The SMARTSEA education approach to leveraging the Internet of Things in the maritime industry

George Katranas[1], Andreas Riel[2,3],
Juan Manuel Corchado-Rodríguez[4], Marta Plaza-Hernández[4]

[1] Cerca Trova Ltd, Sofia 1000, Bulgaria
katranasg@ctrova.eu
[2] Grenoble Alps University, Grenoble INP, G-SCOP, CNRS, 38031 Grenoble, France
andreas.riel@grenoble-inp.fr
[3] ECQA GmbH, 3500 Krems, Austria
Riel_Andreas@ecqa.org
[4] University of Salamanca, BISITE Research Group, 37007 Salamanca, Spain
{corchado|martaplaza@usal.es}

Abstract. The Internet of Things technology solutions are gaining importance in shipbuilding industry to improve transparency, safety, and cost efficiency by optimising procedures, maintenance and energy efficiency. The marine surveying infrastructure transformation through IoT technologies is expected to enable the shipping industry, port authorities or environmental agencies, to inspect shipping assets, offshore structures, waterways and ensure compliance with various standards or specifications. The SMARTSEA approach presented in this paper aims at qualifying students and professionals for working in modern smart maritime and surveying industry. A further objective is stimulating transversal competences such as the increased sense of initiative and entrepreneurship. An original programme for piloting and validating the programme across Europe is also presented.

Keywords: Internet of Things, shipbuilding, marine industry, education, training

1 Introduction

The Internet of Things (IoT) is a network of physical "smart" devices (applicable in vessels, vehicles, buildings, factories, etc.) embedded with electronics, software, sensors, actuators, that allow interconnectivity between these devices and data exchange. Over the past 5 years this new technology has grown rapidly and has found applications ranging from people whose devices monitor health and wellness to manufacturers that utilize sensors to optimize the maintenance of equipment and protect the safety of workers. It is expected that by 2025, IoT may reach a total potential market impact of up to $11.1 trillion [1]. Large shipping corporations are already investing heavily in enabling IoT technology solutions in their fleet to improve transparency, safety, and cost efficiency by optimising procedures, maintenance and energy efficiency. Shipowners are set to spend an average of $2.5m, each, on IoT solutions over the next three years [2]. In addition, the marine surveying infrastructure

transformation through IoT technologies is expected to enable the shipping industry, port authorities or environmental agencies to inspect shipping assets, offshore structures, waterways and ensure compliance with various standards or specifications. In contrast, formal Maritime & Surveying IoT training on development, installation, service, maintenance and sustainability awareness is at its infancy, especially in the European Union. After meticulous research it was made evident that currently there are no hands-on IoT educational and training programs dedicated to the application of these systems to the Shipping industry in all 90 maritime educational institutions inside the EU, neither are there in the 27 European (non-EU) educational establishments [3].

This paper presents the Surveying & MARiTime internet of thingS EducAtion (SMARTSEA) approach and project aiming at developing an advanced interactive certified Master of Science program related to Maritime & Surveyor IoT applications that will train individuals with the necessary skills and knowledge to work in the rising "Smart Maritime & Surveying" industry. The program/postgraduate is also formulated to stimulate transversal competences, such as the increased sense of initiative and entrepreneurship. It is designed to follow the European Credit Transfer and Accumulation System (ECTS) credit standards for certification recognition across the EU.

2 The IoT context in the maritime sector

Digitizing key elements of our physical world is a powerful idea that is changing how goods are made and distributed, how products are serviced and refined, and how health and wellness is managed. Since the introduction of the IoT concept five years ago, it managed to revolutionise the opportunities for businesses to take their operational efficiency to a new level. Combining a large range of smart interconnected devices created new dimensions of opportunities in this digital era. This included the development of new networking capabilities and the design of analytical tools to perform the data fusion. These newly created Machine to Machine (M2M) direct intercommunication services comprise all technologies that allow network devices to exchange information and perform an action without any physical assistance of human beings. This is now used across different industries, such as in retail, banking and financial institutions, telecom and IT industry, healthcare, automotive, oil and gas, and transportation to enhance the safety, productivity, and efficiency of the establishments.

