NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

VOICE RECOGNITION SYSTEMS: ASSESSMENT OF
IMPLEMENTATION ABOARD U.S. NAVAL SHIPS

by

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March 2003

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REPORT DOCUMENTATION PAGE		*Form Approved OMB No. 0704-0188*

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington DC 20503.

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE March 2003	3. REPORT TYPE AND DATES COVERED Master's Thesis

4. TITLE AND SUBTITLE Voice Recognition Systems: Assessment of Implementation Aboard U.S. Naval Ships	5. FUNDING NUMBERS
6. AUTHOR (S) Shawn C. Wilson	

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000	8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the U.S. Department of Defense or the U.S. Government.

12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited	12b. DISTRIBUTION CODE

13. ABSTRACT *(maximum 200 words)*
Technological advances have had profound effects on the conduct of military operations in both peacetime and in war. One advance that has had a great impact outside the military by reducing human intervention is Voice Recognition (VR) technology. This thesis will examine the implementation of a Voice Recognition System as a ship-driving device and as a means of decreasing the occurrence of mishaps while reducing the level of fatigue of watchstanders on the bridge. Chapter I will discuss the need for the United States Navy to investigate the implementation of a Voice Recognition System to help reduce the probability of mishaps occurring. Chapter II will explain voice recognition technology, how it works, and how the proposed system can be fielded aboard U.S. Navy ships. Chapter III will examine the opinions (on the implementation of a Voice Recognition System) of officers charged with the safe navigation of naval ships. Chapter IV will review the concerns of officers, and will justify the implementation by answering these concerns. The conclusion will iterate the advances in voice recognition, and why a Voice Recognition system should be implemented on the bridges of U.S. Navy ships.

14. SUBJECT TERMS Voice Recognition, Reduction in Manning, Wireless, Shiphandling, Ship's Control Console, Helm, Lee Helm	15. NUMBER OF PAGES 63
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UL

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VOICE RECOGNITION SYSTEMS: ASSESSMENT OF IMPLEMENTATION ABOARD U.S. NAVAL SHIPS

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Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN INFORMATION SYSTEMS AND OPERATIONS

from the

**NAVAL POSTGRADUATE SCHOOL
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ABSTRACT

Technological advances have had profound effects on the conduct of military operations in both peacetime and in war. One advance that has had a great impact outside the military by reducing human intervention is Voice Recognition (VR) technology. This thesis will examine the implementation of a Voice Recognition System as a ship-driving device and as a means of decreasing the occurrence of mishaps while reducing the level of fatigue of watchstanders on the bridge. Chapter I will discuss the need for the United States Navy to investigate the implementation of a Voice Recognition System to help reduce the probability of mishaps occurring. Chapter II will explain voice recognition technology, how it works, and how the proposed system can be fielded aboard U.S. Navy ships. Chapter III will examine the opinions (on the implementation of a Voice Recognition System) of officers charged with the safe navigation of naval ships. Chapter IV will review the concerns of officers, and will justify the implementation by answering these concerns. The conclusion will iterate the advances in voice recognition, and why a Voice Recognition system should be implemented on the bridges of U.S. Navy ships.

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TABLE OF CONTENTS

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ACKNOWLEDGEMENTS

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I. INTRODUCTION

A. BACKGROUND

Throughout the history of the United States Navy, ships have been involved in collisions and groundings, and for as many years navy officials have spent time and money conducting investigations into why they occurred. These detailed investigations first look into the ship's surrounding setting. For example, they look at the time of the incident, weather, sea state (a numerical or written description of sea roughness)[1], visibility, position, and surrounding vessels. The investigations then turn to the events that occurred on the ship's bridge. This portion of the investigation examines elements such as: the ship's logs, the personnel on watch, the positions being manned, the experience level of each watch stander, and the amount of rest allowed between watches per person. Great detail is rendered when investigating the elements on the ship's bridge as the controlling aspects of the ship are directed from this station. According to an article in the January/March 2001 edition of *Fathom Magazine*, "Ninety-one percent of all mishaps reported to the Naval Safety Center are caused by human error."[2] These errors are due to a variety of reasons, but because the majority of mishaps occur due to human error, it can be argued that there is a need for improvement in the way ships are handled.

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[1] John Noel and E.L. Beach, *Naval Terms Dictionary*, 1971. 3rd ed. Annapolis: Naval Institute Press.

[2] Tom Binner, "ORM Corner: A Bad Year We Could Have Prevented," *Fathom Magazine*, January-March 2001.

B. SHIPHANDLING MISHAPS

In the summer of 1997, an Afloat Mishap Report sent by a U.S. naval vessel to the Naval Safety Center demonstrated just how dangerous human error in shiphandling can be.

> At approx 1419, the stern mooring leg with the 10 inch line was at 7 O'clock (210T). The CO [Commanding Officer] and the Conning Officer were on the port bridge wing. The OOD was in the pilot house. The Conning Officer used a backing and twisting combination to back the ship into the current while walking the ship to stay in line with the prevailing current. This maneuver was made to reduce strain on the 10 inch line so that it could be taken off the aft capstan and transferred to the port forward capstan. At approx 1430Q forecastle and fantail crews stated they were ready to commence the shift and the strain was off the 10 inch line (now at 6 O'clock). The forecastle took up slack as the fantail removed the line from the capstan aft. Once the 10 inch line was clear of the port quarter chock, the conning officer started to twist the stern to the right, away from the 10 inch line which now led forward up the port side. The ship began to rotate counter-clockwise. As the Gulf Stream current started to catch the ship on its port side, conning orders were made to help offset the current. The 10 inch line had a light to moderate strain. As the buoy to the 10 inch line approached 10 O'clock, the starboard shaft was to be brought briefly to ahead 2/3 to take the final momentum out of the ship's swing. Shortly after the order, the forecastle reported heavy strain on the 10 inch line. The buoy was at 11 O'clock about 1000 feet out. Seconds later, the forecastle safety observer reported extremely heavy strain on the 10 inch line (two times). Immediately after that (1435 Q), the 10 inch line surged on the capstan approximately 50-100 feet. The forecastle safety observer said "Emergency stop, Emergency stop, Medical emergency" (at the time of mishap, engines were answering all back 2/3.) The surge velocity

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caused the 10 inch line to lift off the pile where it was faked down and whipped across the deck striking seven crew members.[3]

Analysis of this incident found the number one cause of the event to be the human error in the conning commands. The report stated that probably because of high noise, the order given from the conning officer to the helmsman was reversed from <u>ahead</u> two-thirds to <u>back</u> two-thirds. And the repeat-back by the Lee Helmsman was not heard.

