THE INTEGRATION OF THE FIRE SCOUT TACTICAL UNMANNED AERIAL SYSTEM INTO LITTORAL COMBAT SHIP MISSIONS

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The purpose of this research is to determine if the Fire Scout unmanned aerial system (UAS) is an effective mission multiplier for the Littoral Combat Ship (LCS). The U.S. Navy relies heavily on unmanned systems, such as the Fire Scout UAS, to enable LCS to conduct several complex littoral missions. Additionally, LCS must reallocate precious shipboard space for one of its manned helicopters to the Fire Scout UAS. Although UAS employment has spread rapidly throughout the U.S. military, the gaps in capability between manned and unmanned systems need to be explored. By analyzing each LCS mission, this study uses a comparative analysis of the task performance of the Fire Scout UAS and the MH-60 manned helicopter in order to identify where the Fire Scout system is complimentary to the LCS mission. This analysis also explores UAS integration issues along with future weapons and sensor capabilities requiring additional research.

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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

THE INTEGRATION OF THE FIRE SCOUT TACTICAL UNMANNED AERIAL SYSTEM INTO LITTORAL COMBAT SHIP MISSIONS, by LCDR James J. Marsh, 80 pages.

The purpose of this research is to determine if the Fire Scout unmanned aerial system (UAS) is an effective mission multiplier for the Littoral Combat Ship (LCS). The U.S. Navy relies heavily on unmanned systems, such as the Fire Scout UAS, to enable LCS to conduct several complex littoral missions. Additionally, LCS must reallocate precious shipboard space for one of its manned helicopters to the Fire Scout UAS. Although UAS employment has spread rapidly throughout the U.S. military, the gaps in capability between manned and unmanned systems need to be explored. By analyzing each LCS mission, this study uses a comparative analysis of the task performance of the Fire Scout UAS and the MH-60 manned helicopter in order to identify where the Fire Scout system is complimentary to the LCS mission. This analysis also explores UAS integration issues along with future weapons and sensor capabilities requiring additional research.

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ACRONYMS

AMCM	Airborne Mine Countermeasures
ASW	Anti-Submarine Warfare
CNO	Chief of Naval Operations
DoA	Department of the Army
DoD	Department of Defense
DoN	Department of the Navy
EO-IR	Electro-Optical and Infrared
EW	Electronic Warfare
GAO	Government Accountability Office
LCS	Littoral Combat Ship
MIW	Mine Warfare
NTTL	Naval Tactical Task List
RDML	Rear Admiral (Lower Half)
SUW	Surface Warfare
UA	Unmanned Aircraft or unmanned aerial vehicle(s)
UAS	Unmanned Aircraft System(s)
UHF	Ultra High Frequency

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CHAPTER 1

INTRODUCTION

> Unstable areas are largely littoral – coastal regions subject to naval power and influence. We can anticipate that the Combatant Commanders will increasingly employ U.S. Naval forces in those areas of the world where our security and economic interests are concentrated. (2006, 8)
>
> *Naval Operations Concept 2006*

Focus on the Operating Environment

The littoral areas of the world are defined by the U.S. Navy as having two parts. The seaward part is "that area from the open ocean to the shore which must be controlled to support operations ashore." The landward part is "the area inland from the shore over which friendly forces can be supported and defended directly from sea." Geographically, most of the world's waterways, which can carry as much as 90 percent of the global trade, flow to and from the seaward littoral areas. Additionally, three-quarters of the world's population reside in the landward portion of the littorals. Joint operations in the littoral areas provide access to as many as 80 percent of all nations' capital cities (US DoN 2006a, 9). This unprecedented access is the reason why the U.S. Navy has placed significant emphasis on developing a new class of ships to operate in these littoral areas.

A New Class of Ships

The Littoral Combat Ship (LCS) is the newest class of surface ships designed to operate in coastal waters. The challenge of building a class of ships that can dominate in the littoral environment comes from the high saturation of information and degree of ambiguity not encountered in the open ocean (US Don 2006b, 77). The LCS is designed to counter these environmental complexities and dominate littoral waters by being a “fast, maneuverable, and networked” ship that has the flexibility to execute many different naval missions (Cebrowski 2004, 6). Multi-mission modules provide this flexibility by introducing the required weapons, sensors and communications gear to the LCS hull that can be applied to a specific mission. As a matter of course, these missions may have to be conducted sequentially rather than simultaneously due to limitations in module capability and LCS hull size. The multi-mission modules may also carry unmanned vehicles for deploying remote sensors (Burgess 2006, 24). One of the largest and most versatile of these unmanned vehicles is the MQ-8B Fire Scout Unmanned Aerial System (UAS). For the purpose of this paper, the term UAS refers to the system of components that can include several unmanned aircraft (UA), a ground control station and all supporting maintenance and communications equipment. The Fire Scout UAS is composed of three MQ-8B UA and the Tactical Control System which acts as the ground control station and data link. The Fire Scout UAS is so important to the LCS missions that the Tactical Control System will be built and integrated directly into the Combat Information Center in LCS (Burgess 2005, 16). However, this unprecedented integration between ship and UA is just the next step in the evolution of shipboard UA programs.

History of Naval Unmanned Aircraft

The U.S. Navy has had a long history of shipboard UAS. The first vertical takeoff and landing UAS to be operated on a surface warship was the QH-50 Drone Anti-Submarine Helicopter. The QH-50 entered service in January 1963 with the mission of attacking submarines with onboard torpedoes. The UA also performed reconnaissance duty during the Vietnam War. Over 400 of 800 QH-50 aircraft were lost during operations mostly due to loss of communications over the horizon. Although cancelled in 1971, the significance of the QH-50 program was that it validated the concept of operating vertical takeoff and landing UA from naval ships (McKee 2006, 3). The program also underscored the need for better automated or autonomous controls and data links between the ship and the UA. Following the QH-50 program, several shipboard UAS were proposed but none were considered until the Pioneer UAS program.

The Pioneer UAS, an Israeli military program tested in combat, consisted of a fixed wing UA and portable ground control unit that was operated from the Iowa class battleships in 1991. After reassignment to LPD-class amphibious ships, the Pioneer UAS conducted reconnaissance, surveillance, and target acquisition missions until being removed in 2003 (McKee 2006, 3). During the same timeframe, the U.S. Navy considered adapting the Hunter UAS for shipboard operations. In 1995, the Commander of the U.S. Atlantic Fleet evaluated the Hunter UAS and rejected deployment because of its short, 100 mile, range and large, 12,000 cubic feet, storage space requirement (GAO 1996, 3). The significance of the Pioneer and Hunter UAS programs are that small, fixed wing UA operations onboard ships can be very cumbersome because of the complex launch and recovery procedures, poor performance, and lack of integration into the ship design.

The Fire Scout Design

The Fire Scout UAS program was reborn in 2003 out of the original winning project from the U.S. Navy's 1999 Vertical Takeoff and Landing Unmanned Aerial Vehicle Competition. This earlier program, designated RQ-8A, was fielded by Northrop Grumman and based its design on the Schweizer 333 manned, light helicopter. The program was cancelled in early 2002 due to defense budget cuts. However, in January 2003, the Fire Scout program was restored by Congress in support of the LCS. This gap of four years between program funding allowed Northrop Grumman to address the shortcomings identified by the 1999 competition and led to an improved MQ-8B that had an increased range and payload along with a change in capability from reconnaissance to multi-mission (Northrop 2007, 1). The Fire Scout program's link to the LCS program not only breathed new life into a cancelled project but allowed for the integration of all ground control station equipment into the hull design of the LCS. In comparison to the aforementioned programs, the Fire Scout UAS has improved upon many of the shortcomings that shipboard UAS have had in the past. In contrast to the UAS programs, the U.S. Navy's history manned helicopters has followed more of an evolutionary process of incremental improvements.

The Manned Helicopter

The U.S. Navy has continuously operated manned helicopters from surface ships for over 59 years (US DoN 1998, 1). The current airframe, based on the UH-60 Blackhawk, was fielded in 1983 and designated SH-60B. The SH-60B was first produced by Sikorsky Aircraft Corporation in 1977 with the purpose of providing "all-weather detection, classification, localization, and interdiction of surface ships and submarines." Other missions included Search and Rescue, Electronic Warfare (EW), and Vertical Replenishment (Jackson 2006, 881). In 2002, the U.S. Navy began remanufacturing the SH-60B, SH-60F, and HH-60H helicopters into the MH-60R. When complete, this upgrade will allow the MH-60R to conduct the following missions: Anti-Submarine Warfare, Anti-Surface Surveillance and Attack, Search and Rescue, Medical Evacuation, Vertical Replenishment, EW, and Communications Relay. Additionally, the U.S. Navy added the MH-60S to its inventory as the cargo variant helicopter. The MH-60S can conduct Airborne Mine Countermeasures (AMCM), Medical Evacuation, and Vertical Replenishment (US DoN 2006b, 68). With the reduction of the Navy's helicopter fleet, the MH-60R and MH-60S will most likely be the two types of aircraft operated from LCS. For the purpose of this thesis, the LCS is considered to only carry the MH-60R or MH-60S. It is assumed that if a mission requires the MH-60R variant then the MH-60R will be used. The same assumption applies to the MH-60S variant. This paper will refer to this pairing of missions to helicopter variants by describing the helicopter as the MH-60R/S.

Scope and Importance of the Research

The scope of this research thesis will be limited to only the missions and capabilities of the Fire Scout UAS and the MH-60R/S helicopter as they apply to the Littoral Combat Ship. As a comparison, past performance and current applications of similar systems in the U.S. and foreign navies will be considered. Fire Scout is not intended to replace the MH-60R/S. The main effort of this thesis is focused on the correct employment of Fire Scout and the MH-60R/S and not on the correct mix of unmanned and manned helicopters on LCS. Specifically, the LCS has a limited capacity to carry only two MH-60R/S helicopters, six Fire Scout UA, or a combination of one MH-60R/S and three Fire Scout UA (Spicer 2004, 13). Therefore, the scope of the analysis will be limited to the last case where the LCS deploys with one MH-60R/S and three Fire Scout UA. This research thesis characterizes the Fire Scout UA as an unarmed system. Only the MH-60R/S can carry weapons.

The importance of this research thesis will extend to several areas within the military, scientific, and industrial communities. Primarily, the findings of this research can be beneficial to naval professionals who either operate or command the LCS and its multi-mission modules. Strike group commanders and staffs will also benefit from the mission analysis for future planning considerations. The scientific community will take advantage of the additional research into semi-autonomous flight and performance capabilities of UA. Finally, the flight industry will value the requirements versus capabilities perspective that a naval project of this scope requires for future project planning.

Thesis Questions

The primary question proposed is: Is the Fire Scout Unmanned Vehicle an effective mission multiplier for the Littoral Combat Ship? In support of the primary thesis question, the research is divided into three areas with corresponding secondary research questions. The first area of research focuses on answering: What are the Navy's requirements of manned and unmanned aerial vehicles deployed on the LCS? Next, the capabilities and performance of the Fire Scout and MH-60R/S will be determined by answering the question: What mission tasks are currently performed by UA and manned helicopters? Finally, the results of the research from the two previous areas will be used to answer the question: What missions of the MH-60R can be enhanced or replaced by the Fire Scout UA? Through the analysis of this last question, the primary thesis question can then be answered.

