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Digital system based on augmented reality technologies for remote technical assistance for maritime vessels

V Dobref[1], L Ali[2], V Mocanu[2]

[1] Professor PhD eng., "Mircea cel Bătrân" Naval Academy, Constanta, RO
[2] University Assistant, PhD eng., "Mircea cel Bătrân" Naval Academy, Constanta, RO
Corresponding author: V Dobref, E-mail: dobref_vasile@yahoo.com

Abstract. Augmented reality in shipping is currently at an advanced stage in most developed countries, but in Romania, there is room for development in this sector. Augmented reality is currently used in the shipping industry, mainly by Western-based companies, but also as a pilot or prototype model in marine engineering, as in the case of the Yara Birkeland, a fully autonomous ship sailing unmanned between 2 Scandinavian ports. Augmented reality has great potential to assist the maritime industry in various operations such as remote assistance, engine diagnostics, surveys, work reporting, and training. The analysis presents numerous examples of augmented reality applications and work needs to be done before implementing these solutions and considering commercial requirements.
Keywords: augmented reality, digital environment, 3D technology, virtual reality, unmanned vehicle

1. Introduction

Nowadays we can see that all the conditions are in place for an industrial revolution, which is taking place before our eyes, especially in the maritime sector, which has started to implement digital solutions. Ship data analytics, augmented and virtual reality, artificial intelligence are just some of the relevant examples of technologies that are currently being implemented by shipping companies, classification societies and all auxiliary parts of the maritime industry. Augmented reality technology is becoming one of the main digital tools to be used in the coming years.

How can shipping companies use AR?

Augmented reality, like any other state-of-the-art technology, can help shipping companies speed up and simplify their processes. It is comparable to going from pen and paper to a computer and will provide new tools to execute tasks faster and smarter.

It will also improve worker performance. For example, in the aviation industry it has been reported that using an AR headset to help a GE technician to connect the control box of a wind turbine improved the performance of a worker by 34% on first use.

Instead of dropping us into an alternate universe, as virtual reality does, devices using augmented reality enhance the actual environment by adding holograms to our field of view to interact. AR makes it possible to merge the real world with the digital world, creating a mixed reality.

There are almost limitless possibilities, especially as technology advances. For example, instead of looking at a general arrangement drawings (GA's) on a screen, workers could look at the entire ship in 3D on a table in front of them. They could look at it from all angles, virtually highlighting certain areas or displaying the main engine, making the interaction feel more natural instead of looking at a screen.

”AR makes it possible to combine the real world with the digital environment, creating a mixed reality.”

The use of AR devices means that screens and monitors could also become obsolete, as employees can access cloud-based data wherever they work. In addition, it will make a lot of hardware redundant. Just as the smartphone included the functionality of many gadgets, such as a camera, phone, calendar or computer, AR devices take it a step further.

For ship inspections, for example, inspectors will no longer need to take extra equipment with them, as the questionnaire could be displayed directly in the room and pictures could be taken with the camera inside the device.

There are also communication benefits. The industry is already working on projects that make virtual meetings possible. Holoportation is a new type of 3D capture technology that allows high-quality 3D models of people to be reconstructed, compressed and transmitted anywhere in the world in real time.

When combined with mixed reality displays such as HoloLens, this technology allows users to see, hear and interact with remote participants in 3D as if they were in the room. Communicating and interacting with remote users will become as natural as face-to-face communication.

The future of AR in shipping

We initially expect management teams to benefit most from AR technology because of the many possibilities it offers to display all kinds of operational and productivity data, such as fleet movement.

Engineers will also benefit from being able to highlight specific engine areas for maintenance purposes. AR will allow them to view an entire ship in 3D and examine certain parts of the ship without even being on board.

The more the technology advances, the more areas of application will be found.

There will probably be some concerns at first, particularly about how complex the technology is to use and if staff will need extensive training to use it. We believe these can be easily overcome. Younger generations tend to be more digitally skilled, so are unlikely to have difficulties at first. Other users may need an introduction to get used to the headset.

