Development of Electro-Technical Officer Program 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. Due to the expanding global trade, and increased automation of ships, the maritime industry is required to improve the crews' training skills and capabilities [1], [2]. Over the past few years, electrical and electronic systems on seagoing vessels have become highly sophisticated. The efficient operation of modern vessels depends upon the operation and maintenance of electrical and electronic equipment. Electro-technical officer (ETO) on a ship is responsible for maintaining electronic equipment like radars, navigational equipment, global positioning systems, and voice data recorders. Currently, no institution of higher education in the USA is offering an ETO degree. Texas A&M University will be the first to develop and offer such a program. The development and implementation of the new electro-technical program at Texas A&M University are discussed in this paper.

I. Introduction

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

The World Bank defines the blue economy 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 (as shown in Figure 1), according to an analysis by the Organization for Economic Co-operation and Development (OECD). This growth will be driven by solid 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 increased by 17% to $5.4 trillion, accounting for about 26% of the country's $20.5 trillion gross domestic product (GDP).

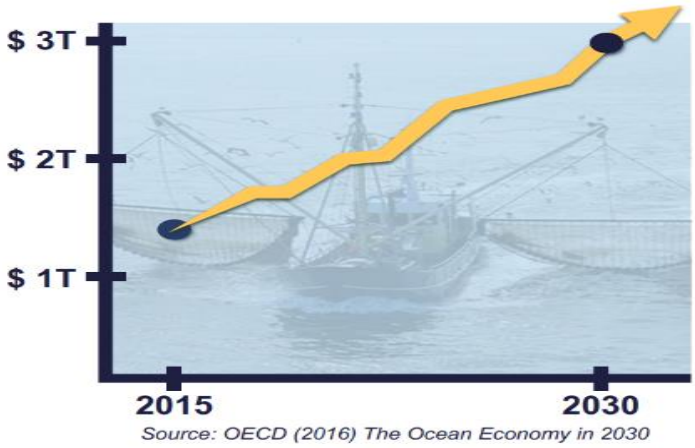

Fig.1. Projection of America's Blue Economy [5], [6].

On the other hand, the International Maritime Organization (IMO) amended STCW 95 (also known as the Manila Amendments) 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 more complex and sophisticated electrical systems that are emerging [7]. Electro technical officer (ETO) is defined as a licensed member of the engine department of a merchant or passenger ship and is in a critical position in the technical hierarchy of modern vessels 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]. In view of the above factors, the Marine Engineering Technology Department at Texas A&M University has decided to develop an ETO program in support of the future workforce for the Blue Economy.

2. Industry Needs for ETO Program Development

The workforce will need to grow in tandem with the growth of the US 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 technological advancements are being 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, and 8. advanced materials [9], [10].

The advancement, intelligent, highly automated, and autonomous ships, stand out among the eight growth areas. The rising usage of intelligent systems for ship management, operation, and propulsion is an example of this trend. The US Coast Guard is expected to adopt this approach soon and mandate that an ETO man all ships in US waters. At present, no higher education institutions, including the seven maritime academies in the US, provide a degree or training

program for electro-technical officers. The Marine Engineering Technology Department at the Galveston campus of Texas A&M University plans to develop this program in collaboration with the Multidisciplinary Engineering Technology Program from the main campus in College Station. This paper discusses the development of a minor to prepare the current license-option students in the program for the ETO endorsement.

3. The 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 each year for sea duty and employment all over the world.

Texas A&M-Galveston is ideally 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 a great desire to give back.

4. Other Institutions Offering ETO Programs

Several European educational institutions provide maritime education, some of which also offer ETO programs [3]:

- Lithuania, Lithuanian Maritime Academy (https://ec.europa.eu/ploteus/en/content/marine-electrical-engineering)
- Southampton, The Corporation of Trinity House
- Greek Maritime Academies, Merchant Marine Academy of Makedonia, Marine Engineering Department
- Ghent, Belgium, MSc in Electromechanical Engineering – Maritime Engineering (finished)
- Croatia Split: Croatia is the University of Split, Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture, MSc in Marine Electrical Engineering Technologies, Master in Maritime Electrical Engineering and Communication Technologies
- Gdynia, Faculty of Electrical Engineering
  Paço de Arcos, Portugal, bachelor's degree Maritime El. Engineering

5. Mandatory Minimum Requirements for Certification of Electro-Technical Officers

In June 2010, significant changes to the STCW (Standards of Training, Certification, and Watchkeeping for seafarers) Convention and Code were agreed upon at an IMO Diplomatic Conference in Manila to bring the Convention and Code up to date with new developments. These changes, known as "The Manila amendments to the STCW Convention and Code," are due to enter into force on 1 January 2012. IMO adopted STCW Convention in Manila to ensure the necessary global standards are in place to train and certify seafarers to operate technologically advanced ships, which includes ETO standards [11]. Based on IMO regulations, mandatory minimum requirements for the certification of electro-technical officers can be categorized into general, application, and training requirements [8].

