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THESIS

ANALYSIS OF OPERATIONAL MANNING REQUIREMENTS AND DEPLOYMENT PROCEDURES FOR UNMANNED SURFACE VEHICLES ABOARD US NAVY SHIPS

by

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March 2006

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13. ABSTRACT (maximum 200 words)

This research was conducted per a Navy Warfare Development Center request that the Naval Postgraduate School update the Navy's TACMEMO: Integration of UVs into Maritime Missions TM 3-22-5-W. Unmanned Surface Vehicles (USVs) are expected to becoming an integral part of the Navy's maritime mission. To incorporate USVs into the fleet, manpower issues must be identified and resolved, i.e., manning requirements supporting USV operations; and analysis of the rate/rating, skill sets, training and procedures required to operate and maintain USVs.

The methodology included Navy lessons learned, operation evaluation reports, and technical documentations from past and ongoing fleet employment of USVs to identify manning issues.

Research findings included: current USV launch-and-recovery systems on host ships are personnel intensive compared to other available systems; knowledge, skills and abilities required of USV support personnel are identified within the BM, EM, EN, ET (Surface), GM, IT, OS, STG (Surface) rating occupational standards, and it would be easier to train personnel from these ratings for USV support; and a formal training path should be established for USV operators. In consonance with Navy Human Capital direction, naval platforms must operate with reduced manning, however, unmanned systems definitely require trained and specialized personnel to operate and maintain.

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ANALYSIS OF OPERATIONAL MANNING REQUIREMENTS AND DEPLOYMENT PROCEDURES FOR UNMANNED SURFACE VEHICLES ABOARD US NAVY SHIPS

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LIST OF ACRONYMS

ACTD	Advanced Concept Technology Demonstration
ARG	Amphibious Readiness Group
ASUWC	Anti-Surface Warfare Coordinator
ASUW	Anti-Surface Warfare
ASW	Antisubmarine Warfare
ASWE	Antisubmarine Warfare Evaluator
AT	Antiterrorism
ATG	Afloat Training Group
AUV	Autonomous Underwater Vehicle
BLOS	Beyound Line of Sight
BM	Boatswain's Mate
C2	Command and Control
C3	Command Control and Communication
CA	Combat Auxiliary
CE	Combat Electronics
CCUSV	Combat Capable Unmanned Surface Vehicle
CIC	Combat Information Center
CONOPS	Concept of Operations
COTS	Commercial Off-The-Shelf
CSG	Carrier Strike Group
DICASS	Directional Command Activated Sonobuoy System
DIV	Division
DMAS	Distributed Mobile ASW Sensors
EMIO	Enhanced Maritime Interdiction Operations
EN	Engineman
EO	Electro-Optic
EO/IR	Electro-Optical/Infrared

ESG	Expeditionary Strike Group
EM	Electrician’s Mate
ET	Electronics Technician
FC	Fire Controlman
FP	Force Protection
GCCS-M	Global Command and Control System Maritime
GM	Gunner’s Mate
GOTS	Government Off-The-Shelf
GPS	Global Positioning System
ISR	Intelligence, Surveillance, and Reconnaissance
IT	Information systems Technician
KSA	Knowledge, Skills, and Ability
L&R	Launch and Recovery
LAMPS	Light Airborne Multipurpose Platform
LCS	Littoral Combat Ship
LOE	Limited Objective Experiment
LOS	Line of Sight (ranges from 0-10 nm)
MCM	Mine Counter Measure
MIO	Maritime Interdiction Operation
MIW	Mine Warfare
MOP	Measure of Performance
MPE	Mission Planning and Execution
MROS	Mobile Remote Operator Station
MUA	Military Utility Assessment
NEC	Navy Enlisted Classification
NEOCS	Navy Enlisted Occupational Classifications Standards
NPS	Naval Postgraduate School
NTSP	Navy Training System Plan
NUWC	Naval Undersea Warfare Center
NWDC	Navy Warfare Development Command

OD	Operations, Deck
OFF	Officer
OI	Operations, Intelligence
OJT	On the Job Training
ONR	Office of Naval Research
OS	Operations Specialist
OTH	Over-The-Horizon (ranges greater than 100nm)
PE	Precision Engagement
PN	Personnel Man
POE	Projected Operating Environment
PQS	Personnel Qualification Standard
PS	Precision Strike
PTZ	Pan/Tilt Zoom
RC	Remote Control
RHIB	Rigid Hull Inflatable Boat
RF	Radio Frequency
RMP	Recognized Maritime Picture
RMS	Remote Minehunting System
ROC	Required Operational Capabilities
ROE	Rules of Engagement
ROS	Remote Operator Station
ROSAM	Remote Operated Small Arms Mount
RWS	Remote Weapons Station
SENSO	Sensor Operator
SIPRNET	Secret Internet Protocol Router Network
SMD	Ships Manpower Document
SN	Seaman
SOF	Special Operations Force
SOP	Standard Operating Procedure
SS	Sea State

SSC	Surface search and control
STG	Sonar Technician (Surface)
SUW	Surface Warfare
TACMEMO	Tactical Memorandum
TAO	Tactical Action Officer
TBD	To be determined
TTP	Tactics, techniques and procedures
UAV	Unmanned Aerial Vehicle
UGV	Unmanned Ground Vehicle
USV	Unmanned Surface Vehicle
USSV	Unmanned Sea Surface Vehicle
USV-S	Unmanned Surface Vehicle-Small
USW	Undersea Warfare
UUV	Unmanned Undersea Vehicle
VBSS	Vertical Board Search & Seizure

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I. INTRODUCTION

A. AREA OF RESEARCH

This research examined manning requirements supporting the operational launch and recovery evolution for Unmanned Surface Vehicles (USV) on US Navy ships. An analysis was conducted of the rate/rating, skill sets, and competences needed to operate and maintain USVs in a maritime environment. Research includes analysis of the knowledge, skills, and abilities (KSAs) needed to remotely pilot a USV in various maritime operations such as Surface Search and Control (SSC), Maritime Interdiction Operations (MIO), Maritime Interdiction Warfare (MIW), Intelligence, Surveillance and Reconnaissance (ISR), and Force Protection (FP). The operational evolution procedural findings are to be incorporated in a new maritime Tactical Memorandum (TACMEMO) being developed by Naval Postgraduate School for the Navy Warfare Development Center (NWDC).

B. RESEARCH QUESTIONS

Primary Questions:

1. What are the human capital manning requirements supporting the launch and recovery of USVs on US Navy host ships?
2. What are the basic knowledge, skills and abilities needed for Unmanned Surface Vehicle operators and maintainers?
3. Which rates/rating support USV operator and maintainer KSAs?
4. What is the optimum composition of a USV watch team?

Secondary Questions:

1. What training is required to support the operation and maintenance of USVs?
2. What role will USVs play in an emerging maritime mission?

C. DISCUSSION

The military has used unmanned vehicles for many applications and is expected to expand its use of unmanned remote and autonomous vehicles in the future. The Navy plans to procure and test a variety of unmanned vehicle systems to include various types of Unmanned Aerial Vehicles (UAVs), Unmanned Surface Vehicles (USVs), and Unmanned Underwater Vehicles (UUVs), and incorporate them into the execution of various maritime mission areas. The basic assumption is that UVs will extend the tactical horizon of the battlespace. Carrier and Expeditionary Strike Groups (CSG/ESG) have deployed with the Spartan Scout and Sea Fox USVs while executing real world operational missions, and the AN/WLD-1 Remote Minehunting System has been installed onboard several naval surface ships.

A USV is a remotely controlled or autonomous craft that operates on the surface of the water. The US Navy has been operating USVs for some time, primarily as surface targets for gunnery exercises such as the QST-33 and QST-35/35A SEPTAR Targets; High Speed Maneuverable Seaborne Target (HSMST), and RoboSki.[1] However, these USVs pail in comparison to the new breed of USVs being tested or employed by the US Navy.

The Navy after next will operate USVs in the littorals and protect the Fleet from asymmetric threats in force protection roles while maintaining an adequate stand-off distance to unevaluated contacts of interest. Expanded USV roles include surveillance and reconnaissance, force protection, mine detections, special operations, anti-submarine warfare (ASW) and intelligence.

The USS Pinckney deployed in 2005 with the Navy's AN/WLD-1 Remote Minehunting System (RMS) and a remote minehunting vehicle (RMV). The RMV is a semi-submerged USV designed to detect submerged mines.[2] The first Littoral Combat Ship (LCS) is scheduled to be delivered in 2006. One design feature is the ability to deploy UAV, UUV and USVs.[3] The same can be said about the DD(X) destroyer and CG(X) cruiser. Although definitive USV acquisition plans do not exist, the Navy is pursuing several USV developmental programs. The Navy plans to continue USV research to perform Intelligence, Surveillance and Reconnaissance (ISR) from older combatant ships. The ISR USV will possibly replace the standard Navy rigid hull inflated

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1 The Growing US Market for USVs, Moire Incorporated.July 9, 2003: http://www.moireinc.com/USVmarketMoire.pdf

2 Sea Power: Bristling with new gear, USS Pinckney, Byron, Robert M.: http://www.findarticles.com/p/articles/mi_qa3738

3 Littoral Combat Ship Flight 0 Preliminary Design Interim Requirements Document.

boat (RHIB) and commanding officer's gig. It will carry EO/IR sensors, a targeting device, a radar, and Line of Sight (LOS) and Over-The-Horizon (OTH) communication links. A larger multi-mission version is likely to operate from LCS, DD(X) and CG(X), incorporating technologies developed from Spartan Scout operational testing.

Further implementation of USVs into the Navy's surface fleet will require an analysis of manpower requirements and personnel assignments. During operational testing of Spartan Scout by USS Gettysburg in 2003, a Personnelman Second Class (PN2) was selected as the remote control operator because he was the best video game player on board the ship.[4] It is imperative that while development and testing are being conducted on the USV concept, the operational techniques and procedures required for safe and effective operations are equally developed.

D. SCOPE

The scope and direction of this study included the following: (1) review the results from past and ongoing USV concept testing; (2) review the Navy Enlisted Occupational Classification System (NEOCS); (3) analyze the Navy Enlisted Classifications (NEC) for Ship Manpower Documents (SMD) of USV host ships; (4) determine the operational manning required by USV evolutions; (5) identify the enlisted rate and rating suitable for USV operator and maintainer; and (6) develop operating guidelines to address team and individual watch station methods and procedures for launch and recovery of USVs. The analysis concludes with a recommendation for the optimal mix of personnel with the necessary knowledge, skills and abilities to operate and maintain USVs. Also considered were resource sponsor guidelines and missions supported by required operational capability/projected operational environments.

