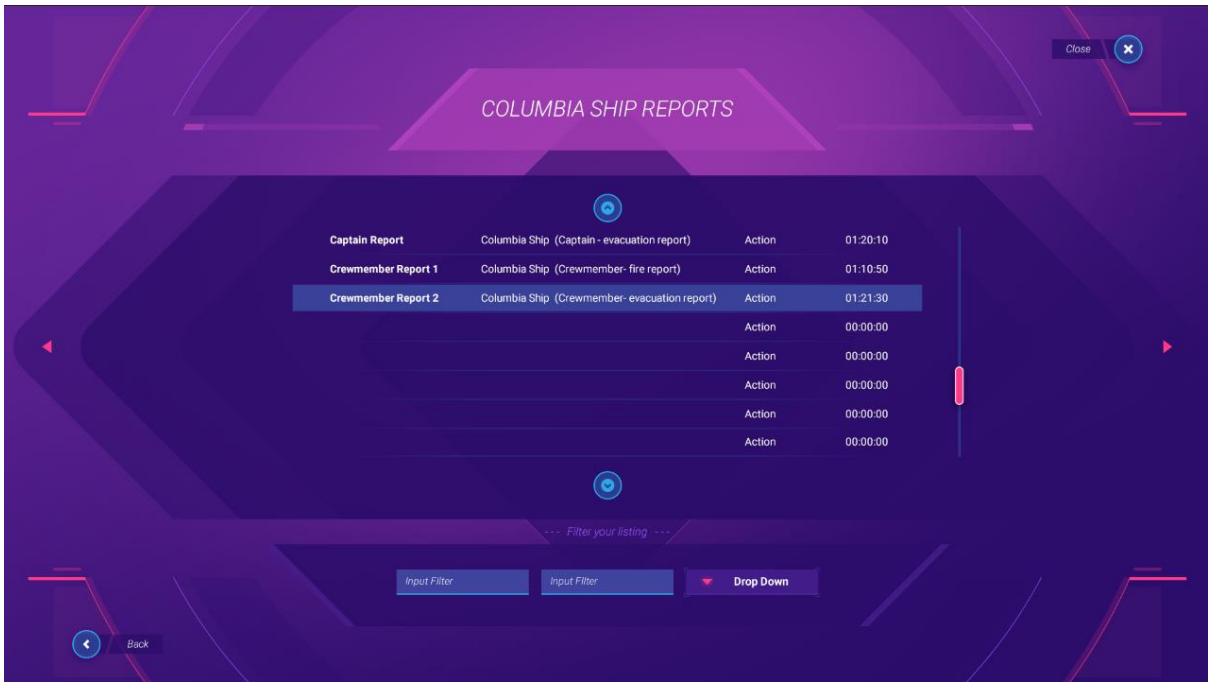

Figure 2-50 Reports screen

Crew members' activity can be configured to be logged in reports. This section also allows users to access and view the logged reports. The AR application has a reports module included and can display reports hosted within the PALAEMON system.
The server connection is improved with RSA+AES keys handshaking and data encryption. The server can host user reports and can act as a black box.

2.1.7.17 Documents module

Figure 2-51 Documentation menu

Crewmembers' can always navigate to the virtual library where important PDF documents are stored. They can always check the documentation before using a specific system or security object. For instance, they can save ISM codes, contingency plans, check the passengers' list, etc.

3 Dependencies and prerequisites

3.1 Technical and environmental

It is important to understand that HoloLens will only successfully work if the safety guidelines mentioned in Annexes 1-3 are respected. HoloLens might not provide the desired results if used somehow outside the scope and the design limits.

3.2 User readiness Crew – Response and on-site teams

All the users and participants that will be involved in the task related to HoloLens should be aware of the guidelines in this document. Additional information and tutorials on the HoloLens can be found at https://docs.microsoft.com/en-us/hololens/.

3.3 PALAEMON components and systems

Within the PALAEMON architecture HoloLens AR device must accurately:

- Receive inputs from designated systems without altering the data or interfering with additional internal or external components.
- Provide the desired outcome with minimal distortions in terms of graphics, motion accuracy, geospatial tolerances.
- The HoloLens setup must safeguard data transfer between involved systems.
- Integrate the software component, front-end and visualizer in the AR architectural layer.

3.4 Integration with external PALAEMON components

As part of its architecture, as we introduced in Section 2 and covered throughout the text, the AR framework interacts with most of the components of the PALAEMON Reference Architecture. The following list compiles those software and hardware modules that show a direct or indirect relationship:

- Weather API
- Shipboard Legacy Systems (e.g., AIS information)
- SSS (Smart Safety System)
- SHM (Structural Health Monitoring) and SST (Ship Stability Toolkit)
- Data Fusion Bus (Access and Core)
- SMS (Safety Management System)
- Context Broker
- DSS (Decision Support System)
- SRAP (Smart Risk Assessment Platform)
- Smart Bracelets (biometric data, alarm notifications)
- PaMEAS (information regarding passengers/crew positioning)
- UAVS and Ground Control Station
- Voyage Report Generator

More information is available within deliverable D2.7 PALAEMON Architecture (v2).

3.5 Communication component

One of the main important functionalities of the PALAEMON AR Headsets (and novelties introduced in this second version of the deliverable) is to allow direct communication among crew members/AR wearers:

- They must send and receive audio inputs from the integrated headset microphone and speaker systems. To reduce lag or any kind of delays between headsets, they are linked directly to a secured channel on a cloud server.
- The audio system is designed to send and receive audio signals with minimal distortions in terms of quality.
- All the information sent between headsets is encrypted and secured within the involved systems.

The developed communication component is using a Photon cloud-based solution (https://www.photonengine.com/pun) optimized for Unity3D that allows also other components to synchronize the virtual elements and the RPCs (Remote Procedure Calls).

One of the advantages of using a cloud-based solution is the possibility to port the components on various operating systems and assure cross-platform communication.

Each of the headsets is identified using a unique ID, which will be linked to each ship communication channel. Even if several ships are hosted on the same cloud server, the communication channels will be different between each ship. The linked headsets can join just the communication channel is linked with.