Assumptions and Anticipated Problems

Assumptions are that the LCS, MH-60R/S, and Fire Scout UAS programs will continue to be supported through completion. Also, it is assumed that the Navy will continue to pursue advanced technology and UAS for the foreseeable future.

The anticipated problems for conducting research for this thesis are classified material and intellectual property. As with any new military technology, there is the probability that specifications may be classified. The solution to this problem is to use only open source material. Because the first two LCS designs are being built under a competitive program, the intellectual property associated with the design and construction of the LCS may not be available. By using only open source material, the potential infringement of this material can also be avoided.

CHAPTER 2

LITERATURE REVIEW

> The familiar saying that UA [unmanned aircraft] are better suited for "dull, dirty, or dangerous" missions than manned aircraft presupposes that man is (or should be) the limiting factor in performing certain airborne roles. Although any flight can be dull or dangerous at times, man continues to fly such missions, whether because of tradition or as a substitute for technology inadequacies (2005, 1)
>
> *Unmanned Aircraft Systems Roadmap, 2005-2030*

Although UA are replacing manned aircraft for missions that are considered "dull, dirty, or dangerous," the Fire Scout UAS is not considered to be a replacement for the MH-60R/S (US DoD 2005, 3). The role of the Fire Scout is to support the missions of the LCS by acting as an extended sensor platform and augmentation for the MH-60R/S (Spicer 2004, 14). Before the requirements of the Fire Scout can be outlined, the missions of LCS must first be determined. The first part of this chapter will review the literature describing the missions the U.S. Navy envisions for the LCS. The second part of this chapter continues the analysis of the LCS missions and introduces the literature that identifies the essential tasks that support each of these missions. The third section will review the literature that outlines the general missions performed by UAS in the military and civilian aviation in order to give context to the tasks that Fire Scout will be expected to perform. Finally, the fourth section will cover the literature that was required for determining the specific operational characteristics of the Fire Scout, MH-60R/S, and associated sensors and payloads.

Littoral Missions

The U.S. Navy's perceived operating environment in the littoral areas based upon the Quadrennial Defense Review 2006 and the Naval Transformation Roadmap 2005. The Quadrennial Defense Review champions the acceleration of the procurement of the LCS based upon the expansion of operation areas beyond the Asian Littorals to all littoral areas worldwide (US DoN 2006b, 36). Along with the accelerated procurement of the LCS, the number of UA will be doubled to achieve persistent surveillance (US DoN 2006b, 36). There will also be an increase in special operations and irregular warfare that will require a robust capability to operate in the littorals. Based upon the Quadrennial Defense Review, the Naval Transformation Roadmap further refines the missions required for control of the littorals.

The Naval Transformation Roadmap 2006 describes the naval capabilities required for a ship to operate in the littorals. LCS is required to perform the three crucial missions of Mine Warfare (MIW), Anti-Submarine Warfare (ASW), and Anti-Surface Warfare (SUW) (US DoN 2003, 12). These three missions are briefly summarized below.

The two domains of ASW and MIW are commonly combined under the term Undersea Warfare. This thesis will treat them as separate missions for the analysis. LCS will execute MIW using systems that employ unmanned surface and subsurface vehicles. As a general concept, these unmanned vehicles will identify sea mines by mapping the ocean floor, identifying objects that resemble mines and then sweeping or neutralizing each object. The MH-60S will work with these unmanned vehicles and employ several different AMCM capabilities. For mines near the surface, the Airborne Laser Mine Detection System will be used to identify sea mines. Once identified, the mines will be destroyed using the Rapid Airborne Mine Clearance System. For sea mines located much deeper, the MH-60S will detect mines using the AN/AQS-20A Sonar Mine detecting set and destroy the mines using the Airborne Mine Neutralization System. Finally, the MH-60S will sweep for mines buried in the sea floor by towing the Organic Airborne and Surface Influence Sweep system through the water. In difficult terrain such as the surf zone and beach zone, the LCS will employ Fire scout with the Coastal Battlefield Reconnaissance and Analysis system to identify minefields, obstacles, and beach fortifications (US DoN 2003, 28).

In the littorals, ASW is focused on gaining maritime superiority by quickly finding, destroying or avoiding enemy submarines (US DoN 2003, 19). The LCS will use unmanned surface vehicles and other deployed sensors to detect and localize submarines. The MH-60R will use the Airborne Low Frequency Sonar and sonobuoys to track the submarines. The submarines will then be engaged using the lightweight torpedo carried by the MH-60R.

LCS will conduct SUW using persistent maritime surveillance and targeting provided by Fire Scout and the MH-60R. The Fire Scout will use its Electro-Optical and Infrared (EO-IR) sensor to maintain continuous surveillance of the sea. The MH-60R will use its radar and EO-IR sensor to detect and engage surface ships. The MH-60R can use the Penguin or Hellfire missile or machine guns in the engagement. The LCS can also engage surface ships using the Non-Line of Sight Launching system or naval guns.

The Government Accountability Office (GAO) reported the details of additional LCS missions that will be required in the littoral areas. These missions ranged from

Homeland Defense to Special Operations Support (GAO 2005a, 4). Chapter 4 will define and analyze each of these additional missions.

LCS Tasks

The GAO report was used to identify the essential tasks that support each LCS mission. One task that was inferred from RDML Spicer's brief and not identified in the GAO report was the identification of land mines buried in the surf and beach zones (Spicer 204, 16). This task was added to the analysis. All of the tasks were compared to the Universal Naval Task List and the Naval Tactical Task List (NTTL) in order to determine validity and relevancy. The analysis in chapter 4 defines these tasks and characterizes the performance of Fire Scout and the MH-60R/S during the execution of these tasks.

General UAS Missions

Currently, there is plethora of published material about the modern UA. Numerous military magazines and professional journals have published articles about the current UA technological achievements and the latest UA projects. Over the past decade, the Defense Science Board, Congressional Research Service, and the General Accounting Office have published reports on the state of U.S. military UA programs. The Army, Navy, and Air Force also have well documented Field Manuals, Concepts of Operations, and Tactics, Techniques, and Procedures for operating UA. However, very few reports have been published about operating UA from naval ships or performing UA missions in littoral waters. Chapter 4 will analyze the development of several U.S. and foreign military programs identified in the review of open source literature. The analysis also includes a review of UA sensors and payloads.

Operational Characteristics

The specific operational characteristics of the Fire Scout, MH-60R/S, and associated sensors and payloads were derived from several sources. Manufacturer's specifications from Northrop-Grumman, Sikorsky Aircraft Association, FLIR Systems, and Raytheon along with data from Jane's Information Group were used to compare important operational parameters. Appendices A and B contain a summary of the data that was used for the analysis.

CHAPTER 3

RESEARCH METHODOLOGY

> For waging war you need guidance, and for victory many advisors.
>
> *Proverbs 24:6*

This chapter provides the guidance for the analysis in chapter 4. The challenge of answering the primary thesis question is that the LCS program has not been fully developed. LCS is an unproven design with the first ship of the class launched but not commissioned. In the same manner, the Fire Scout program has not yet reached operational capability and is still in the test and evaluation phase. The MH-60R/S is the only mature program that has been fully tested and is proceeding beyond initial operating capability. Therefore, the documentation that supports the analysis for chapter 4 will rely more heavily upon the program progress reports and program manager interviews and less upon doctrine, tactics, techniques and procedures.

The methodology used to answer the primary research question is divided into three parts corresponding to the three secondary research questions. The first two parts of the analysis will use literature review to determine the requirements of manned and unmanned helicopters on LCS along with the capabilities of each of these helicopters. Part one answers the secondary research question: "What are the Navy's requirements of manned and unmanned aerial vehicles deployed on the LCS?" The literature review will develop a list of missions and essential tasks. This list will then be refined by deleting any tasks that will not require support from a manned or unmanned helicopter.

The second part of the analysis will focus on answering the secondary research question: What missions do manned and unmanned helicopters currently perform? Using the literature reviewed in chapter 2, the past performance and current applications of similar UAS in the U.S. and foreign navies will be considered. The most recent documentation from the ongoing MH-60R/S and Fire Scout programs will also be used to compare airframe performance and sensor capabilities. This comparison will determine the suitability of the Fire Scout and MH-60R/S to perform a variety of tasks.

The third part of the analysis will answer the secondary thesis question: What missions of the MH-60R can be enhanced or replaced by the Fire Scout UA? Given the list of essential tasks that LCS will be required to perform from part one and the performance capabilities of the Fire Scout and MH-60R from part two, a matrix will be built in order to compare each LCS requirement to the capabilities of the Fire Scout and MH-60R/S. An example of this matrix is shown in the table 1.

Table 1. Sample Task

Fire Scout				MH-60R				Combined Systems			
Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability
+	+	+	+	+	+	+	++	+	+	+	+++
			Total 4				Total 5				Total 6

The three sections of the table above are labeled Fire Scout, MH-60R/S, and Combined Systems. The Fire Scout section represents the graded performance of the Fire Scout UAS for that specific task contained in the title of the table. In the same manner, the next section represents the graded performance of the MH-60R or MH-60S depending on the variant most capable of performing the task. The Combined Systems section represents the graded performance when the Fire Scout UAS and MH-60R/S are used cooperatively. Literature review demonstrated a current trend of operating manned and unmanned vehicles together as an effective mission multiplier. This trend was captured in the third section.

Each section was divided into four columns that represent the four performance categories that were chosen for evaluation. Based on this author's experience, the categories of speed, endurance, survivability, and capability were chosen to represent physical aspects of task performance that would be important to an officer in command of the LCS or mission module. The reason for choosing each category is explained below.

Speed is important to several tasks in order to maintain real time or near real time data that can aid in the commander's decision process. The compressed time sequences in littoral combat situations emphasize using speed to maintain an accurate view of the battle space. An increase in speed may lead to a decrease in loiter time, therefore, endurance will also be analyzed. Endurance is important to tasks that cover vast operating areas or require persistent sensor coverage. The next factor to be considered is survivability. A commander's aversion to mishap is important to task accomplishment and the preservation of assets. This multidimensional criterion will focus more upon airframe characteristics than crew protection. High risk missions that jeopardize crew safety would always lead to a decision to not employ a manned helicopter and would, therefore, bias every study into choosing the unmanned platform. Focusing on airframe characteristics will correct for this bias and keep the analysis equitable. The last criterion, capability, will measure the level of achievement of each task based upon key capabilities identified in the task analysis. The quality of performance of that key capability will be measured among the competing platforms in order to determine the degree of mission success.

This author chose a grading scale based upon a simple points system that assigned one point for each plus sign, a negative one point for each minus sign, and zero points for each n/a based upon the parameters below:

1. Characteristic significantly contributes to task accomplishment (+++).
2. Characteristic was essential to task accomplishment (++).
3. Characteristic partially accomplishes task (+).
4. Characteristic was not sufficient to accomplish task (-).
5. Characteristic is not necessary for task accomplishment (n/a).

The arithmetic sum of each criterion grade will be presented at the bottom of each table. After all tasks have been analyzed, a complete table listing the analysis results of every task was placed in appendix C. Additionally, a table that summarizes each mission area was included in that same appendix.

Finally, the answer to the primary thesis question will be derived from the results of all three secondary thesis questions. The strength of using this methodology is the ability to use several sources of literature to present a coherent, equally weighted matrix that presents a quantitative analysis of platform advantages and disadvantages. This method also corrects for any bias in any one performance parameter by using a sum of all mission parameters. The weakness of using this methodology is that some of the data used for the matrix is based upon unproven or underdeveloped technology. This inherently draws a comparison between current capabilities and futures capabilities which could possibly lead to inaccurate results.