E. METHODOLOGY

The methodology used consisted of the following:

1. A fairly extensive literature review was conducted on applicable books, defense articles, CD-ROM systems, test reports, Navy Lessons Learned, theses, Internet, SIPRNET, and other library information resources on the topic.
2. USV protocols, hardware requirements, and host ship system requirements were reviewed and summarized

4 Spartan Scout Fleet Testing, LT Matthew Richter; USS Gettysburg, 2003.

3. Current rigid hull inflatable boat (RHIB) operating procedures were reviewed.

4. Spartan Scout Advanced Concept Technology Demonstration (ACTD) and Sea Fox Concept of Operations (CONOPS) documents were reviewed.

5. Approximately four personnel involved in and/or knowledgeable of USV operations and maintenance were interviewed.

F. ORGANIZATION OF STUDY

Chapter I: The introduction identifies the focus and purpose of the research as stated in the primary and secondary research questions.

Chapter II is an overview of Unmanned Surface Vehicle Development. It provides an overview of three main USV platforms under operational test in the fleet by the USN. This chapter serves as the basis for illustrating the current and future mission capabilities of Spartan Scout, Sea Fox and RMS.

Chapter III clarifies USN Employment and Testing of USVs, as well as depicting the operational test and employment of Spartan Scout, Sea Fox and RMS.

Chapter IV covers Operational Manning Requirements and Deployment Analysis, and Chapter V provides a summary, conclusion and recommendations. The study ends with suggestions for further research.

II. OVERVIEW OF UNMANNED SURFACE VEHICLE DEVELOPMENT

A. SPARTAN SCOUT

Spartan Scout is an evolving unmanned integrated sensor and weapon system (Figure 1) designed to be a primary force leveler against asymmetric threats by enabling the battleforce commander to match inexpensive threats with an appropriate response. As a low-cost force multiplier, Spartan provides increased sensor coverage in a net-centric environment, thus enabling the possibility of establishing battlespace dominance.[5]

Figure 1. Spartan Scout Test Bed Model, NUWC, Newport, RI.[6]

Spartan is a remotely controlled, semi-autonomous, modular, multi-mission USV centered on the ability to deploy sensors and weapons which provide warfighters with a remote, offensive and defensive barrier in the littorals. The expanded battlespace coverage afforded by off-board sensors can provide an additional layer of defense in the

5 Naval Undersea Warfare Command, “SPARTAN SCOUT Advance Concept Technology Demonstration (ACTD) Management Plan Rev 1” (Executive level, living document that is intended to outline the basic strategies necessary to execute the SPARTAN ACTD, 14 March 2003) 1.

6 Naval Undersea Warfare Command, “SPARTAN SCOUT ACTD Management Plan Rev 1.”

early warning/intercept capability. As a result, Spartan is designed to provide protection for surface combatants, noncombatants, and other national and strategic assets. As a node in the battlespace network, Spartan's extended ISR capability facilitates the development of an accurate tactical picture to ensure information superiority. [7]

The Spartan Scout consists of a core system and several selectable warfighting modules integrated on a seven-meter or 11-meter rigid hull inflatable boat (RHIB). Warfighting modules will be developed to support primary missions of Intelligence, Surveillance, and Reconnaissance/Force Protection (ISR/FP), Mine Warfare (MIW), Precision Engagement (PE) and Anti-Submarine Warfare (ASW). The MIW module will be equipped with side-scan sonar to conduct bottom-mapping and search for undersea mine threats. The ISR/FP module will include enhanced electro-optic (EO) sight/sensors and a gun weapon system with target tracker to conduct in-port surveillance, identification, and interdiction as part of a FP mission. In the future, the ISR/FP module may contain chemical/biological sensors, explosive sensors, etc., to enhance missions assigned to platforms. The Precision Strike/Anti-Surface Warfare (PS/ASUW) module will be equipped with EO sight and target designator and a stabilized missile system (e.g., Javelin or Hellfire) to conduct an armed strike mission and Anti-Surface Warfare (ASUW) missions.

Spartan Scout is under consideration to fulfill secondary mission requirements such as communication relay, trip wire operations, amphibious warfare support, Unmanned Aerial Vehicle Support (UAV), Special Warfare support, harbor/port security shore fire support, decoy, and psychological operations support.

B. SEA FOX

The Sea Fox is a semi-autonomous, reconfigurable, high-speed, unmanned surface vehicle-small (USV-S) (Figure 2). It provides two-way communications with intruders, determination of intent of intruders, and intelligence collection of the situations at safe standoff distances for manned small patrol boats and Visit, Board, Search, and Seizure (VBSS) Teams. The system consists of a Sea Fox USV, the Remote Operator Station (ROS) and Mobile Remote Operator Station (MROS). Through wireless RF relays, the Sea Fox can engage in two-way voice communications and transmit real-time

[7] "SPARTAN SCOUT Advance Concept Technology Demonstration Management Plan Rev 1", 3.

video and infrared imagery to the ROS, thus allowing for standoff engagement of potential threats and increased situational awareness during Enhanced Maritime Interdiction Operations (EMIO) and VBSS missions.

Figure 2. Sea Fox

Sea Fox is designed to provide force protection with more flexibility in EMIO(small boat against small boat scenarios) and safer Intelligence, Surveillance, and Reconnaissance (ISR) gathering to aid in threat assessment, decision-making, and situational awareness, prior to escalation to lethal actions.[8] Initially, Sea Fox will serve as an extension of the eyes and ears of the VBSS/MIO team, allowing close observation of COI while team personnel remain outside effective small arms range.

C. REMOTE MINEHUNTING SYSTEM

The AN/WLD-1(V)1 Remote Minehunting System (RMS) is the Navy's new integrated shipboard unmanned vehicle designed to reduce the threat of hidden mines. It detects, classifies and identifies mines, and records their precise location for removal and or avoidance. Carried aboard the ship in a specially configured starboard aft section, RMS is a diesel-powered, semi-submersible vehicle that can prowl beyond the ship's horizon, autonomously scouting and searching for mines using its forward and side-scanning sonar. Its onboard Global Positioning System (GPS) navigation system takes

8 NAVSEA Warefare Center Norfolk "SEAF0X Concept of Operations (CONOPS)." Draft. June 2005.

commands via a data link from the ship. Sonar data and streaming video from the vehicle's mast mounted camera are continuously transmitted to the ship.

Figure 3. Remote Minehunting System's RMV[9]

The first operational RMS was deployed on the USS Pinckney (DDG-91) and USS Momsen (DDG-92) as shown in Figure 3. Currently, there are plans to expand installations on additional Arleigh Burke Flight IIA Class hulls. It is fully integrated into the ship's AN/SQQ-89(V)15 Undersea Warfare Combat System and include a launch and recovery system integral to the ship. Other surface ships being considered as host platforms for AN/WLD-1(V)1 are the HSV-X2, an interim replacement for MCM command ship, and the Littoral Combat Ship (LCS).[10]

[9] Available from NAVSEA Warfare Centers, Panama City website at URL: http://www.ncsc.navy.mil/Our_Mission/Major_Projects/Remote_Minehunting_System_Focus_Sheet.htm Accessed 11 November, 2005.

[10] NAVSEA Warfare Center Panama City web site: http://www.ncsc.navy.mil/Our_Mission/Major_Projects/Remote_Minehunting_System_Focus_Sheet.htm

D. FUTURE USV DEVELOPMENT

USVs can be considered to be integral to US Navy transformation. They are force multipliers designed to provide flexibility, agility and stand-off distances to threats. Navy planners envision USVs operating in littoral areas and protecting the fleet from asymmetric threats, e.g., terrorists. Possible USV missions include intelligence collection, anti-submarime warfare, precision strike, and special operations**.** The next generation of USVs will be different from today's vehicles. They will have highly integrated hulls that contain all of their sensors, communication antennas, weapons and machinery. These newer USVs will have expanded combinations of speed and endurance, and will be harder to detect.

One such USV is under development by the Navy's Office of Naval Research called the Unmanned Sea Surface Vehicle (USSV), depicted in Figure 4. Lessons learned from Spartan Scout are being incorporated into the USSV to develop a new hull form vehicle with a larger payload capacity, longer range and time on station. The USSV will meet interoperable requirements, i.e., is mission reconfigurable and fits with the modular, multi-functional family of platforms. One operator will be able to supervise several USVs at long range. Spartan Scout ACTD and Sea Fox fleet demonstrations are setting the groundwork for the advancement of USV technology and procedures that will enable USVs to operate safely in the vicinity of manned vessels.

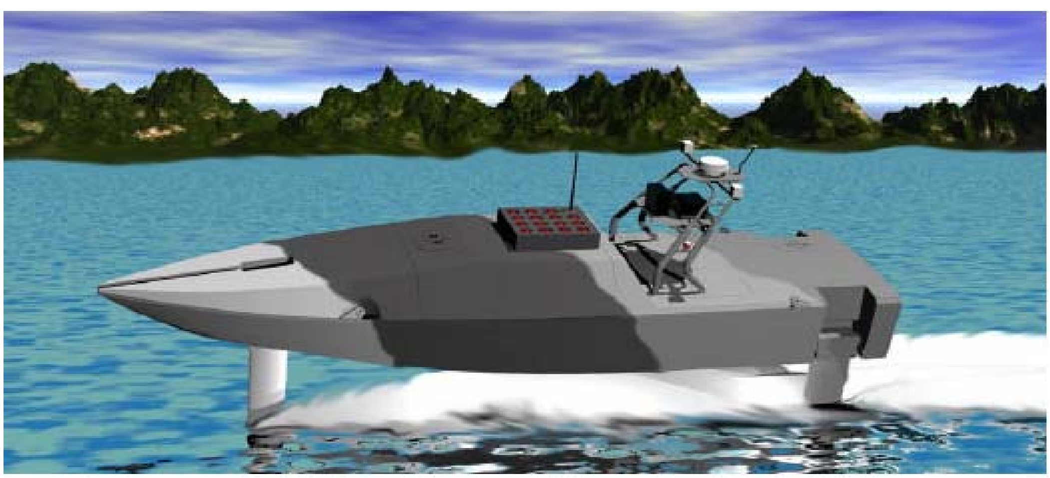

Figure 4. ONR's USSV Concept[11]

[11] The ONR Background Information for SBIR 051-055 Proposes. NAVSEA Warfare Center. 3 December 2004.

E. CHAPTER SUMMARY

USVs are already operational, and are also being researched and developed to support U. S. Navy transformation. Ongoing programs at Navy laboratories and research centers continue to set USV standards, and the Navy might take alternate paths toward USV implementation. One direction consists of less expensive and complicated types like Sea Fox. These USVs could be used in hazardous environments such as high-speed surface targets for force protection training.

An alternate path is more complicated and expensive such as USSV. The Navy's development of this larger multi-mission USV may be designed to operate from its new generation of combatant ships such as the LCS and DD(X). It will make use of technology developed during the Spartan Scout ACTD. The USSV will operate with LOS as well as OTH communication links. These USSVs will be capable of launching and recovering smaller USVs, UUVs and UAVs.

