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THESIS

MISSION TASKING OF UNMANNED VEHICLES

by

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June 2004

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13. ABSTRACT (maximum 200 words)

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The problem was analyzed by applying the factors of METT-T: mission, enemy, terrain and weather, troops and support available, and time available to UV-enabled maritime missions. The analysis identified specific implications for unmanned vehicles and emphasized important considerations for tasking and allocating UVs. METT-T analyses generally result in courses of action, however, tasking is a command and control issue, and therefore, four organizational structures emerge for tasking UVs

A significant finding of this study is that the current doctrinal framework of the composite warfare commander's concept can support tasking unmanned vehicles, but requires revision to effectively address UV allocation issues.

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MISSION TASKING OF UNMANNED VEHICLES

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LIST OF SYMBOLS, ACRONYMS, AND/OR ABBREVIATIONS

ACA	Airspace Control Authority
ADC	Air Defense Commander
AOR	Area of Responsibility
AREC	Air Resource Element Coordinator
ARG	Amphibious Ready Group
ASUW	Anti-Surface Warfare
ASWC	Anti-Submarine Warfare Commander
ATO	Air Tasking Order
CCOI	Critical Contacts of Interest
CNO	Chief of Naval Operations
CO	Commanding Officer
COA	Course of Action
COP	Common Operational Picture
CROP	Common Relevant Operational Picture
CSG	Carrier Strike Group
CWC	Composite Warfare Commander
C2	Command and Control
DOD	Department of Defense
EO	Electro-Optical
EOD	Explosive Ordinance Disposal
ESG	Expeditionary Strike Group
FOV	Field-of-View
FWC	Functional Warfare Commander
GCS	Ground Control Station
HEC	Helicopter Element Coordinator
IR	Infrared
ISR	Intelligence, Surveillance, and Reconnaissance
IWC	Information Warfare Commander
JFACC	Joint Force Air Component Commander
LOS	Line-of-Sight
METL	Mission Essential Task List
METT-T	Mission, Enemy, Terrain and Weather, Troops and Support, and Time Available
MEU	Marine Expeditionary Unit
MIO	Maritime Interception Operations
MOS	Military Occupational Specialty
MTI	Moving Target Indicator
NCW	Network-Centric Warfare
NMETL	Navy Mission Essential Task List
OIF	Operation Iraqi Freedom
OPCON	Operational Control
OTC	Officer in Tactical Command

PWC	Principal Warfare Commander
PTZ	Pan, Tilt, Zoom
RMP	Recognized Maritime Picture
RNS	Rogue Nation States
RSTA	Reconnaissance, Surveillance, and Target Acquisition
SCC	Sea Combat Commander
SIGINT	Signals Intelligence
SOCA	Submarine Operations Coordinating Authority
SSC	Surface Surveillance Coverage
STWC	Strike Warfare Commander
SUWC	Surface Warfare Commander
TACON	Tactical Control
TCS	Tactical Control System
TSC	TLAM Strike Coordinator
UAV	Unmanned Aerial Vehicle
USV	Unmanned Surface Vehicle
UUV	Unmanned Undersea Vehicle
UV	Unmanned Vehicle
UVEC	Unmanned Vehicle Element Coordinator

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Thanks be unto God for His unspeakable gift. (2 Cor 9:15)

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I. UNMANNED VEHICLES

A. INTRODUCTION

The 21st century Navy is undergoing transformation and is envisioned to look significantly different from the Navy of today. Operating under the concept of Network-Centric Warfare (NCW), Naval forces will employ distributed sensors and integrated systems and platforms to provide a networked-force with the ability to share "extremely rapid, high-volume transmission of digitized data," as well as the capability for "precision strike and a common operational picture."[1] Many of the capabilities needed to implement NCW into the Fleet are still under development, but researchers foresee unmanned platforms as primary sensors that will compose the network.[2]

Unmanned vehicles (UVs) are expected to be an integral part of the U.S. Navy's future intelligence, surveillance, and reconnaissance missions. As per the CNO's guidance:

> …As part of Task Force ISR, develop a plan for increased use of unmanned systems for tactical ISR. Leverage extant UAV/UUV systems residing in other DoD components for maintenance, training, and support…Accelerate prototyping and experimentation of autonomous and semi-autonomous naval unmanned vehicles.[3]

Offering tactical and operational capabilities while promising reduction in both cost of manpower and risk of casualties, UVs form a potential means of extending the reach of the military. Rapid growth of innovative technology makes realization of this ideal worth evaluation for changes in doctrine. Command and control (C2) issues for unmanned vehicles require resolution.

The term command and control encompasses a wide variety of systems, processes, and functions and depending upon the author of the publication, varying

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1 Peter J. Dombrowski, Eugene Gholz, and Andrew L. Ross, *Military Transformation and the Defense Industry After Next: The Defense Industrial Implications of the Network-Centric Warfare*, (Naval War College, 2003), 6.

2 Ibid., 8.

3 Admiral Vern Clark, USN, *CNO Guidance for 2004,* [database online] (2004 [cited 28 April 2004]) ; available from World Wide Web @http://www.chinfo.navy.mil/navpalib/cno/clark-guidance2004.html

definitions. For the purpose of clarity, the joint definition of command and control will be used for this study:

> The exercise of authority and direction by a purposely designated commander over assigned forces in the accomplishment of the mission. Command and control functions are performed through an arrangement of personnel, equipment communications, facilities, and procedures employed by a commander in planning, directing, coordinating, and controlling forces and operations in the accomplishment of the mission.[4]

Command and control systems enable a commander to perform C2 functions and are comprised of three building blocks: processes, technology, and organizational structure.[5] As depicted in Figure 1, there is much overlap among these entities. Modification to any of these entities will often result in change to the others.

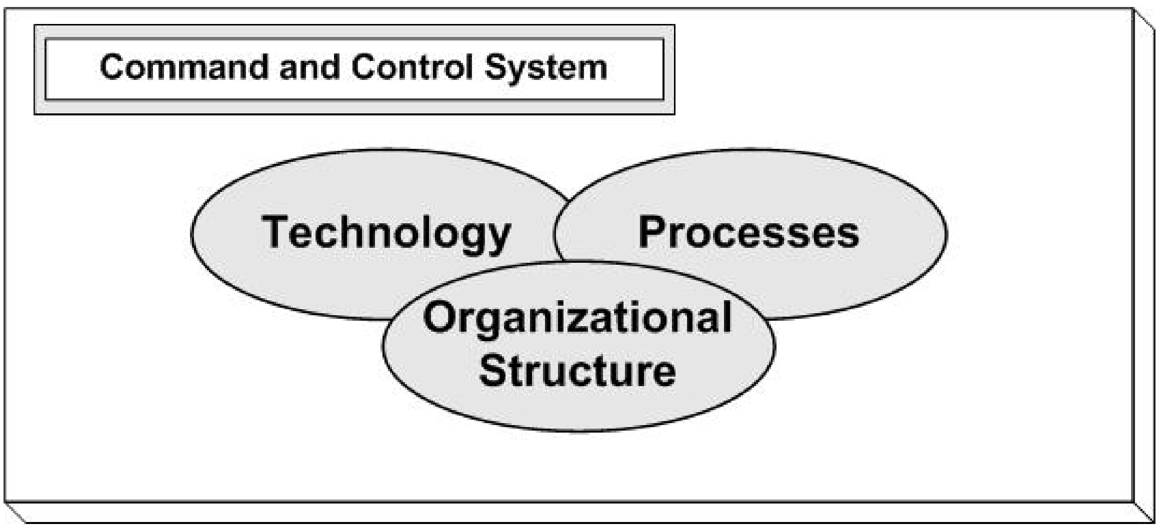

Figure 1.1 Command and Control System

The Department of Defense (DoD) has invested over $4 billion in Unmanned Aerial Vehicle(UAV) development , procurement and operations alone, with an estimated total of $10 billion spent by 2010.[6] Unmanned Underwater Vehicle (UUV) and Unmanned Surface Vehicle (USV) research and development will add to this total,

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[4] Joint Chiefs of Staff, Department of Defense Dictionary of Military and Associated Terms, (Washington: GPO, 1987) .

[5] Dr. Dan Boger*, CC4913: Problems and Policies in C3*, Naval Postgraduate School, March-June 2004

[6]Office of the Secretary of Defense, *Unmanned Aerial Vehicle Roadmap 2000-2025,* [database online] (2001 [cited 15 February 2004]); available from World Wide Web @ http://www.globalsecurity.org/intell/library/reports/2001/uavr0401.htm

greatly increasing the military's inventory of unmanned systems. This change and growth in technology necessitates changes in the other building blocks, processes and organizational structures, of the command and control systems. For a commander to successfully exercise command and control over unmanned systems, processes and organizational structures must be in place to successfully integrate these assets into Fleet operation. This study focuses on finding practical organizational structures with which to employ unmanned vehicles

Changes in technology have historically driven military operational transformations. The advent of radar-guided missiles, nuclear propulsion, enhanced capabilities of the Tomahawk, and increased air-to-ground strike capability have all caused the U.S. Navy to re-examine its doctrinal structure. Unmanned vehicles stand to do the same. In so much as "a truly innovative approach to employing a new system requires concurrent doctrinal, organizational, and technological changes that affect planning, equipping, and training military forces,"[7] the Navy needs to be prepared to leverage and meet the changes presented by unmanned vehicles.

B. BACKGROUND

The history of unmanned systems dates back to 1866 when Robert Whitehead designed the first unmanned underwater vehicle. Unlike UAVs, which emerged during WWII, serious progression in USV and UUV development did not occur until the 1960s. Nonetheless, UV development has progressed to the point where they are being assimilated into the Fleet, making DOD the world's largest consumer of unmanned systems.[8]

UVs are smaller, and lighter than before, and have often replaced humans in fulfilling 3-D missions, tasks that are considered "dull, dirty, and dangerous."[9] Dull tasks include flying a pattern for surveillance or reconnaissance, which is monotonous and

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[7] James R. Reinhardt, Jonathan James, and Edward Flannagan, "Future Employment of UAVS:Issues of Jointness," *Joint Force Quarterly, (*Summer 1999), 39.

[8] Delbert C. Summey et al. *Shaping the Future of Naval Warfare with Unmanned Systems*, Coastal Systems Stations, Naval Surface Warfare Center, (July, 2001), 3-1.