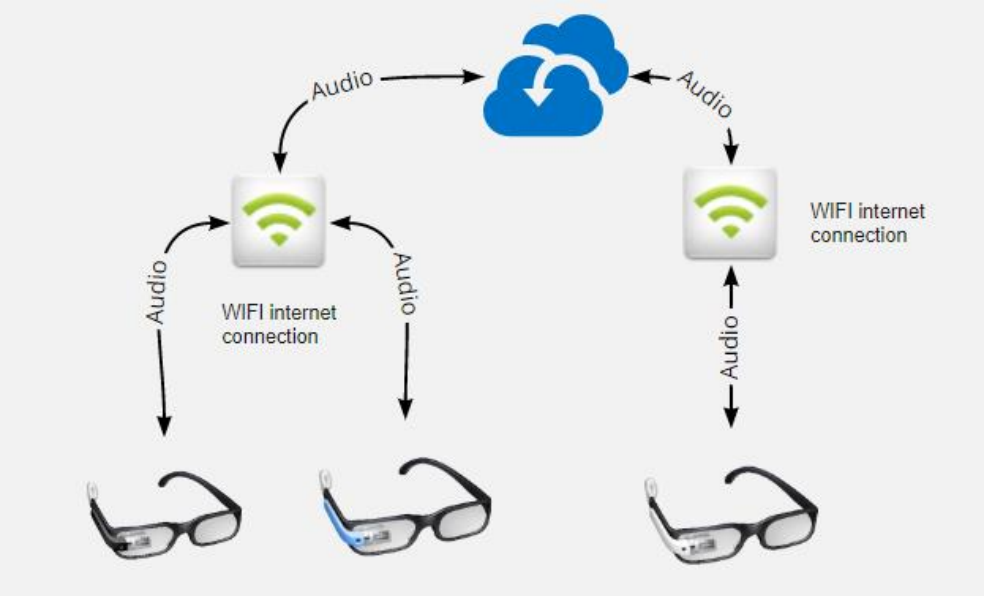

Figure 3-1: Audio connection diagram

The audio communication functionality can be activated/deactivated directly by pressing on the voice Widget found in the GUI.

The service is scalable since they are based on a client to server architecture. It has the availability of scaling up to 10.000 concurrent users. Within the project, we will limit the maximum number of concurrent users to 4, just to demonstrate the functionality.

4 AR Glasses components and systems Management

4.1 Synchronized maintenance and updates with other PALAEMON components.

HoloLens AR device will work in conjunction with various other systems and components within the PALAEMON architecture.

The layout layer will function as a link between the Graphical Interface and the system. It establishes the input, validation, viewing, data validation functions. Therefore, any updates on the above-mentioned elements can possibly impact the AR functionality.

The interface will provide the interaction between the user and the system in a natural way whilst the application will integrate a hybrid interface, accessible on different headset devices. Interface development is based on a user-focused analysis process, therefore optimizing the use of the interface, the application will comply with graphical conventions and usability. Updates on the graphics structure of AR applications for mobile systems will be scalable and adaptable.

4.2 Hardware and software management

Manage HoloLens updates
HoloLens uses Windows Update in the same manner as other Windows 10 devices. When an update is available, it is automatically downloaded and installed the next time that the device is plugged in and connected to the internet.
Managing updates by using Windows Update for Business
Windows Holographic for Business can use Windows Update for Business to manage updates. All HoloLens 2 devices can use Windows Holographic for Business.
Windows Update for Business connects HoloLens devices directly to the Windows Update service. By using Windows Update for Business, users can control multiple aspects of the update process—that is, which devices get which updates at what time.

Note

For HoloLens devices, users can automatically manage feature updates (released two times a year) and quality updates (released monthly or as required, including critical security updates).
Users can configure Windows Update for Business settings for HoloLens by using policies in a Mobile Device Management (MDM) solution such as Microsoft Intune.
Configure automatic checks for updates
Users can use the **Update/Allow Auto-Update** policy to manage automatic update behaviour, such as scanning, downloading, and installing updates.
Manually check for updates

Although HoloLens periodically checks for system updates, there may be circumstances in which users might want to manually check.
To manually check for updates, go to **Settings > Update & Security > Check for updates**. If the Settings app indicates that the device is up to date, there will be displayed all the updates that are currently available.
If WDRT doesn't detect the device
If WDRT doesn't detect the HoloLens device, try restarting the computer. If that doesn't work, select **My device was not detected**, select **Microsoft HoloLens**, and then follow the instructions.

5 HMI AR Glasses implementation

5.1 A peer into the Future of HMI

The trend in HMI devices is going to larger displays and more interfaces. The graphics are getting more advanced, as the expectations for high-quality representation rise. Consequently, more and more powerful processors, and higher and higher memory capacities are required. Additional serial interfaces are becoming increasingly important, as well as redundant Ethernet and CAN connections. Touchscreen operation replaces mechanical keys. Application development will increasingly move to open platforms, making applications independent of proprietary HMI or SCADA software. Long-term availability, longevity and industrial features will remain standard requirements. An array of new sensors is to be included in the future HMIs of ships and vessels detailing in real-time various ships metrics and allowing deeper exploring of the content.

Figure 5-1: A peer into the Future of HMI

5.2 KPIs oversee

The entire AR architecture is designed with the PALAEMON objectives and KPIs in mind. Therefore, the scope of the AR activities would be also to underline the progress on the main KPIs. The AR layer will be therefore to observe and analyse different core indicators within the PALAEMON ecosystem. This initiative will further enable continuous improvement and training events.

5.3 Remote monitoring

Remote monitoring is a critical component within the PALAEMON ecosystem enabled by the AR layer.
This function will provide remote monitoring of ship condition, supporting classification and predictive maintenance activities, with ultimate objective the increase of onboard safety and reliability.

6 Conclusions

The AR technology and HoloLens will be able to greatly enhance the training and development of staff within the PALAEMON ecosystem. Users will be able to visualize content and clues on emergency evacuation in real-time. AR technology enables users to develop specific evacuation reflexes that could be applied in a real setup. Moreover, the AR technology will be able to shorten the learning lead time and convey best practices to the users just in time.
The immersion and collaboration features of the AR technology will enhance the collaboration and cooperation between trainees and supervisors and also the transfer of knowledge and best practices.
Despite the obvious advantages, the AR technology thus HoloLens should be properly configured and implemented within the project.
Users must take into consideration some of the following aspects before using the AR technology:

- Understanding the device functions and features;
- Connecting and integrating the HoloLens device within the existing network of systems;
- Understanding the learning curve for such devices and technology;
- Accommodating with the GUI interface specifically designed for the PALAEMON ecosystem.
- Following Microsoft guidelines; recommendations and tutorials on HoloLens 2.

Finally, it is worth highlighting that all future integrations as part of the PALAEMON Communications Platform, data standardization and homogenization, assessment over real trials, etc. will be carried out and duly reflected in WP7 and WP8's actions and reports.

7 Annex 1 - AR Glasses Component Technical Specifications

In this section, we gather the technical specification of the actual model we have chosen to develop the AR solution.

7.1 HoloLens Components

The AR HoloLens has the following components:

- ***Visor.*** Contains the HoloLens sensors and displays. The user can rotate the visor up while wearing the HoloLens.
- ***Headband.*** To put the HoloLens on, use the adjustment wheel to expand the headband. With the HoloLens in place, tighten the adjustment wheel by turning to the right, until the headband is comfortable.
- ***Brightness buttons.*** When wearing the HoloLens, the brightness buttons are on the left side of the device
- ***Volume buttons.*** When wearing the HoloLens, the volume buttons are on the right side of the device.

