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VIRTUALIZED PLATFORMS TO CONDUCT REMOTE SHIPBOARD TRAINING AND HANDS-ON READINESS ASSESSMENTS FOR CANES

by

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13. ABSTRACT (maximum 200 words)

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This thesis proposes that a delivery mechanism to provide additional hands-on training can offer a solution for IT administrators and improve their ability to respond during daily operations and training assessments. The main objective behind the research in this thesis is to help information system technicians who are depended upon to manage mission-critical networks. By better understanding the gaps these technicians face in training, coupled with current and emerging technology, we can begin to develop a plan of action to address these shortfalls. This thesis concludes that additional hands-on training through virtualization is vital in preparing Sailors to manage and operate CANES. Finally, investing more time and research into improving training models while focusing on the human element in training will ultimately result in ready and equipped Sailors to manage and protect mission-critical networks.

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VIRTUALIZED PLATFORMS TO CONDUCT REMOTE SHIPBOARD TRAINING AND HANDS-ON READINESS ASSESSMENTS FOR CANES

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LIST OF ACRONYMS AND ABBREVIATIONS

AI	Artificial Intelligence
ALT	Adaptive Learning Technology
AMI	Amazon Machine Image
ATG	Afloat Training Group
ATGPAC	Afloat Training Group Pacific
ATO	Authority to Operate
AWS	Amazon Web Service
C2	Command and Control
CANES	Consolidated Afloat Networks and Enterprise Services
CANTRAC	Catalog of Navy Training Courses
CASREP	Casualty Report
CBT	Computer Based Training
CCA	Comprehensive Communications Assessment
CDC	Centers for Disease Control and Prevention
CENTRIXS-M	Combined Enterprise Regional Information Exchange System-M
CNA	Computer Network Attacks
CND	Computer Network Defense
CNO	Computer Network Operations
CoI	Community of Interest
CPO	Chief Petty Officer
CTO	Chief Technology Officer
CUI	Controlled Unclassified Information
DaaS	Desktop as a Service
DOD	Department of Defense
DON	Department of the Navy
ePO	e-Policy Orchestrator
FCAPS	Fault, Configuration, Accounting, Performance and Security
GCCS-M	Global Command and Control system-Maritime
HBSS	Host Based Security System
HCI	Human-Computer Interface

IaaS	Information as a Service
IP	Information Professional
IT	Information Systems Technician
IT	Information Technology
IW	Information Warfare
IWTC	Information Warfare Training Command
KSA	Knowledge Skills and Abilities
MCSTP	Model of Control System for Training Program
ML	Machine Learning
NAVIFOR	Naval Information Forces
NAVWAR	Naval Information Warfare Systems Command
NCTSS	Navy Tactical Command Support System
NEC	Navel Enlisted Classification
NETC	Naval Education and Training Command
NSS	National Security Systems
OPTEMPO	Operational Tempo
OS	Operating System
OJT	On the Job Training
PaaS	Platform as a Service
PEO C4I	Program Executive Office Command, Control, Communications, Computers and Intelligence and Space Systems
PMW	Program Manager Warfare
PRD	Projected Rotation Date
ROI	Return on Investment
RDS	Remote Desktop Services
SCI	Sensitive Compartmented Information
SOVT	System Operability and Verification Test
SPAWAR	Space and Naval Warfare Systems Command
SRG	Security Requirements Guide
TAD	Temporary Assigned Duty
TCO	Total Cost of Ownership
TVE	Training Virtual Environment

VDI	Virtual Desktop Infrastructure
VM	Virtual Machine
VNS	Virtual Network Simulator

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-LCDR Eugene "Tommy" Frye, United States Navy

To my mother, who keeps me covered in prayers and always reminds me, "Through God, all things are possible."

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- LCDR Rashaunda Holloway, United States Navy

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I. INTRODUCTION

Computer-based training used to teach and measure proficiency of Consolidated Afloat Networks and Enterprise Services (CANES) does not adequately train System Administrators (Sysadmins) to manage the challenges presented in "live" networks outside of the training environment. Currently, training on the management of CANES is shore based, requires face-to-face interactions and is delivered via computer-based-training (CBT) modules. This six-month-long training program is not offered to all IT (Information Systems Technician) staff who have a role in managing CANES. For IT staff that is underway, the next opportunity for targeted training is geared toward identifying and correcting mistakes committed by staff due to their rudimentary understanding of a complex system, and comes from the annual ship-wide audits conducted by the Afloat Training Group (ATG).

This thesis proposes that a delivery mechanism to deliver additional hands-on training can provide a solution for IT administrators and improve their ability to respond during daily operations and training assessments. This can be achieved through the development and utilization of virtual networks and infrastructure capable of deploying and conducting shipboard training and assessments remotely. One potential method is to use current shipboard infrastructure to access a virtual training environment via cloud-based technology. This is the ideal method however it is reliant on available network resources and Information Assurance (IA) policies that could restrict access to the existing framework.

Currently, IT staff has no access to on-going education that is available remotely. Access to schoolhouse offered classes is often limited to sailors previously identified for specialized training. Shipboard IT training requires face-to-face interactions and is derived from the combined knowledge and expertise shared by the IT department. Therefore, the shipboard training is restricted in scope, does not allow for specialization, and is reactive. The current Sysadmins training model relies on the mastery level and experience of individual sailors, as they present short trainings to staff. Often topics are selected based upon the errors identified by IT managers. IT staff are responsible for understanding and managing network fundamentals, identifying threats, mitigating vulnerabilities, and preventing and responding to cyber-attacks. This lack of access to continued education hinders their ability to respond with speed and boldness during assessments in training scenarios and daily operations.

The need for virtualized training that is remotely accessible was made more evident due to the Centers for Disease Control and Prevention (CDC) recommendations regarding COVID-19. Face-to-face interactions, including trainings offered at Navy Training Facilities in Fleet concentration areas, were impacted due to COVID-19 Restriction of Movement (ROM) which limits personnel movement and requires additional travel restrictions and protocols prior to and after arrival from the Sailor's previous duty station. The Chief Technology Officer from the Center of Surface Combat Systems (CSCS) states the CSCS is "looking at how to train the instructors to teach electronically, which many have never experienced. Evaluation of our curriculum is also being performed with instructional design in mind for how best to train the material, and how to distribute this training" (Temple, 2020). Travel restrictions and mandatory quarantines further decreased access to this education and increased the time between the recognized need for education and the completed training.

In general, the study of virtualized training within the Department of the Navy (DON) has not been sufficient. In spite of several initiatives to modernize, innovate, and defend Information Systems (IS) onboard Naval ships at-sea, there does not yet exist a virtual framework or the infrastructure that allows for the ability to conduct remote shipboard training and readiness assessments during conditions that require virtualized remote work.

A. PURPOSE STATEMENT

The purpose of this thesis is to explore and evaluate the benefit of employing a virtualized training platform specifically designed to provide remote hands-on training to Sysadmins, familiarize leadership with network and cyber fundamentals, and administer assessments. Virtualized training would allow for continued education in order to maintain proficiency leading up to and through deployment at sea. It would also ensure proficiency before assessment, support the development of subject matter experts, and decrease the need for face-to-face training by internal and external teams and IT managers to prepare the ship for deployment. This is important because our Sailors at sea must be able to respond to abnormal activities or attacks in a quick and decisive manner.

B. RESEARCH QUESTIONS

(1) What are the IT Sysadmin training gaps in preparing to manage an operational CANES network at sea or during times when face-to-face training is not possible?

(2) How can access to additional virtualized training sessions improve IT Sysadmins preparedness to manage CANES?

C. RESEARCH DESIGN

Addressing the first research question relied heavily upon resources from around the academic community and articles from the public sector. What made these sources particularly useful was the authors' unique perspectives and the communities from which the source came. A report published by the Rand Corporation (RAND) titled *Consolidated Afloat Networks and Enterprise Services (CANES): Manpower, Personnel, and Training Implications* proved to be most helpful in this research, as the RAND study's purpose was to evaluate a portion of the identified gaps. To develop and study the gaps, an understanding of the "the status quo" first needed to be understood. To understand the current approach to Sysadmin training, we relied on unclassified, open-source, research reports and documents written by DOD contractors and DON.

Developing a sense of how the model for Sysadmin training might be improved, the literature search shifted towards materials detailing how to close the gaps from the "as-is" model to the to-be model. Doing this required finding sources of successful examples in virtualized training environments with the military, academia and private-sector, and was the starting point for researching the second research question.

Researching the second research question depended on finding resources that described how a CANES network might look. Because this information could have potentially obtained classifications of "for official use only" (FOUO), usage of publicly available and unclassified resources became the priority of focus. Using these resources not only protects the integrity of the research but also allows for the widest dissemination. After defining the basics of a CANES network, it was necessary to understand virtualization. To gather this understanding required the usage of credible and reputable online resources such as IBM and CISCO. Only after obtaining a proper understanding of CANES training gaps, the "as-is" model, and virtualization were solution sets formed.

Based on the synthesis of the literature we designed an idealized future model to accommodate the training needs and close the gaps previously identified. Lastly, we conducted a notional thought experiment to imagine a scenario where "best practices" could be used to deliver training to IT Sysadmins while meeting the goal to provide a solution when face-to-face training is unavailable.

D. ORGANIZATION

This thesis is divided into seven chapters:

- Chapter I is the introduction and introduces the reader to the problem space, purpose statement and research questions.
- Chapter II is a review of literature which establishes the background for CANES and explains terminology and describes the stakeholders who serve as essential role players in the operation, maintenance, manning and management of CANES and current approach to IT Sysadmin training.
- Chapter III describes virtualized environments, and provides a historical reference for how virtualized environments have been used in the past. It also identifies the essential virtual training elements and critical components.
- Chapter IV describes the current state of IT Sysadmin training and identifies the current performance and explores the pain points and areas of improvement.

- Chapter V is the idealized model specifications combined to model a VTE platform that will fit the gaps previously identified and meet all requirements.
- Chapter VI conducts notional thought experiment to test the idealized VTE model built in the previous chapter
- Chapter VII concludes by identifying future research to include emerging technologies, research limitations, and recommendations.

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II. CANES BACKGROUND

The United States Navy is responsible for a broad range of networks both ashore and at sea. The Navy is transitioning away from outdated legacy-type networks to the more robust CANES. This chapter is a review of literature and introduces the reader to CANES, which is replacing legacy networks. It covers installations, locations, and the need for this network. The chapter also provides an overview of the roles played by Sailors who operate and manage these networks. Finally, it introduces the reader to the existing training pipelines for ITs and Sysadmins.

