



# NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

---

## MBA PROFESSIONAL REPORT

---

**DDG 1000 vs. DDG 51:  
An Analysis of U.S. Navy  
Destroyer Procurement**

---

**By: James C. Hagerty,  
Pauleen D. Stevens, and  
Bryan T. Wolfe  
December 2008**

**Advisors: Ira A. Lewis,  
William D. Hatch**

*Approved for public release; distribution is unlimited.*

THIS PAGE INTENTIONALLY LEFT BLANK

<b>REPORT DOCUMENTATION PAGE</b>			<i>Form Approved OMB No. 0704-0188</i>
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington DC 20503.			
<b>1. AGENCY USE ONLY (Leave blank)</b>	<b>2. REPORT DATE</b> December 2008	<b>3. REPORT TYPE AND DATES COVERED</b> MBA Professional Report	
<b>4. TITLE AND SUBTITLE:</b> DDG 1000 vs. DDG 51: An Analysis of U.S. Navy Destroyer Procurement		<b>5. FUNDING NUMBERS</b>	
<b>6. AUTHOR(S)</b> James Hagerty, Pauleen Stevens, Bryan Wolfe		<b>8. PERFORMING ORGANIZATION REPORT NUMBER</b>	
<b>7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)</b> Naval Postgraduate School Monterey, CA 93943-5000		<b>10. SPONSORING / MONITORING AGENCY REPORT NUMBER</b>	
<b>9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)</b> N/A		<b>10. SPONSORING / MONITORING AGENCY REPORT NUMBER</b>	
<b>11. SUPPLEMENTARY NOTES</b> The views expressed in this report are those of the author(s) and do not reflect the official policy or position of the Department of Defense or the U.S. Government.			
<b>12a. DISTRIBUTION / AVAILABILITY STATEMENT</b> Approved for public release; distribution is unlimited		<b>12b. DISTRIBUTION CODE</b>	
<b>13. ABSTRACT (maximum 200 words)</b> The research presented is a comparative analysis of DDG 51 and DDG 1000 Destroyer programs in terms of acquisition strategy, cost structure and capability. The DDG 51 is arguably the most successful surface ship program in modern U.S. Navy history with sixty-two ships purchased between FY 1985 to FY 2005. DDG 51's success can be attributed to excellence in multiple warfare areas, predictable cost structure and the use proven technologies that were incrementally upgraded. The DDG 1000 has been in development since the mid 1990s and has been the subject of harsh criticism due to cost overruns and the slow maturation of critical technologies. Recently, despite years of support from Navy shipbuilding officials, the Chief of Naval Operations requested that the DDG 1000 program be truncated to two ships in order to clear the way for the purchase of eight additional DDG 51s between FY 2010 and FY 2015. The Navy based its reasoning primarily on emerging threats that the DDG 1000 was not able to deter. The research supports the Navy's recommendation to truncate the DDG 1000 program at two ships and reopen DDG 51 production lines. The DDG 51's versatility and established cost structure brings the Navy closer to its goal of 313 ships while ensuring the ability to counter emerging threats. The DDG 1000, despite its impressive new technologies, simply did not add enough capability to warrant its excessive cost growth. The DDG 1000 program, however, was not a waste of time or money. The DDG 1000 will provide the Navy with increased capability in the littorals and serve as a technological test platform that will bridge the gap to future classes of surface ships.			
<b>14. SUBJECT TERMS</b> Arleigh Burke, DDG 51, DDG 1000, Destroyer			<b>15. NUMBER OF PAGES</b> 55
			<b>16. PRICE CODE</b>
<b>17. SECURITY CLASSIFICATION OF REPORT</b> Unclassified	<b>18. SECURITY CLASSIFICATION OF THIS PAGE</b> Unclassified	<b>19. SECURITY CLASSIFICATION OF ABSTRACT</b> Unclassified	<b>20. LIMITATION OF ABSTRACT</b> UU

THIS PAGE INTENTIONALLY LEFT BLANK

**Approved for public release; distribution is unlimited**

**DDG 1000 VS. DDG 51:  
AN ANALYSIS OF U.S. NAVY  
DESTROYER PROCUREMENT**

James Hagerty, Lieutenant, United States Navy  
Pauleen Stevens, Captain, United States Marine Corps  
Bryan Wolfe, Lieutenant, United States Navy

Submitted in partial fulfillment of the requirements for the degree of

**MASTER OF BUSINESS ADMINISTRATION**

from the

**NAVAL POSTGRADUATE SCHOOL  
December 2008**

Authors:

\_\_\_\_\_  
James Hagerty

\_\_\_\_\_  
Pauleen Stevens

\_\_\_\_\_  
Bryan Wolfe

Approved by:

\_\_\_\_\_  
Ira Lewis, Lead Advisor

\_\_\_\_\_  
William Hatch, Support Advisor

\_\_\_\_\_  
Terry Rea, CAPT USN, Acting Dean  
Graduate School of Business and Public Policy

THIS PAGE INTENTIONALLY LEFT BLANK

# **DDG 1000 VS. DDG 51: AN ANALYSIS OF U.S. NAVY DESTROYER PROCUREMENT**

## **ABSTRACT**

The research presented is a comparative analysis of DDG 51 and DDG 1000 Destroyer programs in terms of acquisition strategy, cost structure and capability. The DDG 51 is arguably the most successful surface ship program in modern U.S. Navy history with sixty-two ships purchased between FY 1985 to FY 2005. DDG 51's success can be attributed to excellence in multiple warfare areas, predictable cost structure and the use proven technologies that were incrementally upgraded. The DDG 1000 has been in development since the mid 1990s and has been the subject of harsh criticism due to cost overruns and the slow maturation of critical technologies.

Recently, despite years of support from Navy shipbuilding officials, the Chief of Naval Operations requested that the DDG 1000 program be truncated to two ships in order to clear the way for the purchase of eight additional DDG 51s between FY 2010 and FY 2015. The Navy based its reasoning primarily on emerging threats that the DDG 1000 was not able to deter.

The research supports the Navy's recommendation to truncate the DDG 1000 program at two ships and reopen DDG 51 production lines. The DDG 51's versatility and established cost structure brings the Navy closer to its goal of 313 ships while ensuring the ability to counter emerging threats. The DDG 1000, despite its impressive new technologies, simply did not add enough capability to warrant its excessive cost growth. The DDG 1000 program, however, was not a waste of time or money. The DDG 1000 will provide the Navy with increased capability in the littorals and serve as a technological test platform that will bridge the gap to future classes of surface ships.

THIS PAGE INTENTIONALLY LEFT BLANK

# TABLE OF CONTENTS

<b>I.</b>	<b>INTRODUCTION.....</b>	<b>1</b>
<b>A.</b>	<b>EVOLVING ROLE OF THE MODERN SURFACE COMBATANT .....</b>	<b>1</b>
<b>B.</b>	<b>U.S. NAVY SURFACE COMBATANTS TODAY .....</b>	<b>2</b>
<b>C.</b>	<b>DDG 1000 VS DDG 51 – WHERE WE STAND TODAY.....</b>	<b>2</b>
<b>II.</b>	<b>EVOLUTION OF THE DDG 51 .....</b>	<b>5</b>
<b>A.</b>	<b>DDG 51 CONCEPT DEVELOPMENT.....</b>	<b>5</b>
<b>B.</b>	<b>LOW TECHNOLOGICAL RISK – USE OF PROVEN TECHNOLOGIES.....</b>	<b>6</b>
<b>C.</b>	<b>INCREMENTAL IMPROVEMENTS – THREE DISTINCT FLIGHTS.....</b>	<b>7</b>
<b>D.</b>	<b>PREDICTABLE COST STRUCTURE .....</b>	<b>8</b>
<b>III.</b>	<b>EVOLUTION OF THE DDG 1000 CONCEPT.....</b>	<b>13</b>
<b>A.</b>	<b>DD 21 CONCEPT .....</b>	<b>13</b>
<b>B.</b>	<b>DD(X) AND THE RUMSFELD PENTAGON .....</b>	<b>14</b>
<b>C.</b>	<b>DDG 1000: THE ZUMWALT PROGRAM TAKES SHAPE .....</b>	<b>16</b>
<b>D.</b>	<b>DDG 1000 MISSION AND CAPABILITIES.....</b>	<b>17</b>
<b>IV.</b>	<b>DDG 1000 ACQUISITION RISKS AND INCREASED CONGRESSIONAL SCRUTINY.....</b>	<b>21</b>
<b>A.</b>	<b>SIGNIFICANT TECHNOLOGICAL RISK.....</b>	<b>21</b>
<b>B.</b>	<b>SIGNIFICANT RISK OF COST GROWTH: CONGRESS QUESTIONS THE NAVY’S ABILITY TO ESTIMATE COST .....</b>	<b>22</b>
<b>C.</b>	<b>DDG 1000 PROGRAM IS THREATENED.....</b>	<b>23</b>
<b>D.</b>	<b>THE NAVY CHANGES ITS POSITION – CITES NEW THREAT ASSESSMENT .....</b>	<b>25</b>
<b>E.</b>	<b>DDG 1000 TODAY .....</b>	<b>27</b>
<b>V.</b>	<b>DDG 1000 VS. DDG 51. A SIDE-BY SIDE COMPARISON .....</b>	<b>29</b>
<b>A.</b>	<b>CAPABILITY .....</b>	<b>29</b>
<b>B.</b>	<b>COMPARATIVE COSTS.....</b>	<b>32</b>
<b>VI.</b>	<b>CONCLUSIONS .....</b>	<b>35</b>
	<b>LIST OF REFERENCES.....</b>	<b>37</b>
	<b>INITIAL DISTRIBUTION LIST .....</b>	<b>39</b>