Because of the IoT's penetration to all major industries, the economic impact is expected to reach, by 2025, between $3.9 trillion to $11.1 trillion a year. This is translated to an equivalent of about 11% of the world economy [4].

For most market sectors the potential and the transition towards data-driven technology is a hard to comprehend and cumbersome process. This is in contrast to the transportation and logistics sectors that, due to their nature, have always relied on exchanging decision-making data and information. Hence, this market segment quick-

ly adopted the new sensing and data exchange technology, placing them ahead in the transition towards IoT adaptation [5].

Especially in the Maritime sector, the implementation of IoT technology allows the shipping companies to connect the vessels in one platform for data sharing with the entire corporate ecosystem. Now asset management is possible, to receive data from all types of sensors and monitor the vessel status, location and cargo condition. Shipping companies can finally receive live information from engine and hull measurement systems and perform condition monitoring and predictive maintenance and optimise service time and energy efficiency. In addition, cargo owners can use these systems to receive live information on the status and location of their transferred goods. Overall IoT systems are set to reduce inefficiencies, risks and overall cost and provide a live sea-to-shore connectivity that stakeholders can exploit for decision-making.

Moreover, a major part in the maritime sector is the asset inspection for insurance and quality purposes. This task is handled by certified professionals called Maritime Surveyors, who are employed by the shipping industry, port authorities or environmental agencies, to inspect shipping assets, offshore structures, waterways and ensure compliance with various standards or specifications. Maritime surveys typically include the structure, machinery and equipment (navigational, safety, radio, etc.) and general condition of a vessel and/or cargo or ports and waterways. Maritime Surveying requires talented individuals that combine the impressive understanding of ships and boats with insurance and finance industries. Their knowledge targets the evaluation of a vessel's condition in a case of damage or of a request for appraisal value. In other cases, environmental surveying is mandatory if an incident occurs or if it is instructed by local authorities. In all the above cases the vessels' hull, plumping and electronics are evaluated including the surrounding waters for the presence of pollutants. Maritime Surveyors are individuals, usually with interdisciplinary studies, certified by international bodies [6,7] to collect maritime related asset information for quality, legal and insurance needs. Until recently, a maritime survey was limited in taking photos at the site of interest and filing a report with respect to the regulations that affect the vessels operations. With the introduction of interconnected digital devices, surveyors are now equipped with analytical equipment such as ultrasonics, infrared cameras and in some cases with Remotely Operated Underwater Vehicles (ROUV) together with the support of specialized software for underwater inspection [8,9].

The measured information can now be gathered, processed and visualised through web-based or mobile application user interfaces directly to the stakeholders for decision-making, even across the globe and in real-time. Overall, Information and Communication Technology (ICT)/ and IoT systems are set to reduce inefficiencies, risks and overall cost and provide an unparallel ease of connectivity that stakeholders can exploit for decision-making.

Large shipping industries are already investing heavily on IoT and ICT techniques to improve and optimise transparency, safety and costs of their transports [1,2]. Latest reports show that ship owners are set to spend an average of $2.5m, each, on IoT solutions over the next three years [10].

The European Union, through its Horizon2020 program, is providing significant funding of up to 6.3 billion Euros on the research and development of ICT and IoT technologies, showing the technology roadmap of the future [11,12]. This clearly states that there is a need for a transition to an era of smart systems interconnectivity and procedure optimisation. The market has shown a rapid increase in Maritime & Surveying IoT systems and their infrastructure and corporations globally are interested in investing and promoting their growth. These systems that have and will enter the market are currently designed, developed, installed serviced and maintained by people with no educational background specific to the needs of this market. In other words, there is a global shortage of trained engineers and technicians to cater safely handle this new technology.

