Shaping the Future of the Marine Industry as a Condition for Adaptation in an Innovative Society

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Abstract
The paper provides an overview of the concept design of a Rolls-Royce unmanned ship. Shipping is implementing unmanned navigation projects that combine the tasks which exist in the civil and military fleet.
The work theoretically shows a description of the dynamic autonomy of a Rolls-Royce unmanned vessel project. As a result of the review, unmanned vessels have the necessary data processing units, sensors, control, and communication systems and can automatically perform various assigned tasks without the need for crew support on board.
The work contains links to sources that clarify the presented material.

Keywords
Autonomous navigation, unmanned navigation, navigation safety, innovation

1. Introduction

Comprehensive knowledge of the World Ocean to use its resources is one of the global problems of an innovative society [1].

In an innovative society, an industry such as navigation at its inception defined itself to be innovative. This definition is fully justified. This confirmation is the MariNet group, which was created within the framework of the National Technology Initiative. The group was able to bring together large companies and small start-ups in the field of marine high technology, scientific centers, authorities, and universities.

The main course has been taken, the MariNet "road map" has been approved - collection, integration, transmission, and analysis of information about the situation at sea, on board ships and ashore using electronic means to ensure navigation "from berth to berth", shipbuilding innovations and development technologies of the world ocean. The world of shipping is currently discussing, developing, and using such areas as e-navigation, energy efficient ships, unmanned navigation.

2. The concept of increasing the safety for navigation with the use of heading innovations

One of the most important tasks for a modern fleet is the need for its urgent renewal, because the average age of ships participating in the transportation of goods is about 32 years [2]. Despite the skepticism of many shipowners and shipbuilders on the use of innovations, the largest market players came out to discuss them on the world platform, which set a theoretical and practical basis, such as the efficiency of the development for water transport on the world market in the field of ship safety systems [3]. Rolls-Royce (UK), ABB (Finland), DCNS (France) and representatives of some Norwegian, American, and Japanese organizations can be singled out separately. Whose aim is to increase

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navigation safety using innovation, which based on the original principles of the phase-frequency measurement and transformation theory of the radio-signals [4]. Destinations of the latest technologies are presented in the figures: e-navigation is a technological leap in management of water transport, which allows a fully functional use of IT-tools and telecommunications in fleet management. The process of moving from pier to pier in ports of departure and destination, and related services that ensure safe navigation and environmental protection presented on Figure 1 [5]; latest energy saving ships launched is not easy innovative and comfortable, but less harmful for the environment and economically more efficiently, which serves to strengthen economy and improving the quality of life, because we cannot save on people's health, crews of ships are shown in the figure 2 [6], 3 [7].

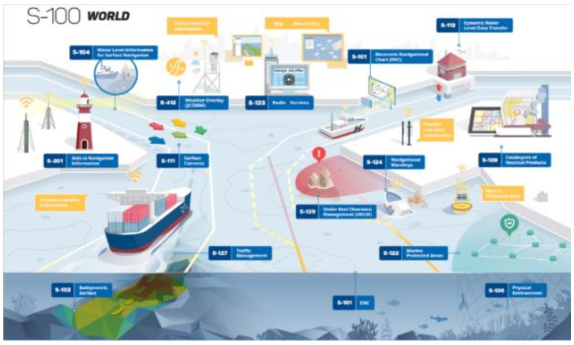


Figure 1: E-navigation

Figure 2: Energy efficient ships

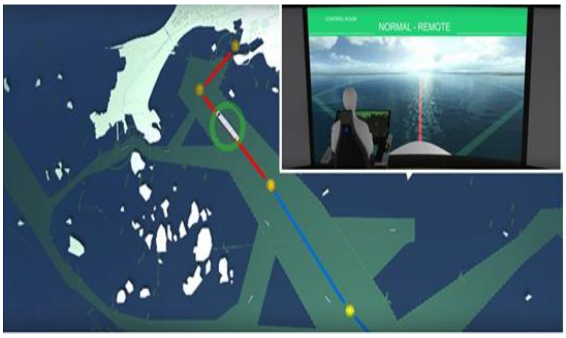


Figure 3: Supervisory teleoperation for unmanned navigation

2.1. Review of the concept project of an unmanned ship from Rolls-Royce

"Autonomous shipping is the future of the maritime industry. As revolutionary as a smartphone, a smart ship will revolutionize the design and operation of ships": Mikael Makinen, President of Rolls-Royce Marine.

The latest technologies have made it possible to develop models of remote and autonomous ships. But the search for an acceptable option for a reliable and economical combination is only just taking its first steps. Interpretation of nautical rules and regulations is not always well accepted by the programmer, which creates problems in model development. The development of decision support systems is an iterative process that will always undergo extensive testing and modeling.

