WHAT IS AN AUTONOMOUS SHIP?

OUR EVOLVING INDUSTRY

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We understand the autonomous ship as a system (see Figure 1) which consists of three essential specific components: the autonomous bridge, the autonomous engine room, and the shore control center. The autonomous bridge is a compilation of various technologies that enable the ship to independently capture a nautical picture of the situation it faces and, based on this, to navigate in accordance with COLREG (the International Regulations for Preventing Collisions at Sea), e.g. to make and implement course and voyage decisions independently.

The aim of the autonomous engine room is to equip the main and auxiliary units for propulsion, power generation and other technical tasks with automation technology that allows the vessel to operate safely without a crew aboard for a journey. The manned shore control center has the task of monitoring autonomous vessels and solving problems by remote access, if necessary.

AUTONOMOUS ADVANTAGES

In general, there are safety-related, economic, and ecological advantages to autonomous ships. A great number of all maritime accidents relate to human error, so comprehensive on-board automation and seamless land-based monitoring will increase safety through a combination of assistance systems and remote monitoring. Further, experts see the main economic and ecological potential of unmanned vessels primarily in the fields of changed investment costs and fuel savings. Completely unmanned ships go without the hotel system and the bigger part of the superstructures. This saves in construction costs, and a lower weight and reduced air resistance due to superstructures contributes significantly in reducing fuel consumption.

However, expenses do arise in ports, as many of the works that a crew would normally do while sailing have to be carried out during port stops if a vessel is unmanned. Overall, however, an autonomous ship is still better value for money. Recent research shows potential savings of 7-10% in relation to the total life cycle costs of a bulk carrier. The potential, of course, varies greatly depending on the type of vessel and operating mode under consideration.

EQUIPPING A VESSEL

An autonomous bridge provides a ship with sensors and intelligence in such a way that it acquires the ability to display "situational awareness", meaning it can react independently to any given situation. The ship can capture and analyze a nautical scenario and then make decisions based on it in order to navigate safely and in compliance with the rules. For this purpose, cameras and sound-detecting systems, as well as algorithms or programmes must be available in the autonomous bridge to enable this complex decision-making process (see Figure 2). Three essential functions are collision prevention, weather routing, and the avoidance of grounding. According to the EU Waterborne TP Platform, this is one of the critical components necessary to enable unmanned autonomous vessels.

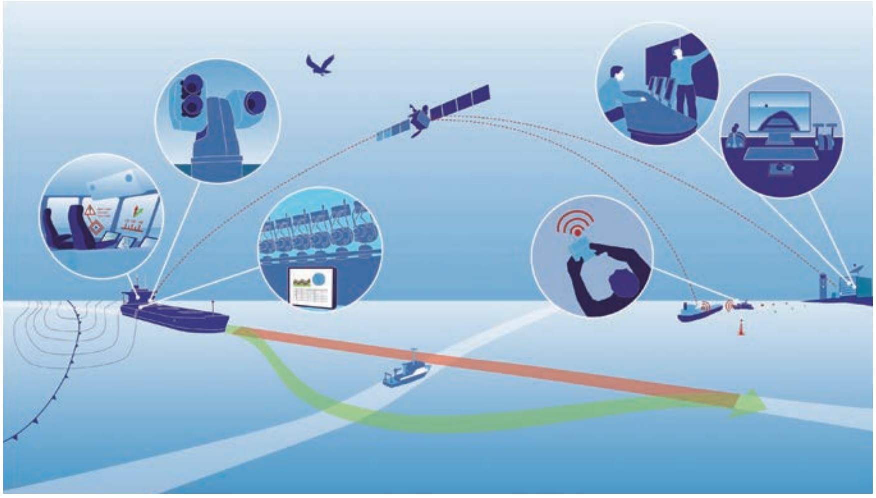
SAFE NAVIGATION

Safe navigation involves identifying other ships in good time, recognizing the collision prevention rules to be applied to the situation, and reacting accordingly. It goes without saying that autonomous vessels must ensure the evasion of shallows (see Figure 3). In the event that an approaching vessel does not behave in accordance with the rules, the 'manoeuvre of the last moment' must be initiated.

Weather routing is about avoiding heavy weather and bad weather zones. Strategic weather routing is carried out before a ship arrives in a bad weather area. This not only avoids stress on the ship and cargo caused by bad weather, but also saves fuel. However, it is not always possible to avoid bad weather areas. This is why a ship has to stand its ground even in heavy weather. In order to reduce the negative effects on the ship and cargo and to ensure the stability and safety of the ship, appropriate course and speed should be determined and controlled.

THE AUTONOMOUS ENGINE ROOM

The autonomous engine room refers to a technical concept in which the main and auxiliary power units for propulsion, power generation and other on-board technical tasks are equipped with automation technology in such a comprehensive manner that safe and permanent operation is possible without direct human intervention onboard. Status data on the technical systems are continuously collected and transmitted to the shore control center. In addition, redundancies in the technical equipment must be provided in order to have replacements available in the event of failure of individual components. This is especially important for elementary equipment such as drives, power generation and steering gear. In the event of foreseeable damage, remote monitoring can then be used to forecast maintenance and repair requirements at an early stage and, if possible, scheduled in the nearest suitable port.