There are many other types of mishaps that involve the deadly combination of ship driving and human error, specifically during close maneuvering situations such as underway replenishments. Another Naval Mishap message[4] describes such an incident. Two ships, an Underway Replenishment Oilier (AO) and a Combat Stores Ship (T-AFS) were running alongside each other when the Master Helmsman of the AO observed a gyro swing to starboard and applied left rudder in an attempt to correct the ship's heading to base course. After observing no change, he increased the rudder to left standard. Still observing no change, the rudder command was increased to hard left. After this attempt, lack of rudder response was then reported as a loss of steering casualty and the helmsman shifted steering control to after steering. At this time, the AO's bow swung hard to port and was pointed at the T-AFS's hull number. The Conning Officer attempted to correct the swing with an order of hard right rudder. With virtually no time for the correction command to take effect, the AO's port

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[3] Naval Safety Center, VA Naval Message, Subject: Afloat Mishap Report, 191600Z Jun 97.

[4] Naval Safety Center, VA Naval Message, Subject: Afloat Mishap Report, 221257Z Aug 97.

bow hit the T-AFS's starboard bow. Once again the prevailing factor that caused this incident was human error. Had the Helmsman followed Standard Operating Procedures by requesting permission to use more than 10 degrees of rudder to maintain the ordered course and called away the casualty upon the first indication of a steering failure, without attempting to correct it, this collision might have been avoided.

As these two examples illustrate, it is clear that human error can cause casualties to personnel and costly damage to ships. Situations such as these occur more frequently throughout the U.S. Navy than is acceptable. Although the mistakes in these events did not result in any fatalities, personnel were maimed, ships were heavily damaged, and the possibility for more extensive damage existed. On September 15, 2000, Admiral Vern Clark, the Chief of Naval Operations, ordered a "safety standdown"-- the first since 1989--due to the fact that "there had been six major ship collisions over the previous 12 months."[5] An important question therefore needs to be answered: is there a way to improve the ship-driving link between the bridge watch standing personnel that give the standard commands and those people or systems who receive and execute them?

C.   WATCHSTANDING AND TECHNOLOGY

Watch standing traditions were established long before the founding of the U.S. Navy, and sailors who have stood watch aboard ships have applied these traditions to the conduct of their watch station. In today's navy, watch

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[5] Robert Burns, "Five months ago, concerns about at-sea mishaps led to 'safety standdown'," *Stars and Stripes*, 13 February 2001.

standing traditions still survive, but many changes have been made in the way watch standers carry out their duties. A member of an engineering watch now has the added convenience of entering all vital engineering plant readings and data into hand-held computers that are then downloaded to a master program that generates all required engineering reports. Operations Specialists and Weapons Technicians have newer and more advanced computers at their disposal allowing them to use touch-screen technology to conduct most of their watch standing duties. And for a Quartermaster, the majority of navigational equipment is now computerized, providing more accurate and efficient means to do navigational plotting. These changes in the way watches are conducted rest on the technological advances and innovations that flood the world today. Yet with all the technology and dependency upon these advances, bridge watch stations remain "left out of the loop" as far as implementing effective technology that can change or enhance the ability of these watch standers to conduct their duties.

Technological advances in transportation, weapon systems and communications have had profound effects on the military and how it conducts operations in both peacetime and in war. One advance not yet exploited by the navy on ships that has had great impact in reducing human intervention within the past few years is the Voice Recognition (VR) system. A Voice Recognition system allows regularly spoken words to be communicated into a microphone and then converts these words into computer signals or commands. Today, there are many uses for Voice Recognition systems. They can be used for "dictation, personal

computer interfaces, inventory maintenance, automated telephone services, special purpose industrial applications."[6] Also, students at the U.S. Naval Submarine School at Groton, Connecticut are now receiving training that is using a new harbor and channel ship-handling simulator called the Virtual Environment for Submarine ship handling and piloting training (VESUB). With the VESUB, Lieutenant Commander Derek J. Rollinson, an instructor for the operations and navigation training department states:

> Voice recognition and synthesis software allows the student to interact with a computer-generated navigator, helmsman and the engineering officer of the watch. The students can issue commands that the computer sub recognizes and responds to just as humans would.[7]

Rear Admiral Richard D. West, Navigator of the Navy, in a recent interview by *Fathom Magazine* commented on the maritime implications of technological innovations such as voice-activated charts, electronic monitoring of engineering equipment, and auto pilot functionality; "Many commercial vessels now operate with one person on the bridge. Obviously, the Navy's requirements are much more demanding than those of commercial vessels, but I do foresee a significant reduction in bridge manning needs."[8] Also, similar applications of voice recognition systems have undergone tests that will enable quadriplegic

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[6] Timothy J. West, "Implementation and Evaluation of Commercial Off-The-Shelf (COTS) Voice Recognition Software as an Input Device in a Windows-Type Environment" (Master's Thesis, Naval Postgraduate School, 1996), 2.

[7] Maryann Lawlor, "Topside Training Submerges Students In Virtual Reality," *SIGNAL Magazine*, July 2001.

[8] Interview between Richard West, Rear Admiral, USN, Navigator of the Navy, and *Fathom magazine*, April-June, 2002.

recreational sailors to independently control sailboats. In 1999, Todd Turner, an engineering student at the University of Calgary, and his team of three other students proposed as their final project for graduation a system that sailors could remotely control by adjusting both the sail and helm through a speech-recognition system.[9] Although this prototype VR project responded to approximately twenty percent of the commands given, in the technological realm, four year-old technology is considered outdated and has usually advanced exponentially since then. To help explain how rapidly technology is advancing, Gordon Moore, founder and chairman of *Intel* states that "for the past several decades, the number of transistors that can be placed on a single chip has approximately doubled every 18 months owing to advances in manufacturing." He continues, "The effect has been a corresponding doubling of processing speed in instructions per second and memory capacity in bytes per chip, with a factor of 10 improvement about every 5 years and a factor of 100 improvement every decade. This phenomenon is called Moore's law."[10]

With the increasing reliability in these systems, there is no reason why research and development should not be conducted to investigate the possibility of VR system installations on the bridges of naval ships. The implementation of a VR system in conjunction with the existing Ship's Control Console would provide a viable

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[9] Mike Smith and others, "Voice-Recognition Controlled Sailboat: Speech-Recognition Control Aids Disabled Sailors," *Circuit Cellar*, December 1999. Database on-line. Http://www.circuitcellar.com/online. Accessed 15 December, 2002.

