Development of Minors and Engine Simulation Laboratory to Meet Future Workforce Needs

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Abstract

Ninety percent of all goods are traded through oceans, and a significant portion of the world's food and energy security depends on ocean-related activities. This growth in worldwide trade and associated developments in marine propulsion and navigational technologies have necessitated improved crews' skills and capabilities [1], [2]. Over the past few decades, electrical and electronics systems on seagoing ships have become highly sophisticated. The efficient operation of modern ships depends upon the operation and maintenance of electrical and electronic equipment. The country's marine engineering and technology programs must prepare for this shift toward ship automation. Simulation software programs offer a cost-effective way to provide training in a classroom, followed by hands-on experience on a vessel. This article discusses developing and implementing two new Mmnors, Marine Electro-Technology and Marine Engineering Technology, and the development of an engine room simulation laboratory, including a high voltage trainer, at Texas A&M University at Galveston to develop the future workforce for the marine industry.

1. Introduction

Today's ships are highly automated, so there are increasing demands for marine electrical engineers in the workforce. Over the last few years, electrical systems on seagoing ships have undergone significant development and change. In addition, the complexity and number of electrical and electronic equipment have greatly expanded [3].

The blue economy is defined by the World Bank as "the sustainable use of ocean resources for economic growth, enhanced livelihoods, jobs, and the health of ocean ecosystems" [4]. The global blue economy is expected to double in size to $3 trillion by 2030, according to an analysis by the Organization for Economic Co-operation and Development. This growth will be driven by strong expansion in new industries like alternative energy, the digitalization and automation of port and transportation operations, food security, and coastal resilience. From 2014 to 2018, the economic activity in American seaports alone increased by 17% to $5.4 trillion, accounting for about 26% of the country's $20.5 trillion gross domestic product. The demand for marine engineers is also expected to grow since the existing vessels must be retrofitted to comply with new pollution and emission standards regulations.

In light of these developments, The International Maritime Organization (IMO) amended STCW 95 (also known as the Manila Amendment) on June 25, 2010, to introduce the certified position of electro-technical officer in place of electrical officers. This was enacted to make modern electrical engineers competent to understand the emerging more complex and sophisticated electrical systems [7]. An electro-technical officer (ETO) is defined as a licensed member of the engine department of a merchant or passenger ship and is a key position in the technical hierarchy of modern ships with automated and conventional electrical and electronic systems [8]. Under the direction of the chief engineer, electro-technical officers are responsible for monitoring and repairing the ship's electrical and electronic equipment to ensure that it is operating as safely and efficiently as possible [8]. To prepare the future workforce for the blue economy, the Marine Engineering Technology Department at Texas A&M University has decided to develop two minors and a state-of-the-art engine room simulator laboratory. ETO program to address industry needs. The first minor in Marine Engineering Technology is designed to increase awareness about marine engineering careers, and the second minor in Marine Electro-Technology is designed to provide foundational courses so students can obtain an ETR rating upon graduation.

2. Future Industry Needs and ETO Program

The workforce will need to grow in tandem with the growth of the U.S. blue economy to satisfy the demands of new technologies and disciplines. With the rising use of automation on ships and shipping terminals, it is projected that skilled people would be required to support this expansion. The following five technological advancements are driven by global trade growth and climate change's escalating effects: 1. artificial intelligence 2. sensor technology 3. robotics and 3d printing 4. big data and iot 5. autonomous control 6. augmented reality 7. ship propulsion systems 8. advanced materials [9][10].

The advancements in intelligent, highly automated, and autonomous ships stand out among the aforementioned eight growth areas. The rising usage of intelligent systems for ship management, operation, and propulsion is an example of this trend. The U.S. Coast Guard is expected to adopt his approach soon and mandate that an ETO man all ships in U.S. waters. No higher education institutions, not even the seven maritime academies in the U.S., currently provide a degree or a training course for electro-technical officers.

In the future, the Marine Engineering Technology Department at the Galveston campus of Texas A&M University plans to develop a new program in collaboration with the Multidisciplinary Engineering Technology Program from the main campus in College Station.

3. Institution

Texas A&M University at Galveston, an ocean-focused branch campus of Texas A&M University, educates early 2,300 undergraduate and graduate students in a diverse range of marine and maritime programs, including majors in science, business, engineering, liberal arts, and transportation. With almost $10 million in research expenditures, it is an essential part of

Texas A&M's unusual land-, sea-, and space-grant mission and is promoting the growth of the blue economy in the Gulf Coast Region.