THIS PAGE INTENTIONALLY LEFT BLANK

## LIST OF TABLES

Table 1.	DDG 51-Class Flights.....	7
Table 2.	DDG 51-Class Shipbuilding Costs per Unit (from RAND) .....	8
Table 3.	DDG 51-Class Shipbuilding Costs per Unit (FY 1998-2004 President's Budget).....	9
Table 4.	Congressional Budget Office 2007 cost estimates for the fifth ship of the DD 21/DD(X) Program.....	16
Table 5.	Proposed DDG 1000 Program Funding, FY2002-FY2013 (Millions of then year dollars, rounded to the nearest million – based on Navy data provided to the CRS on July 7, 2007 and May 8, 2008).....	17
Table 6.	Life Cycle Cost Comparison of the DDG 51 and DDG 1000 Destroyer.....	33
Table 7.	Operating and Maintenance Cost Comparison of the DDG 51 and DDG 1000 Destroyer (All numbers in billions of 2007 dollars).....	34

THIS PAGE INTENTIONALLY LEFT BLANK

## **LIST OF ABBREVIATIONS AND ACRONYMS**

AAW (Anti-Air Warfare)  
AFSS (Automatic Fire Suppression System)  
AGS (Advanced Gun System)  
ASCM (Anti-Ship Cruise Missile)  
ASROC (Anti-Submarine Rocket)  
ASW (Anti-Submarine Warfare)  
ASuW (Anti-Surface Warfare)

BIW (Bath Iron Works – General Dynamics subsidiary)  
BMD (Ballistic Missile Defense)

CBO (Congressional Budget Office)  
CBRN (Chemical, Biological, Radiological and Nuclear Defense)  
CEC (Cooperative Engagement Capability)  
CNO (Chief of Naval Operations)  
CPIF (Cost Plus Incentive Fee)  
CSSQT (Combat Systems Ship Qualification Trial)

DBR (Dual Band Radar)  
DoD (Department of Defense)

FY (Fiscal Year)

GAO (Government Accountability Office)

HAS (House Armed Services)

IPS (Integrated Power System)  
IUWS (Integrated Undersea Warfare Suite)

JTIDS (Joint Tactical Information Distribution System)

LAMPS (Light Airborne Multi-Purpose System)  
LCS (Littoral Combat Ship)  
LRLAP (Long-Range Land Attack Projectile)

MPN (Manpower Personnel Navy Account)  
MW (Megawatts)

NAVSEA (Naval Sea Systems Command)  
NGSB (Northrop Grumman Ship Building)  
NSFS (Naval Surface Fire Support)

O&M (Operations and Maintenance)

PRO (Profit Related to Offer)

R&D (Research and Development)

SCN (Ship Construction Account)

SSES (Shipboard Signal Exploitation Space)

TACTASS (Tactical Towed Array Sonar System)

TLAM (Tactical Land Attack Missile)

TSCE (Total Ship Computing Environment)

UAV (Unmanned Aerial Vehicle)

VLS (Vertical Launch System)

## **ACKNOWLEDGEMENTS**

We would personally like to thank Professor Ira Lewis and CDR (Ret) William Hatch for their continuous guidance and vast knowledge of U.S. Navy shipbuilding programs. Without their direction, our final product would not have been as thorough or comprehensive.

We would also like to thank RADM (Ret) James Greene for providing us with research material and the necessary acquisition background that led to the success of this project.

THIS PAGE INTENTIONALLY LEFT BLANK

## I. INTRODUCTION

### A. EVOLVING ROLE OF THE MODERN SURFACE COMBATANT

The roles and identities of surface combatants changed dramatically following World War II. As the battleship era ended and the aircraft carrier took its place as the primary maritime power projection platform, there were essentially three types of surface combatants remaining in the U.S. Navy – Cruisers, Destroyers and Frigates. Cruisers were essentially light battleships equipped with medium sized guns ranging from six to ten inches. Destroyers were smaller escort ships equipped with five-inch, anti-aircraft guns and an assortment of anti-submarine warfare (ASW) weapons including torpedoes and depth charges. Frigates were even smaller than Destroyers, also used primarily for escort duty. Cruisers and Destroyers had two primary missions – ASW and anti-air warfare (AAW). Some classes only focused on one mission. Secondary missions included anti-surface warfare (ASuW) and naval surface fire support (NSFS) for amphibious operations.<sup>1</sup>

The emergence of the cruise missiles in the 1970s blurred the distinction between Cruisers and Destroyers. Guns became less relevant on these vessels and missiles became the primary weapon. Three major systems developed by the U.S. Navy in the 1980s significantly changed the modern surface force – the Tomahawk cruise missile, the vertical launch system (VLS) and the Aegis Combat System. The Tomahawk cruise missile gave surface combatants the capability to deliver a 1,000-pound warhead with precision accuracy at distances greater than 1,000 miles. The VLS allowed surface ships to carry a variety of offensive and defensive missiles, and launch them with unprecedented rates of fire. The Aegis Weapon System – an integrated combat system centered on the AN/SPY-1 phased-array radar – gave ships the ability to track multiple targets at 250 nautical miles and engage them simultaneously at distances up to 80

---

<sup>1</sup> R. O'Rourke, "Navy DD(X) and LCS Ship Acquisition Programs: Oversight Issues and Options for Congress," (2004), Congressional Research Service: The Library of Congress, 3.

nautical miles. The modern surface vessel evolved from the escort ships of WWII into modern, technology-filled ships with the ability to pack an offensive punch.<sup>2</sup>

## **B. U.S. NAVY SURFACE COMBATANTS TODAY**

Today, the U.S. Navy has two main operational classes of guided missile surface combatants:

- CG 47 class Cruiser (Ticonderoga Class)
- DDG 51 Destroyer (Arleigh Burke Class)

The CG 47 Cruiser is 567 feet long and displaces roughly 9,700 tons. It is equipped with the Aegis combat system and VLS capable of firing Tomahawk cruise missiles, SM2 surface-air-missiles, and antisubmarine rockets (ASROC). The U.S. Navy purchased 27 of these ships from fiscal year FY 1978 to FY 1988. The five ships that do not have VLS or Tomahawk capabilities have been decommissioned. The Navy plans to modernize the remaining 22 ships and keep them in service until 2025.<sup>3</sup>

The DDG 51 Destroyers are 505 feet long and displace roughly 9,500 tons. All versions are equipped with the Aegis Combat System and VLS similar to the CG 47 class ships. DDG 51 class hulls 51 to 78 are considered Flight I and Flight II ships. Hulls 79 and above are considered Flight IIA ships with the primary distinction being a fully functioning hangar for Light Airborne Multi-purpose System (LAMPS) III aircraft. The U.S. Navy currently has firm plans to produce 62 of these ships and is currently requesting to procure an additional eight. Proven and versatile, the DDG 51 destroyers are the backbone of the modern surface fleet.<sup>4</sup>

## **C. DDG 1000 VS DDG 51 – WHERE WE STAND TODAY**

On July 31, 2008, VADM Barry McCullough, Deputy CNO for Integration of Capabilities and Resources (N8), and Ms. Allison Stiller, Deputy Assistant Secretary of

---

<sup>2</sup> R. O'Rourke (2004), 3.

<sup>3</sup> Ibid., 5.

<sup>4</sup> Ibid.

the Navy (Ship Programs), testified before the House Armed Service Seapower Subcommittee. In their testimony, the Navy stated its desire to truncate the DDG 1000 destroyer program at two ships and instead continue to procure DDG 51 destroyers.<sup>5</sup> The DDG 1000 program, which began in the early 1990s, was primarily a land attack destroyer that focused on projecting combat power ashore from the shallow littoral regions of the ocean. In contrast, the older DDG 51 focused more on traditional, open ocean combat power.

In their testimony, the Navy cited new threats such as ballistic missiles, cruise missiles and submarines and stated that the DDG 51 was more capable of defeating those threats.<sup>6</sup> This was a dramatic shift in position. For years the Navy strongly supported the DDG 1000 program despite large cost overruns. They emphasized the DDG 1000's projected smaller crew size, lower fuel costs and significantly improved capability in the littorals. Now, the Navy stated that the DDG 51, a vessel designed in the 1970s and procured throughout the 80s and 90s was better suited for emerging threats.

The Navy's shift in position was influenced by more than these new threat assessments. The DDG 51 is a proven and versatile ship with a predictable cost structure. The DDG 1000 program has significant capability upgrades, but also has the risk of significant cost growth due to maturing technologies. In addition, in an era that might see shrinking defense budgets, the DDG 51 will give the Navy a clearer path to its long term goal of 313 ships. This research will analyze these two destroyer programs and compare their acquisition strategies, cost structures and capabilities. The research will also show how the Navy's shift in procurement strategy affects the future of the surface force.

---

<sup>5</sup> R. O'Rourke (2004), 31.

<sup>6</sup> VADM McCullough testimony before House Armed Services (HAS) Seapower Subcommittee (July 31, 2008).

THIS PAGE INTENTIONALLY LEFT BLANK

## II. EVOLUTION OF THE DDG 51

### A. DDG 51 CONCEPT DEVELOPMENT

The DDG 51 was named after the United States Navy's most famous destroyer squadron commander and three-time Chief of Naval Operations – Admiral Arleigh Burke. The first ship of the class was procured in FY 1985 and was commissioned July 4, 1991. The objective of the DDG 51 program was to develop a surface combatant to replace older Destroyers and Cruisers that were projected to retire in the 1990s. The DDG 51 was designed to be a cheaper and simpler version of the CG 47 Cruiser. Its original mission was to complement the CG 47 in blue water defense of Aircraft Carrier Battle groups and to conduct AAW and ASW operations against Soviet threats.<sup>7</sup>

From FY 1985 to FY 2005, the Navy purchased 62 DDG 51s making it arguably the most successful acquisition of surface combatants in modern US Navy history.<sup>8</sup> There are several reasons why the DDG 51 program has been so successful. One, the DDG 51 is an incredibly versatile platform. It excels in every area of Naval Warfare including AAW, ASW, ASuW, precision strike and NSFS. Two, the DDG 51 design consisted mainly of incremental design improvements from the CG 47. It was built with mostly proven technologies, and the newer technologies had manageable risk. Three, the DDG 51s were incrementally upgraded as subsequent vessels in the class were built. The upgrades took the form of three distinct flights and eight different combat systems baselines.<sup>9</sup> This allowed the class to improve as technology progressed and new needs were recognized. In addition, the lack of significant technological risk and incremental improvements allowed the DDG 51 to maintain a predictable and affordable cost structure throughout its twenty-year procurement cycle.<sup>10</sup>

---

<sup>7</sup> J. F. Schank, et al., "Acquisition and Competition Strategy Options for the DD(X): The Navy's 21st Century Destroyer," (2006) Santa Monica, CA: RAND National Defense Research Institute, 74.

