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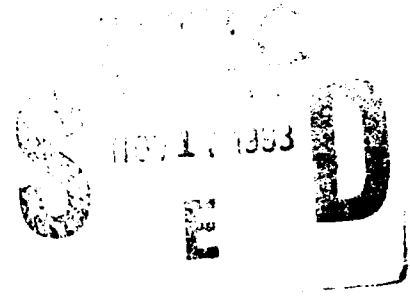
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NAVAL POSTGRADUATE SCHOOL Monterey, California



THESIS

A CONCEPT OF
UNMANNED AERIAL VEHICLES
IN AMPHIBIOUS OPERATIONS

by

Kipp A. Collins

June, 1993

Principal Advisor:
Co-Advisor

Michael G. Sovereign
Y. S. Fu



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A Concept of
Unmanned Aerial Vehicles
in Amphibious Operations

by

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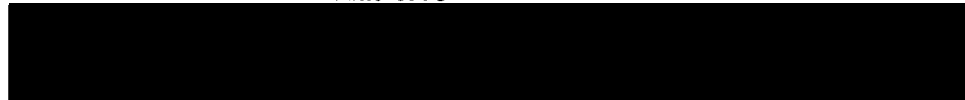
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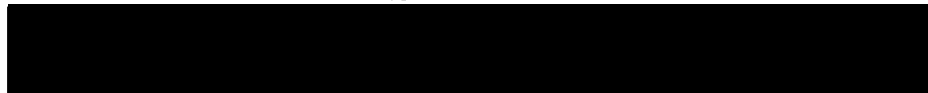
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ABSTRACT

The purpose of this thesis was to perform a conceptual study of using Unmanned Aerial Vehicles (UAVs) in amphibious operations. It focused on the command relations, tasking and critical problems in UAV amphibious operations. This thesis investigated the question of whether using UAVs at sea is a feasible complement to current amphibious operational doctrine and, if so, then what expense is incurred to assets on which it is embarked and assigned to the Amphibious Ready Group.

This thesis concluded that UAVs were a feasible complement to current amphibious doctrine, but several critical issues to include EMI, video distribution and air space management, had to be investigate further. Additionally, topics for future research were detailed in chapter VII.

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I. INTRODUCTION

A. BACKGROUND

In recent years, several changes in the technologies and economics associated with combat have significantly changed the character of modern warfare. The primary reason for these rapid changes has been the recent development of high technology/high lethality weapons and their respective proliferation among nations which represent both friend and foe in the Third World. With the American reorientation toward low intensity conflict in peripheral regional conflicts worldwide and the need to use every possible force multiplier for both political and economic reasons, providing high quality weapon targeting intelligence while not exposing expensive manned reconnaissance platforms has become imperative. One significant development has been low altitude, antiaircraft weapons. These weapons are exceptionally portable, easy to use, and represent a significant probability of hit and kill. They made a significant difference in Afghanistan. The proliferation of these weapons worldwide has made a cheaper reconnaissance platform not only desirable but almost a necessity in today's tactical, political, and economic environment.

The clearest and most elucidating example of a modern, logistically sophisticated army being stalemated by a Third World nation is the Afghanistan War. In this conflict, the Soviet Army's inability to effect a logistical and Close Air Support (CAS) mission had a synergistic effect which was the cause of their ultimate political stalemate - both internationally and internally - with Afghanistan.

In the field, the Soviet Army was eventually unable to resupply their forces by air or protect them with close air support. Due to the geography of Afghanistan and the nature of the American-supported guerrilla forces, it was absolutely imperative for the Soviets to maintain distant forward operating bases from which to strike. Once aerial resupply and close air support were inhibited, the guerrillas could move forces safely and exert their combat power at a decisive point on a weakened and isolated enemy. By making many Soviet aerial missions too risky, many operations were forced onto the Afghanistan road network where guerrillas hold a distinct advantage. Through the use of high technology Stinger and SA-7 missiles, the Soviets were forced into withdrawal. An inexpensive Soviet non-armed aerial platform which could provide accurate and timely intelligence while remaining an elusive target was never found.

As the result of America's experiences and knowledge gained in Afghanistan, Central America, Africa and other nations' low intensity conflicts, the United States initiated

actions which could significantly reduce its political and economic vulnerabilities while enhancing its tactical intelligence collection capability. At congressional urging, the Department of Defense (DOD) has initiated the DOD Unmanned Aerial Vehicle (UAV) Development Program. This program serves as the central point from which all service-specific programs are coordinated and/or directed.

B. SCOPE

The purpose of this thesis is to perform a conceptual study of using UAVs in amphibious operations. It will focus on the command relations, tasking and critical problems in UAV amphibious operations. Current doctrine in the United States Marine Corps is focused primarily on land-based UAV operations. In fact, during exercise Team Spirit 1993, the UAV company participating in the exercise never embarked on a ship. This thesis will investigate the question of whether using UAVs at sea is a feasible complement to current amphibious operational doctrine and, if so, then what expense is incurred to assets on which it is embarked and assigned to the Amphibious Ready Group. This thesis is intended for an audience that is familiar with amphibious warfare doctrine and electromagnetic communications theory. This thesis will draw heavily from Marine Corps doctrine, personnel experience as a logistics officer in the Marine Corps and lessons learned from after action reports.

C. ORGANIZATION

Chapter II will provide a generic description of a UAV. Chapter III will address possible threats to UAV. Chapter IV will discuss in detail the possible missions of UAVs while conducting amphibious operations. C² aspects of UAVs in amphibious warfare will be discussed in chapter V. A discussion of critical issues that need to be addressed if UAVs are to reach their maximum effectiveness will be provided in chapter VI. Chapter VI will only address three of the most imperative critical issues that the author feels need to be addressed in order to optimize UAV operations. Other issues that were not discussed in the paper will be offered in chapter VII, the summary/recommendation chapter, as a bases for further study.

II. UNMANNED AERIAL VEHICLES

A. DEFINITION

A UAV is defined as a powered vehicle that:

- Does not carry a human operator
- Uses aerodynamic lift forces
- Has the capability to fly autonomously or piloted remotely
- Can be expendable or recoverable
- Can carry a lethal or nonlethal payload

By physically disassociating the pilot from the aircraft, a force commander is able to limit hazards of aircraft crew members and therefore significantly reduce political and economic exposure a nation must endure on the battlefield. Cruise missiles, artillery projectiles, ballistic vehicles and semi-ballistic vehicles are not considered to be UAVs.

[Ref. 1:p. 1-1] This thesis will use this broad definition of a UAV to investigate the concept of using UAVs in amphibious operations.

Although UAVs allow a nation's forces to reduce vulnerabilities while putting a reconnaissance platform into an area of interest, the UAV is uniquely able to add to the

capability of real time surveillance/collection for an air/ground/sea commander. This enhancement allows commanders to complete the operational assessment and planning process while continuously updating themselves and their subordinates to a degree never before seen. Because of this ability, UAVs are force multipliers which enable a commander to make more informed and timely decisions that should allow him to exert the combat power at a critical time and place. Additionally, UAVs have the capability to provide a variety of operational missions that include, but are not limited to: Reconnaissance, Surveillance, and Target Acquisition (RSTA); Electronic Warfare (EW); Electronic Signal Measures (ESM); mine detection; command and control; and special operations support roles. UAVs are particularly suited for environmentally prohibitive missions (missions into and near areas contaminated by Nuclear, Biological, and Chemical material), missions which require extreme physical endurance, and those missions in which the loss of aircraft and/or air crew is probable or politically unacceptable. By using UAVs, a commander can allocate his remaining manned aircraft for missions which require on-site human judgement and versatility.