CHAPTER 4

ANALYSIS

The first part of this analysis focused on answering the secondary research question: What are the Navy's requirements of manned and unmanned aerial vehicles deployed on the LCS? The answer to this question was based upon the review of the Universal Naval Task List, the NTTL, a conference proceedings by Rear Admiral Lower Half (RDML)Ray Spicer, and the GAO report titled "Plans Need to Allow Enough Time to Demonstrate Capability of First Littoral Combat Ships." The results of the research generated a list of missions that LCS was required to perform. These tasks were divided into the two categories of focused missions and inherent missions. A focused mission was broadly defined as a single functional role that LCS was designed to execute. The emphasis was placed upon the single role because the LCS will not be expected to perform more than one focused mission at a time without changing the mission module or support from additional naval or joint units. Conversely, inherent missions were defined as enduring functional roles performed simultaneously or in succession with other inherent missions or one focused mission (GAO 2005a, 5).

Focused Missions

As defined in the paragraph above, the essential missions that LCS will be required to perform MIW, ASW, and SUW in the littoral areas. In order to conduct MIW in the littoral environment, LCS will be required to perform the following tasks: detect, avoid, and neutralize sea and land mines, clear transit lanes, or establish and maintain mine cleared areas. The task of clearing transit lanes was deleted from the analysis because it was redundant with the other task of establishing and maintaining mine cleared areas. Littoral ASW contains the following tasks: detect all threat submarines, protect forces in transit, and establish anti-submarine barriers. Littoral SUW requires LCS to detect, track, and engage small boat threats, escort ships through choke points, and protect joint operating areas (GAO 2005a, 6). A summary of the essential missions and their corresponding tasks is listed in the table 2.

Table 2. LCS Essential Missions

Focused missions	**Essential Tasks**
Littoral mine warfare	• Detect, avoid, and/or neutralize mines • Establish and maintain mine cleared areas
Littoral anti-submarine warfare	• Detect all threat submarines in a given littoral area • Establish anti-submarine barriers • Neutralize the submarine threat
Littoral surface warfare	• Detect, track, and engage small boat threats • Escort ships through choke points • Protect joint operating areas

Source: Government Accountability Office, *Plans Need to Allow Enough Time to Demonstrate Capability of First Littoral Combat Ships, GAO-05-255* (Washington DC:GPO, 2005), 6.

Inherent Missions

Using the definition for inherent missions given previously, the additional missions that LCS will be required to accomplish fall into the categories of battle space awareness, joint littoral mobility, special operations support, maritime interdiction, homeland defense, antiterrorism, and force protection. This list of inherent missions was consistent with RDML Spicer's brief but with two exceptions. First, the GAO report characterized intelligence, surveillance, and reconnaissance as battle space awareness. This thesis will use the term battle space awareness. Second, homeland defense was included as an inherent mission in the GAO report but was missing from RDML Spicer's brief. This thesis will include homeland defense in the analysis. Table 3 lists the tasks associated with each inherent mission. The results of this analysis were used to build the analysis framework for section three of this chapter with the goal of answering the third thesis secondary question.

The second part of the analysis focused on the secondary research question: What missions and tasks were currently performed by manned and unmanned aerial vehicles? Using the literature review, the current capabilities of the production versions of the MH-60R/S were assessed. Additionally, the performance of the pre-production versions of Fire Scout and similar UA was reviewed in order to predict the capabilities that Fire Scout will have when deployed in LCS.

The capabilities of the MH-60R/S were proven through the U.S. Navy's test and evaluation program leading up to current production. Generally, the MH-60R and MH-60S were designed to perform the multiple transport missions that any utility helicopter would perform. The MH-60R was enhanced to carry out ASW, SUW, and EW in all weather conditions. The MH-60S, in addition to its transport role, boasts an airborne mine countermeasure capability (Jackson 200, 883). Appendices A and B contain the details of the capabilities of each major system. These capabilities were applied in the third section of this chapter for determining the relationship between the capabilities of the MH-60R/S and tasks required by the LCS. Similarly, the Fire Scout's capabilities were analyzed next.

Table 3. LCS Inherent Missions

Inherent Missions	**Essential Tasks**
Battle space awareness	• Intelligence, surveillance, and reconnaissance
Joint littoral mobility	• Provide transport for personnel, supplies and equipment within the littoral operating area
Special operations forces support	• Provide rapid movement of small groups of special operations forces personnel • Support hostage rescue operations • Support noncombatant evacuation operations • Support and conduct combat search and rescue
Maritime interdiction/interception	• Conduct maritime law enforcement operations, including counter narcotic operations, with law enforcement detachment
Homeland defense	• Perform maritime interdiction/interception operations in support of homeland defense • Provide emergency, humanitarian and disaster assistance • Conduct marine environmental protection • Perform naval diplomatic presence
Antiterrorism/force protection	• Perform maritime interdiction/interception operations in support of force protection operations • Provide port protection for U.S. and friendly forces and protection against attack in areas of restricted maneuverability

Source: Government Accountability Office, *Plans Need to Allow Enough Time to Demonstrate Capability of First Littoral Combat Ships, GAO-05-255*(Washington DC:GPO, 2005), 6.

Since the Fire Scout was still in the engineering, manufacturing, and development program, its capabilities had not been fully explored and proven. The review of literature revealed that the Fire Scout program for the U.S. Navy was much further advanced than foreign navy programs. Therefore, in order to determine the potential capabilities of Fire Scout, the capabilities of similar tactical UAS were compared and analyzed. For clarity, the UAS were divided into two broad categories: naval fixed wing UA and vertical takeoff and landing UA. Likewise, the sensor capabilities of other UAS were also analyzed in order to determine the feasibility of employing a UAS payload to accomplish a certain task.

Fixed Wing UA Programs

Naval UA have the unique and difficult requirement to operate from a ship at sea. The U.S. Navy Pioneer fixed wing UAS was operated by the U.S. Marine Corps and capable of conducting reconnaissance, surveillance, target acquisition, and battle damage assessment. The Pioneer was difficult to operate from a ship because it was not capable of vertical takeoff and landing (McKee 2006, 2). Additionally, the U.S. Navy fleet commanders rejected a similar fixed wing UA, the Army's Hunter, for similar missions due to its short range, cumbersome launch and recovery operations, and the lack of all weather capability (GAO 1996, 2). Other navies have also examined the feasibility of operating fixed wing UA from ships with some degree of success. One example was from the Boeing Scan Eagle test conducted by the British Navy. The Scan Eagle demonstrated the ability to detect objects "as small as a jet ski" while it conducted intelligence, surveillance, and reconnaissance missions (Professional Engineering 2006, 13).

In addition to ship launched UA, several navies conducted evaluations of land-based UA for broad area maritime surveillance. The U.S. Navy had conducted experiments using the Global Hawk UAS to provide persistent radar coverage of the ocean for up to 35 hours. Similarly, Australia demonstrated the ability to conduct coastal surveillance using the General Atomics Mariner UAS by passing radar sensor data to a local Royal Australian patrol boat (Eshel 2006a, 1). The importance of these two examples to this analysis was the demonstration of persistent maritime surveillance and cooperation between several UAS with differing capabilities. This meant that the Global Hawk or other maritime surveillance UA could provide the initial large area surveillance data for the Fire Scout to conduct localized investigation (Burgess 2005, 12).

Vertical Takeoff and Landing UA

The Bell Eagle Eye, a proposed replacement for the U.S. Marine Corps' Pioneer (Hough 2005, 19), was evaluated by the U.S. Coast Guard and the French Navy. The Eagle eye feature an all-weather capability and vertical take off and landing. The U.S. Coast Guard procured the Eagle Eye to conduct surveillance and intelligence gathering using its onboard radar and optical sensors. Eagle Eye had a payload capacity of 300 lb which is half of the Fire Scout's capacity. It also demonstrated a five hour endurance which is over two hours less than Fire Scout (Beshears 2004, 6). The Eagle Eye had a tilt-rotor design but conventional rotary wing designs were also considered.

The French built Orka-1200 UAS consisted of two UA that could conduct tasks similar to Fire Scout. The airframe had a payload capacity of 400lb. and an endurance of eight hours (EADS 2006, 1). Another French Naval UAS design revealed a trend of converting manned helicopters into operational UA. Just as Fire Scout's airframe was based upon the Schweizer 333, the two seat Cabri G2 light helicopter, designed by Bruno Guimbal, was converted to a French Navy UA prototype. This prototype had a 330 lb payload capacity and endurance of 8 hours (McKenna 2005, 1).

UA Sensors

Fire Scout is basically an autonomous airframe that can accept different modular sensor packages and does not have any permanent sensors. The first sensor package developed for Fire Scout is the BriteStar sensor. The BriteStar is a combined electro-optical, infrared and laser designated device (BriteStar 2006,1). Several other UA carry similar EO-IR sensors. One example is the Predator UA sensor that compares very closely to the BriteStar's field of vision and magnification ratio. This sensor will also be integrated into the MH-60R/S airframes in the near future.

Maritime surveillance requires very robust tracking capabilities. The Fire Scout program has not fielded a radar sensor. However, both Israel and France have produced UAS with synthetic aperture radars designed specifically for maritime surveillance (Eschel 2005, 1; Eschel 2006b, 1). Northrop Grumman and General Atomics have both developed synthetic aperture radar packages for Fire Scout but the U.S. Navy has not yet pursued procurement (Nitschke 2003, 27).

The Fire Scout lacks the payload capacity to carry equipment capable of conducting electronic attack like the equipment carried by an EA-6B Prowler (Fulghum 2003, 27). The Navy Global Hawk had demonstrated the use of an electronic surveillance system for detecting radar emissions, but the system exceeded the Fire Scout's payload capacity (Burgess 2005, 12). However, the Rafael company of Israel introduced the Top Scan electronic surveillance system for UA in 2002 with a capability to operate in a "dense emitter environment" while weighing only 132lb (Rafael 2006, 1). These examples demonstrate that the technological capability exists to put an electronic surveillance payload onto Fire Scout.

Two sensor packages not identified outside of the Fire Scout program during the literature review were the airborne communications relay and land mine detection packages. These packages had a very specific application to Fire Scout and this author feels that the absence of information may indicate a lack of commercial interest.

The third section of this chapter is built upon the analyses conducted in the prior two sections and answers the secondary thesis question: What missions of the MH-60R can be enhanced or replaced by the Fire Scout UA? Each essential task identified in the first part of this chapter was analyzed using the capabilities developed in chapter 2 and the previous section in this chapter. Each aircraft system was analyzed for its performance capability in four different categories. The categories of speed, endurance, survivability, and capability were chosen by this author in order to assign grading criteria that represent important physical aspects of task performance. The grading criterion was assigned using a simple point system which is defined as:

1. Characteristic significantly contributes to task accomplishment (+++).
2. Characteristic was essential to task accomplishment (++).
3. Characteristic partially accomplishes task (+).
4. Characteristic was not sufficient to accomplish task (-).
5. Characteristic is not necessary for task accomplishment (n/a).

In order to summarize the grading, one point was assigned for each plus sign, a negative point was assigned for each minus sign, and zero points were assigned for each n/a. The first vehicle system analyzed was the Fire Scout, followed by the MH-60R/S, and then the combination of the MH-60 and Fire Scout as a team. The order of analysis follows the same order of tasks presented in the previous two tables.