The Texas A&M Marine Academy, one of seven in the nation and the only academy incorporated into a Tier 1 academic institution, is located at Texas A&M-Galveston and prepares more than 400 cadets yearly for maritime duty and employment worldwide. Texas A&M-Galveston is perfectly situated in Galveston, Texas, on the Gulf Coast, surrounded by the industry, environment, and programs necessary to carry out its unique mission. Aggies are renowned for their steadfast devotion to one another's success and desire to give back.

4. Pathways to ETO Endorsement

Figure 1 shows the pathways to ETO jobs for the graduates of the MARE program. The targeted population will include transfer students from area community colleges and first-year students entering both Galveston and College Station campuses.

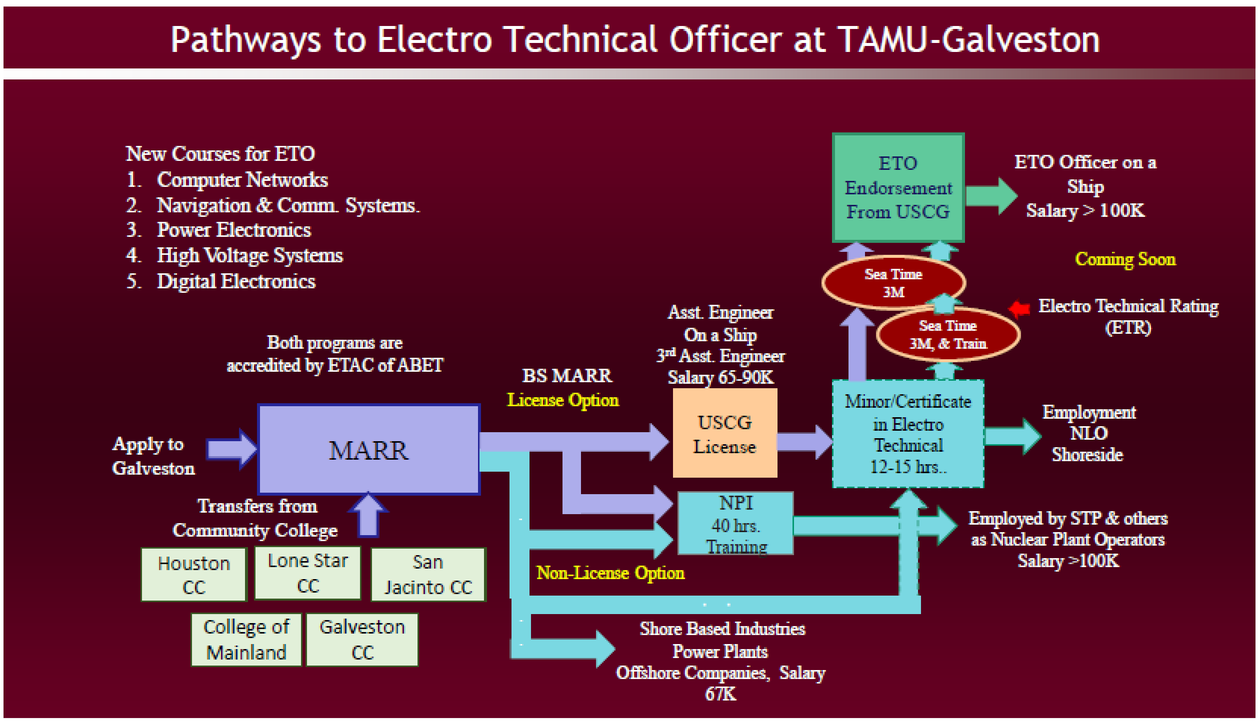

Fig. 1. Curriculum development for ETO program and its impact.

5. Development of a Minor in Marine Engineering Technology

The growth of autonomous vessels and the increased presence of automation has impacted the Merchant Marine. As a leader in maritime education, we at Texas A&M are ready to meet the needs of ship owners and maritime employers. The MARE Department has begun two separate minors to meet this demand, which, according to the Bureau of Labor Statistics, economic projections point to a need for approximately 1 million more STEM professionals than the U.S. will produce at the current rate by 2025 [13].