B. PROGRAM STATUS

In 1988, Congress directed the DOD to consolidate the management of nonlethal UAV programs. Shortly thereafter, DOD

formed a UAV Executive Committee and designated the United States Navy as Executive Service. The DOD also formed a UAV Joint Project Office (JPO) to consolidate the research and development and acquisition efforts of the services. In 1991, the DOD further refined the oversight structure by replacing the UAV Executive Committee with the Defense Acquisition Board (DAB). Through the UAV JPO organizational efforts, the UAV has four distinct class categories: Close Range, Short Range, Medium Range, and Endurance. Table 1 [Ref. 2:p. 13] summarized the mission parameters of these four categories.

The Close Range UAV is currently proceeding toward a planned milestone decision review scheduled for the fourth quarter of FY 93. Additionally, the Close Range Program Office plans to release Requests For Proposals (RFPs) for the common and downsized mission control station hardware and award both contracts this year.

The Short Range UAV has completed its early test and development. In December 1992, IAI's status as prime contractor was switched with TRW and the contract awarded. Currently, the low rate production option to TRW and IAI is in progress. The Navy currently plans to procure 18 systems of eight air vehicles per system during calendar year 1994.

[Ref. 3:p. 1]

The first Medium Range UAV was launched in May 1992 from an air platform. A second launch was conducted in July 1992 demonstrating autonomous flight, imaginary collection and

TABLE 1: Summary of UAV Family Mission Parameters

	CLOSE	SHORT	MEDIUM	ENDURANCE
OPERATIONAL NEEDS	RS TA TS EW MET. NBC	RS TA TS. MET NBC. C2. EW	PRE-AND POST-STRIKE RECONNAISSANCE TA	RS TA C2 MET NBC SIGINT EW SPECIAL OPS
LAUNCH AND RECOVERY	LAND/SHIPBOARD	LAND/SHIPBOARD	AIR/LAND	NOT SPECIFIED
RADIUS OF ACTION	NONE STATED	150 KM BEYOND FORWARD LINE OF OWN TROOPS (FLOT)	650 KM	CLASSIFIED
SPEED	NOT SPECIFIED	DASH > 110 KNOTS CRUISE < 90 KNOTS	350 KNOTS < 20 000FT 9 MACH > 20 000 FT	NOT SPECIFIED
ENDURANCE	24 HRS CONTINUOUS COVERAGE	8 TO 12 HRS	2 HRS	24 HRS ON STATION
INFORMATION TIMELINESS	NEAR-REAL-TIME	NEAR-REAL-TIME	NEAR-REAL-TIME/ RECORDED	NEAR-REAL-TIME
SENSOR TYPE	DAY/NIGHT IMAGING* EW NBC	DAY/NIGHT IMAGING* DATA RELAY. COMM RELAY RADAR SIGINT MET. MASINT. TD. EW	DAY/NIGHT IMAGING* SIGINT. MET. EW	SIGINT MET. COMM RELAY. DATA RELAY. NBC IMAGING MASINT. EW
AIR VEHICLE CONTROL	NONE STATED	PRE-PROGRAMMED/ REMOTE	PRE-PROGRAMMED	PRE-PROGRAMMED/ REMOTE
GROUND STATION	VEHICLE & SHIP	VEHICLE & SHIP	JSIPS (PROCESSING)	VEHICLE & SHIP
DATA LINK	WORLD WIDE PEACE TIME USAGE. ANTI-JAM CAPABILITY	WORLD WIDE PEACE TIME USAGE. ANTI-JAM CAPABILITY	JSIPS INTEROPERABLE WORLD WIDE PEACE TIME USAGE. ANTI-JAM CAPABILITY	WORLD WIDE PEACE TIME USAGE. ANTI-JAM CAPABILITY
CREW SIZE	MINIMUM	MINIMUM	MINIMUM	MINIMUM
SERVICE NEED/ REQUIREMENT	USA USN USMC	USA USN USMC	USN USAF USMC	USA USN USMC

* Baseline Payload Capability

LEGEND

C2 - COMMAND AND CONTROL
 EW - ELECTRONIC WARFARE
 JSIPS - JOINT SERVICE IMAGERY PROCESSING SYSTEM
 MASINT - MEASUREMENT AND SIGNATURES INTELLIGENCE
 MET - METEOROLOGY
 NBC - NUCLEAR, BIOLOGICAL and CHEMICAL RECONNAISSANCE
 RS - RECONNAISSANCE AND SURVEILLANCE
 SIGINT - SIGNALS INTELLIGENCE
 TA - TARGET ACQUISITION
 TS - TARGET SPOTTING
 TD - TARGET DESIGNATOR

airborne recovery of the vehicle. The Medium Range UAV is currently proceeding with both risk-reduction and engineering and manufacturing development. However, the Navy support of this program has been suspended. [Ref 3:p. 1]

The UAV Special Study Group (SSG) Working Group is considering a joint Operational Requirements Document (ORD) for an Endurance UAV. The UAV Joint Program Office is contributing to this effort as well as monitoring other Endurance UAV program initiatives.

The Pioneer short range vehicle is currently fielded by the Navy, Army, and Marine Corps. It was purchased as an interim fill for the UAV requirement. The Navy will continue to purchase Pioneer until the proposed short range UAV is ready for fielding. The Navy intends to purchase an additional four systems of five air vehicles each.

[Ref. 3:p. 2]

The proposed family of UAVs will provide commanders the flexibility and capability they need in the modern battle space. The family provides a logical progressive increase in capabilities and range to satisfy current and projected missions.

III. THREATS TO UAVs

This chapter discusses the threat to UAVs in the modern battlefield. The threat to UAVs is currently quite similar to other low technology/low performance/low altitude aircraft. Moreover, because of the UAVs reliance on its vital electronic control links and the UAVs inability to actively maneuver/defend itself, it is easier to attack and defeat than a similar sized aircraft. However, some UAVs have a reduced radar, infrared, and acoustic signature because of reduced weight. This greatly reduces the enemy's ability to detect and track the vehicle. Therefore, it is markedly more difficult to engage with weapon systems. Additionally, because of the UAVs diminutive physical size, it is extremely difficult to track with visually tracked systems. These characteristics should enhance the UAVs ability to survive in areas of enemy anti-air operations. This chapter will describe the threats that exist to UAVs in low intensity conflict, electronic warfare environments, enemy air environments and possible future weapons. [Ref. 2:p. 2-1]

A. LOW INTENSITY CONFLICT

With the disintegration of the Soviet Union and the United States emerging as the only global superpower, it can be anticipated that modern UAVs will be exposed to mostly low to mid intensity conflicts. In conflicts such as these, the major threat to UAVs will be from Anti-Aircraft Artillery (AAA) and small ground-based conventional arms used in an ad hoc air defense mode. Because of its reduced radar cross-section, the UAV will probably be detected by its acoustic signal initially which then cues enemy personnel.

As radar technology improves and becomes proliferated among Third World nations, it can be expected that UAVs will be detected more easily by radar at increased distances. This will greatly increase the enemy's reaction time and, therefore, enable our enemies to engage our UAVs with Surface-to-Air Missiles (SAM). [Ref. 4:p. 2-1]

B. ELECTRONIC WARFARE

UAV operations are also vulnerable to Electronic Warfare (EW). Our enemies can be expected to focus their efforts at the systems controlling the UAV and the products/information which the UAV is sending back to friendly forces. Without operational data links, the UAV's mission is pointless. Ground-based, shipborne, and airborne (helicopter and fixed-wing) platforms can be expected to carry out the enemy's EW

program.