A. CANES OVERVIEW

Replacing legacy shipboard technology, CANES is a Program of Record (PoR) that provides all infrastructure, hardware, applications, and services necessary to upgrade and consolidate several networks and systems onboard U.S. Navy Ships and Submarine. Considered a paradigm shift, CANES delivers the environmental framework to house over 40 applications for command and control, logistics, and intelligence. Previous network suites consisted of multiple tactical networks that did not support interoperability and had various baselines and configurations. This approach required a tremendous amount of administrative and monetary overhead to maintain. Administratively, each command needed to maintain a percentage of Sailors on board with the necessary Navy Enlisted Classification (NEC) codes to operate each network. Monetarily, commands were required to fund travel to various training locations to obtain the NEC.

Installations of CANES enable the total cost of ownership (TCO) to be reduced as more ships receive the install. This reduction in TCO is achieved through reducing overall maintenance and upkeep cost of numerous and separate platforms down to one overarching network (Space and Naval Warfare Systems Command [SPAWAR], 2011). Designed with two fundamental goals in mind, incorporating platform as a Service (PaaS) and Infrastructure as a Service (IaaS), it replaces existing in-service tactical networks while providing all requisite hardware, software, storage, and services needed to operate (Jackson, 2016). In December of 2014, the USS Milius, an Arleigh Burke-class guided-missile destroyer, finished installing the first iteration of CANES. Northrop Grumman Information Systems received a $638 million contract in 2012 to conduct the installation (Hoskinson, n.d.).

According to Naval Information Warfare Systems Command (NAVWAR, formerly SPAWAR) CANES produces five key benefits (SPAWAR, 2011):

1. As previously mentioned, the total cost of ownership is lowered by migrating to CANES and away from multiple legacy systems
2. Delivers agile and knowledge superiority capabilities to the fleet while supporting Maritime strategy
3. Creates the environment for sharing information and having a shared understanding of the battlespace
4. Creates a ready, capable, and mission-critical network that meets the requirements of the warfighter
5. Integrates video, voice, and data, reducing the overall shipboard bandwidth thresholds

As of March 2018, the United States Navy had installed CANES on over 66 platforms across the fleet (Machi, 2018). Program Manager Warfare (PMW) 160 Tactical Afloat Networks operates within the Program Executive Office Command, Control, Communications, Computers, Intelligence and Space Systems (PEO C4I and Space Systems). They are the system owners for CANES systems to the Naval Fleet. a Navy program management office, is currently tracking an upcoming milestone of the 100th ship installed, expected to occur in 2024. Upon completing the last integration install, CANES will be installed across multiple platforms to include ships, submarines, and select land sites across the Navy (Boehme, 2020).

CANES is maintained and operated by IT; however, each CANES installation affects the entire crew on board. CANES replaces multiple outdated legacy networks across several classification domains to include Coalition networks, Unclassified, Secret, and Sensitive Compartmented Information (SCI). Every Sailor onboard the ship will use

CANES in some capacity. Everyday services such as email, chat, file-sharing, or web browsing to tactical Command and Control (C2) networks are now integrated into CANES (DAMIR, 2016). CANES consolidates multiple tactical networks into one overarching network. Networks consolidated include global Command and Control system-Maritime (GCCS-M), Combined Enterprise Regional Information Exchange System-M (CENTRIXS-M), Navy Tactical Command Support System (NCTSS), SCI, and Network Command and Control System (Thie et al., 2009). The following sections list critical details of the network administrators charged with maintaining CANES.

B. IT SYSTEM PLAYER AND ROLES

This section discusses the personnel responsible for the operation, maintenance, training and installation of CANES. They are identified and referred to by their duties and responsibilities and the roles they play within the IT organization afloat. The "players" identified are the general ITs, specifically trained IT Sysadmins, and IT Managers who are responsible for the operation and maintenance of the networks to include CANES. This section provides background into required training and explains differences in the various types of ITs and how they function within a division.

The fault, configuration, accounting, performance and security (FCAPS) management model is essential for understanding the roles of managing the IT Sysadmins responsibilities. They must be integrated and designed to ensure each functional area is accessible. One thing to note is the IT Sysadmin for CANES shares the management functionalities with PMW 160 and must be able to carry out all network management tasks that are assigned to the various roles. Through the following sections if applicable, the functionalities will be stated as they fit within the parameters shown on Figure 1.

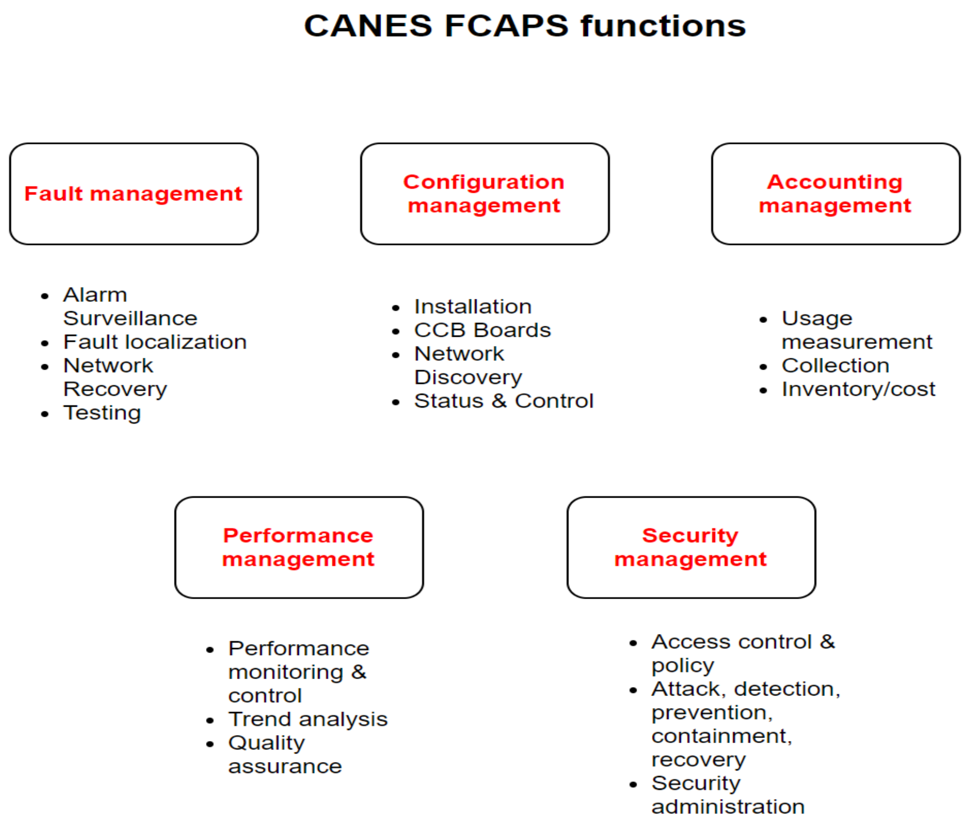


Figure 1. Tentative FCAPS model with additional parameters

1. General IT Roles and Responsibilities

ITs are the operators and maintainers of Navy networks, servers, computers, and peripherals at sea. ITs must learn to perform a broad spectrum of network administrator skills and tasks to keep their networks and computers operational. Though not covered in this study, it is crucial to understand that ITs are also responsible for managing telecommunication systems that operate over data links and circuits. In some instances, on smaller ships, ITs must learn to maintain telecommunication systems in addition to their Sysadmin duties. The list of job roles and responsibilities is only a portion of the required skillset for ITs (Navy Cool, n.d.a):

a. Install applications and peripherals

b. Troubleshoot various user issues

c. Provide customer support and assistance of computer hardware, software, printers, word-processors, electronic mail systems, and operating systems

d. Perform system restores and backups

e. Perform various aspect database management

Taking the previous list into consideration, here is an example of what a typical IT Sysadmin day looks like onboard a ship. Unlike standard 9-to-5 civilian jobs, shipboard Sailors will, on average, work 12 hours per day, dividing the 24-hour day between two watch teams. The first team will work from 0600 to 1800 (12 hours), and the second team from 1800–0600 seven days a week while at sea. Watch teams will continue to man the network in port; however, the team composition might alter slightly. ITs providing user support (as defined by a, b, and c above) will monitor an online helpdesk system for trouble tickets and schedule a time with the user to assist. IT Sysadmins will generally be in charge of server-level tasks (d and e from above) to keep the network running as smoothly as possible. Depending on the ship's IT Managers, IT's roles and responsibilities may change over time; user support may become Sysadmins, and vice versa. Either way, the manager's responsibility is to oversee the teams to achieve optimal performance of the networks and obtain the lowest amount of user downtime possible.

2. Sysadmin Roles and Responsibilities

According to Navy Credentialing Opportunities On-line, the role of Sysadmin is determined based on requirements at a specialty level and if the IT meets the qualification requirements in the duties assigned (Navy Cool, n.d.b), "The duties and responsibilities are to conduct installations, configure, troubleshoot and maintains server and systems configurations (hardware and software) to ensure their confidentiality, integrity, and availability. Administers server-based systems, security devices, distributed applications, network storage, messaging, and performs systems monitoring" (Navy Cool, n.d.b). More specific tasks, knowledge, skills and abilities (KSA) grouped under Sysadmin status are available and used to train and assess Sysadmins. These skills are comparable to the civilian sector counterparts.

Based on the logical set of functions, tasks and different levels of expertise, fault management is assigned to the CANES IT Sysadmin. They receive the initial indicators of a fault and will investigate. They share this responsibility with the engineers and technicians at PMW 160 as they are experts on the system architecture and Simple Network Management Protocol (SNMP). Together the Sysadmin and network engineer can use fault management to identify and trace malfunctions within the CANES network. Configuration management is the responsibility of the Configuration Management Board (CCB) who is comprised of the System Administrators (SYSADMIN) and IT Managers. They are responsible for network configuration that tracks changes to hardware and software for CANES, which enables them to conduct timely backups and restoral.

Accounting management is also the responsibility of the Sysadmin. They are responsible for capturing logs that can be used to evaluate usage and validate future costs. The Performance Manager is responsible for ensuring CANES operates as expected and network resources are equally allocated. Lastly, the Security Manager can be a Host-Based Security System (HBSS) Analyst or Network Vulnerability Technician. It is their task to ensure security of the CANES by implementing policies, auditing procedures, hardening network infrastructure, and ensuring authentication, authorization and confidentiality for the entire network. This is also a shared responsibility with PMW 160. Overall, the Sysadmin is highly involved in all of areas of FCAPS which is why it is essential that they are highly skilled and trained within all functional areas.

3. IT Managers

The "players" within the IT department are the division officer (DIVO), and department head (DH). They report to the executive leadership, comprised of the Executive Officer (XO) and Commanding Officer (CO). These are the direct and indirect managers of the ITs, and they are kept abreast on the daily operations and network issues that require interaction with external entities. Network issues are reported to the ship's immediate superior in command (ISIC) if critical functionality impact mission readiness.