<sup>8</sup> Ibid., 73.

<sup>9</sup> Ibid.

<sup>10</sup> Ibid., 74, 85.

## **B. LOW TECHNOLOGICAL RISK – USE OF PROVEN TECHNOLOGIES**

The DDG 51 is very similar in design and capability to the CG 47. They both feature the Aegis Combat System – making them premiere AAW platforms. They both have twin screw, gas turbine propulsion plants with four LM2500 Main Engines. This engineering plant gives both vessels a maximum speed in excess of 30 knots. They both have three Gas Turbine Generators that supply roughly 2.5 megawatts (MW) of electricity. In addition, they both have VLS systems with the ability to launch SM2, ASROC and Tomahawk missiles.<sup>11</sup> Physically, the DDG 51s have a slightly shorter length, wider beam, lower mast height and smaller displacement than the CG 47s.

There are some areas in which the CG 47 has slightly better capability than the DDG 51. This is true because the DDG 51 was designed to complement, not replace the CG 47. The DDG 51 has 96 VLS cells, while the CG 47 has 128 (this number is decreased slightly by the presence of a missile crane). The DDG 51 also has only one 5 inch Dual Purpose gun rather than two on the CG 47. The CG 47s, designed to be Force AAW assets, also have increased command and control capability, additional fire control channels and spaces for embarked staff. The most significant difference in capability between the original DDG 51s and the CG 47 class is the presence of a helicopter hangar on the CG 47s. DDG 51s were designed to operate closely with large battle groups, where ships with hangars would always be in close proximity. So, to save space, DDG 51s were originally designed without a hangar but retained the ability to land and refuel helicopters.<sup>12</sup>

There are many ways in which DDG 51s are more capable than CG 47s. The most significant improvements are features that make the ship more survivable. DDG 51s have steel superstructures, rather than aluminum found on the CG 47. DDG 51s also have over 100 tons of Kevlar armor for vital spaces while the CG 47 has almost no armor protection at all. DDG 51s have a comprehensive Chemical, Biological, Radiological and Nuclear Defense (CBRN) system. The DDG 51s also have improved noise and

---

<sup>11</sup> Global security.org website.

<sup>12</sup> Schank, 84.

infrared suppression systems and a significantly reduced radar cross section – making them less vulnerable to torpedoes and cruise missiles.<sup>13</sup>

**C. INCREMENTAL IMPROVEMENTS – THREE DISTINCT FLIGHTS**

The first major upgrade was the DDG 51 Flight II, which began with hull 72. This flight mainly includes improved communications gear, such as the SLQ-32 (V3) with active jamming capability, a Shipboard Signal Exploitation Space (SSES) and the capability to launch the SM2 Block IV Extended Range Missile.<sup>14</sup> Then, as the Cold War came to a close, and smaller threats emerged in more remote areas of the globe, the DDG 51 started to operate independently more often than originally planned. This fact made the lack of a helicopter hangar a major drawback in the DDG 51s capability. This led to the most updated Flight of the DDG 51 - Flight IIA. Flight IIA includes a fully functioning helicopter hangar for SH-60 LAMPS III aircraft. This upgrade required the removal of the Tactical Towed Array Sonar System (TACTASS). Additionally, CIWS mounts were removed on some hulls and replaced with the NATO Evolved Sea Sparrow Missile (ESSM).<sup>15</sup> The three distinct Flights are shown in Table 1.

<b>Hull Flight</b>	<b>Fiscal Year Authorized</b>	<b>Hull Number</b>	<b>Number of Ships</b>
Flight I	1985–1992	DDG 51–71	21
Flight II	1992–1994	DDG 72–78	7
Flight IIA	1994–2005	DDG 79–112	34

Table 1. DDG 51-Class Flights.

In addition to the three distinct Flights, the Aegis Combat System has been updated eight times. These updates take the form of four major baselines of Aegis – baseline 5, 6 and 7. Baseline 4 was the original Aegis baseline on hulls 51 - 67. Baseline 5 added the Joint Tactical Information Distribution System (JTIDS) - an advanced

<sup>13</sup> Schank, 74.

<sup>14</sup> Global security.org website.

<sup>15</sup> Ibid.

TDMA data link. Baseline 6 added Cooperative Engagement Capability (CEC), which allowed units to share fire control quality data. The most recent upgrade, Baseline 7, includes advanced computer architecture and is increasingly software intensive.<sup>16</sup>

Another capability that has been incrementally added to the DDG 51 class is Ballistic Missile Defense Capability (BMD). From 2004 through 2008, 15 DDG 51s have been modified for the BMD mission. These modifications include new software for the Aegis Combat System, an advanced signal processor, and the SM3 interceptor missile.<sup>17</sup>

**D. PREDICTABLE COST STRUCTURE**

One of the greatest strengths of the DDG 51 program is that despite multiple upgrades, it has maintained a consistent unit cost over the past 20 years. (See Table 2 and 3):

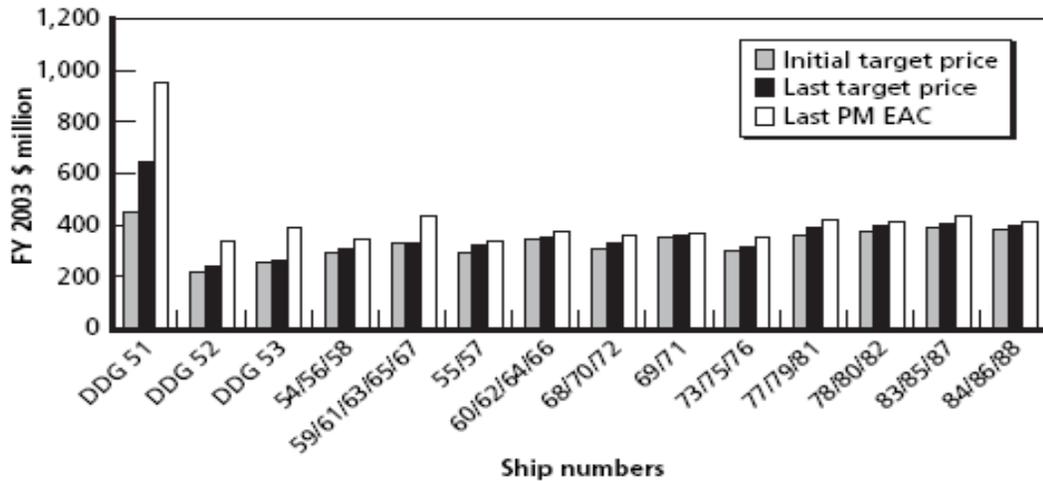


Table 2. DDG 51-Class Shipbuilding Costs per Unit (from RAND)

<sup>16</sup> Global security.org website.

<sup>17</sup> Ibid.

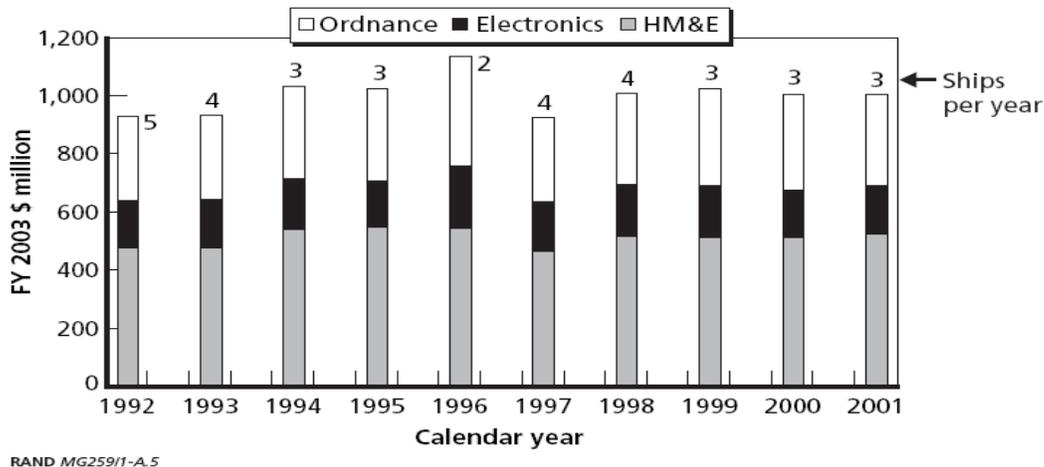


Table 3. DDG 51-Class Shipbuilding Costs per Unit (FY 1998-2004 President’s Budget)

As the graph above demonstrates, the first DDG 51 class ship was fairly expensive, but the costs for the second and subsequent ships were significantly lower and fairly predictable. There are several reasons for this predictable cost structure. One, as previously mentioned, the DDG 51 incorporated only a few new technologies and primarily depended on proven technologies.<sup>18</sup> Two, the Navy used significant post commissioning testing on the first ship of the class to limit future cost growth. Third, the large size of the class allowed the shipyards to learn as they built an increasing number of ships. Lastly, the Navy used contracting policies that encouraged competition between the two shipyards – resulting in lower costs.