During a typical UAV mission, it can be expected that the vehicle will spend considerable time loitering over enemy territory. Because of this, the UAV will be physically closer to enemy jamming capabilities than its own control station. This geometry greatly increases the threat of enemy EW. The enemy will be able to jam the UAV with smaller amounts of power than would normally be used to jam units in friendly territory. [Ref. 4:p. 2-1]

C. ENEMY AIR

Because of the UAV's excellent anti-detection characteristics, the threat from enemy aircraft is relatively limited. However, once the UAV's capabilities and characteristics are more widely disseminated, a realignment of enemy capabilities and resources can be expected. UAVs have a similar flight profile to helicopters. Therefore, it can be expected that they will also have a similar air threat profile as well. Current anticipated enemy helicopters possess a very limited anti-air capability; however, many nations are developing attack helicopters with a more potent air-to-air intercept mission. When combined with their light weight and maneuverability, these weapons platforms can pose a significant threat to UAVs. Fixed-wing aircraft with anti-air capabilities already pose a threat to UAVs that have been detected and tracked. Time and technology will only increase

the air threat to UAVs. [Ref. 4:p. 2-1]

D. FUTURE WEAPONS

Directed energy weapons, such as lasers, electromagnetic pulse weapons, microwave weapons, and particle beam weapons, could also pose a threat to future UAV operations. Currently, these and other technologies are under development in a number of countries. The threat to the UAV from these weapons will be proportional to the enemy's level of development and the previous success of UAV operations in the long run.

[Ref. 4:p. 2-1]

E. SUMMARY OF THREATS

It can be stated, that there exists no credible threat to UAVs now or in the foreseeable future. Until our anticipated enemies realign their forces, UAVs have a window of opportunity that can be exploited. It is imperative that the U.S. design and field systems that will exploit this window and be prepared for anticipated enemy aggression.

IV. MISSIONS OF UAVs

This chapter discusses the current mission capabilities of the existing short-range UAV system and the anticipated growth in missions with future UAV payloads.

A. EXISTING MISSIONS

The current short-range UAV, the Pioneer, has a very limited payload. The payload consists of one daytime television camera/lens zoom system and one Forward-Looking Infrared (FLIR) night sensor system [Ref. 2:p. 3-7]. These two sensors provide the Pioneer with a basic day/night observation capability for the Marine Air Ground Task Force (MAGTF) commander. Because of the low capability/unsophisticated nature of the sensing systems in the payload, the results are subject to all the variabilities that obstruct simple aerial television and infrared (IR) imagery sensing systems. The two primary deficiencies of the daytime TV and nighttime FLIR systems are that poor weather conditions can easily obstruct the UAV's field of view and deny lack of adequate temperature gradients for the FLIR.

As limited as this system may appear to some observers, it can readily provide valuable, high quality overhead imagery to the MAGTF commander. Consequently, the MAGTF, Air Combat Element, or Ground Combat Element commanders task the UAV-SR systems to perform multiple and varying types of reconnaissance, surveillance and target acquisition (RSTA) missions. These missions include, but are not limited to:

- Adjusting close/deep air support missions
- Adjusting all types of indirect fire missions
- Route reconnaissance for landing force, tactical and logistical
- Beach and landing zone surveillance
- Battle damage assessment [Ref. 5:p. 1]

During operation Desert Shield and Desert Storm, Pioneer UAVs successfully accomplished the missions listed above. The Pioneers were by both land-based units and by battleship detachments. In both employment schemes, the UAV proved to be an invaluable asset in conducting RSTA missions during an amphibious operation. Their ability to stealthily approach enemy positions and transmit real-time imagery back to the requesting unit earned rave reviews from those who benefited from the Pioneer capabilities.

B. FUTURE MISSIONS

In the near-term future, with the development of newer/higher technology UAV platforms and payloads, the Amphibious Task Force/MAGTF commander will have the ability to perform additional missions not currently available on present UAV platforms. Several of the new mission packages that are currently under development for the UAV are as follows:

- Radio relay capability between two ground stations or another UAV
- Target designation capability of modern precision weapons
- Mine detection reporting operational capability
- Nuclear, biological and chemical (NCB) warfare detection/reporting capability
- Electronic warfare capabilities
- Electronic countermeasure capabilities
- Synthetic aperture radar sensing systems for the enhancement of RSTA missions [Ref. 4:p.1]

These new mission packages should greatly enhance the MAGTF's commanders ability to wage war without risking friendly forces to enemy fire.

C. SYSTEMS WITH SIMILAR MISSION CAPABILITIES AS UAVs

UAVs are not the only systems that can perform the missions described earlier with regard to amphibious operations. Both the CLF and CATF have access to organic and

non-organic systems, agencies and personnel. A non-inclusive list follows:

- Reconnaissance aircraft
- National assets
- Manned reconnaissance teams
- Observation aircraft
- Helicopters
- Communication satellites
- Electronic warfare aircraft
- Aircraft with an NBC detection capability

These assets would compete with the UAV for missions. The commanders, through their designated representatives, are responsible for determining the mission allocation. The UAV's primary attribute is its ability to fight into hostile environment with out the threat of loss of life to the pilot. It can be expected then that UAVs will be reserved for dangerous areas as discussed earlier.

V.COMMAND AND CONTROL ASPECTS OF UAVs IN AMPHIBIOUS OPERATIONS

This chapter discusses the command and control (C²) aspects of short range unmanned aerial vehicle (UAV-SR) operations in the two distinct and separately controlled phases of an amphibious operation. It includes a discussion on command authority, tasking agencies, task routing, manning, types of missions and factors affecting UAV availability.

To understand UAV requirements, tasking and collection procedures, a basic understanding of amphibious operations is required. Upon the assignment of an amphibious operation by a Theater or Fleet Commander, a Commander Amphibious Task Force (CATF) is designated and task force amphibious units are assigned. The CATF, a Navy officer, commands all Naval, Marine, and other Service units assigned to the task force. The CATF is responsible for the training, embarkation, transport, support, and control of air and naval gunfire support until command of amphibious forces is transferred ashore. Subordinate to the CATF in this phase is the Commander Landing Force (CLF). The CLF is a Marine officer assigned by the Theater or Fleet Commander. The CLF is responsible for the training, coordination, combat service

support and logistical support of the landing force. Upon the establishment of a beachhead and the debarkation of the Landing Force's indirect fire weapons, the command of the operation is shifted ashore with the CLF. Because of the complexity of shifting command in an amphibious operation, control of many assets and units becomes difficult. UAVs are no exception. A smooth shift in command and ensuing control is essential for UAVs to fulfill their full potential.

A. CATF CONTROLLED UAVs

In an amphibious operation where Marine Corps units are embarked aboard amphibious shipping, the operational control remains in the hands of the CATF. The CATF is responsible for the planning, training and execution of all pre-assault UAV missions. The majority of these missions will be flown in direct support of CLF intelligence requirements -the Essential Elements of Information (EEI's) established by the CLF. It is during this period that CATF/CLF staff coordination must be efficient and effective to adequately meet the intelligence requirements of both commanders. Requirements and therefore tasking for embarked/assigned UAV organizations will continually change as the enemy, weather, and tactical situations change. UAVs are well suited for Maneuver Warfare. Their quick responsiveness and RSTA capability fit the high tempo of operations required in this warfare doctrine. While

embarked, tasking for information which requires a UAV collection effort should pass from the requesting unit to the CATF, and finally to embarked Navy UAV units. It would be in the Marine Corps' best interest that Marine personnel be made available to assist the Navy operators for UAV missions flown by the Navy in support of the Marine Corps. This would greatly reduce the chance of misinterpretation at the operator level. In the situation where no Navy UAV assets are assigned or available due to heavy tasking, embarked/assigned Marine units could be utilized to accomplish both CLF and CATF requirements. This is the focus of the rest of the thesis.

Throughout this process, it is imperative that all planning and coordination of UAVs be accomplished through the Supporting Arms Coordination Center (SACC) and Tactical Air Control Center (TACC). Information requirements and intelligence derived from flights should always be channeled through the Joint Intelligence Center (JIC) to eliminate duplication of effort, to pair requirements with the most effective platform, and to ensure target compromise does not occur. [Ref. 5:p. 6]

The SACC is the center hub for close air support request and tasking. The TACC is the agency that coordinates the air control within the battle space. The JIC is the focal point for intelligence request and processing.

