DD21 LAND ATTACK DESTROYER:
EFFECT OF REDUCED CREW
ON DAMAGE CONTROL

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The opinions and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

ABSTRACT

DD21 LAND ATTACK DESTROYER: EFFECT OF REDUCED MANNING IN DAMAGE CONTROL, by Lieutenant Commander Michael Alberto de la Garza, 89 pages.

This study examines the initiative to build a twenty-first century destroyer that has a crew of only ninety-five sailors. DD21 will lead the Navy in the next century.

The crew of 300 in today's destroyers operates systems, sensors, and weapons to conduct combat operations. Damage control is required if the ship sustains damage during operations. The types of damage that may occur are fire, flooding, and hull or structural. A combination of these is a major conflagration. The focus of the crew turns from fighting the ship to saving the ship when this occurs. Automating tasks performed by sailors using integrated monitoring and sensing systems enable the reduction in crew by about 70 percent in DD21. Fully automated damage detection, fire fighting, and flooding control are a few of the areas that are to be augmented by technology to enable the reduction of the crew.

Can a 70 percent reduction in crew and applied technology successfully combat catastrophic damage in DD21? The answer comes from the tasks accomplished, the personnel accomplishing the tasks, and the equipment used to accomplish the tasks. The analysis determined that 70 percent reduction of personnel is feasible assuming some important factors are taken into account.

DEDICATION

This thesis is dedicated to the men and women of the United States Navy who have lost their lives in fighting for their ships, unselfishly giving all they had. Yesterday they gave their lives so that we might be better Sailors today. Today we build our ships so that lives will be saved tomorrow.

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And finally, to my family. Mission Complete. This deployment is over. I am returning to port.

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LIST OF ABBREVIATIONS

AAW	Antiair Warfare
AFFF	Aqueous Film Forming Foam
AGS	Advanced Gun System
ALAM	Advanced Land Attack Missile
ASW	Anti Submarine Warfare
ATG	Afloat Training Group
CINC	Commander in Chief
CNSL	Commander, Naval Surface Forces, Atlantic Fleet
CNSP	Commander, Naval Surface Forces, Pacific Fleet
CO	Commanding Officer, Carbon Monoxide
CO_2	Carbon Dioxide
COTS	Commercial off the Shelf
CSO	Combat Systems Officer
CVBG	Aircraft Carrier Battle Group
DC Central	Damage Control Central
DC	Damage Control
DCA	Damage Control Assistant
DCO	Damage Control Officer
DCPO	Damage Control Petty Officer
DCRS	Damage Control Repair Station
DCTT	Damage Control Training Team
DD	Spruance Class Destroyer

DDG	Arleigh Burke Class Destroyer
DH	Department Head
DO	Division Officer
DOD	Department of Defense
DON	Department of the Navy
ENG	Engineer Officer
EOOW	Engineering Officer of the Watch
ETG	Engineering Training Group
EWFDS	Early Warning Fire Detection System
FP	Fire Pump
HALON	Halogen Firefighting gas
HM&E	Hull, Mechanical, and Electrical
HSI	Human System Integration
ICS	Intelligent Control System
LCC	Life Cycle Cost
MOOTW	Military Operations Other Than War
NMS	National Military Strategy
NSS	National Security Strategy
OPS	Operations Officer
PKP	Potassium Bicarbonate (Purple Potassium Powder)
PQS	Personnel Qualifications Standards
QDR	Quadrennial Defense Review
SCS	Supervisory Control System

SLOC	Sea Lines of Communication
TOC	Total Ownership Cost
USW	Undersea Warfare, see also ASW.
XO	Executive Officer

CHAPTER 1

INTRODUCTION AND BACKGROUND

Introduction

The United States Navy has sailed the oceans of the globe for more than two hundred years in support of the Constitution that established it. The Navy continues to conduct the missions assigned over the past two and one-quarter centuries. Those missions, power projection, and protection of the sea lines of communications are as valid today as in the past. As the age of high technology, remote operation, unmanned vehicles, near artificial intelligence (i.e., "smart systems"), and various other space age advancements compel the Navy to move forward, the Navy is attempting to keep pace.

In today's fast changing world, the need for the Navy to meet and exceed each challenge is as important as ever. While new weapons, navigation, communication, and information systems have been improved by today’s technological advances, the technology of today also is improving a fundamental functional area of shipboard operations: damage control and survivability.

Several options are being explored as to the acquisition and design of future warships. The long-range vision of having a technologically advanced fleet by the middle of the century is quickly coming on line. The family of twenty-first century combatant ships includes the DD21 (guided missile destroyer), CG21 (guided missile cruiser), and CVNX (next generation nuclear powered Aircraft Carrier).[1] All of these projects will set forth to build ships for the future that meet the requirements of joint operations and will be considered an integral part of the fighting forces of the nation in this new century.

The replacement for today's destroyers, USS *Spruance* (DD 963) and USS *Arleigh Burke* (DDG 51), is the USS *Zumwalt* (DD21) Land Attack Destroyer, shown in figure 1. This new ship is being designed with affordability in mind. The goal is to make the life cycle cost of the ship lower than the life cycle cost of present day ships. The Navy is streamlining operations and taking cost-effective measures to reduce spending. All of this is in the attempt to operate within a budget that continues to shrink.

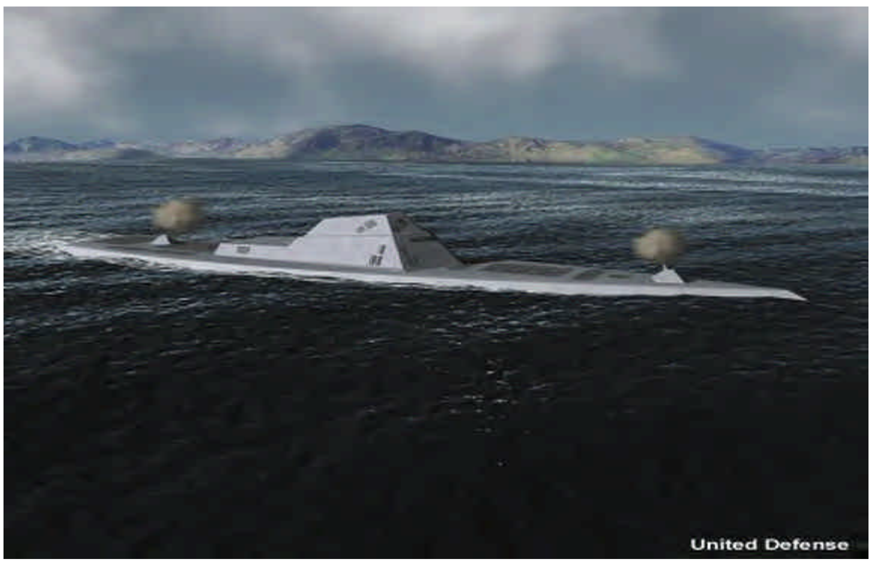

Figure 1. USS *Zumwalt* (DD21) Land Attack Destroyer.
Source: DD21 Land Attack Destroyer Homepage.

To meet the requirements of the 1998 Quadrennial Defense Review (QDR) of having a fleet of 116 surface combatants by 2005, DD21 must be built and must be outfitted and crewed effectively and efficiently.[2] This total number of ships is a considerable reduction from the commencement of building up to the 600 ship Navy during the latter half of the twentieth century.[3] One of the most drastic implementations in the new ship is the reduction by about 70 percent of assigned personnel.

The DD21's design and outfitting as a future warship is based on the concept of reduced manning. Technology is being used as a direct replacement of personnel to accomplish this task. The impact of reduced manning on damage control and ship survivability is significant. The reduced manning in DD21 must accomplish the same tasks and functions as a ship with three times the personnel. This study examines that concept--reduced manning--which when compared to today's destroyers will determine how the crew can be reduced from a nominal 325 to less than 100 personnel.[4] To achieve cost effectiveness, many different factors are being introduced into the design of the DD21 to account for this drastic reduction in crew size. The introduction of modern technology to allow for this reduction is going to be the cornerstone of DD21.

The term life cycle cost describes the cost associated with the investment of capital and program funding from the building of ships through to the disposal of them. Costs include research and development, ship operations and support, including direct associated costs such as maintenance and fuel, and indirect costs such as port facilities and warehousing of stocks for repair.[5] Cost savings in production and operations will reduce the life cycle cost of DD21 to a level that will support the fleet of 116 surface combatant ships that the 1998 QDR established.[6] A reduced budget allowing for only this many ships is placing restrictions on the overall cost of each ship. The limited budget has also caused the Navy and private industry to rethink the way ships are designed, outfitted and manned, and the revolutionary idea that a destroyer-sized ship can operate in a full battle condition with less than a 100 person crew is indeed a twenty-first century concept.

A review of the current manning in today's destroyers as it applies to damage control will be used for comparison. The analysis will determine if a reduced crew of ninety-five personnel can perform damage control effectively in a ship that would normally be manned with more than 300 personnel. USS *Cole* (DDG 67) was hit by a terrorist bomb while refueling in the port of Aden, Yemen in October of 2000.[7] Major structural damage, major fire, major flooding, or a combination of all of these events is possible at anytime during the operation of a ship. The combination of the aforementioned damage is referred to as major conflagration.[8]

A major conflagration is a situation that exists when damage is so overwhelming that the entire crew is required to combat it. A complete reorganization of the available crew is required to conduct damage control in the endeavor to save the ship and continue its mission. The previously described damage can be caused in a variety of ways. Internal sources, such as flammable liquid leaks or a weapons mishap may cause fire or explosions. External sources, such as mine strikes, missile hits, gunfire, or groundings can cause hull structure damage, flooding, personnel injury, explosion and ensuing fire.

Specific areas in the new ship will employ future technology to allow for the reduction in crew. These areas are joint interoperability and network-centric warfare (missile and gun systems and associated sensors) including information systems (communications and electronic integration, to include navigation systems); survivability and stealth (main propulsion and associated auxiliary systems, damage control and survivability systems.); human systems integration (crew support services), and total ship computing.[9] The survivability and stealth portion of these advancements and the impact of reduced manning along with the application of technology to replace personnel in preventing, controlling and combating damage must be examined to determine if the concept of reduced manning will be successful.

The primary research question related to the DD21 Land Attack Destroyer is whether the reduced crew can be effective in successfully combating damage in the case of a major conflagration. To answer the primary question a number of subordinate questions must be addressed and answered first. The objectives of achieving success in combating a major conflagration require coordination and control of personnel and equipment. What are the *tasks* required to fight fires, stop flooding and dewater, repair structural and hull damage and care for personnel casualties? What *equipment* do ships currently use to accomplish these tasks? Will this same equipment be able to be used in DD21? Finally, what *manning* is currently required by doctrine to conduct damage control in all types of damage including major conflagrations?

Background

Looking back through history will establish a pattern of technological innovation and change that has manifested itself in the Navy and the tools the Navy uses to accomplish its mission. The Navy is seeking out systems and mechanisms to save time, space, and money in maintaining its shipbuilding and maintenance programs. A maintenance program that adapts to this change is being adopted as many of the new technologies that are available in the commercial markets are employed in the new DD21 ship design.[10] The employment of currently available commercial technology is called commercial-off-the-shelf (COTS) sourcing. It is a method of purchasing and installing existing new technology and support systems in today's operating ships. This increase in technology supports the reduced manning concept.

Former Secretary of the Navy Richard Danzig testified to the Senate Armed Services Committee on 10 February 2000 regarding the fiscal year 2001 defense budget that, "We are investing heavily in changes that will reduce manpower, reduce acoustic and radar signatures, improve damage control and increase fighting capability."[11]

In an effort to reduce the initial cost and further reduce the sustainment costs, which includes maintenance, an option to reduce the crew size by about 70 percent was provided. This reduction in manpower provides significant cost savings in the life cycle cost of the ship. The nominal life of a naval warship is between twenty-five and forty-five years.[12] The concept of a reduced crew will have the effect of saving approximately 40 to 60 percent of the life cycle cost.[13]

A report on the efforts of researchers at Purdue University to develop automation that will reduce manning stated that "Recent trends have made automated technologies especially necessary; the Navy has seen a 33 percent decrease in military personnel over the last decade and a significant reduction in experienced seamen."[14] The need for automation and establishing a foundation for introducing innovation in technology as required to replace personnel in all functional areas, including damage control is being pursued by all areas of industry. Achieving cost savings and survivability throughout the program's lifetime is the primary goal.

The implementation of new technology and the advancement of existing technology by private industry and the defense community have established a unique innovation in design, procurement, and acquisition of new combatant ships. While there has been an increase in upgrades to the support systems installed over the years, extensive manpower is still required to operate, monitor, and maintain these systems.

These systems are manpower intensive and require a series of complex training evolutions and educational curriculums to operate. To maintain these systems in a combat ready condition, sufficient man-hours of preventive maintenance must be expended by highly trained, highly skilled professionals.

More reactive, more mobile, and more efficiently operated ships today are responding to the needs of the nation's requirements; however, their age is beginning to take its toll on readiness. The first DDG 51 destroyer was launched in 1989.[15] The first DD 963 destroyer was launched in 1975.[16] The need for a new class of ships and eventually a new fleet in this century is not only driven by technological advancements but by increasing maintenance costs for an aging fleet.

A concept of acquisition and procurement known as Total Ownership Cost (TOC) was implemented by the Department of Defense (DOD) and the Department of the Navy (DON) to achieve a reduction in procurement as well as an accelerated acquisition and implementation timetable.[17] This initiative will allow the life cycle cost of the ship to be equal throughout the class and be lower at the outset of the procurement. The Mission Needs Statement (MNS) approved by the Joint Requirements and Operational Capabilities Board (JROC) in 1996 concurred with some prime requirements for the new class of ship.

Among the primary requirements are:

1) Destroy enemy targets ashore through use of precision strike weapons.
2) Destroy/neutralize enemy land forces, merchant shipping, submarines, and aircraft.
3) Contribute to open ocean surface, air, and sub-surface dominance.
4) Be highly survivable.
5) Employ a total ship architectural/engineering approach.
6) Be automated.[18]

The end of the Cold War achieved a security of the high seas by the United States that is unmatched throughout the world. While maintaining a powerful "blue water" Navy is important, the cost of doing so has taken its toll. Because of constant deployments and fleets stationed around the world 365 days a year, maintenance costs have risen to a level that has caused concern among naval leaders. As an article in the San Diego Tribune describes, "From 1988 to 1991, U.S. naval forces were committed to overseas operations an average of 5.4 times per year. The corresponding figure for 1996 to 1999 was an average of 12.25 times per year."[19] These statistics demonstrate the high operational tempo the Navy has had to maintain to continue to maintain sea dominance and project power throughout the world. The cost of maintaining the fleet is increasing due to these deployments. The increasing costs support new initiatives in building a more cost efficient warship such as DD21.

New construction is necessary and is paying great dividends at the turn of this century; however, the increasing complexity of new weapons systems, new sensor systems, and new communications and information systems requires additional costs in these modern warships. A question that may be simply asked may not be so simply answered. Can the Navy provide the required number of ships at an acceptable cost that will remain effective for the near future *and* reduce manning levels by 70 percent? The Navy has begun to answer the question by taking advantage of the wealth of technology that is presented by both research and development agencies and private industry.

Technological Advancements

At the turns of the past two centuries, a significant shift in force structure and warfare engagement has developed in this nation as it has adapted to the changing world around it. Industry research and military necessity allowed advancements to be made in the Navy that utilized the technology of the day. As ships shifted from sail to steam power, they became faster, larger, more powerful. They also became more complex in keeping with technological and industrial advancements.