[10] Dorothy E. Denning, 2000. *Information Warfare and Security*, Reading: Addison-Wesley.

option for the Conning Officer to execute the orders required to drive a naval vessel, and would reduce watch standing requirements.

D.   MANNING ISSUES

Current manning on a ship's bridge can consist of up to eight personnel: an Officer of the Deck (OOD), a Junior Officer of the Deck (JOOD), a Conning Officer (CONN), a Boatswain's Mate of the Watch (BMOW), a Quartermaster of the Watch (QMOW), a Helmsman, a Lee Helmsman, and a Phone Talker.   There are many different combinations of manning that could be implemented with the integration of a VR system that would reduce the number of required watch standers and yet improve the safe operations of the ship. Two positions that could initially be eliminated with implementation of the VR system are the Helmsman and Lee Helmsman.   By eliminating the requirements to man these stations, the ship would be able to remove watch standers who routinely maintain heavy workloads (other than their watch standing duties) from the watch bill.

Looking further into the current manning, it can be observed that there are two other watch standers on the bridge who are qualified to stand the positions of Helmsman and Lee Helmsman in the case of an emergency: the Boatswain's Mate of the Watch and the Phone Talker. Also, in most cases, the ship's Quartermaster of the Watch is qualified as a Master Helmsman and Master Lee Helmsman. And at a minimum, a Quartermaster striker (an apprentice or learner),[11] is qualified as Helmsman and Lee Helmsman.

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[11] John Noel and E.L. Beach, *Naval Terms Dictionary*, 1971. 3rd ed. Annapolis: Naval Institute Press.

Therefore, the majority of the bridge watch standers are either already qualified, or are working on their qualifications to stand watches as Helmsman and Lee Helmsman. With reliable technology such as a VR system and the redundancy of watch stander qualifications, the two watch stations of Helmsman and Lee-Helmsman could be removed from the bridge watch bill.

If ships are able to reduce their manning levels in conjunction with the implementation of a VR system, those watch standers remaining on the bridge watch bill must be qualified in the watch stations which would no longer be manned. In the event of a casualty to the VR system, any member of the watch team would be able to respond so that immediate control of the Ship's Control Console could be regained, and that person responding would maintain the position until a relief, as provided by casualty control procedures, arrived.

According to Admiral Vern Clark in his "CNO Guidance for 2003," "we [the Surface Navy] are enjoying now, the best manning I have witnessed in my career. With few exceptions, we achieved C-2[12] manning status for all deploying battle group units at least six months prior to deployment."[13] In spite of this improving manning status however, many U.S. Navy ships in the fleet today continue to be undermanned with respect to their allocated manning levels and watch station requirements. Additionally, due to

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[12] Status category that indicates a degree of readiness that reflects the unit possesses the resources and had accomplished the training necessary to undertake the bulk of the wartime mission for which it is organized or designed.

[13] Admiral Vern Clark, "CNO Guidance for 2003: Achieving Sea Power 21!" Database on-line. Http://www.chinfo.navy.mil/navpalib/cno/clark-guidance2003.html. Accessed 24 January, 2003.

life-cycle costs of manning ships, the navy continues to seek ways to further reduce manning requirements for watch stations.

E.   ADDRESSING CONCERNS

The ship's bridge is the one station that many Commanding Officers (CO's) tend not to change for many reasons.   These reasons range from the time-honored traditions that are instilled in the conduct of the bridge watch station, to the pure and simple fact that Commanding Officers are reluctant to be the one that "makes the change." According to J. Robert Bost of Naval Sea Systems Command, "The greatest obstacle to reducing manning on U.S. Navy ships has been resistance to change in the U.S. Navy tradition which results from outmoded technology paradigms and organizational culture."[14]   Commanding Officers feel some assurance that as long as they do not make drastic changes, they can attest to the fact that they were operating their ships within standard operating procedures if some type of mishap occurs. The concerns of Commanding Officers need to be addressed to allow new technologies to be successfully introduced to navy ships. Addressing these concerns will serve to improve not only the crew's quality of life, but also contribute to a reduction of seamanship related mishaps.

This work will review the question of whether a Voice Recognition system implemented as an alternative ship

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[14] J. Robert Bost and others, "Is the Navy Serious about Reducing Manning on Its Ships?" 1999. Database on-line. Http://www.manningaffordability.com/S&tweb/Index_main.htm. Accessed 24 January, 2003.

driving device would be an effective tool and if those responsible for driving navy ships would or would not use such a system. By looking at VR technology and the implementation aboard a naval ship, the system's advantages and disadvantages will confirm that an effective system can be installed onto a U.S. Navy ship. In reaching a final conclusion, this work will review and evaluate the opinions of those personnel who have held the position of Commanding Officer, those who are currently Commanding Officers, and junior officers who will be the Navy's future Commanding Officers.

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II. VOICE RECOGNITION (VR) TECHNOLOGY

A.   WHAT IS VR?

Voice Recognition (VR) technology research and development began in the early 1970's with researchers at IBM Corporation and Carnegie Mellon University.   Since then, many companies and universities have contributed to the exponential advances of the Voice Recognition technology that exists today.   According to the IEEE Spectrum Online article, "Talk to the Machine," Voice Recognition is "a truly interdisciplinary field, cutting across computer science, applied math, electrical engineering, linguistics, and cognitive science."[15] Developers of VR systems have incorporated different applications to the technology, but Voice Recognition systems all operate in a similar fashion.

When a voice signal is received by a microphone, the microphone converts the signal into an analog signal--much like the operation of a phone.   Then the analog signal is digitized and divided into very small segments of time, usually 10 or 20 milliseconds.   "Each frame is short enough so that its spectral properties are relatively fixed and long enough to capture at least one pitch period."[16]   The system then captures the spectral features from these segments that it needs for recognition and disregards the remainder of the signal.

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[15] Jean Kumagai, "Talk to the Machine," IEEE Spectrum Online, September 2002. Database on-line. Http://www.spectrum.ieee.org/WEBONLY/publicfeature/sep02/voic.html. Accessed 5 January, 2003.

[16] Ibid.

Voice Recognition technology today is still advancing as additional uses for the technology are developed. Computer system software developed by IBM's ViaVoice PC comes with a library of about 150,000 words, which the user can expand, and hand-held Personal Data Assistants are now able to recognize up to several thousand words with devices as small as cellular phones recognizing up to a hundred words.[17]   Additionally, there are currently VR systems available on the market for purchase that allow you to manipulate items such as televisions, household lighting, stereo systems, etc.   Voice Recognition technology is the "wave of the future" that is breaking down the human-machine communication barrier.