General Requirements

- Must be at least 18 years old
- Sea-Time of 12 months combined workshop and skills training and at a minimum six months approved sea time with the completion of TRB (Training Record Book) OR
- Thirty-six months of approved training and seagoing service, of which not less than 30 months is in the engine department

Regulation III/6 of IMO STCW (The International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers) 2010 Regulations outline the minimum requirements for the Certification of ETOs. The following is section A-III/6 [12]:

Training

1. The education and training required by paragraph 2.3 of regulation III/6 shall include training in electronic and electrical workshop skills relevant to the duties of an electro-technical officer.
2. Table 1 is adapted from IMO Course Model 7.08 and modified to show how this format could be used [12].

Onboard Training

3. Every candidate for certification as an electro-technical officer shall follow an approved program of onboard training which:
    a. ensures that, during the required seagoing service, the candidate receives systematic practical training and experience in an electro-technical officer's tasks, duties, and responsibilities.
    b. is closely supervised and monitored by qualified and certificated officers aboard the ships in which the approved seagoing service is performed; and
    c. is adequately documented in a training record book.

Standard of Competence

4. Every candidate for certification as an electro-technical officer shall be required to demonstrate the ability to undertake the tasks, duties, and responsibilities listed in column 1 of table A-III/6 [6].
5. The minimum knowledge, understanding, and proficiency required for certification are listed in column 2 of table A-III/6, which shall consider the guidance given in part B of this Code.
6. Every candidate for certification shall be required to provide evidence of having achieved the required standard of competence tabulated in columns 3 and 4 of table A-III/6.

Column one of table A-III/6 contains competence, column two has knowledge, understanding, and proficiency, column three includes methods for demonstrating competence, and column four shows criteria for evaluating competence.

Table 1. Curricular requirements for ETO.

Subject Area	**Training Hours**	**Practical Workshop Skills**
CLUSTER 1: **MARINE ENGINEERING SYSTEMS** Thermodynamics for Marine Applications Auxiliary Machineries Deck Machinery Engine Technology Marine Refrigeration and Air Conditioning Systems	75	60
CLUSTER 2: **ELECTRICAL AND ELECTRONIC SYSTEMS** Marine Electro-Technology Electrical Equipment, Schematics, and Safety Generators and Distribution Systems Ship's Communication Systems and Bridge Navigational Equipment Marine High Voltage	90	180
CLUSTER 3: **AUTOMATION AND CONTROL TECHNOLOGY** Electro-Hydraulics Electro-Pneumatics Programmable Logic Controllers with Networking Instrumentation, Automation, and Alarm Systems	90	180
CLUSTER 4: **ANCILLARY TRAINING** Ensure Compliance with Pollution Prevention Requirements Leadership and Teamworking Skills	45	0
Sub-Total Training Hours	300	420
TOTAL TRAINING HOURS	**720**	

6. USCG Electro-Technical Officer (ETO) Requirements – Merchant Mariner Credential

This section presents USCG ETO requirements for merchant mariner credential, which include

General Requirements for STCW Electro Technical Officer (ETO)

- Age: 18 years
- TWIC (Transportation Workers Identification Card)
- Medical certificate
- Drug testing compliance (within six months)
- Sea service letters or discharges

USCG STCW ETO 750kW /1,000 HP or More Operational Level Sea Service Requirements are

- Sea Service Requirements Option 1: Evidence of 1080 days (36 months) combined workshop skills training** & approved seagoing service, ** of which: not less than 900 days (30 months) must be seagoing service in the engine department of vessels. Experience in the deck may be creditable for up to 90 days (3 months) of the service requirements, OR
- Sea Service Requirements Option 2: Completion of an approved training program, which includes a combination of workshop skill training and seagoing service of not less than 360 days (12 months), and which meets the requirements of section A-III/6 of the STCW Code.
- Assessments: Provide evidence of meeting the standard of competence specified in section A-III/6 of the STCW Code
- Sea Service Requirements Option 3: No additional sea service is required if any applicant has served in a relevant capacity onboard a vessel for less than 360 days within the last 60 months (5 years). Anyone who holds an STCW endorsement as OICEW, Second Engineer Officer, or Chief Engineer Officer has met this sea service requirement, OR If QMED or Wiper held, must document 360 days of sea service in the engine department on vessels of at least 750 Kw/1,000 HP. Service may be on any water.