According to the Standard Organization and Regulation Manual (SORM) the DIVO's responsibilities are to supervise the performance of the designated work-centers and ensure shipboard maintenance is being completed within the scope of the ship's maintenance material management (3-M) policy and properly operating (CNO, 2017). The DIVO is also responsible for the IT division training program. They ensure all ITs are assigned a personnel qualification standard (PQS) and placed on a training pathway to ensure they are able to safely operate and conduct maintenance on all network systems that are owned within the particular division. With inputs from the Leading Chief Petty Officer (LCPO) they pick the ITs who attend future training and assign ITs as subject matter experts (SME) to take ownership of a network or IT systems.

In regards to the FCAPS model, management of CANES would prove highly beneficial if the IT Manager has in-depth knowledge and experience to be able to audit and provide guidance for the IT Sysadmin as they navigate the various management tasks.

C. IT AND SYSADMIN TRAINING

This section highlights competencies, training, and milestones necessary for an IT to become a successful CANES administrator. The section begins with an overview of the basic training that all ITs receive and then discusses some prerequisites to becoming a CANES administrator. CANES is a relatively new and complex networking system and so is the training to operate and maintain it. Operating and maintaining CANES is the responsibility of Sysadmins. As per the Navy Cool website, Sysadmins responsibilities are towards maintaining servers and the configuration of systems consisting of both hardware and software. The primary objective of Sysadmins is achieving and maintaining confidentiality, integrity, and availability (CIA) of their networks (Navy Cool, n.d.b). In general, ITs make up the bulk workforce of Sysadmins, but not all ITs will become Sysadmins because not all will meet the training requirements. Also, some ITs are selected to specialize in other areas of communications such as radiofrequency and telecommunications. For a Sysadmin to have the basic knowledge and understanding to operate and maintain CANES, they must go through appropriate training beginning with IT "A" School as a foundation and other potential subspecialty training as available.

1. IT "A" School

Training new ITs to perform proficiently in their rating is neither quick nor easy. New IT Sailors and those who cross-rate other enlisted ratings into the IT rate must attend and complete core technical training known as IT "A" School (Navy Cool, n.d.a). Information Systems Technicians attend their "A" school in Pensacola, Florida, for a period of 24-weeks. They obtain baseline level skills and garner a fundamental understanding of IT roles and responsibilities while preparing for their first assignment, either at sea or shore (Navy.Com, n.d.). Training is conducted in a classroom setting led by instructors and computer-based training. Table 1 illustrates the subjects learned and the methods used for teaching IT "A" School.

Table 1. IT "A" School Training and Methods. Adapted from Navy Cool (n.d.a).

Subjects	• Microsoft, Cisco, and Oracle software • Hardware Fundamentals • ADP • Security • System theory and operation
Training Methods	• Group instruction • Computer lab • Ship simulator training

2. Other Training Available to ITs

This section identifies other training areas available to IT Sailors as they work towards becoming a CANES administrator. Table 2 lists two training areas; the left side displays basic level training and the right-side shows intermediate training. NECs 745 A and 746 A are both highlighted; this is to draw attention to the fact that these NECs are prerequisites to become CANES administrators. Thirty-three days of classroom training are required to obtain NEC 745A, and an additional 90 days are required to earn 746A (Navy Cool, n.d.c).

Table 2. Basic and Intermediate training available to Information Systems Technician Adapted from (Navy Cool, n.d.c)

BASIC	INTERMEDIATE
CIN A-531-0767 Tactical Computers and Network Operator	CYBR1005 Security Essentials
CYBR1005 Security Essentials	NEC 731A Information System Maintenance
NEC 737A Naval Tactical Command Support System (NTCSS) II Manager	NEC 736A Global and Command Control System-Maritime 4.X (GCCS-M 4.X) System Administrator
NEC 745A Information Systems Technician (IAT I)	NEC 738A Global Command and Control System-Maritime (4.1) Increment 2 System Administrator
NEC C26A AN/SSQ-137 Ship's Signal Exploitation Equipment (SSEE) Maintenance Technician	NEC 739A Global Command and Control System-Maritime 4.0.3 (GCCS-M 4.0.3) System Administrator
NEC C27A Submarine Carry-on Equipment Technician	**NEC 746A Information Systems Technician (IAT II)**
NEC C28A Ship's Signal Exploitation Equipment Increment Foxtrot (SSEE INC F) Maintenance Technician	NEC C26A AN/SSQ-137 Ship's Signal Exploitation Equipment (SSEE) Maintenance Technician
	NEC C27A Submarine Carry-on Equipment Technician
	NEC C28A Ship's Signal Exploitation Equipment Increment Foxtrot (SSEE INC F) Maintenance Technician
	NEC N71Z CVN Propulsion Plant Local Area Network (PPLAN) Administrator
	NEC T02A AN/BYG-1 (V) TI04 Combat Control Maintenance Technician
	NEC T04A SSGN Tactical Tomahawk Weapon System (TTWCS) Maintenance Technician
	NEC T09A AN/BYG-1 (V)9 TI-10 Combat Control Maintenance Technician

3. CANES Operator Training

1. Not all ITs can attend CANES administrator training. In addition to completing IT “A” school, several prerequisites exist, limiting those who attend. According to the Catalog of Navy Training Courses (CANTRAC), Sailors must meet the following conditions before attending CANES administrator training(2021): Served for a minimum of three years
2. Promoted to the paygrade of E4 or higher
3. Possessed a minimum of 12 months remaining on their service contracts
4. Awarded the 746A Navy Enlisted Classification (NEC) Code

Installation of CANES introduces challenges to host command and the IT Sailors on board. Trained to operate and maintain legacy networks, they now must learn a new system. Initial training is provided to Sailors immediately following the installation and the system operability and verification test (SOVT). This training is limited in time as the installation training team will eventually detach from the ship. Having Sailors onboard with minimum training to maintain networks that impact C2 leaves the command in a position where sending their IT Sailors to CANES administrator training is essential.

CANES network administrator training only occurs in Norfolk, Virginia, and San Diego, California. Having only two locations makes it difficult for commands stationed farther afield and worldwide to send their ITs to training. In addition to only being hosted in two locations, seats to train Sailors on managing CANES are limited to 10 personnel per classroom. Those who graduate receive a NEC (Jackson, 2016). Upon receipt of the NEC, the Sailors service record will reflect the NEC and new specialty training.

This project’s first objective was to fully understand the training requirements of IT Sailors to become bona fide CANES administrators. Additionally, it highlighted a CANES pilot program bringing training to Sailor’s from remote locations utilizing virtualization. Upcoming objectives are to explore the potential for virtualization and CANES. The next chapter takes a deeper look into the pilot program and goes into detail on what virtualization is with the intent of identifying areas to add improvement for CANES training.

III. VIRTUALIZED TRAINING ENVIRONMENTS

Chapter II highlighted CANES and introduced the IT system players and roles. This chapter takes a deep dive into virtualization and virtualized training to identify essential elements and identify critical pieces of technology.

A. WHAT IS VIRTUALIZATION?

Virtualization is the process of creating virtual representations of physical environments. In the example of computerized environments, virtualization enables creation of multiple virtual machines (VM) through the partitioning on a single physical computer (Microsoft Azure, n.d.). Virtualization permits two or more operating systems and multiple applications to operate on a single physical server (DON CIO, 2013). There are many types of virtualization: desktop, network, software, storage, data, application, data center, CPU, GPU, Linux, and Cloud (Microsoft Azure, n.d.). The primary focus of this section is to provide a descriptive overview of desktop virtualization and essential elements in virtualized training.

1. Desktop Virtualization

With the end-user in mind, desktop virtualization creates software representations of the user desktop. Virtualizing the desktop allows for dissociating users from their operating system and desktop environment. This dissociation means that the users can access their desktop from any computing device on the network. Primarily, deployments of desktop virtualization occur in one of three models. The first model of deployment is called a virtual desktop infrastructure (VDI). In this model, the operating system (OS) resides on a virtual machine (VM), and at the same time, a server hosts the VM. For the user to access their OS and underlying applications, an image of the user's desktop will traverse the network to their physical device. Important to remember related to VDI is the word *hypervisor*. A hypervisor is a software layer from which the user's CPU, drivers, and other OS resources operate (IBM, 2019a). The second model is called remote desktop services (RDS). RDS utilizes Microsoft Windows Server OS for users to access their desktops. End users will not notice a distinction between VDI and RDS. However, whereas with VDI a dedicated VM is required per user, with RDS the server can provide numerous user instances. The third model covered here is Desktop-as-a-Service (DaaS). DaaS is a cloud-hosted computing model that deploys VM faster and is more readily scalable than non-cloud systems (IBM, 2019a).

2. Virtual Training Environments

"Virtual environments" have taken multiple forms and the term will take on a different meaning depending on the setting. One example is immersive virtual environments; this version involves a headset that covers the eyes and allows the user to interact with machinery safely (Tanaka et al., 2017). Another expression is "virtual reality," an oxymoronic word that essentially means the same thing as "immersive virtual environments." The best definition of virtual environments found during this study comes directly from AMC Digital Library. It reads, "we can define virtual environments as interactive, virtual image displays enhanced by special processing and by nonvisual display modalities, such as auditory and haptic, to convince users that they are immersed in a synthetic space" (Ellis, 1994).

This study will deal with virtual training environments as desktop-based environments connected locally or over the cloud to deliver simulated and realistic IT networks to trainees. Ideally, the virtual training environment is not part of the live operation network. This distinction will allow trainees to receive the complete experience of hand-on-training without the fear of interrupting operations.

B. ESSENTIAL ELEMENTS

This section highlights three elements that, through research, are determined to be important when creating virtualized training environments. The three elements covered are human and computer elements, user environments, and media richness. When studying examples of training, these three elements suggest potential areas of improvement.

1. The Human Element of Human-Computer Interface

Any software or hardware enabling the interaction of computers and humans is understood to feature a Human-Computer Interface (HCI) (Webster, n.d.). The human side of HCI concerning CANES training is the Sailor. The human portion of HCI is a challenge for any training platform as no two Sailors are the same; therefore, each Sailor's learning capacity is different. When designing a CANES training environment, we must consider the various skill levels of all IT Sailors. Historically, organizations create training with a one-size-fits-all mindset where all Sailors go through the same training. As stated before, no two Sailors are alike, and therefore we cannot expect the same level of understanding from all Sailors when training is complete. CANES training must be designed so that the software matches the learning capacity of each individual Sailor. Creating CANES training that addresses all humans and the computer side of HCI is a true challenge and should be studied further.

2. Environment

Merriam-Webster defines "an environment" in two ways; both are relevant to this study. The first is a person's surrounding conditions, and the second is the interface of a computer where performing tasks occurs. (Merriam-Webster, n.d.) The Sailor's training environment is another element that should be a consideration when designing training. As an example of surrounding conditions, in a traditional classroom setting Sailors are all gathered into one location and all learn how to administer CANES simultaneously. The location is new, unfamiliar, and can cause the environment to be intimidating for some Sailors to learn, lessening the training experience. However, suppose the dynamics of the environment could be changed by letting the Sailor conduct training virtually from his or her ship. In that case, it would be less intimidating for the Sailor, allowing them the chance to get more out of the training. An example of an interface environment is a desktop terminal by which the Sailor could train. Classroom training typically teaches with baseline versions, while training virtually could afford the Sailor the ability to training on his or her current version of the software. Changing the location from classroom to virtual not only impacts surrounding conditions but also affects interface environments.