7.1.1 Display, Sensors and Audio

Table 7-1. HoloLens Display

Optics	See-through holographic lenses (waveguides)
Holographic resolution	2k 3:2 light engines
Holographic density	>2.5k radiants (light points per radian)
Eye-based rendering	Display optimization for 3D eye position

Table 7-2. HoloLens sensors

Head tracking	4 visible light cameras
Eye-tracking	2 Infrared (IR) cameras
Depth	1-MP Time-of-Flight depth sensor
Inertial measurement unit (IMU)	Accelerometer, gyroscope, magnetometer
Camera	8-MP stills, 1080p30 video

Table 7-3. HoloLens Audio and speech

Microphone array	5 channels
Speakers	Built-in spatial sound

7.1.2 Compute and connectivity

Table 7-4. HoloLens Compute and connectivity

System on chip	Qualcomm Snapdragon 850 Compute Platform

Holographic processing unit	Second-generation custom-built holographic processing unit
Memory	4-GB LPDDR4x system DRAM
Storage	64-GB UFS 2.1
WiFi	802.11ac 2x2
Bluetooth	5.0
USB	USB Type-C

7.1.3 Human and the environment understanding

Table 7-5. HoloLens human understanding

Hand tracking	Two-handed fully articulated model, direct manipulation
Eye-tracking	Real-time tracking
Voice	Command and control on-device; Cortana natural language with internet connectivity

7.1.4 HoloLens environment understanding.

Table 7-6. HoloLens environment understanding

Six Degrees of Freedom (6DoF) tracking	World-scale positional tracking
Spatial mapping	Real-time environment mesh
Mixed reality capture	Mixed hologram and physical environment photos and videos

7.1.5 Power, certifications, and pre-installed software

Table 7-7. HoloLens power specifications

Battery Life	2-3 hours of active use. Up to 2 weeks of standby time.
Battery technology	Lithium batteries
Charging behaviour	Fully functional when charging
Cooling type	Passively cooled (no fans)
Power draw	To maintain/advance Internal Battery Charge Percentage while the device is on, it must be connected minimum to a 15W charger.

Table 7-8. HoloLens certifications

Eye safety	HoloLens 2 has been tested and conforms to the basic impact protection requirements of ANSI Z87.1, CSA Z94.3 and EN 166.

HoloLens pre-installed software.

- Windows Holographic Operating System
- 3D Viewer
- Calendar
- Cortana
- Dynamics 365 Guides
- Dynamics 365 Remote Assist
- Feedback Hub
- File Explorer
- Mail
- Microsoft Edge
- Microsoft Store
- Movies & TV
- OneDrive
- Photos
- Settings
- Tips

7.1.6 Safety and regulatory information

This section is intended to help HoloLens users become comfortable; safe and productive while using this device. Failure to follow the instructions for proper set-up, use, and care for the user's device can increase the risk of serious personal injury or property damage.

WARNING: Parts of this device are magnetic

Parts of the HoloLens device are magnetic and may attract metallic items. To reduce the potential risk of sparks and resulting damage to the device, other objects, and/or possible personal injury, verify the electrical connection areas are free of metallic objects before interconnecting devices or charging connectors. Do not place magnetically sensitive devices, credit cards, other magnetic storage media near the device to reduce the potential for magnetic interference between the HoloLens device and other devices, possible disruption of medical device operation, or corruption of magnetically stored data.

WARNING: Personal medical devices

Radio-frequency emissions and magnetic fields from electronic equipment can negatively affect the operation of other electronic equipment, causing them to malfunction. Although the HoloLens device is designed, tested, and manufactured to comply with regulations governing radio frequency emission, the wireless transmitters and electrical circuits in the device may cause unintentional interference in other electronic equipment.

WARNING: Radiofrequency interference

Although the HoloLens device has been tested for safety and compatibility, it contains a radio that could affect other electronic equipment or medical devices (such as pacemakers) under certain circumstances, causing them to malfunction and result in possible injury or death.

WARNING: Potentially explosive atmospheres

Do not store or carry flammable liquids, gases, or explosive materials in the same compartment as the HoloLens device, its parts, and/or accessories.

Turn off the device, and do not remove or install battery chargers, AC adapters, or any other accessory for the device when users are in an area with potentially explosive atmospheres. Areas with potentially explosive atmospheres are often, but not always, posted and may include fuelling areas or fuel service stations; **below decks on boats or other vessels**; fuel and/or chemical transfer and storage facilities; and areas where flammable chemicals or particles, such as grain dust or metal powders have collected in the air. In such areas, sparks can occur and cause an explosion or fire.

WARNING: Photosensitive seizures

Some users may experience a seizure when exposed to flashing lights or patterns in moving images or videos within the AR headset.

These seizures may have a variety of symptoms, including light-headedness, disorientation, confusion, or momentary loss of awareness. Photosensitive seizures may also cause loss of consciousness or convulsions that can lead to injury from falling or striking nearby objects.

WARNING: General battery safety

HoloLens uses disposable or rechargeable batteries. Improper use or misuse of disposable or rechargeable batteries may cause injury, death, property damage, and may damage the HoloLens device or its accessories because of battery fluid leakage, fire, overheating, or explosion.

Battery fluid is corrosive and may be toxic. It can cause burns and may be harmful or fatal if swallowed.

WARNING: AC power supply safety

Always select and use an appropriate AC power supply for the device. Failure to take the following precautions can result in serious personal injury or death from electric shock or fire or in damage to the HoloLens device.

WARNING: Exposure to radiofrequency (RF) energy

Devices that contain Wi-Fi and Bluetooth® radio transmitters have been designed, manufactured and tested to meet the Federal Communications Commission (FCC), Industry Canada and European guidelines for RF exposure and Specific Absorption Rate.

To ensure that your exposure to RF energy generated by the Wi-Fi and Bluetooth radios does not exceed the exposure limits set forth by these guidelines, orient devices with display screens such that the display side is not directly in contact with the user's body (i.e., placing the display side face down on your lap or upper body)

WARNING: Usage

To reduce the risk of fire, shock, or damage to the HoloLens device, do not expose it to rain, snow or other types of moisture.

WARNING: Be aware of your surroundings

To reduce the potential risk of injury due to distractions, do not use the device while driving, operating machinery, walking, or engaging in other activities that require your undivided attention.

WARNING: Use in safe surroundings

Using the device can distract users and keep them from seeing the surroundings.

Use only in a safe place that is appropriate for the intended activities. Avoid trip hazards, stairs, low ceilings, fragile or electronic and control equipment items that could be damaged, etc., and situations in which people or things might unexpectedly approach. Do not use the device when the view of the surroundings and attention is needed for safety.

Always use caution and be aware of the surroundings, even if there have been created activity boundaries

WARNING: Use requirements

An interpupillary distance between 51 and 74 is needed to correctly and comfortably view Holograms with HoloLens. This range accommodates most adults.

WARNING: Pre-existing vision disorders

Good binocular vision is required to view stereoscopic 3D content. HoloLens can be worn over most glasses and used with contact lenses. If users have a pre-existing vision disorder, should consult a doctor before using HoloLens. A **small percentage of people have a pre-existing vision disorder that may be aggravated when using HoloLens.**

CAUTION: Hearing Safety

Frequent or extended exposure to loud noise or sounds when using a headset can cause temporary or permanent hearing loss.

CAUTION: Using mixed reality comfortably

Some users may experience discomfort such as nausea, motion sickness, dizziness, disorientation, headache, fatigue, eye strain, or dry eyes when using mixed or virtual reality, particularly as they adjust to using it.

Motion sickness and related symptoms can occur when there is a mismatch between what users see and what their body perceives.