The proposed deployment of helicopters on LCS is three MQ-8B UA in one hangar and a single MH-60R/S in the other hangar. This three to one ratio between platforms allows a complete 24 hours of mission coverage based on seven hours of endurance for Fire Scout and three hours of endurance for the MH-60R/S. For missions that do not require this type of persistence, the Fire Scout still has twice the endurance as the MH-60R/S at the same speed. In several tasks where persistence was an important operating parameter, the endurance of the Mh-60R/S was considered the baseline and Fire Scout was graded higher because of its greater endurance. The rest of this chapter will cover the individual analysis of each task.

Littoral Mine Warfare

Littoral mine warfare for this analysis was comprised of the following tasks: detect and neutralize sea mines using AMCM, detect and neutralize land mines in the surf and beach zones, and establish and maintain mine cleared areas. The NTTL measures the performance of these tasks in terms of the number of mine-like objects found, accuracy of identifying the mine-like objects, and the percentage of mines neutralized.

Mine detection and neutralization was a task where the capabilities of Fire Scout and the MH-60S diverge. Fire Scout did not have the capability to conduct AMCM. The MH-60S had the capability to conduct AMCM using several different payloads. For mines near the surface, the Airborne Laser Mine Detection System will be used to identify sea mines. Once identified, the mines will be destroyed using the Rapid Airborne Mine Clearance System. For sea mines located much deeper, the MH-60S will detect mines using the AN/AQS-20A Sonar Mine detecting set and destroy the mines using the Airborne Mine Neutralization System. Finally, the MH-60S will sweep for mines buried in the sea floor by towing the Organic Airborne and Surface Influence Sweep system through the water (US DoN 2006b, 28). According to one study, the AN/AQS-20S might be as much as three times as effective as the current AMCM systems (Vego 2005b, 12). The MH-60S had the endurance to search large areas and the speed to conduct the search quickly. As for the number of mine-like objects found and the accuracy of identifying the mine-like objects, none of these prototype systems have reached initial operating capability which means what little data was available was more anecdotal than objective (US DoD 2001, 76).

For the near term, EOD divers will conduct mine neutralization missions. Only the MH-60S can carry EOD divers. Projected future capabilities for the MH-60S include the ability to destroy sea mines in the water using super-cavitating projectiles. Fire Scout does not have the capability to neutralize sea mines or land mines and was not graded in terms of speed, survivability, and endurance. Based upon mine hunting and neutralization capabilities, the grades were assigned in table 4.

Table 4. Detect, Avoid, And Neutralize Sea Mines

Fire Scout				MH-60S				Combined Systems			
Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability
n/a	n/a	n/a	-	n/a	+	++	++	n/a	+	++	++
			Total -1				Total 5				Total 5

The MH-60S does not have the capability to detect mines buried in the surf zone or on the beach. Fire Scout can use the Coastal Battlefield Reconnaissance and Analysis system to identify minefields, obstacles, and beach fortifications (US DoN 2006b, 28). In one demonstration, this system achieved an 80 percent probability of mine detection and a 30 percent probability of false detection in one demonstration (US Dod 2001, 76). Fire Scout does not have the capability to destroy land mines. The grading for this task was assigned in table 5.

Table 5. Detect, Avoid, and Neutralize Land Mines

Fire Scout				MH-60S				Combined Systems			
Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability
n/a	+	+	+	n/a	n/a	n/a	-	n/a	+	+	+
			Total 3				Total -1				Total 3

The next task, establish and maintain mine cleared areas, can be considered offensive mine warfare. The goal of offensive MIW is to prevent the enemy from laying mines after an area is cleared. The difficulty of this task is that almost any vehicle can be a mine laying platform. Aircraft, surface ships, submarines, and unmanned vehicles can all lay mines (Vego 2005a, 76). Offensive strikes on all mine laying platforms is beyond the capability of LCS. However, the prevention of surface ships and submarines from entering cleared areas essentially becomes a SUW and ASW task, respectively.

Therefore, the analysis of this task is the same as the analysis conducted for protecting joint operating areas for SUW and detecting all threat submarines in a given area for ASW. The scores for these two tasks were combined for each platform and summarized in table 6.

Table 6. Establish And Maintain Mine Cleared Areas

Fire Scout				MH-60S				Combined Systems			
Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability
++	++	+	+	++	+	+	+++	++	++	+	+++
			Total 6				Total 7				Total 8

Littoral Anti-submarine Warfare

Littoral ASW was more complicated than MIW because the adversary was a moving submarine that could evade detection and attack at greater ranges than a sea mine. The NTTL does not define ASW as a tactical task, but the Universal Naval Task List includes ASW in the strategic task of gaining and maintaining theater maritime superiority. The applicable measurements that this strategic task uses were related to the percent of friendly operations that were delayed or disrupted and the amount of time it takes to gain maritime superiority (US DoN 2005, 4). Additional factors that need to be considered were the ability to detect submarines above and below the water surface, to protect forces in transit, and neutralize the submarine threat (US DoN 2003, 5). Transcending all of these factors was the ability to contribute to the common maritime picture through high speed data links and superior processing capability. Three ways to detect a submarine are: acoustically through active and passive sonar, visually through radar and optical sensors, and electronically through electronic surveillance. Acoustic detection of a submarine below the surface was a task that can only be performed by the MH-60R using the airborne low frequency sonar and sonobuoys (Milaero 2005, 32). The Fire Scout does not have any sensors for detecting completely submerged submarines. However, it can detect surfaced submarines and periscopes located above the water's surface using the EO-IR sensor.

Visual searches using an EO-IR sensor cover a small area in comparison to the large operations areas that need to be searched. Finding a submarine periscope at the water's surface was very unlikely against a modern diesel submarine or a nuclear powered submarine. The MH-60R had a similar EO-IR sensor for detecting periscopes but also had an Inverse Synthetic Aperture Multi-Mode Radar. The radar was enhanced to detect surfaced submarines and periscopes (Milaero 2005, 33). This allows the MH-60R to cover the surface area that was an order of magnitude larger than the EO-IR sensor.

Submarines were detected at the greatest range using passive detection of electromagnetic radiation. The ES systems installed on the MH-60R have a detection capability spread across the frequency spectrum that includes some submarine communications and radar systems (Jackson 2006, 880). The Fire Scout does not currently have an ES system as a programmed payload. All of these sensors are not effective if the platform cannot get to the proper location expeditiously and stay on station for extended periods of time. Both Fire Scout and the MH-60R can sprint at greater than 120 knots but Fire Scout has a much greater endurance (Jackson 206, 881). As shown in table 7, both platforms were graded equally in speed. Fire Scout was graded higher in endurance for this task. For the overall task of submarine detection, the Fire Scout capability was graded with (+) and the MH-60R capability with (+++) to show the superior sensor coverage of the latter platform.

Table 7. Detect All Threat Submarines in a Given Littoral Area											
Fire Scout				MH-60R				Combined Systems			
Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability
+	++	n/a	+	+	+	n/a	+++	+	++	n/a	+++
Total 4				Total 5				Total 6			

The tasks of establishing submarine barriers can only be conducted by the MH-60R. Submarine barriers consist of deploying a line of active or passive sonobuoys. Additionally, the persistent use of active sonar can be used to drive a submarine away from an area or towards a barrier. Fire Scout does not have to capability to carry sonobuoys or sonar. Fire Scout's only contribution to this task was the ability to extend the range of the sonobuoy barrier through the use of the communications relay mission package. Table 8 summarizes the grades assigned.

Table 8. Establish Submarine Barrier											
Fire Scout				MH-60R				Combined Systems			
Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability
+	+	n/a	-	+	+	n/a	++	+	++	n/a	+++
Total 1				Total 4				Total 6			

The final task of neutralizing the submarine was analyzed through the review of the weapons delivery capability of each helicopter. This author defined neutralization as using a kinetic weapon to render a submarine incapable of conducting its mission. The MH-60R can carry anti-submarine torpedoes. The Fire Scout does not have the payload capacity to carry any torpedoes (Jackson 2006, 881). For this analysis, the MH-60R was the only platform that could neutralize a submarine. Table 9 summarizes the grading assigned for this task.

Table 9. Neutralize Threat Submarines											
Fire Scout				MH-60R				Combined Systems			
Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability
n/a	n/a	n/a	-	+	+	n/a	++	+	+	n/a	++
Total -1				Total 4				Total 4			

Littoral Surface Warfare

Surface warfare in the littorals was more complicated than open ocean surface warfare because of the high density of coastal shipping and the potential close proximity to fast inshore attack craft and coastal defensive weapons. The littoral environment is also cluttered by the backdrop of coastal terrain, underwater obstacles, background lighting, and shoal water. This situation requires an emphasis on better surveillance and tracking of surface vessels along with speed and persistence in order to prevent, deter, or neutralize attacks. The three tasks evaluated for surface warfare were: detect, track, and engage small boat threats; escort ships through choke points; and protect joint operating areas. All three of these tasks were dependant upon the ability to detect and track all surface vessels.

The MH-60R has a tremendous ability to contribute to the maritime common operating picture using radar and EO-IR sensors (US DoN 2006b, 71). The combination of these sensors and the visual coverage by the helicopter crew enabled the MH-60R to outperform the Fire Scout's ability to detect and track multiple contacts. The Fire Scout's EO-IR sensor did not have the same long range detection capabilities as radar and was able to identify and track only a few contacts at a time in close proximity of each other. The best employment of the Fire Scout was to assign a sector or high interest target for autonomous tracking while the MH-60R conducted large area detection using its radar. In this case, the longer endurance of the Fire Scout was leveraged while the speed and breadth of coverage from the MH-60R was maintained.

After establishing the identity and maintaining an accurate track small boat threats, the next task was to engage the small boats. Since Fire Scout is not armed, the

MH-60R was the only platform that could destroy a surface vessel. The MH-60R armament included Penguin anti-shipping missiles, Hellfire anti-armor missiles, and door mounted machine guns (Jackson 2006, 884). Therefore, the capability of the MH-60R exceeds that of the Fire Scout for this task. Table 10 summarizes the grades for this task.

Table 10. Detect, Track, and Engage Small Boats

Fire Scout				MH-60R				Combined Systems			
Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability
++	+	+	+	++	+	+	+++	++	++	+	+++
			Total 5				Total 7				Total 8

The second littoral surface warfare task was escorting ships through choke points. This task was a focused execution of the previous task of detecting, tracking, and engaging small boat threats. A choke point was an area of constricted maneuver space with increased traffic density (O'Rourke 2005, 104). In a confined operating area, the endurance of the Fire Scout and MH-60R was still a relevant factor while speed performance of the MH-60R and Fire Scout offered an increase in mission capability over the LCS performing this task alone. Both the MH-60R and Fire Scout were given the same performance grades as the previous task. With the combined systems, the Fire Scout was more effectively employed as a surface vessel tracking platform using the EO-

IR sensor and allowing the MH-60R to focus on conducting visual identification and attacks. A summary of the grades is listed in table 11.