3. Media Richness

Media Richness is described as "the ability of information to change understanding within a time interval" (Daft and Lengel, 1984). Transactions of communication requiring a more extended amount of time versus shorter periods are the determining factors for labeling information low or rich in media. Shorter periods equated to communications being rich while more extended amounts of time are low (Daft and Lengel, 1984). As applied to CANES training, media richness pertains to the learning capacity delivered by the virtual environment. Training in a virtual environment in which the Sailor gets hands-on training from a direct simulation of their network, the media is considered richer. Unlike classroom training learning, learning from a book with no hands-on training, or practicing on a baseline version of CANES, the Sailor will be more invested in training because they can relate, making the training rich with information. After all, the simulated networks are relatable to their working environments. Media richness theory was created in 1984 by Richard L. Daft and Robert H. Lengel 1984 and was used to measure mediums of communication of their richness. Table 3 is also a scale designed by Daft and Lengel and measures mediums of communications consisting of face-to-face, telephone, written, personal, written formal, and numeric formal.

Table 3. Characteristics of media that determine richness of information processed Source (Daft and Lengel, 1984)

Information Richness	Medium	Feedback	Channel	Source	Language
High	Face-to-Face	Immediate	Visual, Audio	Personal	Body, Natural
	Telephone	Fast	Audio	Personal	Natural
	Written, Personal	Slow	Limited Visual	Personal	Natural
	Written, Formal	Very Slow	Limited Visual	Impersonal	Natural
Low	Numeric, Formal	Very Slow	Limited Visual	Impersonal	Numeric

C. VIRTUALIZED TRAINING ENVIRONMENTS IN USE

The U.S. Navy has already recognized the problem with sending Sailors to CANES administrator training and has taken steps to address those challenges. This section evaluates two advances the Navy has made in virtualized training and its use for training Sailors to operate and maintain CANES. This section also identifies examples of existing virtualized training environments from other services. Some examples address CANES specifically, and others address virtualization in use by other services.

The DOD utilizes desktop virtual training environments currently to aid in network training. One example is the virtual network simulator (VNS) utilized by United States Strategic Command (USSTRATCOM). USSTRATCOM, as a unified combatant command, utilizes the functions of VNS to help protect information systems and networks for which they are responsible. Primarily it provides USSTRATCOM to test the full effects of computer network operations (CNO) across all levels. Also, VNS is used to train personnel in computer network defense (CND) to assist in the pre-recognition of computer network attacks (CNA) (Fellows, 2004). USSTRATCOM's VNS is relevant to this study as it proves that utilizing virtual training networks can positively impact training. Additionally, VNS's ability to simulate network attacks is a reference that should be modeled after when designing CANES virtualized training for ITs.

In 2017 the management office completed a pilot run of a virtual training session teaching fifty Sailors onboard USS Mount Whitney, the Seventh Fleet Flagship. "Virtual Environment for Training" (VE4T) proved that remote training of CANES is possible (Jackson, K. 2017). This is an example of existing virtualized training comes from the Navy's tactical networks program management office (PMW160). Projected successes from the pilot include the possibility of increasing the number of students who would typically receive CANES training in a classroom from 240 seats to 840 seats virtually. This increase in numbers performed virtually will also save the Navy in travel costs and periderm typical associated with this type of training.

The final and most closely related example is a recent collaboration between the Navy's program management office for tactical networks and the civilian sector. In

December 2018, Deloitte Consulting LLP was awarded a $23,041,113 contract to create the Navy's Training Virtual Environment (TVE) to be delivered by 2023 (DOD, 2018). Together with PMW160 and Deloitte are creating a training environment that provides a training capability. Deloitte is extremely optimistic about this training environment(Deloitte, 2020). TVE will provide three core capabilities to support the Sailor's learning experience. It is scalable, accessible, and adaptable. By "adaptable," Deloitte means it has the capability of supporting both training and troubleshooting.

In San Diego, California, in 2020, the United States Navy, the Program Management office PMW160, and Deloitte Consulting LLP members completed a pilot program onboard the USS Ronald Reagan (CVN-76). It addressed the challenges of getting Information System Technicians to traditional in-classroom training while providing realistic and relevant training to the fleet. It also demonstrated the ability to provide onboard training to CVN-76 and facilitate the training remotely in a virtualized environment. Utilizing CANES TVE, a Sailor can select the components of CANES that make up their system and conduct training (Fuentes, 2020).

Research indicates that the CANES TVE pilot developed by Deloitte is the new standard for CANES virtualized training. The goal of the TVE is to allow Sailors assigned to different platforms, operating different versions of CANES, to receive version-specific training. Also, as per the article in UNSI News, virtual training for IT Sailors can receive one-on-one training from an instructor in the virtual environment directly from the laptop (Fuentes, 2020). Once they log in to the system via laptop, they select their version of CANES and the ship's platform they are on. Because it is the technology that enables TVE to be successful, it was essential to study it a little closer. The study of TVE revealed that it is abundantly reliable upon cloud-based services, specifically Amazon Web Services. Additional research indicates that the technology is computer-centric, meaning the focus is on technology, not the human trainee. Research moving forward will be looking for potential areas to apply emerging technology to address the human-centricity gap and identifying other gap areas in CANES training. The appendix provides a list of the technology used in CANES TVE identified in this research.

IV. UNDERSTANDING THE PROBLEMS AND SOLUTIONS

This chapter introduces the stakeholders who are responsible for the procurement, installation, operation, maintenance, and training of IT Sysadmins both internal and external to their ship. This chapter will then outline the problems encountered by each of these groups of stakeholders with the current training model through a synthesis of the literature. The identification of the gaps will expose the main complaints, pain points, and problem areas of CANES IT Sysadmins and where their training options are falling short.

A. STAKEHOLDERS AND GAPS IT SYSADMIN PREPARATION

There are several organizations that execute various missions within the domain of Command Control Communication Computer and Intelligence (C4I) within the Department of the Navy (DON). However, in this thesis we will limit our focus to four stakeholders. The first is the designated IT Sysadmin and all other ITs who are responsible for the operation, maintenance and troubleshooting of critical system functionalities and anomalies. The IT managers are the second stakeholders whose responsibility it is to conduct the administrative and managerial duties for the IT division. They are also responsible for selecting the next round of the most qualified candidates for schoolhouse training on CANES. The third stakeholders are the Fleet training entities who are responsible for education and training as well as assessing the capabilities of the IT Sysadmins while they continue to train on CANES in scenario-based environments. The PMW 160 program manager is the fourth stakeholder. The PMW 160 program is responsible for the procurement, delivery, and installation of CANES. They also provide all of the necessary technical support to the CANES enabled ships.

1. IT Sysadmins/Shipboard Personnel

Currently, as discussed in Chapter II, students selected for CANES Sysadmin training who meet all prerequisites travel to Virginia or California to undergo a four-week training program. Although the prerequisites have been met by every student, there is a wide variability of experience within the student body. Remedial training is offered to students who fail written examinations or computer-based assessments. If the sailor continues to struggle to pass performance evaluations despite the added support, the student goes before an academic review board (ARB) who decides whether or not they will be allowed to continue the training. If the student completes the training, they will be awarded the NEC and carry the status of CANES Sysadmin. This graduate will then be expected to be the subject matter expert at their next duty station and bear the majority of the OJT responsibilities to those new to CANES.

Four different profiles of ITs can benefit from a virtualized training environment. Understanding these profiles highlights gaps they face: not being able to get training continuously onboard the ship, learning concerns within the schoolhouse, on-the-job-training (OJT), and a permanent solution to not require to send ITs to school once training becomes obsolete. The first profile is the Sailor who recently enlisted and successfully completed IT “A” school and is on their first enlistment. This Sailors opted to sign on for the six-year vice four-year term and if available could be offered an enlistment incentive. CANES Sysadmin training will be attended enroute to their duty station. Virtualized training is needed due to the lack of “hands-on” experience as the schoolhouse is their first exposure to CANES in an CBT environment and needs to mirror as close as possible the CANES network on their ship the second profile is the Sailor who reported onboard and has received all CANES Sysadmin training via OJT from a Sysadmin. If they are selected based on merit and critical manning requirements, they are sent to CANES Sysadmin training. They are in need of virtualized training because the quality of training could vary and the virtualized training would provide a baseline.

The third profile includes the ITs who require remedial/corrective training. These Sailors did not successfully pass the curriculum for CANES but are still required to report under the Sysadmin billet, while not yet fully qualified. These Sailors are in need of virtualized training to correct deficiencies and perform critical tasks required for the NEC without having to go temporary assigned duty (TAD) again to the schoolhouse. Lastly, the fourth profile is the ITs who have been awarded the NEC and require differential training because the version of CANES they trained on is not the same as the one they must now use. These Sailors need virtualized training to stay current on all baseline upgrades regardless if they pass or fail CANES Sysadmin course.

An article published in 2018 during the USS George Washington's (GW) refueling complex overhaul (RCOH), provided insights into to the experiences of IT staff and CANES Sysadmins. This article shared sentiments from the ship's crew. The crew's positive comments about this training opportunity also revealed a perceived lack of ownership and limited hands-on training from previous experience working with and managing CANES. In the situation the article described, the ship's network was transferred to an onshore facility while the ship was undergoing a maintenance phase. Under normal circumstances, CANES would be powered down or, at the very least, not 100% accessible to the crew during portions of this phase. This anomalous setup allowed the CANES Sysadmins to continue training, troubleshooting, and repairing the network in operation during a time when most ship systems are shutdown. The unique benefits increased the length of time the network was available which resulted in increased practice. The GW's IT department was able to continue training on their actual network and not a "mock-up" which allowed the CANES Sysadmins the opportunity to maintain security posture and also save all current configurations. This capitalized on time and energy spent to resolve problems and was an investment into the ship's IT department.

The perceived lack of ownership on CANES in preparing the Sysadmin is related to the lack of full and complete knowledge, access and responsibility of the network. Part of the Navy's culture and traditions is for Sailors to take full ownership and responsibility of the systems that are assigned to them within an IT division. In Chapter II the duties of the Sysadmin were detailed. One of the most important duties is to be able to perform all maintenance on CANES, which includes providing Computer Network Defense (CND). The shipboard personnel do not have the permissions to manage the Host-Based-Security System (HBSS) and the McAfee Agent and ePolicy Orchestrator (EPO). This training has not been integrated into the training for CANES Sysadmins. Even within the structure of the four tracks of IT training, this area of expertise on CANES takes years of experience. The IT manager onboard the USS George Washington stated, "We really took the time with this because we want to take ownership of our system" (Vujevich, 2018 para. 6). A full sense of ownership is not possible if the CND suite is not a part of the Sysadmin's responsibilities and all maintenance, repair and anomalies are managed by the PMW 160.

