UNMANNED SHIPS AND THE MARITIME EDUCATION AND TRAINING

Sauli Ahvenjärvi PhD, Principal Lecturer

Satakunta University of Applied Sciences (SAMK), FI-26200 Rauma, Finland
e-mail: sauli.ahvenjarvi@samk.fi

Abstract

The unmanned ship has become a popular topic in the speculation of the future of sea transportation. Many experts foresee that unmanned and autonomous ships will gradually replace manned ships and become a key technology of safe, cost-effective and environmentally friendly marine transportation. The main benefits would be improved safety and reduction of operating costs. Also better energy efficiency and protection of environment support the idea of using unmanned ships for transportation of goods and raw materials over longer distances. Since the unmanned ship operates without an onboard crew, the development could have a strong impact to maritime education and training. What kind of new competences would be necessary for successful utilization of autonomous ships? How the unmanned ships should be taken into consideration in the education of seafarers? Are seafarers going to lose their jobs and will the profession of seafaring still attract young generations? How quickly and how widely unmanned ships would replace traditional manned ships? The conclusion is that some answers to these questions are more connected with the development of the international legislation than of the development of the technology. Seafaring has been a conservative branch of economy. It has been slow in accepting cultural changes. Therefore, the speed of the development might surprise some of the most eager supporters of the new technology. On the other hand, if the benefits of using unmanned ships are clear and undisputable, the development can be quick. In any case, seafaring as a profession will not disappear but develop and adapt to requirements of the new technical innovations. Opposing the inevitable development is not an option.

Keywords: Unmanned ship, Autonomous ship, Maritime Education and Training

Introduction

Unmanned ships has been recently an up-to-date topic in the discussion of the future of sea transportation. However, different versions of automatic, though not unmanned, ships have existed already for some time (Manley, 2008). For instance, automatic dynamically positioned (DP) vessels have been utilized by the offshore industry for over 40 years. The concept of an unmanned cargo ship was tested and demonstrated in Japan already in the 1980's. Autonomous Unmanned Surface Vessels (USV's) are today fully operational in ocean research, coast guard and military applications.

The shipbuilding industry has started to consider unmanned and autonomous ships as vital components of sea transportation systems in the future. The key arguments are the improvement in safety and the reduction of investment and operational costs. Also better energy efficiency and protection of environment support the idea of utilizing unmanned ships for cargo over longer distances.

Recent European research and development projects are the international MUNIN-project (MUNIN PROJECT, 2016) and the ReVolt project (DNV GL, 2017). A major research and development effort on this subject is the ongoing AAWA project in Finland (Jokioinen, 2016). One of the key findings in the MUNIN-project was that the unmanned vessels can indeed contribute to a more sustainable marine transportation and that the use of autonomous ships might reduce operational costs and the environmental impact of shipping. The ReVolt project revealed that the fully autonomous, unmanned, battery powered concept ship could have a potential for cost savings over a million euros annually (Tvete, 2014).

The impact of the introduction of unmanned ships to maritime education and training

An unmanned ship can be equipped with fully autonomous operation modes as well as with remote manual control modes. The unmanned ship can operate fully independently or it can sail remotely operated. The operating status of an unmanned ship can vary, based on the operational situation, between fully autonomous execution, partially remotely assisted operation and direct remote control (Rødseth et al., 2014).

Introduction of unmanned ships would undoubtedly have a strong impact to the maritime education and training. One might think that by removing the human operator from the ship the human element will also be removed and there is no more need for education of seafarers. This assumption is not correct (Ahvenjärvi, 2016). History has shown that automatization in

general has not reduced the need of skilled people, but underlined the importance of good education. When the degree of automation gets higher, the competence requirements also become higher on those who deal with design, operation and maintenance of the automated system.