Table 11. Escort Ships Through Choke Points

Fire Scout				MH-60R				Combined Systems			
Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability
++	+	+	+	++	+	+	+	++	++	+	+++
			Total 5				Total 5				Total 8

The third littoral surface warfare task was protecting joint operating areas. Joint operating areas vary in size and shape. Littoral areas can extend out from the coastline as far as twenty nautical miles and reach a hundred to several hundred miles along the coast. The LCS with its organic MH-60R and Fire Scouts can effectively survey only a finite area during a given time period, therefore, the number of cooperative LCS ships will increase as the size of the joint operating area increases in size. The task of protecting the joint operating area was essentially the same as the task of detecting, tracking, and engaging small boat threats with the added dimension of cooperating with other naval ships in the joint operating area. Because of the short range of UHF transmissions, the ability to communicate and relay UHF data becomes the critical criteria for evaluation of this task. The MH-60R had capability to transmit precise geographic data to LCS using UHF and satellite data links (Jackson 2006, 881). The Fire Scout only had a UHF line of sight data link (Northrop 2007, 2). Therefore, the MH-60R had a more robust data relay capability than the Fire Scout.

The combination of Fire Scout and the MH-60R will not only overcome the Fire Scout's shorter ranged communications but will also increase the size of the surveillance area. This cooperative use will give the combined systems a great improvement over operating the MH-60R and Fire Scout independently. Table 12 contains a summary of the scoring for this task.

Table 12. Protect Joint Operating Areas

Fire Scout				MH-60R				Combined Systems			
Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability
++	++	+	+	++	+	+	++	++	++	+	+++
			Total 6				Total 6				Total 8

Battle Space Awareness

The mission of battle space awareness was defined as intelligence, surveillance, and reconnaissance. Intelligence is the synthesis of information gained through surveillance and reconnaissance (US DoA 2004, 1-7). The MH-60R and Fire Scout can both conduct surveillance and reconnaissance and relay information to LCS or other naval units for intelligence processing. As discussed in the littoral surface warfare task analysis, the MH-60R had a marked advantage over Fire Scout in conducting surveillance and reconnaissance because it employs radar and visual coverage by the helicopter crew. Therefore, the grade for capability for the MH-60R will be greater than the Fire Scout. Table 13 summarizes the analysis for battle space awareness.

Table 13. Intelligence, Surveillance, and Reconnaissance

Fire Scout				MH-60R				Combined Systems			
Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability
+	++	++	++	+	+	+	+++	+	++	++	+++
Total 6				Total 6				Total 8			

Joint Littoral Mobility and Special Operations Forces Support

Joint littoral mobility was the ability to provide transport for personnel, supplies, and equipment in the joint operating area. The Fire Scout could not transport personnel and had a small payload capacity of 600lbs without the installation of the mission module. The MH-60S payload capacity of 7,829lbs dwarfed the Fire Scout’s capability. The MH-60S can transport personnel and supplies internally or carry equipment and supplies externally on the centrally mounted 6,000lb capacity cargo hook (Jackson 2006, 881). The vertical replenishment capability of the MH-60S makes it a vital asset to the

LCS. The MH-60S received higher grades in capability than Fire Scout in most of the tasks in this section. The evaluation of joint littoral mobility was summarized in table 14.

Table 14. Provide Transport for Personnel, Supplies, and Equipment											
Fire Scout				MH-60S				Combined Systems			
Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability
n/a	n/a	n/a	-	+	+	+	+++	+	+	+	+++
			Total -1				Total 6				Total 6

Special Operations Forces Support

Support to special operations forces entails a variety of different mission areas with unrelated tasks. The four tasks that fall under special operations support were: provide rapid movement of small groups of special operations forces, support hostage rescue operations, support noncombatant evacuation, and conduct combat search and rescue.

The Navy Tactical Task List characterizes the task of conducting tactical insertion and extraction in terms of the time between warning order and execution, the number of casualties received during execution, and the delay in establishing communications with personnel to be extracted (US DoN 2001, 9). Additional items of consideration include the capacity and survivability of the transport vehicle. The MH-60S had a greater personnel capacity than the MH-60R and was assessed for this task. However, the MH-60R was capable of completing all of the task requirements also. Since the Fire Scout could not transport personnel, it was not able to accomplish this task completely. However, it does have a small payload capacity to transport equipment and supplies to special operators plus the ability to act as a communications relay platform. These additional capabilities give an advantage to the Fire Scout and MH-60S team over a lone MH-60S.

The MH-60S was well equipped to perform the rapid movement of personnel. It had a large transport capacity for personnel and equipment, carries a robust communications suite, and possesses the speed to operate in combat situations. The addition of the Fire Scout's aforementioned communications relay capability to the MH-60S' attributes resulted in an even more potent capability to perform this task. The combined systems received higher scores in endurance and capability. The results of the grading were summarized in table 15.

Table 15. Rapid Movement of Special Operations Personnel

Fire Scout				MH-60S				Combined Systems			
Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability
n/a	n/a	n/a	-	+	+	+	++	+	+	+	++
Total -1				Total 5				Total 5			

The next task, hostage rescue and noncombatant evacuation operations, required many of the same capabilities as the previous task. For the same reasons mentioned in the last two paragraphs, the Fire Scout can only be analyzed as performing the support role to the MH-60S. The additional capability that Fire Scout brings to these tasks gives the advantage to the MH-60S and Fire Scout team. Table 16 summarizes the grading for this task.

Table 16. Support Hostage Rescue and Noncombatant Evacuation Operations

Fire Scout				MH-60S				Combined Systems			
Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability
+	+	+	+	+	+	+	++	+	+	+	+++
			Total 4				Total 5				Total 6

In addition to the required capabilities mentioned in the previous two tasks, combat search and rescue required a robust capability to operate in hostile territory and in all weather conditions. The self protection systems of the MH-60S provided a great advantage over the Fire Scout (Jackson 2006, 882). Additionally, the EO-IR sensors on both platforms provided essential support during adverse weather and night time operations. As a team, the Fire Scout would operate as a covert detection sensor which limited the exposure of the MH-60S prior to conducting the personnel extraction.

Therefore, the combined system was the most effective for accomplishing this task. The results of this task analysis were summarized in table 17.

Table 17. Conduct Combat Search and Rescue											
Fire Scout				MH-60S				Combined Systems			
Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability
+	+	+	+	+	+	++	++	+	++	+++	+++
			Total 4				Total 6				Total 9

<u>Maritime Interception Operations</u>

Maritime interception operations include a broad range of naval activities designed to interdict sea lines of communication to prevent the growth of terrorism, piracy, slavery, and illegal drug trade, or enforce economic sanctions (Uhls 2002, 69). These activities rely heavily upon intelligence, reconnaissance, and surveillance culminating with vessel queries and inspections. The tasks normally associated with maritime interception include surveillance, reconnaissance, communications, and network management which have been discussed above but also include boarding and searching selected maritime vessels. The support that Fire Scout and the MH-60R provide during vessel searches is discussed below.

A vessel boarding team normally embarks a vessel under inspection using the LCS organic small boat to deliver the team to a boarding ladder. As the team climbs onboard the vessel, it is vulnerable to attack. The MH-60R provides security by monitoring the crew's activities and covering the boarding team's movement with the door mounted machine guns. The MH-60R also provides a lifeguard function with its ability to retrieve any boarding team members that fall into the water during the boarding. Additionally, if there are injuries to the crew or boarding team that require immediate evacuation, the MH-60R can provide immediate medical evacuation to LCS or shore facilities. The Fire Scout was only capable of maintaining surveillance of the vessel and was not capable of performing lifeguard recovery or medical evacuation. Furthermore, the congestion of the airspace directly above the vessel being boarded increases the risk of collision between the manned and unmanned helicopters. Therefore, using the MH-60R and Fire scout together during boarding and inspection was less advantageous. However, by maintaining Fire Scout in a surveillance role outside of the MH-60R's airspace, the risk of collision was mitigated and a more coherent maritime picture was maintained. For these reasons, the MH-60S and combined systems were graded equally for capability in this task. The assigned grades are presented in table 18.

Table 18. Conduct Maritime Interdiction Operations											
Fire Scout				MH-60S				Combined Systems			
Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability
+	+	+	+	+	+	+	++	+	+	+	++
Total 4				Total 5				Total 5			

Homeland Defense

Homeland defense includes the tasks: providing emergency, humanitarian, and disaster assistance; conducting marine environmental protection; and performing maritime interdiction operations. The analysis of maritime interdiction operations was similar to the maritime law enforcement operations task analysis and was assigned the same grades. These grades are summarized in table 19.

Table 19. Conduct Maritime Law Enforcement Operations											
Fire Scout				MH-60S				Combined Systems			
Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability
+	+	+	+	+	+	+	++	+	+	+	+++
Total 4				Total 5				Total 6			

The MH-60S and Fire Scout assist the LCS crew with providing emergency, humanitarian, and disaster assistance by acting as a communications platform for command and control elements and conducting surveillance and reconnaissance. The MH-60S provides the additional capability of personnel rescue, armed security, and vertical transport. The lift capability of the MH-60S was a great asset to any organization providing assistance. The combination of the Fire Scout as a surveillance platform and the MH-60S as a rescue and transportation platform provides a great increase in assistance capability. The results of the analysis were summarized in table 20.

Table 20. Provide Emergency, Humanitarian, and Disaster Assistance

Fire Scout				MH-60S				Combined Systems			
Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability
+	+	+	-	+	+	+	++	+	+	+	++
			Total 2				Total 5				Total 5

The purpose of marine environment protection was to prevent damage to the marine environment by the discharge of oil and other pollution by vessels at sea. The role of LCS would be to detect and prevent or limit these discharges (Karr 2004, 5). The Fire Scout and MH-60R would be tasked to conduct vessel surveillance and detection of pollution. This task was very similar to the littoral surface warfare tasks involving maritime surveillance. Both helicopter platforms had an effective surface surveillance capability. The MH-60R's radar had an advantage of longer detection ranges in addition to the crewmembers' ability to detect subtle details such as an oily sheen on the water's surface. Operating the MH-60R and Fire Scout as team gave the added advantage of longer endurance which equates to surveillance of a larger area. Table 21 lists the results of the analysis.

Table 21. Conduct Marine Environment Protection

Fire Scout				MH-60S				Combined Systems			
Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability
+	+	+	-	+	+	+	+++	+	++	+	+++
Total 2				Total 6				Total 7			

Maritime interdiction in support of homeland defense had the same requirements of the helicopter platforms as the mission of maritime interdiction analyzed previously. The results of that analysis were summarized in table 22.

Table 22. Maritime Interdiction In Support Of Homeland Defense											
Fire Scout				MH-60S				Combined Systems			
Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability
+	+	+	+	+	+	+	++	+	+	+	++
			Total 4				Total 5				Total 5

Antiterrorism and Force Protection

The role of LCS in the antiterrorism and force protection consists of the general task of providing protection to U.S. and friendly forces at port terminals and in areas of restricted maneuverability. When U.S. and friendly force are located at a port facility, the Fire Scout and MH-60R provide an armed reconnaissance capability. Endurance plays a key role in maintaining continuous surveillance coverage. A lone MH-60R would not be able to maintain a full time surveillance because of crew, maintenance, and refueling considerations. The addition of one or multiple Fire Scouts to the surveillance coverage allows full 24 hour coverage without gaps. One confounding issue was the usage of airspace above a port facility. The location of the port facility near an operating air terminal severely restricts the usage of airborne surveillance. This hindrance affects Fire Scout and the MH-60R equally. Therefore, equal grades for capability were assigned for MH-60R and the combined systems. Table 23 contains the results of the task analysis.