Figure 4: Rolls-Royce unmanned platform ship

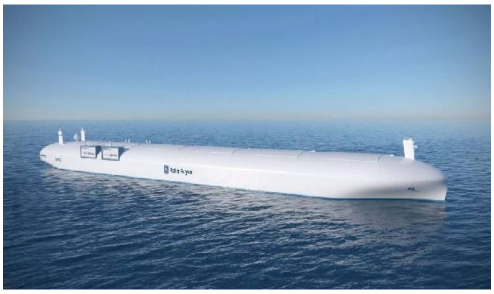
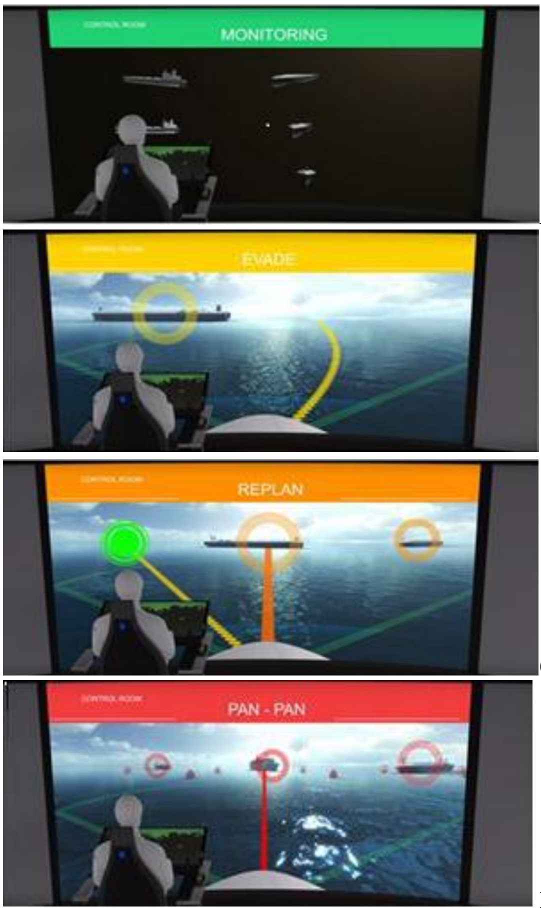


Figure 5: Unmanned commercial vessel option

The ships of the future will still need human involvement from land, communications will continue to be a significant component. Communication should create redundancy and minimize risk. For this, such characteristics are used as: bidirectionality, accuracy, scalability, "speed for measurement accuracy", support by several systems. Sufficient communication channel capacity is guaranteed for monitoring ship sensors and remote control. A permanent, guaranteed connection that allows real-time monitoring of equipment.



A B C D

Figure 6: Participation of operators: a-monitoring; b - evade; c - replan; d - pan-pan

The concept project of autonomous shipping has outlined a range of problems for the industry that await solution:

1.What technologies are needed and how best to combine them to enable the vessel to operate autonomously and for miles offshore;

2. How an autonomous ship can be made as safe as existing ships, what new risks it will face and how to mitigate the risks;

3. What will be the incentive for shipowners and operators to invest in autonomous ships and are autonomous ships legal and who is responsible in the event of an accident?

One of the players in this market is Rolls-Royce (Great Britain), which proposed a concept project for creating a family of unmanned vessels for various purposes (figure 4-5).

Depending on the needs of the customer, such ships could carry a variety of cargo or receive special equipment or weapons for solving combat missions. Dimensions, displacement, weight and composition of the payload and other parameters of a particular sample could be determined in accordance with the requirements of the market and the wishes of the customer. The automatics will take over the driving functions as well as the safety monitoring figure 6 [7]. It is assumed that for safe navigation the unmanned ship will use the Intelligent Awareness System developed by Rolls-Royce. Which automatically collects data from various surveillance devices and sensors, analyzes, takes measures to avoid collisions or other incidents. Such complexes can be used both on automatic warships and on unmanned commercial ships. Let us analyze some of the technical steps of this offshore platform