III. USN USV EMPLOYMENT AND TESTING

A. SPARTAN SCOUT

1. USS Enterprise Carrier Strike Group

In late 2003 and early 2004 Spartan Scout was installed on board USS Gettysburg (CG-64) while deployed to the Persian Gulf with the USS Enterprise Carrier Strike Group. Gettysburg successfully completed military utility assessment (MUA) in anti-terrorist/force protection (ATFP), maritime interdiction operation (MIO), and surface search and control (SSC) mission areas.

a. Operation

Spartan Scout was ISR configured while assigned to Gettysburg. Eighteen personnel consisting of Boatswain's Mates (BM) and Seamen (SN) were used in the launch and recovery of both Spartan Scout and the ship's RHIB. A minimum of four personnel were required to operate Spartan Scout: one to operate the ROS as driver; C2 operator to monitor sensor displays; RC operator to control Spartan Scout during launch and recovery; and a Coxswain for manned operations. USS Gettysburg's USV crew assignments are illustrated Table 1.

USV Team	
Position	**Rate**
Remote Operating Station (ROS)	Officer
Command and Control (C2) Operator	Officer
Radio Control (RC)	PN3
Coxswain	BM2
Electronic Repair	ET2
Mechanical Repair	EN2
Launch and Recovery	Various BMs/Deck Seamen

Table 1. USS Gettysburg's Spartan Scout Team

USS Gettysburg (CG-64) Surface Warfare qualified (designator 1110) officers supervised command and control operations in order to abide by rules of the road and to ensure safe navigation of Spartan Scout. A Personnelman Third Class (PN3) served as RC operator from above decks once the Spartan Scout was within 200 yards of the host ship. The Coxswain provided manual control in case of loss of radio control frequency link between Spartan Scout and the host ship. After approximately one month of operating with Spartan Scout, CG-64 demonstrated both night and day unmanned operations. Additionally, a senior officer in CIC such as the Operations Officer served as mission supervisor relaying pertinent information to the ships Commanding Officer.

b. Training

Prior to the deployment, several of Gettysburg's personnel were informally trained to operate and maintain Spartan Scout. Ships force personnel were trained on board in three phases under the supervision of NUWC technical representatives. The training covered launch and recovery procedures, remote control, Falconview software familiarization, and command and control.[12] Training was conducted weekly at a minimum and lasted approximately one month. The crew was provided training on davit launch and recovery operations. Two ET3's received training in pre and post maintenance checks. This type of training could be categorized as on-the-job training (OJT) and was conducted by operating the USV locally in the Mayport Florida tidal basin. NUWC technical representatives trained personnel in support of the military utility assessment (MUA).

B. SEA FOX

1. USS Tarawa Expeditionary Strike Group

In January 2006, Sea Fox was installed on USS Pearl Harbor (LSD-52), which deployed with the USS Tarawa Expeditionary Strike Group (ESG-1). Sea Fox was employed during various fleet evolutions to analyze its technological viability and future use in Visit, Board, Search, and Seizure/Extended Maritime Interdiction Operations (VBSS/EMIO) mission areas.[13]

a. Operation

Sea Fox was operated by the MIO team in one of three modes; remote control, waypoint navigation or follow-me mode. In remote control mode both wired and wireless joysticks are available for vehicle control. Waypoint navigation allows the vehicle operator to click on built-in charts via embedded software to guide Sea Fox's

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[12] "Spartan Scout Lessons Learned ID LLEA0-08616," in. Navy Lessons Learned Database (NLLDB) [CD-ROM] (Naval Warfare Development Command, vol. 5, no. 2, November 2005 [cited 20 January 2006]).

[13] PMS480 Anti-Terrorism Afloat, "Application for Equipment Frequency Allocation for Sea Fox USV Proof of Concept Demonstrator." (Draft). 13 June 2005.

route. When using the follow-me mode Sea Fox automatically maneuver's to remain behind the MIO teams' RHIB at a pre-specified distance. During operations Sea Fox is kept between the MIO RHIB and the contact of interest as depicted in Figure 5 for optimum communication relay.

As installed onboard USS Pearl Harbor, Sea Fox required a minimum of 20 personnel to launch and recover (Appendix A), in addition to the launch and recovery team for the ships force RHIB. These personnel consisted of BMs and SNs. A minimum of two people are required to operate Sea Fox; one to drive the unit via MROS/ROS, a BM2, and a payload operator, Gunner's Mate Second Class (GM2) to remotely operate the cameras and loud hailer.

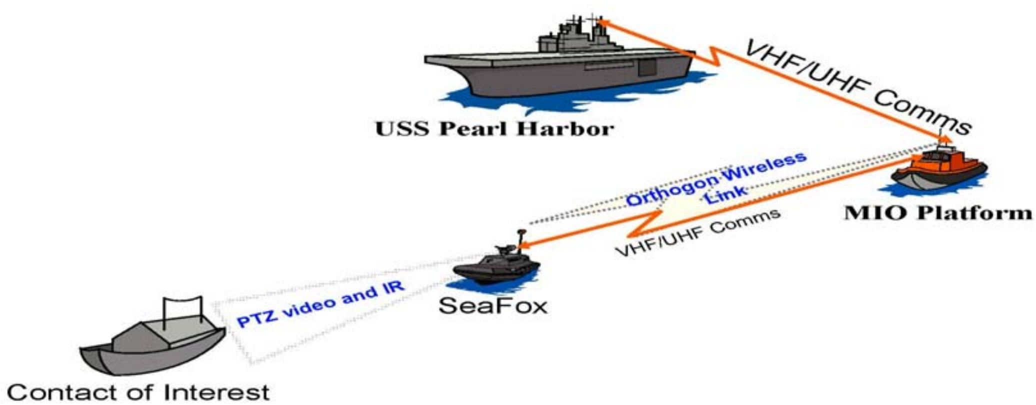

Figure 5. Sample Operational Scenario.[14]

b. Training

Prior to USS Pearl Harbor's (LSD-52) deployment ships force personnel were sent to Northwind Marine and Mercury Marine to receive a three day training course in Sea Fox operations and maintenance. The personnel included two GMs (payload operators), two BMs (Sea Fox drivers), two technicians; one Electronic Technician (ET) and one Information System Technician (IT). The training crew spent the first day in the classroom learning the Falconview software computer program. The

[14] Sea Fox Concept of Operations. NAVSEA Warfare Center Norfolk. June 2005.

next two days were spent on a dock in Lake Washington, familiarizing them with operating and troubleshooting Sea Fox.

2. Distributed Mobile ASW Sensors Limited Objective Experiment

As part of a NWDC developed and executed Distributed Mobile ASW Sensors (DMAS) Limited Objective Experiment (LOE), two Directional Command Activated Sonobuoy System (DICASS) equipped Sea Foxes were used in an ASW tracking exercise to evaluate the utility of low cost remotely operated mobile ASW sensors.[15] This LOE was conducted at the Southern California Offshore Range 7 July 2005, and was not a Fleet employment of the Sea Fox USV. However, Helicopter Squadron Light (HSL-45) assisted NWDC in the experiment.

a. Operation

The two USVs were controlled remotely via a ROS configured electronic kneeboard computer installed onboard a SH-60B Light Airborne Multipurpose System (LAMPS) helicopter by the aircrew. The LOE successfully demonstrated the ability of a helicopter aircrew to direct the movement of multiple USVs from a ROS installed in an aircraft, and detect a moving target.

A commercial support vessel was used to launch and recover the USVs, and initial remote control of the USVs. Remote control was passed after initial system checks are completed to the SH-60B. Two personnel were required in the command and control of the USVs; one aboard the support vessel and one in the helicopter.

b. Training

LOE personnel training were minimal. Launch, recovery, and control of the USVs from the support vessel was by technical representative already familiar with Sea Fox. The SH-60B USV operator received several hours of familiarization training prior to commencement of the exercise.

C. REMOTE MINEHUNTING SYSTEM

1. Arleigh Burke Class hulls DDG 91-96

The Remote Minehunting System (RMS) program has exercised a series of developmental prototypes in a fleet environment enroute to a fully supported operational system. The RMS (V)1 variant was launched pier side and operated from USS John

[15] Post Experiment Report. 22 September 2005.

Young (DD 973) during Kernel Blitz '95. A later variant with shipboard launch and recovery capabilities was installed and deployed on the USS Cushing (DD 985) and successfully demonstrated during SHAREM 119. The final RMS variant, AN/WLD-1(V)1, is now installed and deployed aboard DDG's 91-97.[16]

a. Operation

The remote mine vehicle (RMV) of the RMS can be pre-programmed to perform autonomously or manually controlled at any time via data link by a single operator. Command and control of the RMV is via the AN/UYQ-70 console (Figure 6) by a Sonar Technician (Surface), (STG).

The operation of the RMS falls under pre-existing shipboard combat systems watch team organization for the MIW mission area. The operation is supervised by a qualified tactical action officer (TAO) and executed by the anti-surface warfare evaluator (ASWE) in the combat information center (CIC).

Figure 6. AN/UYQ-70 Console.[17]

[16] Naval Surface Warfare Center Panama City. "Remote Minehunting System Focus Sheet," Available from NSWC website. URL:http://www.ncsc.navy.mil. Accessed 17 January 2006.

[17] Lockheed Martin Corporation." AN/WLD-1 Remote Minehunting System Organic Mine Reconnaissance for the Littorals." 2005.

The RMV is launched and recovered as safely and simply as a ship's boat. A single capture/release device provides a 15-ft. reach from the host ship.[18] Figure 3 illustrates the launch and recovery system on Arleigh Burke Class Flight IIA destroyer. Launch and recovery of the RMV require only five personnel.

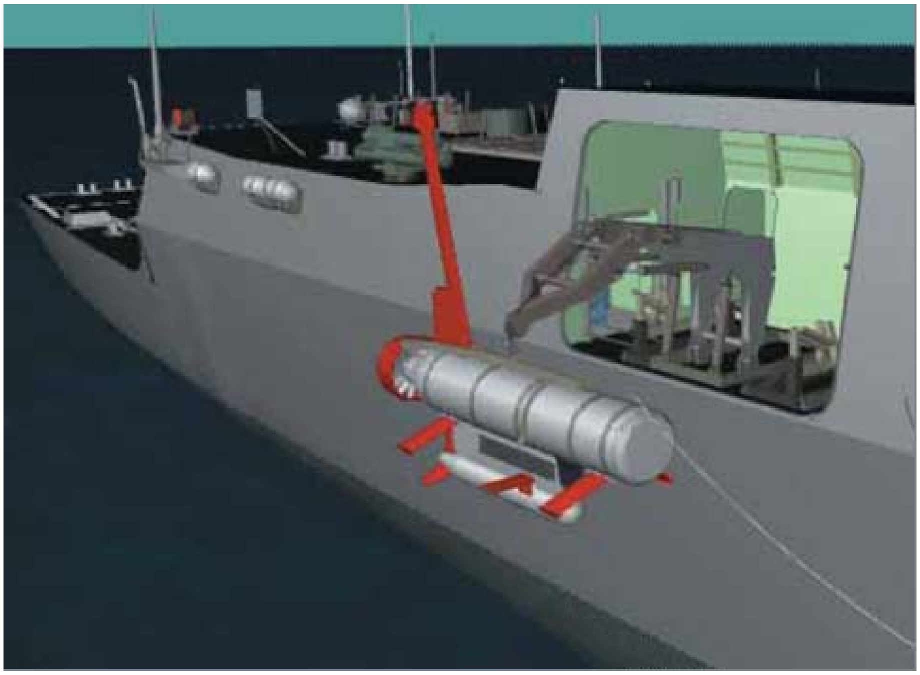

Figure 7. RMS Launch and Recovery System.[19]

b. Training

Currently, personnel working with RMS attend training provided by the Navy and the system manufacture. Some rate specific training is provided by existing "A" and "C" schools. Other courses are under development or provided by the manufacturer. The current and projected training path for RMS operators in the MIW mission area is illustrated in Table 2.