NOTICE: To view 3D content more comfortably

Good binocular vision is required to view stereoscopic 3D content. If users have a binocular vision disorder, such as strabismus (eye misalignment, crossed or wandering eye), they may not be able to view 3D content comfortably. A small percentage of people have a pre-existing binocular vision disorder that they might not be aware of until they try viewing 3D content.

NOTICE: Using Boundaries

Where available and correctly configured, the features on the HoloLens device can be used to set up boundaries to help users avoid obstacles and aid in managing the surroundings.

8 Annex 2 - Getting started with the AR glasses

8.1 Security overview

The HoloLens 2 security architecture was designed and engineered from the ground up to be free from legacy security issues while creating a minimized attack surface. This new, innovative architecture offers secure storage locations and advanced security elements, with mechanisms capable of shielding operating systems from potential threats and vulnerabilities.

HoloLens 2 combines hardware, software, networking, and services to deliver end-to-end security while providing the user with an optimal experience. With HoloLens 2, a large majority of security features are now turned on automatically, minimizing the effort required to correctly set up and configure the operating system.

Windows HoloLens 2 and operating system architecture offers these innovative security features:

- **State separation and isolation**: This new architecture protects critical portions of the HoloLens 2 operating system from change - such as those required for the core operating system to boot into a trusted state. Isolation technology is used to confine untrusted apps in a sandbox area, ensuring that they cannot impact the system security. The entire operating system is segmented into secure sections, with each section shielded by a combination of different security technologies.
- **Data Protection**: If the device is lost or stolen, HoloLens 2 prevents unauthorized applications from reading sensitive information by relying on BitLocker encryption of data.
- **Password-less operating system**: Older, password-based operating systems could inadvertently expose users to phishing threats and were often responsible for compromised accounts. Windows Holographic for Business eliminates the use of passwords for MSA and AAD sign-in and strengthens user-identity protection with Windows Hello™ and FIDO2 sign-in.

8.2 License requirements

When using HoloLens devices, the user will need Azure AD and an MDM. Active Directory (AD) cannot be used to manage HoloLens devices. Using an MDM other than Intune, an Azure Active Directory Licenses is required. Please note that Azure AD is included in the majority of these suites.

8.3 AR Glasses environment considerations

HoloLens blends the holographic with the "real" world, placing holograms in the users' surroundings.

8.4 Setting up an environment

HoloLens device knows how to place stable and accurate holograms by tracking users in a space. Without proper tracking, the device does not understand the environment or the user within it so holograms can appear in the wrong places, not appear in the same spot every time, or not appear at all. The data used to track users is represented in the spatial map.

Tracking performance is heavily influenced by the environment the user is in and tuning an environment to induce stable and consistent tracking is an art rather than a science. Many different environmental factors are fused together to enable tracking, but as a MR (Mixed Reality) developer, there are several factors one can keep in mind to tune a space for better tracking.

8.4.1 Lighting

Windows Mixed Reality uses visual light to track the user's location. When an environment is too bright, the cameras can get saturated, and nothing is seen. If the environment is too dark, the cameras cannot pick up enough information, and nothing is seen. Lighting should be even and sufficiently bright that a human can see without effort, but not so bright that the light is painful to look at.

Areas, where there are points of bright light in an overall dim area, are also problematic, as the camera must adjust when moving in and out of bright spaces. This can cause the device to "get lost" and think that the change in light equates to a change in location. Stable light levels in an area will lead to better tracking.

Any outdoor lighting can also cause instability in the tracker, as the sun may vary considerably over time. A steady 500-1000 lux is a good place to start.

8.4.2 Items in a space

HoloLens uses unique environmental landmarks, also known as features, to locate itself in space.

A device can rarely track in a feature-poor area, as the device has no way of knowing where in space it is. Adding features to the walls of a space is usually a good way to improve tracking. Posters, symbols taped to a wall, plants, unique objects, or other similar items all help. A messy desk is a good example of an environment that leads to good tracking - there are a lot of different features in a single area.

Additionally, use unique features in the same space. One common way of adding unique features is to use lines of masking tape to create unique, non-repetitive patterns along the walls and floor of a space.

8.4.3 Wormholes

If there are two areas or regions that look the same, the tracker may think they are the same. This results in the device tricking itself into thinking it is somewhere else. We call these types of repetitive areas wormholes.

To prevent wormholes, try to prevent identical areas in the same space. Identical areas can sometimes include factory stations, windows on a building, server racks, or workstations. Labelling areas or adding unique features to each similar-looking area can help mitigate wormholes.

8.4.4 Movement in space

If the environment is constantly shifting and changing, the device has no stable features to locate against.

The more moving objects that are in space, including people, the easier it is to lose tracking. Moving conveyor belts, items in different states of construction, and lots of people in space have all been known to cause tracking issues.

The HoloLens can quickly adapt to these changes, but only when that area is clearly visible to the device. Areas that are not seen as frequently may lag behind reality, which can cause errors in the spatial map.

8.4.5 Proximity of the user to items in the space

Similarly to how humans cannot focus well on objects close to the eyes, HoloLens struggles when objects are close to its cameras. If an object is too close to be seen with both cameras, or if an object is blocking one camera, the device will have far more issues with tracking against the object.

The cameras can see no closer than 15cm from an object.

8.4.6 Surfaces in a space

Strongly reflective surfaces will likely look different depending on the angle, which affects tracking. Think of a brand new car - when you move around it, light reflects and you see different objects in the surface as you move. To the tracker, the different objects reflected in the surface represent a changing environment, and the device loses tracking.

Less shiny objects are easier to track against.

8.4.7 Wi-Fi fingerprint considerations

As long as Wi-Fi is enabled, map data will be correlated with a Wi-Fi fingerprint, even when not connected to an actual Wi-Fi network/router. Without Wi-Fi info, the space and holograms may be slightly slower to recognize. If the Wi-Fi signals change significantly, the device may think it is in a different space altogether.

Network identification (such as SSID or MAC address) is not sent to Microsoft, and all Wi-Fi references are kept local on the HoloLens.

8.4.8 Mapping new spaces

When users enter a new space (or load an existing one), they will see a mesh graphic spreading over the space. This means the device is mapping the surroundings. While HoloLens will learn a given space over time, Microsoft provides various tips and tricks to map spaces.

8.4.9 Environment management

Two settings enable users to “clean up” holograms and cause HoloLens to “forget" a space. They exist in **Holograms and environments** in the settings app, with the second set also appearing under **Privacy** in the settings app.

- **Delete nearby holograms**. When you select this setting, HoloLens will erase all anchored holograms and all stored map data for the “current space” where the device is located. A new map section would be created and stored in the database for that location once holograms are again placed in that same space.
- **Delete all holograms**. By selecting this setting, HoloLens will erase ALL map data and anchored holograms in the entire databases of spaces. No holograms will be rediscovered, and any holograms need to be newly placed to again store map sections in the database.

8.5 Hologram quality

Holograms can be placed throughout the environment—high, low, and all around. To get the best view, users must make sure to adjust the device so they can see the entire frame.
For the holograms to look crisp, clear, and stable, the HoloLens device needs to be calibrated for individual users.
To get to the Calibration app, go to **Settings** > **System** > **Utilities**. Select **Open Calibration** and follow the instructions.
If different users are going to be using the HoloLens, they should run the Calibration app first, so the device is set up properly for them.