The first question to be answered is: What kinds of new skills and competences are necessary for successful utilization of unmanned ships? This question can be approached from different angles. Members of different groups of people must have special skills and knowledge to cope with unmanned ships:

Operators of unmanned ships at the remote control center

1) Officers of manned ships and other sea-going vessels interacting with unmanned ships
2) People responsible for development and maintenance of unmanned ships
3) Port operators
4) VTS operators
5) Authorities, class inspectors, legislators, lawyers etc.

The first group, i.e. the operators of unmanned ships, must know how to control and monitor the vessel and its systems, when the unmanned ship is sailing in fully autonomous mode. The task seems easy, but it surely isn't. The work of the operator at the remote control center can be compared with the work of the operator of any automated safety-critical system, for example the user of the dynamic positioning (DP) system of a support vessel at an offshore oil field. Most of the time the DP operator doesn't have much to do. But when things start to go wrong, the operator must quickly understand what is happening, analyze the situation and available options, decide what to do and then act correctly. Such competence can not be achieved without extensive theoretical and practical studies and not be maintained without training of abnormal situations in a purpose-built simulator on a regular basis.

The second group, i.e. deck officers onboard manned ships and other sea-going vessels must also have knowledge about interacting with unmanned ships. There will be a long period – probably tens of years - when manned ships form the majority of vessels sailing on fairways and sea routes. It is a mistake to assume that the deck officers of manned ships would automatically know how to interact properly with unmanned ships sailing on the same traffic area. Today, if the captain has something to ask from or agree with the nearby ship, he can contact the colleague on the bridge of the other ship by phone, for example. What is the procedure when there is nobody on the bridge of the other ship? This might not a problem under normal conditions, but there can be surprises and difficult unexpected situations, for

example if several manned and unmanned ships are close to each other in bad weather. It has been learned from the past that automation has a tendency to provoke new working habits. People are innovative in taking advantage of new opportunities offered by automation, sometimes in ways that were not anticipated or meant by the designers. Undoubtedly this can happen with autonomous and unmanned ships as well. In order to prevent wrong habits and intentional misuse of automated functions of unmanned ships, seafarers must be trained to be aware of these risks and to interact correctly with these ships. Otherwise the expected increase of safety might turn into increased risks and too high dependence on automation.

The third group on the list are those responsible for development and maintenance of unmanned ships. This group consists of shipbuilding engineers, software engineers and maintenance engineers of shipping companies and service companies. Firs of all, unmanned ships must be very reliable, since there is a risk of collision, grounding, pollution, injury or even loss of lives if the ship does not operate correctly. Whenever there is a failure (and there will be one, sooner or later) in a critical system of an unmanned ship, there is no one onboard to fix the problem. The ship's systems shall be made fault-tolerant, which means that all critical components, systems and functions must be redundant. The design, construction and maintenance of the systems of an unmanned ship require different skills and knowledge than the design, operation and maintenance of the machinery of traditional manned cargo ships.

Port operations will also be affected by the introduction of unmanned ships. Apparently this means more automation. Thus the above mentioned remarks about new competence requirements are valid also for people responsible for port operations.

It will be a new situation for VTS operators to control traffic consisting of manned and unmanned ships and even manned and unmanned smaller crafts in the same traffic area. There is no doubt that certain kinds of unmanned boats will also be introduced together with unmanned commercial ships. Communication between the vessel and the VTS center will become quite different when the onboard crew is removed. This kind of setup will require new monitoring and communication procedures and they have to be trained in advance – using a VTS simulator, for instance.

The last group of people in the list above consists of authorities, class inspectors, legislators, lawyers and other persons involved with the legislation of ships and sea transportation. It will be a wide and interesting task to create all national and international laws, rules, regulations and standards that are needed for unmanned ships. Shipping industry is known for its conservatism and the process of updating the international legislation can take quite some

time. Anyway, all persons involved with unmanned ship operations must become aware of the new legislation.

How the introduction of unmanned ships should be taken into account in the development of maritime education and training? An answer can be drawn from the competence requirements above. The obvious conclusion is that there will be need for training on a large number of new subjects, when unmanned ships are taken into wider use in marine transportation. But on the other hand, the need for traditional maritime education and training will not disappear, because the great majority of ships sailing on the seven seas of the world will be manned for a long time from now.

