NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

DAMAGE CONTROL TRAINING TEAM TOOL SUITE

by

John R. Jackson

December 2018

Thesis Advisor: Rudolph P. Darken
Co-Advisor: Perry L. McDowell

Research for this thesis was performed at the MOVES Institute.

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The research effort designed a training and operational system in support of damage control (DC) training, procedure familiarization, and shipboard emergency response teams. The system was aimed to use commercial off-the-shelf systems (both hardware and software) to create an affordable, lightweight, mobile training system focused on filling the gap identified in DC training team (DCTT) deficiencies. It utilized a virtual environment (VE) training system as well as investigated the feasibility of networking ships' drill team members together to provide better-orchestrated drills to provide better training.

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DAMAGE CONTROL TRAINING TEAM TOOL SUITE

John R. Jackson
Lieutenant, United States Navy
BS, U.S. Naval Academy, 2012

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requirements for the degree of

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December 2018

Approved by: Rudolph P. Darken
Advisor

Perry L. McDowell
Co-Advisor

Peter J. Denning
Chair, Department of Computer Science

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ABSTRACT

The research effort designed a training and operational system in support of damage control (DC) training, procedure familiarization, and shipboard emergency response teams. The system was aimed to use commercial off-the-shelf systems (both hardware and software) to create an affordable, lightweight, mobile training system focused on filling the gap identified in DC training team (DCTT) deficiencies. It utilized a virtual environment (VE) training system as well as investigated the feasibility of networking ships' drill team members together to provide better-orchestrated drills to provide better training.

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LIST OF ACRONYMS AND ABBREVIATIONS

AoA	analysis of alternatives
ASA	afloat self-assessment
ATG	Afloat Training Group
ATGLANT	ATG Atlantic
ATGPAC	ATG Pacific
CAC	common access card
CBR-N	chemical, biological, radiological, and nuclear
CG	guided missile cruiser
CHENG	Chief Engineer/Engineer Officer
CO	Commanding Officer
COTS	customer off the shelf
COVE	Conning Officer Virtual Environment
CSTT	Combat Systems Training Team
CSV	comma separate values
CVN	nuclear powered aircraft carrier
DC	damage control
DCA	Damage Control Assistant
DCA/SE	DCA/Senior Enlisted Course
DCAMS	Damage Control Action Management Software
DCC	Damage Control Central
DCTT	Damage Control Training Team
DCTT-TS	Damage Control Training Team, Tool Suite
DDG	guided missile destroyer
DoD	Department of Defense
EDO	Engineering Duty Officer
EDORM	Engineering Department Organization and Regulations Manual
EMCON	emission control
ENIB	École nationale d’ingénieurs de Brest
EOOW	Engineering Officer of the Watch
EOSS	Engineering Operation Sequencing System

ETT	Engineering Training Team
FFG	guided missile frigate
FiRSTE	First Responder Simulation and Training Environment
GOMS	goals, operators, methods and selection
GTG	gas turbine generator
GTM	gas turbine main engine
HFP	hexafluoropropylene
IET	In Port Emergency Team
ITT	Integrated Training Team
Li-Fi	light fidelity
LPH	landing platform helicopter
M&S	modeling and simulation
MANSCEN	Maneuver Support Center
MCM	Minesweeper
MOB-D	mobility of DC
MTT	Medical Training Team
NAVSEA	Naval Sea Systems Command
NEC	Navy Enlisted Classification
NSWCCD	Naval Surface Warfare Center – Carderock Division
NTTP	Navy tactics, techniques, and procedures
OOC	out of commission
ORM	organizational risk management
PKP	potassium bicarbonate
PQS	personal qualification standard
RAC	risk assessment code
RE	repetitive exercise
RPM	Repair Party Manual
SCBA	self-contained breathing apparatus
SFTRM	Surface Force Training and Readiness Manual
SIWCS	Shipboard Internal Wireless Communications System
SME	subject matter expert
SORM	Standard Organization and Regulations Manual

SPAWAR	Space and Naval Warfare Systems Command
SSDG	ship service diesel generator
SSN	fast attack submarine
SWO	Surface Warfare Officer
SWOS	SWO School
TACOM	Tank-automotive and Armaments Command
TORIS-TFOM	Training and Operational Readiness Information Services - Training Figure of Merit
TYCOM	type commander
UI	user interface
VBA	Visual Basic for Applications
VE	virtual environment
VR	virtual reality
Wi-Fi	wireless fidelity
XO	Executive Officer

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DON'T GIVE UP THE SHIP

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I. INTRODUCTION

A. RESEARCH DOMAIN

In the Navy, damage control (DC) refers to a ship's company fighting any injury or impairment to the ship, such as fire or flooding, which might be caused by battle or other sources. DC is one of the cornerstones of the Naval service and it is imperative that our Navy excels in survivability and keeping its ships afloat and fighting. To do this, Navy ships are constantly running drills to ensure that the crew can respond quickly and competently to whatever damage the ship receives. These drills are run by the DC training teams (DCTT).

Unfortunately, most DCTTs are typically undermanned and under trained. This is not due to laziness nor lack of commitment, but rather other priorities consistently taking the place of training in all mission areas. The DCTT members need to spend significant amounts of time planning and rehearsing each drill; without this, they do not understand how to run the scenarios and can make more mistakes than the crew, which quickly causes disorder and wastes training opportunities.

Although DC is one of the Navy's fundamental competencies, the way it prepares DC drills is archaic and inefficient. The current system relies on a single individual to develop a drill package which requires extensive amounts of time and effort to develop and get approved, as three of the ship's senior officers need to approve the package: chief engineer, executive officer, and commanding officer. Additionally, the creator of the drill package needs to know something about how people learn, something that no training teams are ever trained in and is a large issue in the Navy's organization. In turn, these scenarios are limited by the developer's knowledge of the ship, their creativity, time available, and his/her chain of command's meticulous requirements for grammar and punctuation.

These issues often lead to short cuts such as the DCTT coordinator creating easy scenarios, reusing previously used drill packages, or simply using other ship's packages.

Although these practices are not wrong or cheating, they do not maximize a ship's ability to provide its Sailors the training they need.

B. RESEARCH PROBLEM

The main problem this thesis aims to address is the time and labor required to prepare, execute, and assess DC drills onboard surface combatants. This issue is prevalent across many ships due to the inherent time involved in crafting a strong drill as well as the large amount of bureaucracy required to create drill packages. The goal of this thesis is threefold. The first is to provide a 3D interface to make building strong drill packages easier. The second is to streamline the process of preparing drill packages. The third is to conduct an experiment to determine if the output of the application meets or exceeds current practices.

(1) Time consumption

The time required to create these packages is on the scale of multiple days. This accounts for incredible amounts of manhours lost by the ship's subject matter experts (SME) which should be spent in other areas such as training and managing their personnel or attending to degraded equipment.

(2) Error prone

Current practices are error-prone, as DCTT Coordinators can make errors in the package that may not be caught by the chain of command that manifest in the drill execution. Much of the time required in crafting a good drill package is checking and double checking the plan to catch any errors, especially subtle ones.

(3) Formatting

Improper formatting can result in disapproval from the chain of command or a failure to pass Afloat Training Group (ATG) standards. If caught, this inevitable results in rework and lost man-hours. When not caught by the chain, watch teams can act erratic and cause confusion amongst the watch standers and DCTT. This could also lead to safety mishaps.

(4) Training becomes repetitive and inefficient

Because of the large time consumption in creating and routing, DCTT Coordinators utilize previous packages and simply change the date which we will refer to as "canned packages." Due to the reuse of these canned packages, the crew is not trained to react to new drills but instead, forced to remember a script and perform it for an assessment. This, we believe, also leads to a long-term degradation in DC performance.

The Navy has made attempts at modernizing the DC organization on ships; however, these programs, such as the Damage Control Action Management Software (DCAMS), failed costing the Navy countless sailor man-hours and monetary values upwards of $25.3 million in 2005 [1]. Although there have been several attempts at developing IT-based systems, their usability and reliability have been unsatisfactory, and a new approach is required.

Virtual environment (VE) technology has reached a point where it is much more affordable and compact than it once was. The technology is readily available, and the Navy must employ newer technologies in order to sharpen the principles it wants Sailors to instill. The research we proposed will study the benefits of a commercial off the shelf technology – both hardware and software – on DC training. This includes tablets/iPads and the Unity game engine. While the same approach can be scaled to include a variety of situations in the future to include actual DC environments, we initially focused on the implementation by DCTT. The experience that will be presented to the training team will include a network that provides the DCTT coordinator and members of DCTT real-time scenario data, the current drill package, status of all casualties, and the proper DC rapid plotting. We believe that this approach will have positive influence on their skill and efficiency, the drills will be more complex and realistic, and the crew's combat readiness will be stronger. The proposed system will also be tested against current learning practices through the means of a formal user study onboard by a DCTT.

C. INITIAL VISION

If technologies such as described previously were expanded into further aspects of DC, the same devices could be issued to members of the crew such as the commanding officer (CO), damage control officer (DCO), damage control assistant (DCA), rapid response team and the DC lockers to provide real-time statuses of damage throughout the ship. Additionally, multiple training teams such as medical, combat systems, and engineering could utilize these devices and could coordinate efficient integrated training team drills.

D. RESEARCH QUESTIONS

1. Can a computer-based system create drill packages faster than current methods?

2. Can a computer-based system create drill packages that are as good of quality and free of errors, or better than the current methods?

3. Can a virtual environment simulation increase damage control readiness onboard surface ships?

E. HYPOTHESES

1. A computer-based system will create drill packages faster than the current paper and pen method.

2. A computer-based system will create drill packages that are of same or better quality than the current paper and pen method as measured by senior DC assessors.

3. A computer-based system will increase damage control readiness onboard surface ships.

F. SCOPE

This thesis investigates the feasibility of customer off the shelf (COTS) technologies to solve one of the many issues the Navy faces with respect to time management. The work covered begins with the creation of a tool utilizing the Unity game engine to help visualize and construct drill packages, the output of which is converted into Microsoft Office products to create standard drill packages. It will then discuss the two user studies conducted to test the system and provide data and feedback. Finally, it will provide a conclusion and recommendations for follow on work.

G. APPROACH

This thesis was comprised of three goals. The first was to eliminate several inefficiencies in the current methods of drill preparations and produce a streamlined and simple user experience. The second was to provide data showing these inefficiencies and how this program assists the user in creating reliable and quality products in a timely manner. The third is to provide a quality architecture and plan to the research sponsor, SPAWAR Systems Center Pacific (SSC PAC), to expedite further development and deployment to the surface fleet in the near future.

H. THESIS LAYOUT

The remainder of this thesis has the following layout:

Chapter II details the background of the U.S. Navy DC readiness and its current methods of training. It also discusses how commercial institutions are utilizing technologies to train first responders and other professionals that save time and money, and how these technologies can be utilized in the surface Navy.

Chapter III covers the task analysis process in regards to drill package preparations, execution, and assessment.

Chapter IV discusses a proposed low-cost solution to the issues addressed and discuss the reasoning for the layout and architecture chosen.

Chapter V details the user study, its setup, and execution. It details the target audience, recruitment and execution of the study, and lessons learned for the process.

Chapter VI reveals the results of the study and provides the feedback gathered from participants. It quantitatively and qualitatively highlights the issues identified in chapter II and clearly shows why the Navy must further develop automated technologies for training.

Chapter VII combines all aspects into a conclusion and provides recommendations for further work in order to field new technologies and provide the warfighters with cutting edge devices to improve readiness, survivability, and lethality.

II. BACKGROUND

To understand the problems the Navy faces in its readiness for combat, it is important to understand the history of DC in the naval service and how many of the practices employed today were truly "written in blood," which means they arose from efforts to prevent events which caused harm or death to Sailors. The Navy's mission is to "maintain, train and equip combat-ready Naval forces capable of winning wars, deterring aggression and maintaining freedom of the seas" [2]. Doing so has required the Navy to hazard its ships in areas where there is a high likelihood of incurring damage from natural elements or enemy actions. Recovering from this damage while maintaining the fighting capabilities of the ship is vital for the Navy to carry out its mission. This chapter will discuss the history of how sailors have fulfilled these missions in the past, and what the future might be like if new technologies were to be employed to assist this mission.

A. PROBLEM SPACE

The U.S. Navy's history stretches back to before the birth of the nation and since those beginnings, damage control was an essential part of shipboard life. In the 1790s, the carpenter's mate rating was established to employ skilled repairmen onboard ships while at sea. In 1948, the ratings of painter's mate and carpenter's mate were consolidated into damage controlman. The main goal for establishing this new rating was for these "DCmen" to train the ship's crew on the previous lessons learned from World War II and earlier, and to ensure the crew was capable of maintaining their ship in combat. Later in 1954, damage controlman absorbed the additional rating of chemical warfareman and the training of chemical, biological, radiological, and nuclear (CBR-N) warfare became an additional responsibility in preparing crews for combat [3].

1. Notable DC Events in Recent Naval History

- USS *Stark* (FFG-31) was struck by two Exocet anti-ship missiles from an Iraqi fighter jet during the Iraq-Iran Conflict. Thirty-seven Sailors were killed and an additional 21 injured. However, the crew was able to control the damage and the ship was returned to fighting condition [4].

- USS *Samuel B. Roberts* (FFG-58) struck a naval mine in the Persian Gulf on 14 April 1988. The blast broke the keel of the ship which typically results in a ship sinking. However, due to the crew's proficiency in DC, the ship remained afloat and never lost the combat capability of its radars and missile launchers [5].

- USS *Tripoli* (LPH-10) struck a mine on 16 February 1991 in the Persian Gulf while Naval forces were conducting mine-clearing operations in Operation Desert Storm. The ship was saved due to DC efforts and returned to the U.S. for repairs [6].

- USS *Princeton* (CG-59) actuated two mines less than three hours after the Tripoli was struck. The crew's DC organization controlled the damage and restored all systems within 15 minutes [6], [7].

- USS *Cole* (DDG-67) on 12 October 2000 was struck by a small boat laden with explosives during lunch hours while anchored in Aden harbor, Yemen. The explosion killed 17 sailors and caused two engine rooms to flood entirely. Through intense DC efforts, the crew was able to control the flooding and the ship would return to operation a year later [8].

- USS *George Washington* (CVN-73) on 22 May 2008 experienced a fire that lasted for approximately 12 hours. After the crew extinguished the fire, an investigation revealed that the cause of the fire was from unauthorized storage of hazardous materials and cigarettes being disposed of into exhaust fans [9].

- USS *Miami* (SSN-755) while in drydock at Portsmouth Naval Shipyard on 23 May 2012 experienced a fire that was caused by a shipyard worker who was later charged with arson. The fire was started in a bag of rags and quickly spread throughout the ship due to the many open compartments that are common during a maintenance period. The fire raged throughout the night lasting 12 hours and at times scuttling the submarine was considered to extinguish the fire [10]. Due to the large cost to repair the submarine, the Miami was decommissioned.

- USS *Porter* (DDG-78) collided with a merchant vessel on 12 August 2012 near the Strait of Hormuz. The collision was caused by the CO ordering the conning officer to make erratic maneuvers that endangered the ship. The vessel returned to port under her own power and returned to service two months later.

- USS *Hue City* (CG-66) experienced a fire caused by improperly stowed rags in an exhaust room on 14 April 2014. The crew was unable to locate the fire because of its location until it began melting bulkheads. The damage cost the Navy approximately $23 million dollars and forced Hue City to miss a deployment [11].

- USS *Guardian* (MCM-5) ran aground on a reef off the Philippine Coast in January 2013. Due to an oncoming storm and a lack of training, the crew rushed through DC procedures and further endangered the ship. The vessel was unable to be salvaged and was cut into pieces in order to remove it from the reef.

- USS *Fitzgerald* (DDG-62) collided with a merchant vessel on 17 June 2017 in the Pacific Ocean. The vessel resulted in the deaths of seven sailors and heavy damage to Fitzgerald. The crew's DC efforts saved the ship and Fitzgerald returned to port under her own power [12].

- USS *John S. McCain* (DDG-56) collided with a merchant vessel on 21 August 2017 near Singapore which resulted in the deaths of ten sailors and heavy damage to McCain. The crew's DC efforts saved the ship and McCain returned to port under her own power [12].

2. Battle Organization

The damage control battle organization includes damage control central (DCC), various repair parties, and battle dressing stations. The organization varies somewhat from one ship to another. The difference depends upon the size, type, and mission of the ship. Figure 1 describes the overall operational organization in the event of actual casualties.