An additional perceived training gap that was gathered from this article is that computer-based learning is inefficient and Sailors receive no "hands-on" training on the actual CANES network (Thie, 2009, pg. 19, para. 3). Information Systems Technician Seaman Jacob Grella, a member of the CANES division onboard USS George Washington participating in the "hands-on" training at the NAVWAR facility stated, "My favorite part is really getting hands-on experience," (Vujevich, 2018). The lack of hands-on experience results in many ITs stating they do not feel adequately prepared to assume the duties and responsibilities as a Sysadmin when they report to their ship (Thie, 2009) An additional gap is that the training software may not mirror the baseline, version and upgrades that the Sailors would see in their shipboard versions. While in this training environment the Sailor does not have the ability to "touch" the equipment.

One of the benefits of getting orders to go on TAD is the ability to have dedicated time for instruction without interruption. The uniqueness of administrating CANES in a shipboard environment is that fulfilling the duties can compete with other watch-bills that must be fulfilled underway or in port due to manning and qualifications. This is based on the workweek, preventative maintenance, corrective maintenance and supporting efforts as dictated by divisional leadership (Thie, 2009, pg. 13). The challenges make it difficult for the Sysadmin to perform all of his or her maintenance, and coordinate with shore-facilities for additional technical support. The work required for maintenance could at times exceed the work-day. If the Sysadmin has limited availability, it makes it difficult to acquire or provide quality OJT and makes it impossible to become a subject matter expert (SME) on other components within the IT rating that require similar skills and experience. This could adversely impact the Sailor who is following the second training track, relying entirely on OJT training.

In general, a comprehensive review conducted by the Navy found that many of the fleet's forward deployed ships crews were overworked, undermanned, and lacking in training (Olsen, 2017). This theme was also noted during the RAND study which draws the conclusion that a changing technological landscape could reduce the manpower required to operate CANES and minimally impact underway shipboard conditions (RAND, 2009, pg. 16). This is accomplished through the increasing reliance and opportunity to administer and support CANES virtually from shore. As a result, a lot of knowledge, capacity, and skills regarding daily operations held by the CANES Sysadmin goes unexercised. These sentiments are echoed by the CANES Sysadmins above.

2. IT Managers

The gaps from the IT Manager's perspective are understood from the literature and informed by analysis of the thesis author's experience. The IT Managers, Leading Chief Petty Officer (LCPO) and Division Officer (DIVO) have the responsibility to decide what ITs to send to CANES Sysadmin Training. The DIVO onboard the USS George Washington stated,

> I like the unique opportunity we've been given right now with [Space and Naval Warfare Systems Center] (SPAWARSYSCEN) Atlantic where [George Washington] gets to send some of the best and brightest our Navy has to offer over to the CANES lab. Nothing they've learned is taught in any schoolhouse or any Navy Knowledge Online course. (Vujevich, 2018, para.4)

Although talent and abilities to perform well are a strong determining factor there are many additional factors that must be weighed prior to sending an IT to CANES Sysadmin school. The first consideration is the projected rotation date (PRD) and time left on the IT's enlistment. IT Managers want to ensure they will be able to get the Sailor back onboard with enough time for a return on investment (ROI). The next factor is ensuring the Sailor is going to successfully pass the course and has the aptitude to be able to adapt and learn quickly. When these personnel are sent TAD the division must be able to perform the mission in their absence. A loss of one or two key personnel should not hinder the performance of the IT division.

Within the IT Managers the LCPO is the only technical expert who has had the opportunity to work on the systems their Sailors operate and can lead accordingly and provide technical insights. Unless the LCPO or the DIVO received specialized training, they are and have only learned about the nuances of CANES from the perspectives of their

Sysadmins and can be able to brief to leadership the ongoing concerns and issues. They are faced with the challenges of managing a CANES network while themselves having limited knowledge of CANES. Having a networking or computer science background is an excellent framework but does not teach you the skills that your Sailors will require to be proficient.

The operation tempo (OPTEMPO) of each ship can be highly demanding and require that the IT Managers have a rigorous training plan implemented and executed despite the requirement and unplanned schedule changes. Shipboard life is unpredictable. The IT Managers must ensure Sysadmins receive the intensive amount of OJT required to perform in an uncertain operational environment. Failure to meet the mission through failed equipment and/or improperly trained personnel can be viewed as a mismanagement of time and personnel. Having access to a 24/7 virtual training environment would reinforce CANES Sysadmin training.

3. Training Entities (Navy-wide)

The training commands that are relevant within the IW enterprise are the Information Warfare Training Command (IWTC) and the Afloat Training Group Pacific (ATGPAC). Within the Information Warfare (IW) enterprise, Commander, Naval Information Forces (NAVIFOR) mission is to provide an agile, technically superior manned, trained, equipped and certified combat ready IW forces (Commander Naval Information Forces [NAVIFOR], n.d.). The major complaints and or pain points from both of these stakeholders are the lack of innovation and non-existence of emerging technology used to facilitate CANES Sysadmin training. Additionally, the Sysadmins have a lack of familiarity with non-routine or more complex tasks and the unit's operational schedule and length in between focused training reveals a lag or expiration of skills required.

a. Information Warfare Training Command (IWTC)

IWTC is a subordinate command under the Naval Education and Training Command (NETC). Their vision is to remain the global leader in rapid development and delivery of effective, leading edge training for Naval forces (NETC, n.d.a). The strategic goals for this training command are in line with higher headquarters mission statements.

In-person or “schoolhouse” training groups face their own challenges in executing their mission to train the ITs and deploy them into an operational environment. The Fleet receives the best results when force development is implemented alongside and aligned with strategy. The pain points experienced by this stakeholder is having full ownership of training the Sailors and ensuring that the Fleet understands how to unlock the highest potential of the courses offered through rate-specific training apprentice/journeyman and master-level training (NETC, n.d.).

It is not the responsibility of the schoolhouse to choose which Sailors attend the CANES Sysadmin training. The schoolhouse does however set the prerequisite training to ensure that the Sailors have the minimum required foundation to be successful within the training track. Many of the complaints from Sailors state that they were not adequately trained during the course of instruction. Feedback from the CANES Sysadmins revealed many of the students would not categorize the computer-based training as an optimized learning environment with the integration of emerging technology, artificial intelligence or machine learning (NETC, n.d.). This has been proven to be critical capabilities that do not currently exist and should be augmented in the CANES Sysadmin interactive courseware and simulations.

The implications of COVID-19 were briefly addressed in Chapter I. Restricted movement of personnel during the pandemic resulted in the Navy need to address more innovative approaches to providing instruction (Lundquist, 2020). Although some training commands were able to maintain the same number of Sailors through their curriculum, a high number of students coming from the Fleet faced difficulties. Chief Technology Officer (CTO), Jefferey Temple is working with the Office of the CNO to sponsor learning centers to implement the Surface Training Advanced Virtual Environment to develop and integrate training labs, devices and simulations (Lundquist, 2019, para.10). The goal is to ensure that training can be provided to the Fleet sailors while protecting Sailors and their families. During the height of the pandemic this virtual environment could have been deployed to ships that were extended on deployment due to operational gaps. This extended time cuts into the ship’s maintenance availability and training cycle.

b. Afloat Training Group Pacific (ATGPAC)

ATGPAC provides dynamic, quality afloat training to Sailors to ensure a combat-ready force capable of performing a broad spectrum of maritime missions. ATGPAC employs a group of senior enlisted Sailors who provide assessment, training and certification in 18 mission areas (U.S. Pacific Fleet Public Affairs, 2017). ATG is responsible to provide basic training as outlined in the Surface Force Training Manual. The mission area that is assessed during the basic training phase for ITs is the Comprehensive Communications Assessment (CCA) or normally referred within the IW community as "Chuck-Chuck-Chuck" (CCC) warfare area. During this assessment the goal is to provide a thorough look at the ship's communication readiness and identify common deficiencies (Surface Forces Training Manual, n.d.). The services that are provided on CANES are an essential part of the readiness assessment by ATG. The CANES Sysadmin has to be able to demonstrate all of the tasks as required by the assessor.

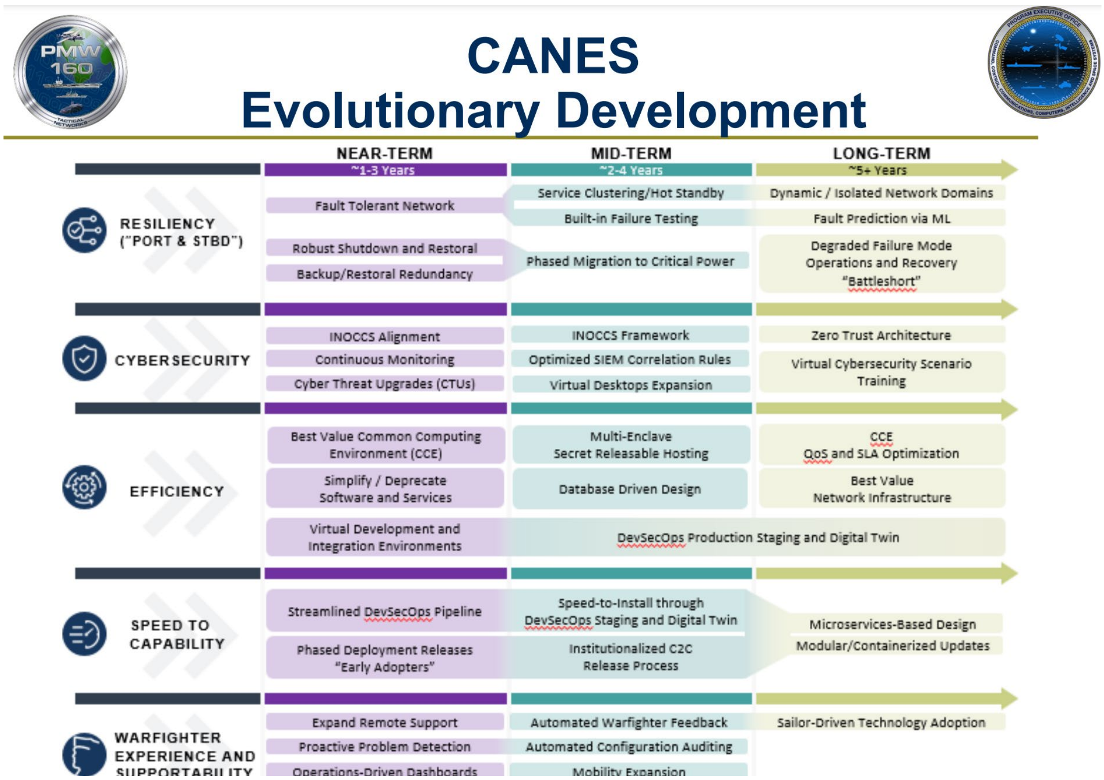
The results of the ATG assessments and previous inspections conducted by the ship's ISIC have shown that the Sysadmins lack familiarity with many of the non-daily, more complicated tasks. Many of the scenarios involve tasks that are rarely done but need to be trained to in case of an emergency or unplanned outage or anomaly. For example, one instance would be responding to a malware attack. The assessors along with the Command Assessment Team (CAT) would have the scenario approved by the training team and all responses will be "simulated."