Our MARE minor addresses the need by offering Maritime business and other engineering majors the opportunity to understand ship engine capabilities and operational requirements. This minor program, once USCG approved, will allow the student to test for their Designated Duty Engineer Coast Guard Certification, allowing them to work on smaller vessels such as tugboats and river barges. This curriculum includes the MARE 200 course, where the student will spend 60-75 days as a cadet on the training vessel, participating in class, standing watch, and performing maintenance. This experience will allow the students to apply the theoretical engineering lessons learned to onboard vessels' practical skills. The classes for the MARE minor are listed below in Table 1.

Table 1. Marine engineering technology minor courses.

Marine Engineering Technology Minor Courses	**Credit Hours**
MARE 100: Marine Engineering Fundamentals	3
MARE 103: Basic Safety and Lifeboatman Training	3
MARE 200: Basic Operations	4
MARE 401: Marine Auxiliary Systems	3
MARE 377: Engineering Risk Management in Maritime Construction and Shipbuilding -or- MARE 441: Engineering Economics and Project Management	3
Total Credit Hours	16

6. Development of a Minor in Marine Electro-Technology

The Marine Electro-Technology minor will introduce students to the cutting-edge technology now on vessels. Digital electronics will be covered with advanced topics in High Voltage operations, Battery Power supply management, and shipboard automation. Upon USCG approval, the student will graduate with an electro-technical rating (ETR) and, with additional sea-time, will be allowed to test for their electro-technical officer endorsement. As ships become more automated and move to alternative propulsion to decarbonize, electrical expertise will be critical onboard the vessel. This minor will allow our students to fill the need in the modern merchant marine. This minor is not limited to our license option students; we are encouraging all of our students to enroll, as the knowledge can be applicable in port engineer or maintenance mange positions. The marine electro-technology courses are listed below in Table 2.

Table 2. Marine electro-technology minor courses.

Marine Electro-Technology Minor Courses	Credit Hours
MARE 235: Digital Fundamentals for Marine Engineers	3
MARE 325: Shipboard Networking Systems	3
MARE 335: Power Electronics for Shipboard Applications	3
MARE 345: High Voltage Technology for Marine Engineers	3
MARE 445: Marine Navigation Systems	3
Total Credit Hours	15

7. Simulation as a Training Tool in Marine Engineering Technology

Simulation-based learning facilitates experiential learning by allowing students to make time-based decisions with repercussions from errors in a controlled environment. This allows students to grow their skills and knowledge, leading to a deeper understanding of their practice. Simulation-based education has proven more effective than lectures and workshops in student engagement and knowledge retention.[14]

The maritime training and education complex adopted simulation, as required by the IMO, following the example of crew resource management training in the Federal Aviation Administration (FAA). The guidelines developed by IMO made simulation training for bridge officers necessary for human element training.[15]. However, engine room simulation was still held back based on limitations of simulation design as recommended implementation.

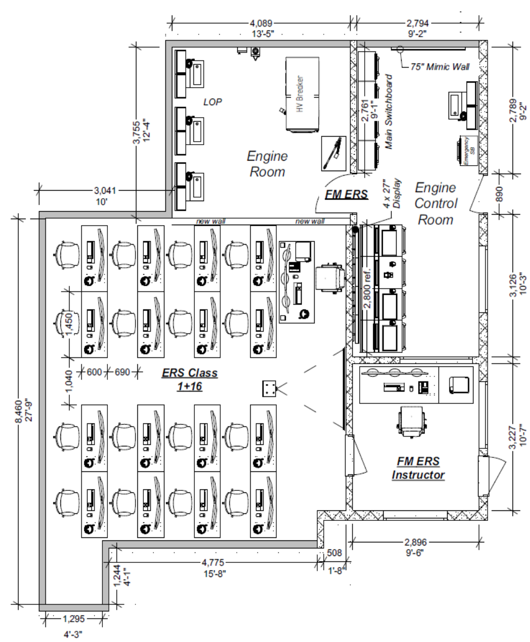

Fig. 2. TAMUG MARE ERS1 and ERS 2 layout.

In the meantime, as software and technology continued to develop, many maritime schools and colleges adopted a traditional desktop or full mission simulator. IMO Model Course 2.07 Engine-Room Simulator describes an engine simulator (ERS I) as consisting of instructor and student consoles with display panels of various diagrams and panels necessary to operate the propulsion plant.[16] The course model also describes a full mission simulator (ERS II) similarly but provides a realistic training environment; this usually involves mock-ups and large displays.

Fig. 3. TAMUG MARE ERS 1 classroom.