This new technology will influence onshore and offshore personnel as they will need to have either an insight of the systems capabilities for corporate decisions, design/service this ecosystem or process/analyse the acquired data. The SMARTSEA project team detected at least 23 positions within the maritime/surveying job sector that are expected to require knowledge on IoT solutions, at various levels [13]. These positions are listed in Table 1.

Table 1. IoT influence on maritime positions**.**

No.	Position	Main Duties	IoT Influence
1	Cargo Surveyor	Inspects vessel cargo and certifies compliance with health and safety regulations.	Consults the IoT systems database to monitor the status and location of goods (stored or in transit).
2	Computer Engineer	Develops and maintains systems software and hardware for industrial applications, as well as performing data analysis.	Develops the IoT software
3	Electro-technical Officer	Deals with maintaining electrical equipment and systems on vessels.	IoT system maintenance
4	Fleet Manager	Plans, directs and coordinates the transportation operations within the maritime company.	Receives vital information on vessel and cargo status.
5	IT Specialist	Provides technical assistance to equipment users, maintenance of intranet and data flow.	Maintains the IoT data flow through the corporate intranet and satellite communication systems.
6	Marine Architect	Designs and oversees construction and repair of vessels.	Incorporates the IoT systems in new-build vessels or retrofits older ones.
7	Marine Engineer	Deals with maintenance and repair of ship's machinery.	Uses the IoT systems to get centralised information on vessel status.
8	Marine Superintendent	Responsible for the supervision of operations, monitoring vessel's condition and compliance with policies and safety.	Receives vital information on ship and cargo status.
9	Marine & Coastal Surveyor	Collects scientific data and maps the underwater geophysics and environmental quality of oceanic and inland water bodies.	Operates ICT/IoT enabled equipment and ROUVs to collect information.
10	Maritime Instructor	Teaches vocational or occupational subjects at the postsecondary level	Responsible for teaching maritime professionals with the IoT systems

		and prepare persons to operate and install industrial equipment.	ecosystem.
11	Naval Architect	Involves planning and designing of vessels.	Incorporates the IoT systems in new-build military vessels or retro-fits older ones.
12	Maritime Engineer	Designs, develops, builds, installs, inspects and maintains vessel systems and equipment.	Responsible for installing the IoT systems on vessels to support the data measurement.
13	Maritime Surveyor	Conducts inspections, surveys or examinations of marine assets.	Receives detailed and vital information from the inspection.
14	Ocean Engineer	Deals with the aspects of constructing offshore structures (planning, designing and construction).	Designs IoT solutions for offshore applications
15	Operations Manager	In charge of the vessels' operation	Receives vital information on vessel and cargo status
16	Port Engineer	Responsible for estimating, planning, and performing short and long-term maintenance, repairs, and modifications on vessels.	IoT system maintenance, condition monitoring and predictive maintenance of maritime assets.
17	Ship Fitter	Involves repairing and maintenance of the ship under the guidance of the ship officer.	Receives information on maritime system condition from the IoT systems and plans maintenance activities accordingly.
18	Ship Operator	In charge of the vessels' operation	Receives vital information on vessel and cargo status.
19	Ship Superintendent	Ensures that all the ship repairing work is performed as planned.	Uses the IoT systems to get centralised information on vessel status.
20	Shipbuilding Engineer	Deals with the engineering aspect of design and construction of ships and marine vessels.	Responsible for installing the IoT systems on new-build vessels.
21	Structural Engineer	Involves designing machinery and offshore structures.	Receives information on machinery condition from the IoT system.
22	Vessel Electrician	Installs, maintains and repairs electrical wiring, equipment, control systems and fixtures.	Installs, maintains and repairs the IoT system.
23	Vessel Mechanic	Involves repairing, installation of machinery and carrying out periodic upkeep or restoration of the vessel.	Receives information on machinery condition from the IoT system and installs the sensors on the vessels equipment and hull.