Developing technologies are the most unpredictable cost factor in ship procurement. Traditionally, new platforms try to have no more than 4 major emerging technologies, in order to limit research and development costs.<sup>19</sup> DDG 51 used pre-existing technologies in many of the weapons systems such as the Aegis Combat System, VLS, Dual Purpose gun, and the Gas Turbine Engineering plant. The additional costs of the first DDG 51 were incurred through the development of a new hull, and integration of the new combat systems suite – both of which decreased significantly over time.<sup>20</sup>

<sup>18</sup> Schank, 74.

<sup>19</sup> Congressional Budget Office Paper (June 9, 2008), 20-28.

<sup>20</sup> RAND Corporation., 75-77.

A significant amount of cost growth was avoided by the Navy through its relationship with industry from the preliminary design work through post commissioning testing. The Commander, Operational Test and Evaluation Force, was heavily involved in the initial phases of testing. New systems were tested by fleet sailors stationed ashore at industrial test facilities. The combat system testing took place at the Combat System Engineering Development Site in Moorestown, New Jersey. The propulsion plant testing took place at the Gas Turbine Ship Land-Based Engineering Site in Philadelphia, Pennsylvania.

After DDG 51 was commissioned, the ship underwent extensive sea trials by the Naval Sea Systems Command (NAVSEA). A major Combat Systems Ship Qualification Trial (CSSQT) was conducted to test the newly integrated Combat Systems suite. During CSSQT, the ship transitioned from an industrial to an operational environment and the ship's crew worked alongside the shipyard technicians to learn how to operate and maintain the Combat Systems. The extensive testing allowed industry to learn from its mistakes.

Traditionally, the first ship of any class is more expensive than the subsequent ships. This is due to the learning curve theory, which states that the production of each successive unit, the production process becomes more efficient. A shipyard may not become completely proficient at building a ship until the second or third ship of the class is completed. This was especially true with DDG 51. The shipbuilding industry perfected the building of the DDG 51 class out of repetition. Also, advances in combat system capabilities may have paralleled the cost reductions in the computer industry, thereby allowing significant improvements in capability while holding costs fairly constant over time.

In addition, the Navy's acquisition strategy for DDG 51 has contributed to cost stability while maintaining a solid industrial base. Over the duration of the program, the DDG 51 Program Office has continued to change its contracting strategies to encourage competition between the two shipbuilding contractors in order to get the best price. There have been two primary methods used to foster competition. The first is traditional price based competition. The second is approach is competition based on profit known as

the Profit Related to Offer (PRO) strategy. The two primary shipyards – Ingalls and Bath Iron Works (BIW) – have responded to the increased competition by producing increasingly capable ships over 20 years at a relatively stable cost per unit.<sup>21</sup>

---

<sup>21</sup> RAND Corporation., 94-95.

THIS PAGE INTENTIONALLY LEFT BLANK

### **III. EVOLUTION OF THE DDG 1000 CONCEPT**

#### **A. DD 21 CONCEPT**

In the mid 1990s, the Navy began to focus on its next generation of surface combatants. The first concept, initiated in 1994, was the DD 21 program. The ship was initially envisioned as a land attack destroyer. After the Cold War ended, senior Navy officials believed that in order to remain relevant, the U.S. Navy had to focus less on blue water supremacy and more on projecting power into the littorals and onto land. Also, in the Persian Gulf War of 1991, four reactivated Iowa class Battleships performed brilliantly in the NSFS role. Although still effective over forty years after they were commissioned, these venerable warships could not be called upon forever and the U.S. Navy sought new solutions for projecting power ashore.<sup>22</sup>

DD 21 was to be the first member of the SC 21 family of 21st century surface combatants. Navy shipbuilding officials initially envisioned purchasing 32 DD 21s beginning in FY 2005. The first ship was to enter service in 2010. The initial plan was to purchase three ships per year to replace the DD 963 and FFG 7 ships that were in service at the time. In FY 2015, the Navy planned to purchase CG 21 – a next generation cruiser based on the DD 21 design – to replace the CG 47 class of ships. Although the land attack mission inspired the ship class, the DD 21 was planned as a multi-mission ship. It would retain traditional maritime dominance capabilities in ASW, AAW and ASuW.<sup>23</sup>

DD 21 was to have a crew of 95 to 150 sailors, much smaller than the DDG 51 with a crew size of 285 or the CG-47 with a crew of 350. The Navy also announced that it would incorporate electric drive technologies in an effort to reduce operations and maintenance (O&M) costs. The hull was to be a new wave-piercing tumblehome design intended to reduce radar, acoustic and infrared signatures. It was to be equipped with VLS and two new 155mm Advanced Gun Systems (AGS) for long range, precision

---

<sup>22</sup> R. O'Rourke (2004), 10.

<sup>23</sup> Ibid.

guided shells. It was not to be fitted with an Aegis Combat System and thus would not have the AAW capabilities of the DDG 51 or CG 47 classes. In order to allow a procurement rate of three ships per year, the Navy wanted DD 21 to have a unit procurement cost lower than the DDG 51. The procurement cost of the first DD 21, which included Research and Development (R&D) costs was estimated at \$2.03 billion in FY 1996 dollars. The procurement cost of the fifth and following DD 21s was \$750 million in FY 1996 dollars. These numbers would soon prove to be highly optimistic.<sup>24</sup>

## **B. DD(X) AND THE RUMSFELD PENTAGON**

After Donald Rumsfeld became Secretary of Defense in 2001, support for the DD 21 decreased. Rumsfeld tried to transition the U.S. Military into a smaller, faster, more technology driven fighting force. Several DOD panels found that the DD 21 program was non-transformational, which ran against Rumsfeld's thinking. Also, in Congressional hearings for the 2002 proposed defense budget, Navy officials could not specifically state the merits of the program that were significant enough to outweigh its rising costs.<sup>25</sup>

By 2001, the vision for the ship drastically changed. The design displacement increased to 16,000 tons – well higher than the 9,000-10,000 tons of DDG 51 class ships. This increase was due to the multiple war fighting requirements including two AGS systems, 128 VLS tubes, and a helicopter/unmanned aerial vehicle (UAV) capable hangar. In addition, DOD officials were concerned about the risks of simultaneously implementing multiple unproven technologies in the same ship. The consensus was that the DD 21 would not meet its unit procurement costs goals. The program took another hit during the markup of the FY 2002 defense appropriation bill when the House Appropriations Committee significantly reduced the Navy's request for R&D funding. In November 2001, Navy acquisition officials announced that the DD 21 program was being replaced by the DD(X).<sup>26</sup>

---

<sup>24</sup> R. O'Rourke (2004), 11.

<sup>25</sup> Ibid., 13.

<sup>26</sup> Ibid., 11.

There were very few differences between DD(X) and DD 21. DD(X) was slightly smaller, with a displacement of 14,000 tons. VLS tubes were reduced to 80 and magazine size for the AGS was reduced to less than 600 rounds. It was still designed to be a multi-mission destroyer with an emphasis on land attack. New technologies included the previously mentioned tumblehome hull and integrated electric drive and several new technologies including a composite material hull, dual band radar and a total ship computing system for increased automation and crew size reduction.<sup>27</sup>

The Navy announced that it intended to procure 24 of these vessels through FY 2017 and then begin procurement of a next generation cruiser – CG(X) in FY 2018. The Navy estimated that the fifth and sixth DD(X) would have an average procurement cost of \$1.2 billion to \$1.4 billion. The Congressional Budget Office (CBO) estimated that the entire 24 ship class built at a rate of two per year would have an average procurement cost of \$1.8 billion in FY 2003 dollars. Cost estimations were rising rapidly.<sup>28</sup>

In May 2003, the Navy sent a report to Congress outlining its 30 year shipbuilding plan. The report called for a 375 ship Navy with 24 DD(X) vessels. A similar report sent to Congress in 2005 saw the plan revised to a fleet of 260 to 325 ships, including 8 to 12 DD(X) ships. This startling change was brought on by tremendous cost growth in the DD(X) program between the President’s 2004 and 2006 budget. In 2005, the CBO estimated that the lead ship in the DD(X) program would cost \$3.3 billion. Estimations about historical relationships between lead ships and follow on ships gave the DD(X) an average cost of \$2.4 billion.<sup>29</sup> In two years, the Navy saw almost a 25 percent cost growth – primarily due to the ships slowly maturing technologies. The 2007 cost estimates from the CBO over time for the fifth ship in the DD 21/DD(X) Program are shown in Table 4:

---

<sup>27</sup> R. O’Rourke (2004), 14.

<sup>28</sup> Ibid., 15.

<sup>29</sup> Congressional Budget Office Testimony (July 19, 2005), 1-2.

	<b>Billions of 2007 Dollars</b>
1996 Objective goal (DD 21)	1.06
2004 Future Years Defense Program	1.4
2005 Navy Estimate	2.0
2005 CBO Estimate	3.4

Table 4. Congressional Budget Office 2007 cost estimates for the fifth ship of the DD 21/DD(X) Program<sup>30</sup>

### C. DDG 1000: THE ZUMWALT PROGRAM TAKES SHAPE

In April 2006, the program's name changed again to DDG 1000. It was given the name Zumwalt after Admiral Elmo Zumwalt, the Navy's visionary CNO from 1970-1974. This name change not only gave the Zumwalt class the name of its first vessel, but also added the "G" to its designation for the first time, indicating the ability to fire guided missiles. The Navy's new plan called for procuring seven of these ships from FY 2007 to FY 2013. The first two ships of the class, DDG 1000 and DDG 1001 were authorized in the FY 2007 budget.<sup>31</sup> The two ships would be built at competing shipyards, NGSB (Northrop Grumman) and BIW (General Dynamics subsidiary). The contracts for construction of the first two ships were cost plus incentive fee (CPIF) contracts.<sup>32</sup> The detailed procurement plan released in 2006 is outlined in Table 5.