Fig. 4. ERS 2 FMS engine control room.

A limitation mentioned above that maritime schools face is the training and education of students on multiple forms of propulsion when only one might be accessible for their education. The maritime colleges have been given the goal by the Department of Maritime Administration to graduate cadets in gas turbine, steam, and diesel propulsion. For professional continuing education programs, a traditional simulator might be usable since they have the exposure to imagine the equipment and scenarios. However, this exposure is limited for new students at a maritime college. This stresses the need to have equipment available to show students. Even a full mission simulator constructed with control consoles and large displays for system diagrams would have the same limitations as the ERS I lab.

8. Development of Engine Simulation Laboratory

Texas A&M University at Galveston's (TAMUG) Department of Marine Engineering Technology (MARE) has recognized this issue and paired with Wärtsilä Simulation and Training Solutions to update their traditional ERS I lab to a fifteen-person multipurpose propulsion simulation and full mission simulator with virtual and 3D capabilities. This new facility can supplement workshops on the training ship and existing labs with fully rendered high-fidelity experiences on six different propulsion types:

- Dual fuel diesel electric
- Dual fuel slow speed
- Slow speed diesel
- Medium speed RoPax
- Dual fuel steam
- Gas turbine

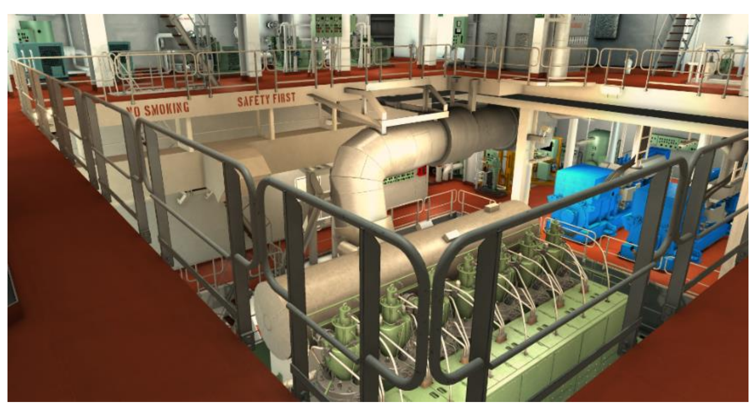

Fig. 5. TAMUG MARE VR machinery space.

Another challenge is the continued advancement of simulation models to meet new industry training and educational needs. Wärtsilä has continued to lead the simulation industry with new high voltage training aids and multiple simulators in alternative fuel sources. MARE has implemented more electro-technical training and alternative fuel source training, research, and education into their programs. This has led to new classes, minors, and exercises utilizing the upgraded full mission simulator with its high voltage breaker and the collection of four LNG models.

Fig. 6. TAMUG MARE virtual PAC.

Fig. 7. HV ERS 2 FMS HV breaker.

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Fig. 8. TAMUG MARE VR engine control room.

Beyond the use of the updated fifteen-person and full mission simulator, MARE plans to use modern virtual and augmented reality (AVR) exercises in high voltage and LNG propulsion. This will allow students to gain a sense of scale and layout for the operation and design of these modern vessels. With AVR, the entire vessel can be simulated in the confines of a twenty-five-square-foot space.

9. Conclusions

The growing maritime trade and an increasing number of highly automated ships require the presence of a skilled electro technical officer on board each vessel to manage and maintain these systems. The Marine Engineering Technology department at Texas A&M University's Galveston campus has developed an electro technology minor so that existing students in Marine Engineering Technology can obtain the required technical background for the USCG endorsement as ETO. Four new courses are under development for the minor in electro technology, and one, the marine power electronics for shipboard applications course, has been developed and offered. Another minor in Marine Engineering Technology was developed to increase awareness about the discipline among other majors. The ETO minor creates a pathway to highly sought-after and lucrative jobs in the marine sector.

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Biographies

ALOK VERMA is the Powell chair and head of the Marine Engineering Technology Department at Texas A&M University in Galveston. Dr. Verma received his BS in Aeronautical Engineering from the famed institution IIT Kanpur, MS in Engineering Mechanics, and PhD in Mechanical Engineering from Old Dominion University. Prof. Verma is a licensed professional engineer, a certified manufacturing engineer, and has certifications in Lean Manufacturing and Six Sigma. Dr. Verma's scholarly publications include more than 87 journal articles, papers in conference proceedings, and over 50 technical reports.

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