”Engineers will also benefit from being able to highlight certain areas of the engines for maintenance purposes.”

Apart from the headset, the technology is software-based - so it's simply a matter of understanding how it works and getting used to having it on.

We've been working with Microsoft HoloLens to make this a reality for the shipping industry. The HoloLens device is the first standalone holographic computer that allows the user to design and interact with holograms.

The researchers from analyst firm CCS Insight predicted that mixed reality devices like Microsoft's HoloLens will start growing in sales from 2019 and that 2018 will mark the beginning of the growth in AR device adoption.

While it's still early days for the shipping industry, those interested in future technologies should keep a close eye on AR as we anticipate it will transform how companies operate over the next five years.

The aim of the research is to investigate the potential use of augmented reality in the maritime industry. The research methodology used was qualitative, based on a literature review, including statements from key players in the maritime industry. One of the biggest advantages of augmented reality is that the system allows information to be displayed on multiple screens, right in front of the end-users' eyes. For example, when a ship is in a difficult situation, such as bad weather with poor visibility, the officer of the deck uses radar to view the area around the ship and evaluate if any ships are approaching dangerously.

Figure 1. The use of augmented virtual reality on board ships [1]

With AR systems [2], the officer of the watch can just look out the bridge windows to get information about the surrounding ships, Fig. 1. Thus, the officer can see where other ships are, their courses and speeds, and the distance between his own ship and other ships, increasing the officer's awareness of the ships' surroundings.

The RA therefore improves situational awareness in different cases [1]:

- the crew on board ships can easily recognise all cables or pipes and specify their function;
- assisting in engine repair and maintenance;
- work reports can be written automatically by dictation;
- video recording;
- video reports using statistical analysis;
- remote support from company departments such as IT and technical departments;
- training in the use of new equipment such as ballast water treatment systems or cyber security systems using pre-recorded instructions;
- On-deck navigation systems integrated into AR helmets/goggles.

A new challenge for the maritime industry is to familiarise the crew with new technologies and equipment. New regulations related to NOx reduction and ballast water have led to the implementation of installations and equipment on board ships. For example, by 2027, all ships must be equipped with ballast water treatment systems, so training is needed to use this new equipment.

In addition, there are new manufacturing companies supplying such systems, with their own vision of ergonomics and human-machine interactions, so competence with this new equipment needs to be shared with seafarers on board. This challenge can be solved with AR, even if the maritime industry has a conservative approach and new technologies are viewed with scepticism, AR training is more attractive when it follows a practical method of training [1].

However, it is important to note that shipowners are cost driven and that any new investment is only undertaken in line with planning and budgetary requirements. Augmented reality technology is new and, for now, very expensive.

On the other hand, there is a great opportunity related to reducing the cost of familiarisation with new equipment used in ship operations. However, the mechanical officers on board need to have a new tool to enable remote familiarisation, maintenance, and support with the product supplier, and this new tool can be AR headsets/glasses that facilitate live familiarisation while the mechanical officers are looking at the equipment.

Ongoing new research shows that shipping companies have expressed interest in investing in AR technologies for ship navigation. A complete set of glasses and helmets displaying information about maps, radars, alarms, and navigation warnings that interact with real vision can be a solution in terms of improving safety and situational awareness. All information will be collected using navigation systems such as GMDSS, BNWAS, AIS, radars, and ECDIS, combining real and digital experiences in real-time. AR technology can therefore drastically transform the maritime industry.

Augmented reality improves ship operations

At the Marine Maintenance Conference held in Amsterdam in June 2018, Valmet's Head of Research presented for the first time new technologies using real reality for the maritime sector, which was originally developed for virtual PC games. Augmented reality is becoming increasingly important in promoting industrial products and informing the public about their potential, and is an important tool in various fields, especially in the maritime industry.