---

<sup>30</sup> CBO Testimony (July 19, 2005), 5.

<sup>31</sup> R. O'Rourke (2008), 2-3.

<sup>32</sup> *Ibid.*, 29.

	<b>FY 02 thru FY06</b>	<b>FY07</b>	<b>FY08</b>	<b>FY09</b>	<b>FY10</b>	<b>FY11</b>	<b>FY12</b>	<b>FY13</b>	<b>TOTAL thru FY13</b>
<b>Research, Development, Test and Evaluation, Navy (RD TEN) account</b>									
DDG1000	4549	756	493	449	521	565	326	174	7832
<b>Shipbuilding and Conversion Account (SCN)</b>									
DDG1000	1010	2557	2757	0	0	0	0	0	6325
DDG1001									
<i>DD/NRE*</i>	994	893	0	0	0	0	0	0	1887
<i>Construction</i>	16	1664	2757	0	0	0	0	0	4437
DDG1002	0	0	150	2503	0	0	0	0	2653
DDG1003	0	0	0	51	2663	0	0	0	2714
DDG1004	0	0	0	0	51	2377	0	0	2428
DDG1005	0	0	0	0	0	50	2569	0	2619
DDG1006	0	0	0	0	0	0	50	2347	2397
<i>Outfitting/ Post Delivery</i>	0	0	0	0	16	61	87	132	295
<b>Subtotal SCN</b>	1010	2557	2907	2554	2730	2488	2706	2479	19430
<b>TOTAL</b>	<b>5559</b>	<b>3313</b>	<b>3399</b>	<b>3003</b>	<b>3250</b>	<b>3053</b>	<b>3032</b>	<b>2653</b>	<b>27262</b>

\* Detailed Design and Non recurring Engineering costs

Table 5. Proposed DDG 1000 Program Funding, FY2002-FY2013 (Millions of then year dollars, rounded to the nearest million – based on Navy data provided to the CRS on July 7, 2007 and May 8, 2008)

#### **D. DDG 1000 MISSION AND CAPABILITIES**

Despite the new DDG designation, the Navy never intended that these ships would replace the DDG 51 class of destroyers. They claimed that these vessels would provide increased capability in the littoral regions - including land attack and shallow

water ASW. The Navy also claimed that the DDG 1000 would be just as capable, if not more capable than current surface combatants in blue water operations. The Navy briefing slides to Congress stated that DDG 1000 would carry the majority of the weapons that were carried on the DDG 51, included TLAM and SM2. The presence of these weapons and the description of the ship's sensors indicated that DDG 1000 was capable of traditional surface combatant missions such as Force AAW, blue water ASW and precision strike.

The Navy also claimed that the ship would serve as a technology bridge to the next generation Cruiser or CG(X) that the Navy wanted to procure after FY 2013 to replace the CG 47 class. There were a total of ten major developing technologies to be integrated into the DDG 1000. The Navy believed that by developing these technologies on the DDG 1000, they were taking a major leap forward in surface ship capability. In addition, they believed that the fuel efficiencies and automation technologies would bring much needed future relief to the Navy's personnel (MPN) and operating (O&M) spending accounts – both of which were trending upward rapidly. The ten new technologies are listed below:

- **Advanced Gun System (AGS):** DDG 1000 will employ a battery of two 155mm AGSs, firing-rocket assisted Long-Range Land Attack Projectiles (LRLAP). This will provide precision strikes at a range of up to 83 nautical miles. This system is equivalent to twelve 155mm howitzers and will significantly improve current NSFS capabilities.
- **Automatic Fire Suppression System (AFSS):** This advanced, automated damage-control system combines automated sensors and cameras to greatly enhance firefighting capabilities. The system significantly reduces damage control manpower requirements.
- **Dual Band Radar (DBR):** The DBR integrates S-band and X-band radar capabilities in a single system. DBR is a multi-function radar, simultaneously supporting AAW, NSFS, ASuW and navigation.

- **Integrated Composite Deckhouse and Aperture:** Constructed of rugged, lightweight composites, the angular deckhouse increases stealth capability by minimizing radar reflectance and by eliminating high-profile masts and rotating antennas.
- **Integrated Power System (IPS):** The IPS generates all the energy needed for propulsion, electronics, and combat systems. IPS can produce six times more electrical power than the three 60 hertz Gas Turbine Generators on the DDG 51.
- **Integrated Undersea Warfare Suite (IUWS):** The IUSW incorporates two types of sonar arrays in one automated system. The high frequency sonar provides mine avoidance capabilities, while the medium frequency sonar optimizes ASW operations in the littoral regions.
- **Mk 57 VLS:** This system can accommodate both existing and future missiles for land attack (TLAM), ASW (ASROC) and AAW (SM 2). Its modular electronic architecture allows the DDG 1000 to easily accommodate new missile designs as technology progresses.
- **Peripheral Advanced VLS:** A system of armored compartments located around the periphery of the DDG 1000. Each PVLS compartment contains and protects one MK57 Vertical Launching System. This design makes launchers and missiles resistant to battle damage while safely isolating them from crew and equipment spaces.
- **Total Ship Computing Environment (TSCE):** The TSCE is the first large-scale implementation of the U.S. Navy's Open Architecture strategy. Designed to bind all DDG 1000 systems together, the TSCE creates a shipboard enterprise network allowing seamless integration of all on-board systems.
- **Wave piercing tumblehome hull:** The tumblehome hull (inward sloping from the waterline) minimizes the DDG 1000 radar cross section for enhanced stealth and survivability. Driven by a quiet and efficient all-electric propulsion system, the hull design optimizes speed, maneuverability and stability while minimizing engine noise and infrared signatures.<sup>33</sup>

---

<sup>33</sup> Raytheon Company website.

THIS PAGE INTENTIONALLY LEFT BLANK

## **IV. DDG 1000 ACQUISITION RISKS AND INCREASED CONGRESSIONAL SCRUTINY**

### **A. SIGNIFICANT TECHNOLOGICAL RISK**

The large number of immature technologies represented a sharp contrast from modern Navy shipbuilding philosophy. Never before had the Navy attempted to incorporate so many unproven technologies into one hull. Also, the concept of a technology bridge was never introduced. For example, when the DDG 51 was developed, the Navy used the Aegis Combat System that was previously tested on the CG 47 class. In fact, the DDG 51 hull, engineering plant and combat system represented small and systematic improvements in proven technologies from the CG 47. In addition, as DDG 51 construction progressed through the years, existing technologies were improved on subsequent hull numbers.<sup>34</sup> These changes also resulted in three distinct Flights of DDG 51 – Flight I, II, and IIA, all of which are incremental improvements from the previous flight.

A Government Accountability Office (GAO) report released in March 2008 highlighted the technological risks of the DDG 1000 program. This report analyzed the current status of the developing technologies and questioned the Navy's timeline. The report found that only three of the critical technologies were fully mature and were tested in an at sea environment. Seven technologies were not fully mature and five of them would not demonstrate full maturity until after installation on the ship. Two of the technologies – the volume search radar and the total ship computing environment were still at low levels of maturity. The land based testing for the volume search radar was not scheduled to begin until May 2008, a delay of 12 months. It was also discovered that the Navy planned on completing only 85 percent of the ship's detailed design prior to the start of construction - a very risky proposal.<sup>35</sup>

---

<sup>34</sup> RAND Corporation (2006), 74-75.

<sup>35</sup> Government Accountability Office (March 2008), 69-70.

In addition, due to scheduling issues for the lead ships, the Navy did not have time to completely test the integrated power system prior to shipyard delivery. The Navy planned on conducting integrated power system testing in 2010 at a land-based site. The report noted that significant software development remained and if problems were discovered during testing, construction plans would be at significant risk because the power systems would have already been delivered to the shipyard. The report also questioned the sea worthiness of the tumblehome hull design. This type of hull has never been employed on a naval surface ship and the only methods that were used to test this hull were scale models and computer simulations. The Navy claimed that testing was ongoing to develop guidance for operating the ship safely at various sea conditions. In Summary, this report made it clear that the DDG 1000 program had significant technological risks.<sup>36</sup>

**B. SIGNIFICANT RISK OF COST GROWTH: CONGRESS QUESTIONS THE NAVY'S ABILITY TO ESTIMATE COST**

The Congressional Budget Office made it clear in their June 2008 report that it believed the Navy was significantly underestimating DDG 1000 procurement costs. The CBO believed that the first two DDG 1000s would cost approximately 56 percent more than Navy estimates and that the subsequent five ships would each cost approximately 64 percent more than Navy estimates. According to the report, the Navy's 2009 budget suggested that the Navy expects the first two ships to cost \$3.2 billion (FY 09 dollars) each and the subsequent five ships to cost \$2.2 billion (FY 09 dollars) each. This represented a cost increase of approximately \$200 million per ship from the Navy's 2008 budget. The CBO based its estimate on the lead ship cost of the DDG 51 class. When adjusted for inflation, the first DDG 51 cost \$390 million (FY 09 dollars) per thousand tons. When this number is translated to the size of the larger DDG 1000, the CBO estimate put the first two ships at \$5 billion each (FY 09 dollars) and the subsequent five at \$3.6 billion (FY 09 dollars) each.<sup>37</sup>

---

<sup>36</sup> Government Accountability Office (March 2008), 69-70.

<sup>37</sup> Congressional Budget Office Paper (June 9, 2008), 20-23.

<sup>38</sup> Congressional Budget Office Testimony (June 9, 2008), 20-23.

