

2010

# Future of Celestial Navigation and the Ocean-Going Military Navigator

Michael Garvin  
*Old Dominion University*

Follow this and additional works at: [https://digitalcommons.odu.edu/ots\\_masters\\_projects](https://digitalcommons.odu.edu/ots_masters_projects)

---

## Recommended Citation

Garvin, Michael, "Future of Celestial Navigation and the Ocean-Going Military Navigator" (2010). *OTS Master's Level Projects & Papers*. 41.  
[https://digitalcommons.odu.edu/ots\\_masters\\_projects/41](https://digitalcommons.odu.edu/ots_masters_projects/41)

This Master's Project is brought to you for free and open access by the STEM Education & Professional Studies at ODU Digital Commons. It has been accepted for inclusion in OTS Master's Level Projects & Papers by an authorized administrator of ODU Digital Commons. For more information, please contact [digitalcommons@odu.edu](mailto:digitalcommons@odu.edu).

**THE FUTURE OF CELESTIAL NAVIGATION AND THE  
OCEAN-GOING MILITARY NAVIGATOR**

A Research Paper

Presented to the Faculty of the  
Department of STEM Education and Professional Studies  
Old Dominion University

In Partial Fulfillment for the Requirements for the  
Master of Science  
Occupational and Technical Studies

By

Michael J. Garvin

August, 2010

APPROVAL PAGE

This research project was conducted and prepared by Michael J. Garvin under the direction of Dr. John M. Ritz in OTED 636, Problems in Occupational and Technical Studies. It was submitted to the Graduate Program Director as partial fulfillment of the requirements for the degree of Master of Science.

Approved By: \_\_\_\_\_ Date: \_\_\_\_\_

Dr. John M. Ritz  
Graduate Program Director  
Occupational and Technical Studies  
Old Dominion University

# TABLE OF CONTENTS

	<u>Page</u>
APPROVAL PAGE.....	ii
LIST OF TABLES.....	v
CHAPTER	
I. INTRODUCTION.....	1
Statement of Problem.....	3
Research Goals.....	3
Background and Significance .....	4
Limitations .....	9
Assumptions.....	9
Procedures.....	10
Definition of Terms.....	11
Overview of Chapters .....	11
II. REVIEW OF LITERATURE.....	13
Developments in Shipboard Navigation .....	13
Changes in Maritime Requirements.....	20
Summary .....	26
III. METHODS AND PROCEDURES.....	28
Population .....	28
Instrument Design.....	28

## TABLE OF CONTENTS (cont.)

	<u>Page</u>
Method of Data Collection.....	29
Statistical Analysis.....	29
Summary.....	30
IV. FINDINGS.....	31
Response Rate.....	31
Report of Findings .....	32
Viability of Celestial Navigation .....	34
Assess Celestial Navigation Utilization.....	37
Instruction Facilitating Implementation Post Graduation.....	40
Summary.....	45
V. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS.....	48
Summary.....	48
Conclusions.....	50
Recommendations.....	55
REFERENCES .....	57
APPENDIX A: Research Questionnaire.....	61
APPENDIX B: Cover Letter.....	66

## LIST OF TABLES

	<u>Page</u>
TABLE 1. Mean and Percentage for Respondent Experience Level.....	33
TABLE 2. Mean and Percentage for Closed-Form Questions	
Viability of Celestial Navigation .....	38
TABLE 3. Percentage for Open-Form Questions	
Viability of Celestial Navigation .....	39
TABLE 4. Mean and Percentage for Closed-Formed Questions	
Assess Celestial Navigation Utilization.....	41
TABLE 5. Percentage for Open-Form Questions	
Assess Celestial Navigation Utilization.....	42
TABLE 6. Mean and Percentage for Closed-Formed Questions	
Instruction Facilitating Implementation Post Graduation.....	46
TABLE 7. Percentage for Open-Form Questions	
Instruction Facilitating Implementation Post Graduation.....	47

# Chapter I

## Introduction

Marine navigation blends both science and art. Every mariner is a navigator of his vessel. A good navigator constantly thinks strategically, operationally, and tactically. One plans each voyage carefully. As it proceeds, the mariner gathers navigational information from a variety of sources, evaluates the information, and determines his ship's position. The mariner then compares that position with his voyage plan, his operational commitments, and his predetermined "dead reckoning" position. A good navigator anticipates dangerous situations well before they arise, and always stays "ahead of the vessel". The mariner is ready for navigational emergencies at any time. The mariner is increasingly a manager of a variety of resources including electronic, mechanical, and human. Navigation methods and techniques vary with the type of vessel, the conditions, and the mariner's experience (Bowditch, 2002).

Celestial navigation is the art and science of navigating by the stars, sun, moon, and planets, and it is one of the oldest of human arts. According to Bowditch (2002), the ocean going professional navigator should become thoroughly familiar with the theory of celestial navigation. The mariner should be able to identify the most useful stars and know how to solve various types of sights. He should be able to construct a plotting sheet with a protractor and improvise a sextant. He should know how to solve sights using tables or a navigational calculator.

With the rise of radio and electronic means of finding location, especially with the increasingly popular Global Positioning System (GPS), based on satellite transmissions, that display latitude and longitude within feet, knowledge of celestial navigation has

experienced a precipitous decline. Celestial navigation involves reducing celestial measurements taken with a sextant to lines of position on a chart using calculators or computer programs requiring accurate predictions of the geographic positions of the celestial bodies observed, computed by hand with almanacs and tables, or using spherical trigonometry (Bowditch, 2002).

In the event of failure or destruction of electronic systems when the vessel itself is not in danger, navigational equipment and methods may need to be improvised. The mariner of a paperless ship, whose primary method of navigation is by electronic means, must assemble enough backup paper charts, equipment, and knowledge to complete the voyage in the event of a major computer system failure. A navigator who keeps a couple of dozen paper charts and a spare sextant will be a hero in such an event (Maloney, 1985).

A navigator should never become completely dependent on electronic methods. The mariner who regularly navigates by blindly pushing buttons and reading the coordinates from “black boxes” will not be prepared to use basic principles to improvise solutions in an emergency. For the mariner prepared with such knowledge the situation is never hopeless. Some method of navigation is always available to one who understands certain basic principles. The modern ship’s regular suite of navigation gear consists of many complex electronic systems. Though these may possess a limited backup power supply, most depend on an uninterrupted supply of ship’s electrical power. The failure of that power due to breakdown, fire, or hostile action can instantly render the unprepared navigator helpless (Maloney, 1985).

Our military maritime training institutions suffer budget cuts like other organizations and are forced to examine their curriculum more so in civilian institutions. Civilian institutions are designed to teach exactly what the Coast Guard examinations require for obtaining a Merchant Mariner's license. The subject of eliminating or modifying the celestial navigation module within the military is always prevalent. Even with all of the evidence and seemingly common sense that a prudent mariner should portray, the mariner who sails for the military is constantly tempted to rely solely on the ship's electronic systems (Bowditch, 2002).

### **Statement of the Problem**

The problem of this study was to evaluate the viability of continuing celestial navigation instruction for ocean-going military navigators sailing into a technologically changing future.

### **Research Goals**

The main goal of this research was to assess whether the instructional value of the US Army Maritime Training Center's Celestial Navigation module is an effective tool that instills and cultivates an awareness of the necessity to maintain piloting proficiency, safe Watchkeeping skills, and life-at-sea survivability. To guide this study the following research objectives were established:

1. Determine the viability of continued instruction of celestial navigation for US Army marine navigators.
2. Assess whether the students who graduate are actually utilizing the material learned while assigned to an ocean going vessel while at sea.
3. Does the instructional method facilitate a change in behavior enough to

implement learned material after graduation while assigned to an ocean going ship?

## **Background and Significance**

On May 20, 1998, it was announced that in the next academic year, midshipmen at the United States Naval Academy, Annapolis, MD, will no longer be taught to use a sextant to look at the stars and plot a ship's course. Instead, the Academy is adding a few extra lessons on how to navigate by computer. Naval officials said using a sextant, which is accurate to a three-mile radius, is obsolete because a satellite-linked computer can pinpoint a ship within 60 feet. While some consider it sacrilegious to eliminate a class that has been taught since the Academy was established in 1845, the Academy's superintendent, Adm. Charles Larson, said he had never used celestial navigation in the fleet (New York Times, 1998).

The Global Positioning System (GPS) became operational in 1996. GPS is the U.S. Global Navigation Satellite System (GNSS) consisting of a network of 24 satellites that continuously transmits high-frequency radio signals, containing time and distance data that can be picked up by any GPS receiver, allowing the user to pinpoint their position anywhere on Earth (Soundings, 2009).

In 1978, the U.S. Department of Defense launched the first GPS satellite, imposing Selective Availability (SA), the intentional degradation of GPS signals to prevent military adversaries from using the highly accurate positioning data. Selective Availability (SA) limited GPS to 100-meter accuracy for non-U.S. military users. Magellan introduced the first handheld receiver in 1989, making GPS available and practical for many new industrial and recreational applications. The network required to

efficiently cover the Earth was completed with the launch of the 24<sup>th</sup> satellite in 1994. The average GPS satellite has an eight year life span, so the Air Force must launch replacements on a regular schedule to maintain the 24-satellite system (Soundings, 2009).

GPS significantly outperforms other position and navigation systems, and it does so with greater accuracy and at a lower cost. Such endeavors as mapping, aerial refueling, rendezvous operations, geodetic surveying, and search and rescue operations have all benefited greatly from GPS's accuracy. What began only as a military application, GPS may now reside in everything from our cars to our smart phones. So it is ironic, if not entirely shocking that Gen. Norton Schwartz, Air Force Chief of Staff said that the military needs to wean itself off dependence on a GPS network vulnerable to jamming and satellite-killing vehicles. *DOD Buzz* (2010) reported that officials have confirmed that GPS has been “jammed or interfered with recently” (p. 2).

Jamming of GPS signals could present a serious problem for U.S. military hardware, said General Norton Schwartz, Air Force Chief of Staff, during a conference sponsored by Tuft University’s Institute for Foreign Policy Analysis. For instance, all those smart bombs and cruise missiles depend upon the GPS constellation of satellites for much of their accuracy. *DOD Buzz* (2010) pointed out that alternatives to GPS include accurate digital maps, if not the good old ink and paper versions.