Augmented reality is defined as a technology that uses virtual components, such as images and graphics, that interact with the real environment. The user interacts with digital images and graphics and can use a smartphone or tablet.

Virtual reality is defined as a new simulated environment created by computers using VR headsets and glasses. The end-user can navigate through virtual reality in all their actions but still benefit from all the information needed in their task.

A good case study, Valmet, a company specializing in marine automation, initially used Mixed Reality technology with HoloLens for marketing purposes at various exhibitions and conferences. Over time, it is an excellent tool to address customer needs when maintenance interventions are needed in case of damage or when any unexpected event occurs on board ships, facts that can lead to major damage when a reaction comes late. With HoloLens, the customer can step into mixed reality, where they can order spare parts, write completion reports or even make suggestions for installing new devices or removing equipment on board.

Another use of AR technology with HoloLens is to conduct training on Valmet's automation systems before actually using them, saving money and time, with training to be conducted repeatedly until familiarization is complete. Another advantage of this training method is the cost saved for the trainer and the officers are trained in a real working environment. Therefore, whenever a new crew member is hired or refresher training is required, virtual training is already available on board.

Safety, reliability, and data protection are taken seriously at sea, and satellite connections are used via remote service. Encrypted protocols ensure secure communications that are used with animations of virtual reality processing devices.

2. AR system components

Explained simply, the AR system collects data from the real world, processes it and presents new data, augmented by new and enlarged views of the real world, as shown in Figure 2.

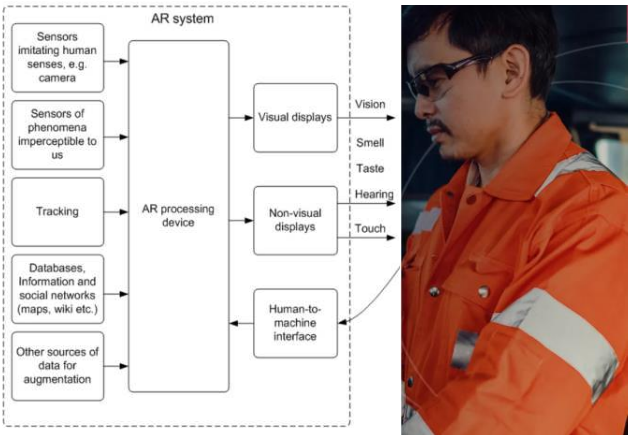
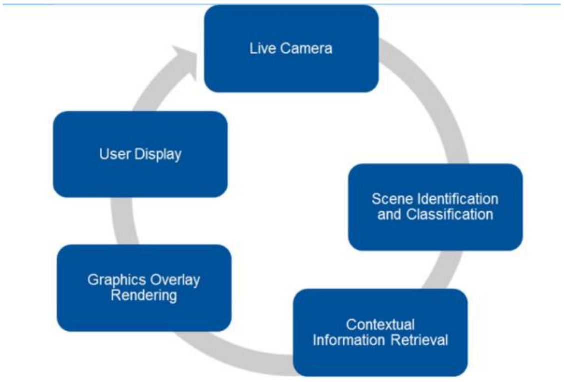


Figure 2. AR system components: inputs and outputs

Information inputs Inputs can be divided into three distinct groups, sensors imitating both human senses as well as senses imperceptible to humans, tracking sensors, and links pointing to various databases. Sensors that substitute and amplify human senses are video cameras, microphones, force sensors (tactile), and temperature sensors.

Video camera replaces vision, a human's most trusted sense, and is typically included in almost all AR applications. Sensors such as infrared cameras or ultrasound microphones are examples where sensing is expanded beyond human bandwidth [3]. Tracking sensors are used for accurate determination of user's position and attitude (orientation) in the real world.

The AR systems use one or more of the following tracking technologies: GPS, digital cameras, and inertial navigation system (INS) which typically include accelerometers, gyroscopes, or solid-state compasses. The links pointing to various databases or other available sources provide auxiliary information for the augmentation of the AR scene. These links provide access to information such as previously stored maps, data about historical buildings, or consumer reviews of various products or restaurants.