This cost estimate startled Congress and led to increased scrutiny about the cost of the DDG 1000 program. The Navy argued that the CBO's cost estimate was not valid because the DDG 51 had several problems in the early stages of construction that were not expected to occur with the DDG 1000. In particular, the Navy pointed out that only 20 percent of detailed design was complete on the DDG 51 before construction began, whereas 85 percent of detailed design was scheduled to be completed before construction of the first DDG 1000. The CBO countered that while the Navy might not encounter the same problems as the DDG 51, it was likely to encounter unforeseen problems that most initial ships experience that would significantly increase cost.<sup>38</sup>

The CBO believed that it was necessary to include this uncertainty into cost estimations. It specifically pointed to recent ship construction programs such as the Littoral Combat Ship (LCS), whose cost doubled, and the LPD 17, whose costs increased by 80 percent. The report made it clear that if the previous two new classes of surface ships that were built experienced cost growth on such a high level, the DDG 1000 would be susceptible to cost growth on the same scale. The CBO also said that the DDG 1000 was incorporating ten major new technologies, whereas in the past the Navy typically only fielded three or four significant new technologies on new platforms.<sup>39</sup>

Finally, the CBO stated that if cost estimates on a relatively small and simple ship such as LCS were so off target, the Navy might have difficulty estimating the cost of larger combatants such as DDG 1000. To make matters worse, in July 2007 the GAO testified that the Navy had assigned a confidence factor of 45 percent to their cost estimate – meaning there was a 55 percent chance that the cost of the DDG 1000 would exceed the Navy's estimate.<sup>40</sup>

### **C. DDG 1000 PROGRAM IS THREATENED**

By the summer of 2008, the DDG 1000 program was under intense fire on Capitol Hill. A third DDG 1000 had already been requested in the FY 2009 budget, but rumors

---

<sup>39</sup> Congressional Budget Office Testimony (June 9, 2008), 20-23.

<sup>40</sup> Government Accountability Office (July 24, 2007), 20-23.

of the program's truncation swirled. One harsh critic of the DDG 1000 program was Representative Gene Taylor (D-Miss), Chairman of the House Armed Services Seapower Subcommittee, whose district includes the Ingalls Shipyard in Pascagoula Mississippi. He was alarmed at the high cost of the program and didn't believe that the DDG 1000 brought enough additional capability to be worth the cost. Taylor also did not believe that the cost of the DDG 1000 would allow the Navy to reach its goal of 313 ships. He encouraged the Navy to instead build additional DDG 51s because of the ship's proven performance and cost structure. Members of Congress opposed to the cancellation of the DDG 1000 included Senators Susan Collins (R-Maine), and Olympia Snowe (R-Maine), whose state is home to BIW Shipyard, and Ted Kennedy (D-Mass), whose state is home to Raytheon, the primary combat systems contractor for the DDG 1000.<sup>41</sup>

On July 31, 2008, VADM Barry McCullough, Deputy CNO for Integration of Capabilities and Resources (N8) and Ms. Allison Stiller, Deputy Assistant Secretary of the Navy (Ship Programs) appeared before the House Armed Services Seapower Subcommittee and made a stunning announcement. VADM McCullough stated that the Navy now supported the truncation of the DDG 1000 program at two ships. He testified that DDG 51's cost structure would give the Navy a better chance to meet its long term goal of increasing the size of the fleet from its current level of 280 ships to 313 ships.<sup>42</sup>

VADM McCullough stated that the Navy supported the reopening of DDG 51 production lines. The three DDG 51s procured in FY 2005 were intended to be the final ships in the program. And budgets after FY 2006 included funds to close out the program.<sup>43</sup> This was a remarkable reversal. For years, Navy officials defended the DDG 1000 program against criticism and rejected a continuation of the DDG 51 program. Since 2005, CNOs Admiral Mike Mullen and Admiral Gary Roughead had consistently supported the DDG 1000, indicating that they wanted to take a step forward, not a step backwards.

---

<sup>41</sup> C. P. Cavas, "DDG 1000 Program Facing Major Cuts," (July 14, 2008).

<sup>42</sup> Navy Testimony before HAS Seapower Subcommittee (July 31, 2008).

<sup>43</sup> Ibid.

#### **D. THE NAVY CHANGES ITS POSITION – CITES NEW THREAT ASSESSMENT**

In his testimony, VADM McCullough reaffirmed the Navy's desire to truncate the DDG 1000 program at two ships and to procure an additional eight DDG 51s from FY 2010 to FY 2015. He also expressed the Navy's desire that the third DDG 1000 – already submitted as a part of the FY 2009 Budget, now be replaced with a DDG 51. This would lead to a total of nine additional DDG 51s. Interestingly, the Navy's new position on the FY 2009 budget was not included in the Navy's request to OSD because by law, they are required to defend their original position while the budget is being considered by Congress.<sup>44</sup> VADM McCullough made it clear that the Navy remained ready to execute construction of a third DDG 1000 if it was funded as originally requested, but that the Navy now preferred an additional DDG 51.<sup>45</sup>

VADM McCullough testified that it changed its position on destroyer procurement because of a recent change in threat assessment. They stated that over the previous two years the threat of ballistic missiles, anti-ship cruise missiles (ASCMs) and modern non-nuclear powered submarines operating in blue waters has increased. VADM McCullough also testified that as a result of this threat assessment, the Navy needed to increase its AAW, BMD and blue water ASW capability through the purchase of additional DDG 51s. VADM McCullough stated that the Navy believed that it currently had enough capacity to support forces ashore with precision guided munitions and Tomahawk cruise missiles. Finally, he testified that the DDG 1000 was well suited for NSFS and ASW operations in littoral waters but was not capable of effective AAW, BMD or blue water ASW operations.<sup>46</sup>

Perhaps the most shocking portion of the testimony concerned the DDG 1000's AAW capability. For years, the Navy briefing slides indicated that DDG 1000 was able to carry the SM2. VADM McCullough now testified that that DDG 1000 was unable to carry this weapon and thus would not be able to carry out the area AAW mission.

---

<sup>44</sup> R. O'Rourke (October 22, 2008), 7-8.

<sup>45</sup> Navy Testimony before HAS Seapower Subcommittee (July 31, 2008).

<sup>46</sup> Ibid.

Instead, he testified that the DDG 1000's AAW capability would be limited to short range, point defense. In addition, he stated that the DDG 1000 was not capable of fielding the SM3 missile for BMD missions.<sup>47</sup>

This testimony stunned members of the Seapower committee. They not only expressed disappointment at the DDG 1000's perceived lack of capability, but they also pressed VADM McCullough for the specific threats that warranted this shift in position. VADM McCullough stated that these threats were classified and that he would not be able to discuss them in the current setting. It was later revealed in Defense News Magazine that the threat discussed was possibly a derivative of the Chinese Dong Feng 21/CSS-5 Ballistic Missile. In addition to developing highly sophisticated ASCMs, Defense News stated that the Chinese were developing ballistic missiles with independently guided re-entry vehicles capable of hitting carrier strike groups at sea at great standoff distances. According to the article, The Navy saw this as a way for the Chinese to counter U.S. Navy power projection capabilities in the Western Pacific. In order to counter this threat, the article argued that the Navy believed it needed additional AAW and BMD capacity – an area in which the cheaper and proven DDG 51 excelled.<sup>48</sup>

In addition to the lack of AAW capability, VADM McCullough also testified that the sonar on DDG 1000 was not ideal for tracking modern non nuclear submarines in blue water environments. He also stated that China, North Korea and Iran were developing increased blue water submarine capability and that the DDG 51 was better equipped for that mission.<sup>49</sup> In essence, VADM McCullough testified that the \$3 billion plus per copy DDG 1000, a program the US Navy developed and fiercely defended for more than ten years, excelled in little else than land attack operations and shallow water ASW.

Although not mentioned in detail in VADM McCullough's testimony, it is believed that cost overruns had a significant impact on the Navy's recommendation. Analysts agree that the Defense Budget is not likely to see significant growth, and might

---

<sup>47</sup> R. O'Rourke (October 22, 2008), 7-8.

<sup>48</sup> C. P. Cavas (August 4, 2008).

<sup>49</sup> Navy Testimony before HAS Seapower Subcommittee (July 31, 2008).

possibly see reductions in the coming years. The wars in Afghanistan and Iraq, the expensive rescue of the American financial sector, the growing national debt and the uncertainty of a new administration in the White House contribute to this belief. It is possible that Navy officials recognized this truth and abandoned an expensive acquisition program in favor of a less expensive, proven program that brings them closer to their goal of 313 ships.

#### **E. DDG 1000 TODAY**

The final version of the 2009 National Defense Authorization Act signed by President Bush in September, 2008 includes partial funding of \$1.5 Billion for a third DDG 1000.<sup>50</sup> This position was pushed by the previously mentioned New England Congressmen in order to maintain a stable industrial base in their states. It is now almost certain that the DDG 1000 program will be no greater than three ships, and that the final number might actually be two because the additional FY 2009 funds might be allocated for cost overruns on the first two ships. In addition, the 2009 Defense Authorization Act includes \$350 million in funding for DDG 51 spare parts and for a possible reopening of DDG 51 production lines at BIW and Ingalls. On September 26, 2008, the CNO made it clear that Navy stands by its stated position at the July 31 Hearing of procuring an additional eight DDG 51s from FY 2010 to FY 2015.<sup>51</sup> It is unknown whether the newly procured DDG 51s will be Flight IIAs or possibly a newer flight with more incremental upgrades.

---

<sup>50</sup> C. P. Cavas, "DDG 1000 Takes Another Hit – From JROC," (October 6, 2008)

<sup>51</sup> Ibid.