The introduction of radar to ships at sea changed the nature of surface warfare, the deployment of aircraft to sea-going vessels was a revolution in total warfare, and the introduction of the advanced submarine completed the ability of the Navy to fight in a three-dimensional battle space. The use of coal for generation of steam in surface ships was replaced by the use of oil. Submarines adopted diesel engines for propulsion as well as for power generation, as boilers were impractical due to size restrictions. The gas turbine engines in surface ships, which allowed for a more efficient use of space and fuel, replaced boilers.

The introduction of gas turbine generators in surface combatant ships also satisfied ever-increasing requirements for electricity. These requirements were due to the increasingly technologically complex equipment used in the Navy's combatant ships. Sonar, towed array sonar, air and surface search radar, fire control radar, fire integration systems, more complex, and robust computer systems to coordinate communications, weapons, and other shipboard systems all added to the load demand on the ship's power requirements. These systems also demanded higher maintenance and reliability requirements.

Reliability is a major factor in a ship's operations and maintenance, as is simplicity and ease of maintenance. These factors are vitally important in a ship whose proposed crew is to be only one-third the size of what it is today. This commitment to reduced manning requires innovation and design breakthroughs that will achieve reduced life cycle cost across a variety of areas in maintenance and support.

The DD21 program mission requirements summarized below describe desired program goals:

> The greatest benefits will be derived from changes in the four dominant cost areas: Depot Maintenance/Fleet Modernization (28%), Mission Personnel (27%), Unit Level Consumption (24%), and Sustaining Support (18%). Changes include designing the ship and its systems for reduced maintenance, open system design for efficient upgrades through modular construction and compatible computer software/middleware, designing for scalability to maintain affordable technological superiority and transition to CG 21, revolutionary manning reductions via automation and system reliability, greatly reduced fuel consumption via use of highly efficient power generators and hull design and global on-line reach back to provide highly efficient sustaining support.[20]

The proposed reduction in crew size mandates DD21 be built with crewmember technical skill level and manning in mind. The advances in technology that will enable the reduced crew to accomplish all of their assigned tasks in whatever area of expertise they may have also logically increases the education and training that will be required for the fewer number of personnel required to man the ship.

The institution of a unique application of teambuilding and contract management is required in building this new twenty-first century warship. A competition to design an acceptable platform to meet the requirements set forth by the Navy will ultimately deliver a winning ship design that will then be shared by two different shipbuilding companies. The two teams that are competing in the design competition are the DD21 Blue Team and DD21 Gold Team. The Blue team is led by Bath Iron Works coupled with Lockheed-Martin and a host of other companies assisting in the design. The Gold team consists of Ingalls Shipbuilding, Inc., Litton Industries, and other assisting companies.

Government agencies also are adding to the developments that will be implemented in DD21. Some of those agencies are Naval Sea Systems Command (NAVSEA), Naval Surface Warfare Center (NSWC) Dahlgren, Crane, Carderock Coastal Systems Station and Port Hueneme, Naval Air Warfare Center, Naval Undersea Warfare Center, Space Surveillance Center and Johns Hopkins Applied Physics Laboratory.[21]

The designing of a modern combatant ship takes into account both technological advancements and the application of human factors to ensure that the objectives of that platform can be met. In the case of DD21, it is being designed as a land attack platform that will support land battles by land forces in the future. The ship is being outfitted with weapons systems, communications systems, navigation systems, and engineering and support systems to ensure that it is the dominant sea-based platform of this new century. Technology is the foundation on which all of the systems in the new ship will be based and applications of advanced systems will alleviate the need for the numbers of personnel that man today's ships.

A basic mission of any modern warship is damage control. The DD21 design concept defines this area as ship survivability. The design of the ship will apply stealth and survivability in revolutionary signature reduction, advanced superstructure, and apertures, and automated damage control systems.[22] These automated systems must operate reliably, and contain redundancy to fully and successfully support the concept of a reduced crew.

A program of Human Systems Integration (HSI) is being used which addresses the human as an integral part of the total system. The concept of HSI takes into account human factors in all of the systems onboard, from weapons to communications to life support. “It is absolutely critical that the Sailor be engineered into the system from the beginning.”[23] The cost saving measures of crew reduction and technology application that planners are proposing will lower the overall shipbuilding, maintenance, operations, and support costs. Technology will be applied across all warfare areas and the operating cost of the ships is intended to be up to 70 percent less than the DDG 51 class.[24]

The Navy continues to keep pace with the changing advances in technology as it transforms itself into a twenty-first century force. The leveraging of technology against manpower is an underlying premise in the advanced ship design of DD21. An assumption is made that to continue to protect this nation's leadership role as the political power and technological leader in today's advanced industries, the Navy mission will not be dramatically changed. Projecting power and keeping the sea lines of communication open and secure from any threats that may exist or arise will still be the primary missions of the future.

Assumptions

An assumption made for this thesis is that the research of integration of reduced manning and the progress of building the DD21 will continue to completion. Currently the proposal and funding for this project is to deliver thirty-two ships of this class over five years beginning at the time of the first delivery in 2008.[25] A number of factors including support in Congress, successful project management, and support, and continued investment of resources and technology by all involved parties will determine if the DD21 project continues.

Another assumption of primary importance that will be made and not discussed in detail is that ships at sea in modern times rely on electrical power for operation. All of the weapons, navigation, communications, propulsion, and support systems are operated with electrical power. An increase in technology and an increase in the application of automated systems to replace personnel would subsequently rely on electrical power. Computers, monitor systems, reactionary systems and information gathering and disseminating systems would all cease to operate without electrical power. This places much more importance and reliability on the crew to conduct the operations required to fight the ship or save the ship manually if/when electrical power is lost.

Today's ships are manned to accomplish the most basic damage control tasks manually if electrical power is lost in the ship. Basic navigation, basic self-defense, basic damage control, and basic preservation of the ship and crew can all be accomplished by sailors if electrical power is lost. However, one of the primary functions of the engineering department sailors would be to restore the electrical power. Regaining power would enable the ship's automated systems to be brought back on-line and allow ship operations to continue. This fact is of primary necessity in the design of the new ship.

Limitations

A number of limitations may be encountered in conducting the research, but will not be of sufficient magnitude to prevent completion of the research. One limitation is that the development of the ship design is still in progress with two separate and independent teams competing for the contract to build the DD21 ship.[26] This competition of design is purposefully kept independent by the Navy department to ensure that the design is completed separately and without collaboration between the two organizations. This method is used in the hope of getting the best design possible at the end of the design phase, whether it is one or the other, or it ends up being a combination of the two. Due to the limitation of restricted information dissemination by the designing teams, there may not be sufficient information to answer the primary question. This limitation may impede full analysis of the primary question of whether or not a radically reduced crew in a U.S. naval warship will be sufficient to maintain combat readiness and be effective while combating a major conflagration.

Delimitations

Delimitations in this research must be made to keep the scope of information gathered relevant to the reduced manning concept *and* damage control operations aboard the DD21. In the United States Navy, there are three specific components. These are the Naval Air Forces, the Naval Submarine Forces, and the Naval Surface Forces. While each of these components relies on aircraft or ships to operate, there are variations to the focus placed on these platforms by their respective commanders. Each force has a unique variety of platforms, such as fighter aircraft, surveillance aircraft, or support aircraft. Similarly, ships come in various types as well. Amphibious ships, combatant ships, support and refueling ships, and aircraft carriers. Submarines are also uniquely built to accomplish certain missions.

To operate these platforms, personnel are required and these personnel are a limited resource. They are educated and trained for the use of specific and unique equipment within its system of aircraft, submarines, and surface ships. The manning requirements of each of these forces are unique unto themselves. Only information regarding the surface forces and only information involving combatant ships such as cruisers, destroyers, and frigates will be used to compare the application of personnel and technology in accomplishing damage control.

The first step of this study will be a literature review designed to determine how much material already exists that addresses the manning variable that exists for DD21. Recent research has been conducted on reducing the damage control organizations on present day ships and resulted in recommendations on how to organize the ships with regard to damage control to achieve a smaller crew. This data is useful and extremely applicable to DD21 research. The next step is to develop the methodology behind gathering the data available, and to conduct an analysis of it as thoroughly as possible. Finally, analysis of the data retrieved and conclusions will be developed to answer the primary question.

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CHAPTER 2

LITERATURE REVIEW

While reducing manpower in the new DD21 destroyer is an approach to reducing procurement and life cycle costs, it can be difficult to introduce a drastic reduction such as 70 percent fewer personnel onboard and not incur additional risk. By installing technology at key points to relieve the need for additional personnel, the Navy is leveraging technology to replace sailors but may be incurring added risk.

Today's destroyers are manned with about 320 personnel.[1] DD21 is proposed to have ninety-five personnel with a maximum limit of 150. This reduction will impact all areas of operations in DD21, including damage control. To examine the impact of the reduction in personnel, the tasking of the crew in the event of damage becomes important. In doing so, a number of factors come into play. In the form of questions regarding damage control, the factors include: What is the primary duty of the sailor? What other duties might that sailor have? What level of proficiency or level of expertise is required in performing those duties? The answers to these questions help in dictating what type of equipment and technology is required to replace the manpower.

There are five major areas in DD21 where automation is proposed to relieve crew of duties. Of the affected areas, only the area of damage control functions and those personnel directly involved in them will be analyzed. Examining specific actions by specific crewmembers at specific times is difficult as situations and conditions vary. The responsibility of the Commanding Officer (CO) for the safety of the ship and crew is prescribed in U.S. Navy Regulations.[2] It is absolute. The CO has complete accountability for the ship, its crew and its safety, and has the authority to change the functions and duties of any crewmember at any time in the name of operational necessity. The term operational necessity is subject to varied definitions by commanders and COs alike, however the ultimate accountability and responsibility is, and continues to be placed squarely on the CO.

In reviewing the damage control aspects of destroyers, a hierarchy of doctrinal publications prescribing the manner in which a ship should be organized exists. Additionally, these publications prescribe manning, equipment, and training in combating damage that may occur in the ship. The damage could be caused by combat or by any type of internal or external mishap. The cause of damage becomes nonincidental once it has occurred and the complete focus of the CO and the crew is on combating the damage and restoring the ship to fighting condition to continue with its assigned mission.

The first document with impact on manning is the *Ship Manning Document (SMD)*. It provides a generic framework for crew manning. This document shows the assigned number of personnel to a specific ship class and outlines the distribution of officers and enlisted personnel in that ship. The *SMD* is published by the office of the Deputy Chief of Naval Operations (DCNO) for Manpower and Personnel (M&P)(N1) and issued by the Commander, Bureau of Personnel (BUPERS) who controls manning for ships.

The *SMD* is derived from a document called *Manpower Authorization (MPA)*. The *MPA* is issued as a reflection of the total force manning and personnel strength. The *MPA* dictates the *SMD* and the *SMD* is the primary authority to issue sailors to ships.

The *SMD* is based on the *Mission Needs Statement* and the *Required Operational Capabilities and Projected Operational Environment (ROC and POE)*. The *ROC and*

POE is the document that provides a ship's mission requirements, weapons systems to perform those missions, and personnel required to operate the systems. Once a ship has its *SMD*, sailors can then begin to be assigned to billets.

The next document that is important in damage control doctrine is the *Standard Organization and Regulations of the U.S. Navy (SORM).* This manual prescribes the foundation for the organization of personnel in any organization of the U.S. Navy. This includes shipboard organization. The manual details how, under the CO, the reporting and supervisory responsibilities should be laid out for a naval unit. There are specific job descriptions in some cases.

In other cases, there are general descriptions of organizational hierarchy in specific situations and evolutions that are conducted during routine or exceptional ship operations. A primary executive board that organizes and schedules the training of the entire crew in areas such as damage control is the Planning Board for Training (PB4T). The board is required to meet at least monthly, and has specific members, including the Executive Officer (XO), department heads (DH), and other primary assistants. These meetings are critical in the every day functions of the crew with relation to damage control as they focus the continuing basic mission and maintain its importance as a top priority.

The SORM also describes and amplifies duties of officers in the damage control organization. The officers in the damage control hierarchy that are responsible for the proper operation and employment of the damage control equipment are the Engineer Officer (Engineer) and the Damage Control Assistant (DCA). Directly under the CO, the Engineer supervises the functionality and readiness of the systems, personnel, and equipment with regard to damage control. Two specific functions are assigned to this one officer. In the role of Damage Control Officer (DCO), the Engineer uses his assistant, the DCA, to carry out the administration of the damage control program throughout the ship and to coordinate with the other departments for the training and exercising of the crew.

The doctrinal publications that follow these two organizational documents deal specifically with functions, actions, equipment, personnel, and training. The first is Naval Warfare Publication (NWP) 3-20.31, *Surface Ship Survivability*. The next doctrinal manual is a technical manual found in the library of Naval Ship's Technical Manuals (NSTM). While the CO has the authority to change existing organizational structure or the use of specific equipment as the commander on the scene, these documents are intended to be doctrinal in nature and provide guidance in conducting damage control.

NWP 3-20.31 is a manual that details what survivability entails in a surface ship. It defines terms and concepts with relation to damage control and survivability so that the sailor on the deck plate can understand and collate the various concepts presented. It also contains procedures and guidance on how to prevent damage, combat damage, and restore from damage. Organizational relationships are defined and recommended; administration of programs is delineated, to include training requirements, personnel protection, chemical defense, biological defense, and radiological defense. A discussion of basic safety requirements, hazardous material identification, shock definition with regard to weapons effects, and an entire chapter dedicated to major conflagration is included. This manual outlines the importance of electrical power in the application of damage control systems and places the knowledge and operation of electrical distribution systems as a top priority in restoration after damage.

The NSTMs are a series of manuals in a library of books containing manuals on a variety of topics from piping and pipe repair to pump alignment, main engine and boiler operations, and firefighting. NSTM 555, Volume 1, *Surface Ship Firefighting*, is dedicated to laying out the procedures a ship will follow in the event of fires onboard. This manual also contains sections discussing basic fire science and delineating specific organizational approaches to firefighting. It outlines the use of specific equipment in certain types of fires and recommends certain procedures to combat fires of the different classifications as described in appendix A. In responding to damage, the ship may set conditions of readiness appropriate to the severity of the damage. Anytime the ship is at Condition of Readiness I known, as General Quarters (GQ) or Battle Stations, the entire damage control organization of the ship is manned and ready. A detailed description of ship conditions of readiness is given in appendix B.

There are currently three volumes of NSTM 555. Volumes 2 and 3 are dedicated to discussion of submarine firefighting and very similar in content to Volume 1. There are differences in some organizational limitations due to crew size and ship specific requirements. Submarine crews are nominally smaller than surface ships simply due to environment. Due to this reduced crew, tactics in damage control for submarines contain concepts that are simply not required in surface ship. However, there are benefits to examining some of the concepts listed in the submarine firefighting volumes of NSTM 555 because DD21 is a reduced crew ship and similarities or useful concepts may exist or apply. Both NWP 3-20.31 and NSTM 555 contain manning requirements for various team organizations required to conduct damage control. These damage control team manning requirements are listed in appendix C and appendix D.

In order to better understand the application of manning in damage control, a description of the organization of damage control functions and responsibilities as it relates to the layout of the ship is necessary. This helps simplify the organization and adds to less complex and more direct communication with Damage Control Central (DC Central). DC Central is the hub of all damage control direction aboard ship. The DCA is assigned control of this space, under the supervision of the Engineer as required, during most shipboard emergencies. The DCA is primarily responsible for communication and clarification of reports by subordinate organizations with regard to damage, stability and restoration of damage in the event of emergencies.