[9] Office of the Secretary of Defense, *Unmanned Aerial Vehicle Roadmap 2000-2025,* [database online] (2001 [cited 15 February 2004]); available from World Wide Web @ http://www.globalsecurity.org/intell/library/reports/2001/uavr0401.htm

time-consuming for manned aircraft. UAVs are also used for surveillance of dangerous hostile areas and “can go into a dirty environment where there's the threat of exposure to nuclear, chemical or biological warfare.”[10] In addition, UVs have replaced manned systems in many missions, alleviating the risk to personnel. An example of this is the use of UUVs for mine hunting and clearing.

Currently, doctrine provides little specification in addressing command and control issues for UVs. In fact, Naval tactics only address issues concerning UAVS and do not provide a guideline for other unmanned systems, such as: Unmanned Underwater Vehicles (UUVs), and Unmanned Surface Vehicles (USVs)[11]. Similarly, there is no formalized accounting for the growth and improvement in technology. Specifically, command and control issues, such as mission tasking, remain undefined and there is no focus on maritime missions.[12] Technological and operational advances strongly suggest the need for an update.

C. PROBLEM STATEMENT

UVs are increasingly being integrated into tactical operations. Unmanned assets, such as the Predator and Global Hawk, are currently being used in Afghanistan and Operation Iraqi Freedom (OIF), while a USV is deploying in the Arabian Gulf. The deployed UAVs are considered tactical assets, however, and are tasked by the Joint Force Air Component Commander (JFACC) while the USV is a prototype with limited capability and deploying alone. Nevertheless, technology continues to develop and enhanced capabilities are impending, yielding greater numbers of unmanned vehicles with increased abilities. These UVs will be distributed with the strike groups in support of maritime missions.

Expeditionary strike groups (ESGs) combine the combat power of marine expeditionary units (MEUs) with the flexibility and strike capability of an amphibious

10 Sandy Riebling, “Unmanned Aerial Vehicles”, in , par. 1[online database] (July, 2002 [cited 12 March 2004]); available from World Wide Web @ http://www.redstone.army.mil/pub_affairs/archive/2002/07Jul2002/articles/0718102142349.html

11 ReinHardt et al. “ Future Employment of UAVS:Issues of Jointness,” Joint Force Quarterly, (Summer 1999), 40.

12 Joint Publication 3-55.1, *Joint Tactics, Techniques, and Procedures for Unmanned Aerial Vehicles*, August 27, 1993.

ready group, and carriers strike groups (CSGs) are the current manifestation of carrier task forces. The terms, coined in the CNO's guidance for 2003, replace the standard terms, amphibious ready groups (ARGs) and carrier battle groups.[13] The ESG/CSG concept represents a highly mobile and flexible force that can be configured to accomplish a variety of missions. The strike groups also equip the fleet with a means of providing more coverage world-wide. "The ESG concept allows the Navy to field 12 Expeditionary Strike Groups and 12 Carrier Battle Groups, in addition to surface action groups."[14]

ESGs can be created based on any configuration of amphibious ships, cruisers, destroyers, submarines and P-3C Orions. Similarly, CSGs would be composed of the same type of ships but configured around a carrier. The carrier or expeditionary strike group (CSG or ESG) organization is structured per the Composite Warfare Commander concept, consisting of warfare commanders who execute mission and warfare coordinators who allocate resources. The problem is: does the employment of unmanned vehicles (UVs) for maritime missions best fit into this framework or might it require a new structure?

Tasking of UVs is not the same as for manned vehicles. Pilots can prioritize given commands and there is a collaborative relationship between the controller and aircrew. This relationship is non-existent with UVs as they only do as ordered. Determining who should be tasked with a specific mission is an important command and control issue. Elements tasked for a specific mission, must have the ability, capability, and knowledge to complete the mission. Misallocation may delay timing, increase cost, and lead to loss of systems or personnel.

Misallocation of resources may also result in over and under-utilization of assets. Under-utilization occurs when the personnel who actually use the asset are not given control or access to it while over-utilization arises when multiple commands need an asset that has no central tasking. For example, under-utilization might occur if an

13 "Carrier Strike Group ", par. 1 [database online] (May 2003 [cited 05 May 2004]); available from World Wide Web @ http://www.globalsecurity.org/military/agency/navy/csg-intro.htm

14 "Expeditionary Strike Group," par. 2 [database online] (May 2003 [cited 05 May 2004]); available from World Wide Web @ httphttp://www.globalsecurity.org/military/agency/navy/esg.htm

unmanned surface vehicle were under tactical control of a submarine command. Over-utilization might occur if a USV were allocated to more than one surface vessel for tasking. With many units responsible for its tasking, the asset lacks direction and is potentially subject to conflicting taskings. This is a disconnect over who has tasking priority and generates confusion. It is therefore essential that a practical guideline be established for tasking unmanned vehicles.

Tasking is a function of command relationships, the authority of a commander to perform responsibilities. Within current operations, commanders receive missions from higher command authorities. They then decide how assets are to be employed, and task assets to execute plans to accomplish the mission. The commander who tasks assets has tactical control (TACON) over them and can direct assets as deemed fit. TACON is the authority to task forces for a limited and specified basis and is "usually limited to the detailed and usually local direction and control of movements or maneuvers necessary to accomplish assigned missions or tasks."[15] TACON is a subset of the second command relationship, operational control (OPCON), a higher level command authority which is not limited in duration. OPCON is "the authority to perform those functions of command over subordinate forces involving organizing and employing commands and forces, assigning tasks, designating objectives, and giving authoritative direction necessary to accomplish the mission."[16]

Support is the final command relationship to be discussed. Support is defined as "The action of a force that aids, protects, complements, or sustains another force in accordance with a directive requiring such action." [17] In a support relationship, the supported commander, the one who requests support, has TACON of the supporting command. An example of this can be seen in the tasking of an explosive ordinance disposal (EOD) unit. EOD detachments are OPCON to a numbered fleet commander but become TACON under the authority of whomever they support. Figure 1.2 below summarizes the command relationships.

[15] Joint Publication 3-0, "Doctrine for Joint Operations," (February, 1995)

[16] Joint Publication 1-02, "Department of Defense Dictionary of Military and Associated Terms," (December, 2003)

[17] Ibid.

Figure 1.2 Command Relationship Summary ([After Figure 5-1 MSTP Pamphlet 5-0.3, *Part V, Key Terms and Graphics*; available from World Wide Web [@ http://www.mstp.quantico.usmc.mil/publications/pamphlet5])

The commander who exercises TACON does not necessarily have OPCON of the assets. An example of this can be seen in the joint targeting cycle. During this process, the JFACC serves as the centralized air commander for joint forces. The JFACC exhibits TACON over available air assets, such as the USMC's FA-18s, although they are not attached to that command. Determining who has TACON of, and thus tasks UVs, is therefore an important command and control issue for determination.

This thesis centers on the question: "What are the important considerations in determining *who* is best able to task unmanned vehicles and *how* this is accomplished?" The research assesses the current doctrine of mission tasking and attempts to apply it to unmanned vehicles (UVs). The objective is to analyze all reasonable alternatives, determine criteria for mission tasking in UVs and to develop a comprehensive and practical set of planning factors for unmanned systems.

The scope of this thesis will be limited to the use of unmanned vehicles as strictly Intelligence, Surveillance, and Reconnaissance (ISR) assets. Only the unmanned vehicles used by naval forces; UAVs, UUVs, and USVs; will be discussed. Focus will rest on the general capabilities exhibited by platforms but not specific vehicles. Likewise, this study concentrates on the technology that is readily available for implementation. It addresses the implications of future systems or technology and joint operations, but not at length. This study focuses primarily on maritime operations or naval ships.

D. ORGANIZATION OF STUDY

Chapter II, *Mission Tasking and the Composite Warfare Commander Concept*, outlines the current method of mission tasking. Specifically, it examines unmanned vehicles in the context of the current doctrinal framework of the composite warfare commander concept. In Chapter III, *METT-T Analysis*, a METT-T analysis is performed on employment of unmanned vehicles to find feasible courses of action (COA) for tasking UVs. Chapter IV discusses advantages and disadvantages of each COA determined in the previous chapter. Chapter V describes conclusions and recommendations for future work to enhance UV usability and summarizes ideas that have been generated in the course of this thesis.

II. MISSION TASKING AND THE COMPOSITE WARFARE COMMANDER CONCEPT

A. MISSION TASKING

In order analyze UV tasking issues; one must first understand the current organizational doctrine. The Composite Warfare Commander (CWC) concept is the foundation on which current command and control (C2) doctrine rests. This chapter provides an overview of doctrine and issues that require analysis in order to integrate UVs into the maritime missions. For the purpose of this study, the following definitions should also be considered:

- *Mission*: The task together with the purpose, that clearly indicates the action to be taken and the reason therefore.[18]
- *Tasking Order*: A method used to task and to disseminate to components, subordinate units, and command and control agencies projected targets and specific missions[19]

Based on these definitions, we will use the term mission tasking to mean:

- *Mission Tasking*: assigning a specific mission and/or projected targets to a subordinate commander to be accomplished without prescribing specifics.

B. COMPOSITE WARFARE COMMANDER DOCTRINE OVERVIEW

The CWC concept was developed at the height of the Cold War to provide "standard procedures for command and control afloat"[20] for the US Navy. The structure accommodated multi-mission manned platforms and advances in weaponry, sensors, and systems. It continues to evolve with the development, acquisition, and proliferation of technology as well as the evolution of asymmetric threats.[21]

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[18] Joint Publication 1-02, "Department of Defense Dictionary of Military and Associated Terms," (December, 2003)

[19] Ibid

[20] NWP 3-56, *Composite Warfare Commander's Manual*

[21] Major T.D. Waldhauser, "Entering the Golden Age with the Composite Warfare/Amphibious Doctrine Dilemma", [database online] (1992 [cited 05 February 2004]); available from World Wide Web @ http://www.globalsecurity.org/military/library/report/1992/WTD.htm

The basic organizational structure of the CWC is composed of warfare commanders who execute missions and warfare coordinators who allocate resources. The Officer in Tactical Command (OTC), equated to the CSG or ESG commander for this study, leads the force in prioritizing and accomplishing its missions. Tactical command is "the authority delegated to a commander to assign tasks to forces under their command for the accomplishment of the mission."[22] Secondary to the OTC is the composite warfare commander (CWC) who "wages combat operations to counter threats to the force and to maintain tactical sea control with assets assigned."[23] CWC and OTC are generally the same command, but the doctrine allows for two separate individuals to hold the responsibility. This study treats them alike.