According to the U.S. Army Maritime Training Campus, Fort Eustis, Virginia, mission statement (2006), is “Develop and present program of resident, academic, and professional instruction in the area of marine and terminal operations to selected military and civilian personnel of the U.S. Armed Forces, Department of Defense (DOD), and foreign governments” (p. 2-1). “The purpose of the resident courses for the Marine Deck

Officer is to train Warrant Officers to command, operate, and maintain Army watercraft in inland, coastal, and open waters for resupply, amphibious, towing, and salvage operations; successfully meet the academic and vessel-specific requirements for U.S. Army Marine License annotated: Master of Class A-1 Motor Vessels upon Coastal and Inland Waters; Mate of Class A-2 Unlimited Motor Vessels upon Oceans; Radar Observer” (p. 2-2). The Celestial Navigation Module of the resident U.S. Army Marine Warrant Deck Officer Course provides students with a basic knowledge of the positions of the celestial bodies and their apparent motion, the relationship between geographical and celestial projections and altitude differences, and how to determine plotting differences when working with observed altitudes of the various bodies (Marine Deck Officer, 2006).

Mariners who sail as vessel masters and mates on the oceans are required by law of the Code of Federal Regulations (CFR) for civilian personnel to possess a license certifying proof that they have had classroom training in celestial navigation techniques. This is a requirement if they intend to obtain an “Upon Oceans” endorsement on their mariner’s license. Whether learned through the military or at a civilian maritime school, these stringent requirements and curriculum are currently the same. Any student who successfully completes the course with a passing grade of 80% will satisfy the Celestial Navigation training requirements for certification as Officer in Charge of a Navigational Watch on vessels of 500 or more gross tonnage and will be considered to have successfully demonstrated the competence to Plan and Conduct a Passage and Determine Position: Ability to Use Celestial Bodies to Determine the Ship’s Position. Students will also satisfy the celestial navigation examination requirements of 46 Code of Federal

Regulation (CFR) 10.215(c) and 10.401(d) for any deck license up to Master Not More Than 500/1600 Gross Register Tons Upon Oceans. This course teaches the most common forms of position fixing by celestial bodies. Teaching is done through lecture, demonstration, and practice (USCG–2006–24371, 74 FR 11240, 2009).

The equipment used for celestial navigation is the sextant. Subjects for this course include, but are not limited to: nautical astronomy, sextant and altitude correction, sight reduction and lines of position, meridian transit, time of sunrise/sunset, and star identification and selection. Celestial navigation involves reducing celestial measurements taken with a sextant to lines of position using calculators, computer programs, or by hand with almanacs and tables or using spherical trigonometry.

Celestial navigation remains among the required competencies in the applicable part of the International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers, 1978, as amended (STCW). The STCW is undergoing a comprehensive review and celestial navigation is among the areas receiving attention.

Celestial navigation performs an important function as a backup means of navigation in the event that other navigation modes fail. The use of either azimuths or amplitudes of a celestial body is the only way to determine accurately a ship's compass error when operating outside of the visual range of terrestrial objects. The United States supports limiting the celestial navigation requirements to those necessary to perform its backup navigation role and in order to perform compass error corrections (Proceedings, 2009).

It is worth noting that celestial navigation has not been eliminated from the Merchant Mariner's licensing examinations, and the changes were made that reflect its

diminished use in everyday watch keeping. In early 2002, the minimum passing grade for celestial navigation exam modules was reduced from 90 % to 80 %. This reduction is consistent with the reduced (but not eliminated) role celestial navigation plays in modern watch keeping. Although the role of celestial navigation has diminished, its use in prudent navigation has not been entirely eliminated, and the Coast Guard does not have any immediate plans to eliminate celestial navigation from its license examinations through the amendment of our regulations found at 46 CFR §10.910 (Proceedings, 2009).

Methods of navigation have changed throughout history. New methods often enhance the mariner's ability to complete his voyage safely and expeditiously and make his job easier. One of the most important judgments the mariner must make involves choosing the best methods to use. Each method or type has advantages and disadvantages, while none is effective in all situations. The mariner must choose methods appropriate to each situation and never rely completely on only one system. With the advent of automated position fixing and electronic charts, modern navigation is almost completely an electronic process. The mariner is constantly tempted to rely solely on electronic systems. But electronic navigation systems are always subject to failure, and the professional mariner must never forget that the safety of his ship and crew may depend on skills that differ little from those practiced generations ago (Bowditch, 2002).

Celestial navigation proficiency is incumbent solely upon the officer. This is the challenge facing the U.S. Army Maritime Training Center to facilitate a change in behavior enough to implement learned material long after graduation. Although the Standards of Training, Certification and Watch Keeping code requires deck officers to show proficiency in celestial navigation, the International Convention for the Safety of

Life at Sea (SOLAS) does not require ships to carry a sextant even for the event of an emergency (SOLAS, 2004).

### **Limitations**

This research has the following limitations:

1. This study was limited to graduates of the U.S. Army Marine Deck Warrant Officer Course at the Army Maritime Training Center, U.S. Army Transportation School, Fort Eustis, VA.
2. The participants were limited to those who were assigned to ocean going vessels of the U.S. Army Transportation Corps.
3. All aspects of this study will be conducted at Fort Eustis, Virginia, and must be approved by the chain of command of the 7<sup>th</sup> Sustainment Brigade, Fort Eustis, Virginia.
4. All participants had the availability to perform celestial navigation throughout their time while assigned to the ocean going vessel.

### **Assumptions**

In this research, several assumptions were made regarding the problem studied:

1. The U.S. Army Marine Deck Warrant Officer Basic Course celestial navigation curriculum is sufficient to actually teach students to become proficient navigators using celestial navigation.
2. Every graduate of the U.S. Army Marine Warrant Officer Basic Course uses celestial navigation while underway upon the open oceans to verify shipboard electronic navigation equipment is working properly.

3. The U.S. Army Marine Warrant Officer Basic Course curriculum satisfies the requirements of the International Maritime Organization Standards of Training, Certification, and Watchkeeping (STCW) for Seafarers.

### **Procedures**

The problem of this study was to evaluate the viability of continuing celestial navigation instruction for ocean-going military navigators sailing into a technologically changing future. A questionnaire was conducted utilizing the descriptive method to gather and analyze the data collected from the U.S. Army Transportation Corps Marine Deck Warrant Officers, and the instructors of the U.S. Army Maritime Training Campus, Fort Eustis, Virginia.

The intent of the questionnaire was to gauge the effectiveness of the instruction to real life scenarios that promoted the use of celestial navigation versus electronic navigation aboard ocean going ships. Personnel were surveyed as to the importance, effectiveness, practicality, and viability of celestial navigation instruction utilizing a Likert scaled questionnaire. The questionnaire was designed to address the previously stated research objectives.

The results of this research were provided to Joseph Thornton, Chief of the U.S. Army Maritime Training Campus. Mr. Thornton will evaluate the findings for future course development of the U.S. Army celestial portion of the Marine Deck Officer program of instruction.

## Definition of Terms

The following terms had special meaning to this study and are listed below to aid in the reader's understanding:

- Celestial Navigation: involves reducing celestial measurements taken with a sextant to lines of position using calculators or computer programs, or by hand with almanacs and tables or using spherical trigonometry.
- Dead Reckoning: is the process of estimating one's current position based upon a previously determined position, or fix, and advancing that position based upon known or estimated speeds over elapsed time, and course.
- Global Positioning System: The Global Positioning System became operational in 1996. GPS is the U.S. Global Navigation Satellite System (GNSS). A network of 24 satellites continuously transmits high-frequency radio signals, containing time and distance data that can be picked up by any GPS receiver, allowing the user to pinpoint their position anywhere on Earth.
- Marine Sextant: The sextant derives its name from the extent of its limb which is the sixth part of a circle, or 60 degrees. The marine sextant is a double reflection instrument, used for measuring angles in same plane. The arc is graduated into degrees from right to left from 0 to 120. However the limb is only 1/6<sup>th</sup> of a circle due to the instrument double reflecting.

## Overview of Chapters

The first chapter of this study introduced the reader to the mariner of the high seas and the different means of navigating a ship far from home to a foreign port with only the stars to guide. Today, we have the Global Positioning Satellite System to assist our

navigation and other means of electronic navigation systems; however, electronic navigation systems are always subject to failure and the professional mariner must never forget that the safety of his ship and crew may depend on skills that differ little from those practiced generations ago. The problem of this study was to evaluate the viability of continuing celestial navigation instruction for ocean-going military navigators sailing into a technologically changing future. This chapter established the basis for this research study and identified the limitations and assumptions to be considered. This chapter also offered the procedures in how the data will be collected and analyzed and defined words with special meaning to the study.

Chapter II will review recent literature. Chapter III contains the methodology and analysis in collecting the data for this research project conducted at Fort Eustis, Virginia. Chapter IV will discuss the relevant findings of this research process. A summary of the findings, conclusions and recommendations for future studies will be provided in Chapter V.

## **Chapter II**

### **Review of Literature**

Throughout the eons humans have sailed the oceans and have contrived many tools to simplify the means for finding a ship's position thereby setting a course to be able to get back home. This chapter described the literature relevant to shipboard navigation with emphasis on celestial navigation, recent developments in electronic means of navigation, the declining requirements for celestial navigation competency, and a growing dependency upon shipboard electronic navigation.

### **Developments in Shipboard Navigation**

Navigators have made latitude observations for thousands of years. To find the latitude of a ship's position, man developed many tools to observe the heavenly bodies discerning the latitude by various means. Today's sextant has many ancestors to include the quadrant, backstaff, and kamal. Measuring the altitude of the pole star Polaris which sits over the North Pole was well known to centuries of navigators. Accurate declination tables for the Sun have been published for centuries, enabling ancient seamen to compute latitude to within 1 or 2 degrees. The sextant is just one tool used historically to measure angles, specifically the angle between a celestial object like a star, planet, the sun, or moon, to the visible horizon. Unfortunately finding longitude eluded mariners for centuries. Finding longitude by magnetic variation was tried, but it was found too inaccurate. The lunar distance method, which determines Greenwich Mean Time (GMT) by observing the Moon's position among the stars, became popular in the 1800s. However, the mathematics required by most of these processes was far above the abilities of the average seaman. The calculations involved were tedious and few mariners could

solve the triangle until Bowditch (2002) published his simplified method in 1802 in *The New American Practical Navigator*.

Columbus knew of navigation by sun and stars, but he was not good at it. His sight of the North Star from Haiti placed him at the latitude of Cape Cod. He knew it was wrong, but never figured out why and put his wooden quadrant aside as needing repair. Heading home to Europe, Columbus simply eyeballed the North Star, sailing northeast until it seemed about the same height as seen off Portugal's Cape St. Vincent. With that rough gauge of latitude, he turned east and hit first the Azores, then fortuitously Lisbon exactly on the nose. This was pure latitude sailing (Ulman, 1989).