A naval ship is organized into zones for ease of tracking locations of equipment and personnel. The zones are then assigned to damage control repair stations, more commonly referred to as Repair Lockers. A destroyer-sized ship is split into four major zones for damage control purposes.[3] Inside each of these zones is assigned a specific repair party with specific assignments to respond to almost any type of emergency that might arise while the ship is at GQ. The main damage control and repair organization in these zones is a called a repair locker. These zones are numbered as follows; Repair II (Forward Repair Party), Repair III (Aft Repair Party), Repair V (Propulsion Repair Party) and Repair VIII (Electronics Casualty Control Team (ECCT)). Repairs II and III are responsible for areas forward and aft in the ship that contain support equipment to the weapons, navigation, and communication systems as well as living spaces and storage areas. Repair V is responsible specifically for the main propulsion spaces that contain main engines and associated support systems such as fuel oil, lubricating oil, salt water for cooling and firemain, and other propulsion related equipment. Repair VIII is responsible for controlling damage and repairing equipment directly related to and supporting electronic systems that control weapons, communications and navigation systems. The zones are shown in figure 2., below.

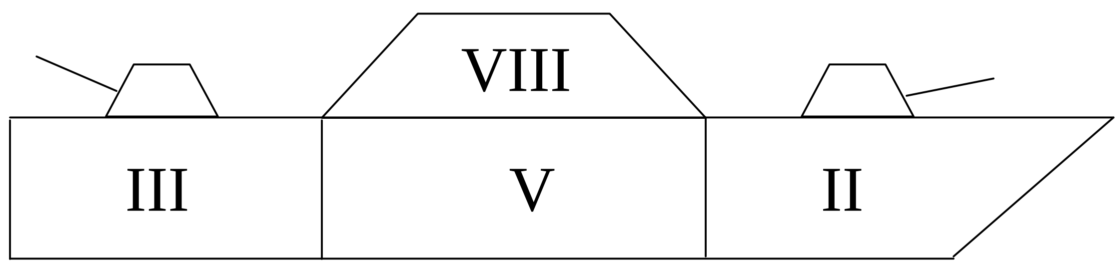

Figure 2. Repair Locker Zones. Source: NWP 3-20.31. 2-14.

Appendix C lists the minimum repair party functional composition for any one of the three main repair lockers aboard ship. The minimum fire party functions are listed in appendix D and analyzed further in chapter 4 in regard to DD21.

These organizations are subject to further guidance on how to organize by the respective Type Commander (TYCOM). The TYCOM is the commander of each of the primary components of the Navy; Naval Air Forces, Naval Submarine Forces, Naval Surface Forces, and provides guidance to the aircraft, ships or submarines on how to organize for and conduct damage control.

In the case of surface ships, the TYCOM is Commander, Naval Surface Forces, Atlantic (COMNAVSURFLANT) or Commander, Naval Surface Forces, Pacific (COMNAVSURFPAC); depending on which coast the ship is homeported. The number of personnel in each of the repair parties, fire parties, or any other damage control teams may be modified by the specific guidance from the TYCOM provided in a repair party manual (RPM) for a particular ship class. This guidance is promulgated to each ship through the RPM.

The make up of teams is further supported by a qualification program that ensures each team member is fully qualified to conduct assigned tasks. The qualifications consist of a series of fundamental knowledge criteria, specific evolutions, and both written and oral examinations that are supervised by qualifying personnel.

These qualifications are the cornerstone to operation of the ship and are supervised by the XO and given final approval by the CO. The program to qualify personnel for specific functions is the Personnel Qualifications and Standards (PQS) program. Qualification in specific watchstations, damage control functions, and various other assignments is managed at the divisional level.[4]

In regard to Damage Control, the qualification and training process is specifically administered by the DCA under the cognizance of the Engineer. In recent years, the XO was added to the hierarchy of administration, training, and qualification to raise the level of awareness and readiness to the absolute highest level possible. The XO is directly responsible to the CO for the execution and training of the DC programs. He is also the Damage Control Training Team (DCTT) Leader.

The DCTT is a team composed of damage control experts onboard that plan, execute, and document each training evolution in the ship. Because the XO is the team leader, this places added emphasis on the importance of the training and actual drills and exercises that are conducted. It also adds a command level of interest in ensuring that the entire crew is trained in accordance with requirements and doctrine.

To provide repair parties with more specific information on functions and equipment to be used aboard ship for damage control, each TYCOM issues its own Repair Party Manual (RPM).[5] This manual provides direction, guidance, and background on specific types of surface ships with regard to damage control. The manual discusses how to go about organizing a damage control repair party, what type of equipment is used for damage control, the application of the equipment and the personnel required to perform damage control functions. This manual is the TYCOM's direct influence on how a specific ship will organize, equip, and train to go into combat and be successful in accomplishing assigned missions in the face of damage that might occur.

This book is considered an all-encompassing manual for all damage control matters onboard specific classes of ships. It contains forms for use by the damage control organization that assist in assigning personnel to specific tasks within a repair locker. It specifically outlines the number of personnel that are assigned to a repair locker and what their functions are. It contains the references for all specific functions and billets by higher authority, primarily some of the documents reviewed here. It also provides recommendations and techniques for accomplishing specific tasks and contains checklists for use by repair party personnel for training and for actual damage control application.

Examples of watchbills are provided in the RPM so that a ship has a format to begin assigning specific personnel with specific functions to a repair party. The organizational diagram of a ship underway is provided in figure 3. The key to the damage control organization as it exists today with a crew of approximately 300 personnel, is the ability to mass personnel against serious damage that may inhibit combat operations, or possibly cause the loss of the entire crew and the ship.

There are a minimum of three repair lockers in a destroyer-sized ship. A notional repair locker manning chart is provided in appendix C. The guidance provided in this series of manuals and doctrinal publications, along with ship specific diagrams, drawings, rosters, qualification lists and equipment inventories allow a ship to develop a doctrine, organization, and training plan to be fully prepared to conduct damage control successfully.

A foundation of personnel required to perform damage control functions aboard a modern surface destroyer is provided within the doctrinal manuals and publications. This foundation is a point of deviation for analysis of where crew reductions will impact damage control, specifically in the worst-case scenario of major conflagration.

The organizational structure for damage control superimposes itself upon the entire underway and inport watch organization of the ship. As the ship conducts combat operations, it is also ready to conduct damage control functions as well. This readiness relies on redundancy in both personnel and equipment. The goal behind the damage control function is to maintain systems readiness for the continued combat operations. As seen in figure 3, the ship is focused on three things simultaneously: combat operations, main propulsion maintenance and combat systems support, and damage control. Each supervisor is a part of the damage control team when and if damage occurs. The Tactical Action Officer is responsible for employment of all weapons systems in accomplishment of the ships mission, including self-defense. The Engineering Officer of the Watch (EOOW) is responsible to maintain propulsion and support to the combat systems when employed. The Damage Control Supervisor, under the EOOW, is responsible for monitoring all damage control systems and coordinating actions and reports with the other primary command and control supervisors (OOD, TAO and EOOW) in the event damage occurs.

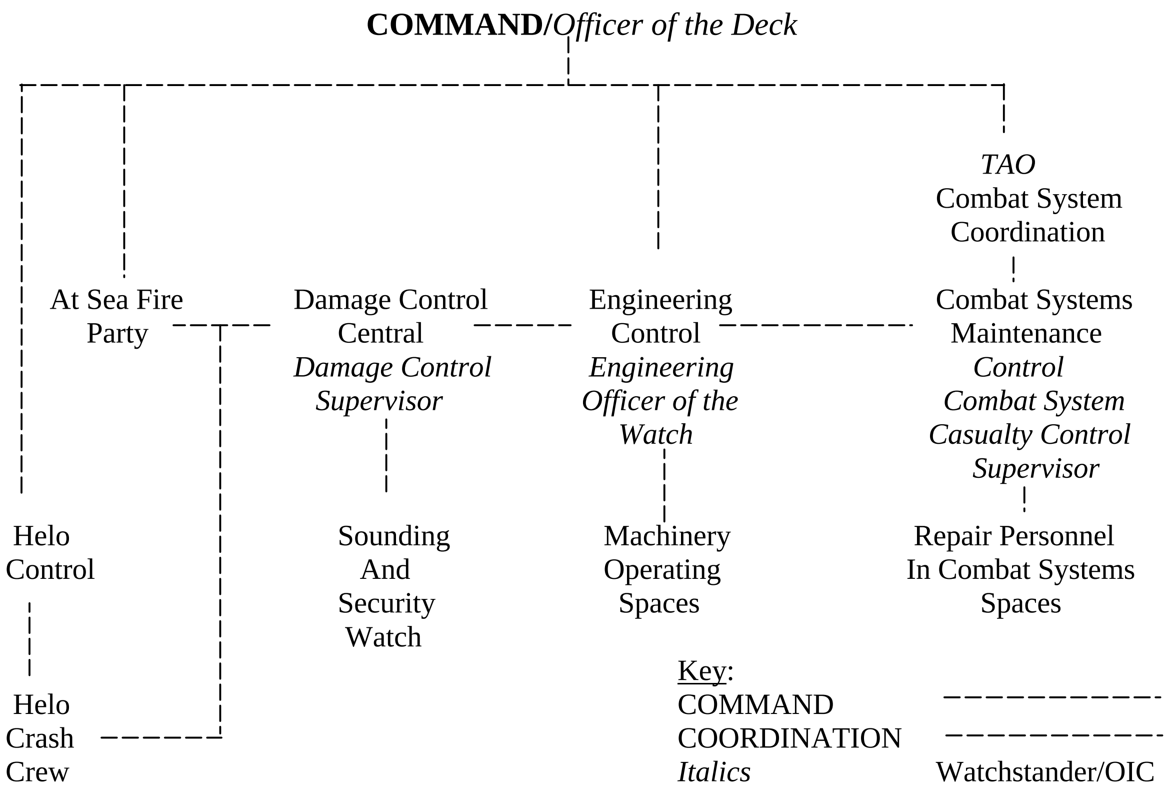

Figure 3. Command and Control Organization Underway. Source: NWP 3-20.31, fig. 2-1, p. 2-7.

Training plays a primary role in a ship's preparation and readiness to conduct damage control as well as any other operation. Damage control training is conducted aboard ships daily to ensure that all equipment is in good condition and fully operable. Personnel that use the equipment train for proficiency in its use and ensure that the equipment is replaced and easily accessible in the event of an emergency. It also adds to the proficiency of the personnel on the different teams and aids in training newly reported personnel.

Fleet Exercise Publication 4 (Rev A) is a list of exercise evaluation sheets used in conducting proficiency assessments by shipboard personnel, training teams, and inspection teams. The publication lists a series of exercises in damage control that can be conducted by shipboard personnel or imposed by assessors from outside organizations. The description and guidance for the exercises suggest a scenario, describes procedures for the conduct of the exercises, and then provides evaluation criteria. In the series of exercises dealing with damage control, there is an exercise to evaluate major conflagration. The following notice is given by the manual to assist trainers and observers in more realistically evaluating the actions of personnel during the exercise:

> Since this exercise is conducted to train all hands in a team effort to combat the disastrous effects of a major conflagration situation, a finite evaluation format is not necessarily appropriate. It is impossible to simulate all the actual conditions inherent in a major conflagration situation; consequently, innovation and enthusiasm is demanded on the part of all hands. Accordingly, subjective assessment of the team is necessary.[6]

It is important to note that the recognition of independent action and thought is provided in the conduct of actions in damage control. While these individual actions are not recommended and independent action is not necessarily doctrinal, this statement suggests that the acceptance of non-doctrinal actions may at times be required and should not be discounted when conducting damage control.

There is ample discussion and opinion offered in various publications by technical personnel and present and former Naval personnel about the reduction of crew proposed in DD21. The views vary. There are positive and negative opinions whether or not reduction in manning is possible or even necessary. These opinions although important are somewhat irrelevant, as the number of personnel in DD21 is already mandated to be ninety-five. The requirement does however allow for a maximum of 150 personnel, to increase the flexibility of the design teams in accomplishing their task.

The office of the Commander, Naval Sea Systems Command (NAVSEA) is responsible for the oversight and development of DD21. The specific office within this organization is the DD21 Program Executive Office (PEO), under the Program Executive Office for Strike Warfare (PEO-S). The organization maintains a website that contains an entire program overview and is updated frequently to ensure that the latest data in the ongoing program is posted and readily accessible.[7] The site also contains links to other websites that are maintained by organizations directly or indirectly involved in the development of the DD21. The site displays information on acquisition, program management, updated news releases, and downloadable presentations that give background information on the concept, the program, and future prospects.

Research and development of new technology has already been conducted by various agencies within the Navy department in regard to the specific topic of reduced manning in damage control. There are multiple departments working the issue now.

Among the offices conducting or having oversight in the research of reduced manning are the Naval Research Laboratory (NRL), the Office of Naval Research (ONR), Naval Surface Warfare Center (NSWC), and the Surface Warfare Development Group (SWDG). These laboratories and offices are the agencies that experiment with equipment, weapons and systems, and methodology, procedures and tactics in both combat and survivability in surface ships.

There is an initiative called Damage Control Automation for Reduced Manning (DC-ARM) that is the foundation for and consolidation point for all research and development program supervision. Any technology advancement applications and manning experiments are reported to the various supervisory offices under the title of DC-ARM. This allows for easier consolidation of information, cross-referencing, and access to information by any office or agency with interest in the topic.

The NAVSEA office responsible for surface ship maintenance and damage control development is Program Manager Ships (PMS) 500. This office reports to the Program Manager (PM) for DD21 with all developments regarding reduced manning and advanced technology experiments. NAVEA has contracted with a firm, MPR Associates, Inc (MPR) of Alexandria, Virginia to make recommendations regarding the reduced manning concept as applied to damage control in DD21. The results of this research are consolidated in a notebook entitled *Damage Control Performance References.*[8]

Within this notebook are results from a number of actual shipboard tests and briefs from actual ship damage that resulted in major conflagrations. The data collected in this reference manual is both doctrinal and objective in nature. MPR collected information that supports analysis of applied future technology and reduced manpower in damage control in DD21. There are several memorandums that offer summaries, analysis, and recommendations for the DC-ARM program based on the collected data. Experiments conducted onboard decommissioned and active naval ships are summarized, analyzed and the results examined. MPR made a number of recommendations specifically dealing with manning and the concept of reduced crew size in the controlling of and restoration from damage that cite present day technology and offer changes in current doctrine. This data will be further analyzed/discussed in chapter 4.

Another document that offers analysis and conclusions of the reduced manning concept is published by the Center for Naval Analyses (CNA). This document discusses data that was collected with regard to the application of technology and the ability to reduce crew size. It cites a study conducted at Johns Hopkins University that proposes a crew of only forty-six personnel to be on watch during combat conditions. The research was part of program entitled Ship Systems Automation (SSA) whose goal was to apply available and future technology in ship automation, reducing the operating crew size. The crew recommended in the research consists of four officers and forty-two enlisted personnel as displayed in appendix J.

The study researched how to fully automate ships and applied this automation to manning a ship.[9] It also summarized research conducted to determine trends in the civilian workforce and the ability to recruit personnel for the future manning of naval ships, aircraft, and submarines. The analysis compares requirements to operate high technology equipment and the background and education of the future sailor. This is an important comparison as it sheds light on the fact that too much technology may not be beneficial due to the inability of the Navy to recruit, train and retain the personnel to proficiently operate it.

The research data collected and analyzed by CNA presented one particular conclusion that summarized the entire analysis of manning versus implementation of technology:

> One area that is intrinsically more difficult to automate is Damage Control. Unpredictable manual requirements, the need to address multiple contingencies, and a scarcity of commercial applications all limit the likelihood that technology will greatly reduce Damage Control manning requirements. Because Damage Control manning is a significant part of shipboard manpower requirements, this is an important limitation.[10]

The final significant document that will be used to measure the effectiveness of the reduced crew concept in damage control in DD21 is a report of experiments and tests conducted by Naval Research Laboratory in September 1998.[11] This report was submitted to provide summaries, conclusions, and recommendations on the tests that were conducted in Ex-USS *Shadwell*, an inactive LST (amphibious landing ship), that is used to conduct live fire testing when new tactics or equipment is being considered for the Navy.