8.6 Temperature and regulatory information

HoloLens Regulatory information: Includes information on temperature range, disposal, radio, and TV interference, and more.
Here are some guidelines to follow when using the HoloLens device:

- Store the device in an environment within the temperature range (either on Standby or Off) for an hour before using the device.
- Use the device in an environment within the temperature range.
- Use device indoors.

- Use the device in shade; even indoors avoid direct sunlight through windows or skylights.

9 Annex 3 - Configuration and deployment of the AR glasses

9.1 User management

HoloLens always operates under a user context. Therefore, there is always a user identity. HoloLens treats identity in almost the same manner as other Windows 10 devices do.

9.1.1 Setting up users

The most common way to set up a new user is during the HoloLens out-of-box experience (OOBE). During setup, HoloLens prompts for a user to sign in by using the account that they want to use on the device. This account can be a consumer Microsoft account or an enterprise account that has been configured in Azure.

9.1.2 Signing in during setup creates a user profile on the device.

The user profile stores apps and data. The same account also provides Single Sign-on for apps such as Edge or Skype by using the Windows Account Manager APIs.
If users intend to use an enterprise or organizational account to sign into HoloLens, HoloLens enrols in the organization's IT infrastructure. This enrolment allows the IT Admin to configure Mobile Device Management (MDM) to send group policies to HoloLens.
Users can access the Settings app to change this behaviour, or the behaviour can be controlled by group policy.

9.1.3 Linked accounts

As in the Desktop version of Windows, users can link additional web account credentials to their HoloLens account. Such linking makes it easier to access resources across or within apps (such as the Store) or to combine access to personal and work resources.
Linking accounts does not separate the user data created on the device, such as images or downloads.

9.1.4 Setting up multi-user support (AAD only)

HoloLens supports multiple users from the same AAD tenant. To use this feature, users must use an account that belongs to their organization to set up the device. Subsequently, other users from the same tenant can sign into the device from the sign-in screen or by tapping the user tile on the Start panel. Only one user can be signed in at a time. When a user signs in, HoloLens signs out the previous user.
All users can use the apps installed on the device. However, each user has their own app data and preferences. Removing an app from the device removes it for all users.
Devices set up with AAD accounts will not allow signing in to the device with a Microsoft Account. All subsequent accounts used must be AAD accounts from the same tenant as the device. To change from using AAD accounts to Microsoft Accounts for signing into the device, you must re-flash the device.

9.1.5 Removing users

One can remove a user from the device by going to Settings > Accounts > Other people. This action also reclaims space by removing all of that user's app data from the device.
Using single sign-on within an app
Any account interrupts that might occur, such as requesting user consent for account information, two-factor authentication, and so forth, must be handled when the app requests an authentication token.
If the app requires a specific account type that hasn't been linked previously, it can ask the system to prompt the user to add one. This request triggers the account settings pane to launch as a modal child of your app. For 2D apps, this window renders directly over the centre of the app. For Unity apps, this request briefly takes the user out of the holographic app to render the child window.

9.1.6 Enterprise and other authentication

If the app uses other types of authentication, such as NTLM, Basic, or Kerberos, users can use Windows Credential UI to collect, process, and store the requested credentials. The user experience for collecting these credentials is very similar to other cloud-driven accounts interrupts, and appears as a child app on top of the 2D app or briefly suspends a Unity app to show the UI.

9.1.7 Deprecated APIs

One way in which developing for HoloLens differs from developing for Desktop is that the OnlineID Authenticator API is not fully supported. Although the API returns a token if the primary account is in good standing, interrupts such as those described in this article do not display any UI for the user and fail to correctly authenticate the account.

9.1.8 How is Iris biometric authentication implemented on HoloLens 2?

HoloLens 2 supports Iris authentication. Iris is based on Windows Hello technology and is supported for use by both Azure Active Directory and Microsoft Accounts. Iris is implemented the same way as other Windows Hello technologies and achieves biometrics security FAR of 1/100K.

9.1.9 How does the type of account affect sign-in behaviour?

If users apply policies for sign-in, the policy is always respected. If no policy for sign-in is applied, these are the default behaviours for each account type:
Azure AD: asks for authentication by default, and configurable by **Settings** to no longer ask for authentication.
Microsoft account: lock behaviour is different allowing automatic unlock, however, sign in authentication is still required on reboot.
Local account: always asks for authentication in the form of a password, not configurable in **Settings**

9.2 Network configuration

HoloLens is, at its core, a Windows mobile device integrated with Azure. It works best in commercial environments with wireless network availability (Wi-Fi) and access to Microsoft services.
Critical cloud services include:

- Azure active directory (AAD)
- Windows Update (WU)

Commercial customers will need enterprise mobility management (EMM) or mobile device management (MDM) infrastructure to manage HoloLens devices at scale. HoloLens does support a limited set of cloud disconnected experiences.
Wireless network EAP support

- PEAP-MS-CHAPv2
- PEAP-TLS
- TLS
- TTLS-CHAP
- TTLS-CHAPv2
- TTLS-MS-CHAPv2
- TTLS-PAP
- TTLS-TLS

Remote Assist Specific Network Requirements
The recommended bandwidth for optimal performance of Remote Assist is 1.5Mbps.

Make sure that these ports and URLs are allowed on the network firewall. This will enable Microsoft Teams to function.

Azure Active Directory Guidance

This step is only necessary if the project involves managing the HoloLens. Ensure that users have an Azure AD License. If plan on using Auto Enrollment, users will have to Configure Azure AD enrollment. Ensure that the users are in Azure Active Directory (Azure AD).

It is suggested that users who need similar licenses are added to the same group.

Create a Group

Ensure that the users (or group of users) are assigned the necessary licenses.

Option 1: Permit all users to join devices to Azure AD. Sign in to the Azure portal as an administrator > Azure Active Directory > Devices > Device Settings > Set Users may join devices to Azure AD to All

Option 2: Give selected users/groups permission to join devices to Azure AD Sign in to the Azure portal as an administrator > Azure Active Directory > Devices > Device Settings > Set Users may join devices to Azure AD to Selected

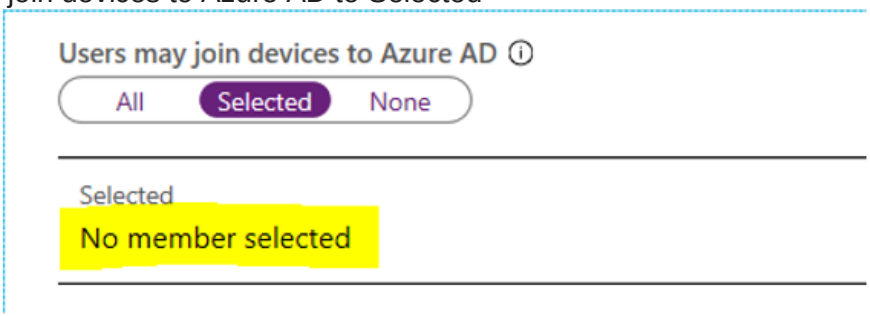

Figure 9-1 Create a Group

Option 3: One can block all users from joining their devices to the domain. This means that all devices will need to be manually enrolled.