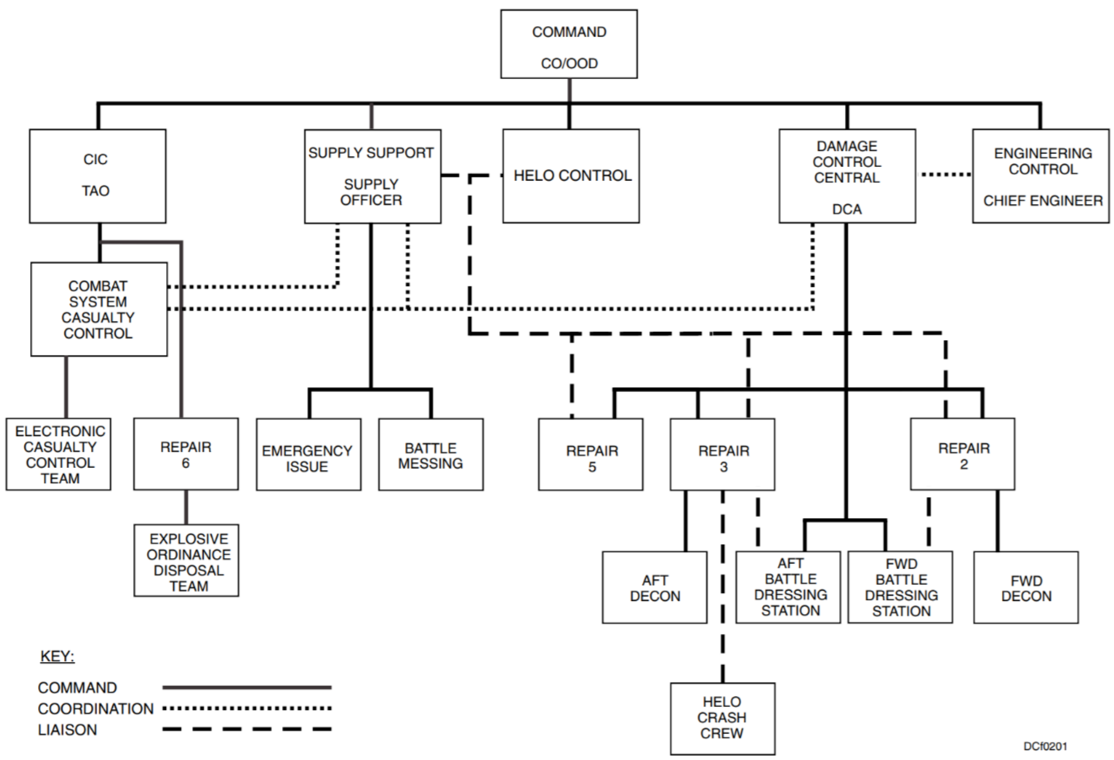

Figure 1. Battle organization structure. Source: [13].

a. Commanding Officer (CO)

The CO is overall responsible the safety of their ship and its crew. The Standard Organization and Regulations Manual (SORM) of the U.S. Navy describes the role as follows:

> The commanding officer is charged with the absolute responsibility for the safety, well-being, and efficiency of the ship and crew until properly relieved by a competent authority. [14]

b. Executive Officer (XO)

The following is a brief description of the XO's duties and responsibilities in accordance with the SORM:

> The executive officer is the direct representative of the commanding officer and shall be primarily responsible to the commanding officer for the organization, performance of duty, training, maintenance, and good order and discipline of the entire command. [14]

This description is obviously not all-inclusive for the responsibilities of the second in charge onboard a ship. The XO has a wide variety of roles they must fulfill, one being the DCTT Leader. As described by the Engineering Department Organization and Regulations Manual (EDORM):

> The XO will participate actively in evolutions and inspections to determine training effectiveness and readiness of the Engineering Department. The XO is normally designated as the Integrated Training Team (ITT) Leader and the Damage Control Training Team (DCTT) Leader in accordance with references NTTP 3–20.31, Ship's Survivability; and OPNAVINST 3120.32C CH-6, SORM. [15]

c. Chief Engineer/Engineer Officer (CHENG)

The following is a brief description of the role of the CHENG from the SORM, however, this is not all-inclusive:

> The head of the engineering department of a unit is designated the engineer officer. They are responsible for the operation, care, and maintenance of all propulsion and auxiliary machinery, the control of damage, and, upon request of the department head concerned, the accomplishment of repairs beyond their department's capabilities. [14]

Additionally, in accordance with the EDORM, the CHENG serves as the damage control officer (DCO) for firefighting and damage control functions in which he provides direction to all repair lockers and designates appropriate casualty power configuration as needed [15].

d. Damage Control Assistant (DCA)

The DCA carries the overall responsibility for the DC readiness of the ship. Reporting to the DCO, the DCA ensures the survivability of the ship. The SORM describes the DCA's role as follows:

> The DCA is responsible for establishing and maintaining effective damage control organization and for supervising repairs to the hull and machinery, except as specifically assigned to another department or division. [14]

The EDORM further elaborates on the role, stating that the DCA shall be responsible for:

> "a. Limit the impact of, and control battle damage, including control of stability, list, and trim. The DCA shall supervise placing the ship in the material readiness condition of closure ordered by the Commanding Officer and shall ensure that assigned closure classifications are highly visible.
>
> b. Prepare and maintain bills for the control of damage, stability and CBR defense readiness.
>
> c. Ensure Compartment Check-Off Lists are kept current and properly posted by respective division officers.
>
> d. Review hull, zone, and other inspections and assessments that list deficiencies affecting the material condition of the ship, and initiate corrective action.
>
> e. Administer overall Damage Control PQS programs. In this regard, the DCA shall:
>
> (1) Keep a current file of instructions related to the Damage Control PQS Program, standards, and qualification requirements.
>
> (2) Advise the chain of command concerning Damage Control PQS Program requirements.
>
> (3) Provide training for and supervise the qualification of all personnel who qualify others in Damage Control PQS (including embarked air and marine detachments).
>
> (4) Provide training for and supervise the qualification of Gas Free Petty Officers, Fire Marshals and members of all emergency parties (Flying Squad, Rescue and Assistance, Inport Emergency Team (IET), Core/Flex Teams, Aviation Fire Fighting, etc.).

(5) Provide training for, and supervise the qualification and performance of Damage Control Petty Officers and Damage Control Maintenance personnel.

(6) Ensure the ship's welder qualifications remain current and proficiencies are maintained as required by their trade.

f. Conduct DCTT training per the Executive Officer's guidance.

g. Supervise ballasting and de-ballasting of the ship, in coordination with the Engineer Officer, EOOW, and ship's Oil and Water King.

h. Submit a schedule of all-hands Damage Control and CBR training requirements, including Battle Problems and Major Conflagration to the Planning Board for Training in accordance with reference NTTP 3–20.31, Ship's Survivability.

i. Serve as the ship's Gas Free Engineer unless otherwise designated by the CO.

j. Implement and tailor the TYCOM issued Repair Party Manual.

k. Supervise the initial qualification and proficiency training for respective divisional watchstations.

l. Prepare and maintain the ship's DC Closure Log. Conduct daily review of the log to ensure the accuracy and adequacy of all entries affecting the prescribed material condition of readiness.

m. Review and initial all tag-out record sheets relating to the isolation of major installed damage control equipment, unless it is incidental to preventive maintenance for a gas turbine module in the main engineering spaces (GTG, SSDG, GTM gas turbine module installed halon/C02/HFP systems)." [15]

e. DCTT Coordinator

The DCTT Coordinator reports to the DCTT Leader (XO) and is overall responsible for the execution of DC drills. They create drill packages, assign DCTT members, coordinate training of DCTT with DCA, execute and assess drills, and maintain the majority of DC admin. On smaller ships (cruisers and smaller), the DCTT Coordinator typically dual-hats as the Fire Marshall as well.

f. Fire Marshall

The Fire Marshall is the SME of DC onboard the ship and reports directly to the DCA and CHENG. Typically, the role is filled by a chief petty officer or senior, the Fire Marshall is a seasoned sailor proficient in technical expertise and management. The EDORM describes the Fire Marshall's role as follows:

> "The ship's Fire Marshal shall assist the Engineer Officer and DCA in training of personnel and the prevention and fighting of fires. The ship's Fire Marshal shall be responsible for the following:
>
> (1) Make daily inspections of the ship, paying particular attention to the items specified in NTTP 3–20.31, Ship's Survivability.
>
> (2) Prepare, route, and follow-up reports of identified fire hazards and their correction.
>
> (3) Under the direction of the DCA and Engineer Officer, conduct training for ship's fire teams, rescue and assistance teams, in port emergency teams, and divisional Damage Control Petty Officers stressing fire hazard consciousness." [15]

g. DCTT Members

DCTT members are assigned to the team as a collateral duty based on their proficiency in DC and their other roles in the command. Their experiences vary based on rank and experience but their overall role is to train the crew in DC and to provide assistance in the event of actual casualties.

3. Battle Principles

While the manner in which each ship actually performs DC is different due to variations in size, manning, and other factors, the basic principles which follow apply to all damage control battle organizations [13]:

1. "Ensure that all personnel within the organization are highly trained in all phases of damage control. They should also be trained in the technical aspects of their ratings to assist in the control of damage.

2. Decentralize the organization into self-sufficient units. These units must have communication with each other. They must be able to take corrective action to control the various types of damage.

3. Have one central station, the DCC, receive reports from all damage control units. The DCC evaluates and initiates those orders necessary for corrective action from a ship-wide point of view. This station also reports to and receives orders from the bridge (command control). These reports concern matters that affect the ship's buoyancy, list, trim, stability, watertight integrity, and chemical, biological, and radiological (CBR) defense measures.

4. Ensure that damage control units assigned work that is peculiar to a single department are under the direct supervision of an officer from that department.

5. Provide for relief of personnel engaged in difficult tasks, for battle messing, and for the transition from one condition of readiness to another. Develop procedures to ensure that all relief crews are informed of the overall situation.

6. Provide for positive, accurate, and rapid communications between all damage control units. An overall coordination of effort and direction can then be readily accomplished.

7. Provide for a repair party, remotely located from DCC, to assume the responsibilities of DCC, in the event that DCC becomes a battle casualty. current approaches"

4. Training

Based on the key aspect of the battle organization, it is clearly a large task to train and maintain battle readiness for the entire crew of a ship. The overall responsibility falls on the DCTT Leader and the DCTT Coordinator. The two are responsible for the following [13]:

- Train DCTT members to be subject matter experts of DC
- Coordinate opportunities to train crew in DC and CBR-N procedures
- Schedule drills with periodicities in accordance with COMNAVSURFLANT/PACINST 3500.11(Series)
- Assess drills in accordance with Afloat Training Group (ATG) guidance and grade sheets from COMNAVSURFLANT/PACINST 3502.3(Series)
- Create watchbills to include general quarters, in-port emergency teams, at-sea fire party (Flying Squad), and crash and salvage teams.

B. CURRENT APPROACH

1. Drill Package Preparation

Drill packages require long quantities of time and experience to create. First, a DCTT Coordinator must identify which drills are to be executed based on drill periodicities, previous drill results, and their judgement of the crew's ability to successfully combat certain casualties. Figure 2 shows the required periodicities for these drills. Additionally, the coordinator chooses which watch team (or duty section) to run the drill on.

COMNAVSURFPAC/
COMNAVSURFLANTINST 3502.7
1 Nov 18

Repetitive Exercises (REs)

NR	EXERCISE NAME	AMPLIFICATION	FREQ	NOTES
01 *	Review ASA Checksheet		90	
02	Set Material Condition Readiness (Z, Y, MOD Z)	All RPLs	90	
03 *	Respond to Non Main Space Fire (All Classes)	All IETs	60	
04 *	Respond to Toxic Gas/HAZMAT Spill	All IETs	90	
05 *	Respond to Flooding	All IETs	60	
06	Respond to Fire	F/S	60	
07	Provide Rescue and Assistance	R&A Team	120	
08 **	Respond to Flooding	F/S	60	
09	Respond to Toxic Gas/HAZMAT Spill	F/S	90	
10	Respond To Non Main Space Fire	All RPLs	90	
11	Respond To Flooding	All RPLs	90	
12 *	Respond To Structural Damage	All RPLs, F/S, IETs	90	
13	Combat A Major Conflagration	Ship-wide	180	
14	Rig Casualty Power	All RPLs (N/A MCM, PC, LPD, DDG 1000) Cables are not required to be energized.	365	
15	Employ Chemical, Biological, Radiological, and Nuclear Environment (CBRN) Defense Procedures	All RPLs. Rotate scenario between 4 agents every 120 days.	365	

*** Must be maintained at all times.**
**** Can be performed in conjunction with RE-11**

Figure 2. Periodicities of REs. Source: [16].

Once a casualty type and watch team(s) have been selected, the DCTT Coordinator then chooses the space to implement the casualty. Typically, the DCTT Coordinator will select an old drill that has been run before and simply change the applicable information in it, such as date and DCTT members. However, if a new space is to be chosen, the DCTT Coordinator would pick a suitable compartment based on several factors such as the size of space, available DC equipment, accessibility, etc. They will then consult the ship's DC plates, Repair Party Manual, and any applicable drawings before walking the space to identify boundaries, mechanical and electrical isolations, safety hazards, and desired DC gear to be utilized.

The next step involves getting the plant status of the ship's engineering plant. This involves meeting with the Engineering Officer of the Watch (EOOW) or Engineering Duty Officer (EDO), depending on whether the ship is underway or in port respectively. The EOOW/EDO provides the anticipated plant configuration and DCTT Coordinator can identify any equipment that may be affected by electrical and mechanical isolations.

After the space is selected and information gathered, the DCTT Coordinator drafts a drill package in utilizing Microsoft Office products which contains all the information discussed above, utilizes organizational risk management (ORM) to ensure the drill can be run safely, create casualty line items, and begin assigning DCTT members to perform tasks during the drill.

Upon completion of the package document, the DCTT Coordinator then prints and routes the package to the CHENG, XO, and CO. At any point, an individual in that chain can make changes which could start the process all over again.

After all personnel have approved the drill package, the DCTT Coordinator coordinates with the Operations and Administrative Departments to have the drill scheduled in the ship's plans.

2. Drill Execution

Once a drill package is approved by the CO, the DCTT Coordinator can distribute the package and execute the DCTT brief. The brief must be completed within 24 hours of execution with all members of DCTT that will be participating in the drill.

When the drill is ready to be executed, DCTT members must complete a safety walkthrough of all spaces that watchstanders will likely be utilizing. They identify hazards and ensure that any discrepancies are fixed prior to drill commencement. After the DCTT Coordinator has received all reports of walkthroughs being completed, they can receive permission from the DCTT Leader to commence the drill.

DCTT Coordinator commences the drill via radio to all other DCTT members to start. During the drill, each DCTT member completes their tasks in the drill package and reports completion to DCTT Coordinator via radio. When all line items have been completed, DCTT Coordinator terminates the drill and all gear is re-stowed and all systems are restored to their original configuration. If the DCTT Coordinator or DCTT Leader determine it to be necessary, the drill can be halted and re-executed at any point during this process.

3. Drill Assessment

During the gear re-stowage phase, DCTT members assemble to debrief the drill. At the debrief, members report the proficiency of the watchstanders at their given positions and the effectiveness demonstrated at extinguishing the casualty. Utilizing a gradesheet similar to that found in Figure 3, DCTT Coordinator assigns grade values and compiles a list of all feedback as well as lessons learned.

CE05 Respond To Fire (IET, F/S, RPLs)				
Data Point	**DP Narrative**	**Assessor Grading Notes**	**Max Points**	**Score**
CE05.01	Were Investigate, Report, and Alarm actions completed?	"Was Casualty reported Correctly? (i.e. Correct compartment number and name, type of casualty.)" "Did controlling station call away casualty Correctly? (i.e. Correct compartment name and number, casualty, repair locker, and team.)" "Was the Rapid Response team comprised of the proper personnel?" FM/Electrician/Two Utility Personnel. Were DC plots kept current and correct? (To include utilizing correct DC chart) Did Rapid Response / Investigators identify class of fire and take correct actions (i.e. A, B, C, D)? 'Were additional personnel called as needed? Was manned and ready report made? Were SCBA activation times tracked?	8	
CE05.02	Were fire boundaries established?	Were all boundaries correctly identified, set and maintained?(i.e. were fire boundaries monitored for heat every 5 minutes, all combustibles removed from the boundaries, all non-essential personnel evacuated, magazines, paint locker, etc) NSTM 555 7-25	10	
CE05.03	Were Smoke Boundaries established?	Was smoke control zone established and maintained? Were smoke curtains/blankets correctly installed on any opening to prevent smoke spread? (i.e. ladder w/out WTH, WTD with obstructions) Was ventilation secured in the buffer zone?	6	
CE05.04	Was the scene electrically isolated?	Was power secured to damaged areas, to include lighting left on at scene leader's discretion ? Did electrician utilize isolation/kill card to secure power? IAW with SHIPS RPM	4	
CE05.05	Was the scene mechanically isolated?	Were systems that feed the fire isolated? (air & fuel sources)	2	
CE05.06	Was the attack team quick at responding to the fire?	Did attack team begin fighting the fire within 12 minutes? IAW NSTM 555-6.1.1, 555-7.2.6 (Start time will commence at the conclusion of the 2nd announcement of the casualty)	10	

Figure 3. Sample DCTT gradesheet for fire casualty (non-main space). Source: [16].