AR processing devices collect all relevant information from cameras, sensors, and associated databases, process data, and generate augmented output in real-time. It is a computationally intensive task that requires powerful processors (CPU). Software that runs on those CPUs is usually dedicated to the specific device and AR applications. 2.3 System-to-human interface System-to-human interface handles all communication between humans and the AR and can be divided into two categories. The first one includes various visual, audio, and tactile displays where data flows from the AR system toward humans. The second group is interfaces where human gives inputs to the AR system e.g. mouse or keyboard.

Figure 3. Augmented reality process, Gartner 2014

The most common display device used in AR applications is a computer monitor or TV. Although widespread, it is characterized by the lack of immersive experience. On the other hand, a Head Mounted Display (HMD) provides the best immersive experience. The HMD is worn on the user's head and has a small display device in front of each eye presenting virtual objects over the view of the real world. A nice example of HMD is AR glasses shown in Figure 3 (source: Vuzix website).

Another well-known example of HMD is a Head Equipment Assembly (HEA) used by military pilots. A different AR display also adopted from military aviation is a Head-Up display (HUD). It renders augmented information directly on the windshield as shown in Figure 4 (source: BMW website). Information is read faster, and the user's attention is never taken away from the main task, i.e. driving. Another type of display is Spatial Display.

They project the AR onto an object in space, i.e. integrate extra information into the environment. This way, the object becomes augmented with the projected data. One of the advantages of spatial displays is that they are not associated with a single user but allow multiple users to collaborate and mutually "enjoy" augmented scenes. Finally, so-called non-visual displays may be used in AR systems. All displays that are not visual belong to this group. Loudspeakers, or even more commonly used headphones, are audio displays that generate sound that creates audible perceptions for the user.

On the other hand, haptic displays interface with the user through the sense of touch. The typical device from this group is hand-worn gloves with sensors that provide tactile feedback for interaction with AR systems. Besides acquiring data from the AR system through displays, there are many ways humans can input data or give commands to the system. Microphones with speech recognition capability and handheld devices with gesture recognition are just a few of the new consumer-grade types of interfaces which could make conventional input devices such as keyboards, mice, joystick, and touchscreen redundant. An example of a military high-tech interface is the High-Off-BoreSight (HOBS) system. It enables the pilot to accurately direct onboard weapons against enemy aircraft just by pointing the head at the target.

Maintenance with AR

Another promising application of AR is the assistance in the assembly, maintenance, and repair of complex systems. Field services in the marine business can be divided into four categories: New building operations; Maintenance; Repair; Refurbishments Instructions, drawings, procedures, and 3-D virtual guides overlaid in real-time on see-through images of the actual equipment can help engineers to complete their job safer, easier, and faster. The first applications of this type were developed almost 20 years ago at Columbia University and Boeing.

A new AR system developed at Columbia University helps marine mechanics carry out repair work. Marine mechanics perform maintenance and repair of complex machinery, very often in a tight space. Instead of carrying laptops and paper documentation with them, mechanics wear a head-worn display while the AR system generates virtual layers of text instructions, labels, warnings, 3-D guiding arrows, and 3-D models of the appropriate tools. AR guides the mechanic through the entire repair procedure. Special AR googles integrated with headphones allow the mechanic to have all information, tools, and animated components overlaid on the actual vehicle [4].