The OTC is responsible for five principal warfare areas; air defense, antisubmarine warfare, information warfare, strike warfare, and surface warfare; and can retain control of these warfare functions but generally delegates them to subordinates known as the principal warfare commanders (PWCs). Within a mission, the force performs specific duties that are often limited in duration. The OTC may assign these duties, such as mine warfare or underway replenishment, to a functional warfare commander (FWC) for completion. FWCs can be permanent or temporary based on the structure of the organization. Coordinators are the last element of the high tactical level of command and control within the CWC structure depicted in Figure 2.1. They allocate resources based on tasking from PWCs or FWCs, execute policy and do not have tactical control over assigned assets. [24]

The CWC doctrine is highly functional and adaptable to many operations, Decentralized authority and command by negation are two main tenets of the CWC concept that allow for this flexibility. Decentralized authority allows for a flexible command and control structure with division of work and minimal micro-management. Commanders are allowed and encouraged to initiate action autonomously while the CWC

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22 NWP 3-56, *Composite Warfare Commander's Manual, 2-2*

23 Ibid. 2-3

24 Ibid. 2-4

"oversees and coordinates these individual efforts"[25] to successfully fulfill the mission. Command by negation enables subordinates to inform the commander of their plans, but does not require them to seek permission.[26] A commander can stop the action of a subordinate at any point deemed necessary and can redirect forces as seen fit. This allows for faster decision-making, which is an essential factor in defeating an enemy in a dynamic environment.

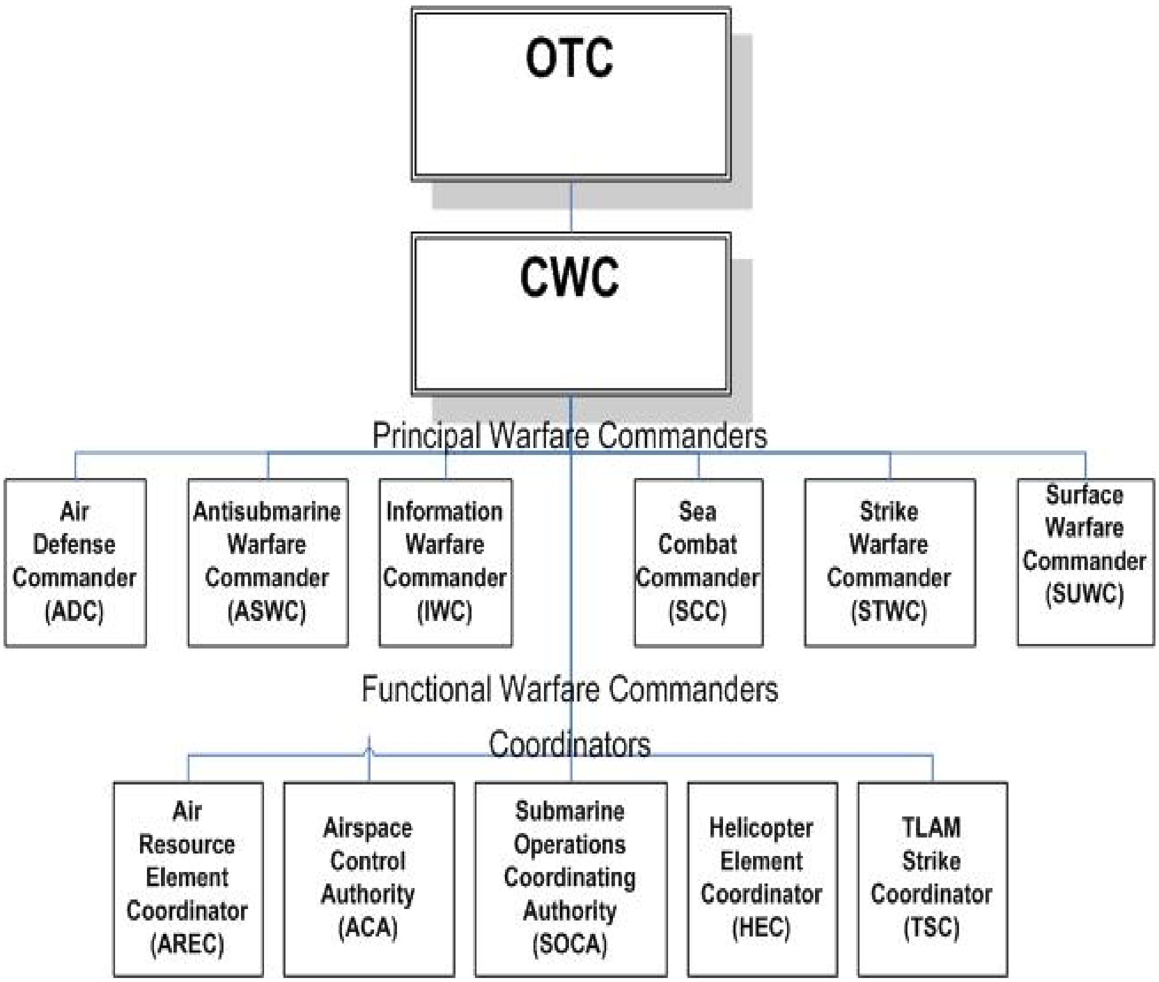

Figure 2.1 CWC Structure ([After Figure 2-1 NWP 3-56, Composite Warfare Commander's Manual])

25 Major J. V. Medina, "Amphibious Warfare And The Composite Warfare Commander Concept: Doctrine In Need Of Change," [database online] (1992, [cited 6 March 2004]); available from World Wide Web@ accessed http://www.globalsecurity.org/military/library/report/1992/MJV.htm

26 Marine Corp Doctrine Publication-1, *Warfighting,* 87.

C. MISSION, COMMANDER'S INTENT, MAIN EFFORT

Mission accomplishment is the driving force of all doctrine; the CWC is no exception. The objective to be accomplished, a mission, is composed of two parts: "the task to be accomplished and the reason (or purpose) behind it."[27] This reason or purpose is known as commander's intent, which explains the *why* of the mission and gives subordinate commanders direction in shaping their plan of *how* the unit will accomplish the mission.[28] Commander's intent serves to unify the independent actions of the various warfare commanders, resulting in a cohesive force.

Within the mission, there is often a central task that must be accomplished foremost or on which hinges the success of the mission. This task is known as the main effort. Top priority is given to this focal point and all units act in support of the main effort, directing the "weight of all combat power" towards it.[29] The main effort will shift as the situation changes.

This study defines allocation as the "distribution of limited resources among competing requirements for employment"[30] Resources are allocated by coordinators to warfare commanders enabling them to accomplish the mission, based on the main effort. Priority is given to the main effort and then units that are directly supporting the main effort.

D. DO UNMANNED VEHICLES FIT WITHIN THE CWC?

This study analyzes the alignment between tasking unmanned vehicles and the structure of the composite warfare commander concept, and considers whether tasking UVs fits current doctrine or necessitates change. In order to answer this question, one must consider the environment in which UVs are tasked. METT-T is an analysis tool used to evaluate command and control issues within missions. METT-T is an acronym

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[27] Ibid., 89.

[28] Ibid., 90.

[29] Ibid., 91.

[30] Joint Publication 1-02, "Department of Defense Dictionary of Military and Associated Terms," (December, 2003)

for: Mission, Enemy, Terrain and Weather, Troops and Support Available, and Time Available.

The first element of a METT-T analysis is mission, which is an analysis of the task(s) to be completed. After identifying the main effort and other tasks needed for success, and initiating preparation for mission accomplishment, planners conduct an analysis of the enemy. Essentially this examines who the threat is, what they are doing or have done, when this occurred and the latest estimates of threat location. In the context of threat location, strength and capabilities are examined. The next elements, terrain and weather, deal with the capabilities, limitations, and vulnerabilities of ones' own forces with respect to the weather and operating environment. The fifth element, troops and support available, considers skill and training levels of the force as well as the amount of resources necessary for mission accomplishment. The final element, time available, prioritizes tasks that must be completed for mission accomplishment and examines "critical time aspects of the operation."[31] The result of a METT-T analysis is the development of practical courses of action to accomplish the mission set forth.

The U.S. Army and Marine Corps use METT-T to develop feasible, reasonable, and distinct courses of action by examining various factors that aid commanders in identifying essential tasks and assigning resources to accomplish those tasks.[32] The next chapter will involve a METT-T analysis (as applicable) for UV-enabled ESGs and CSGs. The result of the analysis will yield feasible course(s) of action for tasking UVs.

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[31] U.S. Army Field Manual 7-20, The Infantry Battalion, Washington, D.C., (April, 1992)

[32] Ibid, 2-16

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III. METT-T ANALYSIS

A. OVERVIEW

The problem of tasking unmanned vehicles is complex with multiple factors to consider. Mission, Enemy, Terrain and Weather, Troops and Support Available, and Time Available (METT-T) is a systematic framework that enables determination of areas that are vital to mission accomplishment, and potential courses of action. Performing the analysis yields specific elements to be addressed and aids in establishing criteria for mission tasking. It also decomposes tasking, allowing for objective evaluation of multi-faceted problems. METT-T analyses result in distinct courses of action for a commander and supports tasking unmanned vehicles in an asset allocation plan. The objective of this study is to define the different organizational structures that can support asset allocation.

Figure 3.1 summarizes the process that we are building for resource allocation.

Figure 3.1 METT-T Analysis

B. MISSION

ESGs and CSGs task unmanned vehicles with maritime missions, including: maritime interception operations (MIO), anti-surface warfare (ASUW) targeting, force protection and, surface surveillance coverage (SSC) missions. Essential to these missions are building and maintaining the Recognized Maritime Picture (RMP), which is also known as the common operational picture (COP), and common relevant operational picture (CROP).[33]

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[33] LCDR Russell Gottfried, USN, *Unmanned Vehicle Tactical Memorandum*, [experiment proposal], Naval Postgraduate School, June 2004

1. Overview of Missions

Maritime interception operations are the law enforcement arm of naval missions, and support UN sanctions, military operations, and international law. Unmanned vehicles assist in surveillance of approach zones, and can provide topside awareness of boarded vessels during querying, boarding and searching. Force protection deals with a ship's right and responsibility to protect itself from any and all threats. This is accomplished by taking measures to prevent attack or responding to attack should it occur. UVs can assist with early warning or disrupting an attack by small boats.