1. Missions of CATF Controlled UAVs

The types of missions which can be accomplished through CATF assignment are as varied as CLF intelligence/fire support control requirements. The Operational Maneuver From The Sea Concept is the application of Maneuver Warfare principles to the maritime portion of a theater campaign. The concept takes advantage of the expanding capabilities of modern naval and landing forces to project power ashore.

[Ref. 6:p. 1] UAVs have the capability to enhance a force's effectiveness under this concept.

In the pre-assault phase of an amphibious landing, UAVs can be used as communications relays, overhead imagery, countermine warfare, anti-submarine actions, meteorological surveys, and NBC detection. Once the assault phase is initiated, Navy UAVs should be shifted towards land based areas of interest so as to provide their capabilities toward the accomplishment of power projection ashore. Figure 1 [Ref. 7:p. 22] depicts the blue water phase where UAV focus goes from fleet protection to Marine tasking. The diagram depicts UAVs being used to target enemy positions ashore and providing imagery data to command element.

Re-tasking of Navy UAVs is critical to exploiting the enemy's weaknesses. UAV re-tasking greatly enhances the Marine's Maneuver Warfare concepts since minimal forces can be applied at a critical place and point in time. Figure 2

BLUE WATER PHASE

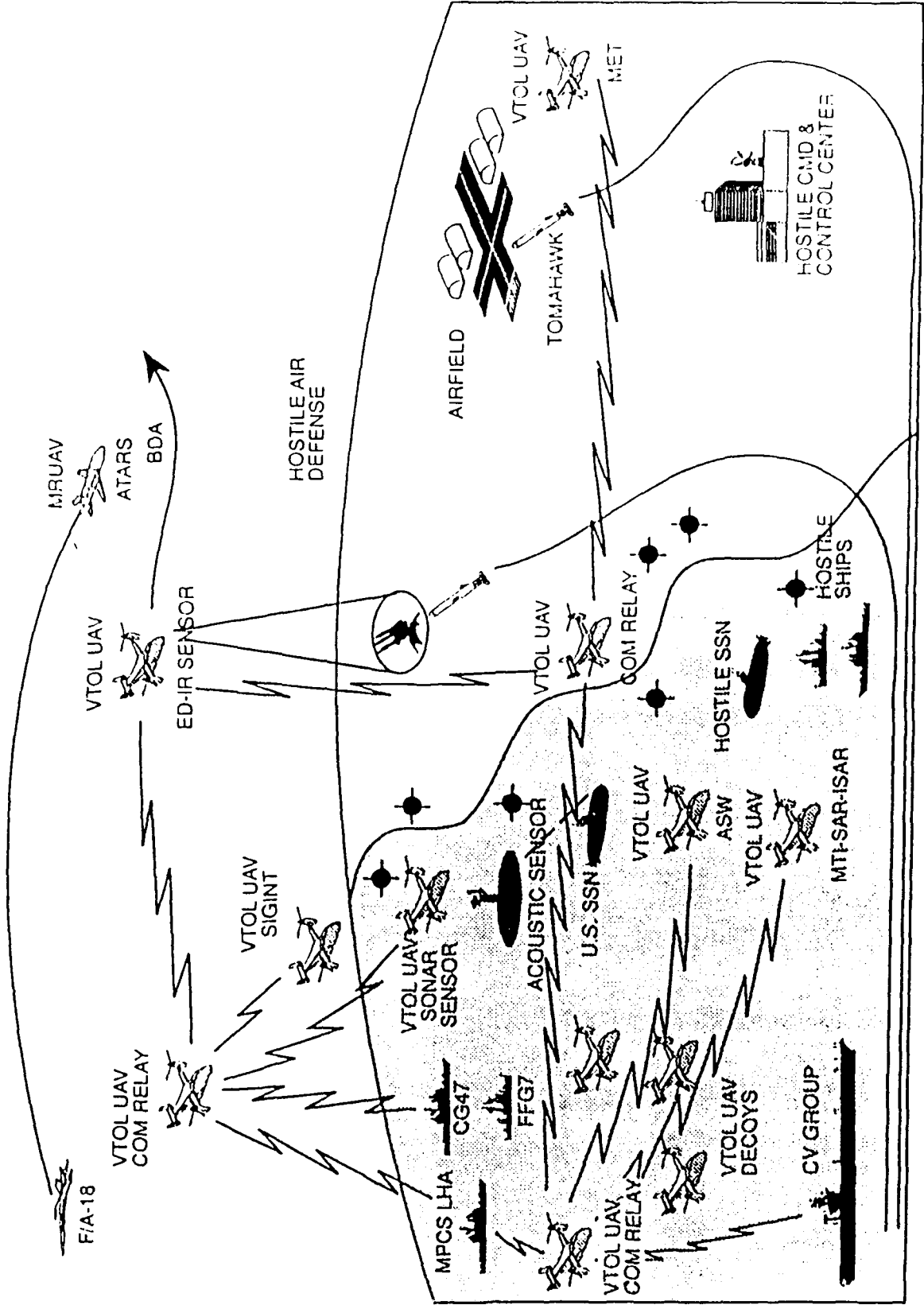


Figure 1

[Ref. 7:p. 23] depicts the green water battle with UAVs during the initial stages of the attack. A portion of UAV assets will be used to ensure the securing of a beach/air head and will also be used at the initial insert point. The UAV's primary mission is to provide imagery to the CATF for exploitation ashore such as target designation and photo intelligence.

Figure 3 [Ref. 7:p. 24] depicts the amphibious assault phase. In this phase, the preponderance of UAV assets are used for shore exploitation. Enemy ground installations are being targeted and observed for friendly force engagements.

CATF operations are design to support the amphibious task force and its power projection ashore. The different phases clearly demonstrate the progression of forces inland in attempt to land friendly forces and gain control of enemy territory.

B. CLF CONTROLLED UAVs

Once ashore, the CLF will have operational control over his Marine Corps UAV assets. Command, Control, and logistical/administrative control of each Marine UAV Company is handled by a Surveillance, Reconnaissance, and Intelligence Group (SRIG). Each Marine Expeditionary Force (MEF) has assigned to it an SRIG which is responsible for all MEF level intelligence collection, production, and dissemination. An MEF is built around a Marine Division, Marine Air Wing, Force