Figure 4. Ship engine-room maintenance with AR

Figure 5. Marine engineer using AR system for ship maintenance

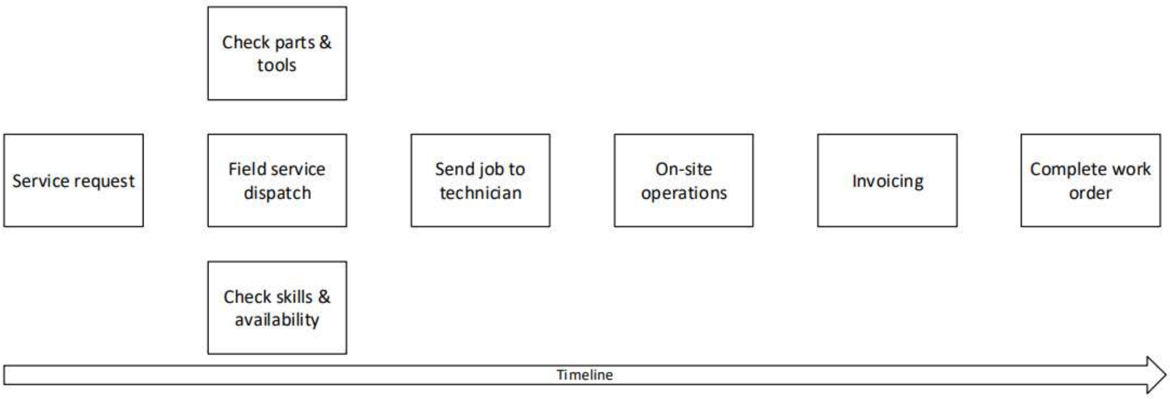


Figure 6. Field service process diagram

Case studies: SeaHarmony

SeaARHarmony, a company specializing in the development of AR products such as facial recognition and 3D modeling and animation, has launched a platform that facilitates remote support between ship officers and technicians located anywhere in the world. This involves the use of AR smart glasses and a web interface for connectivity, enabling navigation services, maintenance checks, tanker emergency response services, and crew familiarisation [5].

Case 1

The ship has a main engine failure while crossing the Bosphorus, causing a chain reaction of communication between the officers on board and the company office management, the ship's agents, and the engine manufacturer. With SearHarmony, the chief engineer will wear smart glasses and connect to the web platform with all parties involved, getting a clear view of the engine, and allowing the engine manufacturer to guide the chief engineer through the diagnostic process. The entire operation is also monitored by the ship's superintendent without actually going on board, allowing for a huge reduction in cost and time.

Case 2

According to the ISM Code, the designated person ashore must carry out an internal audit and a navigational audit at least once a year for each ship. The old process was as follows: the DPA, together with the technical superintendent, traveled on board the vessel by plane, stayed at least one day at the hotel waiting for the vessel, and chartered a high-speed boat to take it on board from the berth to the anchorage area.

The product developed by Seah ARMONY simplifies this process, reducing travel costs. A watch officer will wear smart glasses and connect to the platform, allowing the auditor to evaluate the navigation operations, check all the actions of the officers, verify passage plans, ask questions, and identify safety management system issues, just like a real audit. The whole process is recorded and stored for future reference.

These are just two of the many possible cases in which the AR platform can be used on board ships. In the first case, when repairing the main engine, the company can issue corrective actions and perform a root cause analysis of the failure remotely to avoid this situation for other ships in the fleet.

Augmented reality - a new perspective in education

As mentioned above, there are various ways for AR to improve work processes and workplace safety, its arrival on the market is now changing the way work is done in many industries, improving the ability to be accurate and detailed.

In the maritime industry, the training of future crew members will be done in a virtual and interactive environment. This space allows future officers to become familiar with dangerous environments, and complex situations and can practice responses to possible scenarios until they are comfortable and fully prepared to perform the task in real life.

Case 1 - Winterthur

Winterthur Gas and Diesel opened an augmented reality-based education center at the Shanghai Academy in 2017, simulating the engine room in detail. The idea has been a success, with around 500 crew members trained each year so far. The AR technology contains touch screens used in conjunction with engine room simulation software, creating a digital environment to simulate the exact conditions of the engine room facilities. In addition to the first and second layers, which are the touchscreens and the engine room software, a third layer can be used in conjunction with the others, such as smart glasses and joysticks.