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18 Lockheed Martin Corporation." AN/WLD-1 Remote Minehunting System Organic Mine Reconnaissance for the Littorals." 2005.

19 Lockheed Martin Corporation."AN/WLD-1 Remote Minehunting System Organic Mine Reconnaissance for the Littorals." 2005.

OPERATOR TRAINING							
SAILOR	**CIN**	**COURSE TITLE**	**NEC**	**LOCATION**	**TYPE**	**LENGTH (DAYS)**	**PRE-REQ'S**
STG1	J-041-0103	AMMO ADMIN	N/A	FCTCLANT, DAM NECK	F1	5	N/A
All	A-2G-2758	MIW Core	N/A	Ingleside, Texas	D2	10	E-6 & ABOVE
E-7 & Above	A-2G-2760	MCM Planning Officer	N/A	Ingleside, Texas	F2	10	MIW Core
E-7 & Above	A-2G-0089	MIW OPS Officer Course	N/A	Ingleside, Texas	TBD	5	MIW Core MCM Planning Officer
E-6 & Above	A-121-0007	MEDAL Supervisor	N/A	Ingleside, Texas	TBD	10	GCCS-M
STG	TBD	SNUITT–Side Scan SONAR Recognition	TBD	Ingleside, Texas	TBD	5	SONAR Operator
OS/TBD STG	K-221-2503	ASW/ASUW Tactical Air Controller	0324	CSCS San Diego / Norfolk	C1	TBD	E-5 & Above
E-6 & Above	J-221-2311	GCCS-M Operator	0342	CSCS San Diego / Damneck, Va	C1	TBD	N/A
All	A-647-0009	AN/WLD-1(V)1 RMS Operator (Manufacturer Training)	N/A	NSWC Panama City FL, LOCMAR Syracuse NY	TBD	10	N/A
STG	TBD	STG C School AN/SQQ-89A(V)-15 Maintenance (Manufacturer Training)	0525	Chesapeak, Va	C1	TBD	STG "A" School Advanced Electronics Training
STG	TBD	MP Computing Environment Maintenance	TBD	NSWC Panama City FL	TBD	TBD	N/A

Table 2. RMS Operator Training Path[20]

[20] STGC(SW) Stephan Hurley, "MIW Mission Package Training & Manning Brief" (taken from a presentation presented at Center for Surface Combat System Learning Site, Norfolk, Va, April 2004).

D. CHAPTER SUMMARY

This chapter looked at several instances where the Navy has employed Spartan Scout, Sea Fox and Remote Minehunting System USVs in a maritime environment. Spartan Scout deployed aboard USS Gettysburg during their 2003-2004 Persian Gulf deployment where it was used in surface surveillance and maritime interdiction roles. Sea Fox deployed aboard USS Pearl Harbor for the majority of ESG-1's 2006 Persian Gulf deployment. The Sea Fox USV-S was employed in VBSS/EMIO capacity. Sea Fox military utility was demonstrated while being controlled from an SH-60B. The RMS is installed on several newer Flight IIA Arleigh Burke destroyers, and is the only operational USV in the fleet after numerous years of testing. The RMS can also be employed in a MIW capacity.

USV operations appear to require several different ratings with some overlapping commonality. The BM, IT, ET and EN rating were all used in the three USVs operations with exception of Spartan Scout with GM and RMS with STG. Surface Warfare Officers were used in a command and control rules of the road capacity.

Personnel training remain mostly informal and an established formal training path for USVs operators has yet to be established. The RMS is the closest to having a formal training path utilizing existing Navy schools. The majority of operator training is currently provided by the USV manufacture.

IV. MANPOWER ANALYSIS

A. KNOWLEDGE, SKILL AND ABILITY

What crewmembers need to know and should be able to accomplish to successfully execute USV missions can vary. Table 3 illustrates the basic, general KSA's USV crews need (see also Appendix C). Some of these areas are specific to USVs, while others are found within various enlisted rating occupational standards as illustrated in Table 4. For example, seamanship skills that involve basic rigging can be found within the Boatswain's Mate rating.

Different USV crewmembers are expected to operate a variety of equipment such as radars, sonar, cameras, launch and recovery systems, and weapon systems. Some equipment differs between USV types, such as weaponized vs. non-weaponized, or mission specific differences requiring operators with different skill sets. USV crew KSA performance measures are illustrated in Appendix C.

USV CREW GENERAL KNOWLEDGE, SKILL AND ABILITY							
Occupational Standards	Task Statements						
A. Operate equipment	A1 Operate vehicle functions	A2 Operate cameras	A3 Operate radio frequency link systems	A4 Operate sonar	A5 Operate radars	A6 Operate launch and recovery systems	A7 Operate weapons
B. Pilot the USV	B1 Evaluate environmental conditions and hazards	B2 Dock/undock from along side of ship	B3 Navigate the USV				
C. Perform maintenance/repairs on equipment	C1 Maintain/repair electronics	C2 Maintain/repair hydraulics	C3 Maintain/repair Mechanicals	C4 Use test equipment			
D Maintain communications	D1 Coordinate/integrate with fellow crew members						
E. Use seamanship skills	E1 Perform basic rigging						

Table 3. Occupational Standards and Task Statements of USV Crewmembers.[21]

[21] Knowledge and Skills Guidelines for ROV Technicians. Marine Advance Technology Education Center. 2002.

USV CREW OCCUPATIONAL STANDARDS	
BM (NAVPERS 18068-14B)	• Test crane riggings • Perform winch operations • Perform crane and boom operations • Raise and lower boat cradle • Launch and recover boat • Rig and unrig sea painters • Hook and unhook sea painters
EM (NAVPERS 18068-29C)	• Clean, inspect and test components of small craft electrical systems • Troubleshoot and repair components of small craft electrical systems • Remove components of small craft electrical systems • Replace components of small craft electrical systems
EN (NAVPERS 18068-30B)	• Align/secure small boat oil/water separator systems • Mechanical maintenance
ET (Surface) (NAVPERS 18068-32E)	• Clean and inspect navigation (NAV) radar equipment • Test, operate and evaluate NAV radar equipment • Test and operate commercial radar equipment • Evaluate radio frequency (RF) signals • Analyze RF signals • Troubleshoot and repair loudspeakers
GM (NAVPERS 18068-38C)	• Weapon system operations • Weapon system/components maintenance • Weapons handling/maintenance • Ordnance/component maintenance
IT (NAVPERS 18068-67B)	• System management • Application management • Communications
OS (NAVPERS 18068-59B)	• Tactical support operations • Surface warfare • Navigation • Undersea warfare
STG (Surface) (NAVPERS 18068-73C)	• Sonar operations • Sonar system maintenance • Sonar software maintenance • Technical administration

Table 4. Existing Navy Occupational Standards Applicable to USVs by Ratings[22]

B. LAUNCH AND RECOVERY

The premise is that platforms augmented with USVs increase warfare capability and reduce personnel risks. While the word “unmanned” implies that USV operations should require fewer personnel to operate, analysis indicates that this is not the case.

[22] Manual of Navy Enlisted Manpower and Personnel Classifications and Occupational Standards Vol. I Part A and B, NAVPERS 18068F.

Spartan Scout and Sea Fox fleet operations showed that it requires more people in their launch and recover than in the launch and recovery (L & R) of the ship's RHIB, as illustrated in Table 5. The USV L & R requires the aid of one of the host ship's RHIB to get the USV in and out of the water, thus increasing personnel workload.

LAUNCH AND RECOVERY		
Host Ship	**RHIB**	**USV**
Pearl Harbor	15	20
Gettysburg	11	18
DDG 91-96	9	4

Table 5. L & R Personnel Numbers

The continued use of legacy L & R systems (example shown in Figure 8), has caused an increase in boat deck manning. In a Naval Postgraduate School thesis, Thaveephone Douangaphaivong recommended the US Navy "Pursue a UV launch and recovery system that is similar to an overhead rail system with automated winches and controls operable by only one person...Use Visby Swedish Corvette as a model."[23] Another study done by the US Coast Guard found that the stern launch-and-recovery system on the Swedish Coast Guard vessel KBV 201 is able to launch and recover a RHIB using only two people.[24] The overhead rail and stern launch and recovery systems are designed to require minimum personnel to operate. Such systems should be explored as part of USV employment in the US Navy.

[23] Thaveephone Douangaphaivong, "Littoral Combat Ship (LCS) Manpower Requirements Analysis". Naval Postgraduate School Thesis, March 2004.

[24] U.S Coast Guard study "Stern Boat Deployment Systems and Operability." Available from URL: http://www.skibstekniskselskab.dk/download/WMTC/B2(O21).pdf. Accessed 02 February 2006.

Figure 8. L & R of Spartan Scout aboard USS Gettysburg CG-64

USV deployment from USS Gettysburg and USS Pearl Harbor are clearly a case of a legacy L & R system used to support a new technology, unlike the L & R system for RMS aboard DDG 91-96, which require less people than what it takes to deploy its RHIB (see Table 4). The Spartan Scout ACTD projected spiral development plan does not address this concern, as illustrated in Table 6. USV introduction into the fleet should abide by the Navy's reduced manning initiatives. L & R is an area where manning could be reduced. Reduced manning L & R systems exist that could be incorporated into USV programs.

C. OPERATIONAL MANNING

Operational Manning is the quantitative/qualitative manpower element of the ship's battle bill, which is part of the larger Ship Manpower Document (SMD). The battle bill delineates the (watch stations) operational manning and evolutions required to support the different control stations in order to satisfy the requirements of the Required Operational Capabilities and Projected Operational Environment (ROC/POE). A proposed SMD battle bill modification for a ship equipped with a Spartan Scout or Sea Fox and RMS is illustrated in Table 7. This combination of USVs is a likely combination for DDG 91-96 and future platforms such as LCS and DD(X).

The operational manning requirements for the battle bill would vary depending on the type of USV and mission configuration; thereby influencing the optimum watchteam composition. The RMS watch station would be reserved to the subsurface warfare area. The watch station for Spartan Scout on the other hand with its flexible mission packages, could fall under subsurface and surface warfare areas.