Sighting with a sextant, the marine navigator measures the angle of a heavenly body above the sea horizon and marks the time the instant of sighting to the second. The Nautical Almanac tells him the geographic position on the Earth's surface that was directly beneath the body sighted at the instant timed. A set of log tables or, today, a programmed calculator contains the trigonometry to work out the compass bearing and distance to the body's geographic position. Plot three such sights on a chart and you have a fix. This is an oversimplification, but not too much. Theoretical technology was accuracy, in perfect conditions to within 200 yards. Most navigators would accept a mile error quite happily (Ulman, 1989).

Celestial navigation as practiced by the military was not perfected until the invention of the chronometer at the end of the 18th century. Moreover, it has continued to be modified by innovations in technology such as the calculator and publications including the *Nautical Almanac* as well as navigation instruments such as RADAR, LORAN-C, and the NAVSTAR GPS. Like many other means of navigation, some forms

of alternative electronic navigation systems such as Omega and TRANSIT have been decommissioned. The Coast Guard published a Federal Register notice on Jan. 7, 2010, regarding its intention to terminate transmission of the LORAN-C signal Feb. 8, 2010. A LORAN Programmatic Environmental Impact Statement Record of Decision stating that the environmentally preferred alternative is to decommission the LORAN-C Program and terminate the North American LORAN-C signal was published in the Federal Register on Jan. 7, 2010. The Homeland Security Appropriations Act for Fiscal Year 2010 allowed for termination of the LORAN-C signal on January 4, 2010, after certification from the Commandant of the Coast Guard that it was not needed for maritime navigation and that it is not needed as a backup for GPS (US Coast Guard, 2010).

For Department of Defense vehicles, GPS is the principal means of navigation. U.S. Navy and Marine Corps navigation policy states, “NAVSTAR Global Positioning System (GPS) is the primary external reference system for naval operations requiring position and navigation (POS/NAV), and time data.” Yet GPS has operational characteristics and vulnerabilities (including jamming) that may render it unusable or unreliable under certain conditions. Much work is being devoted to developing strategies for GPS outages. Operational plans now must include the contingency that GPS will not be available at the most critical times provides a somewhat ironic situation for DoD, which has spent (and continues to spend) billions of dollars on the system. Perhaps anticipating an over-reliance on a single type of “black box” navigation, the Chief of Naval Operations stated in a Navy navigation policy letter dated 1991, “Every platform/user with a validated requirement shall have a primary and at least one alternate

means of position determination. The alternate means must be independent of the primary” (Kaplan, 1999).

Celestial navigation was the primary means for navigating surface ships for many years. The rapid development of technology has brought about significant changes in marine navigation and the equipment used to ensure the safety of navigation relegating celestial navigation to a backup role at best. The great success and widespread use of GPS have resulted in the termination of some of the other older means of electronic navigation systems. Celestial navigation is often overlooked as an alternative to GPS because of the drawbacks of its traditional practice of sextant, almanacs, and manual sight plan and reduction procedures involving laborious mathematical equations (Bangert, Dunham, Kaplan, LeBlang, & Pappalardi, 2001).

Commercial GPS units are quickly inundating both civilian and military vessels plying the world's waterways and can be found in an increasingly wide variety of places. Commercial GPS units can now be found within satellite systems, navigations systems, data links, unmanned vehicles, ordnance, and optical sighting systems. One of the largest users of commercial GPS is the Military Sealift Command. As a result, our dependency on commercial GPS technology is also proliferating, increasing the possibility of Electromagnetic Interference (EMI) or damage to these units. In May 2000, Naval Sea Systems Command (NAVSEA) launched an investigation into GPS susceptibility to EMI damages after receiving United States Navy (USN) message traffic indicating a United States Naval Ship (USNS) had experienced commercial GPS damage during a routine boarding operation training exercise (Williams, 2006).

The electronic navigation equipment now used on all ships includes items such as receivers of satellite navigating systems GPS, GLONASS, RADARs, systems of Automatic Radar Plotting (ARPA), and Automatic Identification System equipment (AIS). Electronic Chart Display and Information System (ECDIS) is one direction for use on vessels. The navigator conducts a preliminary plan of the ship's route for intended voyage and monitoring positions of the vessel over the chosen route usually on paper charts. Use of paper charts can be very labor-intensive, demanding certain skills from navigators, and use of the special tools. The ship's position can be inaccurate due to tool error, and various horizontal geodetic data without automatic equipment. Electronic nautical charts eliminate the problems that arise with paper charts (Bokov, 2006).

Electronic Chart Display and Information System (ECDIS) is a computer system which satisfies the special requirements that allows navigators to use an electronic nautical chart instead of plotting on paper charts. Such status ECDIS is determined by rule V/19 of the convention of International Maritime Organization (IMO) on Safety of Life at Sea (SOLAS-74/88). "According to this rule, all ships should have: nautical charts and nautical publications to plan and display the ship's route for intended voyage and to plan and monitor positions throughout the voyage an Electronic Chart Display and Information System (ECDIS) can be accepted as meeting the chart carriage requirements of this subparagraph; back-up arrangements to meet the functional requirements of this subparagraph is partly or fully fulfilled by electronic means. The corresponding complete set of sea nautical charts it can be used as duplicating means for ECDIS" (IMO, 2004).

A careful review of past collisions and groundings involving naval forces supports the notion that the use of such navigational equipment could possibly have prevented many of the costly mishaps the Navy has experienced in recent years. Many commercial companies have had great success with real-time navigation situational awareness equipment, namely electronic chart display and information systems or, simply stated, ECDIS. In fact, one commercial shipping company saw collisions and groundings drop from an average of 2 per year to none over a 4-year period after having employed such equipment. The U.S. Navy Electronic Chart Display and Information System - Navy (ECDIS-N) policy dated 17 March 1998 establishes the goal that all Navy ships be equipped with and trained to use an ECDIS-N system by FY07 and establishes the minimum standard that an ECDIS-N system must meet. This policy has dictated that ECDIS-N systems will be the central component of how the US Navy will navigate in the 21st century. Why does the Navy want to change the way it has been navigating? This question can be answered by two complimentary and very important reasons: 1) The need for Navy ships to operate in the littorals, and 2) the prevention of collisions and groundings (Devogel, Baccei, & Shaw, 2001).

Enhanced Long Range Navigation (eLORAN) is the next generation of LORAN, a radio navigation network that has been in use for decades. It has a reported accuracy near that of conventional GPS positioning in coastwise and harbor applications, and uses the infrastructure that is already in place. Its effectiveness is a result of solid-state transmitters, advanced software applications, and uninterruptible power sources, along with a new generation of shipboard receivers. Because the signal is much more powerful than GPS, eLORAN is not nearly as susceptible to jamming. In February 2008, the U.S.

Department of Homeland Security announced that eLORAN would be implemented as a national backup for a GPS failure, but funding squabbles threaten to scuttle this implementation. Even when fully installed, however, eLORAN's effective coverage would only be several hundred miles offshore (Professional Mariner, 2009).

The U.S. General Accounting Office (GAO, 2009) has warned that aging satellites may not be replaced quickly enough to keep the global positioning system operating at current levels. The government is investing \$5.8 billion in the system between this year and 2013. The Department of Defense predicts that over the next several years many of the older satellites in the constellation will reach the end of their operational life faster than they will be replenished, thus decreasing the size of the constellation from its current level and potentially reducing the accuracy of the GPS service. The GAO (2009) report says, "It is uncertain whether the Air Force will be able to acquire new satellites in time to maintain current GPS service without interruption. If not, some military operations and civilian users could be adversely affected" (p. 51). The GPS system currently has 31 satellites in orbit. Earlier generations of satellites had a theoretical life expectancy of 7.5 years, but most lasted twice that long. New-generation satellites have a theoretical life expectancy of 11.5 years. The system is designed so that a GPS signal is picked up by four satellites that fix the position of the signalling device by measuring the different distances to the satellites. The system is designed to provide a 95 % probability of maintaining a minimum 24 satellites in orbit. The GAO predicts an 80 % probability at times from 2010 and 2014 and as low as 50 to 80 % from 2018 to 2020 (Flannery, 2009).

GPS, or NAVSTAR GPS, as it is officially called, utilizes weak radio wave signals currently generated by about 30 satellites 12,000 miles above the earth. As a result, it can be jammed or rendered unusable naturally by a strong solar storm, or intentionally by other militaries jamming GPS signals. During Operation Iraqi Freedom, U.S. troops captured six GPS jamming units reportedly developed in Russia. It has been 20 years since the first GPS satellite was launched into space, and many of the original satellites will soon be at the end of their useful life. A report issued by the U.S. Government Accountability Office in April 2009 pointed out that although the aging GPS system is due for upgrades, the Air Force is facing delays, huge cost overruns and technical snafus, and is falling behind schedule on modernizing the system. The report noted that the Department of Defense admits that over the next few years the satellites will go out of service faster than they can be replaced (Professional Mariner, 2009).

### **Changes in Maritime Requirements**

The Code of Federal Regulations (CFR) is the codification of the general and permanent rules published in the Federal Register by the executive departments and agencies of the Federal Government. It is divided into 50 titles that represent broad areas subject to Federal regulation. Title 46 governs the regulations concerning shipping. Within Title 46, Chapter 1 Coast Guard, Department of Homeland Security, Part 11 Requirements for Officer Endorsements, Subpart D, Professional Requirements for Deck Officers, “A mariner having a master or mate near-coastal license or MMC endorsement obtained with ocean service may have an MMC endorsed for ocean service by completing the appropriate examination deficiencies, provided that the additional service

requirements of paragraph” (46 CFR, Chapter 11, Subpart D, Paragraph 11.401 (d), 2009).

Under STCW code, there is no distinction between licenses over 500 ITC. The celestial requirements are now the same for Master 1600 near coastal as they are for an unlimited license. The Sub-Committee on Standards of Training and Watchkeeping, at its thirty-ninth session (3-7 March, 2008), considered all of the submissions under agenda item 7. In considering the proposal contained in document STW 39/7/93 to delete celestial navigation from the relevant parts of the STCW Code, the workgroup briefly discussed the identification of other potentially outdated requirements from the tables of competence (IMO, 2008).

The Navy continues to rely more on technology, and as the pace of operations in a rapidly streamlining Navy take their toll, many sailors believe these historical navigational skills and traditions are getting pushed to the sidelines. Navy quartermasters working with all means of navigation are feeling the trend even more so with the increase in technology altering the way a ship can plot its position. Quartermaster First Class (SW) Bradford was the Sailor of the Year serving aboard the submarine tender L.Y. Spear. She said, “I think celestial navigation is definitely getting phased out” (Elazar, 1996). Though there is little danger to the Navy’s mission if outdated skills like these are lost, many sailors are nevertheless concerned. They worry about the potential damage to Navy pride and their sense of identity if all the classic seafaring skills are allowed to die on the vine. Sailors’ catalog their concern about the impact technology is having on today’s navy. Instead of shooting stars with a sextant to plot a ship’s course, albeit a complex task that can take an hour or more to solve the mathematics involved,

quartermasters can punch a button and get their ship's position accurate to within 50 feet in a matter of seconds using an on-board computer and GPS satellites (Elazar, 1996).