GREEN WATER PHASE

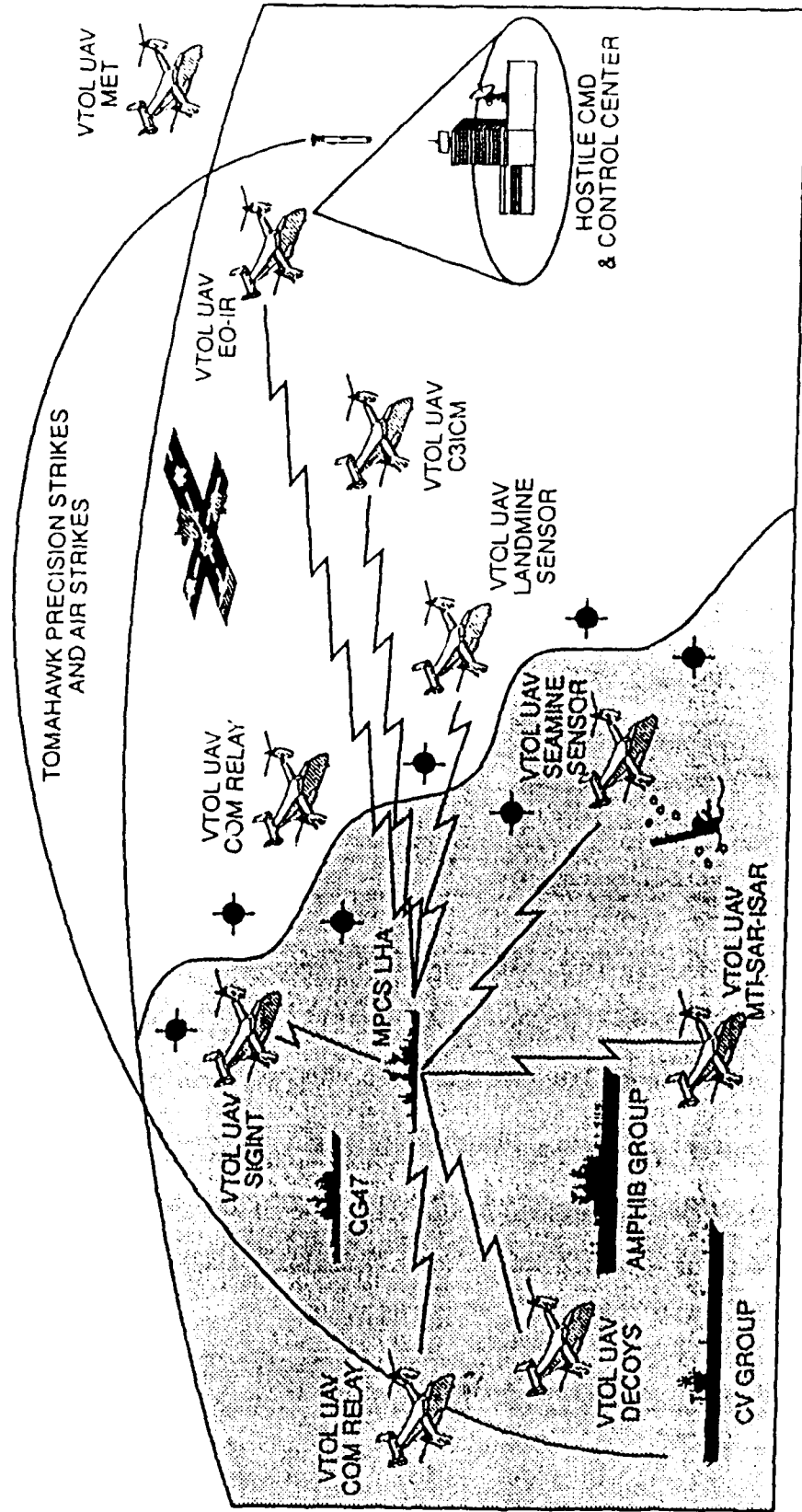


Figure 2

AMPHIB ASSAULT PHASE

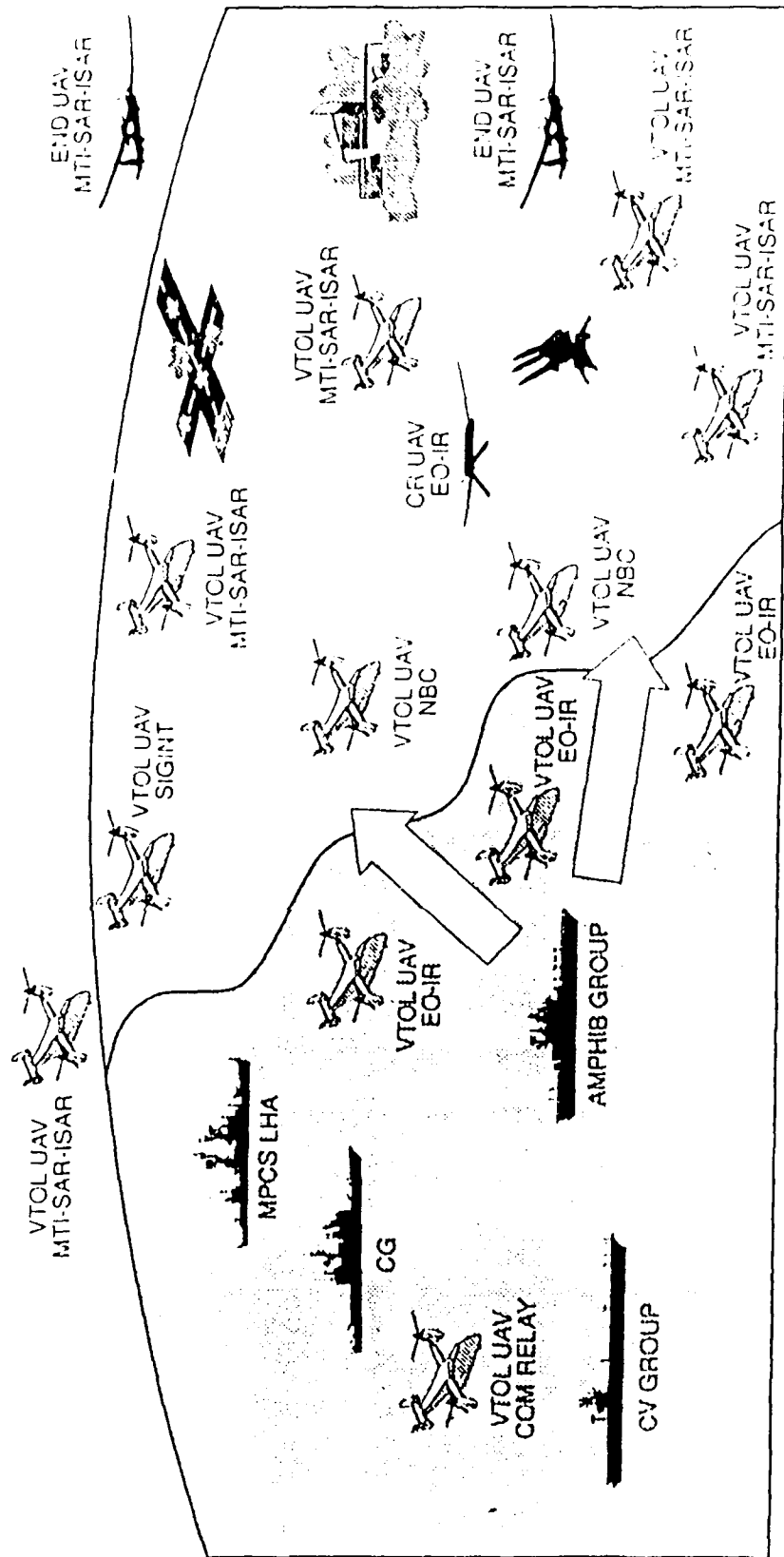


Figure 3

Service Support Group, and MEF command element. Marine expeditionary commands are, primarily, task originated in Marine Expeditionary Brigades, (MEB), Marine Expeditionary Unit (MEU), and Special Purpose Marine Air Ground Task Forces (SPMAGTF). Each Marine commander will enjoy full authority, responsibility, and accountability for any UAV assets assigned. As such, the CLF has the ability to assign missions and priorities to his UAV assets once ashore. These missions will be accounted for on the Air Tasking Order to ensure proper coordination. Navy UAVs will be used to support the CLF whenever possible.

1. CLF Controlled Mission Planning

Mission planning is critical to proper employment/mission accomplishment for all requirements which can be met through the use of UAVs. The most advantageous method of mission planning used by the Marine Air-Ground Task Forces (MAGTF) is the preplanned mission. Unfortunately, warfare is, by its nature, not easily predictable. Because of this fact, immediate missions are to be expected as well. Both are described below.

a. Preplanned Missions

Preplanned missions are those missions planned in advance around intelligence/fire support requirements and other asset activities. The UAV Company representative consolidates all requirements as tasked by higher authority -

normally the intelligence representative (G-2/S-2) and the MAGTF staff and/or the Fire Support Coordinator (FSC) in the operation office (G-3/S-3). Upon mission assignment, the UAV representative must coordinate with the Air Liaison Officer (ALO), the Fire Support Coordinator (FSC), and several other staff officers. After the request coordination, a daily Aircraft Tasking Order (ATO) is published by the G-3/S-3. This order includes fixed-wing, rotary wing, and all UAV missions anticipated to undertaken. [Ref. 4:p. 7]

b. Immediate Missions

Immediate UAV missions also occur in war. Unrealized needs or quickly changing tactical situations necessitate the use of "short fuse" missions that can best fulfill requirements. Two primary methods are used to fulfill these requirements:

- Diversion of a UAV currently performing another mission, usually preplanned, or
- Initiating a new UAV mission by launching a UAV not presently being employed - a stand-by UAV.