SPARTAN SCOUT PROJECTED SPIRAL DEVELOPMENT			
Functional Categories	**Spiral 1**	**Spiral 2**	**Spiral 3**
Core System	Core subsystems integrated into modified RHIB test bed	Core subsystems on Modularized RHIB	Optimized core system with modular payload capability
Command, Control, and Communication (C^3)	Remote control for single vehicle	Semi-autonomous, remote single vehicle control with obstacle avoidance	BLOS, multi-vehicle, semi-autonomous control
MIW Module	Klein 5500 Side-Scan Sonar	AN/AQS-14 Side-Scan Sonar	AN/AQS-20X Mine-Hunting Sonar or LMRS (not currently funded)
ISR/FP Module	ISR capability only	ISR/FP capability (with weapon certification)	IROSSS gun vs. moving target (ASUW)
Precision Strike/ASUW Module	Hellfire Missile vs. Stationary Target SS 0-1	Hellfire Missile vs. Moving Target in SS 1-2	Hellfire Missile vs. Moving Target at sea in SS 2-3 (ASUW)
Training	User training requirements developed	Training plan developed and implemented	Embedded training developed and implemented
Host Ship Integration	Host ship impact analysis	Host Ship Integration Logistics Plan and System Interface Specification	ILS and system integration into host platform
Interoperability	Control of one SPARTAN by USN and/or RSN platforms	Interchangeable subsystems and modules supportable by RSN and USN hosts	Coordinated coalition threat engagement exercise using multiple Spartans (from USN and RSN)

Table 6. SPARTAN Spiral Developments.[25]

[25] NUWC "SPARTAN SCOUT Advance Concept Technology Demonstration Management Plan Rev 1", (14 March 2003). 10.

BATTLE BILL FOR DDG 51 FLIGHT IIA EQUIPPED WITH TWO USVs						
STATION IDENTIFICATION	CONDITION I			CONDITION III		
WATCH STATION TITLE	DIV	MIN RATE	NEC	DIV	MIN RATE	NEC
Subsurface Warfare						
Warfare Coord/Mission Planner	Ship	OFF		Ship	OFF	
Mission Planner/Sensor Oper (RMV)	CA	STGC	0342/0466	CA	STGC	0342/0466
RMV Driver	CA	STGC	0466/0488	CA	STGC	0466/0488
USV Driver	CA	STGC	0466/0488	CA	STGC	0466/0488
USV Driver Sensor Oper	OI	OS1	0325	OI	OS1	0325
GCCS-M Oper	OI	PO2	0342			
PMA/Environmental Analyst		STG2	0466		STG2	0466
Surface Warfare						
Surface/Subsurface Warfare Coord.	Ship	OFF		Ship	OFF	
Surface Warfare continue						
USV Driver	Ship	OFF		Ship	OFF	
USV Sensor Oper	OI	OS1		OI	OS1	
Launch & Recovery						
Safety Supervisor	OD	BM3		OD	BM3	
Deck Supervisor		BM3	0107		BM3	0107
Overhead Crane Operator	OD	BM3		OD	BM3	
Remote Vehicle Oper	OD	BM2		OD	BM2	
Coxswain	OD	BM3		OD	BM3	
Bowhook	OD	SN		OD	SN	
Talker (N12)	Ship	SN		Ship	SN	
Boat Tender	OD	SN		OD	SN	
Boat Engineer	A	EN3	4303	A	EN3	4303
Electronics Repairman	CE	ET2				

Table 7. Notional DDG 51 Flight IIA Evolution USV Battle Bill

D. TRAINING

Sailors require new and/or different KSA's to support collaboration between human and machines indicative of current and future USVs which make use of commercial/government off the shelf (COTS/GOTS) technology. A well established training path is likely crucial to ensure qualified personnel are technically capable to support this evolution. This training path should include position, job, or task KSA identification.

1. Spartan Scout

The Spartan Scout ACTD highlights the planned approach for personnel training:

> The SPARTAN approach to training is to leverage as much as possible off of the training that has already been developed in support of the standard Navy 7-m RHIB program and other programs that share characteristics similar to SPARTAN. The majority of the SPARTAN training will be shipboard on-the-job training (OJT), supplemented by shipboard computer-based embedded training. No new shore-based schoolhouse-type trainers are planned for development. Coupling the spiral development of the SPARTAN with its necessary training modules can facilitate the introduction and integration of new training embedded technologies for shipboard use.[26]

USS Gettysburg's initial operation of Spartan Scout revealed several problems with training:

- The ship only became comfortable with operator proficiency after many weeks of driving the vehicle, and comfort increased incrementally. Off ship operations of the Spartan Scout began with a coxswain aboard and only during daylight hours and with the chase boat in the vicinity. That was followed by unmanned operation during daylight hours and in accompany of the chase boat. Once the ship was comfortable with their operators' daytime operation of Spartan Scout, they shifted to nighttime unmanned operations.
- USS Gettysburg used surface warfare qualified officers for Spartan Scout command and control. This highlights the assumption that C2 operators need to possess a firm knowledge of nautical rules of the road to operate USVs safely in the maritime environment.
- The incremental spiral development methods necessitate retraining of previously trained personnel.
- There is lack of readily available Navy Training System Plans (NTSP).

The Spartan Scout ACTD's approach to training will be able to utilize some aspect of already established training available for navy standard RHIBs, but not all. If Spartan Scout maintains the Navy standard RHIB as a base platform on which mission

[26] NUWC "SPARTAN SCOUT Advance Concept Technology Demonstration Management Plan Rev 1", (14 March 2003). 11-12.

modules are built, then some training aspects for the Navy standard RHIB that are already available will be applicable. Training of mechanical maintenance and L & R systems personnel should be similar between Spartan Scout and the Navy standard RHIB. The addition of COTS/GOTS equipment to Spartan Scout, which is uncommon to the Navy standard RHIB, would require electronic repair personnel to need additional training.

Unlike the RHIB, a weaponized Spartan Scout, or combat capable USV could be considered an extension of the host ship's weapon systems. This capability allows the placement of a remotely controlled vehicle with considerable firepower topside within regular shipping lanes, which can create new problems. The Navy's surface warfare tactical memorandum (TACMEMO) reaffirms:

> When employing any asset for a tactical mission such as contact identification, intercept and escort, or increasing self-defense posture, there are rules of engagement considerations. Addition of UVs to the CSG/ESG produces an incremental shift in ROE planning for the force. Preplanned responses programmed into UV profiles and executed in decentralized control are situational. The introduction of autonomous systems has ROE implications and requires explicit consideration among tactical decision makers to ensure their employment is appropriate and consistent with force-wide posture.[27]

For a level of comfort to be reached in safe operation of a USV, operators must receive formal doctrine training. Training should address issues associated with weapon utilization such as rules of engagement (ROE), and Tactics, Techniques and Procedures (TTP).

2. Sea Fox

At the time of this research, there was no official proposed or projected formal operator training path for the Sea Fox USV-S. However, a formal training plan for Sea Fox provided by Northwind Marine states:

> Operator training for Sea Fox is highly dependent on its intended use and installed options. For manual operations within one kilometer with only one Sea Fox in the area, a three day operator's course should be sufficient. The course would cover architecture basics and remote operation of Stop, Start, Forward Neutral, Reverse, Throttle, and Steering. Operators should

[27] Navy TACMEMO "Integration of Unmanned Vehicles into Maritime Missions TM 3-22-5-SW."

> get two days of stick time to become familiar with the handling characteristics. Sea Fox can be a significant asset even if it is only run manually by an operator within one kilometer. With computer control using maps and waypoints, the scope of operations that Sea Fox can perform increases dramatically, and the complexity of the control system also increases dramatically. A five day course would be required to cover the control of a Sea Fox using a program such as Falconview in addition to the three day operator's course. For payloads similar to the payload on the Sea Fox aboard the USS Pearl Harbor, a five day course would be required to cover the operation of the payload. Technicians should attend the above courses and also a four day technicians' course. Mechanics should receive training at Northwind covering controls, engine removal/replacement and diagnostics. Internal engine repair should be left to full time Mercury mechanics. These courses should be offered in Seattle at Northwind Facilities and on Lake Washington. A training/operators boat will be provided. Northwind expects to produce competent operators given students of average abilities. The courses will include an exam to assure basic competency. Obviously, stellar students or longer classes would increase the effectiveness of the Sea Fox program.[28]

Pre-deployment training can be categorized as insufficient. The time between acquisition and deployment was only a few months which did not allow enough time for proper vehicle testing and training of personnel prior to theater deployment. Analysis indicates that once in theater, Sea Fox suffered initial technical difficulties because of the lack of pre-deployment testing and training. This, along with operational commitments reduced the time available for actual Sea Fox water testing. Between 15 August 2005 and 03 October, USS Pearl Harbor reported 14 (all daytime) hours of operation and 10 hours maintenance.[29]

3. Remote Minehunting System

The RMS is a fully active system installed on several US Navy ships. Existing Navy schools and manufacturer/contractor provided training is used to get operators and maintainers operational (Table 2). This can be considered as a pseudo-formal training path. Many of the required skill sets and competencies for the MIW mission area are found in the STG/OS/EN/ET ratings. All these ratings have established "A" schools and

[28] John Tucker "Sea Fox Training" Northwind Marine. Seattle, WA. 28 November 2005.

[29] USS Pearl Harbor record messages 151440Z Aug 05 and 031748Z Oct 05.

advanced technical training. In addition, Afloat Training Groups (ATGs) approve final operator and maintainer qualifications as part of the ship's certification.

E. ROLE OF USV IN THE MARITIME ENVIRONMENT

1. Validated and Unvalidated USV Missions

USVs have the potential to ease the burden on increasing threat capabilities, rules of engagement parameters, risk management, and personnel operation tempo. The Navy is progressing towards increasing the use of USVs in the maritime environment as shown in the Spartan Scout and Sea Fox fleet demonstrations. Research conducted by the Naval Research Advisory Committee found:

> Demonstrator UV systems have been tested with success in military operations. Technologies for capable sensors and robotics have emerged from the significant government and commercial investments and developments in electronics and computers...Within five years Naval forces could field highly capable UV systems reducing operator risk, with lower manpower requirements and operational cost, while enhancing operational effectiveness. UVs could play major role in the increasing dynamic battlespace of the 21st century.[30]

The final validation of USV mission capabilities as a result of fleet demonstrations to date are shown in Table 8. Validated missions are those missions effectively demonstrated or currently being carried out by USVs. Weaponized ATFP and PS/ASUW are missions to be validated by combat capable USV (CCUSV) versions of Spartan Scout and/or Sea Fox. It is proposed CCUSV could be equipped with a Javelin missile system; a Remote Weapon Station (RWS) with .50 caliber Bushmaster chain gun; and/or Remote Operated Small Arms Mount (ROSAM) with a M2HB .50 caliber machine gun.