2.2 Dynamic autonomy

A solution is being developed to integrate a complete autonomous ship navigation architecture that can leverage the capabilities of the Rolls-Royce dynamic positioning system, which is designed for future autonomous ships, and links it with an automatic navigation system, including situational awareness, collision avoidance, route planning and ship condition detection modules. Since the main challenge for autonomous systems is recognition of the surrounding reality, Rolls-Royce uses Sheridan levels of autonomy to describe the extent to which a car can autonomously operate when determining autonomy levels. In Sheridan's classification, there are 10 levels of autonomy in the "operator-computer" system, corresponding to various degrees of participation of a human operator in decision-making when controlling a complex unmanned system. An adapted version of Sheridan's classification for unmanned system control. In the Sheridan classification, there are 10 levels of autonomy, the characteristic of the level of autonomy: 1.The control of an unmanned vessel is completely carried out by the operator of the ground control complex; 2.The onboard control complex of an unmanned ship offers the operator of the ground control complex a set of action alternatives for deciding; 3. An onboard control complex for an unmanned vessel narrows the choice of the operator of the ground control complex to several alternatives; 4. The onboard control complex of an unmanned vessel offers the operator the means of the ground control complex the only solution; 5. The onboard control complex for an unmanned vessel implements the only solution, having received confirmation of operations from the operator of the ground control complex; 6. An onboard control complex for an unmanned vessel provides the operator with the means of a ground control complex for a limited time to decide before automatically performing operations; 7. The on-board control complex of an unmanned vessel operates automatically, while it necessarily informs the operator of the ground control complex about the performance of operations; 8. The on-board control complex for an unmanned vessel operates automatically and, at the request of the operator of the ground control complex, informs him about the performance of operations; 9. The on-board control complex for an unmanned ship acts automatically and informs the operator of the ground control complex, if it considers it necessary, after the operations are completed; 10. The onboard control complex for an unmanned vessel independently decides on how to operate an unmanned vessel [8].

A solution to integrate a complete autonomous ship navigation architecture that takes advantage of the Rolls-Royce dynamic positioning system developed for autonomous ships and links to an automatic navigation system, including situational awareness, collision avoidance, route planning and ship condition detection modules [7].

The highest level in the system is the module for determining the state of the vessel, which is called the "virtual captain". This module brings together information from various subsystems and other ships, automation systems and the operator to determine the current state of the ship's systems. The state of the ship determines the permitted mode of operation at ship, such as autonomous, remotely controlled, or fail-safe. The status information from the virtual captain is also used to keep the operator always informed of the vessel’s status.

Dynamic Positioning Systems allow a ship to automatically maintain its position or course using propellers, rudders, and thrusters. When combined with a global or local coordinate system such as the Global Navigation Satellite System, as well as wind sensors and inertial measuring instruments, the ship can maintain its position in adverse weather conditions. Advanced dynamic positioning systems such as the Rolls Royce Icon DP can also maneuver the ship at low speed. This allows autonomous behavior to be integrated into ship handling. Since the dynamic positioning system already has information about the ship's maneuvering capabilities, it can calculate where the ship might move in the future.

These dynamic ship movement restrictions are passed on to the collision avoidance module to enable more efficient local path planning.

The route planning module is a software module that is responsible for planning a route from start to finish through predetermined waypoints, avoiding static obstacles defined in electronic navigation charts and following sea routes when appropriate. This module is closely related to the voyage planning that the ship's crew is currently involved in. However, the route planning module uses the planned voyage as information when planning the ship's actual route. A route consists of waypoints, course, and ship speed. The route planning module does not plan routes in real time, as the collision avoidance module is responsible for maneuvers to avoid obstacles.

The collision avoidance module is responsible for safe, collision-free navigation. It uses information from the route planning module to follow the path leading to its destination but may veer off course when it detects a collision risk. The Situational Awareness Module provides a local map and obstacle information that shows the current obstacles near the ship. The dynamic positioning module provides the collision avoidance module with an area in which the ship can maneuver, and thus creates boundaries for new waypoints that can be assigned. The collision avoidance module has two main functions: the first is to assess the risk of collision, and the second is to safely navigate the vessel both in harbor and on the high seas. When a risk of collision is detected, a suitable state is requested from the ship state determination module, in which the final determination of the state of the ship is based on all data from different subsystems.

The situational awareness module of the autonomous navigation system is connected to several sensor devices of different types. The Situational Awareness Module combines sensor data and extracts relevant information about the ship's surroundings for use by the collision avoidance system. The Situational Awareness Module can also perform sensor data truncation for more efficient data transmission on board. Technology development issues related to situational awareness system and ship sensors.

3. Conclusions

The transition to the era of autonomous shipping is a more complex issue than a simple technological invention. The implementation of an autonomous ship requires the systemic integration of many technologies, which means that collaboration is required between different actors who can master different technological areas such as:

1. The development of decision support systems for autonomous ships is an iterative and gradual process that undergoes extensive testing and simulations;

2. The operation of remote and autonomous ships is at least as safe as existing ships. Potential to reduce human error;

3. Development and testing of specific technological solutions for autonomous operations using simulators, as well as testing at sea in various environmental conditions - the best way to combine different sensor technologies in different working and climatic conditions is a subject of discussion;

4. Research to understand the changed and new risks posed by innovation, based on the experience of the maritime industry in systematic and comprehensive risk assessment, to develop new approaches.

The viability of this business requires participants whose input makes it possible to implement the concept project. These include regulators, insurers, classification societies, ship managers, shipowners, shipyards, etc. But a viable shipping business also requires breaking certain rules, for example, the maritime industry needs to overcome its conservative nature if it wants to benefit from new solutions, and society should make digital decisions as improving the quality of life, and not threatening it.

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