In order for a Voice Recognition system to be able to *recognize* what is being said, the system must first have a list of words and phrases entered into the system's data base.   These lists are usually identified as libraries.   In theory, Voice Recognition systems compare speech samples to data entered in these libraries and can be set up to match every known word, spoken in every accent, in every setting. But in order to have a system with all the capabilities described above, expectation of having real-time responses would be unrealistic.   Additionally, the amount of physical space necessary to hold all the memory required to maintain such a data base would be much larger than a desktop personal computer.   However, Voice Recognition systems can be set up to rely on tools known as language or grammar models that help reduce the data required to recognize signals.   Using these models, VR systems can be "taught" to recognize certain utterances in context.   For example, if

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[17] Ibid.

the speaker is asked for a phone number, the system will expect to hear a string of numbers.

There are two types of voice recognition models in general usage; the grammar model and the language model.

The grammar model has common application in the medical field and is used by doctors for transcribing patient records. The speech engine only needs to recognize certain utterances in context.

The language model is better suited for recognizing phrases relying on the tendencies of words occurring together. For example, if the statement "Left Full" or "Right Full" is recognized, the likelihood of "Rudder" following "is nearly 100 percent."[18] In most cases, the system can recognize a signal midway because the probability of those signals occurring is so high. And if the system does not find a match in the library, the system will ask the speaker to repeat the signal.

B. PROPOSED IMPLEMENTATION

With the advanced level of today's Voice Recognition technology, implementation of a language model VR system on a navy ship could occur immediately with existing VR products. The Voice Recognition system devices (the system's hardware) would be physically installed into the ship's current Ship's Control Console, ideally occupying the physical location of the Auto Pilot system, which would be removed with the implementation of the VR system. With the Auto Pilot only capable of maintaining set courses, the

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[18] Ibid.

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VR system will be able to complete the same operations of the Auto Pilot in addition to featuring the additional VR capabilities. The VR system would be connected electronically from the SCC to the engineering propulsion and steering systems for immediate responses to the Conning Officer's orders. The Conning Officer and Officer of the Deck would both be equipped with cordless microphone headsets that would have attached activation switches allowing navigational commands to be given on demand. The activation switches would serve three main purposes.

First, the VR system could identify which watch stander (the Conning Officer or the Officer of the Deck) was giving the command. The system's ability to identify who gives each command allows it to serve as a proprietary device for the Officer of the Deck. If a command given by the Conning Officer is incorrect, the activation of the Officer of the Deck's VR controls will override that of the Conning Officer's, taking VR command precedence and enabling him or her to make the necessary standard order corrections.

The second purpose of the activation switch is to ensure that other normal conversation or discussions about driving the ship would not confuse the VR system with signals that may be interpreted as actual commands. Frequently on the bridge of naval ships, the Officer of the Deck will discuss with the Conning Officer what the next maneuver may be and how the ship should be maneuvered into station. These discussions may at times include the

identical verbiage for standard commands and therefore should not be heard by the VR system and confused as an actual standard command.

Finally, the microphone switch will serve as an activation switch for an automated version of the Deck Log. The Deck Log is an "Official day-by-day record of a ship in commission and thus a legal document when signed."[19] It is a vital device for recording all engine and rudder orders. Each time the Conning Officer or Officer of the Deck activates the switch to give a standard command, the VR system will automatically send a signal to the automated Deck Log to record the command.

In addition to the equipment mentioned above, the VR system would be equipped with a series of speakers installed throughout the ship's bridge. The purpose of the bridge speakers is to broadcast orders given by the Conning Officer as well as the repeat-back by the VR system. This enables all bridge watch standers to hear the orders and repeat-backs, allowing them to maintain situational awareness as to how the ship is being driven and to anticipate the ship's actual movements. The speakers will also serve to provide a means for the VR system to repeat back the ordered command. Standard operating procedures for all naval ships mandate that all rudder, course, and engine-order commands must be repeated by the Helmsman or Lee-Helmsman to ensure that the command is received correctly and understood. Many existing commercial VR systems use the repeat-back process to ensure correct signal reception.

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[19] John Noel and E.L. Beach, 1971. *Naval Terms Dictionary*, 3rd ed. Annapolis: Naval Institute Press.

It is also necessary to consider circumstances that would require a watch stander to assume manual control of the helm or lee helm. This will be achieved by installing manual control switches throughout the bridge that override the VR system. These switches will allow any bridge watch stander to disengage the VR system. These manual control switches will be used in situations ranging from the Commanding Officer or Executive Officer arriving on the bridge and taking control of the ships maneuvering to responses to equipment casualties. Many Commanding Officer's Bridge Standing Orders make allowances for personnel that are not standing watch on the bridge to take the CONN under various scenarios and circumstances. For example, according to the Commanding Officer's Bridge Standing Orders aboard the USS Philippine Sea (CG 58), the CONN may be taken by the Commanding Officer at any time and by the Executive Officer (XO) at any time should he deem it necessary.[20]

In addition, U.S. Navy ships have a standard set of immediate corrective responses that are initiated upon the alert of a casualty. When responding to most engineering casualties, the first action is generally to take manual control of the ship's engineering equipment. This is done to reduce the potential of further damage and to allow operators to manually adjust equipment into normal operating parameters. The same mentality must apply to the use of the VR system. If a casualty occurs that may affect the Ship's Control Console, i.e., propulsion, steering, fire, or in the case of General Quarters, the system must

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[20] Commanding Officer's Standing Orders, PHILIPPINESEAINST 3120.2G, 22 September 2000.

be able to be easily and promptly disengaged, returning the SCC helm and lee helm stations to manual control. And if for no other reason than "something seems to be wrong," there needs to be a way to bring total control back to the bridge watch standers and the SCC by assuming manual control.

Finally, the VR system would be equipped with a status panel of system alarms and indicators that would be located on the Ship's Control Console and in other easily viewed locations on the bridge. The purpose for these status panels is to ensure that if any fault to the system occurred, corrective actions could be taken prior to a VR system failure. Additionally, these panels would serve as both audible and visual alarm indicators displaying which element of the VR system failed.

C.   BRIDGE MANNING

As discussed earlier, the implementation of the VR system would allow several changes to the underway bridge watch station. Mandating that the Quarter Master of the Watch and Boatswain Mate of the Watch are qualified as Helmsman and Lee Helmsman, the watch station could consist of an Officer of the Deck, a Conning Officer, a Quartermaster of the Watch, a Boatswain's Mate of the Watch, and the Phone Talker, thus reducing manning by two watch standers. This manning organization on the bridge would allow the elimination of the Helmsman and Lee Helmsman, as the VR system would execute all helm and lee helm-related duties. The Boatswain's Mate of the Watch would conduct the duties of the helm and lee helm in

emergency cases. Based on the current bridge manning (on a ship without a VR system) as discussed in Chapter I, the implementation of a Voice Recognition system would reduce the bridge watch station manning by twenty-five percent with no diminution of safe navigation.