Table 23. Provide Port Protection for U.S. and Friendly Forces											
Fire Scout				MH-60R				Combined Systems			
Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability
+	++	+	+	+	+	+	++	+	+	+	++
			Total 3				Total 5				Total 5

Force protection in areas of restricted maneuverability was a task that was similar to the task of escorting ships through choke points. The Fire Scout and MH-60R performed the same surveillance and tracking functions. With the combined systems, the Fire Scout would be more effectively employed as a surface vessel tracking platform using the EO-IR sensor and allow the MH-60R to focus on conducting visual identification and attacks. Table 24 summarizes these capabilities.

Table 24. Force Protection in Areas of Restricted Maneuverability											
Fire Scout				MH-60R				Combined Systems			
Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability	Speed	Endurance	Survivability	Capability
+	++	+	+	+	++	+	++	+	++	+	+++
			Total 5				Total 6				Total 7

Upon completion of the analysis of individual tasks, all tables were compiled into a single table presented in appendix C. A summary of the grades by mission area are also presented in the second table in appendix C. The next step of the analysis was to compare the total number of points scored by each platform. Several conclusions can be drawn from the summary table by observing the spread between the points. The implications of the point spread and platform contribution to each task is discussed in chapter 5. The answers to all of the secondary thesis questions are recounted in the next chapter. The answer to the primary thesis question is then derived from this analysis of the secondary thesis questions.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The Naval Operations Concept 2006 discusses how important operating in the littorals is to U.S. security and economic interests (US DoN 2006a, 8). The LCS is one of the U.S. Navy's future weapons of choice for protecting these interests, and chapter 2 discusses the concepts of operation for the LCS within the littoral areas. Chapter 2 outlines the utility and necessity of operating helicopters from the LCS. As a force enabler, the helicopter brings several capabilities not organic to LCS or the multi-mission modules. With the inclusion of the Fire Scout UAS into the LCS design, the question then becomes, "Is the Fire Scout Unmanned Vehicle an effective mission multiplier for the Littoral Combat Ship?" In order to answer this primary research question, the scope of this thesis paper was limited to the missions that LCS is expected to perform as it operates independently in the littoral areas of the world. As discussed in chapter 1, the importance of the study extends to several areas. Primarily the results will be used as a decision making tool for naval professionals who either operate or command the LCS and its multi-mission modules. Additionally, the conclusions are meaningful to Surface Action Group, Carrier Strike Group, Expeditionary Strike Group, Maritime Component, and Joint Task Force commanders who are evaluating the capabilities of a LCS operating within their sphere of influence.

The research methodology, outlined in chapter 3, divided the analysis into three parts corresponding to the three secondary research questions. The first two parts of the analysis used literature review to determine the requirements of manned and unmanned helicopters on LCS along with the capabilities of each of these helicopters. The third part of the analysis focused on how well the Fire Scout and MH-60R/S performed for each essential task in support of the LCS focused and inherent missions.

The first part of the analysis focused on the secondary research question: What are the Navy's requirements of manned and unmanned aerial vehicles deployed on the LCS? The analysis provided a list of three focused missions and five inherent missions that LCS was required to perform. A focused mission was defined as a single functional role that LCS was designed to execute. The three focused missions that this study focused on were: littoral anti-submarine warfare, littoral surface warfare, and littoral mine warfare. An inherent mission was defined as enduring functional role performed simultaneously or in succession with other inherent missions or one focused mission. The LCS was required to perform these five inherent missions: battle space awareness, intra-theater lift and special operation support, antiterrorism and force protection, maritime interdiction operations, and homeland defense. Each mission was comprised of essential tasks that had to be accomplished in order to perform the overall mission. The 20 essential tasks that were identified in the analysis became the framework of analysis for comparing Fire Scout to the MH-60R/S in the last section of chapter 4 (see appendix C for task list).

The next part of the analysis used literature review to determine the performance capabilities of the MH-60R/S and Fire Scout. The MH-60R and MH-60S models have completed operational test and evaluation and are in full production. Research revealed that the U.S. Navy master helicopter plan intended to employ the MH-60R in the ASW, SUW, and EW roles while keeping the MH-60S primarily in the transport role with the ability to perform AMCM. This review also concluded that although the MH-60R and MH-60S are new production models, the ASW, SUW, and EW capabilities were derived from the SH-60B LAMPS III program which enjoyed several decades of success. However, the MH-60S capability to detect and destroy sea mines in the AMCM configuration was not fully developed. Although predictive analysis of AMCM performance was beyond the scope of this research thesis, this author feels that the AMCM technology is mature enough to make the assumption that the MH-60S could adequately perform the MIW mission.

In contrast to the MH-60R/S programs, the Fire Scout UAS has not completed operational test and evaluation. In this prototype and pre-production stage, success or failure of any part of the program hinges upon any significant event such as a change in funding status, loss of a prototype, or a reassignment of contracting agencies or mission priorities. Each element of the entire unmanned system had to be assessed individually due to the different levels of program maturity. The largest element of the system, the helicopter platform, performed well due in part to its lineage as the successful Schweizer 333 manned, light helicopter. The airframe, with its 600lb payload capacity and low CPU utilization, proved to be flexible and capable. The autonomous systems have performed very well in shipboard tests and demonstrated to be reliable, stable, and easy to operate. The various payload or sensor packages were in different stages of maturity. Perhaps the most developed technology was the BriteStar EO-IR sensor which was adequate to perform the LCS essential tasks. Other programmed payloads that were considered in this study were the communications relay and mine detection package. Both packages were in the developmental stage but research provided no indications of impeded progress or risk of failure. This part of the analysis concluded that Fire Scout does not have the capability to conduct ASW, AMCM for sea mines, or ES. However, the recommendations section of this chapter discusses the future programs that might develop technologies that could bridge these capabilities gaps.

The final section of chapter 4 answered the secondary research question: What missions of the MH-60R/S can be enhanced or replaced by the Fire Scout UA? This section analyzed the performance of Fire Scout and the MH-60R/S for each of the 20 LCS essential tasks. The categories of speed, endurance, survivability, and capability were chosen in order to assign grading criteria that represent important physical aspects of task performance. Figure 1 summarizes the results of this analysis and clearly demonstrates three key findings.

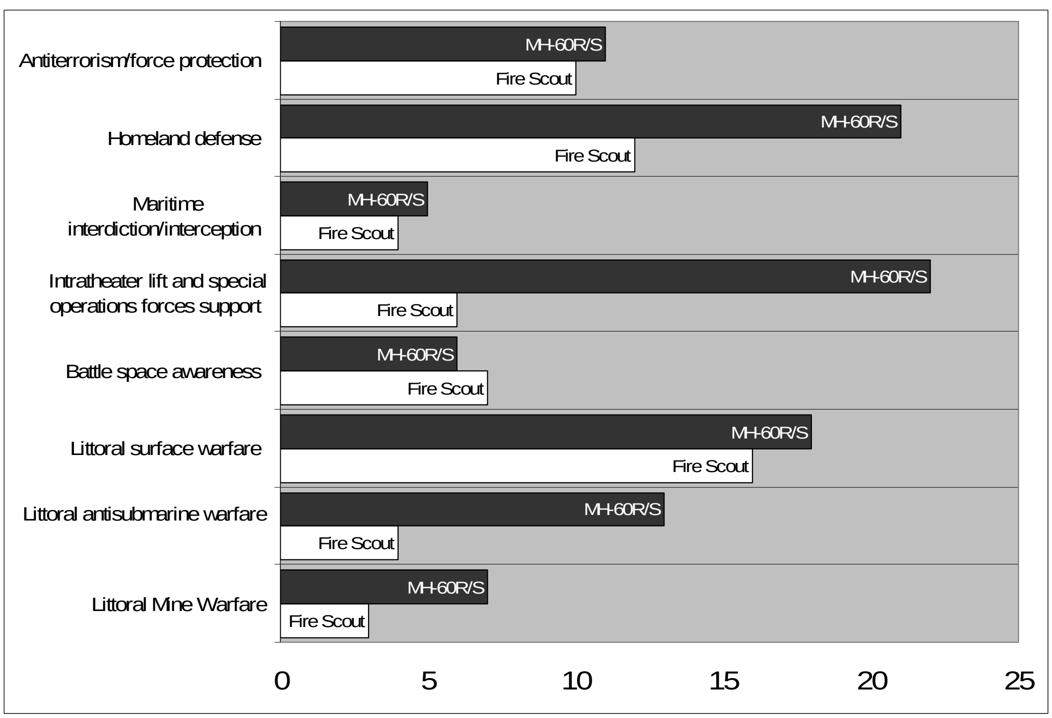

Figure 1. Fire Scout and MH-60R/S Mission Performance (Total Points)

Key Findings

The first finding is that the MH-60R/S helicopter outperformed the Fire Scout in every mission and that the Fire Scout could not replace the MH-60R/S in any missions. This finding is not very profound considering the Fire Scout is not intended to completely replace the MH-60R/S. The second key finding was that the Fire Scout had a much greater endurance over the MH-60R/S because its system contained three airframes operating sequentially versus the lone MH-60R/S. This endurance advantage highlights the value of persistence that a UAS brings to any mission. This advantage became most prevalent in the littoral surface warfare, battle space awareness, and antiterrorism force protection mission areas. The third and most important of the key findings is the validation of the exceptional performance by the combined use of the manned and unmanned helicopters. Cooperative use of the MH-60R/S and Fire Scout in all essential mission tasks yielded higher scores, shown in figure 2, with the greatest improvement in the categories of endurance and capability. This demonstrated resolutely the answer to the overall thesis question: Is the Fire Scout an effective mission multiplier for LCS? Yes, the Fire Scout is effective as long as unity of effort is made a priority. First, the essential tasks need to be planned in conjunction with the helicopter detachment personnel in order to allocate airspace. Second, the execution of the task needs to be executed in conjunction with the MH-60R/S helicopter in order to synchronize sensor placement. Lastly, the deficiencies of the Fire Scout in the airborne mine countermeasures, littoral anti-submarine warfare, electronic warfare, and intra-theater lift roles need to be realized so that the MH-60R/S can be leveraged for greater mission success.

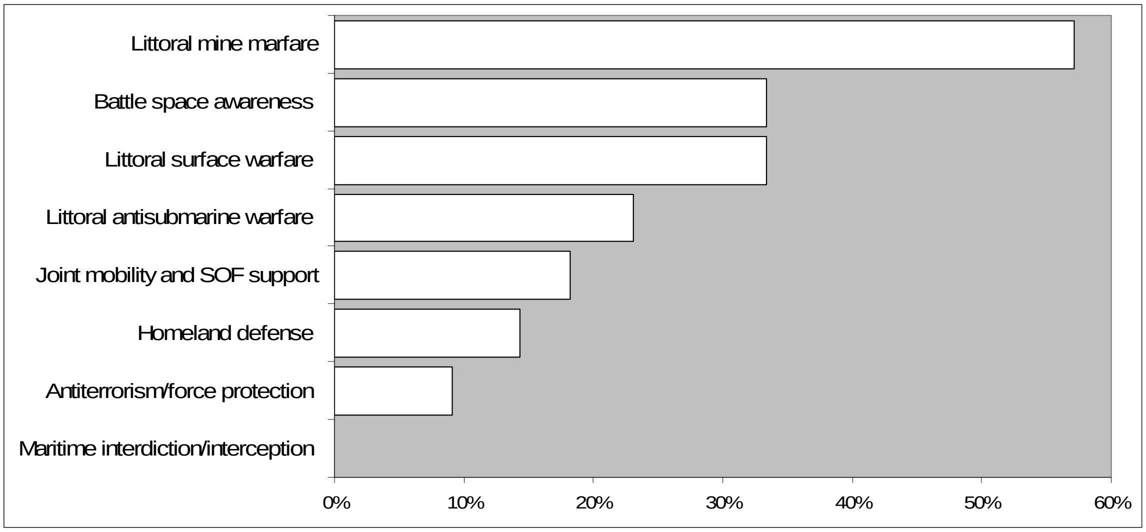

Figure 2. Percent Improvement Of Combined Systems Over Fire Scout or MH-60R/S

Recommendations

As with any new technology, the search for solutions to problems can yield more questions than answers. In the case of the Fire Scout program, there are several areas that require additional research. These areas are divided into payload packages, weapons, and operational concepts.

