EPiC Series in Technology
Volume 2, 2024, Pages 39–43
Proceedings of the International Conference on Maritime Autonomy and Remote Navigation 2023

Factors Influencing the Business Case for Autonomous Ships

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Abstract

Autonomous ships during any transition from conventional vessels may embrace either full or partial autonomy. At present, it is unclear how routine maintenance or breakdown, performed currently at sea, and periodic maintenance and survey, currently undertaken in port, will be scheduled. Along with these considerations matters of safety, security, reliability, availability, and the ability to remotely diagnose potential and actual failure situations will also influence the business case for autonomous ship procurement. While the initial cost of acquiring an autonomous ship is of significance in decision making, this paper principally focusses on various other aspects of the business case. Our research has shown the importance of maintenance in developing the business case for both coastal and deep-sea shipping. Indeed, maintenance and the availability of the ship will be the determining factors in whether autonomous unmanned operations will yield a profitable business case which is attractive to ship owners. Resilience during operation is a further factor that affects profitability, and this is analysed in the context of reliability and security. This paper addresses through discussion, and the results of research, into the factors influencing the business case relating to the acquisition of autonomous ships for coastal and deep-sea ships and further presents recommendations to consider when building a business case for autonomous ships.

1 Introduction

For autonomous ships to be introduced in commercial shipping, they have to be at least as safe as conventional ships. As we expect to first see remotely operated autonomous ships being introduced, such ships will rely heavily on reliable communication between their components, other ships, the remote control centre, and other stakeholders such as vessel traffic services. Autonomous ships rely on sensory information obtained from sensors onboard the ship for their operation.

The components of autonomous ships' systems potentially present unknown interconnections and interdependencies. The fact that autonomous ships rely heavily on collecting sensory information from their environment, and communicating that either to the systems onboard or the remote operator ashore, possibly introduces new cybersecurity risks, potentially making autonomous ships a threat to their own systems, other ships, other sea users, and ports.

Other than safety and cybersecurity, another concern is the resilience of autonomous ships' systems. Having no one on board to maintain the systems for their ongoing operation, the case of a breakdown, failure, cyberattack, or physical attack, creates new challenges in day-to-day maintenance, predictive maintenance, and the ability of the systems to self-recover in the case of system failures. Having to rely on conducting all the necessary maintenance once in port, could potentially increase the time needed for autonomous ships to spend in ports, having as a consequence greater port costs, and reduced profit made overall.

For autonomous ships to be introduced in commercial shipping, they have to make economic sense to ship owners, for whom, ships are capital intensive assets generating profit. In other words, for ship owners to embrace the new technology autonomous ships use, invest in it, and make the necessary changes in the way they conduct maritime operations, they have to be convinced that autonomous ships make a good business case.

2 Factors Influencing the Business Case for Autonomous Ships

2.1 Maintenance

The key to achieving optimum ship system reliability and safety is to have a sound maintenance management system in place for mitigating or eliminating equipment/component failures (Emovon et al., 2018).

Maintenance is a set of activities that ensures that the equipment of systems work as desired or restore system conditions in case of failure (Karatuğ et al., 2022). Maintenance contributes to the prevention of unexpected failures that could lead to large repair or replacement costs, significant production losses, catastrophic safety hazards, for seafarers and the marine environment (Karatuğ et al., 2022) and unplanned downtime of ship systems due to machinery failure (Emovon et al., 2018). Having a sound and effective maintenance scheme in place increases system reliability, availability, and operational efficiency, and reduces the system downtime, the chances of vessel accidents, and management costs (Karatuğ et al., 2022, Emovon et al., 2018). The maintenance expenses of a ship have been stated to be between 20 and 40 per cent of the total operational expenses (OPEX) (Karatuğ et al., 2022; Karatuğ et al., 2023). The maintenance framework to be followed should be determined based on the considered system requirements (Karatuğ et al., 2022) and it has to optimise the three main elements of maintenance which are: risk assessment, maintenance strategy selection, and the process of determining the optimal interval for the maintenance task (Emovon et al., 2018).

The decision making process involves utilising different conflicting maintenance decision criteria, in selecting the optimum maintenance strategy, from among multiple maintenance alternatives (Emovon et al., 2018) which all have different cost consequences: the level of safety required or determined by the maritime industry, and regulation bodies, is a key factor in selecting the maintenance strategy for the machinery system; the value added to the system or equipment as a result of the application of each maintenance strategy alternative; and the applicability of each maintenance strategy alternative in mitigating or eliminating failures (Emovon et al., 2018).

In the case of autonomous ships maintenance could be considered a prerequisite for uninterrupted ship navigation, making it a crucial topic (Karatuğ et al., 2022) The maintenance policy to be applied could vary since the particular degrees of Maritime Autonomous Surface Ships (MASS) include different autonomy levels and unmanned situations. Therefore, the maintenance strategy should be well modelled to maintain influential maintenance operations, considering the ship's requirements. (Karatuğ et al., 2022).

For the maritime industry, maintenance strategies are categorised as Corrective (CM), also referred as reactive maintenance, in which a machine or system is allowed to fail before it is restored to its original state, Preventive (PM) which is scheduled maintenance based on the statistical life of plant systems, and Condition Based Maintenance (CBM) where the condition of the equipment is monitored to detect performance degradation (Emovon et al., 2018). In Karatuğ et al. (2022), marine experts have considered a hybrid maintenance policy combining condition based maintenance with time based maintenance as the most suitable maintenance strategy for 3rd and 4th levels of MASS (Karatuğ et al., 2022).

2.2 Reliability

Reliability is the probability of non-failure over time. Some types of equipment will fail less often and are therefore more reliable than other (Eriksen et al., 2021). Reliability is considered in the design of each machinery component, and the design of the vessel itself, but maintenance also affects reliability (Eriksen et al., 2021).