The tests and results reported include tables and graphs that assist in analyzing actions taken in the ship by damage control personnel. Summaries of progressive damage due to initial fire or flooding are documented. System integrity and operation is also reported in detail to assist in examination of the use of technology and how the damage control team members responded during actual damage. From this series of tests, the Naval Research Laboratory provided specific numbers of crew members required in damage control organizations and included recommendations in changes of doctrine and the application of technology to future ships.

The significance of these doctrinal and research publications is that they identify what is required to conduct damage control in surface ships. The doctrinal publications provide the ship commanding officer guidance on how many people to have at what stations, what equipment is required to be onboard and maintained, what actions to take in combating damage, and how to prepare and train for damage control. The research conducted to date supports the theory that manning reduction is feasible but falls short of demonstrating that the ship will survive in a major conflagration including conflagrations in which loss of electrical power occurs.

In DD21, there is a limit of ninety-five crewmembers. Among these crewmembers, there must be a number, yet to be specified, of damage control experts that can not only train and educate the rest of the crew, but also be involved in maintaining the damage control systems on board. One final task for these sailors is to actually conduct damage control and restoration in the event of an emergency such as those seen in USS *Cole* (DDG 67). With the introduction of technology and the reduction of crew members, a new type of sailor may have to be recruited and trained. A technologically-educated, physically-reactive, and experienced damage control expert seems to be the type of sailor required for service in the DD21. A review of the tasks, equipment, and crew will assist in answering the questions posed in this thesis.

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[1]U.S. Department of the Navy, Deputy Chief of Naval Operations (DCNO) for Manpower and Personnel, (M&P)(N1), *Ship Manning Document (SMD)*, USS *Arleigh Burke* (DDG 51) (Millington, TN: Naval Manpower Analysis Center (NAVMAC) 1998.)

[2]U.S. Department of the Navy. "United States Navy Regulations" (Washington, D.C.: Office of the Chief of Naval Operations (CNO), 14 September 1990.) Chapter 8, Article 0802.

[3]U.S. Department of the Navy, Naval Doctrine Command, Naval Warfare Publication (NWP) 3-20.31, *Surface Ship Survivability,* (Norfolk, VA: November 1996.) 2-14 (figure 2-3).

[4]U.S. Department of the Navy, Office of the Chief of Naval Operations (CNO), *Standard Organization and Regulations of the U.S. Navy,* OPNAVINST 3120.32C (Washington, D.C., 11 April 1994), Paragraph 222.3.

[5]U.S. Department of the Navy, Commander, Naval Surface Forces, U.S. Atlantic Fleet/Commander, Naval Surface Forces, U.S. Pacific Fleet, COMNAVSURFLANTINST 3541.1C/COMNAVSURFPACINST 3541.4B, *Standard Repair Party Manual for Naval Surface Force* (Norfolk/San Diego: COMNAVSURFLANT/COMNAVSURFPAC, 13 Feb 1991.)

[6]U.S. Department of the Navy, Commander, Naval Surface Forces, U.S. Atlantic Fleet (COMNAVSURFLANT), Fleet Exercise Publication (FXP) 4, (Rev A), *MOB-D-8-SF – MAJOR CONFLAGRATION* (Norfolk: COMNAVSURFLANT, 1988), 4-39.

[7]DD21 Land Attack Destroyer.

[8]*Damage Control Performance References,* Comp. by MPR Associates, Inc. (Alexandria, Virginia: MPR Associates, Inc., 1995–2000).

[9]John P. Jackson and Wade Taylor, *Ship Systems Automation Concept of Operations (SSA CONOPS), Revision 4* (Johns Hopkins University Applied Physics Laboratory, STD-R-2486, July 1996).

[10]Martha E. Koopman and Heidi L.W. Golding, Center for Naval Analyses (CNA), CRM 99-59/July 1999, “Optimal Manning and Technological Change” (Alexandria, VA: The Center for Naval Analyses Corporation, 1999), 81.

[11]F. W. Williams and others, eds., *Naval Research Laboratory: Results of 1998 DC-ARM/ISFE Documentation Tests* (Washington, D.C.: Office of Naval Research, 25 April 2000), E-1.

CHAPTER 3

METHODOLOGY

Tasks, manning, and equipment will be analyzed to determine if a reduced crew in DD21 can effectively conduct life and ship saving damage control in a major conflagration. The methodology used to conduct an effective analysis can best be shown by diagrams. Figure 4 depicts different areas where technology is planned on being applied throughout DD21.[1] Each area of operations in DD21 will use technology to replace sailors. All of the personnel reductions in each one of the individual areas impact the basic functions of damage control by the entire crew. As has already been discussed, damage control is an "all hands" function.

Throughout the ship design process, damage control remains an underlying premise. Damage control advancements are of primary concern due to the number of personnel that are currently involved and the drastic reduction proposed. A review of these proposed advancements and their impact on the actual ability of the reduced crew to conduct effective damage control is imperative. The results of this analysis are important at this time because production of the ship has not yet started and the design is yet to be finalized. The conclusions could impact that process, design and other DD21 system requirements such as recruitment and training of sailors.

Technology replacing personnel is the fundamental concept in building DD21. A review of the doctrinal publications governing damage control and firefighting aids in the analysis of what is required or what is recommended in today's destroyers to accomplish damage control and restoration from damage.

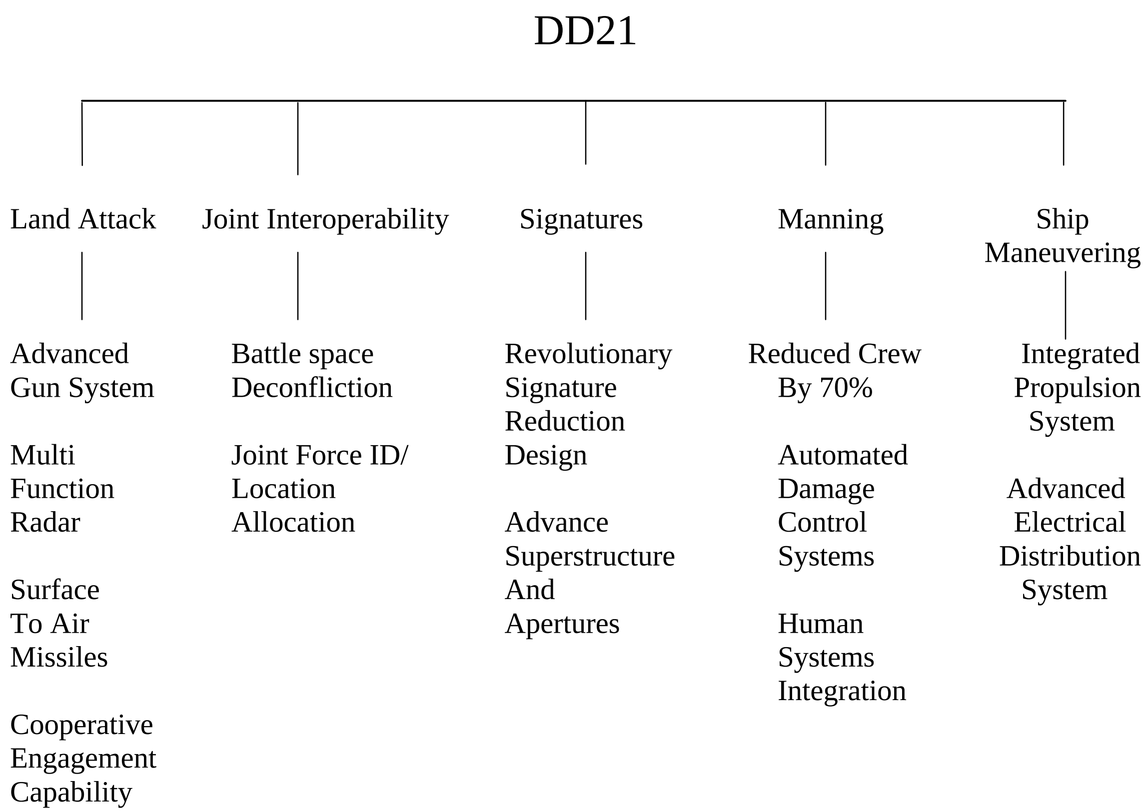

Figure 4. Application of Technology to Specific Areas of Operations. Source: DD21 Land Attack Destroyer

Technology performing the same tasks in tomorrow's destroyer as personnel perform in today's destroyer is the key to a successful strategy of reducing manpower by 70 percent.

In figure 5, a diagram of the different aspects of damage control aboard naval ships is presented. Subordinate to the heading of ship survivability in the DD21 technology application diagram are the most basic damage control functions that are accomplished by repair parties, or in some instances, by individual sailors. The basic tenants of damage aboard naval ships are fire, flooding, structural or hull damage, chemical, biological or radiological attack, and personnel casualties. A combination of these types of damage or a single one of these that consumes the efforts of the entire crew is considered a major conflagration.

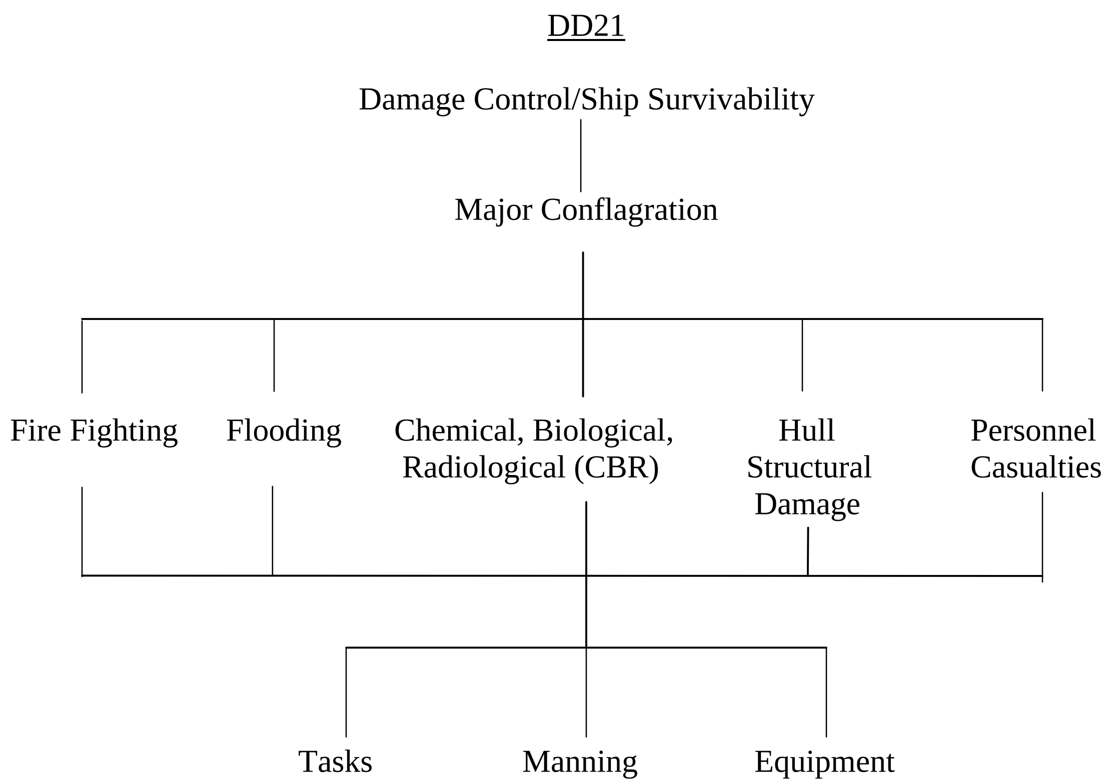

Figure 5. Diagram of Functional Damage Control Areas. Source: NWP 3-20.31. 1-1.

Major conflagration is defined in NWP 3-20.31 *Surface Ship Survivability* as

> damage of a magnitude that cannot be readily handled by the conventional DC organization; therefore, all-hands participation is required to save the ship. A major conflagration may also involve mass personnel casualties. It is imperative that command control and communications be established and maintained to effectively coordinate DC actions over a prolonged period of time. The inflicted damage must be brought under control immediately and simultaneously combat systems must be kept in or returned to a state of battle readiness.[2]

This definition encompasses all types of damage. If a ship can handle a major conflagration to the degree that is defined in NWP 3-20.31, then it must surely be able to handle any of the individual subordinate damage.

The basic functions that every sailor must qualify in are the foundation that further qualification is built on for more advanced functions that are incorporated into the repair parties and the responsibility of the repair teams. These duties will be analyzed to answer the question of whether technology that is proposed in DD21 can replace personnel with sufficiency to keep a ship in combat or save it, while suffering sustained damage or a major conflagration.

NSTM 555 is considered a doctrinal publication with regard to firefighting afloat. It amplifies the concepts that are described and outlined in NWP 3-20.31 and focuses specifically on firefighting. Fires are the most common damage aboard ship and can quickly become the most dangerous. For this reason firefighting is the primary functional area of damage control and fires are the highest priority when conducting damage control. Organizational recommendations and requirements apply to other types of damage as well, and the repair parties and duties do not significantly change when other damage than fires are being attacked.

NSTM 555, Volume 1, is dedicated specifically to surface ship firefighting. NSTM 555, Volume 2, covers submarine firefighting. There are significant differences in the two types of platforms (ships and submarines) and procedures used in combating fires and major conflagrations in each platform are accomplished differently. Only the surface ship firefighting procedures technically apply to DD21.

Since firefighting aboard naval ships has some similarities, there are concepts that can be applied to either. Submarines have fewer crewmembers, are nuclear powered and are more mechanically complex due to the nature of their mission. Underwater operations are inherently more dangerous than surface operations because of the environment in which submarines operate. Some concepts and organizational ideas from submarine firefighting may be used to better develop a viable damage control team with fewer personnel as will be required in DD21. For purposes of this research, submarine operations and engineering will not be discussed. However, applications of concepts in firefighting certainly must be considered if they aid in analyzing the application of fewer crewmembers to major conflagrations. Reorganization of the repair parties may be required to take advantage of the applied technology and lessons learned to fully utilize the availability, or non-availability, of personnel in the conduct of damage control.

Duties of the repair party organization will be analyzed in chapter 4 to discover whether DD21's technological advancements will be sufficient to reduce crew size. Doctrinal publications, research conducted, and other professional opinions will be applied to the requirements of the ship's crew to conduct damage control tasks, what equipment is required to conduct those tasks, and how many personnel are required. Proposed manning and technology will then be applied to this data to determine the feasibility of meeting task requirements. If there is a shortfall in one of the damage control functional areas of tasks, manning, and equipment, they will be identified and commented on.

The tasks required for survivability remain constant in both ships, DDG51 and DD21. Fire must be extinguished, flooding must be stopped and then mitigated, structural and hull damage must be repaired, and personnel casualties must be overcome if the ship is to survive and continue operating. Additional tasks such as reporting the damage, reporting the progress of repair efforts, and reporting an estimated time of repair or restoration, once the extent of damage is fully discovered also are required. Knowing that these tasks remain the same, the variables that change are number of personnel available to operate the equipment at hand and the specific equipment available to conduct effective damage control for ship survivability in a major conflagration.

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[1]DD21 Land Attack Destroyer

[2]Ibid. 10-1.