D.   HOW IT WILL WORK

All watch standers aboard ships are required to adhere to certain protocols in the conduct of their watches. Each watchstander on the ship's bridge and in Combat Information Center (CIC)[21] contributes a specific skill-set to the combined effort of safe navigation. The Quartermaster of the Watch relays all navigation and plotting information, the lookouts relay visual contact information, and the watch standers in CIC relay all tactical information to the bridge. During the constant relay of information between various watch stations, the Officer of the Deck and Conning Officer determine how the ship is to be maneuvered in accordance with the operations being conducted and safe navigation. From this determination, the most important information is passed: the standard commands[22] from the Conning Officer to the Helmsman and Lee Helmsman.

The passing of the standard commands is the most crucial element of ship driving. If a mistake is made, either by the Conning Officer or the Helmsman or Lee Helmsman, the ship could be inadvertently driven into an unsafe situation. Therefore each command given by the

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[21] The section of the ship manned and equipped to collect and collate tactical information.

[22] Official phrases used in such activities as gunfiring, shiphandling, etc.

Conning Officer is repeated back to the Conning Officer verbatim by the Helm or Lee Helmsman, depending upon whether it is a rudder or engine order. This acknowledgement is to ensure that all bridge watch standers know that the order was understood by the Helmsman or Lee Helmsman, and if the command was given or understood incorrectly, corrections can be made immediately after the mistake is recognized. This also allows all those standing watch on the bridge to maintain situational awareness with regards to the maneuvers being conducted by the ship.

In addition to the VR system repeat-back, the system will be electronically connected to all rudder angle and engine order indicators on the bridge, in CIC, in the Central Control Station, and in both the Executive and Commanding Officers cabins. The rudder angle and engine order indicators allow the Conning Officer and Officer of the Deck to visually confirm that the standard command has been recognized correctly and that the steering and propulsion systems are responding properly.

In order for the VR system to maintain the ordered course, a navigational/heading link into the VR system must enable the system to correlate courses ordered with the actual ship's heading. All U.S. naval ships are equipped with a combination of magnetic and gyro compasses. These compasses are electrically connected to repeaters located throughout the ship providing gyro compass input to systems on a ship that require ship's heading input to achieve particular missions. For example, ship's combat systems require the input provided by these compasses to assist in targeting, tracking, and weapons release. By using the

same application of electrical input from the compasses to the VR system, the VR system will be able to effectively steer to and maintain ordered courses.

Technically, the implementation of a Voice Recognition system is a sound and viable alternative for the safe navigation of a U.S. naval ship. If the implementation of Voice Recognition systems on navy ships is to move forward, there is still one set of key stakeholders of the ship driving "system" that needs to be comfortable with the use of the VR system: the officers charged with the safe navigation and operation of navy ships.

III. OFFICER OPINIONS

A.   TECHNOLOGY VERSUS TRADITION

Quite possibly the most important process when investigating the implementation of a Voice Recognition system into the Ship's Control Console is to review the opinions of those officers who are charged with the safe navigation of the ship. The technological advances provided by Voice Recognition can be the most reliable, sound, and effective system that easily processes the demanding signals used for this type of application, but if those responsible for the safe navigation of the ship are reluctant to use it, there is no need to proceed with an implementation of a VR system.

Most U.S. naval ships are currently equipped with an Auto Pilot system that is installed in the SCC allowing the Helmsman to set a specific course which the Auto Pilot system maintains automatically. The current Auto Pilot system has some similarity to the VR system as far as maintaining a "hands-free" ship's heading, but Auto Pilot requires manual intervention to set and change courses. In addition, there is no way of making speed changes without physically manipulating the engine-order telegraph[23]. Many junior officers in the fleet have rarely experienced the use of the Auto Pilot system, and when used, it was only in open-ocean steaming situations with no other ships in close proximity. In response to a survey consisting of questions regarding a Voice Recognition system, discussion turned to the use of this Auto Pilot system as a technological tool

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[23] Device on the ship's bridge to give orders to the engine room. Also called Annuciator.

to aid in driving a ship. A lieutenant stated, "while on a DDG and FFG with auto pilots, it was rarely used and [generally] distrusted."   However, "some mid-watch experimenting found the auto's [*sic*] kept course very well under most situations."[24]   The lieutenant also stated that when the Auto Pilot system was used, prior authorization from the Commanding Officer was necessary. There are other accounts supporting the Auto Pilot's reliability which state that the system worked well when used, but the respondents exhibited reluctance in allowing a "computer to drive the ship." The same lieutenant concluded by stating "We are beholden on Aegis Computers to effectively fight the ship, but we still don't trust a computer to drive the ship under most circumstances."[25]

There are many reasons to be reluctant about relying upon new technologies and not to trust computer interaction when interconnected to driving a ship. One example of this happened as early as 1977 when the concept of an integrated bridge was tested on an FF 1052-class frigate, USS *McCandless*. "The system worked well, and the ship asked to keep the new bridge. Nevertheless, it was removed, and the old bridge reinstalled."[26]   The reason for the removal of the integrated bridge may best be explained in the Naval Institute *Proceedings* article, "Losing the Horse-holders." It states, "The greatest obstacle is resistance to

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[24] E-mail message, 03 December 2002.

[25] Ibid.

[26] J. Robert Bost and others, "Is the Navy Serious about Reducing Manning on Its Ships?" 1999. Database on-line. Http://www.manningaffordability.com/S&tweb/Index_main.htm. Accessed 24 January, 2003.

change."[27]   This chapter will examine several officers' opinions to see if they would allow the use of a Voice Recognition system if they were the Commanding Officer of a ship.

B.   QUESTIONNAIRE

In order to solicit officers opinions concerning the implementation of Voice Recognition, a questionnaire was developed that asked the simple question whether or not they would allow the use of such a system if they were the Commanding Officer of a ship. The following questionnaire was sent throughout the fleet via electronic mail so that a random sampling of individuals was surveyed.

Ladies and Gentlemen-fellow SWO's,

My name is LT Shawn Wilson and I am a student at the Naval Postgraduate School. I have sent this message to ask for your assistance with my research, which requires YOUR OPINION. I know just how busy your schedule is, but if you could take 3-5 minutes to complete this your replies may possibly impact us all in the future. Please feel free to respond either favorably or not to the question, but I do request you explain your answer briefly as there are both positive and negative answers. Your reply is crucial to my research…please take the few moments to respond to the following questions and send it back to scwilson@nps.navy.mil. I'd like to thank you in advance for your time and help.