After the DCTT debrief is completed, DCTT assembles all the watchstanders and debriefs them on their findings and instructions for future casualties. DCTT Coordinator then inputs the grades into the Navy's web-based system for tracking training, Training and Operational Readiness Information Services - Training Figure of Merit (TORIS-TFOM) which provides a report to Navy leadership of the current proficiency level of the ship with respect to overall DC.

C. VIRTUAL ENVIRONMENT TECHNOLOGIES

There is a common misunderstanding of the terms used in our new virtual worlds. Many people use terms interchangeably when they mean one specific type of technology. This section will describe the definitions of often confused or misused terms, current applications which use these technologies, and how they can be used to benefit the Navy.

1. Definition of Virtual Environment (VE)

The term virtual environment is a relatively broad term and can refer to any virtualization of a real-world based location, structure, or model. It can be more simply put: "as a computer-generated environment used to simulate the real world" [17]. The environment can have many different representations of materials or objects, and it can be of infinite size.

2. Current Applications

a. Healthcare

The medical field is one of the largest stakeholders in the development of modeling and simulation (M&S) technologies. The idea of simulation surgery is not a new one, as medical students have been operating on dummies or animals for as long as there have been doctors. What is new, however, is the ability to practice a surgery on an actual patient before the actual patient enters. Doctors are now able to experiment with surgical procedures and maintain their skills even when there are no patients.

One company creating these M&S environments is BreakAway, Ltd located in Hunt Valley, MD. The company has developed several game-like simulations that allow training to doctors in an emergency room, occupational therapists, dental implants, first responders, optometry, and more [18]. These virtual environments enable training whenever and on an unlimited number of patients. The sets and reps these doctors receive enable them to reach higher levels of performance and practice difficult surgeries with zero risk to patients.

b. Emergency Management and First Responders

Another emerging field in the M&S world is for first responders and training them to respond to out-of-the-ordinary emergencies. Several companies have created incident response such as ETC simulations and Bravo Delta, Inc, as well as BreakAway, Ltd. Many of these simulations involve explosions or wildfires, but the military applications could be endless with similar tools.

A group at the University of Missouri-Rolla in collaboration with Battelle Memorial Institute, the Army's Maneuver Support Center (MANSCEN), and the Army's Tank-automotive and Armaments Command (TACOM) have developed a system they call First Responder Simulation and Training Environment (FiRSTE). The system places the user in a harness and fully immersive VR environment that "allow training first responders under numerous scenarios, which replicate actual situations and can be changed quickly to meet the needs of the trainees." [19] This method equates to a safer, cheaper, and more accessible means of training first responders, in this case, in terrorist response.

c. Military

The military has been utilizing some form of modeling and simulation since the early 1900s. Simulations utilizing VEs proved to be a valuable force multiplier in the early 1990s and soldiers with simulator experience exceeded the performances of their counterparts who did not during the Gulf War [20].

Additionally, in July 2007, the U.S. House of Representatives passed House Resolution 487 which officially recognized M&S as a National Critical Technology. This legislation was critical in laying the ground work of the current Department of Defense (DoD) M&S framework and ensuring that M&S be a fundamental part of our future as a military. On average, the DoD spends between $4 billion and $7.5 billion each year on M&S training and development [20]. This number is sure to increase as newer technologies emerge and as new threats are realized on the global scale.

The U.S. Navy has been working with multiple simulation-based training technologies to increase the effectiveness of sailors while at sea. One of these simulations is the Conning Officer Virtual Environment (COVE), a tool for training junior officers in understanding basic seamanship. An official description of COVE is as follows:

> COVE is a device for learning and practicing ship-handling skills that depend on "Seaman's Eye"—the ability to interpret wind, current, ship's speed, and a combination of other visual factors—which includes understanding ship dynamics, interpreting perceptual cues, and other information available to a conning officer on the bridge and, based on this understanding, applying rules of thumb for responding to situations that arise while maneuvering. [21]

This technology allows junior officers to get the experience of getting a multi-billion-dollar ship out to see and immerses them in hazardous situations without jeopardizing any personnel or equipment. This technology also allows these officers the opportunities to attempt new maneuvers and learn basic seamanship without negative consequences.

3. Surface Navy DC applications

a. Firefighting

One scenario that has direct applicability from the commercial sector to shipboard DC is firefighting as it is one of the most common casualties on board ships. Multiple organizations are using virtual environments to train firefighters efficiently.

Several international institutions have realized the needs to train firefighters effectively and cost-efficiently in order to provide better services to the community. One French group at the École nationale d'ingénieurs de Brest (ENIB) created a VE to familiarize firefighters with a multitude of simulations and for them to "learn while doing" by putting the personnel into operational conditions [22].

The Navy has also conducted large research efforts with VEs for vessels apart from DCAMS. One of the earliest was McDowell and King, who created a DC trainer as their master's thesis [23]. This work was continued in Tate, Sibert, and King, which utilized virtual portions of ex-USS Shadwell to fully immerse a user into fire scenarios onboard with a head-mounted display. The results showed that utilizing a VE training system would be an effective way of training crew members in shipboard familiarization as well as combatting casualties [24].

b. Flooding

A team at Florida International University have created a virtual environment that can predict storm surges in real-time and give visualizations based on these predictions. Utilizing map overlays and previous storm data, they can show how rising waters can affect during locations around the globe [25].

This technology can be directly applied to casualties in the Navy involving flooding or open exposure to the ocean, also known as the free-communication effect. Coupled with basic stability and buoyancy principles, a VE could calculate flooding rates and the effects the water weight has on the list and trim.

c. Chemical, Biological, Radiological-Nuclear (CBR-N)

A group at 3DInternet Inc. under the direction of the Department of National Defence of Canada created a VE trainer for first responders responding to CBR-N terrorist attacks. This technology allows users to work together to coordinate evacuations, containment, and decontamination in a training environment [26].

The CBR-N threat is ever present and extremely horrifying to the Navy, and a CBR-N drill is typically one of the most difficult drills to run due to the large amounts of coordination and gear required. Coupled with the large amount of time to develop a CBR-N drill package, it is obvious why the Navy only requires each ship to execute one CBR-N drill per year and that the level of knowledge of crews in CBR-N is extremely low.

D. CHAPTER SUMMARY

The history of damage control in recent Naval history was presented. After discussing the history, this chapter delved into some examples of VEs in the commercial fields as well as some that can directly correlate to Navy applications. Additionally, we listed makeup of the DC organization and how drills are performed onboard ships including a summary of preparation, execution and assessing of those drills. We further showed that many new technologies are being developed in both the commercial industry and military that could be directly applicable to the DC organizations onboard Navy ships.

After reviewing the tedious bureaucratic nature of drill package preparation and coordination, it seems intuitive that we should be able to do these drills better utilizing new technologies and streamlining the process. Virtual environments have the potential to fill gaps in training that we have identified in the surface fleet and Naval leadership continue to struggle to fix. The purpose of this study is to prove that there is an issue with our current methods and to provide one method that could alleviate some issues with drill package creation as well as to add overall awareness to DCTTs in the fleet.

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III. TASK ANALYSIS

A. INTRODUCTION

There are many ways to divide and identify the requirements in creating, executing and assessing drills in the surface fleet. In order to break down specific requirements that must be implemental in our prototype system, we used the goals, operators, methods and selection (GOMS) approach [27].

B. RATIONALE FOR METHOD USED

We utilized the GOMS method for our task analysis because it is ideal for breaking an overarching goal into sub-goals and assigning methods and operators to each piece. This approach allows a DCTT coordinator to break down items of a drill and assign individual operators to each task. Additionally, the GOMS model can be further broken down into specific skills that are required to perform the acts.

C. TASK ANALYSIS PROCESS

1. Drill Package Dissection

The process used was to obtain old damage control drill packages from destroyers and parse them for fundamental line items in each package. The requirements for each casualty were then culminated and baselined to create a model for casualty creation that satisfies every type of casualty possible.

2. Task Analysis Production

The first item to address was to narrow down the overarching goal. The final result we desire is to raise DC awareness onboard a ship and that is shown by the culmination of watchstander knowledge and skills, and the utilization of them to extinguishing a casualty. Due to this, the main goal of our task analysis was to execute a DC drill.

The line items parsed from the drill packages created the framework for the first subgoal of creating a drill package. These line items became methods for the operators to follow in preparation and execution of the drill. This led us into the second subgoal of executing the drill based on the finalized drill package. After completion of the drill, the final subgoal is to assess the drill based on the performance of the watchstanders as perceived by the operators.

D. PREPARING DC DRILLS

GOAL: Create drill package

METHOD: Choose casualty type[s]

OPERATOR: Reference ATG afloat self-assessment (ASA) to determine applicable periodicities

METHOD: Choose watch team to execute drill

OPERATOR: Reference TORIS-TFOM to determine watch teams' expiring drills

OPERATOR: Schedule desired drill execution day and time

METHOD: Choose compartment

OPERATOR: Utilize knowledge of the ship to determine optimal compartments for training

SELECTION: Choose compartment based on complexity for accessing in comparison to the level of the training team

METHOD: Determine agent to combat casualty

OPERATOR: Utilize knowledge of the casualty and in-space equipment to determine desired agent

SELECTION: Equipment should be chosen based on their effectiveness and impact to the ship (i.e. PKP should not be used on electrical equipment if fresh water hose is available and system is de-energized)

METHOD: Determine mechanical isolation requirements

OPERATOR: Use ship's Repair Party Manual (RPM), damage control (DC) book, and knowledge to determine required mechanical isolation components

SELECTION: Choose whether actual or simulated isolation will be utilized

METHOD: Determine electrical isolation requirements

OPERATOR: Use ship's Repair Party Manual (RPM), DC book, and electrician mates to determine required electrical isolation components

SELECTION: Choose whether actual or simulated isolation will be utilized

METHOD: Determine equipment affected by isolations

OPERATOR: Use ship's drawings, DC book, DC plates, Engineering Operation Sequencing System (EOSS) references, and knowledge to determine required isolation components

METHOD: Determine engineering plant status

OPERATOR: Coordinate with Chief Engineer (CHENG) and Engineering Duty Officer/Engineering Officer of the Watch to determine optimum plant status for drill

METHOD: Calculate ORM

OPERATOR: Consult OPNAVINST 3500.39 to review ORM requirements

OPERATOR: Walk through affected compartment and surrounding spaces to determine possible hazards

OPERATOR: Identify all possible hazards and implement controls to mitigate the associated risk

METHOD: Assign DCTT members

OPERATOR: Review watchbills and contact DCTT members to determine availability

OPERATOR: Ensure that proper number of qualified DCTT members are available

METHOD: Culminate all data into drill package

OPERATOR: Open previously formatted drills and alter that differ

METHOD: Route drill package

OPERATOR: Print and route finished package to CHENG

OPERATOR: Upon return from CHENG, correct any changes and print again as needed

OPERATOR: Route to Executive Officer (XO)

OPERATOR: Upon return from XO, correct any changes and print again as needed

OPERATOR: Route to Commanding Officer for final approval

E. EXECUTING DC DRILLS

GOAL: Execute drill package

METHOD: Complete safety walkthroughs

OPERATOR: Tour assigned space and identify safety hazards

OPERATOR: Report status to DCTT Coordinator when completed

METHOD: Stage casualty

OPERATOR: Ensure all required DCTT props are on scene

METHOD: Prompt watchstanders to identify casualty

OPERATOR: Show prop[s] to watchstanders

OPERATOR: Ensure proper casualty is identified

METHOD: Monitor watchstanders while preparing casualty

OPERATOR: Monitor sailors while getting dressed out in proper gear at repair locker

OPERATOR: Ensure watchstanders have required gear to complete their assignment

METHOD: Ensure that watchstanders properly set boundaries

OPERATOR: Ensure watchstanders identify proper boundaries

OPERATOR: Ensure watchstanders identify boundary and remove hazards as required

OPERATOR: Ensure watchstanders utilize proper casualty fighting equipment as necessary

OPERATOR: Ensure watchstanders establish communications back to repair locker

METHOD: Ensure that watchstanders properly set mechanical isolation

OPERATOR: Ensure watchstanders identify proper items to isolate

OPERATOR: Ensure watchstanders isolate equipment properly and safely

OPERATOR: Ensure watchstanders report status of equipment back to repair locker

METHOD: Ensure that watchstanders properly set electrical isolation

OPERATOR: Ensure watchstanders identify proper items to isolate

OPERATOR: Ensure watchstanders isolate equipment properly and safely

OPERATOR: Ensure watchstanders report status of equipment back to repair locker

METHOD: Ensure that watchstanders properly access compartment

OPERATOR: Ensure watchstanders access through proper location

OPERATOR: Ensure watchstanders maintain communications with repair locker

OPERATOR: Ensure watchstanders have functioning equipment to combat casualty as required

OPERATOR: Ensure watchstanders follow proper entry procedures

METHOD: Ensure that watchstanders properly engage casualty

OPERATOR: Ensure that watchstanders demonstrate adequate casualty combatting procedures

OPERATOR: Show applicable prop[s] to watchstanders signifying casualty is engaged

METHOD: Prompt watchstanders when casualty should be extinguished

OPERATOR: Ensure that watchstanders demonstrate proficiency enough to extinguish casualty

OPERATOR: Show applicable prop[s] to watchstanders signifying casualty is extinguished

METHOD: Ensure all gear is properly restowed

OPERATOR: Ensure that gear is returned to locker in accordance with allowance equipage list (AEL)

OPERATOR: Ensure that equipment will be ready for future casualties if required

METHOD: Ensure all equipment is restored to proper configuration

OPERATOR: Ensure watchstanders restore all items that were isolated to their original/normal state

F. ASSESSING DC DRILLS

GOAL: Assess drill

METHOD: Debrief with DCTT members

OPERATOR: Assemble DCTT members
OPERATOR: Collect pertinent drill data from all members
METHOD: Determine scores for TORIS-TFOM line items
OPERATOR: Attribute line items based on feedback from DCTT team
METHOD: Debrief crew
OPERATOR: Assemble crew members involved in drill
OPERATOR: Provide feedback on performance of watchstanders

G. CHAPTER SUMMARY

The entire process of drill execution can be quite cumbersome, and it is clear that DCTT Coordinators should be seasoned sailors capable and effective in managing time and work. It should be noted that DCTT Coordinator is a collateral duty and that the DCTT Coordinator is responsible for many other items are occurring simultaneously with drill preparation, including managing a division, preparing for ship inspections, and scheduling DC evolutions are just a few. The task analysis here is to highlight the steps that are required for creating these drills as well as ensuring that our prototype meets all the requirements for designing a satisfactory drill package.

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IV. TRAINING DEVICES

A. INTRODUCTION

This chapter will demonstrate our thought processing in how our proposed system could be implemented onboard surface ships and our analysis of drill packages which when coupled, drive the design of our prototype, which we called the Damage Control Training Team, Tool Suite (DCTT-TS).

The analysis of alternatives is broken up into several parts that show different methods of implementing a new system and the pros/cons associated with them. We cover designs such as utilizing mobile devices with and without a network, different networking options, a standalone type system, different software options, as well as the current method. This section also includes some technologies that are being developed as well as technologies that we believe should be further researched.

We then dissect current fleet DC drill packages and highlight commonalities amongst all of them. These commonalities drive the design of our UI and how we created our system's architecture. Although we did not anticipate networking any devices due to the current difficulty of wireless networking on Navy ships, we attempted to create a framework that would easily allow networking implementation as it becomes possible in the future

B. IDEAL VISION OF TRAINING AID

Our goal was to provide a tool based on previous experiences and interviews as to what be most beneficial to DCTT Coordinators. To do this, we believe that the system would need to have three distinct parts:

1. Drill preparation

This portion would streamline the package creation process as well as the routing and briefing aspects. Ideally, a DCTT Coordinator could create a drill package in a matter of minutes on their device and have it ready for routing either electronically or in paper form.

2. Drill execution

This aspect would allow DCTT members to communicate efficiently and effectively while being engaged in the training process. This would include all aspects to the execution of the drill including DCTT members providing updates of watchstander progress in engaging the casualty, properly identifying isolations, and effective implementation of casualty equipment to DCTT Coordinator.