The speed of this technical revolution on sea transportation is a very interesting question. How soon will we witness the breakthrough of unmanned shipping? There are different opinions about this matter. The first applications in Finland and Norway will be put into operation in a few years. The *"One Sea – Autonomous Maritime Ecosystem"* in Finland is aiming at establishment of an operating autonomous maritime ecosystem in the Baltic Sea by 2025 (TEKES, 2017). Introduction of unmanned cargo ships in the international sea transportation will not happen over one night, but gradually, step by step (Levander, 2016). It is difficult to estimate the speed of the development globally. It must be taken into account, that the life-time of a commercial ship is around 30 years (Equasis information system, 2016). For this reason most of the newbuildings ordered today will still be in traffic in 2040. So the growth of the popularity of unmanned ships will be limited by the simple fact that the global tonnage is renewed quite slowly. Another breaking factor will be the necessary renewal of international legislation. As stated above, seafaring is very traditional and conservative branch of business. A recent study at Satakunta University of Applied Sciences concludes that "To start operations with unmanned vessels on international traffic would require amendment of international conventions, possibly even compilation of a new convention for unmanned vessels and also its ratification process. Such process would take approximately ten years in minimum" (Roos, 2017).

Are seafarers going to lose their jobs and will the profession of seafaring still be a good choice? Are unmanned ships a threat for a seafarers' career in the future? These questions are asked by young people who read news about unmanned and autonomous ships. As stated before, the profession of a seafarer will not disappear, but perhaps get even more interesting and challenging in the future. We must ensure that the message about the future of seafaring

as a profession is correct and realistic. Otherwise we will witness a decreasing trend in the number of youngsters willing to start studies in a Maritime University.

A model-scale platform for training and testing of the unmanned ship technology

Satakunta University of Applied Sciences decided to establish together with a group of marine technology companies a model-scale platform for training and testing of the unmanned / autonomous ship technology. The platform called ELSA utilizes the 8,4 meter model ship *Kaisa*, which was built in 1994 for training of ship handling and harbor maneuvers by sea captain students at Rauma Maritime College (Markkanen, 1994). *Kaisa* was originally a 1:15 scale towing model of a passenger cruise ship "Society Adventurer", built in Rauma in 1991.

Figure 1. The 1:15 model ship *Kaisa*

A block diagram of the general structure, the instrumentation and the signal transmission of the system is shown in Figure 2. The electric power for the equipment is provided by a battery pack, and the ship is equipped with solar panels for loading the batteries. Shore connection is available for quick load The remote control centre is located in the simulator center of the Faculty of Logistics and Maritime Technology of SAMK. The wireless communication link between the ship and the remote control centre is accomplished using a commercial 4G network. The location of the control centre can be changed. The equipment can be installed on a van and moved to virtually any location with a decent 4G coverage.ing.