Losing GPS capability would have calamitous effects on shipping. The Automatic Identification System (AIS) relies on GPS and is used to direct/monitor vessel traffic in major ports. Without GPS input, AIS would essentially be rendered useless putting our ports at increased risk for collisions, oil spills, and breaches of security as vessel traffic authorities would be unable to identify and track thousands of vessels in harbor areas around the country. Offshore, the numerous drillships worldwide which use GPS input while in active dynamic positioning mode could fall off station, possibly ripping out pipe and causing oil spills as a result. For all close quarter situations, an effective backup to GPS is obviously needed (Professional Mariner, 2009).

The International Maritime Organization mandates the use of GPS or some type of electronic navigation system onboard oceangoing ships, but makes no such requirement for celestial navigation equipment, which is a time-tested means of determining the ship's position at sea. The Standards of Training, Certification & Watchkeeping code requires deck officers to show proficiency in celestial navigation, but SOLAS Chapter V, Regulation 19 does not require ships to even carry a sextant onboard (Professional Mariner, 2009).

Celestial navigation is still included on the Merchant Marine Deck Officer License exams for ocean routes for a number of reasons. First, celestial navigation is among the required competencies in the applicable part of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978 (STCW). For example, the minimum standard of competence for an officer in charge of a

navigational watch includes the ability to use celestial bodies to determine the ship's position. According to the US Coast Guard, the STCW is undergoing a comprehensive review and celestial navigation is among the areas receiving attention. While it is too early to tell the outcome of this review, the position of the United States is that while the role of celestial navigation has significantly diminished, it should not be eliminated entirely. Celestial navigation performs an important function as a backup means of navigation in the event that other navigation modes fail. Second, the use of either azimuths or amplitudes of a celestial body is the only way to determine accurately a ship's compass error when operating outside of the visual range of terrestrial objects. The United States supports limiting the celestial navigation requirements to those necessary to perform its backup navigation role and in order to perform compass error corrections. It is worth noting that although the USCG has not eliminated celestial navigation from the license examinations, there have been changes made that reflect its diminished use in everyday watchkeeping. In early 2002, the U.S. Coast Guard reduced the minimum passing grade for celestial navigation exam modules from 90 % to 80 %. We believe this reduction is consistent with the reduced (but not eliminated) role celestial navigation plays in modern watchkeeping. Although our consensus that the role of celestial navigation has diminished, its use in prudent navigation has not been entirely eliminated (Proceedings, 2009, p. 93).

The calculations that are required for the reduction of a celestial sight, if performed by hand, are slow and error-prone, and discourage the human navigator from taking sights. The traditional procedure imposes several other not-so-obvious limitations on the observations. For example, because observations of the Moon and planets require

a parallax correction, many navigators avoid these objects, despite the fact that in marginal conditions they may be the only ones visible. Because the Moon is so seldom used, the possibility of Sun-Moon fixes is effectively precluded. All of this argues, if an argument is needed, for a computer program to do the calculations. There are many on the market, some embedded in special-purpose navigational calculators. Any reasonably accurate algorithm, implemented in a user-friendly program, would encourage navigators to broaden their observational habits and obtain more sights (Kaplan, 1999).

If celestial navigation is to assume a broader role in the modern U.S. Navy's high-tech environment, its limitations will have to be addressed: low accuracy (a few miles), limited time window for observations (horizon must be visible), and low data rate. The sparse amount of celestial data collected over the course of a day results from the use of a human (with other duties) as a detector and computer, the small number of target objects (usually just the Sun and bright stars), and restrictions on the sky area used (altitudes 15 degrees to 65 degrees). It turns out that all of these limitations are a consequence of the way in which celestial navigation is now carried out, rather than being fundamental to the technique they are a result of the human-intensive observing and computing procedure, and in that sense are self-imposed. However, by thinking a bit more broadly about how celestial navigation could be performed, it is evident that these problems have technical solutions that could be solved with technology available “off the shelf” (Kaplan, 1999).

This researcher conducted an interview with Alvin Lipson, a Senior Civilian Instructor with the U.S. Army Maritime Training Campus, Fort Eustis, VA. Lipson is a retired U.S. Army warrant officer with many years of experience at sea, and behind the podium instructing military and civilian students through every aspect of maritime

training especially celestial navigation instruction. This researcher asked several questions of Lipson regarding the instruction of celestial navigation in the Army marine field. This researcher posed the question, “Do we need to continue celestial navigation?” Lipson replied, “The need for continued celestial instruction is a must especially in this ever changing electronic age! As prudent mariners, the need to remain proficient in all means of navigation is only professional, plus the requirement to check and double check the electronics on board the vessel is imperative to ensure a safe voyage” (A. Lipson, personal communication, March 14, 2010). He explained, “As a vessel takes on cargo, alters her course, and/or changes location on the planet; the electronic signature of the vessel is affected thereby causing an error in the steering compass. The need and requirement to monitor the steering compass is essential aboard the vessel and is a requirement of every watch officer once per watch. These are very simple and extremely important reasons to not only continue celestial navigation, but emphasize the need that we cannot simply eliminate celestial navigation instruction or the licensing requirement” (A. Lipson, personal communication, March 14, 2010). This researcher asked Lipson what he thought could be done to encourage the young maritime officers to continue to practice celestial navigation in an ever changing technological world. Lipson explained, “It is well known within the maritime community that if the vessel master does not require celestial practice from the watch officers, they simply will not do it and will totally rely only on the electronics” (A. Lipson, personal communication, March 14, 2010). Lipson further stated, “Instead of eliminating celestial instruction, the need to alter celestial instruction to bring together celestial and electronic means of navigation is

a viable means of enticing our young officers to stay on course with both celestial and electronic navigation practices” (A. Lipson, personal communication, March 14, 2010).

As of the latest STCW Convention held on the 11<sup>th</sup> and 12<sup>th</sup> of March, 2010, the Merchant Marine Personnel Advisory Committee (MERPAC) believes that a proper implementation of the 2010 amendments would call for the USCG to revise the celestial navigation requirements on the license exams so that they reflect the international decision to consider celestial as a “back-up” navigation method. This would include lowering the passing scores in this area, the allowance of solutions by navigation or programmable calculators, and the reduction of questions to only those deemed critical (MERPAC, 2010).

## **Summary**

The researcher’s goal was to establish an understanding of the basics of shipboard navigation with special regard toward celestial navigation. Historical methods of navigating the oceans were established and recent developments were presented. The researcher utilized this information to correlate the similarities of all of the military and civilian sailors that sail the oceans using the same equipment navigating the seas in very similar fashion, and are all prone to use the fastest, easiest methods possible to establish the ship’s position, ignoring time honored traditions and proven means of navigation.

From the review of the literature in this section, the reader would determine that although electronic means of navigation are the fastest and definitely the easiest, the reliability and longevity of these systems are in question. Furthermore, celestial methods of navigation are currently still being taught albeit at a reduce capacity even though this is a proven valid system of navigation. The overall temperaments of today’s sailors

epitomize the idea that celestial navigation is heading for the same fate as the LORAN and OMEGA navigation systems. The analysis of the material and the conclusions that were drawn are available in the following chapters and will more clearly explain the importance of this information. This research project seeks to find out if a change in current curriculum emphasizing the need to incorporate celestial and electronic means of navigation in a cohesive block of instruction would indeed be the solution to preserve celestial navigation proficiency as well as maintain safe ship operation and navigation.

The following chapters are formatted to answer the following questions and give an indication as to the direction and impact of either eliminating celestial navigation, reduce the current curriculum, or incorporate celestial and electronic means of navigation in a cohesive block of instruction. Chapter III will describe the methods and procedures utilized to collect data and analyze the necessary data required of this study.

## **Chapter III**

### **Methods and Procedures**

This descriptive study sought to determine if the current celestial navigation curriculum is sufficient to teach students to become proficient in celestial navigation for ocean-going military navigators sailing into a technologically changing future.

This chapter explains the research methods and procedures used to gather and analyze data from the study. Included in Chapter III is the population studied, description of instrument used, method of collecting data and procedures used, statistical analysis, and a summary of the chapter.

### **Population**

Participants in this study were graduates of the U.S. Army Transportation Corps Marine Deck Warrant Officer Basic Course (MDWOBC) consisting of 90 participants. These men and women of varying ages are/were active duty soldiers who attended MDWOBC training at the U.S. Army Maritime Training Campus, Fort Eustis, Virginia. The surveyed participants sailed upon the open oceans aboard various U.S. Army vessels throughout their military career.

### **Instrument Design**

The problem of this study was to evaluate the viability of continuing celestial navigation instruction for ocean-going military navigators sailing into a technologically changing future. A questionnaire was conducted utilizing the descriptive method to gather and analyze the collected data from the U.S. Army Transportation Corps Marine Deck Warrant Officers, Fort Eustis, Virginia.

The intent of the questionnaire was to gauge the effectiveness of the celestial navigation instruction, and today's real life scenarios that promote the use of electronic navigation aboard ocean going ships. Participants were to evaluate the importance, effectiveness, practicality, and viability of celestial navigation instruction utilizing the Likert scaled questionnaire. The questionnaire was developed and designed to address the previously stated research objectives. The questionnaire consisted of 20 total questions consisting of 15 closed-ended and five open-ended questions so that participants would have the opportunity to provide additional information or state their opinion. A copy of the questionnaire is included in Appendix A.

### **Method of Data Collection**

Ninety questionnaires and cover letters, see Appendix B, were sent to the available participants. A second mailing of questionnaires and cover letter was sent to the remaining available personnel who had not yet responded. In addition to survey returns through the mail, during the follow-up process participants were also given the option to respond through the researcher's Old Dominion University E-mail account.

### **Statistical Analysis**

The responses to the questionnaire were analyzed and tabulated to determine insight into the use of celestial navigation versus electronic navigation aboard ocean going U.S. Army vessels. The number, frequency, and mean of the responses were determined. The open-ended questions were reviewed and coalesced into like responses and were recorded in number and frequency.

## **Summary**

Chapter III described the methods of data collection and statistical procedures used to analyze the effectiveness of the instruction to real life scenarios that promoted the use of celestial navigation versus electronic navigation aboard ocean going ships. Personnel were surveyed as to the importance, effectiveness, practicality, and viability of celestial navigation instruction utilizing the Likert scaled and open-formed questions. This chapter identified the population studied as graduates of the U.S. Army Transportation School, Marine Deck Warrant Officer Basic Course (MDWOBC). The instrument used to analyze the data was explained as to the importance, effectiveness, practicality, and viability of celestial navigation instruction in conjunction with electronic navigation.