Manage updates

Intune includes a feature called Update rings for Windows 10 devices, including HoloLens 2. Update rings include a group of settings that determine how and when updates are installed. For example, users can create a maintenance window to install updates or choose to restart after updates are installed. Users can also choose to pause updates indefinitely until ready to update.

Application management

Manage HoloLens applications through

1. Microsoft Store

The Microsoft Store is the best way to distribute and consume applications on HoloLens. All applications in the store are available publicly to everyone, but if it isn't acceptable, check out the Microsoft Store for Business.

2. Microsoft Store for Business

Microsoft Store for Business and Education is a custom store for your corporate environment. It lets users use the Microsoft Store built into Windows 10 and HoloLens to find, acquire, distribute, and manage apps. It also lets users deploy apps that are specific to the commercial environment but not to the world. Application deployment and management via Intune or another mobile device management solution

Most mobile device management solutions, including Intune, provide a way to deploy line of business applications directly to a set of enrolled devices.

3. Device Portal

Applications can also be installed on HoloLens directly using the Windows Device Portal. This isn't recommended since Developer Mode has to be enabled to use the device portal.

Certificates

Users can distribute certificates through their MDM provider. If the project requires certificates, Intune supports PKCS, PFX, and SCEP. It is important to understand which certificate is right for the project.

Certificates and Authentication
Certificates can be deployed via the MDM. Certificates can also be deployed to the HoloLens through package provisioning.
Connect HoloLens to a network
To do most things on your HoloLens, users have to be connected to a network.
Connecting for the first time
The first-time users activate the HoloLens, they will be guided through connecting to a Wi-Fi network. If users have trouble connecting to Wi-Fi during setup, make sure that the network is either an open, password-protected network or a captive portal network. Users must also make sure that the network doesn't require to use a certificate to connect.
On HoloLens 2 devices a user may also use a USB-C to Ethernet adapter to connect directly to Wi-Fi to help assist in setting up the device. Once the device has been set up a user may continue to use the adapter or they may disconnect the device from the adapter and connect to Wi-Fi after setup.
Connecting to Wi-Fi after setup
Perform the Start gesture and select Settings. The Settings app will be auto placed in front of the user
Select Network & Internet > Wi-Fi. Make sure Wi-Fi is turned on.
Select a network, then select Connect.
HoloLens contains an 802.11ac-capable, 2x2 Wi-Fi radio. Connecting HoloLens to a Wi-Fi network is similar to connecting a Windows 10 Desktop or Mobile device to a Wi-Fi network.

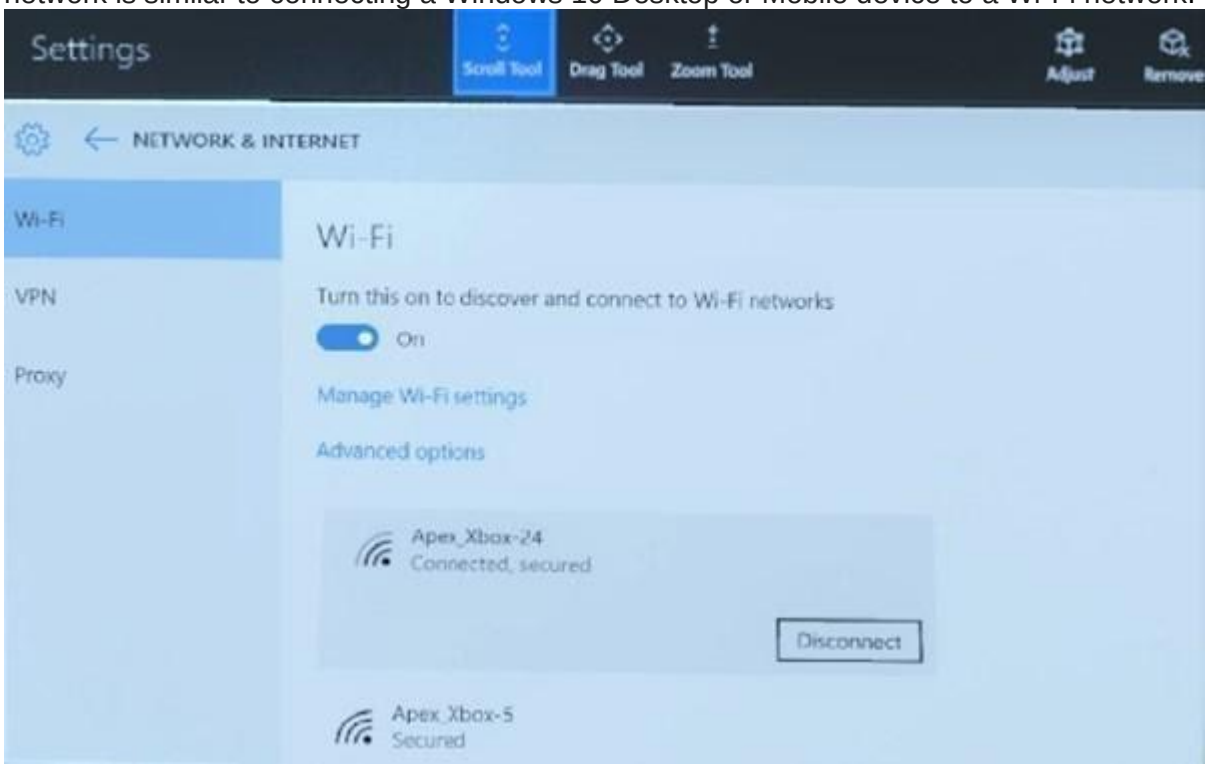

Figure 9-2 Connecting to Wi-Fi after setup

Users can also confirm they are connected to a Wi-Fi network by checking the Wi-Fi status in the Start menu:
Open the Start menu.
Look at the top left of the Start menu for Wi-Fi status. The state of Wi-Fi and the SSID of the connected network will be shown.
Troubleshooting connection to Wi-Fi
When users sign into an enterprise or organizational account on the device, it may also apply Mobile Device Management (MDM) policy, if the policy is configured by the IT administrator.
Connect HoloLens to Enterprise Wi-Fi Network

Enterprise Wi-Fi profiles use Extensible Authentication Protocol (EAP) to authenticate Wi-Fi connections. HoloLens Enterprise Wi-Fi profile can be configured through MDM or provisioning package created by Windows Configuration Designer.
For Microsoft Intune managed device, refer to Intune for configuration instructions.
To create a Wi-Fi provisioning package in WCD, a pre-configured Wi-Fi profile .xml file is required.

EAP Troubleshooting

Double-check Wi-Fi profile has right settings:

- EAP type is configured correctly, common EAP types: EAP-TLS (13), EAP-TTLS (21) and PEAP (25).
- Wi-Fi SSID name is right and matches with HEX string.
- For EAP-TLS, TrustedRootCA contains the SHA-1 hash of the server's trusted root CA certificate.
- On Windows PC "certutil.exe -dump cert_file_name" command will show a certificate's SHA-1 hash string.