Additionally, the timing of the ATG assessment could reflect the ship's OPTEMPO and reveal how much time the ship has to work through the self-assessment sheets for the CCC warfare area. This also affords an opportunity for the ship to work with the entities outside of the ship to remedy trouble-tickets and casualty reports (CAREPS) that will affect functionality and not be able to be assessed during the visit. The results of the ATG assessment also reveals the lag or expiration of skills while the focus was on providing 100% access with minimal downtime and scheduled maintenance. The ATG Assessment team will correct deficiencies and, in some cases, allow the ship to re-train on areas they did not meet.

4. Program Manager (PMW) 160

PMW 160 Tactical Afloat Networks cadre of professionals serve as the technical experts for any issues dealing with CANES operation, maintenance and cybersecurity posture. According to the Tactical Networks Program Manager Robert Wolborsky, "CANES is the culmination of the lessons learned in developing, producing, fielding and supporting all of the backbone networks on ships and subs. In developing the requirement for CANES, we had intense interaction with the fleet to inform users and gather requirements" (Anderson, 2009). In the operational environment when the CANES Sysadmin discovers features of the network are not functioning according to baseline or unable to resolve an issue the ship can submit a ticket to the NAVSUP Consolidated Help Desk. They route the trouble-ticket number to the appropriate contact senior advisor and to a contractor within PWM 160 (NAVSUP, n.d.).

The government civilians (GS), contractors comprised of engineers and technicians, are experts on CANES. The DON branch lead for PMW 160 outlined the afloat network core drivers: the ability for Sailors to fix their system, ability to defend and fight cyber, and manage rapid updates to the system (Boehme, 2020). Through the employment of DevSecOps, PMW 160 is able to plan, develop, build, test, release, deploy, via automation to the CANES Sysadmin to monitor (PMW 160, n.d.a). This delivery pipeline does not inject the feedback from the Sysadmin until the configurations are available on their CANES network. Although there are Fleet feedback addresses via a Fleet Stakeholder Working Group, the trends in trouble calls/CAREPS and urgent fixes (Boehme, 2020). Input from the user is not voiced unless there is a compliance concern and a trouble-ticket opened. Automation is built into CANES to decrease the "hands-on" requirements for maintenance. Additionally, a reporting feature is included to assist IT managers and leadership with the opportunity to view system status, health and compliance with baseline. Figure 2 shows the phases of CANES development from near-term to long-tern.



Note: Warfighter experience should increase and supportability decrease over time

Figure 2. CANES Development Source: Boehmes (2020).

This chapter identified the training concern for CANES through the lens of each stakeholder. This covered all aspects of the CANES success from a Commanders perspective of coordinating and executing installation of the CANES network. Ensuring there is enough personnel to operate this system and overflow to gap while more Sailors are awarded the NEC and fully qualified. The goal is to have this system operating at peak proficiency to support other critical systems. The themes that were identified were a lack of "hands-on" training and ownership, manning and performance concerns, ship's crew unfamiliarity with rogue scenarios, lack of innovative virtual environments and automation of delivery. In Chapter V the idealized model will be introduced. The model is build using components that address and solve the issues identified.

V. IDEALIZED MODEL

In all the research conducted in Chapter IV, two areas of concern stand out when it comes to ITs that are not in any way through any fault of their own: lack of ownership, and lack of hands-on experience with CANES. This chapter suggests a solution that gives Sailors a sense of ownership in CANES and provides much-needed hands-on experience through simulation training in a virtual environment. It proposes an ideal virtual training environment that combines previously used technology with new and emerging technology. The chapter also recommends a new training model that can meet the needs of each Sailor. The following section defines why a new training model should be developed. Later in the chapter describes researched and proposed elements of the ideal model to include environment, oversight, and selected emerging technologies to benefit the system design. The proposed model might supplement or eventually replace current training pipelines, and its purpose is to serve as an option when other sources are not available. Finally, this chapter concludes by presenting a diagram of the model and describing how it works.

A. WHY DEVELOP THE IDEAL TRAINING MODEL?

This section's purpose is to describe why virtualized training environments are essential before later moving on to define the ideal environment. The most basic and practical benefit of virtual training environments is the ability to conduct training remotely. Students at Naval Postgraduate School benefited from this greatly after the spread of COVID-19. Requiring fewer local resources is another benefit that is specific to the user. Thanks to cloud technology, users can store documents, programs, and emails on a remote server freeing up disk space and utilization on personal computers. Virtualization enables business to be conducted from virtually anywhere worldwide with access to a broadband connection as the only limitation. This manner of virtualization training can and will benefit the fleet in training ITs.

Traditional in-person classroom training presents some drawbacks to students. An article from the University of Texas outlined some of these (Srinivasan, 2020). One of those challenges is social inequities amongst students, which are unavoidable in face-to-face classroom sessions. For example, seating selections can produce unintended biases amongst teachers and students. Students who select a front-row seat could inadvertently imply they are more interested in learning than those who select a seat in the back row. Virtualized classroom settings remove this potential bias as all students are on equal ground (Srinivasan, 2020). Srinivasan's article provides a variety of examples of how virtualized environments can positively impact students in classroom settings.

COVID-19 forced students here at NPS to transition to online virtualized classes, and more research is required to determine how it impacted students who made the transition. NPS's transition to virtualized training proves that the United States Navy will adapt and evolve to match private-sector best practices and trends whenever possible. However, the private, unconstrained by the DOD policies, can take full advantage of technologies unafforded to the U.S. Navy. The following sections will bring together some of the technologies described in earlier chapters to represent the ideal virtual environment.

B. DELIVERY, ENVIRONMENT, AND OVERSIGHT

This section introduces the proposed delivery method of the ideal virtual training environment on board the ship. It speaks to the ideal environment of a Sailor in training to provide the best atmosphere for learning. Finally, it describes who has oversight of the environment and responsibility for ensuring Sailors are trained.

There are multiple ways to deliver virtualized training environments. For this study, cloud-to-ship delivery is preferred based on the ready, available, and accessible technology from almost anywhere globally. Delloite's TVE delivers its environment over the cloud with laptops and a broadband connection. For ships at sea, access to a ready and stable connection may not be viable and perhaps a localized installation of the virtual environment is more beneficial when such access is limited. However, a local install would require dedicated server space with enough storage and memory capacity to support it, and again, this may not be ideal for every ship as server rack space is limited. Another benefit of cloud-to-ship delivery is that it may allow for remote assessments from stakeholders such as ATG to take place when face-to-face visits are not an option. Chapter VI conducts a thought experiment that details a scenario of how this type of remote assessment may be possible. For the remainder of this study, the emphasis is on utilizing cloud-based technology to provide the most exhaustive possibility of use.

Chapter III lists environment as one of the key considerations when designing a virtual training program. By placing the Sailor (human) in a comfortable environment, with information-rich training for each student, the potential for more positive results is significantly higher. However, the current model of sending students to unfamiliar environments could create an atmosphere that is not ideal for some students to thrive. The proposed solution is to conduct training virtually on the ship via a laptop or dedicated workstation with internet access. Doing this places the Sailor in a familiar environment, free from any social distractions of other trainees. As each ship is different, the physical location of each Sailor differs based on space availability. Preferably, the Sailor is in his or her work center and learning the system in the exact space whey he or she will be using it Ultimately, final decision to hold training in the IT shop, ship's library, or training office is the decision of IT management and the training officer.

All aspects of training that take place onboard ships are the responsibility of the training officer. Though not responsible for the delivery and execution of training, they track who is assigned and their training progression via the Departmental/Divisional Training Petty Officer (TPO). The Departmental/Divisional TPO would manually log and track Sailors' progression throughout the virtualized training. They would be responsible for ensuring IT management update the trainee's progression, areas of struggle, and completion of training. IT management is responsible for determining which Sailors partake in training. Management's emphasis is on the necessity of obtaining and reaching shipboard NEC requisites. Sailors assigned to training would work independently, updating the TPO on their progress by delivering a progress report generated from the system.

C. SYSTEM DESIGN, SELECTION OF EMERGING TECHNOLOGY

In designing a proposed system, the research looked at emerging technologies used in private and government agencies. By first evaluating the technology used in TVE, it was apparent that TVE relied upon cloud-based services, specifically Amazon Web Services.

This emphasis of TVE on technology suggests that, with respect to HCI, the emphasis appears to be on the computer, not the human. This assumption does not minimize the work of TVE in any way; as stated before, it is the new benchmark for measuring all future iterations of CANES virtualized training. The following sections introduces emergent technologies that can enhance training capabilities and possibilities that focus on the human aspect of HCI.

Through evaluation of TVE, its technology, and essential elements of idealized virtual training, this research has identified four emerging technologies as potential benefits to training: adaptive learning technologies (ALT), artificial intelligence (AI), machine learning (ML), and dynamic parameters. AI and ML can reduce the need for human interaction, and in this case, can reduce the need for the instructor. AI could potentially facilitate effective individualized training instead of one instructor leading multiple students. Also, ML collects and parses data; thus, it can collect data on the student as they progress through training. Combined, AI and ML could produce immediate grading and evaluations of student performances. Implementing ALT and dynamic parameters in combination with AI and ML would allow the student to receive immediate feedback. In addition, the system automatically adjust training to address any shortcomings. The potential benefit is that utilizing these four pieces of emerging technologies could potentially free up man-hours from instructors and provide the ability to provide personalized, tailored instruction to all students. A more detailed description and definition of all four technologies are in ensuing paragraphs.

a. Adaptive Learning Technologies (ALT)

> Adaptive learning enables the delivery of personalized learning at scale.
>
> —Educause, 2017

Historically, computer-based training (CBT) is generally cookie-cutter in nature. When students sign onto a training system, they see replicas of the same training material. Replicative and repetitive training is ideal if we live in a perfect world where everyone learns in the same manner. Unfortunately, we do not live in a perfect world, and no two human beings are alike; thus, they all learn differently. Adaptive learning systems look at the learner's data and dynamically adjust training to match their performance level (Educause, 2017). ALT is an essential concept if the desire is to provide training that is thought-provoking to all students. ALT could resolve the dilemma of having Sailors fall behind in the schoolhouse because it adapts to the student's knowledge level. ALT also enhances the training's informational richness because the training is more relatable to the student.

b. Dynamic Parameters

Dynamic parameters refer to altering or changing conditions in a training environment to meet the session's desired outcome. Dynamic parameters are described in a study titled "An Intelligent Virtual Environment for Training with Dynamic Parameters" (Steshina et al., 2020). It describes how a system may rebuild the training environment using dynamic parameters if a user takes too long to complete a series of task. Time is just one parameter, but in this manner we can see how using dynamic parameters could tailor training to an individual user's needs instead of only offering a one-size-fits-all approach. Figure 3 is the Model of Control System for Training Program (MCSTP) that illustrates the adaptation of a training program to meet a user's needs (Steshina et al., 2020). Notice how it is a causal feedback loop; as the operator enters the immersive environment, the platform evaluates their performance. After the initial evaluation, it changes parameters and adjusts the complexity before generating a training program. This MCSTP model is the inspiration for the ideal system design proposed for CANES virtualized training in the next section.