THIS PAGE INTENTIONALLY LEFT BLANK

## V. DDG 1000 VS. DDG 51. A SIDE-BY SIDE COMPARISON

### A. CAPABILITY

- **Size:** The DDG 1000 is considerably larger than the DDG 51. It is longer (600 ft vs. 505 ft), wider (80.7 ft vs. 62 ft) and heavier (16,000 tons vs. 9,500 tons). The DDG 1000 does have a shallower draft than the DDG 51 (31 ft vs. 27.6 ft), giving it increased ability to operate in littoral regions.<sup>52</sup>
- **Mobility:** The DDG 1000 and DDG 51 are roughly equal in terms of maximum speed (30+ knots) and range. And according to Navy briefings to CRS, the DDG 1000 and DDG 51 are roughly equal in terms of seaworthiness. There have been questions, however, about the seaworthiness of the tumblehome hull on the DDG 1000. A hull of this type has never been built on this large a scale and as of late 2008 only scale models have been tested.<sup>53</sup>
- **Electrical Power:** The DDG 51 has three Gas Turbine Generators that can produce 7.5 MW of electrical power. The IPS on the DDG 1000 can produce 78 MW of electrical power. This allows the DDG 1000 to accommodate more robust weapons and systems and allow for possible future technological upgrades.<sup>54</sup>
- **Signatures and Detectability:** The DDG 1000 has a smaller radar cross section and lower acoustic, infrared, and magnetic signatures than the DDG 51. The improvements in radar cross section are made possible by the tumblehome hull and integrated deck house. The improvements in acoustic signature are made possible by the IPS.<sup>55</sup>

---

<sup>52</sup> Navy briefing to CRS (June 10, 2005).

<sup>53</sup> Ibid.

<sup>54</sup> Ibid.

<sup>55</sup> Ibid.

- **Survivability and Damage Control:** The DDG 1000 and DDG 51 are roughly equal in terms of ship stability when flooded. The DDG 1000, however, has an automatic flood control system which the Navy believes will be more effective at keeping damaged ships afloat. The DDG 1000 also has an automatic fire suppression system throughout the ship, while the DDG 51's system is only automatic in the magazines, engineering spaces and other select spaces. The DDG 1000's electrical system also has "integrated fight-through" capability that automatically isolates damaged areas and reroutes power around them. In addition, all DDG 1000 systems are dual fed in case primary power is cut off. The DDG 51 does not have these electrical features.<sup>56</sup>
- **C4I / Networking Bandwidth:** The C4I and networking systems on the DDG 1000 have five times the bandwidth as DDG 51 systems. This not only gives the DDG 1000 improved warfighting capability, but also makes distance support easier which has the potential to improve at sea maintenance. Also, better at sea internet access has the capability to greatly improve morale.<sup>57</sup>
- **AAW/BMD:** The DDG 1000 combat system will be able to handle 10 times the amount of tracks as the DDG 51's current Aegis Combat System. The Dual Band Radar on DDG 1000 is roughly equivalent to the DDG 51's SPY-1D radar in terms of sensitivity, but it reportedly has a 25 percent longer firm track range (i.e., it can detect targets and generate fire control quality tracks at longer ranges). In addition, the DDG 1000's DBR will be more capable of deciphering "clutter" at the sea/land interface and will thus be more capable of littoral operations. The SPY-1D radar struggles in this area and is better suited for blue water operations.<sup>58</sup>

---

<sup>56</sup> Navy briefing to CRS (June 10, 2005).

<sup>57</sup> Ibid.

<sup>58</sup> Ibid.

- Originally, it was believed that the DDG 1000 would employ the SM 2 missile and be capable of the area AAW mission. Confusion in this area persists, but according to VADM McCullough's recent testimony, the DDG 1000 can not employ the SM 2 and will only be capable of point defense AAW. This is puzzling because Raytheon, the lead combat systems contractor for the DDG 1000, manufactures the SM 2. The problem, however, might be the missile uplink technology that requires SM 2 to communicate in flight with the Aegis Combat System through the SPY radar. The DDG 1000 combat system may not be able to perform this essential task.
- In addition, the DDG 1000 will reportedly not be able to field the SM 3, giving it zero BMD capability. The inability of DDG 1000 to employ these two missiles gives a tremendous capability edge to the DDG 51, especially given the Navy's new threat assessments.<sup>59</sup>
- **Naval Surface Fire Support:** The DDG 1000 has a tremendous capability edge in NSFS. The DDG 51 has one 5-inch gun, while the DDG 1000 has two 155mm AGSs. The DDG 51's gun can fire a shell with 8 pounds of high explosive over 10 miles. The DDG 1000 AGS can fire a shell with 24 lbs of high explosive over 60 miles. The DDG 51 can fire an initial salvo of 20 rounds per minute, followed by a sustained salvo of four rounds per minute. The DDG 1000's two guns have a combined firing rate of 20 rounds per minute that can be sustained until its 600 round magazine is depleted.<sup>60</sup>
- **Anti Submarine Warfare:** The sonar system on the DDG 51 is more suitable for blue water operations while the sonar system on the DDG 1000 is more suitable for littoral operations. The DDG 1000 sonar suite

---

<sup>59</sup> Navy briefing to CRS (June 10, 2005).

<sup>60</sup> Ibid.

will include a bow mounted sonar and a towed array sonar. The DDG Flight IIA does not have a towed array sonar. A towed array sonar is exclusively passive, and is especially helpful because it allows the ship to search at various water depths that have unique sound propagation paths because of differences in temperature, pressure and salinity.

- Both the DDG 51 and DDG 1000 can fire the VLA anti-submarine rocket. The DDG 51 has six 12.75 inch torpedo tubes for firing lightweight torpedoes, but this provides little ASW lethality against modern threats. Both ships would use the same SLQ-25 NIXIE countermeasures to confuse enemy torpedoes, but it is believed that these would work better on DDG 1000 because of its quieter sound signature.<sup>61</sup>
- **Aviation:** All DDG 51s can launch, land and refuel helicopters. DDG Flight IIAs have a hangar to embark two SH-60 LAMPS helicopters. DDG 51s do not have the capability to launch UAVs. The DDG 1000 can embark two SH-60 helicopters, or one SH-60 helicopter and three UAVs. The DDG 1000's flight deck is larger than the DDG 51's, giving it the ability to handle larger aircraft like the MV-22 and CH-53. Its flight deck is also higher above the waterline, giving it the ability to conduct flight operations in rougher sea states.<sup>62</sup>

## B. COMPARATIVE COSTS

Original supporters of the DDG 1000 believed that despite its high construction costs, the DDG 1000 will have lower operating costs than the DDG 51 because of its smaller crew. Some even argued in the early stages of the program that the DDG 1000 might have a lower life cycle cost than the DDG 51. The CBO conducted a life cycle cost analysis for the DDG 1000 and DDG 51 programs in July of 2005 (all numbers below are in FY 2007 dollars).

---

<sup>61</sup> Navy briefing to CRS (June 10, 2005).

<sup>62</sup> Ibid.

In 2005, the CBO estimated the average procurement cost for a 10 ship DDG 1000 class would be approximately \$3.5 billion per copy, with the initial ship costing \$4.7 billion. The CBO also estimated that buying one DDG 51 per year would cost roughly \$1.8 billion per copy and that buying two per year would cost \$1.4 billion per copy. Annual operating costs for a DDG 51 were estimated at \$34 million based on historical Navy data. Annual operating costs for the DDG 1000 were estimated at roughly \$32 million based on a 60 percent smaller crew and a 55 percent higher full load displacement. CBO then calculated total life cycle cost on a discounted Net Present Value basis over the ship's thirty-five year lifespan. According to their results shown in the table below, the operating cost savings of the DDG 1000 are not high enough to offset even the most optimistic procurement cost estimates.

	<b>DDG 51</b>	<b>DDG 1000</b>
<b>Procurement cost for lead ship of the class</b>		
Navy Estimate	2.6	3.3
CBO Estimate	2.6	4.7
<b>Full load Displacement (Thousands of long tons)</b>	8.3	14.3
<b>Procurement Cost per Thousand long tons (lead ship)</b>		
Navy Estimate	385 M	275 M
CBO Estimate	385 M	385 M*
<b>Annual Operating Costs</b>	34 M	32 M
<b>Life Cycle Costs per ship (Avg)</b>		
Navy Estimate	2.1	2.9
CBO Estimate	2.1	4.0

Table 6. Life Cycle Cost Comparison of the DDG 51 and DDG 1000 Destroyer

(All numbers in billions of 2007 dollars) \* A major CBO assumption, disputed by the Navy, was that the lead DDG 1000 would cost at least as much as the lead DDG 51 on a per ton basis.

The question of comparing procurement costs and operating costs appeared again in the spring of 2008, when the DDG 1000 program was in danger on Capitol Hill. On May 7, 2008, Chief of Naval Operations Admiral Gary Roughead responded to a letter from Senator Kennedy requesting information on the capabilities and costs of both destroyer programs. The CNO responded with a letter that outlined the costs of various procurement options. He also compared the operating and maintenance costs of the two ships in FY 2009 dollars. He stated that because DDG 51 production was already phased out, there would be additional start up costs associated with reopening the production lines. As a result, a single DDG Flight IIA would cost \$2.2 billion and two DDG Flight IIAs produced at competing shipyards would cost \$3.5 billion. After these lead ships were procured, subsequent DDG 51s would cost \$1.8 billion. A subsequent DDG 1000, on the other hand, would cost \$2.6 billion. The CNO also laid out the differences in operating and maintenance costs<sup>63</sup>:

<b>Millions of FY 2009 dollars</b>	<b>DDG 1000</b>	<b>DDG 51</b>
<b>Operating (steaming)</b>	18.5	15.7
<b>Maintenance</b>	10.3	5.6
<b>Manpower</b>	8.5	19.9
<b>Total</b>	37.3	41.2
<b>Crew Size</b>	14 officers / 106 enlisted	24 officers / 272 enlisted

Table 7. Operating and Maintenance Cost Comparison of the DDG 51 and DDG 1000 Destroyer (All numbers in billions of 2007 dollars)

The CNO explained that the manpower cost savings achieved by the DDG 1000 were largely offset by higher maintenance costs because the ship was significantly more complex. His numbers also show no fuel savings costs from the IPS – in fact, steaming costs will rise with DDG 1000. He also stated that the life cycle costs of the two ships were similar but did not provide a calculation. In summary, the CNO’s numbers did show a significant decrease in DDG 1000 operating costs to offset its high procurement costs.<sup>64</sup>

<sup>63</sup> Letter from ADM G. Roughead to the Honorable Edward M. Kennedy (May 7, 2008).