Collect network packet capture on the Access Point or Controller or AAA server logs to find out where the EAP session fails.
If the EAP identity provided by HoloLens is not expected, check whether the identity has been correctly provisioned through a Wi-Fi profile or client certificate.
If the server rejects the HoloLens client certificate, check whether the required client certificate has been provisioned on the device.
If HoloLens rejects the server certificate, check if the server root CA certificate has been provisioned on HoloLens.
If the enterprise profile is provisioned through a Wi-Fi provisioning package, consider applying the provisioning package on a Windows 10 PC. If it also fails on Windows 10 PC, follow the Windows client 802.1X authentication troubleshooting guide.

VPN

A VPN connection can help provide a more secure connection and access to the company's network and the Internet. HoloLens 2 supports a built-in VPN client and Universal Windows Platform (UWP) VPN plug-in.
Supported Built-in VPN protocols:
IKEv2

L2TP

PPTP

If the certificate is used for authentication for a built-in VPN client, the required client certificate needs to be added to the user certificate store. To find if a 3rd party VPN plug-in supports HoloLens 2, go to Store to locate the VPN app and check if HoloLens is listed as a supported device and on the System Requirement page the app supports ARM or ARM64 architecture.
HoloLens only supports Universal Windows Platform applications for 3rd party VPN.
VPN can be managed by MDM via Settings/AllowVPN and set via Vpnv2-csp policy.

VPN via UI

VPN is not enabled by default but can be enabled manually by opening **Settings** app and navigating to **Network & Internet -> VPN**.

Select a VPN provider.
Create a connection name.
Enter your server name or address.
Select the VPN type.
Select type of sign-in info.
Optionally add user name and password.

Apply the VPN settings.

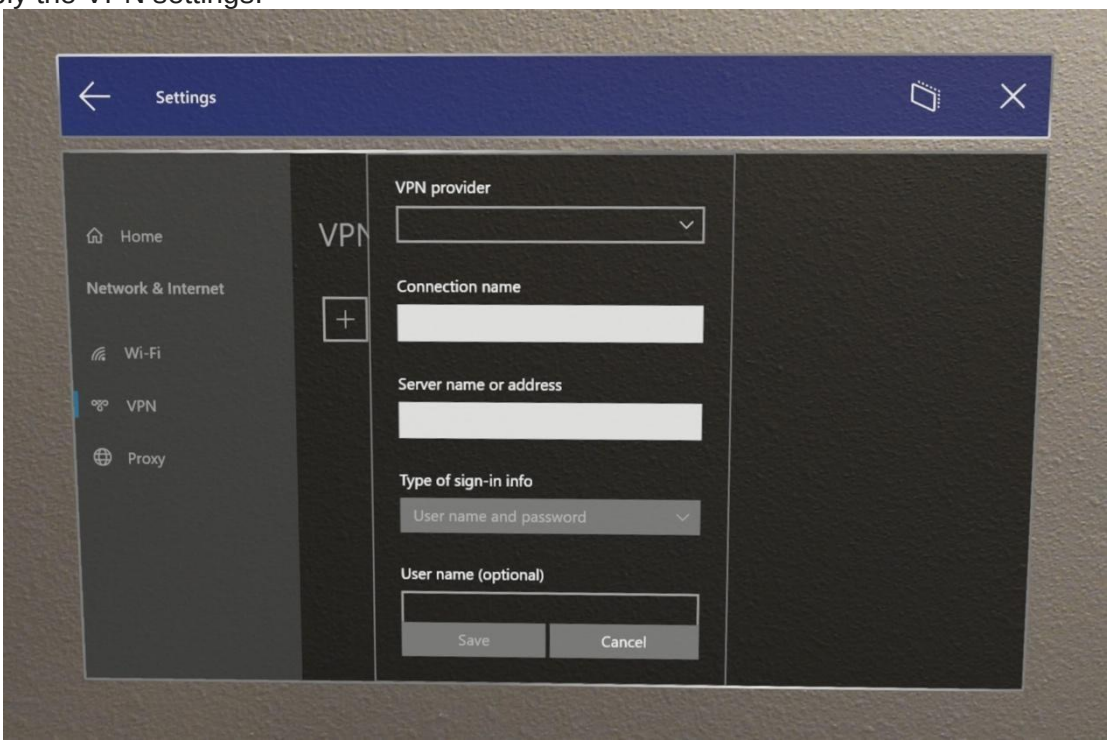

Figure 9-3 VPN via UI

VPN set via Provisioning Package
Launch Windows Configuration Designer.

- Click **Provision HoloLens devices**, then select target device and **Next**.
- Enter package name and path.
- Click **Switch to advanced editor**.
- Open **Runtime settings -> Connectivity Profiles -> VPN -> VPN Settings.**
- Configure VPN Profile Name
- Select Profile Type: **Native** or **Third Party**.
- For Native profile, select **Native Protocol Type**, then configure the server, routing policy, authentication type and other settings.
- For "Third Party" profile, configure server URL, VPN plug-in App package family name (only 3 predefined) and custom configurations.
- Export your package.
- Connect the HoloLens and copy the .ppkg file to the device.

On HoloLens, apply the VPN.ppkg by opening the Start menu and selecting **Settings** -> **Account** -> **Access work or school** -> **Add or remove provisioning package** -> Select your VPN package.
Identify the IP Address of your HoloLens on the Wi-Fi network by using the Settings app

- Open the **Start** menu.
- Select the **Settings** app from **Start** or from the **All Apps** list on the right of the **Start** menu. The **Settings** app will be auto-placed in front of you.
- Select **Network & Internet**.

- Scroll down to beneath the list of available Wi-Fi networks and select **Hardware properties**.