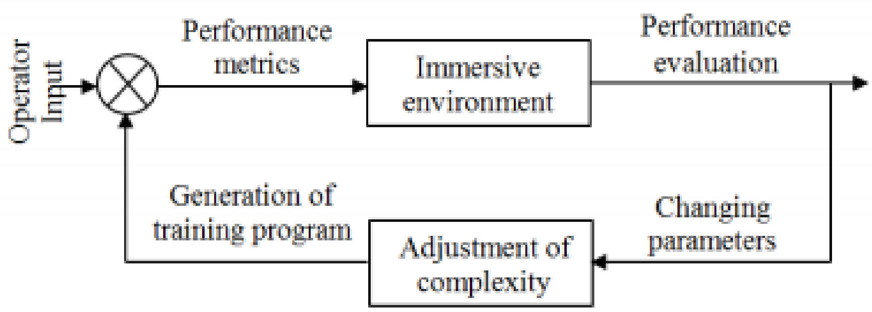


Figure 3. The Model of Control System for Training Program (MCSTP).
Source: Steshina et al. (2020)

D. IDEALIZED VIRTUAL TRAINING MODEL

The ideal model is a combination of the cloud technology utilized in Delloites TVE and the identified areas of emerging technology. The training is delivered via the cloud to the ship, allowing the training officer, TPO, and assessors to monitor both locally and remotely. Figure 4 illustrates how the ideal shipboard virtual training environment should work.

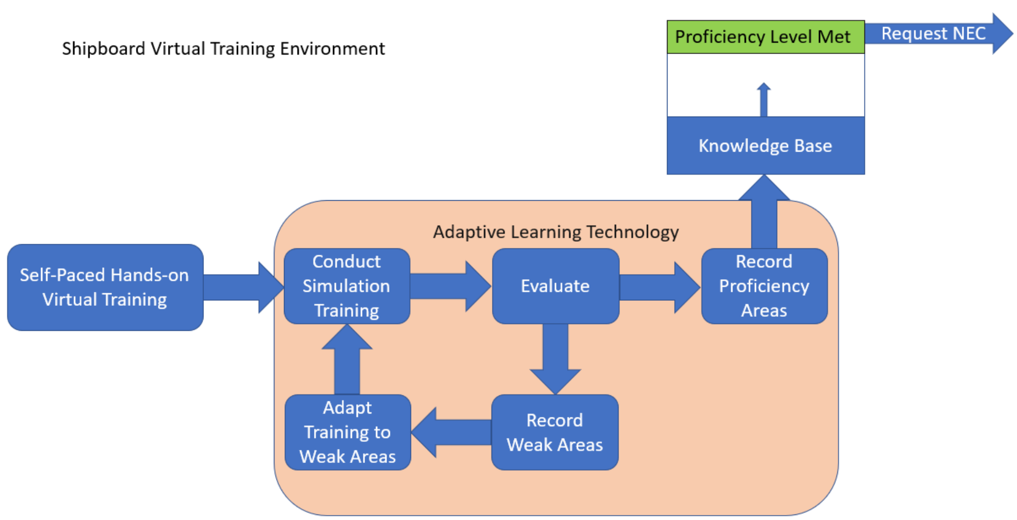


Figure 4. Ideal Shipboard Virtual Training Environment

Hosted in the cloud, the complete and delivered package of the ideal shipboard virtual training environment includes the following components. It includes dedicated computer terminals for Sailors to conduct training on. Not connected to the operational network, these terminals reside on a network of their own. Once a Sailor logs onto the computer and creates an account, they are presented with options to select their class of ship and version of CANES. Their training area populates with a list of training modules they must complete. Module 1 is Canes Introduction and, for obvious reasons, is the easiest of all modules to complete. Module 2 teaches Sailors all aspects of account creations to include standard naming conventions. Module 3 covers the sequences of events that must happen to start up and shut down the network correctly. Module 4 shows the Sailor all the intricacies of backing up and restoring a network. Module 5 teaches the Sailor how to protect their network by showing them how to configure firewalls and virtual private networks properly. Module 6 continues the theme of protection as it goes into proxies, and Module 7 ends the modules with a lesson on server management best practices. Table 4 lists each of module and provides specific goals intended for Sailor's to learn.

Table 4. Proposed Modules in the Ideal Virtual Training

MODULE	GOALS
Module 1 - Introduction	Introduce the Sailor to CANES providing a brief overview of the system.
Module 2 – Account Creation	Teaches Sailors all aspects of account creations including DOD and Navy standard naming conventions.
Module 3 – Start-Up and Shutdown Procedures	Fully understand the sequence of events for shutting down the system and what key elements to check for when starting it up.
Module 4 – Back-Ups and Restores	Understand the different types of back-ups and when each should be used.
Module 5 – Firewalls and Virtual Private Networks	The Sailor will learn why firewalls and VPNs are important to network security. The Sailor will also learn how to properly configure both for optimal operations.

MODULE	GOALS
Module 6 - Proxies	Learn why proxies are important to and how to properly configure them optimal performance.
Module 7 – Server Management Best Practices	Sailors will learn a series of best practices adapted for his or her version of CANES. Included in the list of best practices are methods designed to reduce and conserve bandwidth utilization, minimize expired accounts, and preserve disc space utilization amongst other key areas.

As the Sailor conducts simulated training, the system evaluates their progress for proficiency and areas of weakness. After identifying these areas, the system displays the results in the profile dashboard area. When discovered, areas of weaknesses initiate an adaptation of training to focus where the Sailor needs help. After the training is adapted, the Sailor repeats the training cycle and completes a new evaluation. When the system records areas perceived as proficient, it marks the module as complete and adds it to the knowledge base box. When the Sailor completes all modules and the knowledge base box is full, the system generates an NEC request and sends it to the training officer. This model allows Sailors to work through the training at a relaxed pace and delivers focused training to suit their needs. The next chapter conducts a notional thought experiment to study the ideal model even further

VI. NOTIONAL THOUGHT EXPERIMENT

This chapter tests the new, ideal model introduced in Chapter V through the use of a thought experiment. The overarching scenario is on board a guided-missile destroyer where the ideal shipboard virtual training environment is accessible through the cloud and implemented with the new adaptive learning model. The ship faces two challenges. First, the training officer has advised the IT department of an NEC shortage. Sailors must obtain the CANES NEC to meet minimum shipboard requirements. The shortage of NECs is not due to improper planning by the training officer; they paid for and sent two Sailors to CANES school in San Diego. Unfortunately, one of the Sailors who attended the schoolhouse training could not pass the final exam and did not obtain the NEC. Second, the training officer informed the department of a scheduled visit from ATG two months away. The purpose of the ATG visit is to conduct a readiness assessment of the ITs on board and certify the ship for deployment. After the notification from the training officer, another global pandemic occurs, preventing ATG from coming on board to conduct the assessment; still, the ship must get certified to get underway.

Within the overarching case, the following two scenarios are hypothetical sequences of events utilizing the idealized virtual training environment to achieve both earning an NEC on the ship and conducting remote shipboard assessments. The experiment also evaluates the model variables in both scenarios for areas of improvement and applicability to real-world environments, and the following assumptions apply to both scenarios. First, the development of software containing simulation and training modules already exists in the cloud and is available for shipboard use. Second, training scenarios mimic the exact version of CANES installed onboard the Sailor's ship and it has a dedicated workspace for Sailors to conduct training. Third, the workstations utilized for training do not reside on the operational network; no threat exists of negatively impacting operations due to training. Finally, the divisional Training Petty Officer assigned the returning Sailor to the newly accessible ideal virtual training environment.

A. SCENARIO #1 SELF-PACED SHIPBOARD TRAINING FOR NEC

Petty Officer Thomas arrives at the dedicated training location on the ship and powers on the system. He begins by creating an account; much like any system, he creates a username, and password and enters information about himself such as rate, rank, and date of birth. Because this is his first time using the system, a virtual assistant guides him through the critical areas of the system. The assistant shows him where to find his training curriculum and the modules he must complete. It teaches him where to check his training progress, located in the user profile area. Upon completion of the introductory walkthrough, the assistant aids the Sailor in setting up his training environment. Before he can begin training, he must first select his ship's hull class and the iteration of CANES installed on his ship. He must know the exact version or run the risk of not qualifying to operate the operational network. Once the Sailor has selected the correct ship and version of CANES he is now ready to commence his training.

As training initiates, the assistant once again greets the Sailor and advises him that it is an AI named Shipmate and monitors his progress throughout the training. Shipmate explains to him how many modules he will need to complete and the expected amount of time to complete each one. He has seven modules to complete:

1. CANES Introduction
2. Account Creations,
3. Start-Up and Shutdown Procedures
4. Back-Ups and Restores
5. Firewalls and Virtual Private Networks
6. Proxies
7. Server Management Best Practices

The first module, led by Shipmate, gives a brief history of CANES, and concludes with the only multiple-choice test in the training. Module 2, Account Creations, begins with Shipmate demonstrating how to create an account while the Sailor watches, listens, and learns. Next, it guides the Sailor's actions as he creates an account. It tells him what to type, where to click, when he is correct in his actions, and when he needs to correct a mistake. Finally, Shipmate gives him instructions to create an account without assistance. As the Sailor types away, Shipmate and ML monitor his performance and record his proficiency level. Unbeknownst to the Sailor, this was a practical test of sorts, as he cannot advance from this module until he successfully creates an account.

After completion of round one of the first module, Shipmate presents the results to the Sailor and advises him of his proficient and weak areas. Round two begins with Shipmate giving another lesson, this time only addressing areas where the Sailor struggled. The Sailor's AI guides click-by-click once more and issues another challenge to the Sailor. This time the Sailor masters the skill of creating an account and completes the module. Shipmate records his successful progression in his profile dashboard and fills in the knowledge base box marking his completion. The remaining six modules are all completed in the same fashion as module two, watching, guiding, and doing. Because the Sailor is on the ship, he has watches and duties he must carry out. It took the Sailor four weeks to work his way through all the modules, as Shipmate is strict on training requirements. It does not give a pass when a deficiency exists in a Sailor's performance.