[30] United States Naval Research Advisory Committee (NRAC), Roles of Unmanned Vehicles (March 2003 [cited 08 February 2006]) available from http://www.onr.navy.mil/nrac/docs/2003_es_role_unmanned_vehicle.pdf

USV MISSIONS AREAS		
	Validated	To Be Validated
Spartan Scout	• ATFP • MIO • ISR	• Weaponized ATFP • PS/ASUW • MIW
Sea Fox	• Littoral ASW • EMIO • ISR	• Weaponized ATFP
RMS AN/WLD-1(V)1	• MIW • ISR	• ASW

Table 8. Validated USV Missions to Date

F. CHAPTER SUMMARY

This chapter provided a discussion and analysis of the operational manning requirements and the deployment of USVs from US Navy ships. A notional set of KSAs were identified as essential to USV crewmembers. Many of these KSAs were determined to existent in current Navy Enlisted Occupational Standards. Several enlisted ratings were identified as suitable for USV operators and maintainers by their inherent Navy training. However, it was also determined that due to the unique nature of USV employment and tactical situations that formal training requires further development.

Future ship platforms will likely have a combination of USVs installed. To satisfy ROC/POE requirements, the battle bill must reflect watch stations required to support USV operations.

Fleet USV employment should not cause an increase in manning requirements. However, coupling new USV technology to legacy systems without adhering to the Navy's reduced manning initiatives may set up emerging USV programs for failure. L & R is one area identified as manning intensive for USVs. Improved systems requiring less workload like RMS should be explored as part of the USV program for current and future ship platforms. Capabilities provided by USVs would need to be incorporated in ship class ROC/POEs and subsequent Ship Manpower Documents.

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V. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

A. SUMMARY

This research examined operational manning requirements supporting the operation and launch-and-recovery evolution for Unmanned Surface Vehicles (USV) on US Navy ships, including analysis of the rate/rating, skill sets, and training needed to operate and maintain USVs in a maritime environment. The methodology used included a review of test reports and lessons learned from past military utility assessments and other applicable USV media.

B. CONCLUSION AND RECOMMENDATIONS

1. Primary Research Questions

a. What are the human capital manning requirements supporting the launch and recovery of USVs on US Navy host ships?

This study found that two out of the three USVs examined in operations used relatively high numbers of personnel compared to other available systems to launch and recover (see Table 9). Spartan Scout and Sea Fox required the use of an additional ship's boat to get the USV in and out of the water, incurring a 64 and 33 percent increase in workload respectively. RMS, with a newer L & R system had a 55 percent decrease in required personnel compared to what is required for the ship's RHIB. Data indicated that the use of new or improved L & R systems is feasible and can substantially reduce workload during L & R operations. Table 9 shows the number of personnel required by two Swedish platforms using the L & R for a similar type RHIB and USV. Additionally, there is an important need for launch-and-recovery systems for USVs while the host ship is underway.[31]

[31] National Academy of Sciences, Autonomous Vehicles in Support of Naval Operations [database online] (2005 [cited 28 February 2006]) available from world Wide web @http://www.nap.edu/catalog/11379.html

LAUNCH AND RECOVERY			
Host Ship	**RHIB**	**USV**	**%∆**
Pearl Harbor (Sea Fox)	15	20	+33
Gettysburg (Spartan Scout)	11	18	+64
DDG 91-96 (RMS)	9	4	-55
Swedish Coast Guard KBV 201	2	2	0
Swedish Navy Visby Class Corvette	1	1	0

Table 9. L & R Manpower differences between Ship's RHIB and USV

Recommendations:

- Incorporate new and/or improved launch-and-recovery systems for manned and unmanned surface vehicles, particularly new ship platforms such as LCS and DD(X) that will operate with fewer personnel. Improved or replace legacy L & R systems on older ship platforms to reduce personnel in consonance with Navy Human Capital direction.
- Standardize the base USV platform on the Navy standard RHIB (except the Remote Minehunting Vehicle) to reduce cost maintenance.
- The USV program should adhere to the Navy's reduced manning initiative requiring that new systems/subsystems be designed to consider other available systems meet minimum manning requirements (Swedish).

b. What are the basic knowledge, skills and abilities for Unmanned Surface Vehicle operators and maintainers?

Conclusion: A list of basic KSAs with measures of performance (MOP) are provided and depicted in Table 3 and Appendix C. Many KSAs needed by USV operators and maintainers are found within the BM, EM, EN, ET (Surface), GM, IT, OS, STG (Surface) rating occupational standards. These ratings could then be divided as suggested in Table 10.

An additional conclusion is that it will be relatively easy to train personnel from these ratings because relevant nautical and mechanical fundamentals overlap. Consequently, USV programs could merge with existing Navy schools, incurring relatively minimal actual expansion in training requirements.

USV CREW	
Operators	**Maintainers**
GM	BM
OS	EM
STG	EN
	ET
	IT

Table 10. Rate to Job Suitability

c. Which rates/rating support USV operator and maintainer KSAs?

Conclusion: The rates/rating supporting USVs can be combined to support the Navy's Hybrid Sailor Concept. In an interview with Military Training Technology Online, Admiral Ann E. Rondeau defines the Hybrid Sailor concept:

> ...we are downsizing our crews on ships and we're going toward a hybrid sailor. This means I could bring a sailor onboard a ship and, based on how I've taught him or her before they were brought onboard, I then can continue the learning and teaching experience while onboard, and I can take an electronics technician, a fire controlman and an information technician—three different ratings: ET, FC and IT—and create a hybrid sailor with any of those three skill sets who can cross the deck of a ship ready to work. So now I have one sailor doing three different jobs. Now I can create a 90-person ship, and I can cross deck with a versatile, "ready round in the gun chamber" sailor.[32]

Similarly, the EM and EN; the ET and IT; and the OS and STG ratings could be combined into three separate USV ratings.

Recommendations:

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32 Interview with Rear admiral Ann E. Rondeau, Military Training Technology Online, (originally published 26 July 2005, [vol:10 Iss:3]), accessed 01 Mar 2006, available from World Wide Web site, http:///www.military-training-technology.com/article.cfm?DocID=1033

- Draw personnel needed to support USV operations from rates/ratings possessing the basic KSAs for USV functions. These personnel are easier to train, cost less and fundamentally understand the tactics, techniques and procedures for the different warfare capabilities.
- Combine USV support ratings of similar occupational fields to form USV Hybrid Sailors and identify them through the Navy Enlisted Classification coding system.
- Conduct Task Analysis on USV operations and maintenance to match manpower requirements to workload. The information discerned from on-site data collection could be used to validate manpower estimates and/or fine-tune operational manning requirements for USVs on Navy ships.

d. What is the optimum composition of a USV watch team?

Conclusion: The optimum composition of a USV watch team is contingent upon the number of, and the mission capabilities of the USV installed in the ship. Navy ships of the future may likely be equipped with at least one Spartan Scout and one RMS type USV. Chapter IV, Table 7 depicts an optimum USV watch team.

Current concepts of USV command and control are based on the remotely placed operator as a controller of the vehicle's motion through a desktop computer and a joystick. Future concepts envision the remote operator as more of a "mission manager" providing primarily operational mission information to the vehicle, including data concerning target acquisition and weapons release, and may require a single operator to control and manage several USVs simultaneously. To achieve force multiplication using USVs and to reduce the number of dedicated personnel afloat, the ability for a single operator to simultaneously control and manage more than one of these vehicles may be necessary.

Recommendation:

- Accelerate the introduction of the Navy's standard USV to the fleet so that TTPs, SOPs, CONOPs and SMDs are created accurately. This will clarify battle bills reflecting optimum watch teams.

2. Secondary Research Questions

a. What training is required to support the operation and maintenance of USVs?

Conclusion: All three USVs examined in this study employ manufacturer/contractors to conduct the majority of their operator and maintainer training requirements. None of the USVs has a formal training program. Each of the USV crews received varying amounts and degrees of training prior to employing a USV.

Operating USVs remotely in the maritime environment poses unique nautical and/or sea-launch, control and recovery engineering challenges. The complexity of USV systems and L & R subsystems requires trained and managed support personnel, i.e., dedicated skill sets. A formal USV training path would ensure both operational excellence and ship and nautical safety.

A spiral acquisition approach such as the one envisioned by the Spartan Scout program imposes inefficient burdens for USV trainers, i.e., always being one or more steps out of phase with the capabilities being incrementally fielded. This piecemeal arrangement requires additional training at the unit level and is not cost efficient.

Recommendations:

- Develop and implement a Navy Training System Plan (NTSP) to be applied during USV development stages to have properly qualified personnel arrive on or before USVs are delivered to fleet units.
- Establish and maintain a formal training path to ensure standardized TTPs throughout the fleet, and to ensure consistency in competencies and skill sets of USV operators and maintainers.
- Reuse with some augmentation existing ET, EN, and STG advanced training to capitalize on inherent cross-over of skills.
- Standardize the base USV platform on the Navy standard RHIB (except the RMV) to leverage training costs and to establish common standard operating procedures (SOPs).

- Include nautical rules of the road training for USV operators.
- Include USV mission planning and execution (MPE) team certification and maintenance team certification (including technician training).
- Base all training on personnel qualification standards (PQS).
- Promote the development, adoption, and enforcement of Navy-wide seaworthiness standards for the upkeep, operation, and employment of USVs.

b. What role will USVs play in an emerging maritime mission?

Conclusion: Lessons learned from USVs validation in MIW, ISR, ATFP, MIO, EMIO, and ASW mission areas provides a direction for future concepts of operations (CONOPs). Indeed, some advantages for Combatant Commanders have already emerged, i.e., extended visual and electronic reach, better surveillance, and expanded host ship safety zones. As COTS/GOTS equipment technology changes and a CCUSV becomes available, the tactical application of specific missions of these vehicles will evolve. It is incumbent upon the Navy to keep cognizant of USV technology and to exploit its considerable current and future applications.

Recommendation:

- Pursue military utility assessments of USVs to exploit warfighting benefits, acquire operational experience with current systems, and use lessons learned from experience to develop future USV technologies and CONOPs.

C. AREAS FOR FURTHER STUDY

- Conduct a cost benefit analysis of Navy provided training vs. USV manufacturer/contractor provided training, to include:
    i. Simulations and computer base training
    ii. Establishment of two (one on each coast) USV training sites.

APPENDIX A. SEA FOX LAUNCH AND RECOVERY PROCEDURE

This is the launch and recovery procedure used by the USS Pearl Harbor as taken from the Sea Fox Concept of Operations (Draft), June 2005[33].

HANDLING PROCEDURES FOR THE LAUNCH AND RECOVERY OF THE SEAFOX RIB FROM USS PEARL HARBOR (LSD-52)

BACKGROUND: These procedures are intended to provide guidance to personnel engaged in the launch and recovery of the SEAFOX RIB during USS PEARL HARBOR's CY 2005 deployment. Conditions and situations that may pose a hazard to personnel or equipment have been identified and evaluated. This procedure has been written to mitigate those conditions and situations.