3. Drill assessment

The system should track certain data points throughout the drill provide metrics based on the watchstanders' performance in the drill. These metrics should correspond with the ATG gradesheets such as Figure 2.

C. ANALYSIS OF ALTERNATIVES (AOA)

We looked at several possible options to meet our vision of improving the planning of DC drills, which we describe below.

1. Mobile Device with Wireless Connection

a. Tablet

(1) Rugged tablet

Pros:

- Made to withstand rough environments
- Features may include shatter resistance, water resistance, bullet proof, drop resistance, etc.

Cons:

- Expensive
- Lower computational capabilities

(2) Commercial grade tablets (Apple iPad, Samsung Tab, Amazon Fire, etc.)

Pros:

- Low cost
- Readily available
- High computation power
- Customer service and support readily available

Cons:

- More fragile than their hardened counterparts
- Apple products require additional licensing for software
- Not water resistant

b. Mobile Phone (Smart Phone)

Pros:

- Nearly every sailor has one
- Low cost to maintain and update
- Compatible with wireless and bluetooth

Cons:

- Compatibility (iOS and Android)
- Storage sizes
- Security/vulnerabilities when connecting to unsecure networks
- Small screen size

c. ***Networks***

(1) Wireless fidelity (Wi-Fi)

Pros:

- Low cost options available
- Large area of coverage
- Majority of commercial devices can connect to it
- Utilizes existing protocols

Cons:

- Emission control (EMCON) must be regulated to meet operational requirements. In other words, in certain operational environments, it would have to be secured quickly which means that a mechanism must be in place to secure whole system immediately
- Faster devices that cover more area can get costly
- Unknown how many devices required to cover entire ship

(2) Bluetooth

Pros:

- Short range assists with EMCON
- Low cost
- Majority of commercial devices can connect to it
- Utilizes existing protocols

Cons:

- Short range

- Unknown capabilities onboard ships (i.e., unknown if signals can pass through bulkheads)

(3) Light Fidelity (Li-Fi)

Li-Fi is a newer technology that utilizes preexisting hardware to transmit data. This technology transmits data through light by modifying the current alternating current of 60Hz that we normally find in typical lighting systems. As Dr. Saini at the Ajay Kumar Garg Engineering College in India describes it, rather than turning lights on and off 60 times per second, Li-Fi sends the light in a pattern which corresponds to binary — "if the LED is on, you transmit a digital 1, if it's off you transmit a 0" [28].

Pros:

- Data is concealed inside ship, so it is not affected by changes in ship's EMCON status
- Higher data rates than can be achieved by current WiFi and Bluetooth methods
- Does not affect normal operations
- Low installation costs if only data transmission is required (i.e., transmit but not receive)

Cons:

- Light doesn't pass through bulkheads
- Data flow is currently one-directional
- Hardware will be expensive to allow data flow (cameras and devices that radiate)
- High installation cost onboard ships and modifications

- Interferences can be caused by other sources (sun, flashlights, computer screens, etc.)

(4) Installed hardware

We propose that additional research into the feasibility of utilizing existing radio systems to transmit data might yield useful results. Most surface ships maintain a radio network known as the Shipboard Internal Wireless Communications System (SIWCS) which consists of standard Motorola XTS type radios coupled with multiple repeaters throughout the ship. We believe that these radios would be capable transmitting and receiving data and with a simple USB attachment, provide a means for device to communicate.

Pros:

- No required installation costs
- Low cost radio attachments
- Would not require changes to existing EMCON procedures

Cons:

- No research has been done on this technology yet
- Likely low bandwidth
- Must create new protocols
- Black-out spots onboard ships
- Utilize entire radio channel
- Can be interfered with by unknowing users

2. Mobile Device without Wireless

Pros:

- Nearly every sailor has one
- Low cost to maintain and update
- Compatible with wireless and bluetooth

Cons:

- Single point of failure is voice comms
- Requires coordination in advance to distribute packages (i.e., air drop, Bluetooth sharing, etc.)

3. Standalone Laptop

Pros:

- Single command and control station to control drill
- Inexpensive
- Easy maintenance

Cons:

- Creates single point of failure
- Relies on voice comms

4. Software Licensing

a. Open Source

Pros:

- Allow for faster deployment
- Easy to make changes later on as oppose to waiting for an update or patch
- Cheaper and easier to support than proprietary code

Cons:

- May not be supported as strongly as proprietary

b. Government Developed/Owned

Pros:

- Should meet DoD security requirements
- Government owns the product, so no licensing fees

Cons:

- Long development lead time
- Expensive to create
- Difficult and costly to maintain support

c. Proprietary

Pros:

- Cheaper than government developed
- Greater number of users likely familiar with the software
- Customer service and support
- Can utilize commercial industry for support

Cons:

- Licensing fees
- Security could be issue

5. Paper and Pen

Pros:

- DCTT Coordinators are familiar with the current methods
- Mobile
- Rugged
- Does not require power source
- Easily distributed

Cons:

- Single point of failure communicating solely via voice comms
- Formatting often an issue
- Prone to human error

D. AOA CONCLUSION

Following the AoA, we believed that in order to create a training aid that would be suitable for the shipboard environments and the DCTT, a system would require rugged mobile devices on a network that allowed DCTT members to communicate through their devices.

The system to complete this task we deemed out of the scope of a thesis and as such, we focused on the drill preparation. Based on this task, we chose to utilize a rugged tablet and a proprietary software called Unity game engine to create a prototype that we named the Damage Control Training Team, Tool Suite Design (DCTT-TS). No decisions were made as to the network type to be used if any, however we inserted several items into the system to allow for future use if a network be implemented.

E. DAMAGE CONTROL TRAINING TEAM TOOL SUITE DESIGN (DCTT-TS)

1. Drill Layouts

In order to design an efficient and intuitive system, we first had to identify the main structure of drill packages and what the required items were. We requested drill packages from multiple sources in order to compare and analyze. Each package we examined followed a similar structure: drill name and watch team, DCTT briefing and execution information, amplifying DCTT information, plant status, ORM and safety, amplifying drill information, props and DCTT assignments, and individual line items for the casualties.

a. Drill Name and Watch Team

The commanders of the Atlantic and Pacific fleets have ordered surface ships to maintain DC readiness at all times and provided the guidance on how to do so through the Surface Force Training and Readiness Manual (SFTRM) [16]. This document additionally dictates the periodicity of drills broken down by casualty and watch teams responsible for executing them as shown in Figure 2. These drills are also referred to as Repetitive Exercises (REs).

Because these REs occur frequently, and documentation of these drills require to be maintained for one year, it becomes burdensome for DCTT Coordinators to organize and maintain such documents. Compounded with additional certification events during inspections, DCTT Coordinator must inherently be effective and efficient in devising a serialized means of tracking all required documents. Upon analysis, many ships created a title page for the drills with all required signatures on it along with the date, watch team, and an identifiable title.

b. DCTT Briefing and Execution Information

The next items on the majority of the drill packages analyzed were the briefing and execution information. This portion typically consisted of the time that the drill was scheduled, the DCTT briefing time and location, drill duration, and debrief time and location for both DCTT and the watch standers following the drill. These DCTT briefings are important because they are where many conflicts with the package can be identified prior to drill execution, scheduling of drills and briefs can be determined in advance, and the assessment of the drill can be analyzed by DCTT members with feedback to give to the watch standers.

c. Amplifying DCTT Information

This portion of the analyzed drill packages contained an eclectic amount of information due to the lack of official requirements and guidance on the matter. This portion's lack of standardization made it difficult to determine what is required for a successful drill package, but we determined that the following were the main items required:

- Communications for DCTT
- Proficiency levels of DCTT (walkthrough, training, or assessment)
- Proficiency levels of watch team (walkthrough, training, or assessment)
- Scenario integration (standalone, parallel, or integrated)

d. Plant status

The plant status portion of the drill package is to inform the CO of what equipment could be affected by the drill and the resulting capabilities of the ship. It also allows other training team coordinators (Engineering, Combat Systems, etc.) to ensure that no equipment is damaged by watch standers manipulating equipment during the drills. This portion also identifies equipment that may be degraded or out of commission, so that all parties are aware of any safety concerns that may arise.

e. ORM and Safety

ORM is a program for the Navy aimed for sailors to ensure they accept no unnecessary risk. It derives its decision-making paradigm by these five factors [29]:

- Identify hazards.
- Assess hazards.
- Make risk decisions.
- Implement controls.

- Supervise (and watch for changes)

Sailors are encouraged to utilize these items to determine different hazards and assign them codes based on their probability and severity. Sailors would then utilize a table to determine a risk assessment code (RAC) from a matrix as seen in Table 1. Mitigations would then be put into place to decrease the risk of injury and/or damage to equipment. These are utilized for most Navy evolutions involving CO permission to help make a determination whether they would like to proceed with the evolution, implement additional safety precautions, or cancel the event. Heat stress was a hazard that was identified in every drill package observed.

Each drill package contained an additional piece for safety walkthroughs. This portion assigned each DCTT member to a specific compartment(s) on the ship that must be patrolled to identify any safety concerns. This involves checking space DC equipment; ladders, doors, scuttles and hatches; valve alignments; and any other safety concerns that could be identified. Upon completion of the walkthrough, DCTT members give their reports to the DCTT Coordinator who coordinates with the DCTT Leader to "go or no-go" with the drill.

Table 1. ORM RAC determination. Source: [29].

Risk Assessment Matrix				**PROBABILITY** Frequency of Occurrence Over Time			
				A Likely	**B** Probable	**C** May	**D** Unlikely
SEVERITY	**Effect of Hazard**	**I**	Loss of Mission Capability, Unit Readiness or Asset; Death	**1**	**1**	**2**	**3**
		II	Significantly Degraded Mission Capability or Unit Readiness; Severe Injury or Damage	**1**	**2**	**3**	**4**
		III	Degraded Mission Capability or Unit Readiness; Minor Injury or Damage	**2**	**3**	**4**	**5**
		IV	Little or No Impact to Mission Capability or Unit Readiness; Minimal Injury or Damage	**3**	**4**	**5**	**5**
Risk Assessment Codes							
1 - Critical **2** - Serious **3** - Moderate **4** - Minor **5** - Negligible							

f. Amplifying Drill Information

The amplifying information portion of the package is what provides detailed information such as self-contained breathing apparatuses (SCBA) being used, mechanical and electrical isolations being simulated or actually manipulated, smoke machine usage, etc. For our design, we added SCBA status, isolations, and SCBA refill station status. This section can also be expanded for ship specifics as needed.

g. Props and DCTT assignments

Each drill studied has a specific portion to designate the individual DCTT members partaking in the drill and their role in the drill. Some of the roles being assigned include the boundaries, the investigators, a locker, or the scene. This designation area also typically shows whether or not each individual assigned to that position is qualified to fulfill the role or whether the DCTT member is under the instruction of another.

The next item in this portion was a listing of all the props that would be used in the drill. ATG provides a list of recommended props, also known as disclosures, to the fleet, however ships may tailor the list to their liking. Typical props include flags that designate a specific casualty, meter sticks to represent flooding levels, or rags that represent agent being expelled from a fire extinguisher. Any applicable props for a drill are typically designated in a table format in this section of the package.

h. Scenario and Individual Line Items for The Casualties

The final piece that was present in every drill package was a scenario and individual line items in a list format. Although the scenario that explains how the damage occurs was found in multiple places in the various packages examined, we decided to put it just prior to the line items in the prototype.

The final and most important part of each drill package is the line items for the casualties. These line items describe in detail the different components of DC efforts that DCTT members should be participating in and observing. They describe the actions, the props, amplifying information, and the DCTT member assigned to monitoring it. The number of line items vary by ship and based on the type of casualty, but when all items of the list have been completed, the drill can terminate.

2. Usability

We followed Shneiderman's eight "golden rules" in creating the prototype's UI. His rules are [30]:

1. Consistency in action sequence, layout, terminology, and command used.
2. Frequent use of shortcuts, such as abbreviations, special key sequences and macros, to perform regular, familiar actions more quickly.
3. Give proper informative feedback to every user action, at a level appropriate to the magnitude of the action.
4. Design dialogs to yield closure so that user knows when they have completed a task.
5. Offer error prevention and simple error handling so that, users are prevented from making mistakes.
6. Permit easy reversal of actions.
7. Support internal locus of control.
8. Reduce short-term memory load.

With these rules, we were able to layout a rough low fidelity model of what DCTT-TS should look like and how to navigate through the different parts of our system. When studying case studies, we noticed that UIs of successful projects follow three similar patterns: they control colors, control screen space, and do not overwhelm the user with selectable options. Utilizing these three rules coupled with Shneiderman's principles, we developed the UI of DCTT-TS, which is further described in the next sections.

3. Virtual Environment Design

The first piece to our prototype is our VE. We chose to use a 3D rendered model of a ship interior for several purposes: provide familiarity to DCTT, identify progressive casualties in a visual manner, and for compatibility with future research and systems such as VR applications. We also chose the Unity game engine to create our system due to familiarity, its ability to create and manipulate VEs, and not having any licensing fees for research purposes.

We searched for a digital model of a DDG to use as a prototype from the following institutions: Bath Iron Works which built and helped designed the original Arleigh Burke class destroyer, USS Arleigh-Burke (DDG-51); Program Executive Officer for shipbuilding (PEO Ships), specifically PMS-400D (DDG-51 program) at the Naval Sea Systems Command (NAVSEA); Naval Surface Warfare Center – Carderock Division (NSWCCD) which was responsible for testing survivability of ships in the fleet; and the EDO community. After not finding a model that showed the interior of a DDG, we chose to make one.

Our solution was to utilize the drawings that were provided by PMS-400D and construct our own model utilizing the open source software Blender. An image file (jpeg) of each deck was laid horizontally in Blender and bulkheads erected using the image as a blueprint. The decks were then laid in a hull exported from the 3D model provided by the ED community and the cumulative product was exported as an FBX file and imported into Unity. An additional firemain piping diagram was created and imported into Unity the same way. The model was then overlaid with materials representing deck colors that would be applied to the actual shipboard compartment and frame numbers to help identify where on the ship the user is.

This model became the first piece of a four-part DCTT-TS. We named the four parts as Hullform, Casualty List, DC Plates, and Drill Package, which will be further discussed in the following sections. The Hullform part provided the UI of moving through the ship, cycling through decks, enabling and disabling piping diagrams, and inserting casualties. Once a casualty was initialized, a visual representation such as a fire or piping rupture would immediately show at the selected location and the remaining parts would be populated with the casualty’s information.

4. Casualty Organization

A problem that DCTT Coordinators face is the organization of mass conflagration (multiple casualties at once) drills, also known as mass conflags. These drills require large amounts of coordination amongst multiple drill teams and when drafting individual line items for a drill with several casualties throughout the ship with all DCTT members employed, many errors can be overlooked or line items missing all together.

This motivation drove our design for the second part of our DCTT-TS, the Casualty List. For our system, we decided to implement a casualty tracking system that allows DCTT Coordinators to easily track and manipulate each of their casualties. These manipulations include starting, pausing, restarting, and deleting casualties as determined by the DCTT Coordinator. Although none of the buttons we used had functionality, the idea was to lay framework for future implementation if this project were later expanded. However, the ability to sort casualties by the time they occur and showing that in a UI manner is requirement to maintain order. Figure 4 shows how the casualties would stack once added in the Hullform tab.

Figure 4. Screenshot of the Casualty List populated

5. Rapid DC Plotting

Rapid plotting is a skill that all personnel involved in charge of a control station must learn. This technique involves a series of letters and symbols that represent actions and statuses of casualties. Figure 5 shows an example of rapid plotting symbology for a flooding casualty. This symbology is used on DC plates which are large laminated sheets that map out the ship and assist controlling stations with DC efforts.

We decided to insert DC plates into our system for two reasons: to provide ease of assess of DC plates to DCTT members and to ensure rapid plotting is being done properly throughout the ship. Rapid plotting is a trait that if not practiced regularly can be easily forgotten. Often times it is found the DCTT members including the DCTT Leader do not know rapid plotting proficiently.

Because plotting should be uniform shipwide, we believe that a feature that plots damage and updates throughout the drill would be an important feature to have for DCTT members; however, because we did not further develop DCTT-TS for drill execution for this thesis, the functionality is not yet there. Figure 6 shows what the plotting should look like if implemented into DCTT-TS.