Case 2 - Canadian Navy

MAN Energy Solutions has already recognized that digitalization will play a key role in shipping and power generation, so a new department specializing in AR has been set up. The stated aim of the head of MAN Energy Solutions is to optimize work processes and increase work efficiency, making virtual and augmented reality an essential part of the company's future development.

The Canadian Navy has contracted MAN Energy Solutions for training services for naval officers, using the MAN augmented reality platform for this purpose. The main focus of the training is the operation and maintenance of MAN engines on board the Navy's patrol vessels. In this case, the equipment contains VR goggles, a controller, and a touch screen, replicating engine room resources in detail. The virtual screen displays information about how the engines operate, allowing operations such as starting/shutting down the engine and also viewing the engine crankcase, crankshaft, main bearings, and pistons during operation, all using augmented reality. During the training, students may face real situations such as low lubrication oil pressure, where action needs to be taken to keep the ship running.

Case 3- Yara Marine Technologies

Yara Marine Technologies is a product provider specializing in creating solutions for a more environmentally friendly marine industry and implementing products across a wide range, from Sox scrubbers compliant with the latest regulations to software for fuel oil consumption, fleet statistics, and automation systems. At the time of the COVID pandemic, when Yara's service engineers were restricted from going on board ships, the company began experimenting with AR smart glasses to train marine engineers and provide solutions to customers when malfunctions occurred.

Their AR software allows for marking up, sketching, and adding any text or notes on various engine components for future reference in education. This has proven useful when giving instructions and has seemed to be a good tool in remote crew training. However, Yara did not specify what type of glasses are used for such services but did indeed state that they use several types of smart AR glasses.

After the COVID pandemic, Yara Marine conducted a successful test in Shanghai using AR glasses to provide the best possible training to a crew on board a ship located in Japan. In addition to the functionality mentioned above, there was apparently a challenge with internet connectivity, particularly in the engine room where any electromagnetic field was blocked. According to the company's statement, this issue has been resolved and the system is continually being improved.

Application for ship bridges

As defined above, augmented reality technology overlays digital information on top of the real environment, implemented via smart glasses or displayed on video images on screens.

When wearing AR interfaces, AR glasses, headsets, and head-mounted displays as a watch officer, while the vessel is performing docking/ undocking operations in a busy port, the user will be able to access and process digital information relevant to their task. The user will have access, via AR technology, to valuable information: speed, heading, power, the distance between vessels, or any navigation alert or alarm. Conventionally, the officer of the watch has to sit and look down at the navigation equipment on deck to collect and process all this information, while a second person, usually a capable mariner, looks through the navigation windows on deck to assess whether any dangerous situation may arise (distance to berth, distance to tug, speed of tug, distance between own vessel and other obstacles) [5].

When using AR technology, the officer of the watch can be alone on the bridge and look through the bridge windows, while receiving all the information already collected from the navigation equipment on the bridge on a single screen.

AR in performing navigation tasks

In 2022, a Polish research group conducted an experiment with the aim of using augmented reality in navigation on water and determining its usefulness. They started with several hypotheses, such as [5]:

- AR will describe the water and weather conditions in which the ship is and help the crew reach their destination safely, avoiding dangerous places;
- the app on which AR is based will improve voyage safety and avoid navigational obstacles;
- GPS will be the location source;
- the app will include a navigation map and display information such as location, speed, and direction.

The architecture of the application is based on interconnected blocks, each of which is responsible for a different task, consisting of several modules, such as:

- location module: responsible for obtaining position and direction based on sensors (GPS, accelerometer, and gyroscope);
- interaction module: allows users to interact with hardware devices;
- display module: where AR content is displayed;
- communication: carried out between the user and the server, responsible for sending and receiving information.

Tests were carried out in the coastal waters of Poland and on Lake Beldany to determine the suitability of augmented reality in the aquatic environment. Even though the water was calm and flat, the software could not calculate the center and orientation of the reference system where other objects were located, nor could it find any tracking surface. A second test showed that the device could only calculate the above parameters when the shoreline was displayed on the camera screen, and when the device was moved, displaying only water, all virtual reality parameters placed on the screen failed.