All under this option must document experience IAW 10.232(a) by service letter or other official documents from marine companies signed by the owner, operator, master, or chief engineer of the vessel in the following subjects:

All under this option must provide evidence of meeting the standard of competence specified in section A-III/6 of the STCW Code. This can be done in the required coursework for options 1 and 2.

** The total workshop skills training days should be 180 days. Workshop skills training may include, but is not limited to, shore-based laboratories, in-port watchkeeping, and maintenance, engine room simulator, and/or internships in an appropriate field of study (shipyards, power generating stations, or facilities where mechanical and electrical systems must be operated, maintained, and managed).

USCG Approved Training for ETO are required for all qualifying under Option 1 (see above) in sea service requirements & check program approval if qualifying under Option 2 (see above) in sea service requirements as may be included in the program.

- Onboard computer networking and security
- Radio electronics
- Integrated navigation equipment
- Ship propulsion and auxiliary machinery
- Instrumentation and control systems
- High voltage power systems
- Medical first-aid provider (unless previously completed)
- Proficiency in survival craft (unless previously completed)
- Basic and advanced fire-fighting course within five years of application date (advanced fire must show continuing competencies if not within five years)
- Basic training

7. ETO Pathways

The ETO program will be developed in partnership with the multidisciplinary engineering technology program (MXET) on the main campus and the marine engineering technology program (MARE) on the Galveston campus. Figure 2 shows the pathways to ETO jobs via the MXET program at the top of the figure and the MARE program at the bottom of the figure. The targeted population will include transfer students from area community colleges and first-year students entering both Galveston and College Station campuses. MARE department has entered into a collaborative agreement with the South Texas Project nuclear plants to provide graduates for training as nuclear plant operators by the Nuclear Power Institute, as shown in Figure 2. It is anticipated that some cargo ships in the future will use atomic energy.