Chapter III described how the data would be gathered, reported, and measured using a Likert scaled instrument. To capture opinions, five open-ended questions were also put forward to participants. The results of this study will determine if continued instruction with the current celestial navigation curriculum in place is a viable option in an ever changing technological world. The findings of this statistical analysis will be discussed in Chapter IV.

## **Chapter IV**

### **Findings**

The problem of this study was to evaluate the viability of continuing celestial navigation instruction for ocean-going military navigators sailing into a technologically changing future. This chapter is composed of the following sub-sections: Response Rate, Report of Findings, and Summary.

In this chapter, the findings of the questionnaire conducted with the U.S. Army Marine Navigators at the U.S. Army Maritime Training Center, Fort Eustis, Virginia, will be reported. The questionnaire was administered to answer the following research goals:

1. Determine the viability of continued instruction of celestial navigation for U.S. Army marine navigators.
2. Assess whether the students who graduate are actually utilizing the material learned while assigned to an ocean going vessel while at sea.
3. Does the instructional method facilitate a change in behavior enough to implement learned material after graduation while assigned to an ocean going ship?

### **Response Rate**

The instrument used in this study was in two parts with 15 closed-form Likert scaled questions and five open-form questions. This study was conducted utilizing a descriptive method to gather and analyze data from U.S. Army Transportation Corps Marine Deck Warrant Officers of the U.S. Army at Fort Eustis, Virginia. In the spring of 2010, there were 90 Marine Deck Warrant Officers of the U.S. Army Transportation Corps. Ninety questionnaires were sent to the available participants, with only 50%

response rate after the first mailing. A second mailing was sent to the remaining available personnel who had not yet responded. Of the 90 questionnaires sent, a total of 78 responses were received. This was an 86.6% response rate. The results reported in this chapter were a compilation of the data collected by this questionnaire.

## **Report of Findings**

Each of the 20 questions was discussed in this portion of the chapter. Each respondent had to select one response to each of the 15 close-formed questions. Questions 16 through 20 were open-formed questions enabling participants the opportunity to provide additional information or state their opinion.

The first two questions were designed to establish the experience level as a Ship's Watch Officer/Vessel Master, and the frequency of the respondent to sail upon the open ocean. For Questions 3 through 15, the participants had to answer by selecting from a Likert scale that ranged from 1- 5, where "1" represented Strongly Disagree, "2" was Disagree, "3" was Neutral, "4" was Agree, and "5" was Strongly Agree.

### **Question 1: Years of sea service as a ships watch officer/vessel master?**

Of the respondents surveyed, 34.6% (27) reported as having "More than 10 less than 20" years of sea service; 26.9% (21) had "Less than five" years of sea service; 25.6% (20) had "More than 5 but less than 10" years of sea service; and 12.8% (10) reported as having "More than 20" years of sea service. The majority of the respondents had more than five, but less than twenty years experience as a ships watch officer/vessel master.

**Question 2: As a watch officer, I have sailed upon the open ocean \_\_\_\_ times in my career to date.**

Of the respondents surveyed, 66.7% (52) reported to have “More than 20” voyages upon the open ocean; 16.6% (13) had “More than 5 but less than 10” voyages upon the open ocean; 14.1% (11) had “More than 10 less than 20” voyages upon the open ocean; and 2.6% (2) reported to have never sailed upon the open ocean. The majority of the respondents had over twenty voyages upon the open ocean in their career to date. See Table 1 for a summary of this information.

Table 1

*Percentage for Respondent Experience Level and Time at Sea*

	<b>X &lt; 5</b>	<b>5 &gt; X &gt; 10</b>	<b>10 &gt; X &gt; 20</b>	<b>X &gt; 20</b>
	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>
1. Years of sea service as a ships watch officer/vessel master?	21	20	27	10
<i>Percentage (%) of responses:</i>	26.9%	25.6%	34.6%	12.8%
	<b>5 &gt; X &gt; 10</b>	<b>10 &gt; X &gt; 20</b>	<b>X &gt; 20</b>	<b>I have never sailed upon the open Ocean</b>
	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>
2. As a watch officer, I have sailed upon the open ocean ____ times in my career to date.	13	11	52	2
<i>Percentage (%) of responses:</i>	16.6%	14.1%	66.7%	2.6%

## **Viability of Celestial Navigation**

Closed-formed Questions 7, 9, 11, 13, 14, and open-formed Questions 18 and 19 addressed Research Goal 1: Determine the viability of continued instruction of celestial navigation for U.S. Army marine navigators.

**Question 7: The celestial navigation instruction I received from the U.S. Army Maritime Training School was complete, enabling me to fulfill my responsibilities as a ship's watch officer.**

Of the respondents surveyed, 41% (32) strongly agreed with this statement; 33.3% (26) agreed; 7.7% (6) were neutral; 28.2% (22) disagreed; and 2.6% (2) strongly disagreed. The mean was 4.21 indicating a response of agreement.

**Question 9: I am more than confident in my abilities to perform celestial navigation on my vessel due to the celestial navigation curriculum at the U.S. Army Maritime Training School.**

Of the respondents surveyed, 34.2% (27) strongly agreed; 42.3% (33) agreed; 14.1% (11) were neutral; 2.6% (2) disagreed; and 6.4% (5) strongly disagreed with this statement. The mean was 3.96 indicating a response of agreement.

**Question 11: As a vessel master, I require my watch officers to perform celestial navigation while out to sea.**

Of the respondents surveyed, 3.9% (3) strongly agreed; 38.5% (30) agreed; 24.4% (19) were neutral; 25.6% (20) disagreed; and 27.7% (6) strongly disagreed with this statement. The mean was 3.05 indicating an average response of neutral.

**Question 13: I believe that celestial means of navigation are old fashioned and outdated.**

Of the respondents surveyed, 15.4% (12) strongly agreed; 14.1% (11) agreed; 20.5% (16) were neutral; 29.5% (23) disagreed; and 20.5% (16) strongly disagreed with this statement. The mean was 2.74 indicating a neutral response.

**Question 14: The only time I do celestial navigation is to prepare for school, or while in school.**

Of the respondents surveyed, 15.4% (12) strongly agreed; 18.0% (14) agreed; 14.1% (11) were neutral; 34.6% (27) disagreed; and 18.0% (14) of the respondents strongly disagreed with this statement. The mean was 2.78 indicating a neutral response.

**Question 18: Why do we, or don't we need to continue celestial navigation?**

Of the respondents surveyed, 57.1% (40) reported that there is a need to continue celestial navigation since this is what every mariner should know; 18.6% (13) reported that there is no need for celestial navigation due to having far more limitations than the modern, more redundant electronic means of navigation; 8.6% (6) of the respondents reported that if the U.S. Coast Guard keeps it as a requirement, then the US Army should as well; 8.6% (6) of the respondents reported that the typical vessel master or watch officer "may" need to know how to use celestial navigation but absolutely "must" know how to operate the instruments in order to safely navigate the vessel; 7.1% (5) of the respondents reported there is not a need to continue celestial navigation and that it should be eliminated from the curriculum. Most respondents agreed that we need to continue celestial navigation instruction since celestial navigation is something that every mariner should know.

**Question 19: The Merchant Marine Personnel Advisory Committee (MERPAC) is suggesting revising the celestial navigation requirements on the USCG license exams lowering the passing scores in this area, allowing the solutions by navigation or programmable calculators, and reducing the number of questions to only those deemed critical. This is good/bad, why?**

Of the respondents surveyed, 34.2% (26) of the respondents reported that this is bad idea to lower the passing scores for celestial navigation, and requirements establish a reason and a process of understanding the basics not just solving a problem to get an answer; 34.2% (26) of the respondents reported that this is good to lower the passing scores for celestial navigation, and since not all technology is bad it should be allowed to use calculators and computer program to speed up the process; 14.5% (11) report it is good to lower the passing scores for celestial navigation, the truth is that very few mariners practice celestial navigation today; 10.5% (8) stated that it is good to lower the passing scores for celestial navigation stating that celestial navigation is outdated; and 6.6% (5) stated that it is good to lower the passing scores for celestial navigation since they would only ever use celestial navigation in an emergency to get back to port.

Most respondents agree that it is a good idea to lower the passing scores for celestial navigation and to allow programmable calculators and computer programs to facilitate celestial navigation instruction, stating that not all technology is bad and very few mariners practice celestial navigation today and would only ever use celestial navigation in an emergency to get back to port. There is a large percentage of respondents who agree that it is bad idea to lower the passing scores for celestial navigation, and that these requirements establish a reason and a process of understanding

of the basics of celestial navigation and not just solving a problem to get an answer. Please refer to Table 2 for the closed-formed question summary and Table 3 for the open-formed question summary of this information regarding Research Goal 1.

### **Assess Celestial Navigation Utilization**

Closed-formed Questions 5, 6, 10, 12, and open-formed Question 17 addressed Research Goal 2: Assess whether the students who graduate are actually utilizing the material learned while assigned to an ocean going vessel while at sea.

**Question 5: Every time I have been out to sea, I performed the proper steps to calculate our ships position by means of celestial navigation.**

Of the respondents surveyed, 7.7% (6) strongly agreed; 26.9% (21) agreed; 19.2% (15) were neutral; 34.6% (27) disagreed; and 18.0% (14) strongly disagreed with this statement. The mean was 2.53 indicating that the average response was neutral.

**Question 6: Every time I have been out to sea, I used celestial navigation to check the accuracy of my ships compass.**

Of the respondents surveyed, 3.9% (3) strongly agreed; 33.3% (26) agreed; 12.8% (10) were neutral; 32.0% (25) disagreed; and 19.2% (15) strongly disagreed with this statement. The mean was 2.74 indicating a neutral response.

**Question 10: I only use electronic means of navigation, and rarely perform celestial navigation while out to sea.**

Of the respondents surveyed, 15.4% (12) strongly agreed; 28.2% (22) agreed; 12.8% (10) were neutral; 35.9% (28) disagreed; and 7.7% (6) strongly disagreed with this statement. The mean was 3.08 indicating a neutral response.