Very Respectfully,

LT Shawn Wilson

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[27] J. Robert Bost and others, "Losing the Horse-holders," U.S. Naval Institute *Proceedings*, October 1995.

Question:

If you were the Commanding Officer of a Naval Vessel, and a voice activated/recognition system was installed in the Ship's Control Console, which allowed the Conning staff to drive the ship and walk freely around the bridge area (wireless microphone system) while leaving the Helm station unmanned, would you allow it to be used? If yes, under what conditions would you allow its use? If no, please explain why. Are there other areas of concern to consider with the use of this type of system?

Demographic Information:

Are you an:

Ensign – Lieutenant (01-03)?

Lieutenant Commander or Senior (04 or higher)?

Follow-on Questions:

May I contact you if I have follow-on questions?[28]

C.   RESPONSES

Responses to this questionnaire were received from officers (identities withheld) ranging in ranks from ensign

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[28] Shawn Wilson, Thesis Research Questionnaire. 28 October 2002.

to captain who had varying levels of ship handling experience. In all, 110 Responses were received. A breakdown of responders is as follows: fourteen ensigns, nine lieutenants (junior grade), sixty-eight lieutenants, four lieutenant commanders, four commanders, and eleven captains. Of these responders, seventy percent stated they would employ the VR system with varying restrictions (until proven reliable), ten percent gave full support to employing it with no restrictions, and twenty percent stated they would not allow use of such a system under their command. Statistically, the majority of the officers that replied stated they would either fully employ the VR system or use the system only under certain circumstances until issues and concerns were addressed.

According to a Destroyer Squadron Commander, the idea of automating the bridge and reducing manning levels had great merit if certain issues were addressed. He stated:

1) Restrict use of the system to open-water maneuvering until reliability and accuracy of the Voice Activation system are established and proven.

2) The wireless system must be secure with regards to Electromagnetic Interference-hardening so that off-ship monitoring by nearby contacts could not use knowledge of maneuvering orders to gain a tactical advantage-not a small issue.

3) Some sort of audible summary alarm needs to be integrated into the system so that bridge watch standers would be alerted to a system failure, and know to take manual control. Along with that, the manual control "take over" needs to be something that just a flip of a switch will

disengage the VR system for situations that range from the OOD to the Commanding Officer taking control of the Conn.

4) The system must be able to account for high ambient noise (wind, alarms, gunfire, etc.) as well as changes in Conning Officer voices caused by colds, moods, excitement, volume, etc.[29]

The first and third issues that the Destroyer Squadron Commander raises are issues that deal with the physical characteristics of a VR system and the confidence that must be gained in any new system as it proves its reliability. Switches and other devices would be installed throughout the ship's bridge to allow the watch stander to engage and disengage the system. Any new system must be reliable and easy to use as its acceptance depends upon the comfort levels the Commanding Officer and those officers that stand the watches that will operate the VR system. The second and fourth issues are more serious technical issues and require a great deal of consideration. According to a navy commander, "wireless systems aboard ships carry serious vulnerabilities."[30] There are many concerns today with implementing wireless systems aboard naval ships that will be covered in the next chapter, and quite possibly the only reason to not consider the implementation of a VR system would be the existence of any insurmountable vulnerabilities of a wireless system.

Many of the questionnaire responses stated the same concerns and allowances in the use of the Voice Recognition

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[29] Interview between Destroyer Squadron Commander and the author, 02 September 2002.

[30] Telephone conversation between a commander in Information Assurance, and the author, 23 December 2002.

system.   Most officers said that the system would be an excellent device used during open-ocean operations, but not for situations that required close proximity maneuvering. A lieutenant replied, "I would employ the system." However:

> in underway evolutions such as UNREP [Underway Replenishment], Plane Guard, Sea & Anchor (restricted maneuvering) I would be inclined to have a manned station. In considering such a system, I would carefully consider reliability, casualty procedures, back up systems, maintenance and training. I would also consider how the system performs when a Conning Officer is performing during an emergency or under pressure when his voice characteristics may change considerably.[31]

Another lieutenant stated, "I'd allow it to be used but only for trans-oceanic voyages and in low traffic density situations. My concern with the system is that if the Conning Officer is wearing the mic, and the OOD need to take control, would he have a mic as well or would he have to take it from the Conning Officer?" Furthermore, he continued, "What if the CO or XO need to take emergency command of the conn?"[32]   One lieutenant gave full approval to the use of the VR system as long as "it had a fail-proof method of the CO/OOD/Navigator instantly being able to take the CONN even if they weren't wearing a head set."[33]

Although there is no "fail-proof" method for the Commanding Officer, Executive Officer or Navigator to take CONN <u>instantly</u>, the combination of the manual control switches and proper training for those standing watch on

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[31] E-mail message, 04 December 2002.

[32] E-mail message, 04 December 2002.

[33] E-mail message, 03 December 2002.

the bridge to respond immediately to the assumption of the CONN will alleviate this concern. Ensuring that qualified bridge watch standers are trained to take manual control of the SCC should it be necessary, the time lapse for the Boatswain's Mate of the Watch to deactivate the VR system and assume manual control should last but a moment, or a "flip of a switch."

Other officer responses indicated that they would not consider using a Voice Recognition system for reasons ranging from time-honored traditions to complete distrust in allowing a computer to intervene with ship-driving. A lieutenant (junior grade) said, "No, because having the human factor there and the delay (between the helmsman understanding and reacting) acts as a check in ensuring the proper command is given and received. Plus there would be no way to check that the order was received correctly."[34] Another lieutenant said:

> No, I would not use it. I feel it is important that all bridge watch standers hear the commands as they are ordered. Most QM1s [Quartermaster First Class] will not hesitate to tell a J.O. [Junior Officer] that he made a bad command. Such a system might encourage commands to be spoken at a lower volume which would prevent others from hearing them.

He continues to explain his reluctance to the use of a VR system by adding:

> I like to know that I'll receive an "Orders to the Helm" if I give an order that is clearly wrong. We all know it's a response that means more than, "I didn't hear you" or that your order

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[34] E-mail message, 04 December 2002.

was in the wrong format, or conflicting directions. Good helmsmen use the response to imply you're making an error.[35]

Although there were some responses to the questionnaire that expressed unwavering opposition to the use of the system, the majority of the officers that replied were willing to use the system in the most relaxed situations, and were willing to increase the use based on the system's proven reliability and effectiveness as well as the user's "comfort level." Many of these questions and concerns that were stated in the officer opinions are valid and require attention. In the next chapter, specific officer opinions and concerns, and further explanation of Voice Recognition systems capabilities and limitations will be addressed with respect to these opinions and concerns.