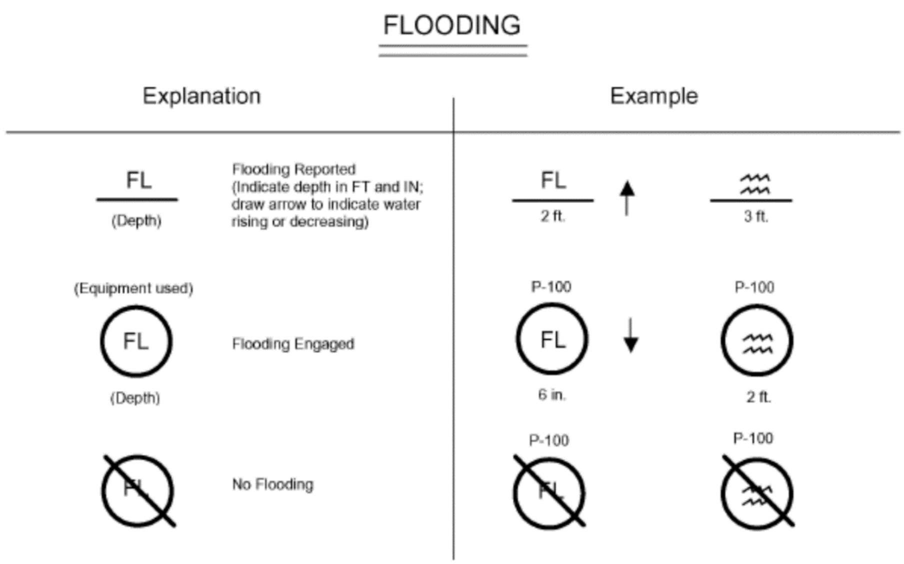

Figure 5. Rapid plotting symbology. Source: NSTM chapter 079, volume 2 – Practical Damage Control, appendix B.

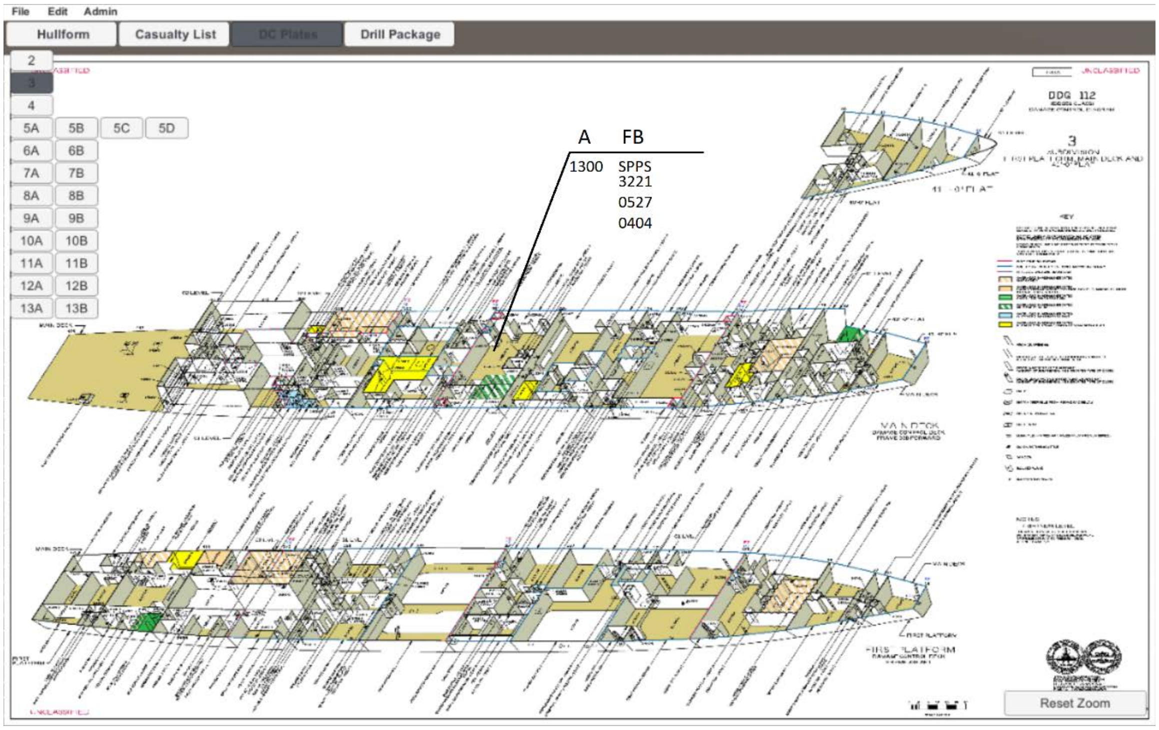

Figure 6. DC rapid plotting in DCTT-TS

6. Drill Package Information Compilation

The final part of the system is the Drill Package portion that utilizes a series of buttons, toggles, and input fields to fill in the remaining package requirements. We accomplished this by breaking down the drill package items that we identified from the fleet samples in section 1. These items we broke up into additional tabs: General Information, Plant Status, Space Walkthrough, ORM, and DCTT Assignments.

a. General Information

The General Information section is populated with items such as drill, brief and debrief dates and times; communications; proficiency levels; and miscellaneous items. Figure 7 shows a snapshot of the finalized General Information section with several items populated. We utilized scripts to create a calendar function to assist in selecting dates, and then a series of dropdowns, toggles and input fields to populate the remaining fields.

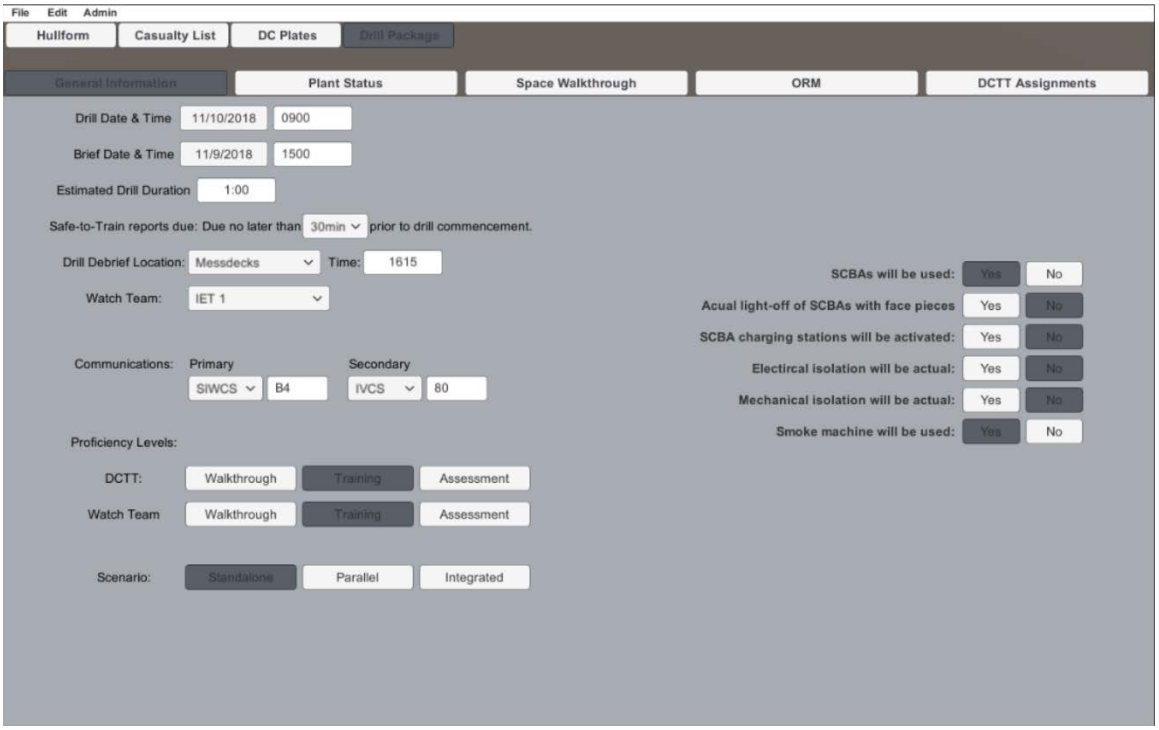

Figure 7. General drill information layout in DCTT-TS

b. Plant Status

The second portion of the drill package items is the Plant Status. Figure 8 shows a screenshot of our design which features a group of toggles and 3-way buttons that enable the user to cycle through different conditions for the equipment. The key at the bottom shows the meaning of the button options and an input allows the user to manually add any DC equipment that is out of commission (OOC) and give reasoning or a departure from specifications of use.

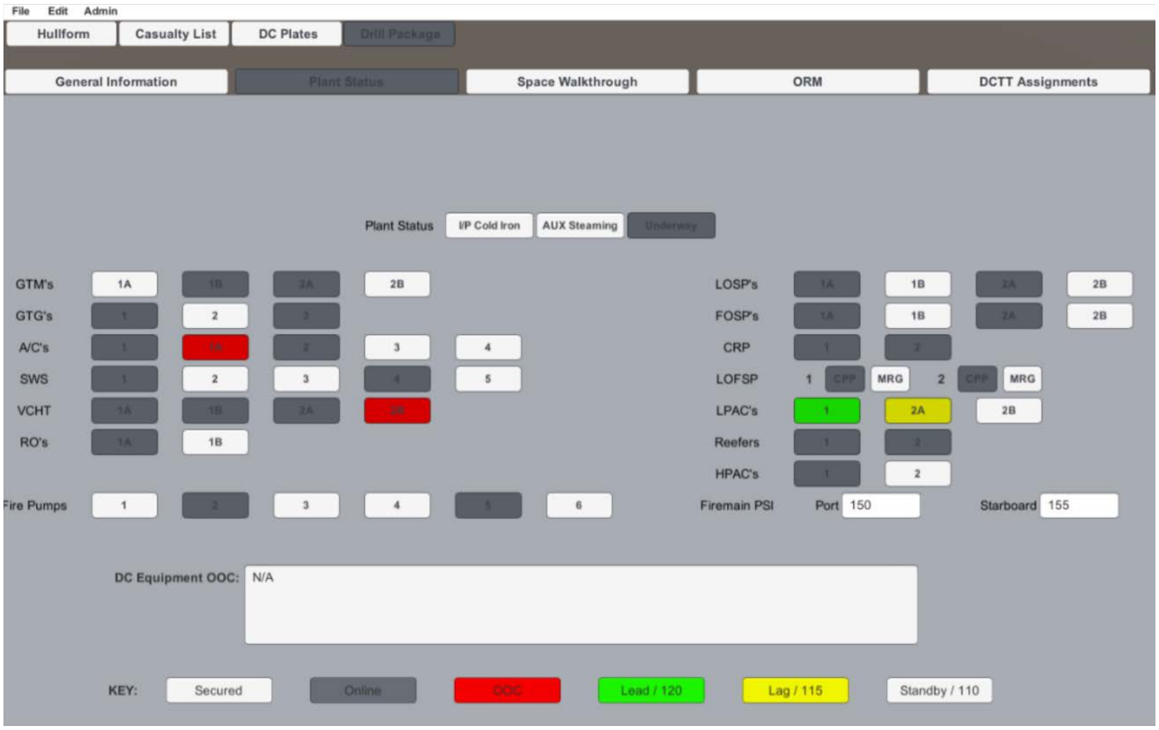

Figure 8. Plant Status layout in DCTT-TS

c. *Space Walkthrough*

The third portion of the Drill Package section is the Space Walkthrough tab. This portion was not implemented for this research, but we wanted to designate a section for it to demonstrate that it would be incorporated into DCTT-TS in future work once a network is established and walkthrough reports could be transmitted to DCTT Coordinator.

d. *ORM*

Part four of the Drill Package section is ORM and identifying hazards associated with executing a drill. For our DCTT-TS prototype, we only programmed two hazards as seen in Figure 9 (heat stress and ladder safety). Along with being able to select a hazard, the user can assign a severity and risk code to each item based on circumstances surrounding the drill such as location of the drill (traversing multiple decks), rough seas, abnormally hot weather, etc. The key for how the codes be assigned to hazard is in the top right of the screed for ease of reference. For future development of DCTT-TS, we aim to create a master list of all hazards that are identified by DCTT Coordinators in the fleet and allow them to choose from the list as applicable for each drill.

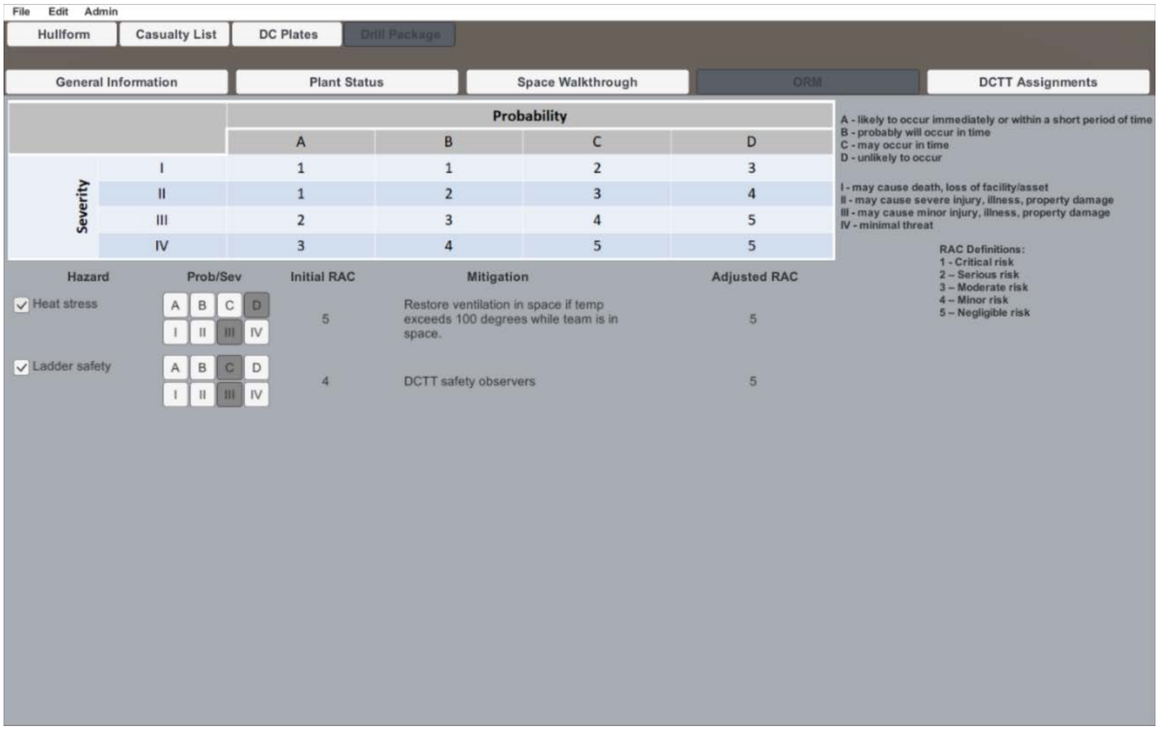

Figure 9. ORM layout in DCTT-TS

e. DCTT Assignments

The last part of the Drill Package portion is the DCTT Assignments tab. To complete this, we created a master list of line items that we found common across all sampled drill packages and developed a dictionary with the key being the casualty type and the value returned being the line item list. When a casualty is created in the Hullform section, it populates both the Casualty List and queries the dictionary for the values associated with the key and utilizing a "for each" loop to generate each line item in the list. Figure 10 shows a screenshot of the DCTT Assignments list required for a Class "A" fire.