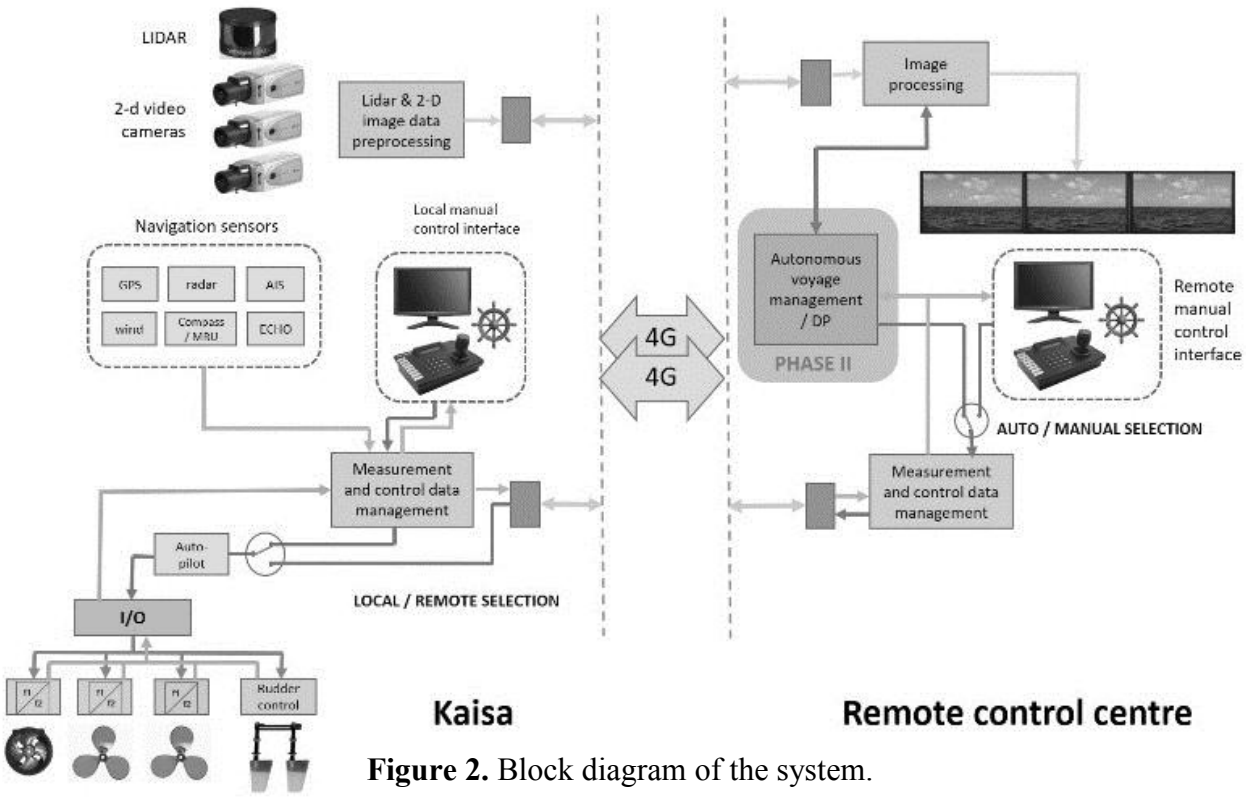

Figure 2. Block diagram of the system.

The use of the "ELSA" platform

The goal of the ELSA project is to create a useful and a cost-effective environment for training purposes and for testing, demonstration and development of the autonomous ship technology. ELSA offers the possibility to run practical tests and demonstrations cost-effective in the real environment. The capital costs, the operation expenses and the safety risks are smaller, when the size, mass and the speed of the ship are scaled down. The platform can be used for research purposes in different ways. Interesting research areas would be, for instance

- the use of lidar and machine vision cameras for detection of objects
- algorithms for controlling the ship in abnormal traffic situations
- ergonomics and functions of the human-machine interface at the remote control centre
- training needs and good ways of building competence of the operators of the remote control centre

- necessary modifications in legislation and classification rules for autonomous ships
- autonomous operation in port, automatic berthing systems etc.
- interaction between an autonomous ship and an intelligent fairway

The ELSA project offers good opportunities for sea captain and marine engineering students of SAMK to increase their knowledge about the autonomous ship technology. Several Master's and Bachelor's degree theses will be published during the ELSA project on topics related to unmanned ship technology.

Conclusion

Within the coming decades we will witness a break-through of unmanned ships in sea transportation. It has been predicted that unmanned cargo ships will gradually replace manned ships, beginning from short routes and special applications and expanding later to international traffic. Unmanned ship technology has the potential to bring many benefits to the ship owners and to the public. The following ones have been proposed (Haugland, 2016):

a) Increased safety
b) Reduced operational cost
c) Reduced construction costs
d) Increased environmental sustainability
e) Increased social sustainability
f) Increased competitiveness
g) Reduced risk of piracy