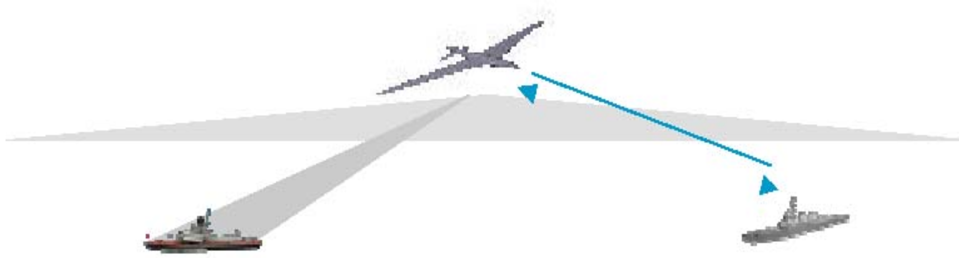

Figure 3.3 UV Scenario ([after Figure 18 in Naval UAV Operational Concept Document])

Generating and maintaining the recognized maritime picture is one of the most important missions of UVs in their ISR role. Through the use of various sensors, unmanned systems provide raw data pertaining to the area of operations. When analyzed, this refined data provides operators and decision makers with a processed picture of the area of interest and establishes situational awareness for the CWC. Thus ESG or CSG collect information and disseminate it to all members of the battle group and higher levels of command as well. Surface Surveillance Coverage (SSC) also helps in building and maintaining the RMP. In SSC, ISR assets search the sea space surrounding the ESG/CSG for surface contact. Surface surveillance coverage allows potential threats to be neutralized before they can attack. Should a surface contact be positively identified as a threat, surface warfare targeting attempts accurate location of threat contact in order to employ weapons.

The implication for unmanned vehicles is that near real-time intelligence is needed for the accomplishment of the maritime missions discussed above. Intelligence is the "product resulting from the collection, processing, integration, analysis, evaluation, and interpretation of available information concerning foreign countries or areas." The intelligence cycle in Figure 3.2 shows the process, by which information is collected, converted to intelligence, and disseminated to various sources. Reconnaissance, Surveillance, and Target Acquisition (RSTA) is a principal employment of UVs as collection assets, gathering relevant information about the enemy in support of maritime missions.

MIO, SSC, ASUW targeting, and force protection compete for RSTA assets with the other principal warfare missions. Allocating resources to fulfill each mission becomes a strain on limited resources, and compete for use of collection assets that have multi-mission capabilities. Prioritized tasking is required and must be established to allocate these resources.

2. RSTA

An understanding of the reconnaissance, surveillance, and target acquisition missions, with which UVs would be tasked, provides insight into asset allocation courses of action. While both reconnaissance and surveillance are associated with gathering raw data, surveillance missions are more general and occur for an unlimited period of time. Reconnaissance missions focus on specific targets and are limited in duration. Reconnaissance and surveillance provide the commander with the information needed for mission accomplishment.

Reconnaissance and surveillance missions support target acquisition, the detailed localization of a contact. Accuracy in location of the target as well as near-time transmission of this information is important for successful target acquisition.[34] For these missions, UV platform range and endurance are key performance characteristics under consideration to enable proper execution.

[34] Major Anton Massinon, USA, *Collection Tasking of the Corps Unmanned Aerial Vehicle-Short Range*, (School of Advanced Military Studies, Kansas, 1993).

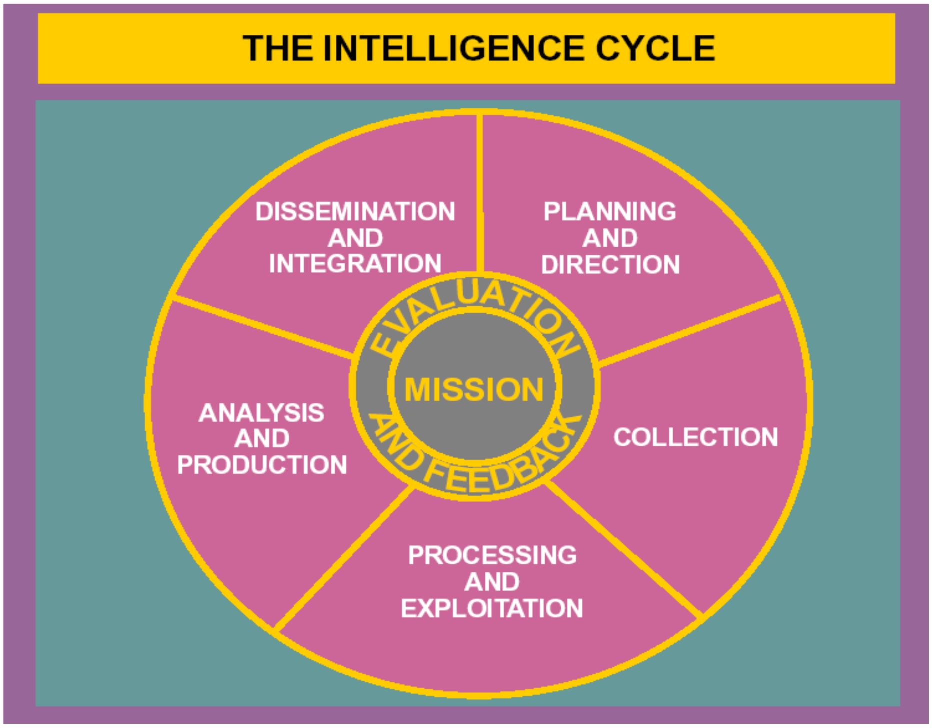

Figure 3.2 Intelligence Cycle ([From Figure 1-1 JP 2-02, National Intelligence Support to Joint Operations, SEP 98])

Range is the maximum distance at which a UV can operate and is a function of payload weight, fuel consumption, and endurance. It is also a function of camera resolution and sensitivity because data throughput decreases with range. Line of sight connectivity is also an issue. With as little exposure to the platform as possible, unmanned vehicles with sufficient range can locate or acquire targets. Endurance pertains to the duration or quantity of time that an unmanned vehicle can operate before refueling. It is also a function of weight and fuel consumption, as well as engine performance. Transit time to and from the assigned area is also a factor in a total endurance calculation. UVs with suitable endurance can accomplish RSTA missions as required. The advantage of UVs is that they are unmanned and can be sent into dangerous environments with no risk or loss of personnel. Unmanned does not equate to expendable, however, and planning efforts to minimize vulnerability of these systems ensures the assets are available for subsequent tasking.

C. ENEMY

A scenario will be used to highlight important considerations for evaluating the enemy.

1. SCENARIO[35]

Expeditionary Strike Group-Unnumbered, ESG-U, is sent to the Gulf to perform maritime missions. The strike group is also responsible for its own force protection while building and maintaining the RMP is a top priority. The strike group is centered on an amphibious assault ship and is comprised of one guided-missile cruiser responsible for air defense, an Aegis destroyer focused on maritime missions, and a nuclear attack submarine conducting precursor operations. Specifically, USS Destroyer is enforcing an embargo whereby suspicious ships are intercepted and inspected, USS Cruiser is conducting air defense in support of USS Amphib against any air attack, and USS Submarine is conducting pre-cursor operations for securing a border. Unmanned vehicles are embarked on both of the surface combatants as well as the submarine and are available for tasking.

In the above scenario, the area of responsibility is a cluttered environment with multiple contacts. These contacts can be critical contacts of interest (CCOI), friendly forces, neutral entities, and friendly forces. It is therefore necessary that unmanned systems possess the sensors that discriminate between targets. The sensors should be an EO camera that allows the GCS to visually identify the contact or an electronic system such as Identification Friend or Foe. Once an enemy or CCOI is identified, characteristics such as location, course and speed, capabilities, and size of enemy forces become important. In order to know the location of the enemy, unmanned systems must possess some form of global positioning system that allows the host platform to know the location of the UV, and in turn, the position of the enemy. Allocation of UVs will consider whether they have sufficient time on station to perform surveillance of these contacts in order to determine the size and capability of enemy forces. Specifically, in the case of the UVs tasked with MIO, sensors on board must have the resolution to allow the GCS to closely monitor shipboard activity.

[35] All Use Case Scenarios taken from: *Naval UAV Operational Concept Document*, PMA-263 Unmanned Vehicles Program Office, Naval Air Systems Command (NAVAIR), Patuxent River, MD

D. TERRAIN AND WEATHER

1. Operating Environment and Weather

The naval doctrines, *From the Sea*, *Forward…from the Sea*, *Operational Maneuver from the Sea*, and, *Sea Power 21* chart the shift in naval maritime strategy from blue water to a blue and brown water navy. This strategy calls for a flexibility and mobility to access anyplace on the globe; operate in the littoral regions, or in narrow seas lanes. This littoral strategy is designed to improve naval force missions of deterrence, forward presence, and strike warfare.[36] Employing strike warfare, enforcing dominance of air space, and maintaining underwater awareness are complicated operation in littoral seas. This challenges any asset allocation process, much less on that is resource limited. Weather is an additional influence

Whether it is the rare forecast combination of acceptable conditions for sea, air, and land operations that occurred on D-day or the drowning of Navy SEALS during violent thunderstorms in Grenada, weather can be an invaluable ally or a considerable opponent.[37] It affects both the performance of troops and the technology that supports them. Meteorological effects are critical factors in UV operations and are therefore important considerations in mission tasking.

Sea state, tides, and inclement weather such as rain and ice will all affect UV operations. The current UV platforms are not very robust and are particularly vulnerable to inclement weather. Specifically, decreased visibility will compress the range of unmanned systems. Similarly, UVs may be limited in endurance or unable to operate due to adverse weather conditions They are also dependent upon the host platform to provide optimal launch and recovery conditions.

Meteorological factors also affect the sensors employed by unmanned systems, including radio propagation and radar detection. Many systems utilize RF via line of site for communication between the GCS and the UV. Precipitation causes attenuation of the signal and could result in a loss of communication with the UV. Since, ESG groups are

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36 Department of Defense, *1995 Annual Defense Report- Maritime Forces: Report of the Secretary of the Navy*, [database online] par. 5 (Washington, D.C 1995 [cited 23 May 2004]), available from World Wide Web @ http://www.pentagon.gov/execsec/adr95/navy_5.html

37 G.R. Svoboda, *Army Weather Support,* [database online] (A. Deepak Publishing, 1986 [cited 05 May 2004] available from World Wide Web @ http://www.atc.army.mil/meteorology/history.htm]

deployed all over the world in varying climates, it is essential that more robust platforms and weather-resistant sensors be developed for unmanned vehicles. “Weather and terrain conditions will dictate how to fight and what equipment is most effective to support the fighting force.”[38] The impact of surface clutter and presence of precipitation diminish visual and infrared (IR) sensor effectiveness, as well.