**Table 2***Mean and Percentage for Closed Form Questionnaire Questions***Viability of Celestial Navigation**

Question	Likert Scale					Mean
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	
7. The celestial navigation instruction I received from the U.S. Army Maritime Training School was complete, enabling me to fulfill my responsibilities as a ship's watch officer.	<u>1</u> 2	<u>2</u> 22	<u>3</u> 6	<u>4</u> 26	<u>5</u> 32	<b>4.21</b>
<i>Percentage (%) of responses:</i>	2.56%	28.21%	7.69%	33.33%	41.03%	
9. I am more than confident in my abilities to perform celestial navigation on my vessel due to the celestial navigation curriculum at the U.S. Army Maritime Training School.	<b>5</b>	<b>2</b>	<b>11</b>	<b>33</b>	<b>27</b>	<b>3.96</b>
<i>Percentage (%) of responses:</i>	6.41%	2.56%	14.10%	42.31%	34.15%	
11. As a vessel master, I require my watch officers to perform celestial navigation while out to sea.	<b>6</b>	<b>20</b>	<b>19</b>	<b>30</b>	<b>3</b>	<b>3.05</b>
<i>Percentage (%) of response:</i>	7.69%	25.64%	24.36%	38.46%	3.85%	
13. I believe that celestial means of navigation are old fashioned and outdated.	<b>16</b>	<b>23</b>	<b>16</b>	<b>11</b>	<b>12</b>	<b>2.74</b>
<i>Percentage (%) of responses:</i>	20.51%	29.49%	20.51%	14.10%	15.38%	
14. The only time I do celestial navigation is to prepare for school, or while in school.	<b>14</b>	<b>27</b>	<b>11</b>	<b>14</b>	<b>12</b>	<b>2.78</b>
<i>Percentage (%) of responses:</i>	17.95%	34.62%	14.10%	17.95%	15.38%	

**Table 3**

*Percentage for Open Formed Questions*

***Viability of Celestial Navigation***

	Eliminate	Need to know electronics	USCG requires it	We do not need it	Every mariner should know celestial
18 Why do we, or don't we need to continue celestial navigation?	<b>5</b>	<b>6</b>	<b>6</b>	<b>13</b>	<b>40</b>
<i>Percentage (%)of responses:</i>	7.1	8.6%	8.6%	18.6%	57.1%
	Bad idea to lower standards	Good celestial outdated	Good not all technology is bad	Good, few mariners practice celestial	Only required to get back to port
19. The Merchant Marine Personnel Advisory Committee (MERPAC) is suggesting revising the celestial navigation requirements on the USCG license exams lowering the passing scores in this area, allowing the solutions by navigation or programmable calculators, and reducing the number of questions to only those deemed critical. This is good/bad, why?	<b>26</b>	<b>8</b>	<b>26</b>	<b>11</b>	<b>5</b>
<i>Percentage (%)of responses:</i>	34.2%	10.5%	34.2%	14.5%	6.6%

**Question 12: I realize that the Global Positioning System (GPS) has errors, but I prefer electronic means of navigation over celestial navigation.**

Of the respondents surveyed, 23.1% (18) strongly agreed; 44.9% (35) agreed; 19.2% (15) were neutral; 12.8% (10) disagreed; and 0.0% (0) strongly disagreed with this statement. The mean was 3.78 indicating an average response of agreed.

**Question 17: I might use celestial navigation more if it ...**

Of the respondents surveyed, 27.4% (20) of the respondents reported that they would use celestial navigation more if it were easier, faster, less dependent upon weather, and if the vessel master required it; 26.0% (19) declined to answer; 21.9% (16) reported that they would use celestial navigation more if it were taught with the use of navigation calculators and/or computer programs; 13.7% (10) reported that they would use celestial navigation more if the redundant electronic means of navigation were not so prominent; 11.0% (8) reported that they would use celestial navigation more if it were the only option left. Most respondents agree that they would use celestial navigation more if it were easier, faster, less dependent upon weather, and if the vessel master required it. Please refer to Table 4 for the closed-formed question summary and Table 5 for the open-formed question summary of this information regarding Research Goal 2.

**Instruction Facilitating Implementation Post Graduation**

Closed-formed Questions 3, 4, 8, 15, and open-formed Questions 16 and 20 addressed Research Goal 3: Does the instructional method facilitate a change in behavior enough to implement learned material after graduation while assigned to an ocean going ship?

**Table 4***Mean and Percentage for Closed Form Questionnaire Questions**Assess Celestial Navigation Utilization*

Question	Likert Scale					Mean
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
5. Every time I have been out to sea, I performed the proper steps to calculate our ships position by means of celestial navigation.	<b>14</b>	<b>27</b>	<b>15</b>	<b>21</b>	<b>6</b>	<b>2.53</b>
<i>Percentage (%)of responses:</i>	17.95%	34.62%	19.23%	26.92%	7.69%	
6. Every time I have been out to sea, I used celestial navigation to check the accuracy of my ships compass.	<b>15</b>	<b>25</b>	<b>10</b>	<b>26</b>	<b>3</b>	<b>2.74</b>
<i>Percentage (%)of responses:</i>	19.23%	32.05%	12.82%	33.33	3.85%	
10. I only use electronic means of navigation, and rarely perform celestial navigation while out to sea.	<b>6</b>	<b>28</b>	<b>10</b>	<b>22</b>	<b>12</b>	<b>3.08</b>
<i>Percentage (%)of responses:</i>	7.69%	35.90%	12.82%	28.21%	15.38	
12. I realize that the Global Positioning System (GPS) has errors, but I prefer electronic means of navigation over celestial navigation.	<b>0</b>	<b>10</b>	<b>15</b>	<b>35</b>	<b>18</b>	<b>3.78</b>
<i>Percentage (%)of responses:</i>	0.00%	12.82%	19.23%	44.87%	23.08%	

**Table 5**

*Percentage for Open Formed Questions*

*Assess Celestial Navigation Utilization at Sea*

	My only option	Redundant Electronics unavailable	Use PC or calculator	Declined to answer	Was easier, faster...
17. I might use celestial navigation more if it ...	<b>8</b>	<b>10</b>	<b>16</b>	<b>19</b>	<b>20</b>
<i>Percentage (%)of responses:</i>	11.0%	13.7%	21.9%	26.0%	27.4%

**Question 3: The nomenclature in the celestial navigation module of the Warrant Officer Basic Course was extremely challenging for me.**

Of the respondents surveyed, 6.4% (5) strongly agreed; 34.6% (27) agreed; 28.2% (22) were neutral, 24.4% (19) disagreed; and 5.1% (4) strongly disagreed that the nomenclature in the celestial navigation module of the Warrant Officer Basic Course was extremely challenging. The mean was 3.09 indicating that the response was neutral.

**Question 4: The mathematics involved in the celestial navigation module of the Warrant Officer Basic Course was extremely challenging for me.**

Of the respondents surveyed, 7.7% (6) of the respondents strongly agreed; 33.3% (26) agreed; 19.2% (15) were neutral; 30.8% (24) disagreed; and 9.0% (7) strongly disagreed. The mean was 3.00 indicating the response was neutral.

**Question 8: The celestial navigation curriculum at the U.S. Army Maritime Training School should not be changed or altered in any way.**

Of the respondents surveyed, 14.1% (11) strongly agreed; 15.4% (12) agreed; 20.5% (16) were neutral; 37.2% (29) disagreed; and 11.5% (9) strongly disagreed with this statement. The mean was 2.79 indicating neutral response.

**Question 15: Due to the instruction I received in celestial navigation techniques, I continue to use celestial navigation every time I go to sea.**

Of the respondents surveyed, 1.3% (1) strongly agreed; 35.9% (28) agreed; 15.4% (12) were neutral; 33.3% (26) disagreed; and 14.1% (11) strongly disagreed with this statement. The mean was 2.72 indicating a neutral response.

**Question 16: I would like to change the way celestial navigation is taught by incorporating ...**

Of the respondents surveyed, 34.7% (25) felt that by incorporating more electronic navigation skills through the use of navigational calculators and PC programs would benefit the celestial navigation curriculum; 27.8% (20) declined to answer; 20.8% (15) would not change anything about the current celestial navigation curriculum; 11.1% (8) of the respondents would like to eliminate the celestial navigation curriculum; 5.5% (4) would like to incorporate more hands-on time for the celestial navigation curriculum. Most respondents agree that by incorporating more electronic navigation skills through the use of navigational calculators and PC programs would benefit the celestial navigation curriculum.

**Question 20: How did/did not the instructional method used for celestial navigation facilitate a change in behavior enough to implement learned material after graduation while assigned to an ocean going ship? Did you use the material learned after graduating? Why, or why not?**

Of the respondents surveyed, 36.4% (28) stated that the instructional process was rewarding and challenging; 31.2% (24) reported that they did not use celestial navigation after graduation; 14.3% (11) declined to answer; 10.4% (8) of the respondents reported that they still use celestial navigation, and always plan on the next event while underway; 7.8% (6) admitted that they only performed celestial navigation procedures when the vessel master made them do it. The majority of the respondents agree that the instructional process was rewarding and challenging, but most report that they did not use celestial navigation after graduation. Please refer to Table 6 for the closed-formed

question summary and Table 7 for the open-formed question summary of this information regarding Research Goal 3.

### **Summary**

This chapter discussed the relevant findings and statistical analysis of the data obtained from the Celestial Navigation Questionnaire. The questionnaire used in this study included 15 closed-formed Likert scaled questions, and five open-form questions. This questionnaire was conducted utilizing the descriptive method to gather and analyze data collected from the U.S. Army Transportation Corps Marine Deck Warrant Officers from Fort Eustis, Virginia. In the spring of 2010, there were 90 graduates of the U.S. Army Transportation Corps Marine Deck Warrant Officer Basic Course. Of the 90 questionnaires sent, a total of 78 responses were received. An 86.6% response rate was determined successful to continue the study. The results of the questionnaire were analyzed using a narrative account of respondents' remarks, calculated mean and frequency, and tabulated each question. The data received and tabulated in Chapter IV will be summarized in Chapter V with conclusions and recommendations for future studies offered based on the findings of this study.