CHAPTER 4

ANALYSIS

DD21 will be revolutionary in its application of technology. It is proposed to be both affordable and abundant in its support to the land battle. The first ship of the twenty-first century will lead the Navy at least half way through it. Advanced weapons systems, advanced navigation and communications systems, advanced surveillance systems, and an advanced propulsion system all will be operated by a crew that is about 70 percent less than today's destroyers are. The advancements that are proposed for this ship span a family of computerized systems that include a fully automated damage control system that is supposed to reduce the need for manpower. Reducing the number of personnel is the aim of most of the technological applications. The doctrinal tasks, available personnel, and installed equipment that are required by today's destroyers need to be replaced by technology to meet the reduction in manning requirements of DD21. To complete the analysis of the conducted research the data will be reviewed in three major areas. These areas are tasks, manning, and equipment, the basis for all damage control as shown in figure 5, and summarized below as figure 6.

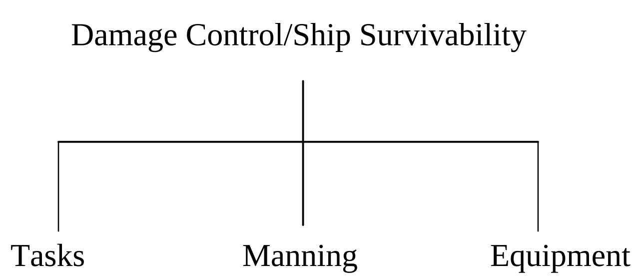

Figure 6. Basic Elements of Damage Control.

Tasks

The requirements for conducting firefighting, flooding, hull, and structural damage repair are established by doctrine and must be performed to combat any type of damage. Figure 7 depicts these tasks as applied to the areas that comprise damage to be controlled.

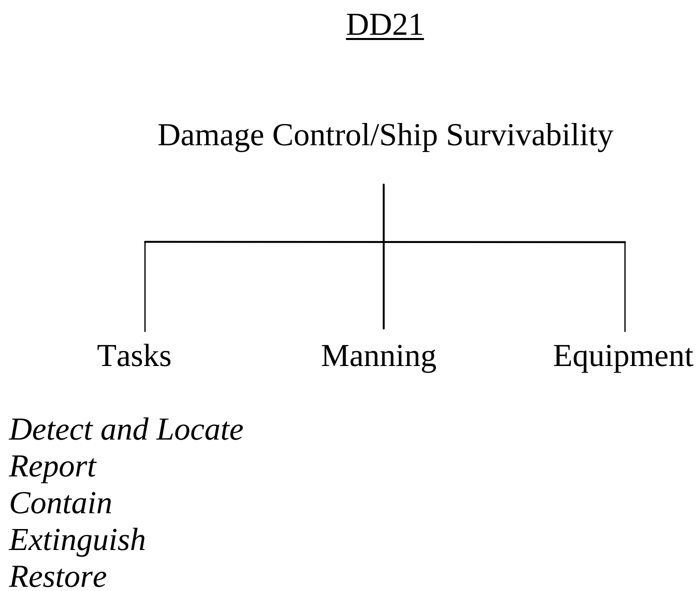

Figure 7. Summary of Individual Tasks.

The tasks will not significantly change whether the crew of a ship is 325 or 95. Historical examples of major conflagrations in U.S. naval ships and results from experiments conducted in Ex-USS *Shadwell* show that no matter what type of technology is applied or how many sailors are involved, the basic tasks are still required to be conducted if the ship is to be saved. The priorities in conducting damage control as detailed in a naval ship damage control handbook are “fires, flooding, structural damage, machinery repair and finally tending to personnel casualties.”[1] This priority dictates the actions by both supervisory and subordinate personnel in the repair lockers and the fire parties. A summary of the individual tasks can be simplified to just a few. They are to locate, report, contain, extinguish, and restore.[2]

A detailed list of individual tasks along with reporting requirements in the event an individual discovers damage is listed in appendix F, *Individual Reporting Requirements*. Tasks required by repair lockers are listed in appendix G, *Repair Party/Repair Locker Functions*. Additional tasks, required by DC Central are listed in appendix H, *Damage Control Central Functions*. The compilation of tasks for each type of damage is the sum of the tasks that must be accomplished during a major conflagration.

Exercises and drills in combating all types of damage, most importantly, a major conflagration, are continuously conducted onboard ships today. The conduct of drills and the prescribed preplanned responses by team members are evaluated by the damage control training team for proficiency. Repair parties, firefighting teams (attack teams), pipe patching teams, hole plugging teams, and shoring teams all receive training and conduct exercises to better coordinate their actions with those of the supervisors in the repair lockers or in DC Central. The actions of the teams are further evaluated in accordance with various other Naval Ships Technical Manuals and the Repair Party Manual as amended by each individual ship. A damage control drill of some sort is conducted daily while the ship is in port and in most ships a minimum of weekly while underway.

Another reason for the exercises is to familiarize newly reported personnel or train replacements for the next higher station. This allows for upward mobility of subordinate team members and increases the proficiency level of the entire team. For example, a hoseman's next step once proficiency is achieved as a hoseman is to move up to nozzleman. This step up in the hierarchy of command of the firefighting team then allows that person to exercise more initiative and practice greater leadership when conducting actual damage control. In the firefighting team the nozzleman becomes responsible for applying firefighting agent to a fire while simultaneously coordinating the actions of two or more personnel. The nozzleman also becomes the leader of the team in the event the Attack Team Leader is disabled.

The most complex exercise, the Main Space Fire Drill or Major Conflagration drill is designed to evaluate the skills needed to combat the damage. The exercises must be scheduled in advance and coordinated throughout the ship as it impacts the entire crew and ship operations, by the XO, as DCTT leader to ensure that the proper coordination is conducted throughout the ship prior to running the exercise. The complexities involved in the exercise come from the entire crew responding to the damage by manning their General Quarters stations (Battle Stations).

Engineering equipment, including main propulsion, and combat systems are affected due to isolation of electrical power in the effected area of the exercise. The primary goal of these exercises is to gain proficiency in attacking and repairing the damage. Secondary goals are to allow the crew to become familiar with the adverse effects on the ship as a fighting platform, experience a loss of electrical power and its complications, and devise or implement alternatives to ensure that the ship is able to conduct its mission while simultaneously combating the damage incurred.

The tasks must still be accomplished, no matter how many personnel or what equipment is available to combat fire, flooding, hull, or structural damage. Electrical damage repair, machinery repair and personnel casualty assistance are emergencies that tend to allow for individual initiative, innovation, and imagination in the application of damage control. There is no specific doctrine on prioritizing machinery repairs, although a hierarchy of damage control exists as previously described. This general guidance leaves the experience of the personnel on the scene to determine the best course of action using available technical and repair manuals. Damage to machinery, their components, and damage to personnel require humans to perform because machinery and personnel cannot usually repair themselves. In addition, the loss of electrical power is crucial to the operation of a ship and its loss is often a debilitating casualty that can lead to further complications in organizing repair teams or accomplishing certain damage control functions. Communicating and reporting from station to station or off ship can become impossible due to loss of electrical power.

In the event of catastrophic damage inflicted by an enemy weapon, collision with another ship or grounding, or internal damage caused by a main space fire or major conflagration the tasks are simultaneously performed by any number of personnel and repair parties. As the definition of major conflagration describes, these casualties require an “all hands” effort.

The tasks that are required to fight fires, stop flooding, repair hull damage, or save lives are all tasks that must be accomplished if a ship is to survive and continue to fight. For this reason, the tasks will remain constant.

A summary of the major tasks required by crew members and the repair party is provided below.

1. *Detect and Locate* (Discover damage)
    a. Fire
    b. Flood
    c. Structural
    d. Personnel
2. *Report* damage
    a. Class of fire
    b. Compartment number and noun name
    c. Damage: Type and location in compartment (fwd, aft, port, stbd)
    d. Amount of flooding, size of fire, amount of damage
    e. Attack fire, isolate flooding, secure equipment
    f. Report progress and situation
3. *Contain* (Action)
    a. Actions by Repair Party
    b. Manned and ready
    c. Boundaries set (fire/flooding/smoke)
    d. Electrical power isolated
    e. Damage contained
4. *Extinguish* fire/flooding controlled
    a. Fire overhauled/dewatering started
    b. Compartment dewatered/desmoked
    c. Gas test completed
5. *Restore* equipment/repair damage/evacuate personnel casualties

Applying basic safety thought and common sense also support these tasks in that fires must be extinguished, flooding must be stopped, structural damage must be repaired, and personnel casualties must be cared for or the ship will not survive. The threat of losing an entire ship or other personnel onboard is great enough in a major conflagration that all personnel available will be called upon to perform the tasks described above to save the ship. Whether technology or personnel perform the tasks, the tasks still must be performed to ensure that the ship does not suffer catastrophic damage that will cause its ultimate loss. The constant in the damage control process is the tasks to be performed and the DD21 project must ensure that each of the tasks required is covered by reliable, accurate, and flexible technology to ensure the task accomplishment.

Manning

Damage control manning in a DDG 51 destroyer will vary depending on the type of damage, the location of the damage and the extent of damage reported. This analysis specifically addresses major conflagration. Short of employing the entire crew of about 325 personnel at once, the initial response to a catastrophic damage occurrence is approximately 125 personnel. Watch teams, Rapid Response teams, At Sea Fire Party and at least one repair party will be called upon to respond to damage. Total manning in DD21 is mandated to be ninety-five. With this reduced crew, an elementary conclusion can be made that the same amount of damage control tasks will have to be accomplished by one-third the crew. While this is a simplification of the reduction of crewmembers from today's destroyer to DD21, it does lead one to believe that this drastic reduction in manning might be critical and even prohibitive in conducting damage control during a major conflagration. Figure 8 displays the simple comparison of crew size in DDG51 and DD21.

In an *Arleigh Burke* (DDG 51) class destroyer, where there are 325 total crewmembers, the damage control functions are managed by a small number of expert personnel with the rating of Damage Controlmen (DC). Among the functions and duties of the damage control personnel are training, education, and exercising of the rest of the crew in damage control. There are eight DC men assigned to USS *Arleigh Burke* (DDG

51), the lead ship in the class of modern destroyers at sea today.[3] These sailors are well trained, educated, and considered experts in all damage control subjects.

<u>DD21</u>

Damage Control/Ship Survivability

Tasks — Manning — Equipment

Tasks	DDG 51	DD21
Detect and Locate	*1*	*0*
Report	*3*	*0*
Contain	*8*	*0*
Extinguish	*30*	*0*
Restore	<u>*10*</u>	<u>*10*</u>
Total	*52*	*10*

Figure 8. Summary of Individual Tasks and Manning.

For the most part, they are sent to the fleet with the ability to perform complex damage control functions as well as teach and train crews in their assigned ships.

Following is a damage control personnel employment escalation scenario typical of tasks accomplished by personnel in today's ships:

A casualty is first *detected, located, and reported,* and a Rapid Response Team dispatched to *contain* the damage. The team consists of a minimum of four personnel and responds to assist watchstanders in combating the casualty.[4] After this initial response, the At Sea Fire Party may be called to respond. The At Sea Fire Party assists in damage control that cannot be handled by watchstanders and the Rapid Response Team. The At Sea Fire Party consists of a minimum of eighteen personnel.[5] Once the At Sea

Fire Party responds to a casualty, and a decision is made to request more assistance, the next team to be called is the Repair Party. This team reports to the appropriate repair locker in the responsible area and prepares to assist the teams that require it to *extinguish* the fire or stop flooding.

The Repair Party in DDG 51 comprises about thirty personnel. The standard damage control organization of a DDG 51 destroyer includes three repair lockers.[6] A fourth repair locker for combat systems repair technicians is manned with a minimum of four personnel.[7] In the scenario above, if only one repair locker is required to be manned, the total number of personnel responding directly to the casualty would be fifty-two. If the ship were required to go to General Quarters for a full damage control response, the number goes up to about 125 total personnel, not including watchstanders. In addition to the specific damage control personnel, the entire command and control organization throughout the rest of the ship is notified. Thus, when a major conflagration occurs, about 150 total personnel are involved immediately upon the imposition of the casualty.

The primary command and control personnel are the Officer of the Deck (OOD), and bridge watch team, the Tactical Action Officer (TAO), and Combat Information Center (CIC) watch team, and the CO and XO. The need for the watch teams to have reports on the extent of damage and progress of repair information is imperative to maintain the ship in a combat ready status and keep it navigating safely.

As discussed earlier, at the discretion of the CO, the number of personnel may be adapted to meet each specific emergency or casualty. NWP 3-20.31 further states that “It is not necessary to have an individual person for each function; a person may perform one of more functions simultaneously or sequentially."[8] Other personnel may be added as required to *restore* the equipment or repair the damage.

DD21 is targeted to have only ninety-five personnel onboard. Because the ship is still in the design stage, very little research, recommendations, or conclusions have been made as to the make up of the crew. There is little information regarding how many officers and how many enlisted personnel will man the ship, but the emphasis is squarely on technology to replace personnel. The one recommendation made by the study at Johns Hopkins University and cited by the Center for Naval Analyses report on optimum manning, offers that a crew far less than that proposed in DD21 could fight a ship. The figure is displayed in appendix J, Conceptual Condition I Watch Organization for SSA Ship.[9] This study shows a depiction that with advanced technology applied in a warship, only about 40 personnel would be required to operate a fully functioning ship in combat.

The studies, experiments, and exercises conducted by the Naval Research Laboratory on the Ex-USS *Shadwell*, employ reduced manning tactics and use some automated equipment to assist the firefighters and damage control teams. None of the equipment however, meets the proposed complexity and fully automated state of the art computing proposed for DD21.

A review of the proposed technological advancements may help to determine if the number of personnel proposed to man DD21 is sufficient. A complete analysis of the tasks versus manning in DD21 cannot be made because the type of equipment and number and sophistication of equipment proposed is necessary but not available due to ongoing testing and design. If the proposed technological advancements and employment of data systems and sensors can sufficiently replace personnel to accomplish the basic tasks, then the primary research question will entail a greater chance of success than risk of failure.

Equipment

To accomplish the basic tasks of damage control, equipment in today's destroyers support the *contain* and *extinguish* functions more than the *detect and locate* functions. Equipment used in firefighting and basic damage control varies from permanently installed and automatically energized, to portable and manually operated equipment brought to the scene by fire party members. All of the damage control equipment, whether portable or installed, supports the personnel in the accomplishment of the basic tasks of damage control. Installed firefighting equipment and damage control systems are composed of firemain, AFFF bilge sprinkling, Halon flooding, carbon dioxide (CO_2) flooding and hoses, Aqueous Potassium Carbonate (APC), and fresh water hose stations.

These systems are permanently installed and are operated manually, remotely, and/or automatically. This allows the crew to activate them either when required or if the automatic activation systems fail. Figure 9 displays the equipment proposed in DD21. In the case of firemain, isolation valves have both remote and manual operators. Halon and CO_2 flooding systems have remote, manual, and automatic operators. APC has a heat-sensing device for activation or it can be manually activated by galley personnel. AFFF bilge sprinkling also can be manually activated or remotely operated from a number of different areas. Magazine sprinkling systems are operated remotely and manually and have a number of different sensing devices to ensure that firemain is constantly supplied to the system. Today, although some of the systems have automatic energizing apparatus, most systems are activated by personnel. Firemain must be operational and have sufficient pressure to supply fire hoses for firefighting and dewatering.

DD21

Damage Control/Ship Survivability

Tasks	Manning	Equipment
Detect and Locate	*DDG51: ~52*	*Halon*
Report	*DD21: 10*	*AFFF*
Contain		*CO_2*
Extinguish		*H_20 (Water Mist)*
Restore		*APC*
		Automated Sensors
		Supervisory Control System (SCS)
		Intelligent Control System (ICS)
		Early Warning and Fire Detection System (EWFDS)

Figure 9. Summary of Individual Tasks, Manning, and Equipment.