Even when the Sailor has completed all of the modules, his training is not complete. He must conduct a final practical exam demonstrating everything he has learned over the past four weeks. Shipmate sets the stage with a fictitious scenario: the ship has experienced a significant outage affecting the network. The Sailor must utilize everything he has learned the past four weeks to get the network operational before getting underway the following day. Once he restores the network, the ship welcomes Commander Task Unit 5, and he must create accounts for the Commander and his crew. He needs to make sure he adheres to proper formatting while he creates all accounts. Like the modules, Shipmate tracks his progression and presents him with a pass or fail upon completion, and automatically notifies the TPO of his score. As with the modules, Shipmate identifies areas of weakness and proficient areas. Shipmate addresses any areas of weakness by taking him to the appropriate module as before. If he is proficient in all areas, the system generates a "Request for NEC," sending it to the training officer for approval.

B. SCENARIO #1 ANALYSIS

Three areas for improvement or further consideration came up during the thought experiment. These areas include recommendations for administrative control management, improvements to system design, considerations for the final practical.

1. Administrative Control Management

The proposed design leaves room for error, and addressing this issue during the software design phase of the training is the solution. If not noticed, the Sailor can select the incorrect ship and version of CANES. In addition to the time wasted going through the wrong training, the Sailor must then put more time in conducting the correct training version. The recommendation is to adjust the software permissions giving administrative control to the TPO. Before starting the training, the TPO validates the class of ship and CANES versions. Taking it a step further, the Sailor requests validation through the system to the TPO requesting authorization to train. The TPO looks over the request to verify and approve.

2. System Design

Analyzing the system in this experiment identified another potential area of improvement. The assumption that all Sailors have zero experience is incorrect, and the fact is that some have significant experience and should not go through the entire series of modules. Applying an option to the registration process to select either a new or experienced CANES administrator enhances the system. Selecting "experienced" will present the Sailor with a knowledge assessment practical exam. The AI identifies areas of weakness, cutting down on the amount of time he or she spends in training.

Two areas have the potential to cause delays. The first is not mandating sequential progression through the modules. If new trainees are allowed to jump around with no particular order, they may skip a required lesson necessary to complete higher modules. The second is allowing the AI to be very stringent in the assessment process. If the AI fails every mistake, four weeks of training could quickly turn into four months. The recommendation is to build control options into the system. The options should consist of easy, moderate, and hard or some similar variances. The goal of the AI is to learn the student's weaknesses so that it can build their confidence, not crush their enthusiasm.

3. Final Practical

The final practical is where the training department can get the most value as this is the chance to add additional pressure by adding an audience. Adding pressure allows management to understand how the Sailor performs under pressure. If they cannot perform when in a safe training environment, how they perform at sea when systems are down, and the Department Head is hovering? One option is to mandate the Sailor take the practical with TPO or their Chief present. The final practical is when the Sailor can earn their NEC; having another set of eyes on the training as witnesses would validate their education.

C. SCENARIO #2 REMOTE ASSESSMENT

Luckily for the department, Petty Officer Thomas in the above scenario earned his NEC, and now meets minimum requirements. However, the ship needs to get underway, and ATG still cannot certify the crew because of the new pandemic. Seeing how well the ideal virtual training environment worked when Petty Officer Thomas conducted the final practical, the training officer has an idea. He suggests that ATG conduct the assessment inside the ideal virtual training environment. ATG can log into the system remotely and watch the crew perform live actions on the training network to satisfy certification requirements. ATG agrees to conduct the assessment remotely in order to accommodate during these times of restricted movement. The assessment takes place in two phases, a training phase followed by the assessment phase. The training officer configures the virtual network in manual mode and grants ATG trainers access.

During the training phase, ATG requires all ITs to be present while they teach the required material. Because cameras are not allowed in the training space, the training officer takes muster and verifies that all Sailors are present with ATG. While ATG is conducting training in the virtual environment, the ship's crew watches ATG's actions on a large monitor while ATG talks through a speakerphone. Everything seems to be working great; the instructors are asking questions, and the ITs are responding. However, to complete the ATG's assessment and certify the crew, they must complete a training scenario. ATG informs the training officer that they cannot certify the crew unless they can complete an assessment. The Chief, who recently watched Petty Officer Thomas earn his NEC, recommends the entire crew work through the final practical exam together. The Chief also understands that the system is hosted in the cloud which means that Sailors and ATG can be online at the same time. The Chief briefs that ATG can assess the team remotely and at the same time the AI can generate a report explaining both strong and weak areas of the crew. ATG agrees and watches the assessment remotely; they receive their report, recommend areas they need to improve, and certify the crew for deployment.

D. SCENARIO #2 ANALYSIS

Two areas for improvement or further consideration came up during this portion of the thought experiment. These areas include recommendations for recommendation for ATG, and improvements for making the assessment run better.

1. ATG

It is clear that ATG should be a stakeholder in the design of virtual training environment. Having the ability to conduct remote training and assessments not only minimizes travel but also allows them to efficiently deliver feedback. It is recommended for ATG to develop a different scenario from the practical exam to encourage thinking from Sailors and ensure they are not reacting to muscle memory. At the end of the scenario, ATG agrees to accept the AI's printout to aid in the assessment. That is a significant decision point for ATG to make; they accept the printout or use their checklist to grade the Sailors. Optionally, if ATG is a stakeholder, they can optimize the AI to concentrate on specific areas. This could minimize ATG receiving unnecessary data, thereby speeding up the assessment.

2. The Assessment

The scenario was not clear as to how the Sailors conducted the training. Assuming the training took place on the two training workstations dedicated in Scenario 1, training more than two at a time would not have been possible. The recommendation is that the system is designed with a minimum 24 port switch, allowing maximum participation in the assessment. Another recommendation is to configure the system in two modes of operation. The first mode is a training mode, and this mode is where Petty Officer Thomas conducted his training. The design of the training mode auto-generates reports for the TPO and training officer. The second mode is the assessment mode; this is where ATG staff conducts their assessments. The system not only generates reports for ships company but also delivers them to ATG. Finally, both modes of operations can assess and identify knowledge base deficiencies.

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VII. RECOMMENDATIONS AND CONCLUSION

This thesis responded to two research questions: “What are the IT Sysadmin training gaps in preparing to manage an operational CANES network at sea or during times when face-to-face training is not possible?” and “How can access to additional virtualized training sessions improve IT Sysadmins preparedness to manage CANES?” The use of literature reviews, model designs, a thought experiment, and an analysis of the experiment provided several outcomes. A literature review justified the research, identified gaps in current training pipelines, identified technology used to conduct virtual training for CANES, and identified new and emerging tech for future use. The models used provided a visual depiction of the current structure for training and the proposed design of a virtualized training alternative. The thought experiment allowed for testing the practicality of the ideal virtual training environment. Analyzing the thought experiment provided five areas for development not identified prior to the experiment. Some are concerns for the environment and some are enhancements.

Though the new model is only an idea and does not provide the perfect solution for ITs to conduct training, it may serve as a starting point to supplementing existing training environments. Future research should focus on the delivery medium for cloud-to-ship environments. This study assumes that peer connectivity is readily available for ships to use during training. Research should also be conducted towards delivering training with emphasis placed on media richness. Additionally, further research is needed on the software design mentioned in this thesis and the emerging technology suggested in training. Finally, this research strictly focused on ITs and their utilization of virtual networks. Future research is recommended to determine if the proposed model could be applied to other areas in the military, such as medical, or conducting shipwide exercises and assessments.

Several limitations emerged during this study, some resulting from the sudden onset of the COVID-19 pandemic. Restrictions of maneuvering prevented travel and limited opportunities to collaborate with experts from around the United States. Without direct physical access to the library the researchers in this study relied heavily on online resource. This study is also limited to physical wired connectivity and does not consider connectivity produced via satellite communications. Finally, to prevent unnecessary elevations in classification, data used in the research was limited to open-sourced and unclassified sources only.

The main objective behind the research in this thesis is to help Information System Technicians who are depended upon to manage mission-critical networks. By better understanding the gaps they face in training, coupled with current and emerging technology, we can begin to develop a plan of action to address these shortfalls. This thesis concludes that additional hands-on training through virtualization is vital in preparing Sailors to manage and operate CANES. Finally, investing more time and research into improving training models while focusing on the human element in training will ultimately result in ready and equipped Sailors to manage and protect mission-critical networks.

APPENDIX. COMPONENTS OF VTE TECHNOLOGY

This appendix described in-depth the technology and critical components of CANES TVE. Introduced in Chapter III while setting the framework for this pilot program, this is additional information that could be further researched and referenced for future research.

A. AWS GOVCLOUD

Compliant with Department of Defense (DOD) Cloud Computing Security Requirements Guide (SRG) for three impact levels. Level 2 contains information approved for public and non-critical mission information, such as public websites. Level 4 contains DOD Controlled Unclassified Information (CUI), and level 5 contains DOD CUI and National Security Systems (NSS)(GSA, n.d.). AWS GovCloud is also compliant with FIPS 140–2; Security Requirement for Cryptographic Modules (U.S. Department of Commerce, 2002). In addition to meeting compliance mandates, AWS Govcloud safeguards sensitive data, strengthens identity management, improves cloud visibility, and protects accounts and workloads (AWS, n.d.c).

B. AWS CLOUDFORMATION

Working with templates CloudFormation Treats infrastructure as a code while providing an easier way to model third-party resources and collections of related Amazon Web Services (AWS, n.d.b).

C. AMAZON MACHINE IMAGES (AMI)

AMI makes available all necessary information to launch an instance. Definition of instances defined in the next section (AWS, n.d.a).

D. AMAZON EC2 BARE METAL INSTANCES

Amazon EC2 Bare Metal Instances Allows direct access from applications to a scalable processor and memory resources located in underlying servers. A potential key benefit of Bare Metal EC2 as it applies to canes is it allows for legacy workloads not supported in virtual environments to run (AWS, 2019d).

E. AWS SECURITY TOOLS

Used to protect and secure customer stored cloud-based data and protect AWS storage services (Pachava, 2020). IaaS

F. INFORMATION-AS-A-SERVICE (IAAS)

Created from virtualized and physical resources, IaaS provides the foundation for running applications and workloads in the cloud. IaaS delivers network and storage resources to customers required to compute in the cloud. Resources are scalable as needed to suit the customer's needs and reduce the costs of infrastructure (IBM, 2019b).

G. PLATFORM-AS-A-SERVICE (PAAS)

PaaS is a cloud computing model complete with infrastructure, hardware, and software. This model provides servers and operating systems, networks, storage, operating systems, and databases. PaaS providers manage all platform infrastructure functionalities while the customer operates the platform to deploy developed applications (IBM, 2019c).

H. APPLICATION INTEGRATION

Application Integration allows different applications built separately from each other to work with one another. It is a process of merging workflows and data while optimizing them between multiple software applications. As it relates to CANES and the cloud, it allows on-site local systems to work together with cloud-based software and applications (IBM, 2020). Application integration is how different applications and software running on different legacy networks can work together in a single CANES network.

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