The positions mentioned in Table 1 are well known neuralgic positions within the maritime industry and are required to get up to date with the new advances on vessel related technology and benefits as part of their job descriptions. These are positions based either on land and/or at sea. Positions affected by the IoT technology phenomenon will be requested by surveyors, authorities, vessel operators, shipyards as well as thousands of private companies that deal with the new-builds, retrofit, maintenance, repair of vessels.

After meticulous research it was made evident that currently there are no hands-on IoT programs dedicated to the application of these systems to the Shipping industry in all 90 maritime educational institutions inside the EU, neither are there in the 27 European (non-EU) educational establishments [3]. Some engineering educational institutions, mainly in Northern Europe, have begun offering general ICT/IoT courses that are unable to convey solution to practical and technical problems that are faced within the shipping industry and it does not offer a hands-on training onboard vessels. Cur-

rently, the only ICT course globally in the market is the “ICT for Maritime Education and Training” by the World Maritime University, that focuses on software development introduction; its duration is five days, corresponding to 2.5 ECTS credits [14].

Our mission is to provide an innovative curriculum in the theme of Maritime & Surveying IoT systems and land-based infrastructure that includes interactive teaching methods and partnerships with major educational and industrial organizations, giving students a solid grounding for starting a fruitful career in the corresponding industry or enable professionals to gain extra skills knowledge and at the same time prompting local communities and authorities to embrace the new technologies and their benefits. Hence, the output of the partnership is to design a MSc program that will give additional skills to those interested in a maritime career and allow the partners to create an ongoing degree that will go well beyond the duration of this project.

For this purpose, seven academic institutions, two SMEs, one research centre and three shipping/environmental surveying and shipping companies joined in November 2019 to create the joint program SMARTSEA. More precisely, the consortium members are as follows (in alphabetic order, clustered by academic, research, SME, company):

- Infante D. Henrique Nautical School, Portugal;
- International Hellenic University, Greece;
- Maritime University of Szczecin, Poland;
- Tallinn University of Technology, Estonia;
- University of Ljubljana, Slovenia;
- University of Salamanca, Spain;
- National Institute for Marine Research and Development "Grigore Antipa"; Romania;
- Cerca Trova Ltd, Bulgaria;
- ECQA GmbH, Austria;
- RINA Hellas SA, Greece;
- Creocean; France;
- Danaos Shipping Company Ltd.; Greece.

3 Curriculum Design

The aim is to provide an innovative and eclectic mix of teaching methodologies that include state of the art equipment combined with work experience for students in real industrial environment and the globally acknowledged ECTS certification.

The interdisciplinary curriculum was meticulously designed with the participation of all consortium partners who brought their expertise from their academic/industrial background on ICT, Maritime, Marine & Business.

The syllabus will include reconfigurable laboratory apparatus, innovative demonstrator group assignment and an industrial experience to equip the participants with the necessary experience to enter the emerging market of IoT systems.

The program focuses in the following objectives:

- To develop an innovative program on Maritime & Surveyor ICT/IoTs to complete the market void in technical and maintenance specialists created by the rapid expansion of this industry;
- To develop and adapt a joint curriculum between participating HEIs, designed on an exhaustive needs analysis and focusing on a “real-life” transnational approach.
- To create a program recognized by academia and industry throughout the EU by offering a recognized and comparable educational path by using the ECTS credit system;
- To address participants from backgrounds with fewer opportunities;
- To enhance opportunities for cooperation and mobility between partner countries;
- To modernize the didactic techniques of higher education institutes by creating interactive learning methods and industrial tools;
- To create cost effective reconfigurable tools used across industries and online platform for global access to reduce the learning cost in academia and empower distant learners;
- To increase competence in new languages by interconnecting participants of different ethnic and linguistic background;
- To ignite entrepreneurship by using interactive teaching and participation methods that boost innovative thinking and to emerge them to this industry sector;

Figure 1. Rolls Royce DART 510 Engine. A view through the head-worn display predicts information provided using Augmented Reality (AR) to assist the marine mechanic [15].