This means that the firemain system must be intact and that sufficient fire pumps must be on line to provide the proper pressure for system operation. Halon and CO_2 flooding systems must also be intact and operable to ensure that all available firefighting equipment is available. APC systems and hose reel systems, whether CO_2, freshwater or firemain, must also be operable. These permanently installed systems provide the first line of defense in *containment* and *extinguishing*.

When personnel are required to operate these systems, they have remote operators at various locations including DC Central and usually adjacent to the compartment which they serve. When a crewmember deems the situation severe enough to energize one of the installed firefighting or damage control systems, activation sensors register in DCC to signal personnel there that the system has been activated. This will alert the DCC supervisor to send an investigator to the area or call the compartment to find out why the system was activated.

Again, the human interface takes place in both the operation and monitoring of the situation and the compartment. In a major conflagration such as those that occurred in various U.S. naval ships in recent history the number of personnel injured or killed, impaired the damage control efforts, but did not completely debilitate the crew from continuing and successfully fighting the damage.

In support of these installed systems, portable equipment is also available. Fire hoses, compartment access tools, such as axes and pry bars, portable CO_2 bottles, portable potassium bicarbonate (PKP) bottles, oxygen breathing apparatus (OBA), extra oxygen canisters, investigation equipment, Naval Firefighter’s Thermal Imager (NFTI), battery packs, battle lanterns, atmospheric test equipment, desmoking equipment, smoke curtains, communication equipment and various other personal protective equipment. All of these systems provide the firefighters/damage controlmen with the equipment and tools they need to combat damage and begin repair to equipment and the ship.

All of the permanently installed systems require electrical power directly or indirectly to function. Portable equipment employed by damage controlmen include portable fire extinguishers, portable eductors, NFTI, plugging, shoring, and pipe patching equipment, P250/P100 portable fire pump and personal protective equipment. This equipment operates manually or independently of ship's electrical power. The NFTI is battery operated and the P250/P100 pump operates via its own internal combustion engine. Close coordination and communication is required in employment of all of these systems to maintain an accurate status of *manning* and *equipment* employment in performing the *tasks* that control damage.

DD21's primary achievement of reducing the crew size can have both an adverse and a positive effect on the damage control problem that plagues naval ships. The adversity lies in the fact that fewer crewmembers are an obvious reduction in a valuable resource and the primary source of *detection* and *location* of damage. Manpower is one important factor that ships have historically benefited from. During damage control efforts, more people applied to a problem helps stabilize the situation so *repair* and/or *restoration* can be conducted. As a benefit, fewer personnel onboard means the statistical probability of injuring or killing personnel is reduced because there are less total personnel.

While this statement is obvious in its nature, saving lives is not the primary mission of the ship. The mission of the ship--to conduct combat operations while sustaining and repairing damage--is of primary concern. Sailors embark in ships to carry out assigned missions. Technology has placed the Navy in a position to leverage technology and potentially save cost and lives in DD21. Striking the proper balance in crew size and application of technology is the goal of the project to build DD21.

DD21 proposes innovative and robust applications of technology in all areas of ship operations including damage control. These advances will reduce required crew size, the number of personnel susceptible to injury or death, and critical damage containment response times.[10] The lead agency in supervising and ultimately recommending the approval of any advances is the Office of Naval Research (ONR) in the Damage Control Automation for Reduced Manning (DC-ARM) division.[11] This division observes, coordinates, consolidates, and reviews data from testing whether it is from private industry or the Navy's own Naval Research Laboratory (NRL). DC-ARM then keeps all other program offices informed as to the results of testing or assessments of data that it has collected.

To simplify the analysis of applying technology to reduce manning and answer the primary question of whether or not a crew of ninety-five personnel can accomplish the required tasks in a major conflagration, systems and equipment will not be viewed in technical detail. The computing systems and networks proposed are replete with complex programming and algorithms for data processing and information dissemination. The technological advancements proposed for DD21 will be reviewed and then applied to the tasks, personnel, and equipment to ascertain if the crew reduction is able to meet the challenges of a major conflagration.

A computer system called Intelligent Control will integrate a hierarchy of data collection and display devices in DD21. It includes the Early Warning Fire Detection System (EWFDS) incorporating a multicriteria sensor array, remote operation of system configuration by use of "smart valves," remote fire suppression agent application (Water Mist), and analysis and display of data in the Supervisory Control System (SCS) for automated situation awareness for all available users to *detect, locate and report* damage or emergencies.[12] This technology is being designed to increase the responsiveness of available personnel, increase situational awareness of supervisory personnel, and increase more accurate dissemination of status of damage to command and control stations. The system can begin to conduct damage control before personnel are able to respond to *extinguish* a fire or begin *dewatering* flooding.

The EWFDS exists throughout the ship, is monitored in DC Central and can be accessed from any number of display terminals. The integration of the early warning with the SCS can then employ the water mist fire suppression system to put out any fire that may be detected. This is a fully automated function and completely alleviates the need for any personnel intervention in firefighting.

While this situation is optimal and relates to fire only, ONR, supported by test data conducted in *Shadwell*, recommends having a single Rapid Response Team (RRT) go to the scene of a detected (and hopefully extinguished fire) to verify damage control system effectiveness. In addition to the RRT, a Back up Response Team (BRT) is also maintained. ONR does not specifically detail the makeup of the RRT; however, the live fire testing conducted at *Shadwell* reports that a minimum of thirteen personnel can be used.[13] The RRT would respond only as precaution and in the event of system failure. The RRT and BRT would be required to conduct hull repairs, structural repairs, and personnel casualty aid and evacuation. In addition, they would be required to set the condition for accomplishing machinery and equipment repair or restoration to ensure that combat capabilities are not lost or optimally, regained.

Most of the testing to date has been conducted with respect to fire because of its inherent capability to grow and spread if left uncontrolled. Being at the top of the priority of damage to combat, it has received the most attention. Flooding is also of concern in ships, as it can cause electrical power loss due to grounding of systems, and can cause stability problems, which if left uncontrolled can cause the ship to capsize.

The system of smart valves and automatic system reconfiguration addresses the problem of internal flooding. Imbedded microprocessors and network transceivers aid in flow balance logic, which is monitored and controlled at the SCS, and will allow for rapid isolation of a fluid system in the event a pipe ruptures. System reconfiguration and fluid flow restoration is conducted automatically without manual intervention.[14]

Dewatering of flooded compartments was not addressed. This is extremely important with regard to stability and personnel safety. Remotely operating eductors to dewater compartments is done today and can be easily incorporated in DD21. According to appendix C, *Repair Party Manning,* nine personnel in a repair party of today are dedicated specifically to flooding. These personnel are no longer required. Members of the RRT and BRT would have to be trained in flooding control and dewatering operations, in the event of system failure, and primarily to conduct structural repair, pipe patching, shoring and hull damage and repair.

Summary

Fire and flooding, two of the four main areas of damage control aboard ships have been addressed and technology is proposed to replace personnel in these areas. This is to accomplish the near 70 percent reduction in crew in DD21. Fire and flooding are of primary concern. Isolation of ruptured piping has been tested in live scenarios. Fires resulting from missile, bomb or torpedo hits have been experimented with and have been successfully combated with a minimum number of personnel and advanced technology.

In combating damage during a major conflagration, fire and flooding are almost certain to occur. Major structural damage, hull damage, and personnel casualties are also portions of major conflagrations. These types of damage have not been addressed in the DC-ARM program to date.

Historically, ships that have suffered a major conflagration have all the elements of damage occurring simultaneously and the crew responds in full force to combat the damage and eventually save the life of the ship. In 1987, while patrolling in the Persian Gulf, USS *Stark* (FFG 31) was struck by two air-to-surface missiles. Thirty-seven sailors were killed. The ship survived due to the damage control efforts of the entire crew but was rendered mission incapable.[15] In 1988, while conducting operations in the Persian Gulf, USS *Samuel B Roberts* (FFG 58) struck a mine that nearly broke the keel. Six crewmen were injured, including the Commanding Officer. The entire crew fought all of the damage valiantly and saved the ship from sinking. Although the ship survived it was placed out of action.[16] In 1991, during Desert Storm, USS *Tripoli* (LPH 10), operating in the Persian Gulf, struck a mine that put a 16-foot by 20-foot hole in her hull, 10 feet below the water line. Four crewmen were injured. Again, the application of personnel saved the ship but the ship was unable to continue her mission.[17] Three hours later, ten miles away, also in 1991, USS *Princeton* (CG 59) struck two mines that cracked the superstructure. Three crewmen were injured. The ship survived due to the crew's damage control efforts but the ship was rendered "not mission capable.[18]" In 2000, USS *Cole* (DDG 65) was struck by a bomb that put a 40-foot hole in her side. Seventeen sailors were killed. Again, damage control efforts by the entire crew saved the ship, despite the loss of electrical power, flooding, personnel injuries and extensive structural damage.[19]

These incidents contained all the elements of major conflagrations; fire, flooding, hull and structural damage, electrical power failure, equipment damage and personnel injuries and death. The crew aboard each of these ships trained in damage control in accordance with the required doctrine of the time and applied the tools and equipment of damage control to save their ship. Each of these ships is different in size, with the exception of *Stark* and *Samuel B. Roberts*. They have different numbers of sailors, and they have various amounts of damage control equipment and systems, based on the ship and crew size.

Shadwell experimentation has been useful in applying the technology proposed in DD21 and the live fire tests also have validated that doctrine in damage control must change to support the reduced manning concept. Table 1 portrays where technology reduces the need for personnel in a repair party and what tasks can be accomplished by system operation in accordance with tests, experiments, and research that has been conducted to date. The Rapid Response Team and the Back up Response Team recommended by the ONR/DC-ARM research at *Shadwell* of thirteen personnel each is required to verify system effectiveness.

Table 1. Summary of Personnel Reduction by Application of Technology in DD21.

	DDG 51		DD21	
	Personnel	Equipment	Personnel	Equipment
Tasks				
Discover	1	None	0	EWFDS
Report	3	Telephone/Radio	0	EWFDS/ICS/SCS
Act	38	RepLkr equipment*	0	Watermist/SCS/ICS

Repair/recover	8	Repair tools*	8*	Repair tools*
Report	1	Telephone/Radio	0	ICS/SCS
Total Personnel	52		8*	

*Repair Locker equipment and Repair tools are all casualty dependent. If damage occurs that does not require equipment or repair tools it is not necessary to provide that equipment to the scene. The number of personnel in the repair team also varies depending on the type of casualty. For example, a machinist may not be required for an electrical or electronic casualty and vice versa.

To see the effect of this reduction in crew and the application of technology a comparison of the total crew for each ship is presented in Table 2.

Table 2. Total Personnel Comparisons.

	DDG 51	DD21
Total	326	95
Organization		
DC	150[1]	26[1]
Com Sys	87	?[2]
Nav/Admin	13	?[2]
Eng	52	?[2]
Ops	84	?[2]
Sup	30	?[2]

(1) These numbers are damage control duties of the crew. They are in addition to the primary duties that professional training and qualification skills require of them for normal ship operations, including combat.

(2) These variables are yet to be assigned and have not been discussed in the research that was conducted. The importance of these variables affects the application of personnel to the 26 required to man the Rapid Response Team and Backup Response Teams. Whether or not these personnel are primary or collateral duty personnel will affect the overall manning of the ship.

Source: USS *Gonzalez* (DDG 66) *Manpower Authorization (MPA)* dated 01 April 2001, interview conducted by author on 1 April 2001.

The application of technology and reduction in the damage control organization in DD21 can be compared to present day destroyers based on how many members of the crew would not be required. While the analysis shows that if DD21 had a fire or flood, technological advancements would satisfy the basic tasks of *detect, locate, contain*, and *extinguish.* This alleviates the majority of the crew for hull and structural repair and personnel casualty treatment.

If ninety-five personnel in DD21 are all that are available for conducting damage control in a major conflagration then there are not enough personnel. More are needed to complete the individual and organizational tasks that are required by doctrine. Fire, flood, hull, and structural damage and personnel casualties is overwhelming for only ninety-five personnel. This, in addition to a likely loss of electrical power and the potential non-functionality of systems that are supposed to relieve personnel only increases the severity of the catastrophe. Initially, the RRT and BRT can apply damage control effectively if all installed systems operate properly. A loss of electrical power will likely significantly cripple the ship with no effective backup means of controlling and repairing damage until power is restored. With a crew reduced to only nine-five sailors, there would not be enough personnel onboard to overcome induced fire, flood, and hull and structural damage simultaneously as demonstrated by the aforementioned ship examples where manpower was the key to containing damage and restoring power.

The conclusion that tasks and equipment are sufficient with reduced manning to conduct damage control effectively in individual casualties is most likely correct based on the sustainment of electrical power. Once the level of damage rises to that of major conflagration and electrical power is lost; however, ninety-five personnel likely cannot effectively conduct damage control to save the ship.

As an example of the flexibility that personnel add to the damage control problem, in the *Cole* incident, the day after the bomb blast struck and initial damage control had been conducted, one of the flooded compartment's bulkheads gave way and caused progressive flooding into an adjacent compartment. This action threatened to capsize or at the worst, sink the ship. Since electrical power still had not been restored, installed shipboard dewatering equipment could not be used. The remaining crew, now about 300, formed a bucket brigade and began dewatering manually. Damage controlmen also increased the effectiveness of shoring by adding more to prevent further damage. Computers and high technology could not have accomplished those tasks, nor would a computer or decision aid system have recommended it. Robotics currently do not exist to conduct damage repair. What saved the ship that day was the heroic efforts of the available personnel with the skills, determination, and the numbers required to combat the damage that was inflicted. They not only fought for their lives but also for the lives of their shipmates and their ship.

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[1]USS *Nimitz* (CVN 68) *Damage Control Handbook* (Bremerton, WA: USS *Nimitz* (CVN 68), 1997).

[2]NWP 3-20.31. 2-11.

[3]USS *Arleigh Burke* (DDG 51) *Ship Manning Document*.

[4]NWP 3-20.31. 9-5.

[5]U.S. Department of the Navy, Commander, Naval Surface Forces, U.S. Atlantic Fleet Instruction (COMNAVSURFLANTINST) 3541.1C/Commander, Naval Surface Forces, U.S. Pacific Fleet Instruction (COMNAVSURFPACINST) 3541.4B, *Standard Repair Party Manual for Naval Surface Force* (Norfolk/San Diego: COMNAVSURFLANT/COMNAVSURFPAC, 13 Feb 1991), 107.c.

[6]NWP 3-20.31. 2-17.

[7]Ibid., 2-15.

[8]Ibid., 2-19.

[9]John P. Jackson and Wade Taylor, (STD-R-2486.) *Ship Systems Automation Concept of Operations (SSA CONOPS), Revision 4,* July 1996 (Johns Hopkins University Applied Physics Laboratory, July 1996.)

[10]DC-ARM, *Objectives.*

[11]DC-ARM, *Program Objectives, Payoffs, and Task Descriptions.*

[12]Ibid.

[13]Naval Research Laboratory, *Results of 1998 DC-ARM/ISFE Demonstration Tests.* Table 9 – Refined Rapid Response Team Organization and Response Procedures, (Washington, D.C.: Naval Research Laboratory, 25 April 2000), 68.

[14]DC-ARM, *Smart Valve Development.*

[15]Michael Vlahos, "The Stark Report," *U.S. Naval Institute Press Proceedings/ Naval Review,* 1988, 64-67.

[16]Capt. J. M. Martin, USNR (Ret). "We Still Haven't Learned," *U.S. Naval Institute Press Proceedings* 117, no. 7 (July 1991): 64-68.

[17]Ibid.

[18]Ibid.

[19]Robert Burns, "Cohen Says No Negligence in Cole Bombing," *The Associated Press,* 19 January 2001.