3. ARMMS project developed by the Romanian Naval Forces

The ARMMS project, which will be developed by the Romanian Naval Forces between 2023-2025, aims to develop and test in an operational environment a prototype of a remote interaction system using augmented reality technology. The project is designed to become modern support for technical-level activities on board a ship, as well as logistical ones, specific to the defense domain of the Naval Forces. At the same time, the project aims to make the theoretical and experimental developments modular and flexible in order to allow easy conversion to other usage scenarios.

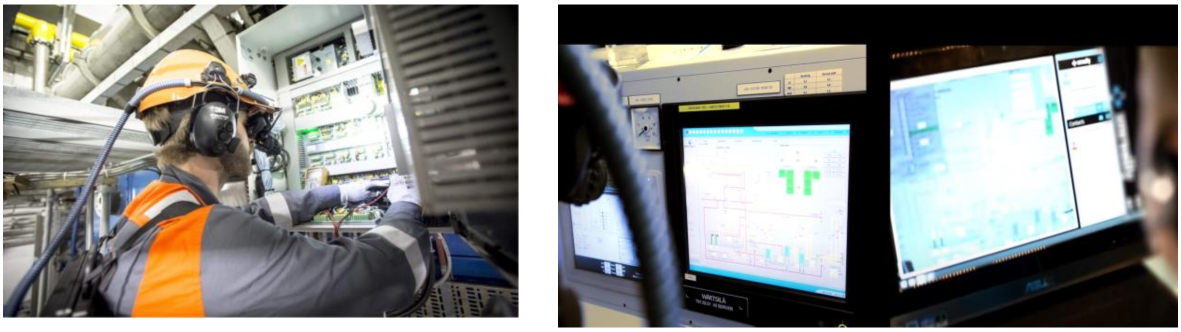


Figure 7. Shipboard maintenance using augmented virtual reality

Such a system is extremely useful when technical failures occur on board ships on a mission, which is a common occurrence, especially as a technical stress factor. In such circumstances, most often the available human resource is reduced due to involvement in other urgent activities so that immediate repair and/or rehabilitation of the ship's systems is a priority that overrides other priorities of the moment. With augmented reality, there is the possibility to access know-how or to bring it from a command point where the number and level of specialists are theoretically much higher.

For efficiency, formalized technical expertise will be deployed on smart glasses via the available app, which does not require an internet connection. However, if the technician cannot find the necessary information, he will call an expert in the command center. Due to the fact that a ship on the move only communicates data via satellite, the internet connection is relatively poor and bandwidth is narrow. Therefore special attention will be paid to optimizing communication and data flow between the parties involved.

The project aims to develop an experimental model at Technology Readiness Levels (TRL6). The concept of operation will be developed in several study phases:

- Definition of functional and non-functional requirements for the design and implementation of a remote support and interaction software platform, used on board a ship with an internet connection, according to the requirements defined by the Naval Forces. The software platform will provide an audio-video connection, a two-way link between a remote technician and a local operator. The operator will be able to be equipped with smart glasses, allowing the application to be installed and used hands-free, but the application will be possible to use on any Android mobile device.

The users of the platform (technician and local operator) will be able to interact through Augmented Reality (AR) technologies, which will allow advanced directions directly on the video link, as well as file transfer (manuals, guides, etc.).

- Implement the platform in a hardware-agnostic way, so that its performance requirements can be achieved in a flexible and scalable way. The online component will be implemented in the internal communication infrastructure of the MApN, which will ensure the scalability and availability of the system.