Figure 2. A Remotely Operated Underwater Vehicle (ROUV) used to underwater inspections, by the International Hellenic University [15].

Following the steps of the Fourth Industrial Revolution, a high-tech teaching set of experiments including computer sensory data analysis and ROUVs [15], along with computer guidance and Augmented Reality (AR) [16] will be an important asset of the curriculum and will match the emerging trend among surveying and shipping companies and researchers [17,18]., The surveying & maritime industry, educations and local economies are expected to benefit from this MSc program. Furthermore, a set of interactive reconfigurable laboratory apparatus will be developed to bring to life the modules'/courses' lessons and equip the participants with the latest industrial tools to enter this emerging market. The innovative teaching methods included are designed to stimulate entrepreneurship and enhance the participant's employability. The main modules/subjects presented in the curriculum will cover analysis and implementation of tools for advanced engineering problems, real life technical hands-on problems and maintenance techniques designed for Maritime & Surveyor IoTs, as well as market insight, business and innovation. Among the tools that the consortium will develop is the advanced e-Learning platform, that will be designed to offer teaching material, online experimentation and networking between the students.

The project aims towards the vocational education, certification and imminent professional rehabilitation of the students as also to improve the skills of the participating bodies and provide opportunities for entrepreneurship. The project also aims to sensitize and familiarize the local communities in order to accept and prepare for the future of smart sensing by presenting the benefits of this transition to Maritime & Surveyor IoTs in special seminars held at the locations of each partnership. The program is also addressed to participants from backgrounds with fewer life opportunities (immigrants, economically disadvantaged) to foster social integration and enhance intercultural understanding.

The modules'/courses' lessons that will cover the necessary background information and skills for teaching all major ICT/IoT components, technologies and surveying knowledge to the students as well as an insight on the market trends. Emphasis will be given to design a program with applied engineering concepts as well as industry insights to emerge the students into Maritime & Surveyor IoT core components, functionality, maintenance, safety and sustainability. This program is also designed to cater for the mobility of the students and educators. It is split into two time slots (TS) (Table 2), comprising 24 modules.

Table 2. Proposed SMARTSEA curriculum.

Code	Module title	ECTS	Lab	Work Hours	Lecture		Lab	Exams	H/W	Practice
					Class	Web				
TS1.1	Maritime Control Systems	2	Y	50		24	10	4	12	
TS1.2	Marine Surveying	2	-	50	30			5	15	
TS1.3	NI LabVIEW Training	2	Y	50	10	8	20	3	9	
TS1.4	Data Acquisition and Sensors	2	Y	50		24	10	4	12	
TS1.5	IoT Platforms & Systems	2	Y	50		18	20	3	9	
TS1.6	ROUV Electric System	2	Y	50	24		10	4	12	
TS1.7	Artificial Intelligence	2	-	50	30			5	15	
TS1.8	Maritime Environment	2	-	50	15	15		5	15	
TS1.9	Safety at Work on the Sea	2	-	50	20	10		5	15	
TS1.10	Diving Observation Techniques	2	-	50		30		5	15	
TS1.11	Language Lessons	2	-	50	30			5	15	
TS1.12	Intermediate Project	2.4	Y	60	20		40			
TS2.1	Remote Sensing and Positioning	2	-	50	10	20		5	15	
TS2.2	Distributed Ledgers - Blockchain	2	-	50		30		5	15	
TS2.3	Lightweight Materials	2	Y	50		24	10	4	12	
TS2.4	Underwater Comms & Navigation	2	Y	50	16	8	10	4	12	
TS2.5	Data Processing	2	Y	50	24		10	4	12	
TS2.6	Geographic Information Systems	2	-	50	30			5	15	
TS2.7	Underwater Physics	2	Y	50		24	10	4	12	
TS2.8	Innovation & Entrepreneurship Mgmt.	2	-	50		30		5	15	
TS2.9	Business Administration	2	-	50		30		5	15	
TS2.10	Maritime Legal Arrangement	2	-	50	20	10		5	15	
TS2.11	Language Lessons	2	-	50	30			5	15	
TS2.12	Developing Tool Demonstrator	2.4	Y	60	20		40			
-	Industrial Practice	11.2	-	280					120	160
	TOTAL		**8**	**1500**	**329**	**305**	**190**	**99**	**417**	**160**