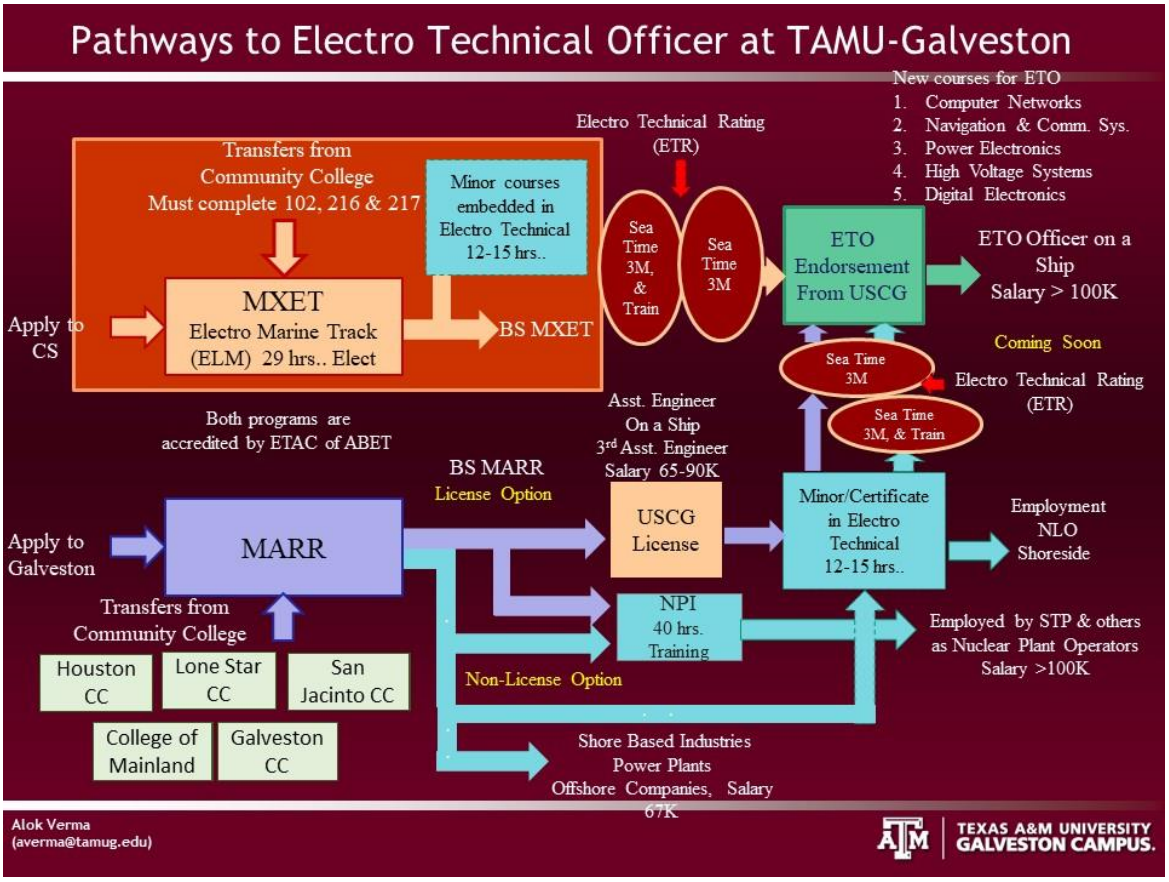

Fig. 2. Curriculum development for ETO program and its impact.

This program will be developed in two phases. Phase I will consist of creating a minor in electro technology with five courses, built using content from IMO Course Model 7.08:

1. Marine Computer Networks
2. Marine Navigation and Communication Systems
3. Marine Power Electronics
4. High Voltage Systems
5. Digital Electronics

Table 2 shows a comprehensive insight into this program.

Table 2. Overall insight into the developed ETO program.

Overview	Electro Technical Officer Program
Location and availability	Texas A&M University, Galveston, and College Station campuses
Entry requirements	US Citizen, 18 years of age
Career and future study	ETO officer, assistant engineer, shore-based industries, power plants, offshore companies, nuclear plant operators
Courses	marine computer networks, marine navigation and communication systems, marine power electronics, high voltage systems, digital electronics
Credential	USCG endorsement as ETO
Duration	at least 29 hours
Salary	more than 100k

8. Course Content

a. Marine Computer Networks

This course provides an overview of computer networks, protocols, and devices used for data communications. Specific topics include fundamentals and basic concepts of the seven-layer OSI model, analog and digital data communication techniques, packet switching and routing, and major communication protocols. The course will include a lab component providing router and switch configuration exercises, virtual LAN setup, and protocol analysis with WireShark software.

b. Marine Navigation and Communication Systems

This course introduces Shipboard Navigation system components, electronics, and electrical systems. The fundamentals and basic concepts of communication systems such as global maritime distress safety system, single sideband radio, emergency position-indicating radio beacon, positioning systems such as global positioning systems, hyperbolic long-range radio navigation (Loran-C) and chart plotters. Radar, auto-pilot systems, the design, maintenance, and, troubleshooting of the shipboard navigation station and its power supplies alternating current and direct current.

c. Marine Power Electronics

This course will cover topics like introduction to power electronics and their application in the marine environment. DC/DC Converters principle and design. Inverters and converters' concept of operation, design, and applications. Rectification of utility input: concepts and control. Several laboratory experiments and computer-based exercises are conducted to enhance and consolidate the understanding of power electronics design principles and applications in the marine environment.

d. High Voltage Systems

This course will contain topics like introduction to high voltage electrical systems; HV generation and testing; electrical safety of HV equipment; protective relaying HV systems; electrostatic field and break-down strength in dielectrics; design consideration of HV equipment; overvoltage and surges in HV system along with their protection.

e. Digital Electronics

This course provides an overview of modern digital devices used for computing, automation, system monitoring, and control. It introduces the logic and devices that enable these applications throughout many industries. Specific topics include fundamentals and basic concepts of number systems; Boolean algebra, digital logic functions; logic gates, flip flops, counters, registers, and analog-to-digital conversion. The course will include a lab component that will provide exercises with basic logic gates, combinational design, shift registers, and timer circuit design and implementation.

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 intends to develop an ETO program so that existing students in the Marine Engineering Technology and Multi-disciplinary Engineering Technology programs can access the ETO program and minor to achieve USCG endorsement as an ETO. Four new courses are under development for the minor in Electro Technology, and one, the Marine Power Electronics Course, has been developed and offered. The ETO minor and the ETO program create 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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