A few studies have been done in the specific field of autonomous and unmanned ships (Eriksen et al., 2021). The MUNIN project was the starting point in the literature reviewing the risk and reliability of MASS (Li et al., 2023).

The reliable design and the risk evaluation of mass is critical to ensure safe operations (Li et al., 2023). The lack of reliability data and the difficulty of testing remain significant obstacles when considering reliability and maintenance of machinery equipment for autonomous ships (Li et al., 2023). In addition, traditional maintenance strategies do not consider the reliability of the ship systems and subsystems as a whole (Eriksen et al., 2021).

As MASS will be deployed without humans on board, monitoring the state of equipment effectively will be a fundamental requirement (Li et al., 2023). Also, maintaining reliability of remote operators and communication, should be closely investigated. The communication ability between Remote Control Centre (RCC) and MASS should be maintained, including monitoring, command, and control (Li et al., 2023).

Reliability and maintenance, are closely related, and both subject to a balance between cost and effect, when developing a suitable maintenance strategy for autonomous ships (Li et al., 2023).

2.3 Short Sea Shipping and Deep-Sea Shipping

The nature of the operational challenges autonomous ships will face when operating near the shore, and in deep sea, is different.

As human and economic activity is more rigorous near the shore, autonomous ships operating near the shore will experience denser traffic, and sea users such as fishing boats moving in unpredictable ways, making collision avoidance in terms of safety more challenging. In addition, in terms of maritime security threats such as piracy, pirates are more likely to operate near the shore than in deep sea waters.

In terms of maintenance, autonomous ships near the shore, are more easily accessible by a team of engineers than in the case of autonomous ships operating in deep sea, making getting a maintenance team on board, less costly. In case of mechanical failure or breakdown, an autonomous ship near the shore could be expected to remain out of operation for a shorter period of time, and therefore affect the ship's profitability less, than in the case of an autonomous ship operating in deep sea, where reaching the ship in need, and providing replacement parts becomes more challenging.

In terms of communication requirements, near the shore, there are more options for an autonomous ship to maintain communication with the shore, while in deep sea operation, autonomous ships have to rely on satellite communication, which is more costly than other options. However as more businesses will offer communication support in the future, communication costs are expected to decrease.

As in the case of physical maritime security threats, cybersecurity threats could also be higher near the shore, where hijacking the autonomous ship remotely, or interfering with its sensors, could potentially cause more damage. As autonomous ships rely on communication between the ship's systems, the ship and the shore, and the ship and other ships, in higher levels of autonomy where there is no crew on board, mitigating cybersecurity threats is going to be equally vital for ships operating near the shore and in deep sea waters, potentially making the overall cost of maritime security higher for autonomous ships than conventional ships.

From all the above, we may conclude that, the different operational requirements for autonomous ships operating in short sea shipping and deep sea shipping, and the area of trade, are going to affect costs, and therefore the potential profitability of the business case differently. Ship owners will have to think about the specific operational profile they have in mind for the autonomous ship they wish to invest in, and determine the likely capital costs, operating costs, and voyage costs, for the autonomous ship in question, before deciding whether to invest in it.

3 Recommendations for Building a Business Case for Autonomous Ships

When building a business case for autonomous ships, one has to think about how the different operational requirements, autonomous ships have, will change the way the industry works, on an industry level, and a shipping company level. A ship owner will have to think about the cost of acquiring autonomous ships, the cost relative to supporting their operation, and what that will mean for the strategy of their company, and the way day-to-day operations are conducted, in order to make an informed decision about whether investing in autonomous ships is preferable to continuing operating only conventional ships, and if so, for which trade, and which operational profile. Things to consider and incorporate in a business case for autonomous ships include the following:

- As legislation around MASS will be changing, it is important to consider the short term and long term implications of any new rules that may be developed on the cost of acquisition of autonomous ships, the operating expenses, and voyage costs.
- There is the possibility that not all ports are going to be ready or able to accommodate and support MASS operation. It may be that for financial reasons, or strategic reasons, certain ports will not wish to invest in the needed changes. Therefore, when deciding to invest in autonomous ships, ship owners will have to think about the operational profile of the specific ship(s) they wish to invest in, and consider the potential port availability for the specific, type, and size of ship.
- When considering the design of autonomous ships, safety, reliability, and security, should be considered by naval architects as early as possible. Requirements may be specific to changing level of autonomy during operation, or manufacturers' recommendations.
- When considering safety, reliability and security around autonomous ships, a holistic approach needs to be taken where the ship itself, the Remote Control Centre, and the communication link between them is considered.
- When deciding whether to invest in autonomous ships, a ship owner will have to look into whether the addition of the specific autonomous ship they have in mind to invest in, will be adding value to the current fleet composition they have.

- Investing in autonomous ships, may mean for a shipping company, that its strategy and day-to-day operation will have to change, to accommodate for the changes needed to take place to support autonomous operation
- In the case of Remote Control Centres, it is yet unknown whether more than one centre will be required to support a single autonomous ship during its deep sea voyage. Having multiple Remote Control Centres placed around the globe, to support autonomous operation through different time-zones, could raise team work issues within the company, due to language or cultural barriers. Corporate culture may need to be redefined, and further development of employees may be required, to ensure a more uniform operation within the company.
- Engaging in autonomous shipping operations, will require the development of training programmes, specifically designed to train personnel ashore and at sea, for them to develop the relevant competences that will be needed to support autonomous shipping operations, something that will add extra training costs.

Acknowledgments

The author would like to express appreciation for the support of the Worshipful Company of Tin Plate Workers Alias Wire Workers, a City of London Livery Company, for their generous support for travel.

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