<sup>64</sup> Ibid.

## VI. CONCLUSIONS

The truncation of the DDG 1000 program sent shockwaves through all stakeholders in the surface ship acquisition process. The Navy has seen its reputation on Capitol Hill tarnished because of its inability to estimate cost and determine ship capability requirements. Congress has shown that its failure to provide adequate oversight at key points led to dramatic cost overruns and unrealistic expectations. Industry has shown that its inability to deliver mature technologies on time and at or under budget leads to a drastic course correction by its most valued customers (U.S. Navy).

To make sense of recent events, it is important to examine exactly what happened. The Navy established a requirement in the mid 1990s for a land attack destroyer that could operate in the littorals and project power ashore. Industry responded with dramatic warship designs that included new and exciting technologies that emerged in the recent technology boom. Over time, new complex technologies were added resulting in major cost overruns. The Navy, occasional victims of groupthink, defended DDG 1000 rigorously and ensured Congress it was the surface combatant of the future. Eventually, the Navy realized that the requirements of the 1990s were different from the requirements of today and came to the conclusion that DDG 1000 did not add enough capability to make it worth its tremendous cost. The result was a scramble by the Navy, Congress and industry to reestablish requirements based on threats, protect the industrial base, and set a new shipbuilding course for the future.

The Navy must now take a hard look at itself and rethink methods used to establish and update requirements, program surface ships and take them through the acquisition process. One lesson learned by the Navy is that it is never too late to make the right decision. The enormous amount of monetary resources already spent on DDG 1000 is a sunk cost and cannot be recovered. Another lesson learned is that there is no sense in continuing a program that will not be able to meet emerging threats, even if the program has been supported by top officials for several years.

In the end, the Navy deserves credit for re-evaluating the previous decision. The recommendation to truncate the DDG 1000 program at two ships and reopen DDG 51 production lines caused a stir, but will put the Navy in better position to take ownership of surface ship acquisition. In a period of declining defense budgets and increasing global responsibilities the prudent choice of building a larger number of ships that meet current capability requirements to include operational and fiscal was paramount. If the Navy did not reverse course, they risked the possibility being undercut by a new administration, a declining defense budget and a failing program. They also risked spending large portions of their ship construction (SCN) account on a ship that is not able to meet emerging threats.

The DDG 51 is the backbone of the surface fleet because of its affordability and versatility. The research shows the Navy is making the correct decision by trying to procure an additional eight DDG 51 Flight IIAs over the next five years. The DDG 1000 program, however, was not a waste of time or money. The Navy will benefit from the large amounts of research and development that was done when it comes time to procure the next large surface combatant – possibly the CG(X). Technologies such as the Integrated Power System, Automatic Fire Suppression System, Dual Band Radar and the tumblehome hull have the potential to change surface combatants forever. In the end, however, it is important to remember the successes of the DDG 51 program – proven technologies, incremental upgrades, predictable cost structure and manageable risk.

## LIST OF REFERENCES

- Cavas, C. P. (July 14, 2008). *DDG 1000 Destroyer Program Facing Major Cuts*. Retrieved July 15, 2008 from <<http://www.defensenews.com/story.php?i=3626171>>.
- Cavas, C. P. (October 6, 2008). *DDG 1000 Takes Another Hit-From JROC*. Retrieved October 7, 2008, from <<http://www.defensenews.com>>.
- Cavas, C. P. (August 4, 2008). *Missile Threat Helped Drive DDG Cut: Zumwalt Class Could Not Down Chinese Weapons*. Retrieved August 7, 2008, from <<http://www.defensenews.com/story.php?i=3657972>>.
- Congressional Budget Office Paper (U.S. Congress) Washington, D.C. (June 9, 2008). *Resource Implications of the Navy's Fiscal Year 2009 Shipbuilding Plan*. Defense Technical Information Center. Retrieved June 9, 2008, from <[http://cbo.gov/ftp-docs/93xx/doc9318/06-09-Shipbuilding\\_Letter.pdf](http://cbo.gov/ftp-docs/93xx/doc9318/06-09-Shipbuilding_Letter.pdf)>.
- Congressional Budget Office Testimony (July 19, 2005). Statement of J. Michael Gilmore, Assistant Director for National Security before the Subcommittee on Projection Forces of the House Armed Services Committee on the Navy's DD(X) Destroyer Program. Retrieved July 21, 2008, from <<http://cbo.gov/ftpdocs/65xx/doc6561/07-19-NavyDDX.pdf>>.
- Global Security. *Aegis Ballistic Missile Defense (Aegis BMD)*. Retrieved October 10, 2008, from <<http://www.globalsecurity.org/military/systems/ship/systems/aegis-bmd.htm>>.
- Global Security. *Aegis Combat System (ACS)*. Retrieved October 10, 2008, from <<http://www.global-security.org/military/systems/ship/systems/aegis.htm>>.
- Global Security. *DDG-51 Arleigh Burke – Flight I*. Retrieved October 10, 2008, from <<http://www.global-security.org/military/systems/ship/ddg-51-flt1.htm>>.
- Global Security. *DDG-51 Arleigh Burke – Flight II*. Retrieved October 17, 2008, from <<http://www.glo-balsecurity.org/military/systems/ship/ddg-51-flt2.htm>>.
- Global Security. *DDG-51 Arleigh Burke – Flight IIA*. Retrieved October 17, 2008, from <<http://www.glo-balsecurity.org/military/systems/ship/ddg-51-flt2a.htm>>.
- Letter from Admiral G. Roughead to the Honorable Edward M. Kennedy (posted on internet: May 30, 2008). Retrieved October 24, 2008, from [www.insidedefense.com](http://www.insidedefense.com).

- O'Rourke, R. (October 28, 2004). *Navy DD(X) and LCS Ship Acquisition Programs: Oversight Issues and Options for Congress*. Congressional Research Service: The Library of Congress. Retrieved October 24, 2008, from <[http://assets.opencrs.com/rpts/RL-32109\\_20041028.pdf](http://assets.opencrs.com/rpts/RL-32109_20041028.pdf)>.
- O'Rourke, R. (October 22, 2008). *Navy DDG-1000 and DDG-51 Destroyer Programs: Background, Oversight Issues, and Options for Congress*. Congressional Research Service: The Library of Congress. Retrieved October 22, 2008, from <[http://assets.open-crs.com/rpts/RL32109\\_20081022.pdf](http://assets.open-crs.com/rpts/RL32109_20081022.pdf)>.
- RAND Corporation (2006). *Acquisition and Competition Strategy Options for the DD(X): the U.S. Navy's 21<sup>st</sup> Century Destroyer*.
- Raytheon. *Zumwalt-Class Destroyer Critical Technologies: Advanced Gun System (AGS)*. Retrieved October 17, 2008, from <<http://www.raytheon.com/capabilities/products/zum-walt/tech/index.html>>.
- Schank, J. F., Smith, G. K., Birkler, J., Alkire, B., Boito, M., Lee, G. T., Raman, R., and Ablard, J. (2006) *Acquisition and Competition Strategy Options for the DD(X): The U.S. Navy's 21st Century Destroyer*. Santa Monica, CA: RAND National Defense Research Institute. Retrieved October 17 2008, from <[http://www.rand.org/pubs/mono-graphs/2006/RAND\\_MG259.1.pdf](http://www.rand.org/pubs/mono-graphs/2006/RAND_MG259.1.pdf)>.
- Statement of Vice Admiral Barry McCullough, Deputy Chief of Naval Operations for Integration of Capabilities and Resources before the Subcommittee on Seapower and Expeditionary Forces of the House Armed Services Committee on Surface Combatant Requirements and Acquisition Strategies. (July 31, 2008). Retrieved October 24, 2008, from <[http://armedservices.house.gov/pdfs/SPEF073108/McCullough\\_Stiller\\_Tes-timony073108.pdf](http://armedservices.house.gov/pdfs/SPEF073108/McCullough_Stiller_Tes-timony073108.pdf)>.
- United States. Government Accountability Office (GAO) Report to Congressional Committees. (March 2008). *Defense Acquisitions: Assessment of Selected Weapon Programs*. Washington, D.C.: U.S. Government Accountability Office. Retrieved October 17, 2008, from <<http://www.gao.gov/new.items/d08467sp.pdf>>.
- United States. Government Accountability Office (GAO). (July 24, 2007). Testimony before the Subcommittee on Seapower and Expeditionary Forces, House Armed Services Committee by Paul L. Francis, Director Acquisition and Sourcing Management Team on Defense Acquisitions: Realistic Business Cases Needed to Execute Navy Shipbuilding Programs. Retrieved June 11, 2008, from <<http://www.gao.gov/new.items/d07943t.pdf>>.

## INITIAL DISTRIBUTION LIST

1. Defense Technical Information Center  
Ft. Belvoir, Virginia
2. Dudley Knox Library  
Naval Postgraduate School  
Monterey, California
3. CDR William Hatch, USN, Ret  
Naval Postgraduate School  
Monterey, California
4. RADM James Greene, USN, Ret  
Naval Postgraduate School  
Monterey, California
5. Marine Corps Representative  
Naval Postgraduate School  
Monterey, California
6. Director, Training and Education, MCCDC, Code C46  
Quantico, Virginia
7. Director, Marine Corps Research Center, MCCDC, Code C40RC  
Quantico, Virginia
8. Marine Corps Tactical Systems Support Activity (Attn: Operations Officer)  
Camp Pendleton, California