CHAPTER 5

CONCLUSION

Implementation of the concept of reduced manning in a modern naval combatant is not a unique concept. It is a logical step in the progression of naval warfare based the availability of advanced systems. As technology becomes available, its implementation affords replacement of sailors with machines and computers. Reducing personnel on naval ships has become necessary in today's fleet as a dwindling budget and declining force levels become more critical. Technology is a logical substitute for personnel due to its availability, continuous improvement, speed of operation, capacity for information exchange, and complete integration with human systems. DD21 will apply these innovative and modern technologies.

As discussed and analyzed in chapter 4, a single type of damage such as fire or flooding may be effectively combated by remotely operated equipment allowing rapid response of personnel to complete repairs and restore from the damage. Due to the reliance of technology on electrical power; however there is a gap in the reliability and effectiveness high technology application. The answer to the primary question, based on the definition of major conflagration and the application of modern and future technology is this: DD21 does not have the ability to save itself with the mandated 70 percent reduction in personnel.

The research and development organizations of the various project members have come up with many unique and advanced concepts for ships to handle damage inflicted by combat or other mishaps. This technology has the capacity to accomplish certain tasks that are normally accomplished by sailors. Detecting smoke, fire, and flooding can be accomplished by the advanced technology installed in the DD21. Systems that will continuously monitor all compartments onboard for signs of anything unusual such as fire or smoke will enable a single person to watch multiple compartments simultaneously and is a tremendous advancement. This function alone reduces the number of personnel required to monitor compartments throughout the ship. In addition, an automated system of activating fire suppression, smoke clearance, and dewatering systems as a result of exceeded parameters that are maintained and monitored in an integrated intelligent surveillance computer system will increase responsiveness to the threat of damage. This automatic action also increases the flexibility of the crew and decreases the response time of crewmembers in the Rapid Response Team and Backup Response Team by conducting some of the initial actions normally conducted by personnel. These automated responses are laudable and effective in initial damage control in the DD21.

Today, as personnel are applied to the problems encountered in a major conflagration (a combination of hull damage, fire and flooding occurring simultaneously), a number of trained teams, (three, in DDG 51) with portable equipment, not reliant on shipboard electrical power, can respond to the damage. The team can control the damage, contain it, and possibly repair it or at least mitigate it to a level that allows the ship to continue to fight. This type of damage is extremely complex and often requires experience and innovation, in addition to rapid response, and proper procedural execution to combat a major conflagration successfully. When a major conflagration occurs in the ship, electrical power is often disrupted if not completely lost for a period of time. Systems may or may not be damaged, and personnel may or may not be killed or injured to the point of incapacity.

Examples that are cited in chapter 4 of this thesis supports the conclusion that manpower was key to saving their ship. Fire, flooding, structural damage, restoration of power, and combat systems all were accomplished by the crew of the afflicted ships. A DD21 reduced manpower crew will not have enough manpower to effectively handle a major conflagration especially if electrical power is lost.

All of the technology that will be installed and relied upon by the crew of DD21 relies itself on electrical power. An increase in reliance on electrical power leaves the ship extremely vulnerable to a loss of that power. Each of the computerized systems runs on electricity. The monitoring, data collection, data analysis, detection, operation, and application of damage control measures all rely on electrical power. Without electricity, all of these systems are useless to accomplish their assigned tasks and the ability to control damage then falls on personnel.

With automation and advanced technology, the design of this modern warship will attempt to meet the requirements set forth in the mission needs statement and operational requirements documents which dictate a reduced crew. The reduction in crew of about 70 percent is a revolution in manning and is currently being aggressively researched by all of the teams involved in the DD21 project.

The impact of the reduced crew on damage control is significant because on a ship with a large crew, such as DDG 51, personnel are applied to the damage control problems with the knowledge that the sailors are a resource with great depth in fighting damage. If a ship receives or sustains catastrophic damage (such as a major conflagration) that would prevent *any* amount of personnel and *any* amount of equipment to save it, then personnel are of no consequence. Personnel are a resource in the damage control problem in modern ships that the Navy has relied upon for years. The large crew size is also required to maintain and operate the ship and all associated weapons and support systems in combat. The DD21 program is taking complete advantage of the opportunity that technology has availed to replace personnel.

Damage control operations in warships have become more complex as new technology is installed. More powerful computers for data analysis and remote operation of equipment, fiber optic networks for near instantaneous data access, new types of fuel and lubricating oils for operation of better and more advanced machinery, advanced weapons and delivery systems, and extensive electrical distribution systems have added to the necessity to react more quickly and decisively to damage in the ship. It does not matter if the damage has been inflicted internally or externally. During a major conflagration or catastrophic damage control effort, the entire crew must apply all of its efforts to saving the ship from complete loss - abandonment or sinking. If a complete loss of the ship occurs, not only would the mission fail, but also many lives could be lost.

With a reduced crew, a major conflagration would statistically cause less loss of life because fewer personnel are actually onboard. The added crew required to combat the damage; however would not then be available to overcome a catastrophe. Due to the reduced crew, rapid, exact and overwhelming response to any damage that may occur, becomes imperative. To enable this response, technology is being applied at all levels of shipboard operations. Equipment, monitors, sensors, and fully integrated automation are all being installed to ensure that complete ship operations can continue even when damage has occurred. Firefighting and flooding control are all to be fully automated and unmanned operation is possible through use of computers and data analysis systems. The ability to monitor and respond to damage almost instantaneously and automatically is a positive advancement in the operation of naval warships.

An assumption at the beginning of this research is that electrical power would be available at all times or would at a minimum be lost and recovered in a short length of time. USS *Cole* (DDG 67) spent more than a day without electrical power, yet was able to effectively continue to contain and correct damage that had occurred from the bomb blast that she received.[1] Crewmembers were still able to dewater flooded compartments, conduct structural repair, care for injured shipmates and eventually troubleshoot and restore electrical power. The vulnerability of reliance on automated systems to replace personnel is great.

Redundancy in the generation of electrical power and distribution then becomes the primary concern and operation of the ship. This requirement in ship design then becomes more important than any other criteria that are applied in the shipbuilding process. It is the conclusion from this research that personnel are indispensable. While it seems an obvious conclusion, it must be stated so that the future designers of combatant ships will not attempt to replace personnel with systems but enhance personnel capabilities with those available systems.

The most recent example of the resiliency, innovation, and heroic actions by sailors in a major conflagration is the bombing of USS *Cole* (DDG 67) in the port of Aden, Yemen. Over three hundred sailors set sail in *Cole* on a deployment that for some would be their last. Advanced systems, sophisticated and highly developed computing power, redundant mechanical capabilities, a high state of readiness and training, and the logistical support of the most powerful nation on earth could not assure the safety and the lives of all the brave men and women who sailed in that ship. Seventeen sailors died on 12 Oct 2000, but the ship survived because there were still over three hundred more sailors, including officers and chief petty officers, able to continue to combat the catastrophic damage that was suffered by the ship that day.

The tools of technology are making it possible for the U.S. Navy to continue to sail the high seas in the protection of national borders and projection of power throughout the rest of the world as has been done for centuries. In the future environment of extensive world trade and interaction, the importance of the Navy to respond to likely threats to the sea lines of communication has not diminished.

In providing a superior force as a tool in the accomplishment of our national security strategy, the Navy must remain ready at all times to fulfill its assigned missions for the nation. As the Navy continues to change in today's technologically advancing world, it continues to seek cost effective ways of supporting its mission. The ability to provide assistance or show interest almost instantaneously, has been, and remains the unmatched capability of the U.S. Navy. In today's Navy, improving those capabilities is paramount and hinges on the use of all available technology for accomplishing this.

Ensuring the viability of high-technological weaponry and advanced automated systems requires new programs like DD21 to seek innovative solutions that will ultimately result in a stronger, more affordable twenty-first century Fleet. This new fleet will be the maintainer of United States dominance of the seas in the century to come.

Recommendations for Further Research

One recommendation for further research that is critical in future combatant ship design and operations is the application, distribution, and repair of electrical systems to support a high technologically-advanced platform such as DD21. If the ship is to rely on mechanization and automation for response to sustained or inflicted damage, electrical power is critical to its operation.

Another area of research is the exact number of personnel required to operate an automated ship and still be able to reduce the number of sailors onboard. Many more research questions need to be answered prior to implementing such a drastic reduction in crew. The ability of the reduced crew to maintain the mechanical and support systems throughout the ship is critical to determine if automation becomes more or less difficult to maintain.

This thesis did not analyze the number of personnel that is proposed to man the DD21, only to answer the question of whether or not the application of technology can satisfactorily replace personnel and enable the crew to be reduced by 70 percent, and still combat catastrophic damage such as that described in the definition of major conflagration.

Future research is required to find just how many crewmembers are necessary to maintain the ship, fight the ship, and ultimately save the ship. There a number of influences on crew manning that impact the assignment of personnel to DD21. Manpower availability, training requirements, educational requirements and the ability to repair the systems that are installed in DD21 to the point that they will continue to work even after fire, flooding, chemical, biological, and radiological effects have been sustained in the ship, all need to be researched prior to concluding that ninety-five personnel can man this modern warship.

[1]ABC News, *Primetime,* "Attack on the USS *Cole,*" 18 January 2000.

APPENDIX A

CLASSIFICATION OF FIRES IN THE U.S. NAVY

Class A (Alpha) Fires. Class A fires involve wood or wood products, cloth, textiles and fibrous materials, paper and paper products. Class A fires are extinguished with water in straight or fog pattern. If the fire is deep seated, aqueous film forming foam (AFFF) is more effective than seawater and can be used as a wetting agent to rapidly penetrate and extinguish the fire.

Class B (Bravo) Fires. Class B fires involve flammable liquids such as gasoline, diesel fuel (F-76), jet fuels, hydraulic fluid and lube oil. These fires are normally extinguished with AFFF, Halon 1211, Halon 1301 or potassium bicarbonate (PKP). Class B fires also involve flammable gases which should never be extinguished unless there is a reasonable certainty that the flow of gas can be secured. Securing the fuel source is the single most important step in controlling a gas fire.

Class C (Charlie) Fires. Class C fires are energized electrical fires that are attacked at prescribed distances using non-conductive agents such as $CO_{2,}$ Halon 1211, or water spray. The most effective tactic is to de-energize and handle the fire as a class A fire. When the fires are not deep seated, clean agents that pose no cleanup problem such as Halon 1211 or CO_2 are preferred.

Class D (Delta) Fires. Class D fires involve combustible metals such as magnesium and titanium. Water in quantity, using fog patterns, is the recommended agent. When water is applied to burning class D materials, there may be small explosions. The firefighter should apply water from a safe distance or from behind shelter. Metal fires on board ship are commonly associated with aircraft wheel structures.

Source: NSTM 555, Vol. 1, revision 7, 1-15.

APPENDIX B

CONDITIONS OF READINESS

<table>
<tr><td>Combat Systems Department</td><td>Navigation/ Admin Department</td><td>Operations/ Deck Department</td><td>Engineering Department</td><td>Supply Department</td></tr>
<tr><td colspan="5">Condition I: General Quarters (Battle Stations)
Ship is fully combat capable. 100% of crew outfitted for war.</td></tr>
<tr><td colspan="5">Condition II: Specific threat or Mission. (AW, USW, SUW, EW)
One half weapons are operationally capable. One half of crew outfitted for war and manning those ready weapons.</td></tr>
<tr><td colspan="5">Condition III: Wartime Steaming (Non specific threat environment. Ship is able to respond in self-defense.)
One half or one third of weapons operationally capable. One third of the crew outfitted for war and manning those ready weapons.</td></tr>
<tr><td colspan="5">Condition IV: Peacetime Steaming (ISE)
Ship is in self-defense posture only. One third or less of the crew is on watch.</td></tr>
<tr><td colspan="5">Condition V: Ship is inport in its homeport. The crew is on a rotation that allows for the maximum number of personnel to be off the ship, depending on the ship’s schedule, and activities and the Commanding Officer’s requirements for crewmembers to be onboard.</td></tr>
</table>

Source: OPNAVINST 3120.32C, *SORM*. 430.2.

APPENDIX C

MINIMUM REPAIR PARTY FUNCTIONAL COMPOSITION

Function	Number of Personnel Required	Condition When Required	Notes
Repair Party Leader	1	All	
Scene Leader	1	All	
Plotter	1	All	
S/P Phone Talker	1	All	
Messenger	1	All	
Investigator(1)	2	All	
Electrician	1	All	
Team Leader(2)	1	Fire	(1) The Investigator will have a thorough knowledge of the Repair Locker's area of responsibility and be qualified in the use of Naval Firefighter's Thermal Imager (NFTI).
Nozzleman	2	Fire	
Hoseman	4	Fire	
Plugman	2	Fire	
Smoke Control/Removal	2	Fire	
Boundaryman	4	Fire	
Accessman	1	Fire/Flooding	
Overhaulman	1	Fire	
Post Fire Test Assistant	1	Fire	(2) The Team Leader will be the next most qualified individual to the scene leader and will be cpapble of assuming the scene leaders' responsibilities for fire fighting, flooding and CBR defense.
Reflash Watch	1	Fire	
Dewatering	2	Flooding	
Shoring	4	Flooding	
Pipe Patching	2	Flooding	
Hull Patching/Plugging	2	Flooding	
Sounding	As Needed	Flooding	
Stretcher Bearers/First Aid	4	Personnel Casualty	
Radiological Plotter	1	CBR Defense	
Internal Monitor	1	CBR Defense	
External Monitor	1	CBR Defense	
Recorder	1	CBR Defense	
Messenger	1	CBR Defense	
Hoseman	2	CBR Defense	
Scrubber	1	CBR Defense	
Decon Station Operators/Cutters	2	CBR Defense	
CP-95 Operator	1	CBR Defense	
Monitor (Traffic Control)	1	CBR Defense	
Medical Representative	1	CBR Defense	
Group CMWD Operator	1	CBR Defense	
Closure Detail	By Area	Immediately GQ/Battle Stations	
Space Isolation Detail	As Needed	When Ordered	
Magazine Sprinkler Operator	1	Fire	
TOTAL	55	All	

Source: NWP 3-20.31. 2-17.

APPENDIX D

MINIMUM FIRE PARTY FUNCTIONS

Number of Personnel	Function
1	Repair Party Leader[1]
1	Fire Marshall[2]
1	Scene Leader
1	Team Leader "Attack Team"[3]
2	Nozzleman "Attack Team"
4	Hoseman "Attack Team"[4]
2	Plugman
2	Investigator
4	Boundaryman[8]
2	Messenger/Phone Talker
1	Electrician
1	NFTI Operator[5*]
1	Access*
1	Reflashwatch*
1	Overhaul*
2	Smoke Control*
1	Post Fire Test Assistant*
2	Dewatering*
As Assigned	First Aid[6*]
4	Rapid Response[7*]

(1) Repair locker leader function is required only during Condition I.
(2) Fire Marshall function is required inport and at sea during non-Condition I.
(3) The team leader is required when the hose team requires use of the Naval Firefighter's Thermal Imager (NFTI). If the scene leader determines the NFTI is not required, the number 1 nozzleman may assume team leader responsibilities.
(4) Number of hosemen required is based on minimum manning for two 1-½ inch hoses. More hosemen may be required based on compartment layout, length of hose run and size of hose employed.
(5) NFTI operator functions may be combined with other functions. At a minimum personnel assigned the function of scene leader, team leader, investigators, electrician, boundarymen and overhaulman shall be trained in its use.
(6) All personnel assigned shall be trained in performing basic first aid and burn treatment and at least one person should be trained in CPR.
(7) The rapid response team is required inport and at sea during non-Condition I. The team shall be led by the fire marshal. Several of the assigned boundarymen and the electrician may be used to comprise the remainder of the team.
(8) It is recognized that 4 boundarymen may not be sufficient to set fire boundaries. Additional personnel may be obtained from other sources, i.e., inport duty section, other repair lockers, non-critical watch stations etc.
(9) The Scene Leader will make the decision to employ one or more hoses in the attack of the fire.