**Table 6***Mean and Percentage for Closed Form Questionnaire Questions****Instruction Facilitating Implementation Post Graduation***

Question	Likert Scale					Mean
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
3. The nomenclature in the celestial navigation module of the Warrant Officer Basic Course was extremely challenging for me.	<b>4</b>	<b>19</b>	<b>22</b>	<b>27</b>	<b>5</b>	<b>3.09</b>
<i>Percentage (%)of responses:</i>	5.1%	24.4%	28.2%	34.6%	6.4%	
4. The mathematics involved in the celestial navigation module of the Warrant Officer Basic Course was extremely challenging for me.	<b>7</b>	<b>24</b>	<b>15</b>	<b>26</b>	<b>6</b>	<b>3.00</b>
<i>Percentage (%)of responses:</i>	9.0%	30.8%	19.2%	33.3%	7.7%	
8. The celestial navigation curriculum at the U.S. Army Maritime Training School should not be changed or altered in any way.	<b>9</b>	<b>29</b>	<b>16</b>	<b>12</b>	<b>11</b>	<b>2.79</b>
<i>Percentage (%)of responses:</i>	11.54%	37.18%	20.51%	15.38%	14.10%	
15. Due to the instruction I received in celestial navigation techniques, I continue to use celestial navigation every time I go to sea.	<b>11</b>	<b>26</b>	<b>12</b>	<b>28</b>	<b>1</b>	<b>2.72</b>
<i>Percentage (%)of responses:</i>	14.10%	33.33%	15.38%	35.90%	1.28%	

**Table 7***Percentage for Open Formed Questions***Instruction Facilitating Implementation Post Graduation**

	More Hands-on time	Eliminate	Do not change	Declined to answer	Use technology
16. I would like to change the way celestial navigation is taught by incorporating ...	<b>4</b>	<b>8</b>	<b>15</b>	<b>20</b>	<b>25</b>
<i>Percentage (%) of responses:</i>	5.5%	11.1%	20.8%	27.8%	34.7%
	Yes, always preparing for next event	Only when skipper made me	No I did not use celestial navigation	Declined to answer	Instructional process rewarding and challenging
20. How did/did not the instructional method used for celestial navigation facilitate a change in behavior enough to implement learned material after graduation while assigned to an ocean going ship? Did you use the material learned after graduating? Why, or why not?	<b>8</b>	<b>6</b>	<b>24</b>	<b>11</b>	<b>28</b>
<i>Percentage (%) of responses:</i>	10.4%	7.8%	31.2%	14.3%	36.4%

## **Chapter V**

### **Summary, Conclusions, And Recommendations**

This chapter summarizes the information contained in the study, draws conclusions based upon the findings, and makes recommendations for future studies as a result of the findings in this study.

#### **Summary**

This study was conducted to evaluate the viability of continuing celestial navigation instruction for ocean-going military navigators sailing into a technologically changing future. This research project sought to explore and establish if a change in current celestial navigation curriculum was warranted. This study sought to answer the following research goals:

1. Determine the viability of continued instruction of celestial navigation for U.S. Army marine navigators.
2. Assess whether the students who graduate are actually utilizing the material learned while assigned to an ocean going vessel while at sea.
3. Does the instructional method facilitate a change in behavior enough to implement learned material after graduation while assigned to an ocean going ship?

This research had the following limitations:

1. This study was limited to graduates of the U.S. Army Marine Deck Warrant Officer Course at the Army Maritime Training Center, U.S. Army Transportation School, Fort Eustis, VA.

2. The participants were limited to those who were assigned to ocean going vessels of the U.S. Army Transportation Corps.
3. All aspects of this study were conducted at Fort Eustis, Virginia, and was approved by the chain of command of the 7<sup>th</sup> Sustainment Brigade, Fort Eustis, Virginia.
4. All participants had the availability to perform celestial navigation throughout their time while assigned to the ocean going vessel.

This study introduced the reader to the mariner of the high seas and the different means of navigating a ship far from home to a foreign port with only the stars to guide. The Global Positioning Satellite System assists navigation and other means of electronic navigation systems; however, electronic navigation systems are always subject to failure and the professional mariner must never forget that the safety of his ship and crew may depend on skills that differ little from those practiced generations ago. The literature examined information relevant to shipboard navigation with emphasis on celestial navigation, recent developments in electronic means of navigation, the declining requirements for celestial navigation competency, and a growing dependency upon shipboard electronic navigation.

The research methods and procedures used to gather and analyze data collected from the U.S. Army Transportation Corps Marine Deck Warrant Officers from Fort Eustis, Virginia, was a questionnaire that used 15 closed-formed Likert scaled questions and five open-formed questions. In the spring of 2010, there were 90 graduates of the U.S. Army Marine Deck Warrant Officer Basic Course, U.S. Army Transportation School, Fort Eustis, Virginia. Ninety questionnaires were sent to the available

participants, with only 50% response rate after the first mailing. A second mailing was sent to the remaining available personnel who had not yet responded. Of the 90 questionnaires sent, a total of 78 responses were received. This was an 86.6% response rate. Data from these questionnaires were gathered, analyzed, tabulated, and served as the basis for the conclusions and recommendations made in this chapter.

## **Conclusions**

The following research goals guided this study and revealed the following conclusions:

### **1. Determine the viability of continued instruction of celestial navigation for U.S. Army marine navigators.**

Several questions addressed this research goal. Of the close-form questions, Question 7, “The celestial navigation instruction I received from the U.S. Army Maritime Training School was complete, enabling me to fulfill my responsibilities as a ship’s watch officer”. The mean was 4.21 indicating the response was agree. Question 9, “I am more than confident in my abilities to perform celestial navigation on my vessel due to the celestial navigation curriculum at the U.S. Army Maritime Training School”. The mean was 3.96 indicating the average response was agree. Question 11, “As a vessel master, I require my watch officers to perform celestial navigation while out to sea”. The mean of this question was 3.05 indicating a neutral response. Question 13, “I believe that celestial means of navigation are old fashioned and outdated.” The mean of this question was 2.74, indicating the average response being neutral. Question 14, “The only time I do celestial navigation is to prepare for school, or while in school.” The mean of this question was 2.78 indicating a neutral response.

Of the open-formed questions, Question 18 asks, “Why do we, or don’t we, need to continue celestial navigation?” From the respondents surveyed, 57.1% (40) reported that there is a need to continue celestial navigation since this is what every mariner should know; 18.6% (13) reported that there is no need for celestial navigation due to having far more limitations than the modern, more redundant electronic means of navigation. Question 19, “The Merchant Marine Personnel Advisory Committee (MERPAC), is suggesting revising the celestial navigation requirements on the USCG license exams lowering the passing scores in this area, allowing the solutions by navigation or programmable calculators, and reducing the number of questions to only those deemed critical. This is good/bad, why?” Most respondents agree that it is a good idea to lower the passing scores for celestial navigation and to allow programmable calculators and computer programs to facilitate celestial navigation instruction, stating that not all technology is bad and very few mariners practice celestial navigation today and would only ever use celestial navigation in an emergency to get back to port. There is a large percentage of respondents who agree that it is bad idea to lower the passing scores for celestial navigation, and that these requirements establish a reason and a process of understanding of the basics of celestial navigation and not just solving a problem to get an answer.

The participants agreed that the celestial navigation instruction did enable the officer to fulfill the responsibilities as a ship’s watch officer; additionally, most agreed that they are more confident in their abilities as a watch officer due to the celestial navigation curriculum and instruction method. However, as reported in Questions 11, 13, and 14, the majority of the surveyed officers reported that they do not require their watch

officers to regularly perform celestial navigation and believe celestial navigation to be outdated. Based upon these findings, this researcher must agree that celestial navigation is an antiquated form of navigation; furthermore, this form of navigation should indeed embrace some form of technology enabling the watch officer the ability to complete the work in a safe and timely manner. The findings also show an overwhelming agreement that the US Army needs to continue celestial navigation instruction as all mariners need to know the basics in the case of emergencies, however, the module should include changes to implement technological enhancement.

**2. Assess whether the students who graduate are actually utilizing the material learned while assigned to an ocean going vessel while at sea.**

This research goal was assessed by several questions. Question 5 asked, “Every time I have been out to sea, I performed the proper steps to calculate our ships position by means of celestial navigation.” The mean was 2.53 indicating that the average response was disagree. Question 6 was “Every time I have been out to sea, I used celestial navigation to check the accuracy of my ships compass.” The mean was 2.74 indicating a neutral response. Question 10 asked, “I only use electronic means of navigation, and rarely perform celestial navigation while out to sea.” The mean was 3.08 indicating a neutral average response. Question 12 asked, “I realize that the Global Positioning System (GPS) has errors, but I prefer electronic means of navigation over celestial navigation.” The mean was 3.78 indicating an average response of agree.

The open-formed Question 17 asked, “I might use celestial navigation more if it ...” The overall body of data suggested that the use of celestial navigation would

potentially increase if it were easier, faster, less dependent upon weather, and if the vessel master required it. Based upon these findings, it was evident that over 50% of the officers do not use celestial navigation every time when at sea, nor do they use celestial navigation to check the ship's compass as required. The majority of the surveyed officers reported that they would use electronic means of navigation over celestial navigation. Over 50% of the officers reported that they would use celestial navigation more if it were easier, faster, less dependent upon weather, and if the vessel master required it. Nearly all participants requested the use of navigational calculators, or computer programs, to aid in the solution of the celestial navigation solution, thereby, making celestial navigation faster and easier to utilize.

**3. Does the instructional method facilitate a change in behavior enough to implement learned material after graduation while assigned to an ocean going ship?**

Several questions addressed this research goal. Of the close-form questions, Question 3, "The nomenclature in the celestial navigation module of the Warrant Officer Basic Course was extremely challenging for me." The mean was 3.09 indicating that the average response was neutral. Question 4 was similar asking, "The mathematics involved in the celestial navigation module of the Warrant Officer Basic Course was extremely challenging for me." The mean was 3.00 indicating that the average response was neutral. Question 8 asked, "The celestial navigation curriculum at the U.S. Army Maritime Training School should not be changed or altered in any way." The mean was 2.79 indicating a neutral response. Question 15 stated, "Due to the instruction I received

in celestial navigation techniques, I continue to use celestial navigation every time I go to sea.” The mean was 2.72 indicating a neutral response.

The open-formed Question 16 asked, “I would like to change the way celestial navigation is taught by incorporating ...” The overall data suggested that by incorporating more electronic navigation skills through the use of navigational calculators and PC programs would benefit the celestial navigation curriculum. Question 20 asked, “How did/did not the instructional method used for celestial navigation facilitate a change in behavior enough to implement learned material after graduation while assigned to an ocean going ship? Did you use the material learned after graduating? Why, or why not?” The overall data suggests that the instructional process was rewarding and challenging, but most respondents reported that they did not use celestial navigation after graduation.

Based upon these findings, the majority of the officers reported that they felt the nomenclature, and the mathematics, involved in the Warrant Officer Basic Course was challenging but not overwhelming, however, most expressed the need to update the celestial navigation curriculum by incorporating the use of navigational calculators and PC programs.

The data analyzed supports the need of incorporating the celestial and electronic means of navigation into one cohesive block of instruction; this would indeed be a solution to preserve celestial navigation proficiency as well as maintain safe ship operation and navigation. Celestial navigation proficiency was incumbent solely upon the officer aboard ship. The challenge facing the U.S. Army Maritime Training Center and its instructors was the ability to facilitate a change in student behavior enough to implement learned material long after graduation.