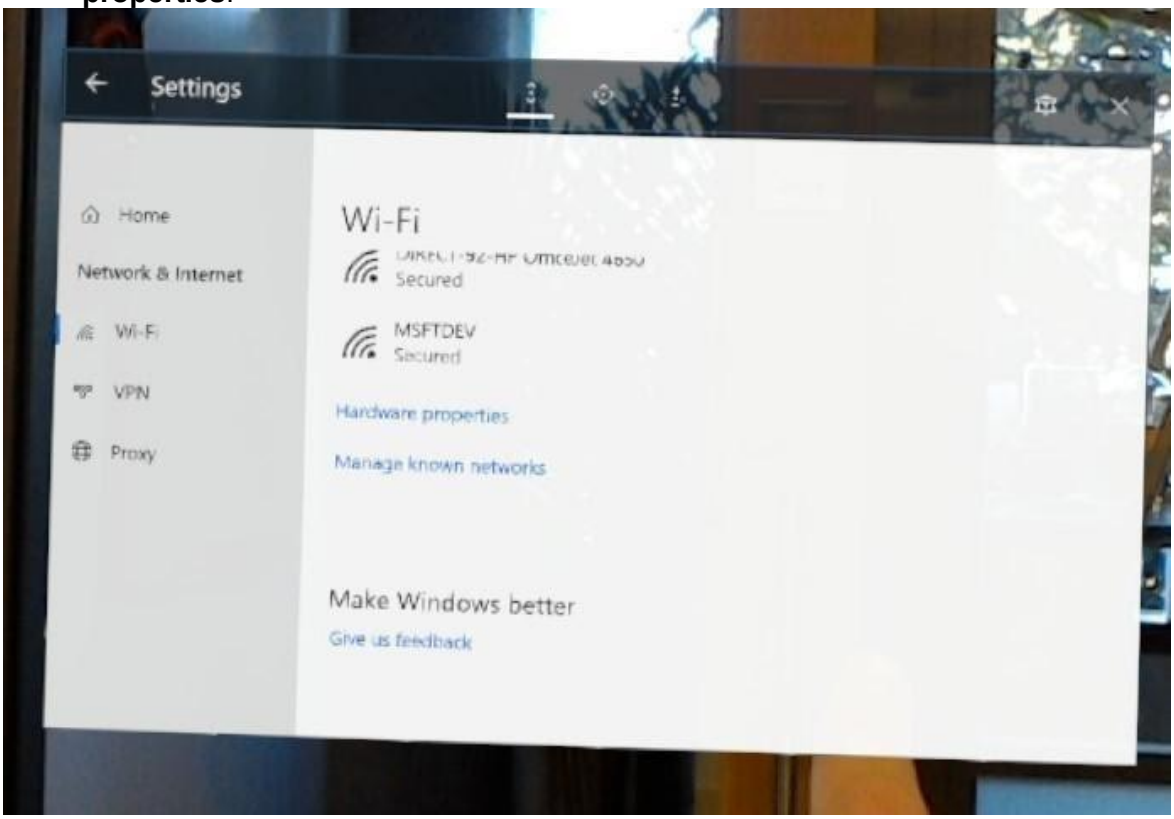

Figure 9-4 Identifying the IP Address of your HoloLens on the Wi-Fi network by using the Settings app

The IP address appears next to **IPv4 address**.
By using voice commands
On builds after 19041.1103 speak "What's my IP address?" and it will be displayed.
By using Windows Device Portal
In a web browser on the main PC, open the device portal.
Navigate to the **Networking** section.

This section displays the IP address and other network information. By using this method, users can copy and paste the IP address on the development PC.

9.3 Application management overview

For HoloLens 2, apps can be deployed on four different paths:

1. **Mobile Device Management (MDM)**,
2. **Microsoft Store for Business**,
3. **Microsoft Store**,
4. **Provisioning**.

Mobile Device Management (MDM)
An MDM solution enables IT decision-makers and administrators to privately auto-install (push) their in-house, line-of-business apps, or purchase apps through the store for a group of users. HoloLens devices work best with Microsoft Endpoint Manager (Intune) for application management. Intune also offers users finer-grained control over IT-managed apps through the Company Portal downloadable experience.
Note

The following instructions are for users who want to manage their applications with Intune. Microsoft recommends using Intune for application and device management.
Mobile Device Management (MDM) is applicable for:

- MDM deployed + Company Portal
- Line of Business (non-public) apps
- Manual installation of available applications through Company Portal
- Admin push through MDM policy
- Auto-update through MDM

Microsoft Store for Business
The Microsoft Store for Business provides IT decision-makers and administrators in businesses to find, acquire, manage, and distribute free and paid apps. IT administrators can manage Microsoft Store apps and private line-of-business apps in one inventory, plus assign and re-use licenses as needed. For more information, visit Prerequisites for using the Microsoft Store for Business.
The Microsoft Store for Business is applicable for:

- Public or Line of Business apps
- Automatic installation of required applications through MDM association
- User manually downloads apps
- Auto Update

Microsoft Store apps
The Microsoft Store provides IT decision-makers and administrators in businesses to find, acquire, manage, and distribute public apps.
This Microsoft Store is applicable for:

- Public apps only
- User manually downloads apps
- Auto-update if connected to the Internet

Install via Provisioning Packages
Provisioning Packages allow users to install custom or Line of Business apps, allowing IT pros and administrators to quickly install apps to a local device(s) via USB. This can be done without an internet connection and for any identity type.
Installing via Provisioning Packages is applicable for:

- Line of Business / Self-developed (non-public) apps
- Public apps (if the offline installer is available)
- USB side-load only
- No auto-update (requires manual updates via Provisioning Package)

Install Apps on HoloLens via App Installer
Using the App Installer users can have an experience that is simple for installing Apps on local devices or sharing an app with someone else who is unfamiliar with other app install methods on HoloLens. This can be done without needing to enable Developer Mode or use Device Portal. This is a simple method of distributing a completely built app.
Installing via App Installer is applicable for:

- Line of Business / Self-developed (non-public) apps
- Side-load only
- Does not require Developer mode or Device portal
- Easy for end-user to install

9.4 Troubleshooting

My HoloLens is unresponsive or won't start

If your HoloLens won't start:

If the LEDs next to the power button don't light up, or only one LED briefly blinks, users may need to charge your HoloLens.

If the HoloLens becomes frozen or unresponsive:

Turn off your HoloLens by pressing the power button until all five of the LEDs turn themselves off, or for 15 seconds if the LEDs are unresponsive. To start your HoloLens, press the power button again.

Holograms don't look good

If the holograms are unstable, jumpy, or don't look right, try:

Calibrating the HoloLens. Go to **Settings** > **System** > **Utilities**. Under **Calibration**, select **Open Calibration**.

HoloLens doesn't respond to hand input

To ensure that HoloLens can see users' hands, they need to keep them in the gesture frame. The Mixed Reality Home provides feedback that lets users know when their hands are tracked.

On HoloLens 2, a fingertip cursor appears when the users hand is close to a slate, and a hand ray appears when slates are further away

Many immersive apps follow input patterns that are similar to Mixed Reality Home.

HoloLens doesn't respond to voice commands

If Cortana isn't responding to users voice commands, make sure Cortana is turned on. On the All apps list, select **Cortana** > **Menu** > **Notebook** > **Settings** to make changes.

Users can't place holograms or see holograms that have been previously placed

If HoloLens can't map or load a given space, it enters Limited mode and users won't be able to place holograms or see holograms that have been previously placed. Here are some things to try:

1. Make sure that there's enough light in the environment so HoloLens can see and map the space.
2. Make sure that the device is connected to a Wi-Fi network. If not connected to Wi-Fi, HoloLens can't identify and load a known space. If users need to create a new space, connect to Wi-Fi, then restart your HoloLens.
3. To see if the correct space is active, or to manually load a space, go to **Settings** > **System** > **Spaces**. If the correct space is loaded and users still having problems, the space may be corrupt. To fix this issue, select the space, then select **Remove**. After the space is removed, HoloLens starts to map the surroundings and create a new space.

Users getting a "low disk space" error

Users will need to free up some storage space by doing one or more of the following:

1. Delete some unused spaces. Go to **Settings** > **System** > **Spaces**, select a space that is no longer needed, and then select **Remove**.
2. Remove some of the holograms that you've placed.
3. Delete some pictures and videos from the Photos app.
4. Uninstall some apps from your HoloLens. In the **All apps** list, tap and hold the app you want to uninstall, and then select **Uninstall**.

HoloLens can't create a new space

The most likely problem is that the device is running low on storage space