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[35] E-mail message, 03 December 2002.

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IV. OFFICER CONCERNS AND REMEDIES

A.   EXAMINATION OF THE ISSUES

As discussed in Chapter III, further examination of the VR system/user interface needs to be conducted to ensure that all questions and concerns are both answered and addressed before implementing the Voice Recognition system. To ensure a successful introduction of the system, those bridge watch standers who drive the ships must be recognized as experts in ship driving, and must be used as vital resources in the proper development and implementation of such a system.

As noted in the previous chapter, the Destroyer Squadron Commander stressed four important issues: 1) Restrict use of the system until reliability and accuracy are proven, 2) Security of the wireless system to ensure no electromagnetic interference from both on and off the ship due to spoofing, 3) The need for a series of alarms and indicators to monitor the operation of the system, and 4) The system's ability to filter ambient noise such as wind, alarms, gunfire, etc, as well changes in voices (giving the commands) caused by colds, moods, excitement, volume, etc. These issues will now be addressed.

1.   Reliability

The issue of reliability was a common concern raised by all who responded. Open-ocean steaming with no surrounding vessels (for many) would be the only time they would currently consider employing the system. However, they were willing to consider the system's use in more

potentially hazardous situations such as mooring evolutions, underway replenishments, flight operations, and close aboard events, as the system itself is proven to be a reliable option to the manned SCC.   Aboard U.S. naval vessels, a certain level of trust must be attained before adoption of unfettered use of any tool, device, or system. The reason for such a demand in reliability is best stated by a lieutenant commander who said "It's not worth the risk."[36]   He continued [should an undetected VR system casualty occur], "In the worst case scenario, my JO's were not as vigilant as they should have been, the ship veers off course and runs aground, the ship running aground causes a main space fire in which one or more of my crew are killed, resulting in a JAG [Judge Advocate General] investigation where I lose my command and career."[37]   In the hypothetical situation described by this officer, many other oversights and mistakes occur after the undetected failure of the VR system, yet the first component he chose to blame for the grounding, fire, deaths, and the loss of his career was the use of a new technology that operated the rudders and engines of the ship.   Perhaps a re-evaluation of the situation above would reveal that the "risk" was not in the use of the VR system, but in assignment of the watch standers who were not able to detect the ship deviating from the ordered course and into an unsafe condition.   As stated in "Is the Navy Serious about Reducing Manning on Its Ships," "Taking risks is how

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[36] E-mail message, 17 November 2002.

[37] Ibid.

innovations are made and how the organization moves forward; The U.S. Navy needs to reward risk takers, even when they may fail."[38]

No matter to what extent an automated system's reliability and effectiveness are proven, there is a culture that will continue to reject the use of a component that can play such an important role in the navigation of a ship. Those who are willing to expand the use of the VR system will see that when a casualty occurs, corrective actions will eventually come naturally as is the case when learning any new system. Just as the Destroyer Squadron Commander indicated, only time and repeated use will gain the confidence of those standing the watches of Conning Officer and Officer of the Deck, as well the Commanding Officers who put their trust and confidence in these watch standers.

2.   Security and Vulnerability

The second issue that the destroyer squadron commander raised with respect to the implementation of a VR system is the security and vulnerabilities of a wireless system operating in a highly electromagnetic-active environment. The Office of the Secretary of Defense issued a policy document for Pentagon Area Common Information Technology (IT) Wireless Security on 25 September, 2002. Although the electromagnetic activity of land-based wireless networks or WLANs (Wireless Local Area Networks) differs from that on a

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[38] J. Robert Bost and others, "Is the Navy Serious about Reducing Manning on Its Ships?" 1999. Database on-line. Http://www.manningaffordability.com/S&tweb/Index_main.htm. Accessed 24 January, 2003.

U.S. Navy ship, this policy possesses relevance to the importance of security for all government-associated Wireless Networks.

The U.S. Navy does not yet have an IT wireless security policy developed for shipboard networks due to the infancy of wireless networks installed aboard navy ships. The Pentagon Area Common IT Wireless Security Policy states in its introduction, "Although wireless computing devices and infrastructure support systems can provide an increase in connectivity, they also provide an increase in security vulnerabilities and risks to DoD information and operations."[39]   In order to ensure a secure wireless network (e.g., VR system, etc.), information passed throughout a wireless network must meet five Information Assurance (IA) axioms: 1) Confidentiality, 2) Integrity, 3) Authentication, 4) Nonrepudiation, and 5) Availability. As defined in this policy,

> **Confidentiality** verifies that information is private and therefore seen and accessed only by intended recipients. Confidentiality is created primarily through the use of protocols that use encryption. **Integrity** verifies that information received is the same information transmitted by the originator, and is unchanged. **Authentication** identifies an individual or computer to ensure access to information is authorized. Authentication goes hand-in-hand with identification and confidentiality. **Nonrepudiation** ensures that an individual cannot deny sending or receiving information. **Availability** ensures that information (voice, video, and data) and supporting service resources

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[39] *Memorandum for Secretaries of the Military Department*, Pentagon Area Common Information Technology (IT) Wireless Security Policy, 23 September 2002.

(e.g., server, local networking infrastructures, and transport medium) are up and running when needed.[40]

Based on the axioms listed above, the Pentagon's wireless policy goals are:

1. Protect DoD information, users, and wireless devices from unauthorized disclosure, 2. Ensure that DoD information is protected against an intrusion that could alter, disable, or circumvent the transmission, 3. Require centralized oversight, configuration management and control of wireless information systems, 4. Ensure protection against physical compromise (e.g., immediate notification of misplaced or missing DoD wireless devices to the appropriate authority), 5. Ensure user authentication of DoD information transferred via wireless computing devices, and 6. Ensure there will be no adverse impact to DoD critical operations if wireless computing devices and the supporting infrastructure are rendered inoperable.[41]

Of these six goals, the first, second, and sixth hold the most importance, when considering VR system applications.

The first goal discusses a need to assure no unauthorized disclosure of wireless systems transmissions. For obvious reasons, when using the VR system, there is a need to ensure that rudder and engine-order transmissions are not disclosed to areas surrounding the ship. Just as the Destroyer Squadron Commander stated, "so that off-ship monitoring by nearby contacts could not use knowledge of maneuvering orders to gain a tactical advantage"[42]

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[40] Ibid.