E. TROOPS

Given the scenario, MIO, air defense, and precursor missions that UVs are to support, decision-makers assess unmanned system capabilities to assign them properly. UV capabilities, vulnerabilities, and limitations form the basis for analyzing troop and support availability. The platform is a primary component of the unmanned vehicle. It is the physical structure of the UV and exhibits capabilities such as speed, endurance, control, payload weight and survivability, which enable it to operate within a particular environment.[39] Its size depends upon the payload weight, dimension, and desired time on station. Sensors are currently one of the most expensive components of unmanned vehicles and require specific platforms built around them. Payload drives the platform availability. More capable systems are much more limited in numbers. Table 3.1 summarizes UV capabilities.

1. Unmanned Aerial Vehicles

UAVs such as Pioneer, Global Hawk, and Predator, have been used in Serbia, Afghanistan, and in Iraq. These high altitude and endurance (HAE) UAVs are expensive; but capable of handling multi-mission payloads. Considered strategic-level assets, they are tasked by the JFC via the air tasking order (ATO). The UAVs discussed in this thesis, however, are tactical-level vehicles that are just now deploying in maritime missions. The basic platform and payload planning considerations for UAVs extend to UUVs and USVs as well.

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38 FM 3-5, *Chapter 6:Effects of Environmental Conditions*, par. 1 ([cited 13 May 2004]); available from World Wide Web @ http://www-nehc.med.navy.mil/nepmu2/pmttoolbox/Chem%20Bio%20Warfare_files/FM%203-5%2C%20FMFM%2011-10%20NBC%20DECON/Ch-6.pdf

39 DOD, *UAV Roadmap 2002-Appendix A,* Washington, D.C., April 2001

a. Platform Characteristics

Survivability is a critical platform capability needed for unmanned vehicles. A highly survivable platform ensures the safety of the sensors. This is not to say that the platform must be indestructible, but simply implies that a platform should be robust to withstand various environments.

UV Capabilities	
Platform Characteristics	
1. Survivability 3. Control 2. Endurance 4. Altitude	5. Speed 6. Payload Weight 7. Shipboard Operations
Payload Capabilities	
Sensor Types	Sensor Characteristics
1. Electro-Optical 3. Radar 2. Infrared	1. Field of View 2. Resolution 3. Sensitivity

Figure 3.4 UV Capabilities in Support of Maritime Missions

Adding stealth technology, materials or devices that decrease or disguise a vehicle's signatures or emissions, enhances the survivability of the platform. Stealth enables unmanned vehicles to operate covertly, making them less vulnerable to attack. This also serves to increase the cost of the vehicle, making it a more precious asset and influencing its availability.

Endurance entails the length of time that a vehicle can stay in operation before re-fueling. It is driven by fuel consumption and engine performance power. Time-on-station is also a function of the battery life of sensors and control package. The current generation of UAVs has a proposed endurance of four hours in operation, which is sufficient to perform reconnaissance and surveillance missions, but may prove too short for target acquisition. [40] In fact, these UAVs may be best suited to perform reconnaissance missions that are limited in duration. The current characteristics of UAVs support this type of operation more than surveillance missions.

Control deals with how the UAV operates. UAVs are currently semi-autonomous. They are launched and recovered by a crew but can operate on autopilot once in flight. As the technology continues to develop, UAVs will become more autonomous. The Tactical Control System (TCS), under development by the DOD as a ground control station for tactical UAVs, is designed to control multiple UAV payloads and disseminate gathered data to various C4I systems. It can potentially provide multiple platforms, ships and submarines, with control capability.[41] For example, if a UAV is performing a RSTA mission, control could be switched to a ship in closer proximity to the UAV. Multiple platforms with control capability could also lead to conflicting asset requirements and strongly dictates the need for an established procedure for allocating unmanned vehicles.

The operating altitude of current tactical UAVs is 500-3000 ft, giving a maximum operating radius of 60 miles. Current speeds are 30-100kts. Altitude and speed of the unmanned system are limited by the weight and size of the vehicles. Engine performance also affects the speed of the vehicle. Shipboard operations are also an important aspect, considering the impact of host platform maneuvering on UAV operations. When ships are limited in changing its course or speed due to missions, or sea space, this restricts launch windows for UAVs. Access to flight competes with other ongoing helicopter or aircraft operations. Launch and recovery of unmanned vehicles may also be affected by wake turbulence generated by the moving ship, which will affect the wind patterns on the flight deck. [42] This could lead to unsuccessful launch or recovery, resulting in loss or damage to the UAV.

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40 Ibid.

41 U.S. Atlantic Command, *UAV Tactical Control System: Joint Concept of Operations*, [database online] (13 July 1998 [cited 15 June 2004]) available from World Wide Web @ http://www.fas.org/irp/program/collect/conops1_2.pdf

42 Ray Prouty, *Operations: Helicopters and Ships*, in NASA Civil Helicopter Safety Column [database online] (September, 2001 [cited 30 March 2004]); available from World Wide Web @ http://safecopter.arc.nasa.gov/

b. Payload Capabilities

Today, the most used sensors on UAVs are electro-optical (EO), Infrared (IR), and radar. Sensors are the means by which platforms locate targets or contacts of interest. The configuration of systems and sensors that enables the vehicle to accomplish RSTA missions is known as the payload. At a minimum, unmanned vehicles require electro-optical (EO) and IR cameras for reconnaissance and surveillance missions. An EO/IR combination enables UVs to be employed during day and night operations. For target acquisition, UAVs need a moving target indicator (MTI) radar to track CCOIs effectively and provide accurate targeting capability. While use of synthetic aperture radar allows sensors to operate in inclement weather and focus specifically on fixed targets, these again increase UV costs, which drives system availability.

Some basic characteristics of the sensor that should be taken into account are field-of-view (FOV), resolution, and sensitivity. FOV involves the range of angles that a camera can view. Resolution deals with the ability of the optics to "distinguish separate objects or parts of an object within its field-of-view,"[43] and sensitivity is an estimate of how fast the camera reacts to light. High sensitivity means that the camera does not need much contrast to capture an image. The range of the camera, combine with its resolution capability will limit the altitude of an unmanned vehicle. For RSTA missions, a wide FOV would enable the vehicle to cover a wider area. Also a high resolution would allow the camera to focus in on specific targets and a high sensitivity would yield a discernable signature even in clutter or low-contrast environments.

2. Unmanned Surface Vehicles

Like UAVs, USV extend the reach of naval sensors, yielding greater range for threat detection and extended AOR coverage. The characteristics of the Spartan Scout, a prototype currently undergoing operational testing, are examined for payload and platform considerations.

a. Platform Characteristics

This USV is small in size (7-11meters), which adds to its stealth and increases survivability. The small size of this USV also allows for greater speed and

[43], *Principles of Naval Weapons Systems*, ed. CDR Joseph Hall, USN Kendall/Hunt Publishing Company: Dubuque, IA. 2000.

improved maneuverability.[44] It operates on conventional sources of power, like diesel fuel, instead of being constrained by a battery at speed in excess of 40 knots with an endurance of 8 hours depending upon the speed and payload. Spartan Scout operates in heavy seas up to sea state three. Beyond this state, waves are larger than the height of eye of the platform, resulting in poor visibility.[45]

b. Payload Capabilities

This USV currently has the greatest payload capacity of today's unmanned systems with the ability to carry up to 5000 pounds. EO, IR, and radar all make up the existing sensor package. [46] The height of eye, the distance from the surface of the water to the radar antenna, limits the radar range. Likewise, due to a low silhouette, USVs can get closer to a contact of interest with less chance of detection than UAVs and provide horizontal vice vertical imagery. [47]

3. Unmanned Undersea Vehicles

UUVs can provide early warning by using acoustics to identify CCOI engine noises. They can also provide tactical, stealthy signals intelligence (SIGINT) in forcible entry and access operations. UUVs do not have the same depth and endurance limitations as humans and thus would be useful for gathering oceanographic data and mapping the ocean bottom. UUVs can also accomplish shallow water missions, which would be harmful for submarines and surface vessels.[48]

a. Platform Capabilities

The upcoming crop of UUVs will be launched and recovery from submarine torpedo tubes. The undersea vehicle would have to weigh less than 5000 pounds and be "approximately 21 inches in diameter, and 21 feet in length."[49] Likewise

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[44] Vittorio Ricci, Richard A. Erwin, and Benjamin S. Yates, *Spartan Scout Unmanned Surface Vehicles Concept of Operations (CONOPRS)*, NUWC-NPT Technical Memo 02-080, July 2002

[45] Ibid.

[46] Michael Hundt, *Unmanned Surface Vehicle for Assured Access and Force Protection,* (12 August 2002 [cited 31 May 2004]), available from World Wide Web @http://www.stl.nps.navy.mil/~brutzman/Savage/Robots/Spartan/hundt.SpartanSeaScoutNdia2002August13.pdf

[47] Vittorio Ricci, Richard A. Erwin, and Benjamin S. Yates, *Spartan Scout Unmanned Surface Vehicles Concept of Operations (CONOPRS)*, NUWC-NPT Technical Memo 02-080, July 2002

[48] Center for Strategy and Technology, *Unmanned Undersea Vehicles Master Plan*, April 20, 2000, 3-18.

[49] Ibid.

current UUVs operate at speeds of 8kts, which would make them unsuitable for long range or time sensitive missions because of the large amount of transit time required.

b. Payload Capabilities

To perform reconnaissance and surveillance tasks, the UUV, like the USV and UAV, would need basic electro-optical and infrared for imagery intelligence. It would need the ability to transmit these images as well as the ability to communicate with its control stations. High latency, or throughput delay, restricts the communication ability of UUVs and further limits the missions with which it can be tasked. Sonar will be used to perform target acquisition and safely navigate. For covert surveillance and tracking of targets, passive sonar is available and SIGINT antennas would be used to intercept emissions from CCOIs. [50]

F. TIME AVAILABLE

Not all missions are time critical. For example, "dull" missions like flying a pattern for reconnaissance and surveillance are not limited in duration. For UVs, missions where there is hostile intent, "the threat of imminent use of force by a foreign force, terrorist(s), or organization against the United States, US national interests, or US forces" [51] will be considered hostile. Missions such as air defense, particularly using UAVs as early warning launch and tracking of in bound missiles assets, are examples of time-critical events, which require surveillance assets to acquire or locate the threat within a small window of time. The first critical time aspect occurs once a CCOI or missile is located. The image must then be sent to an analyst to be identified. Once this occurs, the control station must task the asset with tracking the missile or, if the missile is neutral, re-task it to conduct reconnaissance and surveillance on another target. Figure 3.5 below is an example of tasking events that occur during the course of UV operations.