In the first method, the UAV is directed to a higher priority or more immediate requirement. These UAVs can be airborne or on the ground preparing for an operation. If the initial requirement is not met then another mission must be flown to fulfill the need or another collection platform

tasked, or the requirement may go unfulfilled. None of these is a great option, but one has to be chosen. In some situations, a UAV can be launched toward the area of interest/target area prior to the end of immediate mission planning. This enables the detailed planning to be done while the aircraft is traveling to the target. This technique greatly enhances the reaction time of the mission.

[Ref. 5:p. 7]

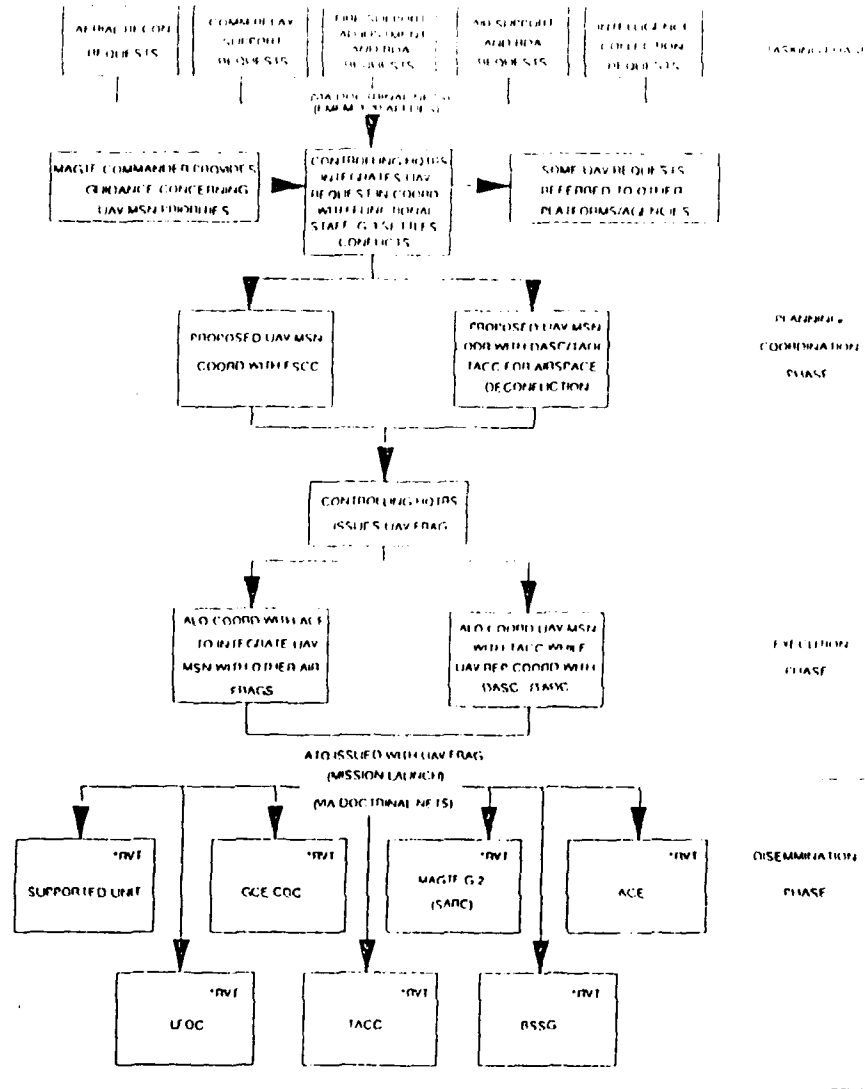
2. CLF Controlled UAV Operational Concept

CLF-controlled UAV operations have four distinct phases: the tasking phase, planning/coordination phase, execution phase and dissemination phase. These phases combine to form a dynamic, coordinated, and intelligent command and control process capable of executing a multitude of UAV missions within the MAGTF. Figure 4 [Ref. 5:figure 2] shows pictorial line diagrams of this command/operational concept.

a. Tasking Phase

In the tasking phase, requesting units route their requests for fire support spotting and information through the Intelligence/Air Liaison organization to the controlling headquarters. It is important to note that the requesting units are requesting information or a spotting capability, not a UAV. The assignment of UAVs to the mission must be made at the MAGTF so that a balance between platforms is reached to optimize the capabilities of all the completing platforms.

UNMANNED AERIAL VEHICLE-SHORT RANGE (UAV-SR) OPERATIONAL CONCEPT



*LOCATION OF REMOTE VIDEO TERMINALS
DEPENDENT ON MISSION/DISSEMINATION PRIORITY

Legend:

- GCE COC Ground Combat Element Combat Operations Center
- SARC MAGTF Surveillance and Reconnaissance Center
- ACE Aviation Combat Element
- LFOC Landing Force Operation Center
- BSSG Brigade Service Support Group

Figure 4

b. Planning Coordination Phase

In the planning and coordination phase, the controlling headquarters (usually G-3) integrates the MAGTF commander's guidance with all units' requests. During the planning coordination phase, many requests will be passed to other platforms or participating agencies by the commander, while the remaining requests are screened as valid UAV missions. Additionally, during this phase the proposed mission is initially coordinated with the Fire Support Coordination Center to ensure Mortar/Naval Gunfire/Artillery coordination if the UAV is flying beyond the Fire Support Coordination Line (FSCL). The proposed mission must also be coordinated through Tactical Air Control Center (TACC) to ensure airspace deconfliction. The last thing to occur in the planning/coordination phase is the issuing of the UAV mission order. This parallel coordination ensures both that the airspace and ground "pictures" have been coordinated and that a conflict between UAVs and other platforms does not occur.

c. Execution Phase

In the Execution Phase of UAV operations, the Air Liaison Officer and the UAV command representative continue to coordinate extensively and continuously. This is the phase of UAV operations which is most critical. This is where the UAV is airborne and coordination is absolutely critical in a mission. Mission accomplishment and safety are key points

which must, on occasion, be balanced for maximum effect. Air space deconfliction is essential for proper battle space safety management. Friendly mid-air collisions are unacceptable at any time including combat. It is essential that all controlling agencies are aware of the UAV's flight plan.

d. Dissemination Phase

During the Dissemination Phase of UAV operations, live target information is linked to ground receiving stations for immediate use or recording. The location of remote video terminals is dependent on the mission type and priority. Each operation/flight must be balanced against current requirements and the tactical situation.

In an amphibious operation, there may be instances when the CLF and his staff are still embarked, but his UAV assets are capable of operations ashore. In these instances, the operational concept described above still applies. The only difference is that the CLF's command center is afloat instead of ashore. The communication circuits that would be used ashore are also available for the embarked staff. Coordinating with the Navy becomes an additional burden for these types of scenarios. It becomes imperative that air space deconfliction and fire support control be maintained in the Navy Marine Corps team.

The operational concept described provides a logical sequence to follow and to control UAVs effectively and safely. It also ensures that the UAV mission is appropriately tasked and controlled and that the information is disseminated properly.

VI. ISSUES OF UAVs IN AMPHIBIOUS OPERATIONS

There are several critical issues that limit or alter the effectiveness of the UAV system operating as an embarked unit in support of an amphibious operation. This thesis will discuss the three that the author feels are most important. The foremost of these Command, Control and Communications (C³) concerns is the issue of Electromagnetic Interference (EMI). EMI in control links may cause a severe degradation of capabilities or complete loss of aircraft. The second critical C³ issue is the dissemination of the video products from the UAV. Without the timely transmission of intelligence to the requesting unit, the mission can be considered a waste. The last C³ critical issue is airspace management. Safe UAV integration into coordinated airspace is essential. Other activities will not want to operate in the same airspace if the situation becomes unsafe due to UAV operations. The purpose of this chapter is to explore in detail these C³ UAV issues and possible solutions.