The SMARTSEA curriculum is innovative also in the fact that it comprises interactive teaching methods and partnerships with expert academic and maritime organizations to give to the students a solid background for starting a fruitful career in the industry. The duration of the MSc program is nine months. During the execution of the program, three mobility periods are programmed. For the first two periods (duration: 14 days) the students and two educators from one university will travel to the other, and vice-versa, to participate in large-scale laboratories. The third period (duration: 1 month) is reserved for an industrial placement, a maritime on-the-job experience. Students will produce a master's thesis during the placement.

Although the postgraduate will be taught in English, local language lessons will be provided to enable the participants to immerge in the local culture during the exchange periods. The master's degree will be open for participation for anyone with a basic marine, electrical or mechanical technical background. Priority will be given according to their academic performance.

4 Conclusion and Outlook

The Industry 4.0 revolution is bringing to our everyday lives the concept of creating networks of smart interconnected objects with direct application in almost all major industries, including the maritime & surveying industry. The transportation & logistics sector has rapidly adopted the new sensing and data exchange technology, placing them ahead in the transition towards ICT and IoT adaptation. This market will rapidly require skilled individuals to design, develop, install, service and maintain these new systems.

The objective of the SMARTSEA Joint Master's Degree in Maritime & Surveying ICT/IoT systems presented here is to train engineers in the skills and knowledge they need to work in the maritime/surveying industry of the future. Hence, the rapid market growth will demand that this postgraduate program will become an integral part of academic institutions and maritime academies in Europe and beyond.

The first edition of the program (pilot program) will be financed by the European Commission. Financial sustainability of subsequent editions will be ensured by collecting student fees and through the scholarships that industrial companies will offer to train their personnel and stay competitive in this emerging field. The fees will cover the participant's training, laboratory apparatus and demonstrator equipment maintenance. It will also cover the student's mobility between academic institutions and to the industrial partners for their practice. Furthermore, the objective is to create a synergetic partnership with maritime industry key players for co-financing the education program. Their return on invest will be clearly visible and measurable in terms of highly qualified students and professionals that can significantly help drive digitalization forward in the maritime sector.

Acknowledgements

This project is a highly collaborative endeavour requiring intense contributions of a huge number of individuals. We regret that we cannot cite all their names here and want to express our thanks to them in this way. Some of them, however, gave particularly valuable input to the work programme published in this article without being cited as co-authors. Special thanks is therefore due to Javier Prieto-Tejedor, Sara Rodríguez-González, Ana B. Gil-González from University of Salamanca; Aleksander Grm from University of Ljubljana; Theodoros Kosmanis, Dimitrios Tziourtzioumis, George Minos, Kalliopi Kravari, Fotis Stergiopoulos from International Hellenic University; Panagiotis Maroulas from Cerca Trova Ltd, Mariana Golumbeanu from National Institute for Marine Research and Development "Grigore Antipa"; Kinga Lazuga, Marcin Maka, Mariusz Dramski, Maciej Gucma from Maritime University of Szczecin; Kadi Kasepõld, Raivo Sell and Priit Ruberg from Tallinn University of Technology; Olga Delgado Ortega, Miguel Silva from Infante D. Henrique Nautical School; Michael Reiner from ECQA GmbH; Stefanos Chatzinikolaou from RINA Hellas S.A.; Olivier le Brun, Olivier Herlory, Elina Delord from Creocean; Fotios Oikonomou, Panagiota Arampatzi from Danaos Shipping Company.