For all system components (platform, mobile application, and hardware requirements), the following will be considered:

- choice of the optimal communication mode, in terms of security, resilience, and data connection stability, to ensure continuity;

- choice of the optimal communication format, to ensure optimal bandwidth utilization (which may be limited due to environmental factors, availability, etc.);
- study and choice of the optimal mobile augmented reality device models available on the market;

The design and implementation of the software platform, as the central element of the system, will follow the classical rules applicable to the field, so that it works as an integrated, modular, flexible, and scalable system, made up of various modules and sub-modules, which will perform numerous functions. Modularity and flexibility will provide the possibility of further development of additional functionalities, which can easily call on modules already developed. The system will be accessible to users through intuitive web interfaces, which will provide the possibility to administer the system and perform most of the system functionalities. AR means will be integrated into maintenance, remote assistance, diagnostics, work tasks, work checklists, and training purposes, and the results obtained with AR equipment will be exportable, as PDF or video reports.

In addition, the use of AR technologies will facilitate increased awareness of operational and situational contexts, for example:

- on board ships, the crew will be able to easily recognize the pipes or cables and specify what each one is for;
- machinery maintenance assistance with detailed steps and concrete instructions;
- checklist control and inspections (no need to be edited on computers, the report can be given verbally);
- officers will be able to use it for daily tasks;
- video reporting with statistical analysis (shared in real-time from ship to shore);
- remote support from offices with IT and Technical departments;
- training in advanced technology equipment using pre-recorded instructions;
- bridge systems transferred and integrated into AR helmets.

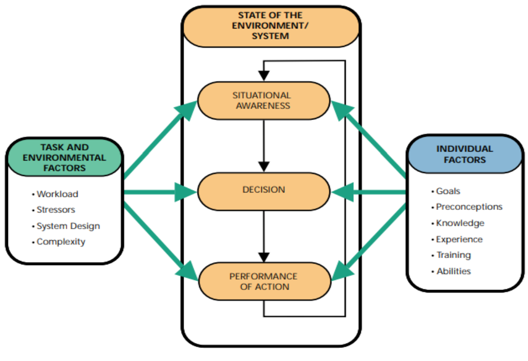


Figure 8. Operational context assessment (Endsley model [6]) using AR

Secondary to performing exclusively military activities, this prototype system can be used for:
- remote support and maintenance in any technical field, ground or airborne;
- emergency medical operations provided on board ships;

- specialised medical assessment operations, provided on-board ships, with the help of specialized medical personnel at a great distance.

5. Conclusions

This paper describes the latest developments of augmented reality in the maritime industry, but there are some technical difficulties when using these systems, such as severe weather conditions and environments including extreme temperatures, intense wind, and strong wave movements, the use of wireless networks for data transmission due to limited speed or signal blockage, ship roll, and pitch, and the lack of requirements for the design and use of these systems.

The analysis showed that augmented reality used to educate and assist crew aboard ships is an excellent solution, but the use of augmented reality in the naval domain is a complicated and difficult task, as this sector needs a uniform standard for designing, building, and using augmented reality.

AR is not a new technology, but it hasn't had the chance to get widespread until now. The need for advanced and usually computationally expensive technologies has been one reason why AR has been hidden for a long time in academic and industrial research labs, only finding its way into military applications. The attractiveness of AR has led technological and academic proponents to continue to wait and come up with new ideas, which sometimes sounded like science fiction. Unfortunately, RA often failed to deliver. Today, however, the technology required for AR applications has matured and, as a result, the number of commercial augmented reality applications and, in particular, consumer AR applications is growing exponentially. The quality, size, and cost of an augmented reality system components such as such as cameras, displays, tracking devices, computing power and, speed and flexible data links with databases have made AR available to the general public.

In addition, augmented reality system components are expected to improve dramatically, opening up new horizons and bringing currently unimagined AR applications to market in the near future. We can expect virtual layers to be indistinguishable from real ones, and future applications could easily become full virtual reality-based environments. AR is definitely a technology of the future, which will find use in almost any segment of our lives and is currently, according to many companies in the market, a technology of the future market analysts, one of the top ten most disruptive new technologies.

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