[41] Ibid.

[42] Interview between Destroyer Squadron Commander and the author, 02 September 2002.

The second goal explains the importance of protecting the network from intrusion by unauthorized persons. This is a crucial element of the VR system's security, for if there were an intrusion, it could possibly maneuver the ship in ways that could drive it into a hazardous situation. Even though manual control switches would be placed throughout the bridge, denying any attempt to take more than momentary control of the ships maneuvering, it is imperative that interference from unauthorized intrusion be obstructed.

The sixth goal explains that if a casualty to the wireless system occurs, the system's integrity must assure that there is no adverse impact that would render the system inoperable. One major advantage to meeting this goal is that the navy relies heavily upon system redundancy. Throughout navy ships, redundancy is critical to mission accomplishment. By ensuring redundancy, U.S. Navy ships are capable of continued operations following damage from weapon attacks, groundings, collisions and fires. By maintaining an operable SCC on the bridge with manual control switches, the VR system would not diminish the ability to maneuver the ship should a VR system casualty occur.

In reviewing the Pentagon's wireless security policy, it becomes apparent many concerns and goals of a land-based wireless network are identical to those of a ship-board wireless network. Until a wireless network policy can be developed for ship-board networks, following the policy goals and objectives of the Pentagon Area Common IT

Wireless Security Policy would serve as a means to meeting the destroyer squadron commander's concerns about network security.

3. System Monitoring

A third issue discussed the need for a series of alarms and indicators to monitor the operation of the system. This concern was addressed in the proposed implementation section in Chapter II. It is imperative to have these alarms and indicators for continuous monitoring of the VR system.

4. System Fidelity

The final concern of the Destroyer Squadron Commander was the VR system's ability to filter ambient noise such as wind, alarms, gunfire, etc, as well changes in voices (giving the commands) caused by colds, moods, excitement, volume, etc. As previously mentioned, language model Voice Recognition systems are designed with libraries of words and phrases that can be set up to match every known word, spoken in every accent, in every setting. However, by limiting the words and phrases that need to be recognized by the VR system, every example of the words and phrases required for maneuvering ships could conceivably be entered into these libraries. By entering only the words and phrases associated with standard commands, the VR system would be able to discriminate the intended commands with greater ease. Also, by using the activation switch for the cordless microphone headsets, a substantial amount of ambient noise such as wind, alarms, gunfire, etc. would be

negligible due to the operator's ability to activate the microphone when desired. Additionally, according to Chicago-based speech consultant Judith Markowitz, "Thankfully, noise and speech frequencies travel differently. You try to identify those frequencies that are moving differently from how you would expect speech to move," she explains, "and then strip out a lot of that from the signal-a lot rather than everything, because some of those frequencies are also speech frequencies."[43] Therefore, specific noises, such as wind, alarms, and gunfire can be measured ahead of time, making them easier to filter. Finally, much can be said for the position and type of microphone used. Ensuring that a high-quality microphone is pointed towards the operator's mouth will assist in blocking out any ambient noise by receiving signals primarily from the users voice.

B.   SUMMARY

The majority of the officers that stated they would use the VR system under certain restrictions expressed many of the same issues and concerns that were raised by the Destroyer Squadron Commander. Surface Warfare Officers are taught from the onset of their training (in ship driving) to consider all possible events and casualties that may occur during their watch, and how to respond to these events and casualties. Therefore, it is not unusual to see similarities in the way these officers evaluated the idea of a VR system. From the perspective of a Surface Warfare

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[43] Jean Kumagai, "Talk to the Machine," IEEE Spectrum Online, September 2002. Database on-line. Http://www.spectrum.ieee.org/WEBONLY/publicfeature/sep02/voic.html. Accessed 5 January, 2003.

Officer, the basic design requirements needed for the VR system to be accepted and used by those responsible for safe navigation are: correct and secure information exchange with proper system relay to both propulsion and steering mechanisms. With the Voice Recognition system's achievement of these requirements, smooth and efficient operation of any U.S. Navy vessel can be attained.

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V. CONCLUSIONS

The capability and reliability of Voice Recognition technology is ever-growing. With more attention and implementation into the world's common operating devices, this technology will continue to develop. According to a statement by Victor Zue, director of the Massachusetts Institute of Technology's (MIT's) Laboratory for Computer Science, "I think of the next frontier as one in which machines are really not a device that you program, but a partner in conversation-you talk to it, it understands you, and it will try to do things for you."[44] This statement makes it is clear that in order to maintain the most technologically advanced naval vessels, it is imperative to further investigate, develop and field Voice Recognition systems aboard all U.S. Navy ships.

As technology continues to improve, it is only a matter of time before Voice Recognition or command systems are part of everyday life. Automobile manufacturers today are rapidly integrating this technology into the operation and navigation of their vehicles. In a recent commercial for the Honda Accord (February 2, 2003), the driver is depicted operating the climate control, radio, and windshield wiper systems through Voice Recognition in addition to talking to the car's Global Positioning System to access directions to a specific address. This new element to everyday life will soon impact society with an electricity similar to that of the introduction of personnel computers, personnel data assistants (PDA's),

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[44] Ibid.

cellular phones, and the internet. Had these devices not been developed, daily routines for people throughout the world would be considerably different than what they are today. Soon this same point of view will be expressed for Voice Recognition systems.

Daily routines will be forever changed with the implementation of VR systems. When pulling into the driveway of a house, people will only need to give the command "open garage door" to activate the door opener, and when walking through the house, commands such as "lights on" and "air conditioning, seventy-two" will turn on the lights and lower or raise the room temperature to seventy-two degrees. Just as sending and checking for e-mail messages has become a common every day activity for many, so will the use of Voice Recognition systems.

With the future commonality of Voice Recognition use, it is clear that this technology aboard U.S. Navy ships will not be considered futuristic, but more of a common application; as if it were always expected to be a part of these ships. Systems aboard U.S. Navy ships must always maintain pace with the latest technologies and be considered to be on the cutting edge of the country's military systems. In order to continue to advance with U.S. naval ship applications and systems, there is a need to continuously develop and research the "next step" in technology. As revealed in the Officer's Opinion chapter, it is clear that the majority of those who take the responsibility of the safe navigation and maneuvering of navy ships encourage the idea of Voice Recognition as an alternative to the currently manned SCC. Voice Recognition

is the next significant technological advancement that will affect humankind. It is imperative that the United States Navy conduct the necessary research and development to implement Voice Recognition systems as a reliable and efficient alternative to the safe maneuvering of U.S. Navy ships.

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