The implication for unmanned vehicles is that they must be responsive assets. Unlike theater-level assets that are tasked via the air tasking order (ATO), a 24-hour

[50] Secretary of the Army, *1998 Army Science and Technology Master Plan*, [database online] (1998 [cited 21 March 2004]); available from World Wide Web @ http://www.fas.org/man/dod-101/army/docs/index.html

[51] Joint Chiefs of Staff, Department of Defense Dictionary of Military and Associated Terms, (Washington: GPO, 1987)

tasking cycle, tactical unmanned vehicles will be deployed in dynamic environments and will often require quick tasking.

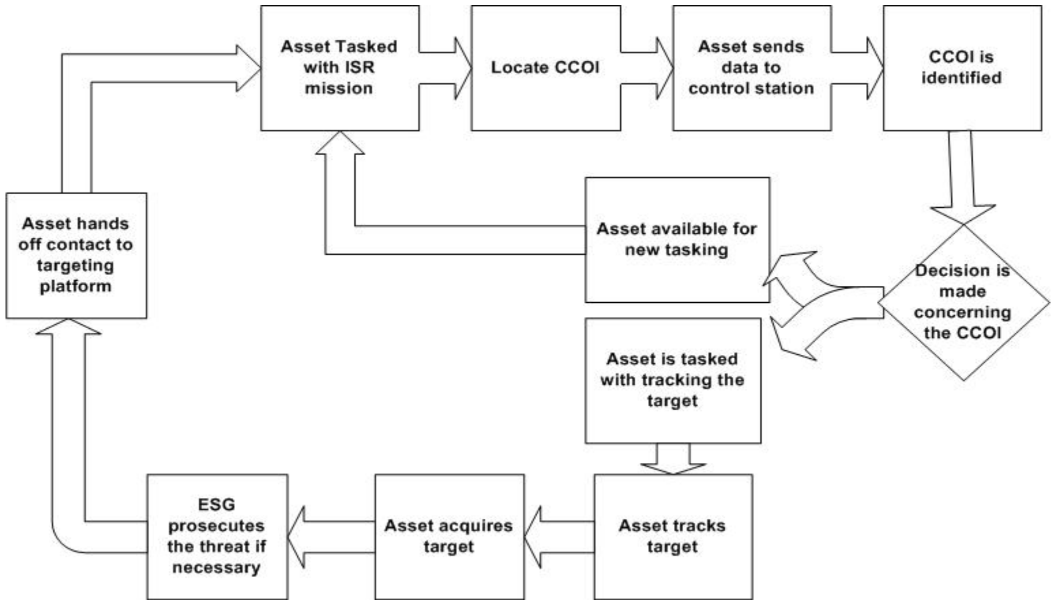

Figure 3.5 Mission Tasking Data Flow

To accomplish time-critical events, UVs must be designated as ALERT, on standby, ready for launch or on station, with the control team briefed and in watch spaces. UAVs and USVs are suitable for this designation. UUVs, however, are limited by slow speed and would be unsuitable for time-sensitive operations. Unmanned vehicles must have reactionary capability to reduce response time and accomplish time-sensitive operations

G. RESOURCE ALLOCATION

The analysis performed in this chapter highlighted unmanned vehicle mission tasking considerations summarized in Table 3.6. By identifying these considerations, practical means for allocating and tasking UVs can be developed. Resource allocation is the "distribution of limited resources among competing requirements for employment." [52] METT-T analysis reveals critical factors for UV mission tasking. These factors together provide a basic allocation scheme for distributing UV resources. There is no formal structure today within the CWC concept, however, to allocate these assets.

[52] Ibid.

METT-T ANALYSIS APPLIED for UV-ENABLED FORCES	
MISSION	**UVs will be tasked with ISR, targeting, and early warning missions**
WEATHER	**UVs will operate in the littorals, a cluttered environment as opposed to the open ocean. Will also be expected to operate in various weather conditions (precipitation, heavy seas)**
ENEMY	**UVs provide data that enables strike groups to distinguish between CCOIs, neutrals, and friendly contacts, including location, size, and capability of threats.**
TROOPS	**UVs require the platform characteristics and sensors discussed in this section**
TIME	**Unmanned vehicles must have reactionary capability to reduce response time and accomplish time-sensitive operations**

([Figure 3.6 Deductions from METT-T Analysis ([After Table 2.2 METT-T deductions, FM 7-20]))

For the purpose of this discussion, effectiveness is defined as the right commander having TACON of the right UV for the appropriate mission. An example of effectiveness would be an air warfare commander who has TACON of a UAV asset and can task it in support of air defense missions. The air warfare commander (AWC) would be the "right" commander in this scenario because of designated authority, view of operating environment, and resource utilization. The AWC has a focus on and understanding of the UAV operating environment, which would ensure that assets are utilized in an appropriate manner.

In contrast, AWC having TACON of a UUV or USV for air defense would constitute a mismatch. The AWC's primary concern is with air defense and would therefore have little use for waterspace resources. This disconnect between mission and asset leads to ineffective tasking and under utilization of assets. In the case of the scenario presented above, the process would be efficient if the AWC were allocated resources in sufficient time to task the UAVs and have them carry out assigned tasks.

1. Organizational Structures for Tasking Unmanned Vehicles

Four distinct organizational structures that enable ESGs to task unmanned vehicles are introduced below for discussion in the following chapter.

The CWC concept is comprised of warfare commanders who execute missions and element coordinators who allocate resources. Treating unmanned vehicles, as organic assets would use this concept. UVs would be allocated by element coordinators and then tasked by the warfare commanders to whom they are allocated. (1) In the first structure, the AREC allocates UAVs, the SCC allocates USVs, and the SOCA allocates UUVs. (2) The second structure develops a new element coordinator, the Unmanned Vehicle Element Coordinator (UVEC) responsible for allocating all UVs regardless of operating environment. (3) The third organizational structure for tasking UVs is platform-centric. UVs are organic to host platforms and tasked by the CO to execute shipboard missions. (4) The final organizational structure is the direct support option whereby unmanned vehicles are an extension of the CWC and tasked like an EOD or SEAL detachment currently are.

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IV. ORGANIZATIONAL STRUCTURES FOR TASKING UVS

Three interwoven building blocks: technology, processes, and organizational structure compose the command and control function (see Figure 1.1). Introducing unmanned vehicles into the fleet represents a change in technology, and as such, processes and organizational structures need to be developed that reflect these changes and allow the fleet to effectively and efficiently employ these resources. This chapter discusses four possible architectures for tasking UVs.

Figure 4.1 below shows the tasking cycle. Available resources are allocated and then tasked. The commander to whom assets are allocated has the authority to task those resources. The four options are: (1) Platform-centric option, (2) Organic Option-Split Configuration, (3) Organic Option-UVEC configuration, or (4) Detachment option.

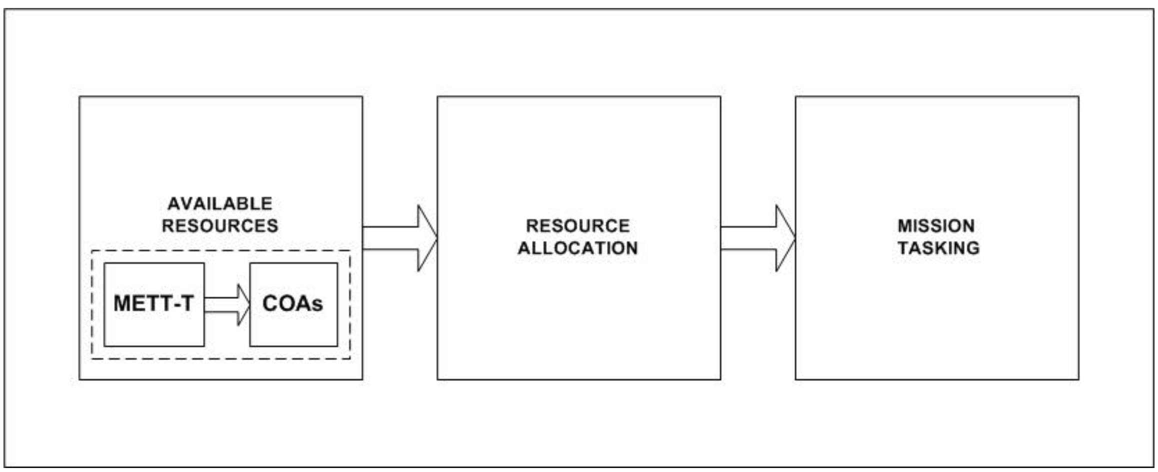
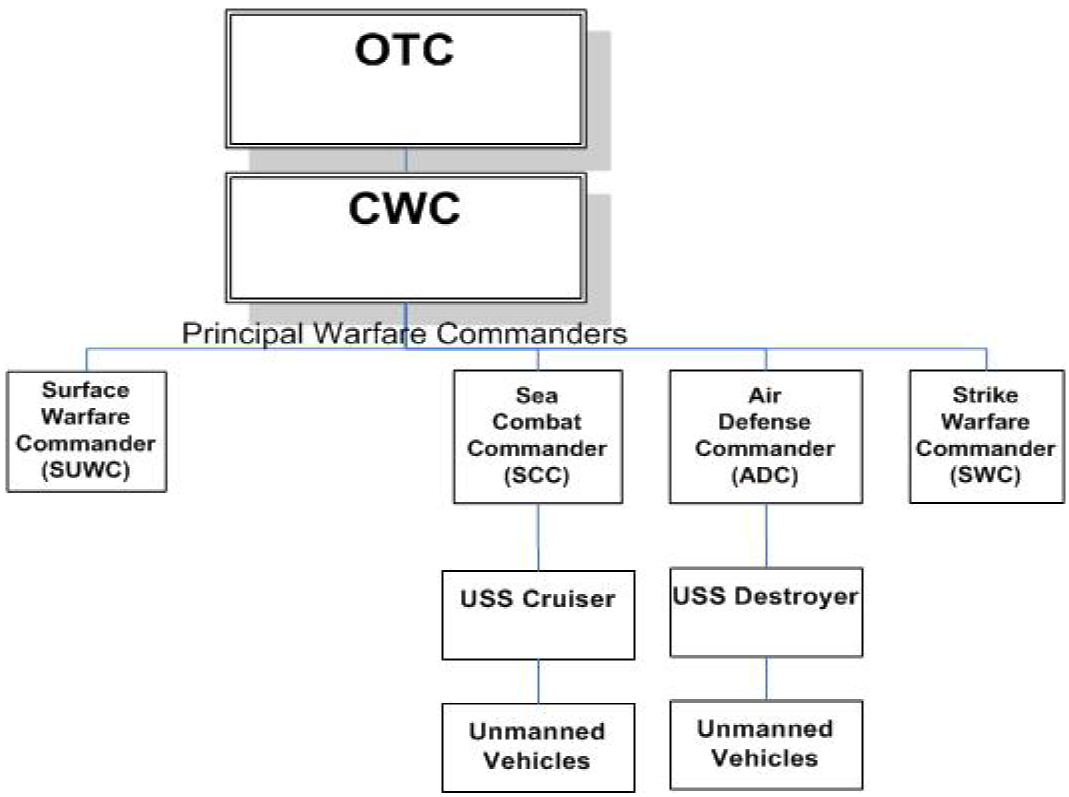


Figure 4.1 Mission Tasking Cycle

Mission management is an issue for consideration for all four structures. In the same vein that ongoing flight operations restrict the maneuverability of an aircraft Carrier, deploying unmanned vehicles does the same when deployed from a surface platform or submarine. From the scenario, deploying a USV from USS Cruiser potentially limits the maneuverability of the ship, which would limit the ship's ability to provide air defense for USS Amphib. Changing the course and speed of the ship to prosecute air threats may not present appropriate flight conditions needed to recover any UV. Sufficient planning on the part of the host platform may reduce these conflicts, but not necessarily. Similarly, the host platform will also have to coordinate with the resource and space managers to ensure that deploying UVs from the ship will not result in conflict with other strike group operations.