*Denotes functions which may be performed by personnel assigned other functions.

Source: NWP 3-20.31. 9-2.

APPENDIX E

REPAIR ORGANIZATION CHART (NOTIONAL)

Scene Leader	**Attack Team Leader**	Plotter
#1 Investigator	#1Tender	Telephone Talker*
#2 Investigator	#2Tender	CKT#

Attack Team	#1	#2	**CMWD SYSTEM**
	Nozzleman	Nozzleman	VLV#
	Hoseman	Hoseman	VLV#
	Hoseman	Hoseman	VLV#
	Hoseman	Hoseman	
	Hoseman	Hoseman	
	Hoseman	Hoseman	
	Plugman	Hoseman	

Access/Emergency Cutter
CO_2/PKP
AFFF/In Line Eductor Operator
Smoke Control (X2)
Messenger
Electrician
Post Fire Atmospheric Test Operator
AFFF Station Operator
Magazine Sprinkler Operator

CBR-D TEAM

INTERNAL SURVEY TEAM
M256/ANPDR 43 (X2)
Messenger (X2)

EXTERNAL SURVEY TEAM
Monitor (X2)
Recorder/Marker (X2)
Messenger (X2)

PIPE PATCH TEAM	**PLUGGING TEAM**	**DECON TEAM**
In Charge	In Charge	In Charge
Kit	Kit	Scrubber (X2)
Kit	Kit	Nozzleman
		Hoseman (X5)

SHORING TEAM	**DEWATERING TEAM**	**CCA (CHEM ONLY)**
In Charge	In Charge	In Charge
Kit	Pump	Cutter
Kit	Pump	
Shoring	Hose/Fuel	

Source: COMANSURFLANTINST 3541.1C/COMNAVSURFPACINST 3541.4B *Standard Repair Party Manual for Naval Surface Force.*

APPENDIX F

WEAPONS EFFECTS

Threat	Blast	Frag/ Debris	Fire	Shock	Flood	Whipping	Penetration
Air Delivered ASCM	P	P	S	S	S	N	P
Bombs/ Projectiles	P	P	S	P	S	N	P
U/W-Delivered Torpedoes	P	S	S	P	P	P	N
Mines	P	S	S	P	P	P	N

*P = Primary S= Secondary N= Negligible/None

* These designations are the effects of damage by various weapons and the ensuing damage in order of imposition. They would also indicate the priority of damage control efforts.

DEFINITION OF TERMS

BLAST Overpressure from warhead detonation that results in ripping of internal compartment bulkheads, shell plating, and personnel injury. Watertight subdivision bulkheads provide significant protection. Other internal bulkheads provide some protection, depending on charge size. Expected effects include flying debris, equipment destruction and misalignment, and loss of affected compartment.

FRAG/ DEBRIS High-velocity fragments of metal that can rip through unarmored superstructures and cables, causing equipment damage and personnel injury.

FIRE Fires that are ignited from explosive reactions and/or burning of unexpected propellant.

SHOCK Damage to equipment from the rapid acceleration of the ship in an upward or horizontal direction. Unhardened equipment may malfunction, short out, or come adrift. Electrical power may be interrupted and false alarms may occur. Effects are generally more severe from underwater detonations in lower regions of the ship. Personnel injury may occur to personnel not properly braced and from loose gear that may come adrift.

WHIPPING Loss of hull strength that can lead to loss of watertight integrity in moderate sea states.

PENETRATION Shaped charge jets or semi-armor piercing warheads that penetrate deep into a ship, causing major internal damage or magazine detonation.

FLOODING Loss of watertight integrity because of holes in the hull and rupture or failure of hull penetration or piping.

Source: NWP 3-20.31, 10-3.

APPENDIX G

INDIVIDUAL REPORTING CRITERIA

1. Type and location of fire(s) and when extinguished.
2. Presence of dense smoke and when cleared.
3. Location, rate, depth and cause of flooding and when controlled.
4. Type and location of weakened structure and when shoring is completed.
5. Any electrical power loss to equipment, and rigging and energizing of casualty power.
6. Any ruptured piping that may affect vital systems or cause flooding.
7. Any personnel casualty that will affect the performance of a battle situation.
8. Any damage that affects watertight integrity.
9. Location and intensity of hot spots (radiological contamination) and when decontaminated

Source: NWP 3-20.31, 2-11.

APPENDIX H

REPAIR PARTY/REPAIR LOCKER GENERAL FUNCTIONS

Repair Party Functions

1. Making repairs to electrical and sound powered telephone circuits.
2. Administering first aid and transporting injured personnel to battle dressing stations without seriously reducing the DC capabilities of the repair party.
3. Detecting, identifying, measuring dose and dose-rate intensities from radiological involvement, and survey and decontamination of contaminated personnel and areas (except where specifically assigned to another department as in the case of nuclear weapons accident/incident).
4. Detecting and identifying chemical agents and decontaminating areas and personnel affected as a result of biological or chemical attack.
5. Controlling and extinguishing all types of fire.
6. Evaluating and correctly reporting the extent of damage in the area. This will include maintaining:
    a. Deck plans showing locations of CBR contamination, location of battle dressings and personnel cleansing stations, and safe routes to them.
    b. Graphic display board showing damage, and action taken to correct disrupted or damaged systems. Standard DC symbology and plotting techniques shall be used.
7. Familiarity with assigned area and related DC systems and equipment. Provision must be made for all repair parties to gain access to all spaces within the respective zones for drill and for familiarization with the spaces.[1]

Repair Locker Specific Functions

1. Maintenance of stability and buoyancy. Repair parties must be:
    a. Stationed to reach all parts of the ship with minimum opening of watertight closures.
    b. Able to repair damage to structures, closures, or fittings that are designed to maintain watertight integrity, by shoring, plugging, welding, caulking that bulkheads and decks, resetting valves, and blanking or plugging lines through watertight subdivisions of the ship.
    c. Prepared to sound, drain, pump, counterflood, or shift liquid in tanks, voids, or other compartments, and be thoroughly familiar with the location and use of all equipment and methods of action.
2. Maintenance of ship's structural integrity and maneuverability. Repair parties must be able to:
    a. Make repairs to primary and auxiliary methods of steering.

b. Clear the upper decks of wreckage that interferes with operation of the battery, ship, or fire control stations or that fouls the rudder, propellers, or sides of the ship, and be ready to extinguish all types of fires.
c. Maintain and make emergency repairs to battle service systems, such as ammunition supply, ventilation supply, high- and low-pressure air lines, internal communications systems, electrical systems, and cooling water systems.
d. Provide emergency power to electrical equipment using casualty power cables.
e. Assist that crash and salvage team as required.
f. Stream and recover minesweeping equipment during GQ.
g. Rescue survivors from the water and render assistance to other ships.
h. Repair above water damage that could cause flooding in the event of further damage.

3. Maintenance of ship's propulsion is the responsibility of Repair 5, which must be able to:
    a. Maintain, make repairs, or isolate damage to main propulsion machinery and boilers.
    b. Operate, repair, isolate, and modify the segregation of vital systems.
    c. Assist in the operation and repair of the steering control systems.
    d. Assist in the maintenance and repair of internal communications systems.
    e. Assist Repairs 1, 2, 3 and 4 and the crash and salvage team when required.
    f. Relieve ship's propulsion personnel in the event of casualties.
    g. Assist in CBR recovery operations.
    h. Maintain an engineering casualty control status board showing the condition of readiness of main propulsion and principal auxiliary machinery. This shall permit graphic display of engineering casualties and other pertinent information, if required, by TYCOMs.[2]

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[1]NWP 3-20.31, 2-15.

[2]Ibid. 2-16.

APPENDIX I

DAMAGE CONTROL CENTRAL FUNCTIONS

1. Receiving and evaluating information from all repair parties.
2. Inform command of conditions affecting the material condition of the ship, including buoyancy, list, trim, stability, and watertight integrity.
3. Initiate orders to repair parties, as necessary, to direct control of damage.
4. Report items of damage to the commanding officer.
5. Report DC measures that require command approval:
    a. Ballasting, deballasting.
    b. Counterflooding
    c. Material condition
    d. Establishing MPE (Maximum Personnel Exposure)
    e. Establishing command dosage
    f. Unusual loading conditions of the ship
    g. Jettisoning
    h. Activation/deactivation of water washdown system
    i. Maneuver to avoid CBR contamination
    j. Sending CBR monitors out
    k. Flooding magazines
6. Control watertight integrity, flooding, counterflooding, and dewatering.
7. Maintain the following material:
    a. Charts and diagrams posted and suitably labeled to show subdivisions of the ship and its systems
    b. An up-to-date casualty board showing the damage sustained and corrective action(s) in progress
    c. A stability board showing liquid loading, the location of flooding boundaries, effects on list and trim caused by flooded compartments and corrective action(s) taken with regard to stability. A liquid loading and flooding effects diagram may best be used for this purpose.
    d. List of preplanned routes for ready and deep shelter, combat system casualty control, battle dressing and battle logistics
    e. Graphic displays showing action taken to correct disrupted or damaged systems
    f. Deck plans to indicate areas contaminated by CBR agents, locations of battle dressing stations, decontamination stations and safe routes to them
    g. A closure log showing the state of closure of the ship
    h. Reference publications listed in NSTM, Chapter 079, Volume 2
    i. CBR contamination prediction plot.
8. Provide for maintenance on the bridge of a simplified schematic on DCC-reported casualty data, for visual reference by command. (To facilitate this, DC plates 2 and 3, covering ship's schematic and all decks, as necessary.)

9. Make provisions for an alternate DCC. This station may be one of the repair party stations, engineering control or secondary engineering control. The station designated must have the capability to communicate with repair parties, engineering control, and the bridge

In addition to these tasks specific information is recommended for reporting that assists command and control stations to better conduct combat.

Source: NWP 3-20.31, 2-11, 2-13.

APPENDIX J

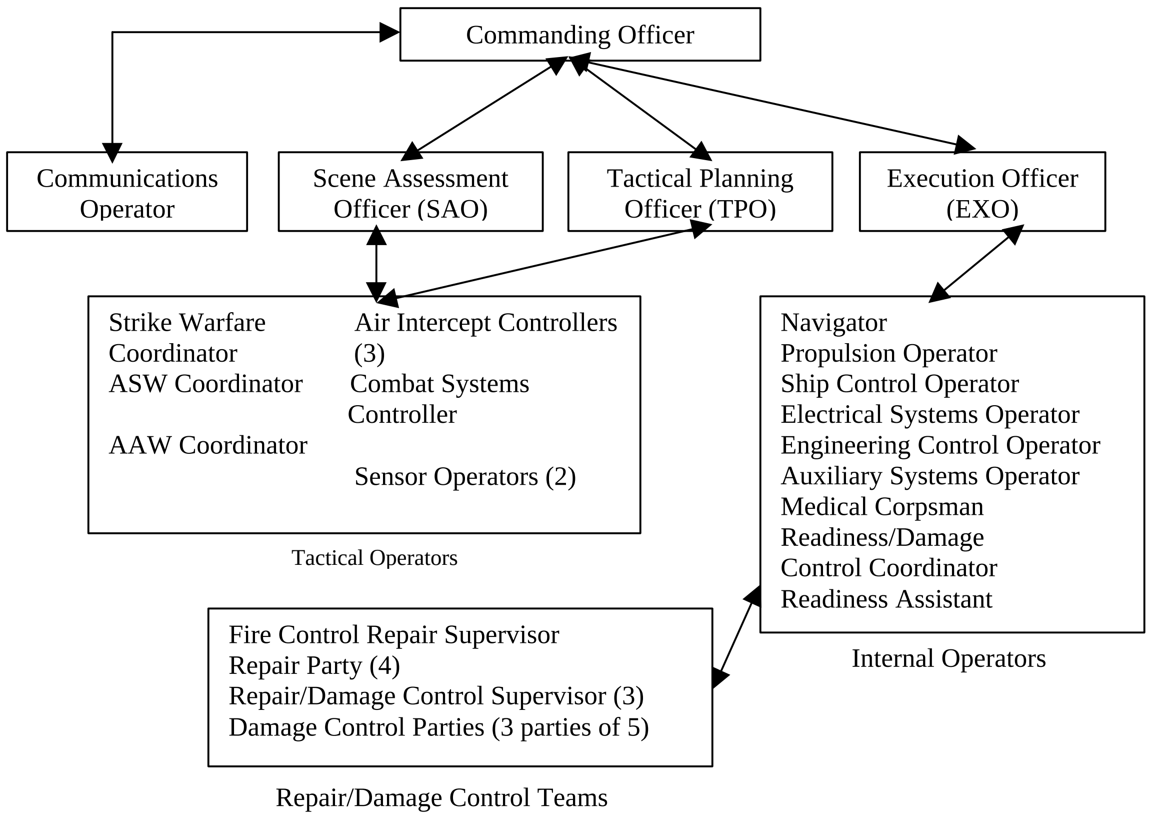
CHECKLIST FOR SHIPBOARD FIRES SAMPLE

____Fire/Smoke Reported Compartment ______________________
____Rapid Response Team________ (Comms)________ Ckt______
____Check Firemain Pressure (P250/100 reqd)
____Repair Locker Manned/Ready (Comms)__________ Ckt______
____Z Set Time ___________
____Investigators Out (NFTI)
____Order Fire Boundaries (6 Sides, Topside critical)
____Order Smoke Boundaries (Smoke curtains, blankets)
____Order Electrical Isolation
____Order Mechanical Isolation (Flammable liquid piping)
Secure recirc vents (compressed air systems)
Secure fuel transfer (heat sources)
____Space Evacuated/Casualties _____________________
____DCC/CDO notified
____Command's Mission Affected
____Space Hazards (Check NB 4-3 RPL Notebook)
____Class of Fire A________ B__________ C __________
(Fuel source) (Secure Elec Pwr)
____Installed F/F System Activated
____FFE Required?
____Status of ventilation
____Status of flammable/explosive spaces near casualty
(Check DC plates Color Code IAW NWP 3-20.31)
(Magazines/Fuel Tanks/CO_2/Halon Flooding/Battery Lockers/Storerooms)
____Off Ships Assets Reqd/Backup Fire Party Location____________
____Inv Rpt at Least Every 15 Min Time________
____Fire_______ Smoke Boundaries Set
____Status of Mechanical_______Electrical_________Isolation
____OBA Activation Time__________
____Enter Space – Direct or Indirect Method
____Forcible Entry Reqd – PECU/PHARS
____Status of Dewatering Space (FFW Affecting Stability Space High or Low in Ship)
____Fire Under Control (Contained)
____Status of OBAmen—Coordinate Relief_____________(Location)
____Fire Out
____Major Fire-Vital System Restoration-Coordinate with EOOW Using Master Lite-Off Check Off Sheet
____Reflash watch Set_______________ (Name)
____Overhaul______Complete Dewatering
____Desmoke w/CHENG's Permission (Ensure Clear of Ship)
____Oxygen Test
____Explosive Test
____Toxic Test ____CO _____CO2 ___NO2 (Check NB 4-3 Space Hazards IAW NWP 3.20-31 FIG 7-4)
____Reman Post Fire Damage Report

Source: COMANSURFLANT 3541.1C/COMNAVSURFPACINST 3541.4B *Standard Repair Party Manual for Naval Surface Force.* NB 1-2.

APPENDIX K

CONCEPTUAL CONDITION I WATCH ORGANIZATION FOR CONSOLIDATED OPERATIONS (CONOPS) IN THE SSA



Source: John P. Jackson and Wade Taylor, *Ship Systems Automation Concept of Operations (SSA CONOPS), Revision 4.*

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