Additional research is required to explore the effect of new payload packages on Fire Scout's task performance. The U.S. Naval Air Systems Command is currently developing radar, SIGINT, and EW payload packages. This author recommends further research into the effect of adding AMCM, vertical replenishment, sonobuoy, and dipping sonar packages to Fire Scout.

The next area that requires immediate attention is the effect of installing weapons on Fire Scout. The U.S. Naval Air Systems Command has already fired 2.75 inch laser guided rockets from Fire Scout. This capability opens the door to adding other weapons such as Hellfire and the Joint Common Missile which will have a dramatic improvement in the Fire Scout's effectiveness in SUW. Furthermore, the addition of air to air weapons such as Sidewinder, will introduce Fire Scout to entirely new air defense missions.

Lastly, additional research needs to focus on the operational concepts of integrating manned and unmanned helicopters. Currently, the Fire Scout UAS is part of the SUW mission module for LCS, but there are advantages of assigning the Fire Scout UAS to the helicopter detachment that operates and maintains the MH-60R. This action would facilitate the inclusion of the naval aviators into the planning and execution of the Fire Scout missions. Another operational concept that needs to be explored is using the Fire Scout for search and rescue at sea where personnel are located and either retrieved or receive a life raft dropped from the air. In a grander scheme, other non-traditional missions need to be explored in order to leverage the additional capabilities that unmanned technology brings to a traditionally manned environment.

APPENDIX A

FIRE SCOUT SPECIFICATIONS

Fire Scout VTUAV will provide multi-mission tactical UAS support to the Littoral Combat Ship (LCS). Fire Scout will support LCS core mission areas with modular payloads as well as organic ISR, targeting, and communication-relay functions. The Fire Scout will employ the Tactical Control System (TCS) and the Tactical Common Data Link (TCDL) as the primary means for UAS command and control and sensor payload dissemination. Fire Scout is a critical component of LCS off-board sensors. The Fire Scout Vertical Take-Off and Landing Tactical Unmanned Aerial Vehicle system is comprised of ground control stations, up to three MQ-8B Fire Scout air vehicles, and associated control handling and support equipment. The UAS is designed to operate from air capable LCS and will provide a significant improvement to organic surveillance capability. The air vehicle is capable of providing UHF/VHF voice communications relay and has a baseline payload that includes electro-optical/infrared sensors and a laser designator that enables the system to find tactical targets, track and designate targets, accurately provide targeting data to strike platforms and perform battle damage assessment (US DoN 2006b, 68).

The air vehicle component of the UAS was designated the MQ-8B to reflect the Fire Scout's evolution toward an increased, multi-functional role. Some of the notable improvements include increased power, fuel, and payload capacity. Additionally, the MQ-8B offers more than double the mission radius and time on station than the prototype. The MQ-8B completed first flight in December 2006. When operational, Fire Scout will provide critical situational awareness, intelligence, surveillance, reconnaissance, and targeting data to the forward deployed war fighter. The vehicle is based on the Schweizer Aircraft model 330 helicopter.

General Characteristics, RQ-8A and MQ-8B Fire Scout Unmanned Aerial Vehicle

Contractor: Northrop Grumman Unmanned Systems
Date Deployed: The program is currently completing EMD (engineering, manufacturing, development), and should begin low rate initial production in FY 07. Fleet introduction is on schedule for FY 08, with full rate p
Propulsion: One Rolls-Royce 250C20W heavy fuel turboshaft engine
Length: 31.7 feet
Height: 9.8 feet
Weight: Zero fuel weight - 2,073 pounds; maximum takeoff, 3,150 pounds
Airspeed: 110 knots
Ceiling: 20,000 feet
Range: 110 nautical miles radius, five-plus hours on station
Load: 600 pounds, including electro-optical/infrared sensor and laser

Payloads
Fire Scout's sensors are mission dependant and based upon a modular architecture which allows for different payloads to be installed accomplishing a mission. The baseline payload includes electro-optical/infrared sensors and a laser rangefinder / designator which can find and identify tactical targets, track and designate targets. Programmed payloads include:

The Airborne Communication Package acts as a data and voice UHF communications relay.

The Coastal Battlefield Reconnaissance and Analysis (COBRA) processing station detects coastal and surf zone minefields and relays to data to a COBRA workstation for processing and analysis. In the beach and surf zone environment, Northrop-Grumman's Coastal Battlefield Reconnaissance and Analysis multi-spectral sensor system will be carried aboard the Fire Scout unmanned air vehicle.

The Compact Rapid Attack weapon (CRAW) is an anti-submarine torpedo that is lightweight and compact enough to be carried by the Fire Scout (Northrop 2007, 1).

APPENDIX B

MH-60R AND MH-60S SPECIFICATIONS

The MH-60R and MH-60S multi-mission combat helicopters are the two pillars of the CNO's Naval Helicopter Concept of Operations for the 21st Century. The Seahawk will deploy as companion squadrons embarked in the Navy's aircraft carriers, surface warships, and logistics ships. The MH-60R will provide surface and undersea warfare support to Sea Shield operations with a suite of sensors and weapons that include low frequency (dipping) sonar, electronic support measures, advanced Forward Looking Infrared, and precision air-to-surface missiles. The MH-60S will provide mine warfare support for Sea Shield and will partner with the MH-60R for surface warfare missions carrying the same Forward Looking Infrared air-to-ground sensors and weapons. The MH-60S will be reconfigurable to provide Combat Search and Rescue and Naval Special Warfare support to joint theater operations. Airborne mine countermeasures operations will be accomplished using advanced sensor and weapons packages to provide detection, localization, and neutralization to anti-access threats. The MH-60S will anchor the fleet logistics role in carrier strike group and expeditionary strike group operations. MH-60R/S platforms are produced with 85 percent common components (e.g., common cockpit and dynamic components) to simplify maintenance, logistics, and training.

General Characteristics
Contractor: Sikorsky Aircraft Corporation (airframe); General Electric Company (engines); IBM Corporation (avionics components).
Propulsion: Two General Electric T700-GE-700 or T700-GE-701C engines; thrust: up to 1,940 shaft horsepower.
Length: 64 feet 10 inches (19.6 meters).
Height: Varies with the version; from 13 to 17 feet (3.9 to 5.1 meters).
Rotor Diameter: 53 feet 8 inches (16.4 meters).
Weight: Varies; 21,000 to 23,000 pounds (9,450 to 10,350 kg).
Airspeed: 180 knots maximum.
Range: Generally about 380 nautical miles (600 km);
Crew: Three to four.

MH-60R Sensors and Weapons

The AN/AAS-52 is a long-range, multipurpose, infrared and Electro-Optical sensor and laser designator. It provides long range tracking, surveillance, designation and range finding for AGM-114 Hellfire missiles and other laser-guided munitions.

The AN/ALQ-210 electronic support system provides situational awareness, threat warning and precision targeting by detecting, identifying, and locating combat threats.

The Emission Sensor Measurement (ESM) system can detect and classify a variety of sophisticated types of radar signals in areas with signal clutter. It is very effective against frequency agile emitters.

The AN/APS-147 is a multi-mode maritime search radar that includes a fully integrated IFF. It had an Automatic Inverse Synthetic Aperture Radar with a longer pulse interval for better periscope detection along with an air-to-air mode.

The AQS-13 sonar system with airborne low frequency sonar provides long detection ranges and an enhanced detection capability by using lower frequencies, less signal attenuation, longer pulse lengths, improved processing, and increased transmission power.

The AGM-114 Hellfire missile was designed to defeat armored vehicles at standoff ranges. The laser guided Hellfire is a subsonic missile with a maximum range of 8,000 meters.

The Penguin is an anti-ship missile that had been designed to meet the challenge of littoral environments by discriminating targets from islands and other natural obstacles through its passive IR homing head. Additionally, the Penguin had selectable trajectories and is immune to radar countermeasures, decoys and jamming.

MH-60S Sensors and Weapons

In its MCM role, the MH-60S will be equipped with Raytheon’s AQS-20A sonar (towed through the water); Northrop Grumman’s electro-optical Airborne Laser Mine Detection System, which uses a laser to penetrate shallow water and detect moored mines; and EDO Corp’s Organic Airborne and Surface Influence Sweep that provides magnetic and acoustic influence mine-sweeping capabilities. To neutralize mines, Raytheon and BAE’s Airborne Mine Neutralization System is capable of destroying deep sea mines using BAE’s tethered Archerfish expendable underwater vehicle, while shallow mines are handled by Northrop Grumman’s Rapid Airborne Mine Clearance System (RAMICS), a 30mm gun firing super-cavitating projectiles capable of penetrating the water column and destroying mines (US DoN 2006b, 68).

APPENDIX C SUMMARY OF ANALYSIS

Table 25. Summary of Mission Analysis

Essential Mission Tasks	Fire Scout	MH-60R/S	Combined Manned and Unmanned Helicopter System
	Total	Total	Total
Littoral Mine Warfare	3	7	11
Littoral antisubmarine warfare	4	13	16
Littoral surface warfare	16	18	24
Battle space awareness	7	6	8
Intratheater lift and special operations forces support	6	22	26
Maritime interdiction/interception	4	5	5
Homeland defense	12	21	24
Antiterrorism/force protection	10	11	12
Total	62	103	126