The SMARTSEA project [19] is financially supported by the European Commission in the Erasmus+ Programme under the project number 612198-EPP-1-2019-1-ES-EPPKA2-KA. This publication reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

References

1. Accenture: Hyundai Heavy Industries and Accenture to Build Connected Smart Ships. https://newsroom.accenture.com/news/hyundai-heavy-industries-and-accenture-to-build-connected-smart-ships.htm. 2015. Last accessed on 12/04/2020.
2. Harvard Business School: Maersk – Reinventing the Shipping Industry Using IoT and Blockchain. https://digital.hbs.edu/industry-4-0/maersk-reinventing-shipping-industry-using-iot-blockchain. 2018. Last accessed on 12/04/2020.
3. List of Maritime Colleges: https://en.wikipedia.org/wiki/List_of_maritime_colleges# Europe. Last accessed on 12/04/2020.
4. McKinsey: Unlocking the potential of the Internet of Things. https://www. mckinsey.com/business-functions/digital-mckinsey/our-insights/the-internet-of-things-the-value-of-digitizing-the-physical-world. 2015. Last accessed on 12/04/2020.
5. International Institute of Marine Surveying (iims.org.uk).
6. Lloyds Maritime Academy. https://lloydsmaritimeacademy.com/event/marine-surveying-distance-learning-course. Last accessed on 25/03/2020.
7. The Application of Technology in Marine Surveying. The Report. https://iims.org.uk/wp-content/uploads/2014/03/The-Report-December-2015.pdf. 2015, Nr. 74, pp. 44.
8. NCBI - Kao CC. et al. A Comprehensive Study on the Internet of Underwater Things: Applications, Challenges, and Channel Models. 17(7), 2017. https://ncbi.nlm.nih.gov/pubmed/28640220. Last accessed on 03/10/2019.

9. IIMS Baltimore 2017 Conference Proceedings. https://iims.org.uk/media/marine-surveying-videos/iims-baltimore-2017-conference. 2017. Last accessed on 12/04/2020.
10. Inmarsat: Industrial IoT Maritime. https://inmarsat.com/press-release/inmarsat-research-programme-offers-unique-maritime-iot-insights. 2018. Last accessed on 12/04/2020.
11. European Commission Press Release: EU leads the way with ambitious action for cleaner and safer seas. https://europa.eu/rapid/press-release_MEMO-17-3588_en.htm. 2017. Last accessed on 12/04/2020.
12. Horizon2020: Smart, Green and Integrated Transport. https://ec.europa.eu/programmes/horizon2020/en/h2020-section/smart-green-and-integrated-transport. 2020. Last accessed on 12/04/2020.
13. O*Net Online: Maritime Job Descriptions. https://onetonline.org. Last accessed on 12/04/2020.
14. World Maritime University. ICT for Maritime Education and Training. https://wmu.se/professional/ict-maritime-education-and-training. 2018. Last accessed on 19/01/2019.
15. Kosmanis T. et al. Building a cost-effective research ROUV. 2017. https://researchgate.net/project/Building-a-cost-effective-research-ROUV-Remotely-Operated-Underwater-Vehicle. Last accessed on 12/04/2020.
16. Columbia University: Marine Augmented Reality Systems. https://nextbigfuture.com/2009/10/augmented-reality-helps-marine.html. Last accessed on 12/04/2020.
17. Geo Oceans: Marine Survey Solutions. https://geooceans.com. Last accessed on 12/04/2020.
18. Teng L. et al. Automated Water Quality Survey and Evaluation Using an IoT Platform with Mobile Sensor Nodes. In: Sensors 2017, 17, pp. 1735 – 1748.
19. SMARTSEA – MSc on Smart Maritime & Surveying Systems. 2019. http://smart-sea.eu. Last accessed on 16/04/2020.