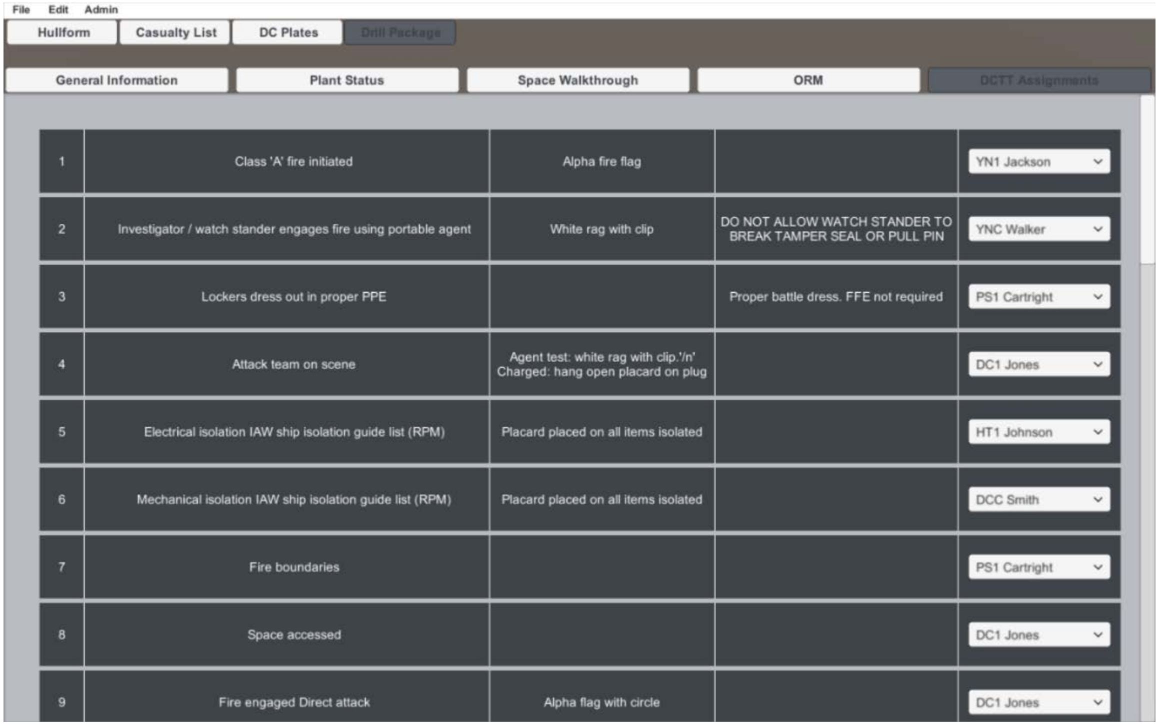

Figure 10. DCTT Assignments layout in DCTT-TS

7. Drill Package Population via Exportation

In order to make this prototype compatible with current Navy policies, we decided to make packages exportable to a Microsoft Word file for further editing and the ability to print for routing. This posed a problem, however, because Unity doesn't not have the ability to export data to Word type document. In order to bridge the two, we first had to understand what can be exported from Unity. Exporting data from Unity in the form of a comma separate values (CSV) format is well documented and we decided that be a good starting point since Microsoft files can read CSV files. The next step was automating the population of a Word file. After several web searches, we discovered the use of Visual Basic for Applications (VBA) and macros could fulfill the gap we were missing. We then developed a macro in an additional Excel file that utilizes bookmarks in Microsoft Word, matches the bookmark with a value in the CSV file, and replace it with another value from the CSV. Figure 11 shows this sequence in visual form and Figure 12 shows the code used in VBA to execute the macro.

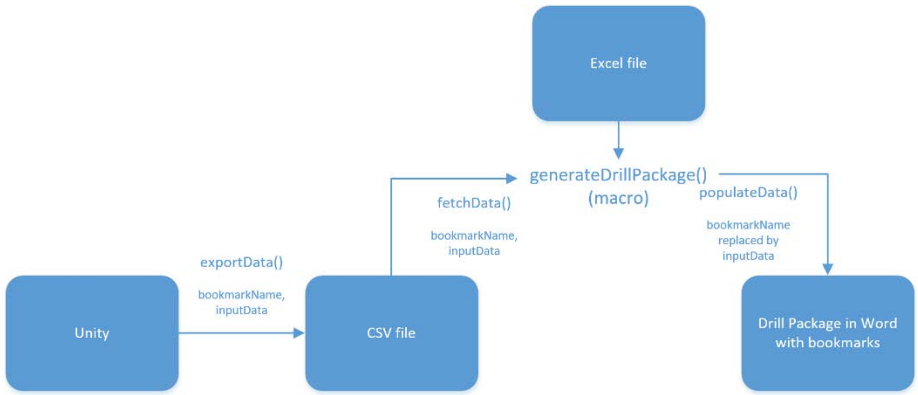

Figure 11. Macro package population breakdown

```
Option Explicit

'change this to where your files are stored
Const FilePath As String = "C:\Users\FilePathInsertedHere...\"

Dim wd As New Word.Application

Dim LineItem As Range

Sub GeneratePackage()

ImportCSV

'create copy of Word in memory
Dim doc As Word.Document
wd.Visible = True

Dim ItemRange As Range

'create a reference to all the people
Range("A1").Select

Set ItemRange = Range( _
ActiveCell, _
ActiveCell.End(xlDown))

'open word doc
Set doc = wd.Documents.Open(FilePath & "Word Template.docx")

'for each item in list
For Each LineItem In ItemRange

'go to each bookmark and type in details

CopyCell LineItem.Offset(0, 0), 1


Next LineItem

End Sub

Sub CopyCell(BookMarkName As String, ColumnOffset As Integer)

'copy each cell to relevant Word bookmark
wd.Selection.GoTo What:=wdGoToBookmark, Name:=BookMarkName
wd.Selection.TypeText LineItem.Offset(0, ColumnOffset).Value

End Sub
```

Figure 12. VBA code for populating Word document with CSV data

F. CHAPTER SUMMARY

We showed the workflow of designing the system and identifying alternative means of implementing the desired system from a technologies standpoint. We then discussed how we chose the items that must be incorporated into the system through research of fleet DC drill packages. Then, we discussed the principles of usability that drove the design of DCTT-TS's layout and the justifications of partitioning the sections in the matter we did. Finally, we discussed the difficulties of exporting from Unity into a Word document and our bridged system that performed this task via a macro in Excel.

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V. USER STUDY

A. INTRODUCTION

The goal of this study was to provide numerical data for examination and to answer the research questions and prove or disprove the hypotheses. The study was broken down into a series of goals: create tasks, identify users and locations, draft and submit request to IRB, and execution.

B. TASKS

The tasks required to study chosen for the users to perform were established based on periodicity and complexity of drills. We chose to implement the most basic of casualties: class "A" fire and firemain ruptures.

1. Consent to Participate

Prior to each user's participation, a consent form was required to be completed by the participant to ensure that participation was entirely voluntary and provide the user with the tasks to be performed and any risks involved with participation.

2. Class "A" Fire Task

The class "A" fire is one of the most basic casualties and is the most commonly run of the four types of fires (A, B, C, D). Users in this study were asked to insert a class "A" fire in a designated compartment. The investigator chose the compartment based upon common compartments that were utilized by the fleet DCTT Coordinators and observed by the studied drill packages. Upon completion of the directions and answering any questions the users had, a timer was started to record the time to complete the task. They would then begin to insert the class "A" in the designated location. Upon completion, they were then asked to complete the remainder of the drill package items that would normally be incorporated in a package. After completing all the information required, the participant was tasked to export the package. After they successfully found the button that exports the data, the timer was stopped, and the user was given training on opening the Excel file that contained the macro for package population and how to execute the macro.

3. Firemain Rupture Task

Upon completion of training of the macro use, the user was requested to insert a firemain rupture at a designated location on the main deck and the timer was started again. Upon insertion of the rupture, they were requested to complete the drill package as before, export the file, and execute the macro. Upon completion of executing the macro, the timer was stopped again.

4. Grading

Each package created using DCTT-TS as part of this experiment was then graded against four drill packages taken from those we collected for our earlier investigations. All identifying information was removed from the packages. We chose a group of SMEs from the ATGs to grade the set of drill packages to assess the quality of those produced by DCTT-TS with those commonly produced currently in the fleet.

5. Survey

The final item for each user study was participation in a survey. The survey consisted of twelve questions designed in three parts. The first part was to attain the demographic information of the users to verify that they were a solid target audience for this study. The second was to gain a better insight into the current time and resources required to create and route a drill package. The final part of the survey was to provide feedback on the usability of our prototype.

C. SUBJECTS

1. Damage Control Assistants (DCA)

For Surface Warfare Officers (SWOs), an option for a second tour billet is as a DCA. These individuals serve as a subject matter expert in DC. Their roles include training the entire crew in DC, maintaining DC readiness, and providing recommendations to the CHENG and CO for all matters relating DC on the ship. They consistently interact with the DCTT members in training and drill executions, and their additional proficiency with DC administrative matters and management make them well qualified as participants for a new DC tool.

2. DCA/Senior Enlisted Course (DCA/SE)

There are two DCA/SE locations, San Diego and Norfolk, that provide the training for all DCAs in the Navy and Coast Guard and give a specialty Navy Enlisted Classification (NEC) to the senior enlisted personnel upon graduation. The specific NEC is Senior Enlisted Damage Control Program Management and Training Specialist (U46A, formerly 4811). Both DCA/SE locations fall under is the Surface Warfare Officer School (SWOS) is located in Newport, RI. The mixed group of officers and senior enlisted provides an interesting research dynamic and the specialty training they receive make them an optimal group for research in a new DC computer-based system.

3. ATG

There are multiple ATG locations around the world: Mayport, FL; Norfolk, VA; San Diego, CA; Everett, WA; Pearl Harbor, HI; and Yokosuka, Japan. These locations fall under two commands: ATG Pacific (ATGPAC) and ATG Atlantic (ATGLANT). These commands provide both training and assessments to the fleet across the globe and are filled with seasoned officers and senior enlisted who are subject matter experts in specific areas. One of the mission areas of the ATGs is mobility of DC (MOB-D) in which ships must maintain proficiency 365 days a year. The MOB-D teams are tasked with ensuring that all surface ships maintain such proficiency or receive the resources to reach proficiency. These assessors too will make for well qualified participants into a study of an automated DC system.

D. STUDY DESIGN

1. Locations Chosen

a. Naval Postgraduate School, Monterey, CA

This location was chosen to administer the pilot program due to its location and population of SWOs.

b. San Diego, CA and Norfolk, VA

These locations were chosen because both have an ATG and DCA/SE in near proximity to one another.

2. Desired Subjects

a. Prior DCAs

Prior DCAs were chosen as the desired subjects for the pilot program because there are a number of students enrolled at NPS with this background. Their feedback assisted greatly in the pilot program process and the future tests due to their familiarity with the DC organization and their prior experiences.

b. Former and Current DCTT Coordinators

This population was chosen for obvious reasons as the primary test subjects for the study at both DCA/SEs in San Diego and Norfolk. These individuals took part in testing of DCTT-TS class "A" fire and firemain rupture implementation, as well as the survey.

c. ATG Assessors

The ATG assessors, both ATGLANT and ATGPAC, were chosen to partake in the grading portion and survey. Their prior experiences as DCTT Coordinators and their additional training as assessors provided good feedback for future iterations of DCTT-TS and its possible implementation.

E. EXECUTION

1. NPS Pilot Program

The pilot program's goal is to test for faults in the DCTT-TS prototype, practice executing the user study, and identify bad UI aspects.

a. Participants

(1) The senior SWO at NPS sent a mass email to all student SWOs that requested anyone with prior DC experience to participate in user testing. Five DCAs and one former repair locker officer participated.

Three other former DCAs responded, however, but further feedback was deemed not required.

(2) Participation in the study took approximately 30 minutes per person

b. Tasks

(1) Participant created class “A” fire in a designated compartment

(2) Participants added flooding in a designated compartment

(3) Participants exported the drill scenarios to a Microsoft Word file

(4) Feedback was requested on system performance

2. DCA/SE

a. Participants

(1) Students at DCA/SE were briefed on the research being conducted and those with DCTT Coordinator experience were requested to participate in user testing and survey

(2) Nineteen individuals participated in the study

(3) Participation in the study took between 30 and 45 minutes per user.

b. Tasks

(1) Participant created class “A” fire in a designated compartment

(2) Participants added flooding in a designated compartment

(3) Participants exported the drill scenarios to a Microsoft Word file

(4) Survey questions were administered

(5) Feedback was requested on system performance

3. ATG

a. Participants

(1) ATG personnel were briefed on the research being conducted and volunteers were requested to participate in grading of drill packages and survey

(2) Fourteen ATG personnel participated in the study

(3) Participation in the study took approximately 25 minutes.

b. Tasks

(1) Participants were provided five drill packages, four from ships with all identifying information removed, and one produced by a DCA/SE participant

(2) Participants were requested to give a qualitative grade to both packages

(3) Participants were shown system and allowed to create drills

(4) Survey questions were administered

(5) Feedback was requested on system performance

F. CHAPTER SUMMARY

The user study and justifications for the selected audiences and locations were chosen due to proximity and the user groups available. Additionally, the execution of the study for the pilot program in Monterey, as well as the testing at DCA/SE and ATG locations in both San Diego and Norfolk were discussed and organized to optimize participation and quality of subjects. The results of this user study are covered in the following chapter.

VI. RESULTS AND FEEDBACK

A. INTRODUCTION

This chapter discusses the results from the user studies conducted in Norfolk and San Diego at both DCA/SEs and ATGs. We analyze the data that collected and provide statistics and graphs to help draw a conclusion on the research at hand.

This chapter also discusses the feedback collected with respect to ideas of future work, open-ended feedback, and the requirements in order to make DCTT-TS a reliable alternative to the current approach.

B. TIMED OPERATIONS

Timed operations were collected at both DCA/SE locations in performing the two tasks of creating a class "A" fire and a firemain rupture, and the additional information associated with a drill package as discussed in Chapter V. The shipboard locations selected were chosen at random based on a list of typical locations used in the fleet.

No training was given to the users and the tasking was simply to implement a class "A" casualty at a designated location and to enter all additional drill package information, then export into a Word document. The clock was started immediately upon completion of the directions and was stopped once the export button was selected. Training was then conducted on how to utilize an Excel file macro that would automatically populate the Word document. The program was then restarted, and the user was then asked to create a firemain rupture at a designated frame number. Clock was started upon completion of the directions and the clock was stopped after they successful implementation of the Excel macro. Results of the testing are shown in Table 2 and graphically in Figures 13, 14 and 15.

Table 2. Timed operations from DCA/SE students for implementing casualties with DCTT-TS

		Alpha Fire			Firemain Rupture		
Rate	Paygrade	Location	Time	Unrelated Clicks	Location	Time	Unrelated Clicks
DCC	7	Berthing #3	6:45	5	FR 290 STBD	2:34	8
DC1	6	Berthing #2	7:13	17	FR 310 STBD	4:13	22
DC1	6	General Workshop	8:59	26	FR 145 PORT	5:41	16
HTCS	8	Berthing #1	6:47	3	FR 125 STBD	4:52	25
DCCS	8	Berthing #2	9:40	7	FR 250 PORT	3:59	4
DCC	7	General Workshop	9:21	6	FR 50 PORT	4:52	9
DCC	7	Berthing #1	5:54	3	FR 225 STBD	3:57	4
DCCS(CG)	8	General Workshop	7:24	7	FR 225 STBD	4:22	12
DCCS	8	Berthing #3	6:40	19	FR 310 PORT	4:10	19
DC1	6	General Workshop	5:42	4	FR 110 STBD	4:52	16
DCC	7	Log Room	6:21	19	FR 180 PORT	4:10	32
DC1	6	Berthing #1	6:31	14	FR 320 PORT	4:17	12
DCC	7	Berthing #2	7:46	16	FR 120 STBD	4:55	9
DCC	7	CPO Berthing #2	6:00	4	FR 265 PORT	4:12	11
DC1(CG)	6	Laundry	6:30	6	FR 310 STBD	3:32	2
LT(LDO)	12	Berthing #1	8:31	22	FR 65 STBD	3:16	4
DCC	7	Berthing #3	8:50	19	FR 310 PORT	3:22	3
ENS	10	Berthing #7	6:48	16	FR 290 STBD	2:41	3
DC1	6	Laundry	9:53	24	FR 230 PORT	3:32	8
DC1	6	Supply Support	7:21	12	FR 150 PORT	2:31	0
	7.3	Average:	7:26	12.45	Average	4:00	10.95
		Max:	9:53	26	Max:	5:41	32
		Min:	5:42	3	Min:	2:31	0
		SD:	1:18	7.63	SD:	0:50	8.51
		Median:	7:00	13	Median:	4:10	9

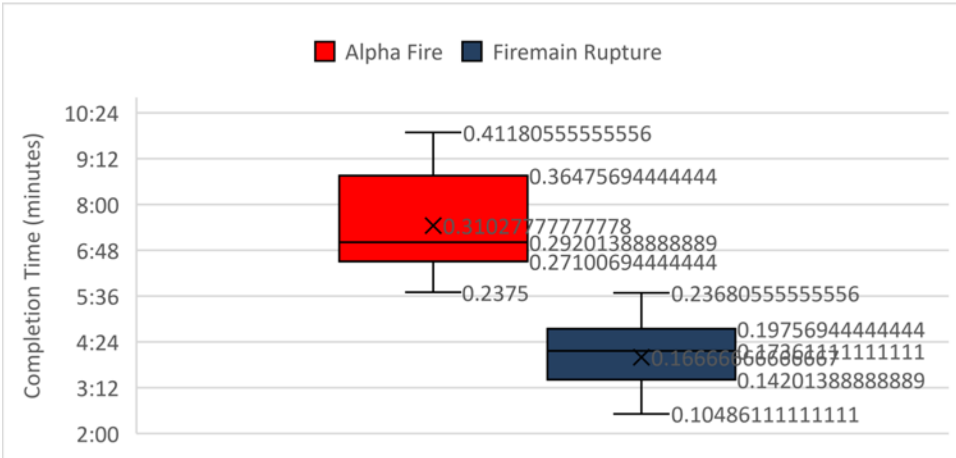

Figure 13. Class “A” fire and firemain rupture package completion times using DCTT-TS