DEFINITION: For the purpose of these procedures, sea state 3 is defined as significant (average of one third highest) wave heights up to 5 feet, average wave period 8 seconds, sustained winds up to 16 knots.

NOTE: THESE PROCEDURES WERE DEVELOPED FOR LAUNCH AND RECOVERY OF THE SEAFOX RIB IN CONDITIONS UP TO AND INCLUDING SEA STATE 3 WITH THE USS PEARL HARBOR (LSD-52) TRAVELING AT 3 TO 5 KNOTS INTO QUARTERING SEAS WITH A LEE ON THE STARBOARD SIDE. ANY CONDITIONS OUTSIDE OF THIS OPERATING WINDOW LISTED MAY REDUCE THE SAFETY OF THE LAUNCH/RECOVERY EVOLUTIONS AND MUST BE APPROVED BY THE OFFICER IN CHARGE.

For ready reference, these procedures have been separated into the following categories:

1. EQUIPMENT LIST
2. PERSONNEL CHECKLIST
3. PRE-LAUNCH AND RECOVERY CHECKS
4. RIB LAUNCHING
5. RIB RECOVERY

[33] ESG-1 USV-S Monthly status report (USS Pearl Harbor 031748Z Oct 05) which outline corrections to the above launch and recovery instruction.

1. EQUIPMENT LIST

a. 30 ton cargo crane

b. SEAFOX lifting pendant with Cranston –Eagle model APR-356-CB/CBH lifting hook

c. SEAFOX lifting sling w/shackles

d. 2 steadying line leader lines w/ snap hooks (attached to fore and aft pad eyes on SEAFOX)

e. 1 sea painter leader line w/ snap hooks (attached to forward pad eye of SEAFOX)

f. Steadying lines

g. 1 lifting sling leader w/ snap hook (attached to lifting sling ring)

h. Ship's capstans, bollards and cleats

i. 1 boat hook (on board chase boat)

j. SEAFOX cradle with associated tie downs

2. PERSONNEL CHECKLIST

a. Officer In Charge - The Officer in Charge (OIC) shall supervise the entire boat handling operation.

b. Safety Officer

c. Line handlers

d. Crane Operator

e. Chase boat crew (Coxswain, Boat Hook and Aft line handler, SEAFOX operations personnel)

3. PRE-LAUNCH AND RECOVERY CHECKS:

NOTE: THE CHASE BOAT SHALL BE LAUNCHED PRIOR TO LAUNCHING THE SEAFOX RIB. THE CHASE BOAT WILL STAND OFF ON THE STARBOARD SIDE OF THE SHIP UNTIL INSTRUCTED TO PROCEED TO A POINT BETWEEN THE STARBOARD SIDE OF THE SHIP AND THE INBOARD SIDE OF THE SEAFOX AFTER THE SEAFOX BECOMES WATERBORNE.

a. Muster the OIC, the chase boat crew, line handlers, and the crane operator. Ensure that all crewmembers are wearing proper personnel safety equipment (i.e. Lifejackets, hard hats and safety shoes) and have been briefed on and understand their duties.

b. Perform any pre-operational checks required on the SEAFOX RIB communication equipment.

c. Launch the chase boat.

d. Establish communications with the chase boat crew.

e. Inspect the operating area to ensure that there are no foreign objects that might interfere with operation. Ensure that the SEAFOX securing tie downs are removed and stowed clear of the handling area.

f. Ensure that the SEAFOX lifting sling is properly installed and ready for use. Verify that the sling will not foul any SEAFOX antennas or other gear during launch.

NOTE: THE SEAFOX LIFTING PENDANT, WHEN INSTALLED ON THE CRANE AUXILIARY HOIST HOOK, ASSISTS IN PROTECTING PERSONNEL IN THE CHASE BOAT AND PREVENTS DAMAGE TO THE SEAFOX BY KEEPING THE CRANE AUXILIARY HOISTING HOOK CLEAR OF THE SEAFOX.

g. Rig the SEAFOX lifting pendant to the crane main hoist hook.

h. Ensure that the crane main hoist hook throat is moused closed to secure the SEAFOX lifting pendant into the hook.

i. Ensure that the boat bilges are dry and that the bilge plugs are in place and that the SEAFOX is ready to launch (fuel and oil levels are correct).

j. Attach two forward and two aft steadying lines (inboard and outboard) to their respective leader lines on the SEAFOX.

k. When at the rail, ensure that the sea painter is properly attached to the sea painter leader line on the SEAFOX. Once SEAFOX is at the rail, detach inboard (port) steadying lines forward and aft, leaving only outboard (starboard) forward and aft steadying lines.

l. Ensure that all non-operating personnel are clear of the area.

m. Notify the chase boat coxswain that the SEAFOX is ready to launch.

n. Confirm with the crane operator that the crane is ready to operate.

o. Confirm that the line handlers are ready for launch/recovery.

p. Establish communication with the bridge and advise that preparations for SEAFOX launch/recovery are completed and the SEAFOX is ready to be launched/recovered.

WARNING: ALL REPORTED SAFETY AND OPERATING DEFICIENCIES MUST BE CORRECTED PRIOR TO START OF HANDLING OPERATIONS.

4. SEAFOX LAUNCHING:

a. Ensure pre-operational checks were conducted and are satisfactory. The OIC and safety observer will observe the entire SEAFOX handling evolution and stop the handling operation immediately if abnormal or unusual conditions arise.

b. Ensure all handling personnel are familiar with the planned evolution and their responsibilities. Instruct the SEAFOX handling crew and crane operator to immediately report any abnormal or unusual conditions observed during launch operations.

c. Assign the SEAFOX handling crew and crane operator to their stations.

d. Advise the Bridge that the SEAFOX is ready to launch. On authorization from the bridge, begin handling operation.

e. Lower the crane main hoist hook to the 01 level and attach the SEAFOX lifting pendant. Position the SEAFOX lifting pendant over the SEAFOX lifting point.

WARNING: ENSURE THAT THE SEAFOX SLING RING IS PROPERLY SEATED IN THE THROAT OF THE CRANSTON EAGLE QUICK RELEASE HOOK AND ENSURE THE HOOK IS SECURELY LATCHED

f. Lower the SEAFOX lifting pendant and attach the SEAFOX sling ring to the lifting hook of the pendant. Ensure that the SEAFOX sling ring is securely latched in the lifting hook of the SEAFOX lifting pendant.

g. Hoist the SEAFOX high enough to clear the stowage cradle and life rails.

NOTE: THE LAUNCH POSITION OF THE SEAFOX SHOULD BE FAR ENOUGH OUTBOARD SO AS TO HAVE ENOUGH ROOM TO SAFELY MANEUVER THE CHASE BOAT BETWEEN THE STARBOARD SIDE OF THE SHIP AND THE PORT SIDE OF THE SEAFOX.

h. Slew the SEAFOX into launch position.

i. Lower the SEAFOX to the water. Use the steadying lines to tend the SEAFOX during its descent. The SEAFOX operator should start the engine two feet above the water for immediate control in the water.

j. Maneuver the chase boat alongside the starboard side of the SEAFOX and maintain this station.

NOTE: A BOAT HOOK FROM THE CHASE BOAT MAY BE NEEDED TO REACH THE RELEASE LANYARD, STEADYING LINES, AND SEA PAINTER LEADER LINE.

CAUTION: THE FOLLOWING SEQUENCE OF RELEASING THE SEAFOX STEADYING LINES, HOIST HOOK, AND SEA PAINTER IS IMPORTANT TO ATTAIN A SAFE LAUNCH OF THE SEAFOX WHILE THE SHIP IS UNDERWAY.

k. Using the release lanyard on the SEAFOX lifting hook, the chase boat crewmember shall release the lifting hook. The chase boat crew shall signal to the OIC that it is safe to raise the crane auxiliary hoist hook. Upon receipt of authorization from the OIC, the crane operator shall raise the crane auxiliary hoist hook.

l. The sling ring of the SEAFOX shall be hooked to the SEAFOX grab bar using the sling ring leader line.

m. The aft steadying line handler will slack the aft steadying line until the chase boat crew can reach it. The chase boat crewmember will unhook the aft steadying line from the aft leader line at the leader line release hook.

n. The aft line handler will retrieve the aft steadying line.

o. The chase boat crewmember shall hook the aft leader line to the SEAFOX grab bar.

p. The fwd steadying line handler will slack the fwd steadying line until the chase boat crew can reach it. The chase boat crewmember will unhook the fwd steadying line from the fwd leader line at the leader line release hook.

q. The fwd line handler will retrieve the fwd steadying line.

r. The chase boat crewmember shall hook the fwd leader line to the SEAFOX grab bar.

s. The SEAFOX operator shall increase the speed of the SEAFOX in order to create slack in the sea painter. The chase boat shall match this speed increase.

t. The chase boat crew will then release the sea painter from the SEAFOX sea painter leader line using the sea painter quick release hook.

u. The chase boat crewmember will hook the sea painter leader line to the SEAFOX grab bar.

v. The SEAFOX operator will maneuver the SEAFOX away from the ship and commence with the planned operation.

w. The chase boat will also maneuver away from the ship and commence operations.

x. All shipboard handling gear shall be stowed until the SEAFOX is to be recovered. The crane will be returned to the stowed position.

5. SEAFOX RECOVERY:

a. Ensure all applicable pre-operational checks in paragraph 3. have been accomplished and are satisfactory.

b. Ensure all handling personnel are familiar with the planned evolution and their responsibilities. Instruct the SEAFOX handling crew and crane operator to immediately report any abnormal or unusual conditions observed during recovery operations.

c. Assign the line handlers and crane operator to their stations

d. Advise the Bridge that the SEAFOX is ready to recover. Upon authorization from the Bridge, begin the SEAFOX recovery operation.

NOTE: ISSUE CLEAR AND SUFFICIENT ADVANCE WARNING THAT BOAT HANDLING OPERATIONS ARE COMMENCING

e. Using the 30 ton cargo crane, lower the crane main hoist hook to the 01 level and attach the SEAFOX lifting pendant. Ensure that the crane auxiliary hoist hook throat is moused closed to secure the pendant into the crane auxiliary hoist hook.

f. Position the lifting hook of the SEAFOX lifting pendant approximately 15 feet off of the water at the pickup point of the SEAFOX.

g. Maneuver the SEAFOX to a position 5 to 6 feet forward of the SEAFOX lifting pendant.

h. Maneuver the chase boat to a position alongside the SEAFOX so that the SEAFOX is between the ship and the chase boat.