1. Platform-Centric Option

The platform-centric option is pictured in Figure 4.2 below. In this option, UVs are platform-centric assets tasked by the CO of the ship on which they are embarked; the unit commander has both OPCON and TACON of the assets. With regard to the scenario, all platforms have unmanned vehicles embarked. The CO of USS Cruiser might task embarked UVs with reconnaissance and surveillance in support of air defense, the CO of the submarine would task UVs with early warning tasks or force protections mission, and the CO of the destroyer would task UVs with RSTA in support of MIO.



4.2 Platform Centric Option

Direct UV control is an advantage of this structure. Currently, operators utilize a control station to maneuver unmanned vehicles. The host platform directly controls the UV. An advantage of this option is inherent in the CWC concept: command by negation. The CWC can re-direct assets to fulfill strike group missions as he sees fit. Likewise, the unit commander can task UVs in support of force protection or any other mission when not being tasked by the CWC.

Flexibility is a drawback for this structure. UVs, as organic assets, are attached to a host platform regardless of utilization. For example, USS Cruiser would retain organic USVs although it would be unlikely to use them in support of its' air defense missions. USS Destroyer, on the other hand, could use those USVs for force protection missions but has no control over or means to access the asset it requires. The lack of centralized tasking for this option necessitates that appropriate UVs are matched with platforms with suitable missions.

2. Organic Asset Option (Split Configuration)

In this organizational structure shown in Figure 4.3, UVs are organic assets attached to the ESG. UAVs are allocated by the AREC, USVs by the SCC and UUVs by the SOCA according to the CWC's main effort. The warfare commander to whom these assets are allocated then tasks them and has TACON of the assets; while the CWC maintains OPCON. The AREC is responsible for maintaining aircraft readiness and airspace planning. Warfare commanders submit air support requests for assets to the AREC. Based on the main effort, guidance, and priorities of the CWC, the AREC allocates the resources. AWC, located on USS Cruiser, would then task the allocated UAVs with ISR missions in support of air defense. USS Destroyer and Submarine would also task their UAVs as allocated resources dictated by AREC. They would receive UV support of their mission areas, as allocated by appropriate warfare commanders.

A primary advantage of this organizational structure is that it is operational and doctrinally defined. SOCA, AREC, and SCC are already responsible for managing assets that fall within their realm of responsibility. Adding unmanned vehicles to the mix would not require much organizational re-alignment. Unmanned platforms, supporting systems and maintenance requirements require specification in the respective coordinator's responsibilities section of CWC doctrine.

This structure keeps each element coordinator allocating assets within its' area of expertise. For example, AREC's primary focus is on air operations and airspace planning in maritime missions. In contrast, AREC has no authority in the undersea or surface operating environment and little, if any visibility. The AREC's designated authority, resource utilization, and view of the aerial operating environment make this the "right" staff to allocate UAVs. The same is true for SOCA and SCC with UUVs and USVs respectively.

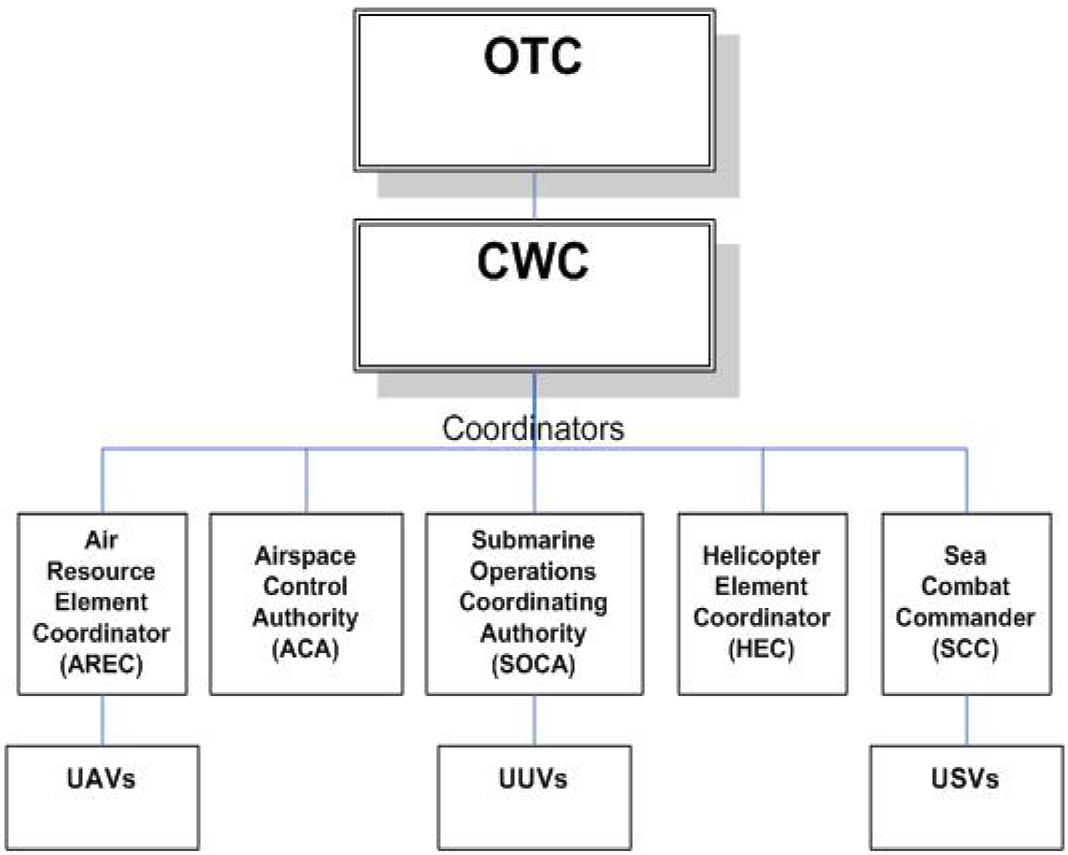


Figure 4.3 Organic Option (Split Configuration)

One specific challenge to the organic option is that it requires more time to task assets than the platform and direct support options. In this option, coordinators manage resources for allocation to warfare commanders. They are solely asset and resource managers. For example, the AREC can tell the warfare commanders that the UAVs are unable to fly due to technical problems but does not have the authority to ground the assets. This option requires more time for tasking resources than the platform and direct support options and may not be the most efficient means of tasking unmanned vehicles. Another important issue for consideration is communication. With this option, three different coordinators speak for unmanned vehicles. For instance, SOCA, AREC, and SCC would all be speaking to the UUVs, UAVs, and USVs located on a single host platform. This organization may add complexity to the allocation process.

3. Organic Asset Option (UVEC configuration)

In this option, depicted in Figure 4.4, all UVs are allocated by a UV element coordinator (UVEC). The commander to whom the unmanned vehicles are allocated then tasks them. The CWC has OPCON and each warfare commander has TACON of assets. Many of the tradeoffs discussed for the split configuration organic option also hold for the UVEC configuration. One major difference is the unmanned vehicle element coordinator. Duties and responsibilities would have to be developed within CWC doctrine for this coordinator.

Since unmanned vehicles are multi-mission assets that operate above, on, and below water, this role has a higher level of complexity. Unlike having a coordinator who has one area of responsibility, a UVEC manages and aligns assets in three different environments. The multi-mission capability coupled with the different operating environments make it difficult for one person to single-handedly manage and align all UVs and could potentially result in misallocation issues.

Alternatively, this single point of contact makes resource apportionment very straightforward. The simplicity of this organization allows for the centralized management of UVs and streamlines tasking requests for warfare commanders. Likewise, the UVEC, with equal visibility of the air and waterspace, creates an interface among the operating environments. This also enables the CWC to address only one coordinator with respect to UV allocation issues.