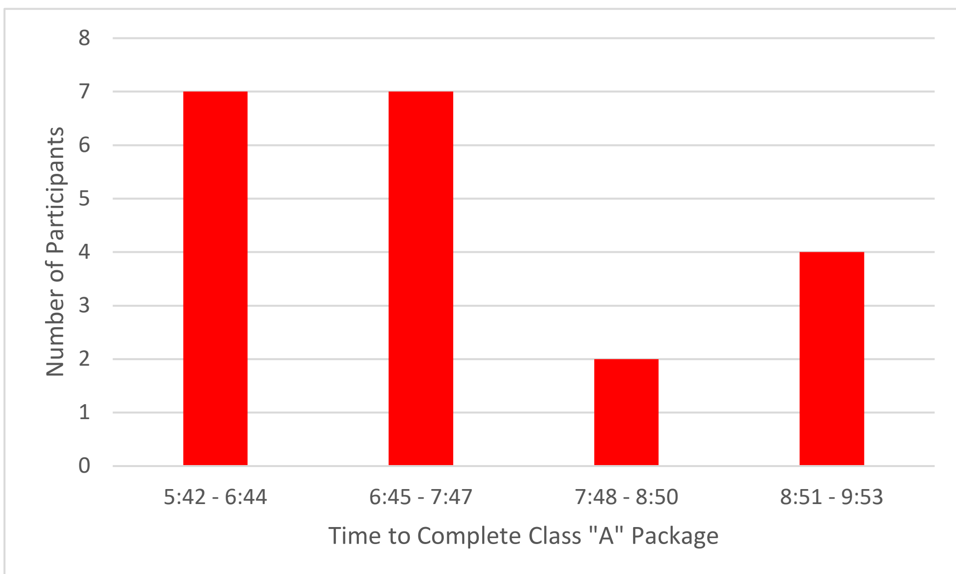

Figure 14. Time groupings for class “A” fire implementation

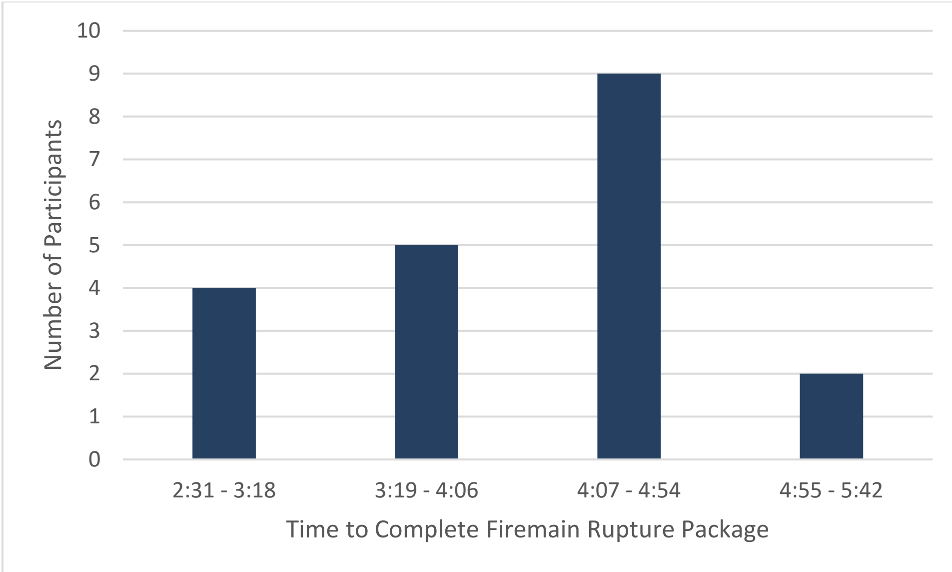

Figure 15. Time groupings for firemain rupture implementation

C. PRODUCT QUALITY

Several drill packages were provided from active DDG DCAs and four were selected at random. All possible identifying information was removed from the fleet packages and the one produced by DCTT-TS, which were then brought to ATG and given to volunteer participants for grading.

The grading scale used was for a number to be assigned between 1 and 7. The scores of 1–3 would be deemed as an unsatisfactory package with 1 being the lowest. 4–7 were satisfactory where a 7 represents a drill package with no mistakes found and all required and amplifying information is available. The drill packages were labeled at the top A through E for identification purposes. The DCTT-TS automated system was labeled D. Table 3 shows the results of the graded packages. Failing grades are highlighted in red.

Table 3. Grading of four drill packages from the fleet and a drill package populated by the DCTT-TS automated system (D)

	A	B	C	D	E
DC1	6	6	5	6	5
DC1	5	4	4	5	5
DCC	6	4	4	6	4
DCC	6	5	5	5	6
DC1	6	2	4	6	4
DCCS	7	3	5	5	4
DCC	5	3	3	7	5
DC1	7	2	4	5	3
DCC	5	4	4	5	4
DC1	6	6	6	6	5
DCC	6	4	5	6	4
DCCS	7	6	6	5	3
DC1	5	3	3	5	4
DCCS	6	5	5	6	4
Avg:	5.93	4.07	4.50	5.57	4.29
Max:	7	6	6	7	6
Min:	5	2	3	5	3
SD:	0.73	1.38	0.94	0.65	0.83
Median:	6	4	4.5	5.5	4

D. SURVEY RESULTS

Surveys were requested to be filled out by all personnel that participated at both DCA/SE and ATG. All personnel at DCA/SE chose to also fill out surveys however, several members of ATG chose not to due to time constraints. Table 4 shows the survey questions asked and Table 5 shows the results from all survey data. Questions 7 – 12 used a scale of 1 through 5 with 1 meaning the participant strongly disagreed and 5 meaning the participant strongly agreed with the statement. Additionally, survey questions 9–12 should not have been answered by ATG personnel, but several individuals from ATG answered these anyways which are highlighted in red. Blank spaces represent responses that were not quantitative such as “a lot” or “a routing system was not used.”

Table 4. Survey questions issued following user study

Q1:	How many ships have you been DCTT Coordinator aboard?
Q2:	Approximately how many months of experience do you have as DCTT Coordinator?
Q3:	Approximately how many drill packages have you created as DCTT Coordinator?
Q4:	What is the average time it takes you to complete a drill package from scratch (i.e., not reusing old package) from start until it's ready for routing?
Q5:	Once you submit a package for routing, on average how much time do you personally spend routing it?
Q6:	Once you submit a package for routing, on average how long does it take the chain of command (CHENG and XO) to return it to you?
Q7:	The time/difficulty required in creating and routing packages reduces the number of drill packages you produce.
Q8:	Decreasing the amount of time required to create a new drill package would improve DC readiness.
Q9:	A system like this would increase the DC readiness of my ship.
Q10:	The system was easy to use.
Q11:	The system's output would be useful in conducting DC drills.
Q12:	I would use such a system if it were available.

NOTE: Questions 7 – 12 were used a scale of 1 through 5 with 1 meaning the participant strongly disagreed and 5 meaning the participant strongly agreed with the statement

Table 5. Survey data of all participants and their associated ranks

Test Number	Rank	Q1	Q2 (months)	Q3	Q4 (days)	Q5 (days)	Q6 (days)	Q7	Q8	Q9	Q10	Q11	Q12
1	DCC	6	81	500	2	0.25	1.5	4	4	4	5	5	5
2	DC1	2	14	10	1.5	7	10	4	4	4	4	4	4
3	DC1	1	36	15	3	1.25	3	5	1	5	3	5	5
4	HTCS	1	24	300	0.083	1.25	1	4	5	5	5	5	5
5	DCCS	2	60	600	0.083	0.042	0.021	5	5	2	4	5	5
6	DCC	1	48	100	0.333	0.083	1	5	5	5	4	4	5
7	DCC	1	10	50	0.104	0.042	2.5	5	5	5	5	5	5
8	DCCS(CG)	3	108	500	4	2	1	5	5	5	5	5	5
9	DCCS	5	228	1000	0.083	0.042	1	5	5	4	5	5	5
10	DC1	2	114	1000	0.125	0.021	0.083	5	5	5	5	5	5
11	DCC	2	30	35	0.125	0.5	1.5	3	5	4	4	5	5
12	DC1	1	24	180	0.125	0.125	0.042	5	5	5	5	5	5
13	DCC	1	36	100	2	2	2	5	5	5	5	5	5
14	DC1	1	30	25	1.25	0.5	3	3	5	5	5	5	5
15	DCC	2	40		0.125	2	2.5	5	5	5	4	5	5
16	DC1	1	6	10	0.5	1	1.5	5	5	5	5	5	5
17	DCCS	3	72	150	2	1.5	1.5	3	5				
18	DCC	1	24	150	1.5	0.021		3	5				
19	DCC	1	30	60	2	0.083		5	5	5			
20	DCC	4	110	1500	0.104	0.021		2	4				
21	DCCS	1	60	1000	2.5	2	0.021	3	4	4	4	4	4
22	LT	2	60	55	0.1667	0.0417	1	4	4	5	5	5	5
23	DC1(CG)	2	48	130	0.0833	2	1	4	4	5	4	4	4
24	DCC	2	48	300	2	0.1458	2.5	5	5	5	5	5	5
25	DCC	2	84	1200	2		0.0417	5	5	5	4	5	5
26	ENS	1	24	120	0.0833	1	2	5	5	5	4	5	5
27	DC1	2	60	180	0.125	0.02083	4	5	5	5	5	5	5
28	DC1	2	32	20	0.125	0.125	3	4	5	5	5	5	5
29	DC1	1	18		0.02778	1	3	5	5				
30	DCC	1	60	50	0.08333	0.04167	1.5	5	5	5	5	5	5

Test Number	Rank	Q1	Q2 (months)	Q3	Q4 (days)	Q5 (days)	Q6 (days)	Q7	Q8	Q9	Q10	Q11	Q12
31	DCC	1	60	35	0.04167		6	3	2				
32	DC1	3	24	50	0.20833	0.08333	3	3	1				
33	DC1	1	36	150	1.5	0.08333	1.5	5	5				
	Averages:	1.88	52.70	308.87	0.91	0.85	2.06	4.30	4.48	4.69	4.56	4.84	4.88
	Max:	6	228	1500	4	7	10	5	5	5	5	5	5
	Min:	1	6	10	0.02778	0.02083	0.021	2	1	2	3	4	4
	SD:	1.22	42.27	407.19	1.07	1.36	2.00	0.92	1.09	0.68	0.58	0.37	0.33
	Median:	2	40	130	0.1667	0.1458	1.5	5	5	5	5	5	5

NOTE 1: ATG participants are highlighted in tan

NOTE 2: Red highlights designate survey responses that should not have been answered

NOTE 3: Blank spaces represent responses that were not quantitative

Based on the results from the survey, several analysis techniques were used to validate the feasibility of some responses. By calculating the amount of drill packages routed per month as DCTT Coordinator (Q3/Q2), several individuals became outliers and were removed from further data calculations as they stated that they would be routed 10+ packages per month whereas the average packages per month were 4.54. The subjects removed were test numbers 4, 5, 21, and 25. However, removing these individuals did not change the results significantly.

Additionally, we removed the invalid answers provided by ATG participants who answered questions 9–12. After removing these figures, new results were calculated as can be seen in Table 6.

Table 6. Adjusted survey results with outliers and invalid responses removed

	Q1	Q2 (months)	Q3	Q4 (days)	Q5 (days)	Q6 (days)	Q7	Q8	Q9	Q10	Q11	Q12
Averages:	1.96	53.81	239.81	0.93	0.77	2.30	4.26	4.41	4.75	4.56	4.81	4.88
Max:	6	228	1500	4	7	10	5	5	5	5	5	5
Min:	1	6	10	0.04167	0.02083	0.042	2	1	4	3	4	4
SD:	1.32	45.51	366.31	1.08	1.44	2.09	0.94	1.19	0.45	0.63	0.40	0.34
Median:	2	36	100	0.20833	0.125	1.5	5	5	5	5	5	5

1. Participant Background

The first three questions as well as the collection of the paygrades focused on the backgrounds of the participants and to provide justification as them being valid test subjects.

a. Paygrade

The average paygrade of participants who partook in the time-based tasks was 7.3 equating to a chief petty officer in the Navy (E-7). The highest rank was a lieutenant limited duty officer (LT/O-3) who was a prior E-7. The most junior paygrade was E-6 or first class petty officer and the median an E-7 as well.

b. DCTT Experience

As seen in Tables 5 & 6, the average participant served as DCTT Coordinator on approximately two ships with one being DCTT Coordinator on 6 different vessels. The distribution can be seen further in Figure 16.

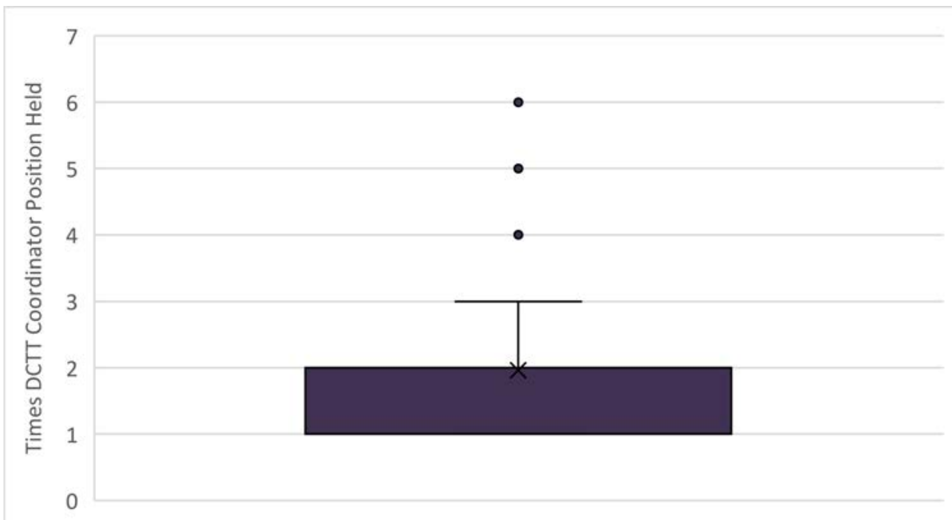

Figure 16. Distribution of DCTT Coordinator positions held

The average amount of time spent as DCTT Coordinator was approximately 54 months with the least experienced possessing the role for just 6 months and the most seasoned DCTT Coordinator having 228 months. This distribution can be further seen in Figure 17.

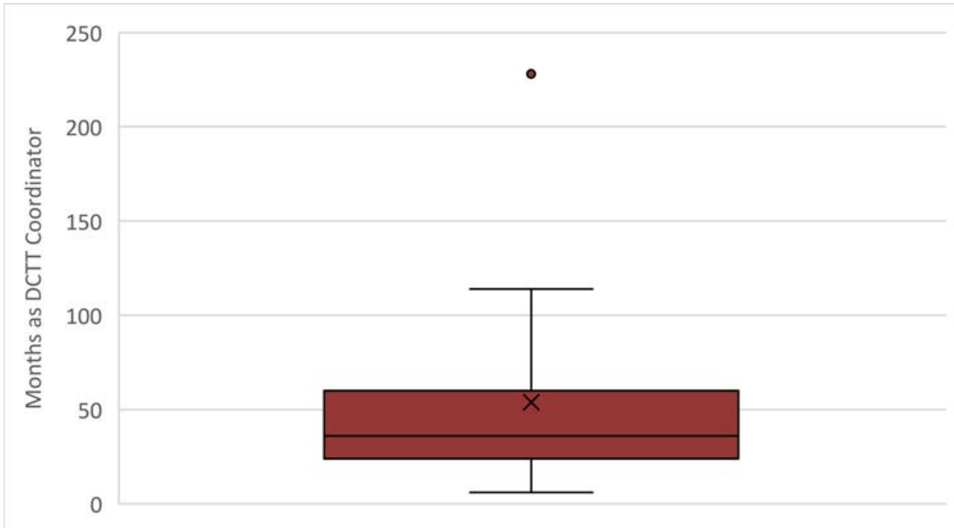

Figure 17. Distribution of months as DCTT Coordinator

The average amount of drill packages routed was approximately 240. The max was approximately 1500 drill packages routed by one individual and the minimum only routing 10. See Figure 18.