Table 26. Summary of Task Analysis

Essential Mission Tasks	Fire Scout Unmanned Aerial System					MH-60R/S					Combined MH-60R/S and Fire Scout Systems				
	Speed	Endurance	Survivability	Capability	Total	Speed	Endurance	Survivability	Capability	Total	Speed	Endurance	Survivability	Capability	Total
Littoral mine warfare					3					7					11
Detect and neutralize sea mines	n/a	n/a	n/a	-	-1	n/a	+	++	++	5	n/a	+	++	++	5
Detect and neutralize land mines	n/a	+	+	+	3	n/a	n/a	n/a	-	-1	n/a	+	+	+	3
Establish and maintain mine cleared areas	n/a	+	+	-	1	n/a	+	+	+	3	n/a	+	+	+	3
Littoral antisubmarine warfare					4					13					16
Detect all threat submarines in a given littoral area	+	++	n/a	+	4	+	+	n/a	+++	5	+	++	n/a	+++	6
Establish submarine barriers	+	+	n/a	-	1	+	+	n/a	++	4	+	++	n/a	+++	6
Neutralize threat submarines NTA 3.2.1.2	n/a	n/a	n/a	-	-1	+	+	n/a	++	4	+	+	n/a	++	4
Littoral surface warfare					16					18					24
Detect, track, and engage small boat threats	++	+	+	+	5	++	+	+	+++	7	++	++	+	+++	8
Escort ships through choke points	++	+	+	+	5	++	+	+	+	5	++	++	+	+++	8
Protect joint operating areas	++	++	+	+	6	++	+	+	++	6	++	++	+	+++	8
Battlespace awareness					7					6					8
Intelligence, surveillance, and reconnaissance	+	++	++	++	7	+	+	+	+++	6	+	++	++	+++	8
Intratheater lift and special operations forces support					6					22					26
Provide transport for personnel, supplies and equipment within the littoral operating area	n/a	n/a	n/a	-	-1	+	+	+	+++	6	+	+	+	+++	6
Provide rapid movement of small groups of special operations forces personnel	n/a	n/a	n/a	-	-1	+	+	+	++	5	+	+	+	++	5
Support hostage rescue operations and noncombatant evacuation operations	+	+	+	+	4	+	+	+	++	5	+	+	+	+++	6
Conduct combat search and rescue	+	+	+	+	4	+	+	++	++	6	+	++	+++	+++	9
Maritime interception					4					5					5
Conduct maritime interdiction operations	+	+	+	+	4	+	+	+	++	5	+	+	+	++	5
Homeland defense					12					21					24
Conduct maritime law enforcement operations	+	+	+	+	4	+	+	+	++	5	+	+	+	+++	6
Provide emergency, humanitarian and disaster assistance	+	+	+	-	2	+	+	+	++	5	+	+	+	++	5
Conduct marine environmental protection	+	+	+	-	2	+	+	+	+++	6	+	++	+	+++	7
Maritmie Interception in support of Homeland defense	+	+	+	+	4	+	+	+	++	5	+	+	+	+++	6
Antiterrorism/force protection					10					11					12
Provide port protection for U.S. and friendly forces	+	++	+	+	5	+	+	+	++	5	+	+	+	++	5
Provide force protection in areas of restricted maneuverability	+	++	+	+	5	+	++	+	++	6	+	++	+	+++	7

WORKS CITED

Banks, Ronald L. 2000. The Integration of Unmanned Aerial Vehicles into the Function of Counterair. Master's Thesis, Air Command and Staff College.

Beshears, Troy. 2004. The HV-911 Eagle Eye Tiltrotor VTUAV: An Exciting Future for Coast Guard Aviation. *American Society of Naval Engineers "ASNE Days" Technical Paper*, June 2004.

Burgess, Richard R. 2006. Fast Swap: Changes to Littoral Combat Ship Components may Speed Reassignments of the Multimission Vessel. *Seapower*, February: 24.

________. 2005. A Smarter Scout. *Seapower*, May: 16.

Butler, Amy. 2006. Scouting Ahead. *Aviation Week & Space Technology* 165, no. 17:28.

Cebrowski, Arthur K. 2004. Elements of Transformation. Center for Strategic and Budgetary Assessments. Article online. Available from http://www.csbaonline.org/4Publications/PubLibrary/S.20040225.LCSSlides/S.20040225.LCSSlides.pdf. Accessed on 2 December 2006.

Eshel, Tamir ed. 2006a. SPERWER Tactical UAV System, 5 September 2006. Article online. Available from http://defense-update.com/news/ausi-uav-906.htm. Accessed on 12 December 2006.

________. 2006b. Australia Tests Maritime Surveillance UAV, 4 September 2006. Article online. Available from http://defense-update.com/products/s/sperwer.htm. Accessed on 12 December 2006.

________. 2005. I-View Tactical UAV Systems, 12 December 2005. Article online. Available from http://defense-update.com/products/i/iview.htm. Accessed on 12 December 2006.

EADS Systems and Defense Electronics. 2006. *ORKA-1200*. Database online. Available from http://www.sysde.eads.net. Accessed on 13 May 2007.

FLIR Systems. 2006. BRITE Star. Database online. Available from http://www.flir.com/imaging/Airborne/Products/BriteStar.aspx. Accessed on 9 May 2007.

Fulghum, David A. 2003. Battle Buzz. *Aviation Week & Space Technology* 158, no. 12: 27-28.

Government Accountability Office. 2005a. *Plans Need to Allow Enough Time to Demonstrate Capability of First Littoral Combat Ships, GAO-05-255.* Washington, DC: GPO.

________. 2005b. *Unmanned Aircraft Systems.* Washington, DC: GPO.

________. 2001. *Navy Acquisitions: Improved Littoral War-fighting Capabilities Needed.* Washington, DC: GPO.

________. 1996. *Unmanned Aerial Vehicles: Hunter System Is Not Appropriate For Navy Fleet Use.* Washington, DC: GPO.

Hough, Michael. 2005. The Flyer, Interview with Lieutenant General Michael Hough, Marine Corps Deputy Commandant for Aviation. *Seapower,* November: 19.

Jackson, Paul ed. 2006. *Jane's All the World's Aircraft 2006-2007.* Alexandria, VA: Jane's Information Group Inc.

Karr, Michael B. 2004. Champion's Point of View. *Proceedings of the Marine Safety and Security Council,* Winter 2004-2005: 4.

McKee, Michael W. 2006. *VTOL UAVs Come of Age: U.S. Navy Begins Development of VTUAV.* Database online. Available from www.vtol.org. Accessed on 12 March, 2007.

McKenna, James T. 2005. Bringing Home the Bacon, 1 August 2005. Article online. Available from http://www.aviationtoday.com/rw/commercial/offshore/1696.htm. Accessed on 19May.

Nitschke, Stephan. 2003. Unmanned Aerial Vehicles: What Do Navies Really Need? *Naval Forces,* June.

Northrop Grumman Integrated Systems. 2007. *MQ-8B Fire Scout Program Overview.* Database online. Available from http://www.northropgrumman.com/unmanned/. Accessed on 12 May 2007.

O'Rourke, Ronald. 2006. Navy Littoral Combat Ship (LCS): Background and Issues for Congress. *Congressional Research Service.* August.

________. 2005. Navy DD(X), CG(X), and LCS Ship Acquisition Programs: Oversight Issues and Options for Congress. *Congressional Research Service.* August.

Professional Engineer Magazine. 2006. ScanEagle Takes to the Skies for the First Time from UK Frigate, 31 May: 13.

RAFAEL Armament Development Authority Ltd. 2006. Smart and to the Point. Article online. Available from www.rafael.co.il/marketing/SIP_STORAGE/FILES/5/515.pdf. Accessed on 8 December 2006.

Russell, Jonathan C. 2006. The Littoral Combat Ship: Is the Navy Assuming Too Much Risk? Master’s Thesis, U.S. Army Command and General Staff College.

Sikorsky Aircraft Corporation. 2006. Seahawk. Database online. Available from http://www.sikorsky.com/details/0,9602,CLI1_DIV69_ETI264,00.html. Accessed on 2 December 2006.

Spicer, Ray. 2004. Littoral Combat Ship. Database online. Available from http://www.csbaonline.org/4Publications/PubLibrary/S.20040225.LCSSlides/S.20040225.LCSSlides.pdf. Accessed on 12 September 2006.

U.S. Department of the Army. 2004. *Field Manual 2-0. Intelligence.* Army Training and Doctrine Command. Washington, DC: GPO.

U.S. Department of Defense. 2006. *2006 Quadrennial Defense Review Report.* February 6, 2006. Database online. Available from http://www.defenselink.mil/qdr/report/Report20060203.pdf. Accessed on 07 November, 2006.

________. 2005. *Unmanned Aircraft Systems Roadmap, 2005-2030.* August 4, 2005. Article online. Available from http://www.acq.osd.mil/usd/uav_roadmap.pdf. Accessed on 05 October, 2006.

________. 2001. *Joint Warfighting Science and Technology Plan*. Deputy Under Secretary Of Defense (Science And Technology). Database online. Available from http://www.hawaii.edu/resrel/workshops/dod/2001/jwstp.pdf. Accessed on 12 April, 2007.

U.S. Department of the Navy. 2006a. *Naval Operations Concept 2006.* Chief of Naval Operations. Washington, DC: GPO.

________. 2006b. *Sea Power for a New Era 2006: A Program Guide to the U.S. Navy.* Chief of Naval Operations. Washington, DC: GPO.

________. 2005. Navy Warfare Development Command. Universal Naval Task List. Database online. Available from http://www.nwdc.navy.mil/Library/UNTL_NMETL/files/UNTL%203%200%20of%2030%20Jan%2007.zip. Accessed on 14 March 2007.

________. 2003. *United States Naval Transformation Roadmap 2003: Assured Access and Power Projection From the Sea.* Chief of Naval Operations. Washington, DC: GPO.

________. 2001. Navy Warfare Development Command. OPNAVINST 3500.38A Navy Tactical Task List. Database online. Available from http://www.nwdc.navy.mil/Library/UNTL_NMETL/files/CHAPTER%203.doc. Accessed on 10 March 2007.

________. 1998. Naval Historical Center. HO3S-1 (Korea). Database online. Available from http://www.history.navy.mil/branches/hist-ac/ho3s.pdf. Accessed on 12 February 2007.

Uhls, Daniel B. 2002. "Does the Fast Patrol Boat have a Future in the Navy?" Master's Thesis, US Army Command and General Staff College.

Vego, Milan. 2005a. Future MCM Systems: Organic or Dedicated, Manned or Unmanned? *Naval Forces,* April.

________. 2005b. Mine Warfare: Are We Prepared for the Worst? *Naval Forces,* March.

SOURCES CONSULTED

Clark, Vern. 2002. Sea Power 21: Projecting Decisive Joint Capabilities. *United States Naval Institute Proceedings*, no. 10: 31.

Defense Science Board. 2004. *Unmanned Aerial Vehicles and Uninhabited Combat Aerial Vehicles.* Washington, DC: Office of the Under Secretary of Defense For Acquisition, Technology, and Logistics.

Dudney, Robert S. 2005. Where Do UAVs Go From Here? *Air Force Magazine,* July.

Fitzgerald, Steve. 2004. Homeland Security - The National Strategy; U.S. Northern Command's and the U.S. Navy's Roles in Homeland Defense and Civil Support, Master's Thesis, U.S. Army Command and General Staff College.

Goodman Jr., Glenn W. 2006. Hover and Stare. *Aviation Week & Space Technology* 165, no. 5: 22-27.

Klein, John J. 2002. Strategic Implementation of Navy and Marine Corps Unmanned Combat Air Vehicles with Respect to Military Transformation. Master Thesis, U.S. Naval War College.

Landay, William E., Hunter C. Keeter. 2005. Breaking the Mold. *Seapower,* March : 42.

Meger, James P. 2006. The Rise of the Unmanned Aerial Vehicle and its Effect on Manned Tactical Aviation, Master's Thesis, U.S. Army Command and General Staff College.

Sotherland III, Jack L. 2001. Network Centric Operations and the Navy's SH-60R: Strategic Force Multiplier. Master's Thesis, U.S. Army Command and General Staff College.

Sweetman, Bill. 2006. Long-range Endurance UAS Targets the Adversary. *Jane's International Defence Review,* August 2006: 40.

Tornga, Brent K. 2005. Unmanned Aerial Vehicles: Trendy Technological Toys or Flying Force of the Future. Master's Thesis, U.S. Army Command and General Staff College.

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