The unmanned ship operates without an onboard crew. This will have also an impact to maritime education and training. The nature of this impact is discussed in this paper. What kind of new competences are needed for successful utilization of unmanned ships? How this will affect the education of seafarers? Are seafarers going to lose their jobs and how the profession of seafaring will maintain its attraction among youngsters? The conclusion is that maritime education and training must develop hand-in-hand with the technical development. New skills and competences are necessary for those who deal with design, operation and maintenance of unmanned ships. Also automated port operations, developing legislation, VTS operations and also interaction between manned and unmanned ships ask for good education and training of many new subjects. An interesting question is the speed of this development. Seafaring has been a conservative branch of economy and it is slow in accepting cultural changes. The time of first commercial unmanned ships in international traffic can be a

surprise. In any case, seafaring as a profession will not disappear but develop and adapt to requirements of the new technical innovations.

Satakunta University of Applied Science has decided to be involved in the development of training facilities for the future by planning a model-scale platform for training, demonstration and development of the unmanned ship. The ELSA platform is a cost-effective alternative for research, development and training purposes. ELSA will offer great opportunities for students of SAMK to get familiar with the technology and challenges of unmanned ships.

References

Manley J. 2008. Unmanned Surface Vehicles, 15 Years of Development, Proc. Oceans 2008 MTS/IEEE Quebec Conference and Exhibition (Ocean'08) pp. 1-4 2008.

MUNIN PROJECT 2016. Reports of the MUNIN project at: http://www.unmanned-ship.org/munin/ [acc. 10.2.2017]

DNV GL 2017. The ReVolt – A new inspirational ship concept, at https://www.dnvgl.com/technology-innovation/revolt/index.html [acc. 10.2.2017]

Jokioinen E. 2016. Advanced Autonomous Waterborne Applications (AAWA) Initiative, Rolls-Royce plc, at: http://www.maritime-rdi.eu/media/18556/Advanced-Autonomous-Waterborne-Applications-AAWA-initiative.pdf [acc. 10.2.2017]

Tvete H. 2014. The Next Revolt, *Maritime Impact 2/2014*, at: http://www.gcaptain.com/wp-content/uploads/2014/09/ReVolt-Details.pdf *[acc. 10.2.2017]*

Rødseth O. & Tjora Å. 2014. A System Architecture for an Unmanned Ship. In Volker Bertram (ed.), *13th International Conference on Computer and IT Applications in the Maritime Industries, COMPIT'14*, Redworth, 12-14 May 2014, pp. 291-302, Technische Universität Hamburg-Harburg, 2014

Ahvenjärvi S. 2016. The Human Element and Autonomous Ships. *TransNav, the International Journal on Marine Navigation and Safety of Sea Transportation*, Vol. 10, No. 3, pp. 517-521, 2016

TEKES 2017: One Sea – Autonomous Maritime Ecosystem introduced roadmaps to autonomous shipping at: https://www.tekes.fi/nyt/uutiset-2017/one-sea--autonomous-maritime-ecosystem-introduced-roadmaps-to-autonomous-shipping/

Levander O. 2016. Unmanned ships. Presentation at the seminar *Älykäs meriteollisuus*, Rauma 17.11.2015, available at: *www.hel.fi/static/kanslia/elo/rollsroycemarine.pdf [acc. 10.2.2017]*

Equasis information system 2016. The world merchant fleet in 2015, Statistics from Equasis at: http://emsa.europa.eu/publications/technical-reports-studies-and-plans/download/4429/472/23.html

Roos P. 2017. Master's Role in Unmanned Vessels – Juridical Aspect. Master's thesis, Satakunta University of Applied Sciences, Rauma, Finland

Markkanen A. 1994. Pienoismallialus, Sea Captain's Thesis, Rauman merenkulkuoppilaitos, Rauma, Finland (in Finnish)

Haugland B. 2016. Towards Unmanned Shipping. at: https://www.linkedin.com/pulse/towards-unmanned-shipping-bj%C3%B8rn-kj%C3%A6rand-haugland [acc. 10.2.2017]