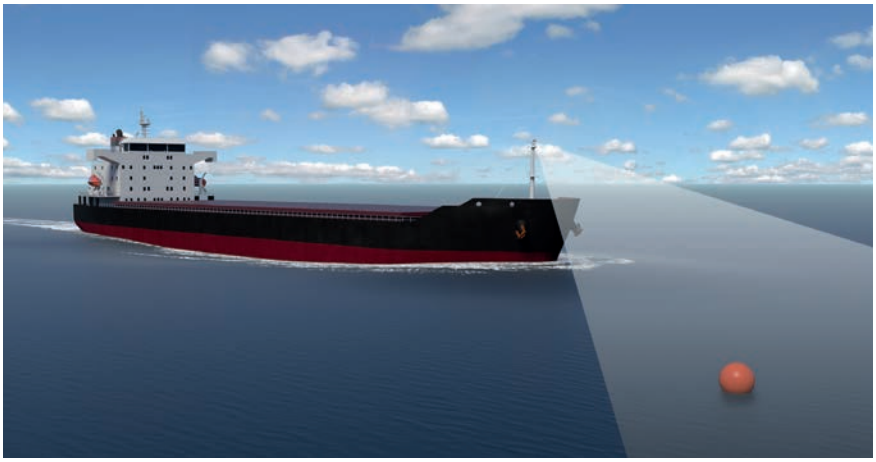


Figure 1 (top): System and components of autonomous shipping ©Fraunhofer CML;
Figure 2 (middle): Object detection by camera and sensor systems ©Fraunhofer CML;
Figure 3 (bottom): Visualization of an autonomous collision avoidance manoeuvre ©Fraunhofer CML

SHORE CONTROL CENTRES

Autonomous ships are monitored in the shore control center. For this purpose, the ships are in permanent contact with the shore control centre wherever possible. A ship's movement and condition data is continuously transmitted to the shore control center, so that a real-time situation reading is available. Thus, reliable and secure communication is key to the success of the autonomous vessel.

In addition, systems of a shore control center should be equipped with intelligence in such a way that technical and nautical situations that deviate from their normal state are recognized. Alarms should also be displayed and decisions supported on the basis of data or algorithms (see Figure 4).

Nautical officers and ship operation engineers man shore control centers to evaluate the information ships are producing and intervene as and when required. Autonomous ships can thus be remotely controlled by a shore control center in the case of unclear nautical situations. In the event of technical problems, automatic maintenance cycles or fail-to-safe-states can be initiated and individual units can be switched off. The technology for a shore control center is available in basic form. However, there is a need for development to integrate technologies into systems ready for series production. There is also a need for the further development with regard to the reliable, seamless and manipulation-free communication between ship and shore. A special consideration here is cybersecurity.

WHEN WILL WE SEE AUTONOMOUS VESSELS?

The issue of autonomous vessels has recently been taken up by a growing number of developers in companies, research institutes and universities. In particular, projects have been initiated in Finland, Norway, Great Britain, Japan, Korea and Germany with the aim of gradually realizing the vision of unmanned navigation. Different system concepts are pursued in research and development. In the EU part-financed MUNIN project, for example, a concept was developed in which a part of an ocean voyage is unmanned.

Promising prototypes have been created for key core components of autonomous ships, such as autonomous navigation. Important navigation technologies, e.g. for collision prevention and weather routing, are always available. Their integration into onboard systems is still open. In addition, new holistic sensor systems must be developed, integrating camera systems (and related technologies) in order to be able to transmit optical position images efficiently from board to land control stations. Further development tasks still have to be carried out for the safe execution of unmanned port manoeuvres and for the safeguarding of the obligatory tasks for sea rescue by an autonomous ship.

With the autonomous engine room the core component for autonomous ships, there is still a great need for further development, since the technology previously used onboard is designed for operation with human assistance for monitoring, maintenance, repair and cleaning. Maintenance-free ships and the redundancy of technical systems and their comprehensive automation are examples of this.

Figure 4: Picture of a Shore Control Center ©Fraunhofer CML

The core question of whether there will be autonomous ships is usually answered with yes. Some experts see the year 2020 as possible, while others see the years 2030 to 2040 as more realistic. However, companies such as Kongsberg with the YARA Birkeland project have announced the challenging goal to put an autonomous vessel on the ocean by the end of this decade.

In addition to the technological and economic challenges of autonomous ships, numerous legal regulations still have to be created and adapted on an international level. So far, only a few countries have opened test areas for unmanned vessel operation, but as the IMO start to investigate the topic, a rapid uptake of this challenge is to be expected.

ABOUT THE AUTHOR

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ABOUT THE ORGANIZATION

The Fraunhofer Center for Maritime Logistics and Services CML develops and optimizes processes and systems along the maritime supply chain. Within practically oriented research projects CML supports public and private sector clients of port operations as well as from the logistics services industry and from the shipping business.

ENQUIRIES

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