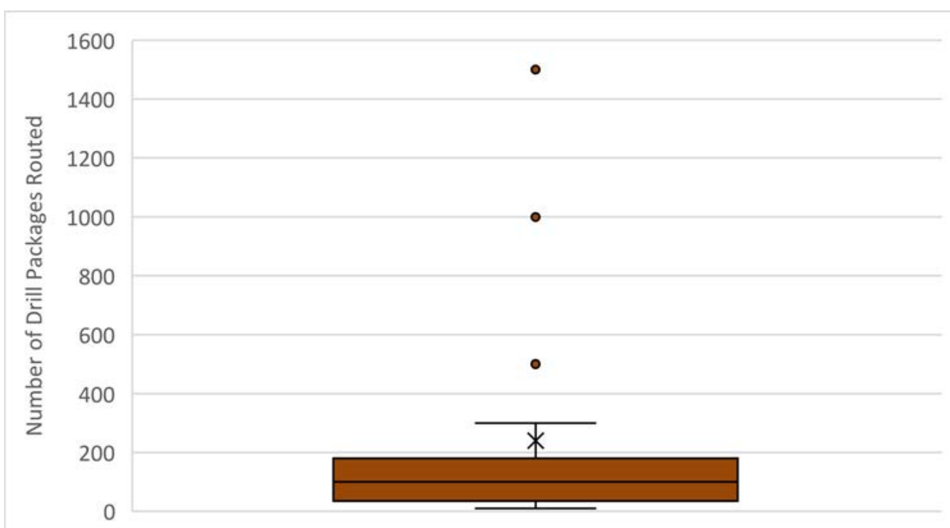

Figure 18. Distribution of number of DC drill packages routed

2. Package Creation and Routing Times

The times for drill package creation and routing received an eclectic range of responses. Some participants claimed they can route a drill package in just 30 minutes whereas one took 7 days to route it. One who responded that they could route a package in 30 minutes also claimed to be able to create a drill from scratch in only 1 hour whereas another required at least 4 days. Although the standard deviation was large, the average amount of time was quite high with the averages to create a drill, route by hand, and route by inbox system were approximately 22 hours, 18.5 hours, and 55 hours respectively.

3. DC Readiness

A commonality amongst participants was their views on the presence and culture of the "canned drill packages" in the fleet and the redundancy of packages. The DCA/SE participants agreed or strongly agreed that having an automated system generate drill packages would directly improve the DC readiness on their ship. ATG participants were less optimistic and showed multiple individuals disagreeing with the statement as can be seen in Table 5. These statements can be seen in the responses to question 8 with the average response being in between that they agree and strongly agree and that only two strongly disagreed and only one stating that they disagreed with the statement. It should be noted that the both who strongly disagreed were E-6s and the individual who disagreed was an E-7, as all the more senior individuals agreed or strongly agreed. Figure 19 shows the distribution of the question 8 & 9 pertaining to the links between DC readiness and the tediousness of creating drill packages.

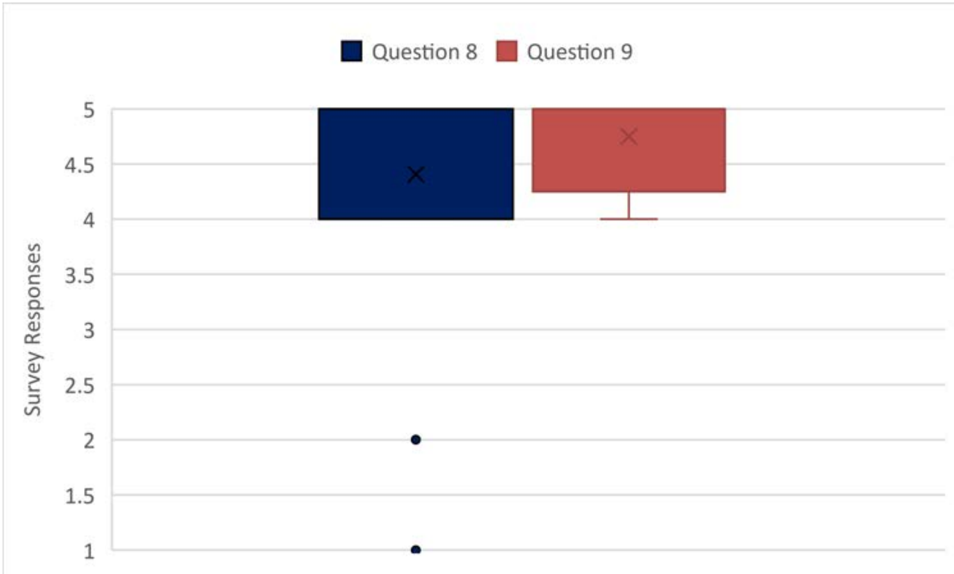

Figure 19. Survey responses to questions 8 and 9 regarding DC readiness

4. Usability and Usefulness

The usability and usefulness of the system was determined through a combination of survey results of questions 10–12 and the number of unnecessary clicks to fulfill the task. Only one individual did not agree with the statement “The system was easy to use.” All users stated DCTT-TS would be useful on their ships and that if available they would use it. Figure 20 shows the distribution of question 10-12.

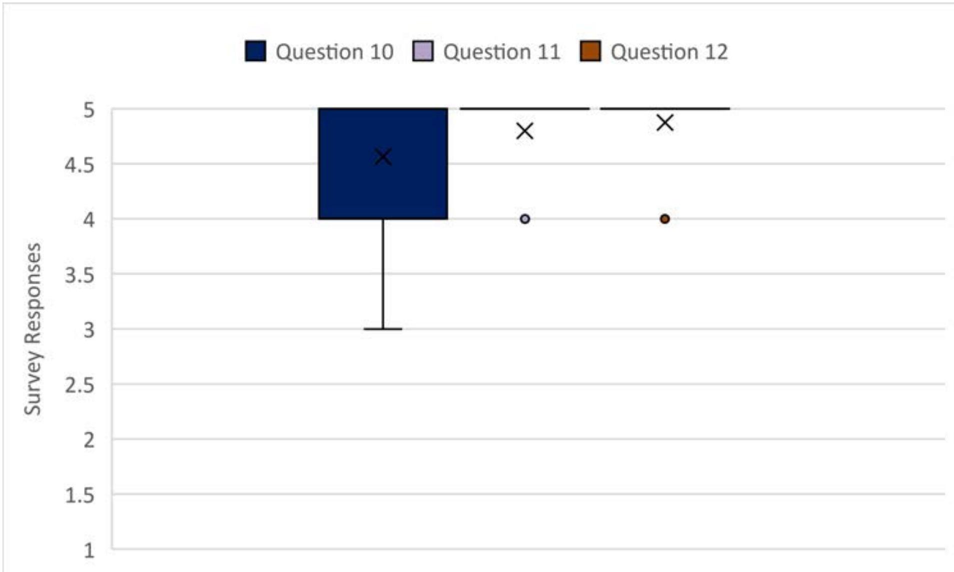

Figure 20. Survey responses to questions 10–12 regarding usability and usefulness of DCTT-TS

E. OPEN-ENDED FEEDBACK AND USER RECOMMENDATIONS

The overall receptiveness to our prototype system was positive and productive. Several individuals at both ATG sessions were skeptical towards the probability of seeing this fielded and thus considered our presence offensive and a waste of time. However, both user groups provided phenomenal feedback to improve the system.

1. Boundary and Isolation Identification

The most common feedback given was that boundaries and isolations take a long time to identify and verify when developing a drill package. As such, most users stated that if DCTT-TS could identify both boundaries and isolations, it would be incredibly beneficial to DCTT Coordinators. Additionally, being able to show DCTT members boundaries in the Hullform VE would give heightened awareness to all members of the team. Both of these items were considered “must-haves” by multiple senior participants.

2. Common Access Card (CAC) – Enabled Website

The members of ATG were skeptical about fielding a standalone system to perform the capabilities we seek in future iterations of DCTT-TS. They believed is unfeasible to promulgate the system to the fleet and to maintain it for logistical reasons, however, they believed that a CAC-enabled website could allow for a more rapid solution. None of us agreed with this recommendation nor endorse pursuing this route.

3. Sound Powered Phone Network

One recommendation that stood out to us was from a DC1. After the briefing and a discussion regarding networking on a ship and utilizing preexisting equipment, this individual raised a question about utilizing sound-powered phones on a ship to set up a network. Upon further research, the Office of Naval Research (ONR) is currently developing a similar technology to the one he described, which could serve as a way to network a system for running drills if the research produces results.

4. Notes and Statistic Keeping

Several individuals recommended DCTT-TS provide a means for DCTT members to keep notes and the DCTT Coordinator consolidate lessons learned from previous scenarios. Additionally, statistics can be provided based on the amount of drills performed in certain locations or performance percentiles.

F. CHAPTER SUMMARY

Results of the user studies conducted in Norfolk and San Diego at both DCA/SEs and ATGs were shown. We discussed the analyzation of the data collected and provided statistics and graphs that help determine the answers to our proposed questions.

This chapter also discussed the feedback collected with respect to ideas of future work in order to make DCTT-TS a reliable alternative to the current approach.

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VII. CONCLUSIONS AND RECOMMENDATIONS

A. MAIN CONCLUSIONS AND RECOMMENDATIONS

This chapter summarizes the findings of the study with respect to our hypotheses and questions, as well as the overall feasibility of delivering DCTT-TS to the fleet. The chapter additionally discusses recommended future avenues and research we deem worthy of pursuit.

1. Main Conclusions

The goal of this thesis was to answer these three questions:

1. Can a computer-based system create drill packages faster than current methods?

After comparing the results from the survey for preparation and generation of drill packages (question 4) to the data collected by DCA/SE students, we can conclude that utilizes an automated system such as DCTT-TS can drastically decrease the amount of time required to build a drill package.

2. Can a computer-based system create drill packages that are as good of quality and free of errors, or better than the current methods?

Upon comparison and grading of drill packages that were provided from DDGs in the fleet and the output DCTT-TS produces, the automated package is a consistently satisfactory and better than most, not all. What makes DCTT-TS a viable alternative to the current method is that it can provide a standardized package across the fleet and still allow DCTT Coordinators to customize or make additions as needed in a timely manner.

3. Can a virtual environment simulation increase damage control readiness onboard surface ships?

The survey results revealed that most individuals believe that using a VE simulation would increase the overall DC readiness of their ships. This is achieved by raising the situational awareness of the DCTT members and by enabling the DCTT Coordinators with the flexibility of running drills in dynamic locations without the burdens of the current approach. It is also concluded that all participants of the user test would utilize DCTT-TS or a similar system if available to them.

2. Recommendations

a. Automated Drill Packages

The Navy should invest into standardizing and automating all drill packages for the fleet, not exclusively DC. The time spent by the ship's SMEs can be better resourced than on creating and routing drill packages in an inefficient manner.

b. Wireless Technologies

It is our belief that the Navy should streamline the implementation of wireless technologies onboard surface ships. This would enable many newer technologies to be networked onboard ships and giving sailors more tools to complete their missions.

We also believe that the Navy should investigate the feasibility of manipulating existing hardware to perform this such as sound powered phones or SIWCS radios as means of transporting data.

c. Virtual Environments

Following the results of the data collected, most DC SMEs believe that there is merit to the future development of DCTT-TS or like systems. The idea of leveraging VEs to familiarize training team members in ship procedures and layouts enables the members to achieve higher levels of understanding and training. There are many other practical applications that can utilize VEs that would significantly assist sailors executing their missions.

d. 3D Ship Models

The Navy should have a readily available model of a ship's interior. There are certainly institutions in the Department of the Navy that either have a model or could create one. This would enable future researchers to develop newer technologies such as DCTT-TS without having to create one.

B. LESSONS LEARNED

1. 3D Model Acquisition

Although [23] had similar difficulties in attaining a 3D model of a DDG for their thesis research, we expected that in the ensuing 23 years finding such a model would have become simpler. However, the difficulty in attaining a 3D model was surprising. We searched for a digital model of a DDG from the shipyard at Bath Iron Works, which is the design yard for the DDG-51, Program Executive Officer for shipbuilding (PEO Ships) (specifically PMS-400D (DDG-51 program)), Naval Surface Warfare Center – Carderock Division (NSWCCD), and the Engineering Duty Officer (ED) community. Although some of these organizations provided us we various models and drawings, none could provide a model representing the full compartmentalization, or suggest where we could successfully find one. In the end, we used drawings provided by PMS-400D to create a 3D model ourselves.

2. User Study

a. Plan of Action and Milestones (POA&M)

Having a POA&M in place from early on deconflicted many issues early and allowed for us to make travel plans early to San Diego and Norfolk. It also enabled us to manage our milestones for the Institutional Review Board's (IRB) requirements such as receiving CO authorizations and submission of forms.

b. Coordination

Coordination is inherently difficult when dealing with multiple groups of people in different time zones. For us, we were constantly on the phone with individuals in Washington, DC, Maine, Virginia, Hawaii, and California. Thanks to the POA&M, we were able to coordinate meetings and significant calendar events. We additionally took notes on all phone conversations so that we could reach back to them or provide ties to other individuals as needed. This was incredibly helpful in coordinating groups and managing our timetables as we started early and had travel arrangements approved by all chains of command well in advance.

c. Pilot Program

Our pilot program was pivotal in finding bugs in certain parts of the code, practicing the execution of the user study, and identifying problems with the UI. Several items of code had to be addressed as they would crash the exportation process regularly. Practicing the script and what to say to the users was extremely beneficial as the following studies went seamlessly. And finally, several items were not as intuitive as we originally believed with regards to the UI. These items were immediately addressed and changed before departing for San Diego and Norfolk for final testing.

3. Unity Game Engine

a. Resources

Unity game engine is a phenomenal asset to use when dealing with VEs because there is so many resources available via simple web searches. Much of what was done in DCTT-TS was researched through forums or from other programmers who had similar projects. Additionally, it is consistently updated and many projects are well documented online and often provide tutorials.

b. C# Coding

A great benefit to Unity is that it utilizes C# as a language for scripting. This is very beneficial as most proficient programmers have a decent amount of experience in either C++ or JavaScript which both translate fairly easily to C#. As stated before, there is a significant amount of resources available via web searches for C#.

4. IRB

a. Start Early

The whole process takes a decent amount of time and requires many different signatures to be routed to the IRB. When a thesis proposal has been approved and it has been identified that IRB approval is required, consider that to be the number one priority before all other thesis work.

b. More Is Better for The Reviewers

Many students forget that most of the faculty at NPS have zero military background and that “military speak” is not their natural tongue. When the IRB personnel review a package, it can be expected for them not to understand military acronyms, chains of commands, or command structures as different locations.

c. Meet with the IRB Staff

The faculty in the IRB office are an incredible asset and extremely friendly. If IRB approval is required, time taken to meet with them and letting them help with the package is well worth it. It will also save time from playing email ping-pong back and forth with them to get clarification on specific matters.

d. Be clear and If in Doubt, Give Ranges

Many of the line items in the application require numbers that are not always well known i.e., how many test subjects. This can be caused by several factors such as in my case, I was uncertain of how many individuals would be willing to participate in a pilot program designed to identify any bugs prior to starting user testing on my desired participants. This led to assigning a large estimated range of participants for the study as a whole which was obviously questioned by the IRB. It turned out to not be a huge deal but it needed to be elaborated on further so once again, more information to them is better.

e. Keep the Study Under 100 Participants

A situation arose because my study was to span multiple commands. This required OPNAV N1T (Dr. Richard Linton) approval which required several phone calls and additional paperwork. The paperwork was several forms that must show the effects to operational readiness, cost of manhours, and multiple documents requesting flag-level approval. Luckily after multiple conversations with him, he granted approval and waived these requirements due to its low impact on personnel and the Navy as whole. One thing he noted was that if the study is less than 100 users, these requirements will most likely be waived and simple notification to him of the multiple commands to be studied is all that is required. Additionally, he is expecting the release of a new instruction laying out these new requirements in the coming months

C. FUTURE WORK

1. We propose that further research be done in developing DCTT-TS or similar software into a networked system and allowing DCTT members to execute drills while providing real-time inputs to DCTT Coordinator.

2. We believe that further testing should be done to determine if a computer-based system such as DCTT-TS can quantitatively increase situational awareness amongst DCTT members.

3. We propose that future research should be done to develop a system that assist DCTT Coordinators in assessing drills.

4. Finally, we propose that additional training teams such as combat systems (CSTT), engineering (ETT), medical (MTT), etc., be investigated for similar VE technologies. Additionally, these technologies could be merged to streamline the creation and execution of integrated training team (ITT) scenarios.

D. SUMMARY

The research conducted in this thesis shows the feasibility and necessity to create new processes to streamline different mission areas of the surface Navy. It additionally demonstrates the endless possibilities that emerging technologies can provide to sailors in assisting with their jobs to become more efficient and effective. The Navy must modernize itself to maintain its status as a superior naval power for the best interest of its sailors, its ships, and the nation it serves.

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