CAUTION: THE FOLLOWING SEQUENCE OF ATTACHING THE SEAFOX SEAPAINTER, STEADYING LINES, AND LIFTING HOOK IS IMPORTANT TO ATTAIN A SAFE RECOVERY OF THE SEAFOX WHILE THE SHIP IS UNDERWAY.

i. Once the chase boat is alongside the SEAFOX, lower the sea painter to the chase boat. Detach the sea painter leader line hook from the SEAFOX grab bar and attach the sea painter to the sea painter leader line.

j. Reduce the speed of the SEAFOX so that the sea painter is allowed to deploy to its pre-determined full length. Follow this maneuver with the chase boat.

k. Lower the forward steadying line to the chase boat. Detach the forward steadying line leader line from the SEAFOX grab bar and attach it to the forward steadying line.

l. Lower the aft steadying line to the chase boat. Detach the aft steadying line leader line from the SEAFOX grab bar and attach it to aft steadying line.

m. Lower the SEAFOX lifting hook pendant to the outboard edge of the chase boat at a point amidships of the SEAFOX. Detach the SEAFOX sling ring leader line from the grab bar and secure the sling ring into the lifting hook of the SEAFOX lifting pendant.

n. Signal the crane operator that it is safe to take any slack out of the SEAFOX lifting pendant.

o. Maneuver the chase boat to a stand off position away from the ship.

p. Upon command from the OIC, hoist the SEAFOX from the water. Shut down the SEAFOX engine off as it comes out of the water.

q. Tend the steadying lines to control the motion of the SEAFOX during hoist operations. Once the SEAFOX is at the rail, add inboard (PORT) steadying lines to the forward and aft of the SEAFOX.

r. Place the SEAFOX in its stowage cradle.

s. Secure the SEAFOX in its stowage using the tie downs. Once the SEAFOX is secure, release the lifting hook of the SEAFOX lifting pendant from the SEAFOX lifting sling. Stow steadying lines and any other gear used in the recovery process.

t. Remove the SEAFOX lifting pendant from the crane auxiliary hoist hook and stow it in a secure area.

u. Recover and stow the chase boat.

v. Return the 30 ton crane to its stow position.

APPENDIX B. GENERIC BRIDGE USV LAUNCH AND RECOVERY CHECKLIST

<u>Propose Bridge USV Launch Checklist</u>

1. _____ Pass the word over the 1MC to "man the Boat Deck for small boat operation."

2. _____ Order CCS to come to split plant.

3. _____ Obtain USV intended mission plan from CIC.

4. Establish communications between:

   _____ Boat Deck (ensure launch and recovery checklist completed)

   _____ Chase Boat Crew

   _____ USV Operators

5. Verify manned and ready:

   _____ Boat Deck

   _____ CIC (USV mission planners and Operators)

6. _____ Pass seas and winds condition to USV operators and the Boat Deck.

7. _____ Request permission to place the boat(s) at the rail.

8. _____ Maneuver the ship to place the Boat Deck in a Lee.

9. _____ Slow the ship to applicable small boat launch speed.

10. _____ Give the Boat Deck permission for personnel to embark the boat(s).

11. _____ Give the Boat Deck permission to launch Chase boat (if applicable) and USV.

12. _____ Once Boat Deck reports that Chase Boat and USV are safely away, pass the word over 1MC "secure from small boat operation."

Propose Bridge USV Recovery Checklist

1 _____ Pass the word over the ship public address system to "man the Boat Deck for small boat recovery."

2. _____ Order CCS to come to split plant.

3. _____ Verify Boat Deck manned and ready.

4. Establish communications between:

    _____ Boat Deck

    _____ USV Operators

5. _____ Obtain permission from CO to recover USV and chase boat (if applicable).

6. _____ Maneuver the ship to place the Boat Deck in a Lee.

7. _____ Slow the ship to applicable small boat recovery speed.

8. _____ Give the Boat Deck permission to recover USV and chase boat.

9. _____ Once Boat Deck reports that USV and chase boat are proper stowed in their cradles, pass the word over the 1MC “secure from small boat operation.”

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APPENDIX C. USV CREW OCCUPATIONAL STANDARDS

OCCUPATIONAL STANDARDS		
Task Statements	**Measures of Performance**	**Knowledge, Skills and Abilities**
A1. Operate vehicle functions	• USV is operated in a timely, safe and successful manner. • USV functions respond as expected. • Mission is accomplished	• Knowledge of USV systems • Ability to operate all USV functions (e.g., lighting, cameras, vehicle controls) • Basic knowledge of computers • Ability to use operating systems and original equipment manufacturer (OEM) software • Ability to comprehend hardware and software manuals
A2 Operate cameras	• Desired images are obtained • Images are clear • The appropriate camera is used for the desired results	• Knowledge of and ability to operate cameras and video equipment • Knowledge of different camera types, and their applications • Knowledge of video distribution system • Knowledge of lighting and how it affects video images • Knowledge of environmental conditions (e.g., rain, winds, snow, fog)
A3 Operate radio frequency (RF) data link systems	• USV arrives at destination in a safe and timely manner • USV is remotely controlled successfully • USV is tracked successfully • Environmental parameters are measured correctly	• Ability to operate RF data link equipment • Knowledge of and ability to apply principles of RF transmission • Knowledge of OEM specific RF data link equipment • Knowledge of environmental conditions (e.g., rain, sunlight, snow, fog)
A4 Operate sonar	• USV arrives at destination in a safe and timely manner • Target is located correctly • Obstacles are avoided • Sonar is operated properly	• Knowledge of sonar (theory and equipment) and ability to select proper settings • Ability to locate target(s) • Ability to recognize and avoid obstacles • Ability to adjust radar for

OCCUPATIONAL STANDARDS		
Task Statements	**Measures of Performance**	**Knowledge, Skills and Abilities**
		optimum operation
A5 Operate radars	• USV arrives at destination in a safe and timely manner • Target is located correctly • Obstacles are avoided • Radar is operated properly	• Knowledge of radar (theory and equipment) and ability to select proper settings • Ability to locate target(s) • Ability to recognize and avoid obstacles • Ability to adjust radar for optimum operation
A6 Operate launch and recovery systems	• USV launch and recovery is completed safely and in a timely manner	• Ability to perform crane and boom operations • Ability to raise and lower boat cradle • Ability to launch and recover USV • Knowledge and ability to exercise safety requirements
A7 Operate weapon system	• Target is engaged accurately • Weapon is operated properly and safely • No collateral damage is sustained	• Ability to locate and engage the right target(s) • Ability to demonstrate proper ROE • Ability to manipulate weapon position • Ability to demonstrate weapon-camera-eye coordination • Knowledge of ordnance safety • Knowledge of weapon specifications • Collateral damage is avoided
B1 Evaluate environmental conditions and hazards	• USV is deployed and recovered safely and without injury • USV is deployed and recovered safely without damage or loss of equipment	• Knowledge of safe operating parameters (sea state limitations, currents, weather) • Knowledge of weather and currents • Ability to interpret sea state from camera projections
B2 Dock/undock from along side of ship or pier	• Dock/undock is successful. • USV arrives safely and without damage. • Handoff between C2 operator and R/C operator is successful	• Knowledge of docking/undocking procedures • Knowledge of small craft sea keeping • Ability to measure environmental

OCCUPATIONAL STANDARDS		
Task Statements	**Measures of Performance**	**Knowledge, Skills and Abilities**
	• All environmental factors are considered properly.	conditions and react properly • Ability to demonstrate hand-camera-eye coordination
B3 Navigate the USV	• USV arrives at destination in a timely manner. • USV arrives safely and without damage • Adhere to safety of navigation and nautical rules of the road • Sound and visual signals used properly •	• Ability to drive the USV • Ability to demonstrate hand-eye coordination and spatial awareness • Knowledge of small craft sea keeping • Ability to read digital nautical charts (DNC) • Knowledge of longitude and latitude • Ability to use various mapping system • Ability to navigate by GPS • Ability to calculate vectors and waypoints • Knowledge of nautical rules of the road • Knowledge in maritime safety • Knowledge of nautical visual and sound signals
C1 Maintain/repair electronics	• Electrical safety is maintained. • Electrical failures are minimized. • Electrical systems demonstrate increased reliability. • Inspection is completed regularly, as per schedule. • Repairs are completed safely, correctly, and in a timely manner. • Diagnostic programs are used properly. • Measurement data are accurate.	• Knowledge of basic electronics • Knowledge of electrical system safety (tagout) • Knowledge of system layout • Ability to use diagnostic programs within the system • Ability to solder • Ability to interpret fault codes • Ability to replace faulty components
C2 Maintain/repair hydraulics	• Hydraulic safety is maintained. • Hydraulic failures are minimized. • Hydraulic systems demonstrate increased reliability.	• Knowledge of basic hydraulic systems • Knowledge of hydraulic system safety (tagout) • Knowledge of system layout

OCCUPATIONAL STANDARDS		
Task Statements	**Measures of Performance**	**Knowledge, Skills and Abilities**
C2 Continue	• Inspection is completed regularly, as per schedule. • Repairs are completed safely, correctly, and in a timely manner. • There are no environmental mishaps. • Diagnostic programs are used properly. Measurement data are accurate.	• Ability to inspect equipment (e.g., corrosion, wear, damage, leaks) • Ability to use diagnostic programs within the system • Ability to interpret fault codes • Ability to replace faulty components
C3 Maintain/repair Mechanics	• Mechanical safety is maintained. • Mechanical failures are minimized. • Mechanical systems demonstrate increased reliability. • Inspection is completed regularly, as per schedule. • Repairs are completed safely, correctly, and in a timely manner. • Diagnostic programs are used properly. • Measurement data are accurate.	• Knowledge of basic mechanical systems • Knowledge of mechanical system safety (tagout) • Knowledge of system layout • Ability to inspect equipment (e.g., corrosion, wear, damage, leaks, proper lubrication) • Ability to use diagnostic programs within the system • Ability to interpret fault codes • Ability to replace faulty components • Ability to use hand and power tools (e.g., drills, screwdrivers)
C4 Use test equipment	• Test equipment is used properly to accomplish required task(s). • Test are conducted in a safe manner. • Correct instruments are chosen for each task. • Test and measurement data are used to troubleshoot and resolve problems successfully.	• Ability to determine the proper equipment for the test • Ability to operate various test and measurement instruments (e.g., oscilloscope, megohmeter, multimeter) in a safe manner.
D1 Coordinate/integrate with fellow crew members	• Briefing accomplishes objective(s). • Miscommunications are minimal • Mission is successful	• Ability to conduct a brief/debriefing (e.g., communicate mission and clarify tasking) • Ability to plan USV mission employment • Ability to solve problems

OCCUPATIONAL STANDARDS		
Task Statements	**Measures of Performance**	**Knowledge, Skills and Abilities**
D1 Continue		• Ability to communicate verbal and written information clearly • Knowledge of chain of command • Knowledge of ship's procedures •
E1 Perform basic rigging	• Knots, gear, and rigging equipment are used properly. • Rigging is accomplished safely, correctly, and in a timely manner. • Items are moved or secured safely and without damage. • Hand signals are used properly.	• Knowledge of rigging equipment (e.g., shackles, eyes, snatch blocks, bridles, slings) • Knowledge of and ability to tie knots • Knowledge of salvage gear • Knowledge of deck safety • Ability to use hand signals

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