A. ELECTROMAGNETIC INTERFERENCE IN CONTROL LINKS

UAVs are much more reliant on the electromagnetic spectrum than ordinary aircraft because of their electronic control links. When these links are interfered with or cut, the UAV can become lost or destroyed. In the best case, the UAV will initiate its lost signal return home sequence which will interrupt the on-going mission. There are many reasons an electronic link can be lost. This section will focus on the electromagnetic interference.

EMI can be originated at many locations. A poorly designed system can create its own EMI that renders the system useless. Enemy jamming is another form of EMI. The last type of EMI, and the one focused on in this report, is friendly system EMI.

With the confined and overloaded electromagnetic spectrum we currently work within, it is not uncommon to have different systems operating within the same frequency ranges. The close proximity of two frequencies can cause frequency interferences due to spectrum overload. Spectrum overload occurs when two signals have a portion of the signal overlapped with each other. In some cases, even if the operative frequencies are widely spaced, EMI can occur. This happens when one system's power output is so great that it can impinge itself on the other systems' internal circuits. In the case of the UAVs operating off amphibious ships, the cause of EMI is primarily the ship's radars and communications systems.

During May 1992, the Navy attempted to temporarily station Pioneer UAVs on the USS New Orleans (LPH-II) for exercise Tandem Thrust 1992. When UAV operations are conducted, the flight deck must be secured for safety reasons. Because the LPH is home to so many high value air assets (AV-8Bs and troop helicopters), UAV missions in a multifaceted operation would become prohibitively expensive in terms of time lost to higher priority missions. Therefore, the LPH is not the platform of choice for UAV deployment; however, it was used due to hardware arresting gear problems on Navy LPDs. At that time, the arresting gear had not been modified from battleship use to LPD use. The Pioneer uses a C-Band uplink with a UHF uplink backup and a single C-Band downlink. This is the same frequency range as the proposed short-range "Hunter" UAV system. [Ref. 4:p. 5-2]

During Tandem Thrust 1992, it was observed by Navy UAV controllers that the AN/SPS-40 air search radar interfered with the C-Band uplink of the Pioneer. Consequently, the SPS-40 radar was secured during UAV operations. [Ref. 8:p. 1] The securing of the AN/SPS-40 radar means that air threats are possibly undetected. A further analysis was conducted to isolate the cause and derive a possible solution to this interference. When the Navy initiated the permanent stationing of UAVs on LPD's, Navy engineers attempted to use the Wave Form Recording and Playback System (WRAPS) to mathematically analyze the frequency spectrum of the LPD.

LPDs also had an AN/SPS-40 air search radar and it was feared that a similar EMI problem would exist. The use of WRAPS determined that the cause of the EMI was "case penetration" of the C-Band control circuit on the UAV. An entire spectrum analysis of LPH electromagnetic radiators and Pioneer electronic gear was also done. The results are summarized in Table 2. [Ref. 8:Appendix F:Enclosure 1] This chart indicated where possible EMI problems exist in the frequency spectrum in the Pioneer operating sub-system. The test engineers recommended that additional shielding be applied to the control circuits of the Pioneer in order to reduce EMI caused interference by the AN/SPS-40. [Ref. 8:Appendix A:p.1]

In January 1993, the Navy had hardware arresting gear problems solved by Patuxent River engineers and were prepared to deploy a UAV attachment aboard an LPD. The USS Denver (LPD-9) was chosen as the initiation/host amphibious ship. The Denver was modified during the Spring of 1993 to accommodate the Pioneer system package.

A three-phase test plan was developed in which EMI problems were studied in a systematic manner along with other systems such as arresting gear and antenna placement.

[Ref. 8:p. 5] During Phase I, EMI was tested while the UAV was powered up and in the launch position. All radios and radars were energized to check for EMI problems. If any indications of interference were observed during a period when any of the ship's emitters were activated, single emitters

TABLE 2

PIONEER SHORT RANGE REMOTE PILOTTED VEHICLE
 INTERSYSTEM ELECTROMAGNETIC COMPATIBILITY TEST MATRIX

NOTE.

SOURCE \ VICTIM	NOTE.																						
	215 MHz	430 MHz	925 MHz	1300 MHz	3100 MHz	5850 MHz	9277 MHz	14,000 MHz	4,940 MHz	4,805 MHz	5,385 MHz	6,400 MHz	7,585 MHz	7,990 MHz	9,050 MHz	9,803 MHz	11,0845 MHz	12,045 MHz	16,080 MHz	18,038 MHz	20,510 MHz	23,180 MHz	
C-BAND LINK	*	*	*	*	*			*			*	*	*	*	*	*	*	*	*	*	*	*	*
UHF LINK											*	*								*	*		
PROGRAM FAIL		*	*	*	*			*			*	*	*	*	*	*	*	*	*	*	*	*	*
PROGRAM LOAD					*			*			*	*	*	*	*	*	*	*	*	*	*	*	*
VIDEO	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
CONTROL SURFACE	*	*						*			*	*	*	*	*	*	*	*	*	*	*	*	*
TCU FAILURES			*	*								*						*	*	*	*	*	*
PAYLOAD CONTROL		*		*													*	*	*	*	*	*	*
ATTITUDE IND.				*				*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
IND. ALTITUDE				*				*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
RPM METER	*	*	*	*							*	*	*	*	*	*	*	*	*	*	*	*	*
RATE OF CLIMB				*				*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
HEADING/AZIMUTH		*	*	*				*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
ENGINE TEMP		*									*	*	*	*	*	*	*	*	*	*	*	*	*
RATE OF TURN				*				*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
BUS VOLTAGE				*																			
FUEL SAUGE				*																			
THROTTLE				*							*	*									*	*	*
ENGINE TRAP BOX																				*	*	*	*
AIRSPEED				*																			
AUTO TRACKER	*										*	*					*	*	*	*	*	*	*
ENGINE CUT LAMP	*										*	*											

NOTE.

KEY:

- EMIDETECTED
- NO EMIDETECTED

NOTE: Radar systems that use these frequencies are not installed on the LPD 9/11 at this time.

were secured for the isolation of the offending emitter. The AN/SPS-40 radar was tested while at sea due to Navy restrictions concerning energizing the radar while in port. This test was done so that the point of UHF radar signal entry into the UAVs' C-Band receiver could be isolated. All other UAV controls (i.e. flight controls and engine RPM) listed in Table 2 were also monitored for EMI responsible problems.

Phase II of the installation process involved flight testing. In this phase, EMI checks were conducted with the UAV flying within visual range of the ship while maintaining the safeguards established in Phase I. If any EMI was observed, the AN/SPS-40 radar was secured and additional shielding was added to the UAV.

Phase III of the test plan emphasized an expanded airborne testing with emphasis on operational capabilities. UAVs were flown on simulated missions to check EMI existing in the payload package of the downlink signal. If EMI was observed, an offending emitter was secured for the duration of the flight.

The results of this test plan were very encouraging. In Phase I, no EMI was detected between the shipboard HF transmitters and non AN/SPS-40 radars and the Pioneer system. EMI was detected, however, between the AN/SPS-40 radar and the Pioneer UHF secondary uplink when their frequencies were within 10 MHz of each other. It is interesting to note that there were no EMI problems between the AN/SPS-40 radar and the

Pioneer as occurred on the New Orleans. Apparently, the additional shielding that was recommended after that deployment worked. [Ref. 9:p. 9]

During flight testing, no EMI problems existed when the UAV was greater than 200 meters from the ship and 15 MHz separation was maintained between the AN/SPS-40 and the Pioneer UHF secondary control uplink. Consequently, the AN/SPS-40 radar has to be secured during launch and recovery operations until a more permanent solution can be developed in the future. [Ref. 9:pp. 8-9] Many important lessons can be learned from this testing. First, EMI considerations must be included in the initial design stages. Admittedly, the Pioneer system was never intended to fly off a ship, so the current problems can be expected. However, in future UAV systems, EMI problems should be minimized at all cost.