## **Recommendations**

From the data analyzed, there was a prevailing sense for a need to revise the current curriculum. The majority of the respondents stated that although some still perform celestial navigation while at sea, the use of technology to speed up the process by calculating the lengthy mathematical problems would encourage further use. The data also suggested a need to incorporate electronic navigation, navigational calculators, and computer programs into the celestial navigation curriculum if this instruction was to continue to be viable in a technologically changing world. Nearly every respondent agreed that the current celestial navigation was challenging and rewarding, however, the need for a quicker solution was imperative to sustain continued use after graduation from the course. The caveat was to teach an old skill with new technology incorporated into a challenging, interesting, and modernized lesson.

Based on the results of this study, the following recommendations were made by the researcher:

1. A Critical Task Selection Board be convened to review the current celestial navigation instruction module and define the critical tasks needed in the current navigation profession.
2. A study should be conducted to devise and implement an alteration of the current Marine Deck Warrant Officer Basic Course to integrate the electronic navigation module with the celestial navigation module.
3. A study should be conducted to verify the practicality of implementing distributed learning (DL) courses into the Marine Deck Warrant Officer professional development program to be accomplished post graduation as part of

a continuing education program. This program could include modules such as mathematics, updates in electronic navigation, and celestial navigation procedures.

4. An attempt should be made to alter the current celestial navigation curriculum with additional lessons added for incorporation of navigational calculators and computer program instruction.

5. The data collected through this study suggested the adoption of the Merchant Marine Personnel Advisory Committee (MERPAC) by revising the celestial navigation requirements, lowering the exam passing scores, and allowing the solutions by navigation or programmable calculators.

## REFERENCES

- Baccei, P., DeVogel, G., & Shaw, P. (2001). The United States Navy Navigating in the 21<sup>st</sup> Century. *Oceans*, 3, 1460-1465.
- Bangert, J., Dunham, S.J., Kaplan, G., LeBlang, M.E., & Pappalardi, F.,(2001). Alternatives to GPS. *Oceans*, 3, 1452-1459.
- Bokov, G. (2006). Training Preparation of Navigators for Work with Electronic Charts. TCSET 2006, February-March 2006, Lviv-Slavsko, Ukraine.
- Bowditch, N. (2002). *The American Practical Navigator, An Epitome of Navigation*. (NSN 7642014014652 NIMA), Washington, DC: U.S. Government Printing Office.
- Chen, D. (1998). Navy Cadets Won't Discard Their Sextants. *The New York Times*. May 29, 1998. A17 Retrieved from <http://www.nytimes.com/1998/05/29/us/c-navy-cadets-won-t-discard-their-sextants-169919.html>
- Clark, C. (2010). Find More Backups for GPS: AF Chief. *DOD BUZZ Online Defense and Acquisition Journal*. Wednesday, January 20th, 2010. Retrieved from <http://www.dodbuzz.com/2010/01/20/back-away-from-gps-af-chief/>
- Elazar, E. (1996). Lost Arts. Has the Navy lost touch with its traditions? *Navy Times*, September 12, 1996.
- Flannery, J. (2009). Agencies Debate the Health of the GPS System. *Soundings*, August 2009.
- Ifland, P. (n.d.). The History of the Sextant. Retrieved from <http://pwifland.tripod.com/historysextant>

Independent Working Group. (2008). Missile Defense, the Space Relationship, and the Twenty-First Century. 2009 Report. Retrieved from [https://www.claremont.org/repository/docLib/200901291\\_iwg2009.pdf](https://www.claremont.org/repository/docLib/200901291_iwg2009.pdf)

International Maritime Organization (IMO). (1988-2003). *International Convention for the Safety of Life at Sea (SOLAS)*, 1974, (text modified by the protocol of 1988 relating thereto, including Amendments) Edition of 1988, revised in 2003, London.

International Maritime Organization. (2004). *International Convention for the Safety of Life at Sea (SOLAS)*. Ch V, Regulation 19.

International Maritime Organization Subcommittee on Standards of Training and Watchkeeping 40<sup>th</sup> Session, (2008). Comprehensive Review of the STCW Convention and the STCW Code.

Kaplan, G. (1999). New Technology for Celestial Navigation. *U.S. Coast Guard Proceedings*, March, 1999, 239-254.

Maloney, E. (1985). *Dutton's Navigation and Piloting* (14<sup>th</sup> ed.). Annapolis, Md: Naval Institute Press.

Marine Deck Officer Certification Course. (2006). *Program of Instruction*. POI 8C-SQI (880A). Director, CASCOM Training Directorate, Fort Lee, VA 23801-1511.

Marine Safety Security Council. (2009). Ask the MSSC – Why is celestial navigation still a test subject for merchant marine officers and are there any plans to discontinue it? *U.S. Coast Guard Proceedings*. Retrieved from <http://www.uscg.mil/proceedings/Spring2009/articles/92>

- Merchant Marine Personnel Advisory Committee (MERPAC), (2010). MERPAC Task #64 Addendum. Initial Recommendations on Areas in the STCW Convention and STCW Code Identified for Comprehensive Review. March, 2010. Retrieved from <http://www.regulations.gov>
- Saylor, M. (2009). Ye Old Ways Matter. *Soundings*, February, 2009, 29-30. Retrieved from <http://www.soundingsonline.com/boat-shop/know-how/231952-ye-olde-ways-matter>
- Stavanger, P. (2007). “Mandatory ECDIS – IMO takes the first steps”. Retrieved from <http://primer-stavanger.org>
- Sweeney, K. (2009). Keeping both GPS and sextant onboard is advisable. *Professional Mariner*, September, 2009, 128-129.
- Ulman, N. (March 1989). Computers Make Celestial Navigation Less Celestial? *The Wall Street Journal*, 29-30.
- US Coast Guard Navigation Center, (2010). LORAN-C Termination Information. Retrieved from <http://www.navcen.uscg.gov/loran>
- US Coast Guard Navigation Center. (2010). Enhanced LORAN (eLORAN). Retrieved from <http://www.navcen.uscg.gov/eLORAN>
- U.S. Coast Guard Marine Safety and Security Council. (2009). Why is celestial navigation still a test subject for merchant marine officers, and are there any plans to discontinue it? *Proceedings*, Spring, 2009, 92-94.
- Williams, S. (2006). RADAR'd GPS Vulnerable to High-Power Microwaves. *GPS World*, April 2006, 26-35.

46 Code of Federal Regulations. (2009). Chapter 11, Subpart D, Paragraph 11.401 (d).

Retrieved from <http://ecfr.gpoaccess.gov>

## APPENDIX A

### Celestial Navigation and the Military Shipboard Navigator

The purpose of this questionnaire is to provide data to complete the study evaluating the viability of continuing celestial navigation instruction for ocean-going military navigators sailing into a technologically changing future. The responses to the questionnaire will be analyzed and tabulated to determine insight into the use of celestial navigation versus electronic navigation aboard ocean going US Army vessels. Personnel will be surveyed as to the importance, effectiveness, practicality, and viability of continued celestial navigation instruction. Please honestly answer each question to the best of your ability.

1. Years of sea service as a ships watch officer/vessel master?

- less than 5
- More than 5 less than 10
- More than 10 less than 20
- More than 20

2. As a watch officer, I have sailed upon the open ocean \_\_\_\_ times in my career to date.

- More than 5, but less than 10 times.
- More than 10, but less than 20 times.
- More than 20 times
- I have never sailed upon the open ocean.

3. The nomenclature in the celestial navigation module of the Warrant Officer Basic Course was extremely challenging for me.

Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5
<input type="checkbox"/>				

4. The mathematics involved in the celestial navigation module of the Warrant Officer Basic Course was extremely challenging for me.

Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5
<input type="checkbox"/>				

5. Every time I have been out to sea, I performed the proper steps to calculate our ships position by means of celestial navigation.

Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5
<input type="checkbox"/>				

6. Every time I have been out to sea, I used celestial navigation to check the accuracy of my ships compass.

Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5
<input type="checkbox"/>				

7. The celestial navigation instruction I received from the US Army Maritime Training School was complete, enabling me to fulfill my responsibilities as a ship's watch officer.

Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

8. The celestial navigation curriculum at the US Army Maritime Training School should not be changed or altered in any way.

Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5
<input type="checkbox"/>				

9. I am more than confident in my abilities to perform celestial navigation on my vessel due to the celestial navigation curriculum at the US Army Maritime Training School.

Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5
<input type="checkbox"/>				

10. I only use electronic means of navigation, and rarely perform celestial navigation while out to sea.

Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5
<input type="checkbox"/>				

11. As a vessel master, I require my watch officers to perform celestial navigation while out to sea.

Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5
<input type="checkbox"/>				

12. I realize that the Global Positioning System (GPS) has errors, but I prefer electronic means of navigation over celestial navigation.

Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5
<input type="checkbox"/>				

13. I believe that celestial means of navigation are old fashioned and outdated.

Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5
<input type="checkbox"/>				

14. The only time I do celestial navigation is to prepare for school, or while in school.

Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5
<input type="checkbox"/>				

15. Due to the instruction I received in celestial navigation techniques, I continue to use celestial navigation every time I go to sea.

Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5
<input type="checkbox"/>				

16. I would like to change the way celestial navigation is taught by incorporating...(please complete the sentence in your own words)
17. I might use celestial navigation more if it...(please complete the sentence in your own words)
18. Why do we, or don't we, need to continue celestial navigation?
19. The Merchant Marine Personnel Advisory Committee (MERPAC) is suggesting revising the celestial navigation requirements on the USCG license exams lowering the passing scores in this area, allowing the solutions by navigation or programmable calculators, and reducing the number of questions to only those deemed critical. This is good/bad, why?
20. How did/did not the instructional method used for celestial navigation facilitate a change in behavior enough to implement learned material after graduation while assigned to an ocean going ship? Did you use the material learned after graduating? Why, or why not?

## APPENDIX B

TO: US Army Deck Warrant Officers  
From: Michael J. Garvin CW3(R), Old Dominion Graduate Student  
Subject: Research Study on the Celestial Navigation and The Ocean-Going  
Military Navigator

Dear Fellow Warrant Officers,

The purpose of this survey is to provide data to complete the study evaluating the viability of continuing celestial navigation instruction for ocean-going military navigators sailing into a technologically changing future. I am a graduate student pursuing a M.S. degree through Old Dominion University. This research study is one of the requirements for graduation; furthermore, I have a vested interest in this study since I am a retired US Army mariner and consider this subject of high importance.

I am asking you to voluntarily complete this survey. You can choose to not participate. I have told you your rights, and if you elect to complete the survey you are telling me that I can use your information in my study. Completing or not completing this survey will have no reflection or ties to you at your current positions. To protect the privacy of the participants, this data will be kept strictly confidential, used only for the purpose of the study, and destroyed when no longer required. I greatly appreciate your assistance in this study.

Respectfully,

Michael J. Garvin