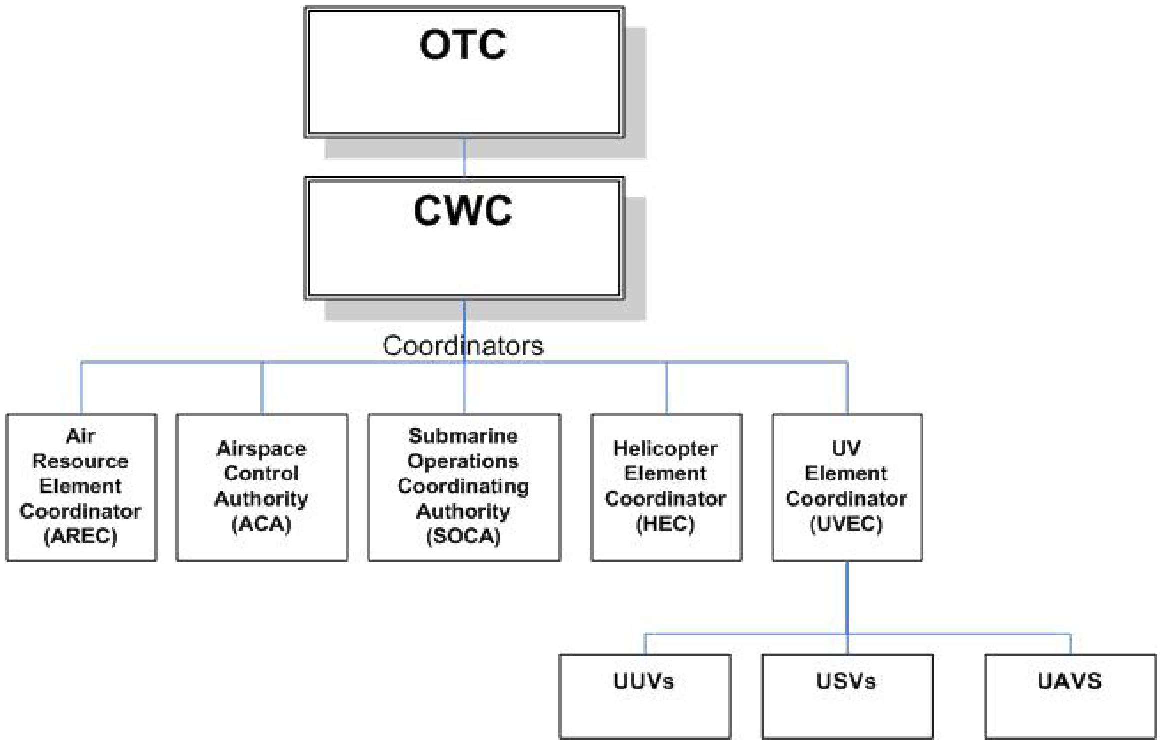


Figure 4.4 Organic Asset Option (UVEC Configuration)

4. Direct Support Option

This final option, shown in Figure 4.5, has the UVs as non-organic provided from a shore facility and available for tasking on request. CWC has TACON but not OPCON of assets and they are tasked similarly to a SEAL or EOD detachment. With regard to the scenario, the UV detachments are embarked in their launch platforms, but CWC directly tasks assets via the UV Officer in Charge (OIC) in the flagship.

An advantage of this option is that it enables centralized control of the assets, and directly responds to the CWC. The OTC's wider perspective ensures UVs support main effort and ultimately, mission accomplishment. The direct support option is also a faster, more efficient means of tasking unmanned vehicles. This organizational structure might best accomplish time-sensitive operations in a dynamic environment where UVs require quick tasking, or flexibility to change tasking to fulfill missions.

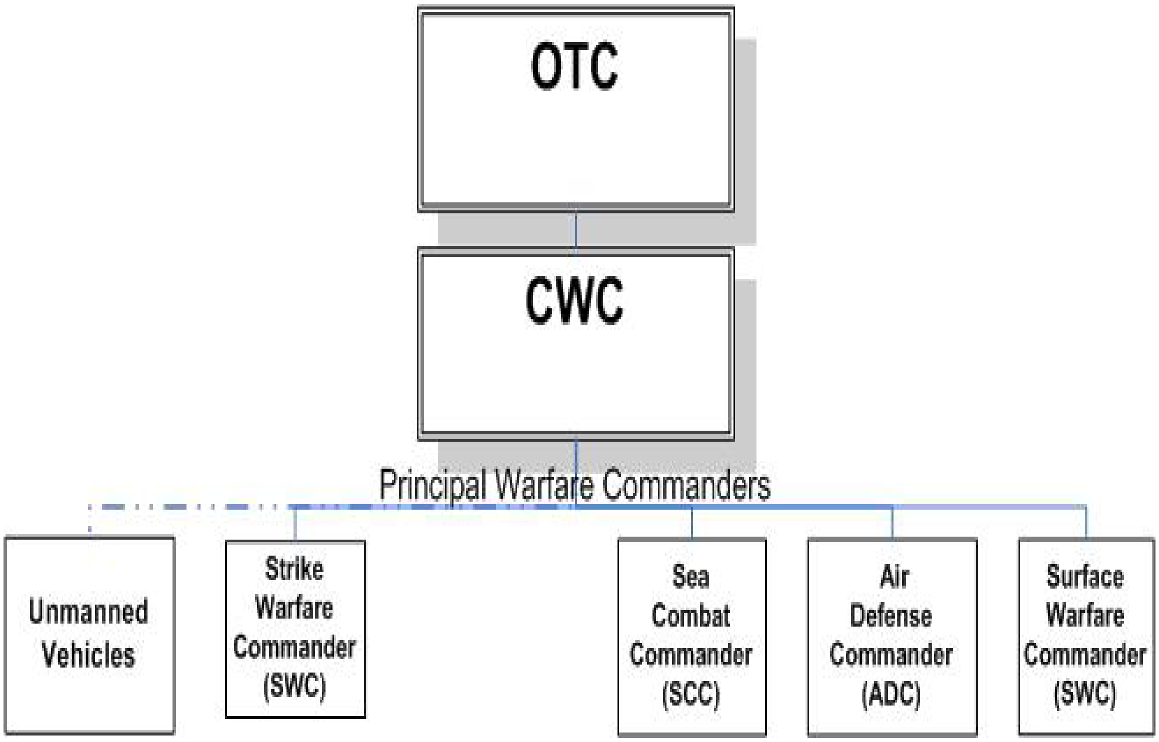


Figure 4.5 Direct Support Option

For this organizational structure to be effective, the UVs need to be *capable* assets that the ESG/CSG commander would actually task. A resource that is severely restricted by weather and other operating conditions would not be utilized much by a strike group. Thus, this option relies heavily on UV capabilities. As technology continues to improve and UVs become more proficient in certain areas, the direct support option will become a more feasible option.

A. NAVY MISSION ESSENTIAL TASK LISTS

A framework for evaluating and determining which structure is best for a particular mission may be derived from the Navy Mission Essential Task List (NMETL).

NMETL specifies "those tasks considered essential to accomplish and support [assigned] missions", along with the variables in the environment that can affect the performance of a given task, it provides measures of performance that can be applied by a commander to set a standard of expected results.[53]

53 CNO, *Universal Naval Task List (UNTL)*,[database online] *(* March 2001 [cited 30 May 2004]); available from World Wide Web @ http://neds.nebt.daps.mil/Directives/3500/ch-1.pdf

The scope and standards of performance given for each task make Mission Essential Task Lists (METLs) a valuable training and evaluation tool. Analysis highlights specific preparation and resources needed to complete that task, and commanders can assign assets accordingly. In fact, "the purpose of the METL is to assure alignment between a unit's mission and its training status."[54] Forces train to accomplish mission essential tasks. Resources are limited, however, and COs must further prioritize the METL to ensure that appropriate resources are allocated for mission accomplishment. In this manner, commanders can evaluate organizational effectiveness by using the measures of performance given with each task to assess their unit's readiness.

The four organizational structures presented above are all practical options for allocating unmanned vehicles and each has associated advantages and disadvantages. One structure, however, may work best for a specific mission while another may work best in another situation. It is essential that ESG and CSG staffs war-game UV C2 options to determine which one best suits the personalities at play and the specific scenario in which they operate.

[54] U.S. Army, ECP 2.2 Training and Training Records, [database online] ([cited 16 June 2004]); available from World Wide Web @ http://ecpub.lrh.usace.army.mil/ec/ecm/ecmq/ISO/Controlled%20Documentation/LV%202%20EC%20Procedures/ECP%20WORD%20Files/2_2%20Training%20and%20Training%20Records.htm

V. CONCLUSIONS AND RECOMMENDATIONS

With the expected growth in the role of UVs in maritime mission, CSG and ESG staffs need to anticipate allocation processes for these assets and adoption of the appropriate framework to task them. This research has resulted in four organizational structures for allocating and tasking unmanned vehicles. These structures are the platform-centric option, direct support option, organic option-split configuration, and organic option-UVEC configuration. The platform-centric option allows the CO of the host platform to directly task UVs in support of specified missions while the CWC/OTC tasks detached unmanned vehicles in the direct support option. For the organic option, element coordinators allocated UVs to warfare commanders, who then task them.

The organizational structures were developed by application of METT-T to UV enabled maritime missions. The problem was analyzed by applying the factors of METT-T: mission, enemy, terrain and weather, troops and support available, and time available to unmanned vehicles. The analysis identified specific implications for unmanned vehicles and emphasized important considerations for tasking and allocating UVs. Specifically, it highlighted the requirements necessary to accomplish the mission of tasking UVs as summarized in Figure 3.6. METT-T analyses generally result in courses of action, possible plans to accomplish the assigned mission.[55] However since tasking is a command and control issue, four organizational structures emerge for tasking UVs. The advantages and disadvantages or each structure are shown in Table 5.1.

Command and control systems are the means by which commanders accomplish missions. An effective C^2 system results when the three dimensions, processes, technology and organizational structures, are developed in tandem. As UV technology evolves, concurrent development and implementation of processes and organizational structures must occur before these systems are deployed with strike groups.

A. RECOMMENDATIONS

The organizational structures presented in this thesis should be tested operationally to validate their feasibility as viable options for tasking unmanned vehicles.

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[55] U.S. Army Field Manual 7-20, The Infantry Battalion, Washington, D.C., (April, 1992)

Expeditionary and carrier strike groups should determine which structure enables them to best task unmanned vehicles through war-gaming the organizations in simulated operations, or trying out different structures during training exercises, using NMETLs as

OPTIONS	ADVANTAGES	DISADVANTAGES
1. Platform Centric	Direct UV Control, CO can task unmanned vehicles in support of ship's missions CWC can re-task if/when necessary.	Lacks Flexibility. UVs remain under TACON of host platform regardless of utilization.
2.Organic-Split Configuration	Currently operational, doctrinally defined, element coordinator has designated authority, view of operating environment, and resource utilization	Requires more time to task assets. Communication conflicts with three different element coordinators speaking for UVs.
3.Organic-UVEC Configuration	Single point of contact makes apportionment straightforward, streamlines tasking requests, adds a layer of interface between operating environments. Simplicity of organization	Requires development of UVEC. Duties and responsibilities must be specified in CWC manual. Difficult for one person to align multi-mission capable assets that operate in three different environments. Requires more time to task assets. Communication conflicts with three different element coordinators speaking for UVs
4.Direct Support	Enables centralized control of assets, Faster, more efficient means of tasking UVs	Highly UV dependent. UVs need to be a *capable* asset for the CWC to task it.

Table 5.1 Summary of Advantages and Disadvantages

measures of performance. Likewise, personality and leadership style of the OTC/CWC will influence the option chose by each strike group. The appropriate forum for this activity is war gaming among strike groups staffs.

Lessons learned from using unmanned systems in ongoing operations should be taken into consideration when evaluating the effectiveness of these structures. Finally, as UV capabilities progress, the advantages and disadvantages presented in this thesis should be re-evaluated.

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