Secondly, a thorough analysis of the candidate host ship's emitter spectrum and proposed UAV electronics package vulnerabilities should eliminate these problems prior to deployment. The WRAPS system is the perfect candidate to perform this analysis. Proper integration into ships' operating environment is a cornerstone of C³ interoperability and system employment suitability. No system, such as the AN/SPS-40, should have to be secured in a normal operating situation when another system is operating. This increases the ship's vulnerability due to a far less effective warning.

B. OPERATIONAL VULNERABILITY TO VIDEO LINKS

UAV systems relay their raw intelligence data back to the control unit via radio links. In the case of the Pioneer, and its follow-on version, the Hunter, this is a C-Band line-of-sight link. This means that the ship and UAV must remain within a line of sight arrangement, or the video link will be lost. If the unit requiring the imagery is located on the same ship as the control unit, the imagery dissemination is quite easy. The ship merely has to tap into the video output at the control station and route onto the ship's own organic video distribution system for the appropriate users.

The difficulty comes when the user is not on the same vessel. In fact, the user may be ashore or in aerial transit. The challenge then becomes to supply real-time video to the appropriate user when not aboard the host ship. The Remote Receiver Station (RRS) has theoretically solved a lot of this problem.

The RRS has the remote television capability of receiving an unprocessed real-time image from the aerial UAV. It has a directional antenna that must be mounted in the line of sight of the UAV. [Ref. 4:p. 3-9] In shipboard applications, this means the antenna should be mounted as high on the mast as possible for optimal reception. Once the signal has been received and processed, the ship's own video distribution system has the requirement to disseminate it internally. The

RRS enables imagery customers who are in the line of sight to receive their imagery directly.

In complex exercises, it is possible that several UAVs will be flying and sending signal imagery at the same time. It is also possible that there will be times in which different images will be required by different units on the same ship simultaneously. The current RRS does not have the capability to serve multiple subscribers simultaneously.

A new system is needed that will satisfy this operational void. The new system would require a high gain omni-directional antenna with a multi-channel processor. The high gain antenna is necessary to retain the video's high definition image quality while operating at the UAV's maximum ranges. The omni-directional antenna is necessary because there may be two UAVs operating many miles apart from each other serving different customers on the same ship simultaneously. The multi-channel processor is required to process different video signals from different frequencies at the same time. The multi-channel processor would also be required to input all desired received signals into the ship's internal video distribution system.

One key point in multi-UAV operations becomes extremely important. This point is the frequency allocations for each control and data link on each UAV. These frequencies need to be disseminated so that users will know which frequency to tune to so he may receive their respective video. All this

should be done during the planning and coordination phase of UAV operations as discussed earlier.

Another key aspect of UAV operations is the dissemination of data to ships out of range of the UAVs downlink or without an RRS. Several different exploitation methods were investigated during exercise Tandum Thrust-92. The first method is the use of the limited secure voice radio to other ships in the Amphibious Ready Group (ARG). The next method used was the Teletype Intelligence Network, a slow message service. The third method involves the use of a Reconnaissance Exercise Report (RECCEXREP) by regular message reporting channels. These first three methods of transmission do not transmit imagery. These are all subject to the interpretation of the radio operator. Clearly, much timeliness and accuracy of the data is lost using these methods.

The fourth method of data relay is through the use of Fleet Imagery Support Terminal (FIST) broadcasts. The FIST broadcast only transmits single frame pictures; therefore, the customer loses the advantage of seeing a moving video image of the intended target. The fifth and last method of data relay is through the use of video recording equipment. The ground control station video records the UAV missions onto commercial video tape. At the termination of the mission, a helicopter with the video recording is dispatched to the unit requesting the information. The key problem with the video recording

technique is the time lost while physically transporting the video tape. Consequently, decisions regarding tactical operations will be made with information that is possibly several hours old. [Ref. 9:pp. 6-7]

In summary, the Navy needs to develop a robust video relay system capable of securely sending video images over significant distances to various ships. This new system would also need to be integrated with the Joint Intelligence Center (JIC) through the command vessel and into the various database systems.

C. AIR SPACE MANAGEMENT

Air space management is always a difficult task in any modern battle space. The combination of close air support, fighter cover, helicopter transits and artillery fire provide a difficult deconfliction problem. UAVs add an additional and unique burden to this complex situation.

By nature, UAVs do not have internal pilots. The ground-stationed pilot does not have the advantage of being on board with the natural human senses and width of view. He does not have the ability to quickly change his azimuth of view and re-focus on new objects. This creates a very dangerous situation for the other pilots in the air. The UAV's small size and limited visual "senses" can become significant factors leading to midair collisions and, possibly, loss of life. To avoid

this, a UAV concept of operation must include a reliable, timely and accurate integration of UAV operations in the air space management scheme. The UAV operational scheme illustrated in Figure 5 provides for such coordination. By coordinating earlier in the planning stages with both the fire support agencies and air control agencies, UAV operations are accounted for in their respective schemes of maneuver. Later in the UAV operational scheme, the fire support agencies and air control agencies are constantly being updated regarding UAV position, heading and anticipated movements. This type of continuous information flow is essential if the air space is to remain safe and predictable for all concerned.

The three critical issues discussed above are not the only issues confronting UAV employment in amphibious operations. They represent the three most important that the author feels need to be address. A more comprehensive list is provided in the summary and recommendation chapter to follow. The three issues discussed above represent a sever degradation of vehicle and consequently mission performance if they are not solved.

VII. SUMMARY AND RECOMMENDATIONS

This thesis investigated the concept of using UAVs in amphibious operations from amphibious ships. This thesis described a generic UAV, stated the threats to UAVs in hostile environments, stated the missions that UAVs are capable of, detailed the integration of UAVs in the amphibious warfare concept and also discussed several critical C³ issues. The issue of stationing UAVs on amphibious ships is not as simple as saying its a good idea and then doing it. There are many trade offs that need to be considered.

The first point that needs to be stated very clearly is that, yes, UAVs would greatly enhance the commander's war fighting capability in amphibious warfare in circumstances where extreme danger exists to friendly forces. Because of the extreme inherent danger and the need for immediate accurate intelligence during amphibious operations, UAVs could provide a much needed service to the commanders which is currently not available. Therefore, a trade-off points exists in which the use of conventional manned assets becomes too risky and the use of UAVs, even with its inherent weakness, becomes desirable. There exists a certain point in which the cost of conducting normal manned operations becomes too

expensive when compared to UAV operations. It should be clearly stated that UAVs possess a high overhead cost (e.g, set-up time, launch time, recovery time) and lack the flexibility of manned systems. This kind of analysis was not the subject of this thesis, but is necessary in order to optimize the entire force structure under the commanders control. It is recommended that a study regarding this trade-off be conducted.

The list below provides additional areas of research that needed to be conducted but were not discussed in Chapter VI. This list is not exhaustive. It only provides a starting point for future research in this field.

- A trade-off analysis of space requirements of manned aircraft vs UAVs on amphibious ships
- What other activities onboard a ship need to be altered during UAV operations
- Storage problems of UAV AVGAS fuel
- Rocket Assisted Take-off (RATO) storage and signature plume
- A feasibility study to determine if the proposed short range UAV is capable of landing on a LPD equipped with a net arresting gear in light of its excessive weight and wing span.
- Time required to set up, fly, take down the UAV system on ship

These issues need to be addressed in order to have a complete understanding regarding the cost and benefits of doing UAV operations in amphibious warfare.

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