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A Case for an Aerial Refueling Capability for the United States Marine Corps UH-1Y Helicopter

Scott Suckow
University of Tennessee, Knoxville

To the Graduate Council:

I am submitting herewith a thesis written by Scott Suckow entitled "A Case for an Aerial Refueling Capability for the United States Marine Corps UH-1Y Helicopter." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Aviation Systems.

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Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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A CASE FOR AN AERIAL REFUELING CAPABILITY FOR THE UNITED STATES MARINE CORPS UH-1Y HELICOPTER

A Thesis Presented
for the
Master of Science Degree
The University of Tennessee, Knoxville

Scott Paul Suckow
May 2006

DEDICATION

I want to express my gratitude to Professor Bob Richards, for his advice, guidance and patience. Also, to my beautiful, resilient and even more patient wife Shelley, this effort really was inspired by you, thanks babe.

There is but one LORD and Savior, Christ Jesus. To Him alone I give all the glory and praise.

"Praise be to the LORD my Rock,
who trains my hands for war,
my fingers for battle."
Psalm 144:1, NIV

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I would take this opportunity to thank those who have helped me complete my Master of Science in Aviation Systems, and specifically, for helping me research, create, and edit this thesis project. First, I would like to thank Professor Robert Richards for always making himself available to me and for his wisdom in assisting me in the completion of this task. Second, I want to thank those at the Naval Air Systems Command (NAVAIR) Program Office (PMA-276) who helped with the details of the engineering and technical details of this work. Additionally, my appreciation also goes out to my friends and co-workers at Air Test and Evaluation Squadron TWO ONE (HX-21) who were only too helpful in fleshing out this thesis. I owe special thanks to Lieutenant Colonel D.A. Anderson, Major Schreiner, Major Eggstaff, Major Hank Vanderborght and Major Jack Perrin, USMC. I also would be remiss in not thanking Colonel PJ Gough, USMC, for his encouragement throughout my career in the Corps and his experience as a true strategic warrior.

Finally, I would like to acknowledge the ultimate sacrifice of Captain Aaron Contreras, USMC and his crew. They were killed in action, while taking off from a Forward Arming and Refueling Point (FARP) on 30 March 2003 in southern Iraq during Operation Iraqi Freedom. With the capability described herein, the need for FARP use to sustain operational tempo in combat may not have been necessary.

ABSTRACT

The goal of this thesis is to generate interest, discussion, examination and ultimately installation of in-flight refueling capability on the UH-1Y, to enhance the utility of the UH-1Y in support of Marine Corps strategic and operational concepts. Material presented herein was acquired from numerous reference documents and publications to include aircraft flight manuals; tactics, techniques and procedures manuals; program office documents; contractor literature; and the author's experiences as a Fleet Marine Force UH-1N pilot. Air-to-Air Refueling (AAR) systems are presented using currently fielded equipment in both tested and untested configurations, incorporating empirical data, tactics and past experiences. The resultant conclusions to the data, as presented, clearly indicate the need and highlight the intrinsic value of AAR at the strategic and operational level in order to maximize capability and efficiently support the strategic and operational requirements of the Marine Corps. Additionally there is an obvious tactical level utility of the system for an air-to-air refueling mission kit for the UH-1Y.

In November 2000, then Commandant of the Marine Corps, General James L. Jones, outlined his vision for how the Corps should be organized, equipped, and prepared to fight and win conflicts in *USMC 21*. In October 2001, then Chief of Naval Operations, Admiral Vernon Clark, outlined his vision for how the USN and USMC should work together to organize, integrate, equip, and transform their forces to meet the emerging threats of the future in *Sea Power 21*.

This thesis will examine the larger scope and scale of how this AAR capability can better support the Marine Air Ground Task Force within the operational, tactical and strategic visions of *USMC 21* and *Sea Power 21* requirements. USMC rotary wing assets still have a few aircraft that are not AAR capable. As long as the Marine Corps have even one aircraft that can't air-to-air refuel, it is limited by a most restricted capability and must continue to rely on land and sea based facilities.

PREFACE

All material within this document is Unclassified. Specifications, capabilities and characteristics of specific aircraft or equipment were obtained from aircraft flight manuals or other public sources. The discussion of proposed usage or capabilities of current or existing aircraft and equipment, as well as analysis, conclusions, and recommendations are presented as the opinions of this author and are not an official position of the United States Department of Defense, the Naval Air Systems Command, or the United States Marine Corps.

PREFACE

[illegible] is [illegible] development [illegible] and [illegible] of [illegible] of [illegible] were [illegible] or [illegible]. The discussion of [illegible] of [illegible] as well as analysis [illegible] recommendations [illegible] in the [illegible] position of the United States Department of Defense [illegible] United States [illegible]

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LIST OF ABBREVIATIONS

AAR	Air-to-Air Refueling
ACE	Air Combat Element
ADM	Admiral
AO	Area of Operations
ARG	Amphibious Ready Group
CAS	Close Air Support
CMC	Commandant of the Marine Corps
CNO	Chief of Naval Operations
CSAR	Combat Search and Rescue
DAS	Defensive Armament System
EMI	Electro Magnetic Interference
FARP	Forward Arming and Refueling Point
FMF	Fleet Marine Force
GCE	Ground Combat Element
GFE	Government Furnished Equipment
GPM	Gallons Per Minute
HERS	Helicopter Expedient Refueling System
HIGE	Hover In Ground Effect
HMLA	Marine Light Attack Helicopter Squadron
HOGE	Hover Out of Ground Effect
IMC	Instrument Metrological Conditions
JFC	Joint Force Commander
KTAS	Knots True Air Speed
MAGTF	Marine Air Ground Task Force
MARSOCOM	Marine Corps System Command
MCCDC	Marine Corps Combat Development Center
METL	Mission Essential Task List
MEU	Marine Expeditionary Unit

MNS	Mission Needs Statement
MPS	Maritime Prepositioning Ships
OAS	Offensive Air Support
OEI	One Engine Inoperative
OMFTS	Operational Maneuver From The Sea
PMA	Program Management Aircraft
PSI	Pounds per Square Inch
RGR	Rapid Ground Refueling
SAR	Search And Rescue
SDD	System Development and Demonstration
SIXCON	Six Container
TBFDS	Tactical Bulk Fuel Dispensing System
T/M/S	Type/Model/Series
TOS	Time on station
TRAP	Tactical Recovery of Aircraft and Personnel
USMC	United States Marine Corps
USN	United States Navy
USSOCOM	United States Special Operations Command
V_{Cruise}	Cruise Airspeed
V_H	Maximum Level Flight Speed
VMC	Visual Metrological Conditions

DEFINITION OF TERMS

Aviation Combat Element (ACE): The core element of a Marine air-ground task force (MAGTF) that is task-organized to conduct aviation operations. The aviation combat element (ACE) provides all or a portion of the six functions of Marine aviation necessary to accomplish the MAGTF's mission. These functions are antiair warfare, offensive air support, assault support, electronic warfare, air reconnaissance, and control of aircraft and missiles. The ACE is usually composed of an aviation unit headquarters and various other aviation units or their detachments. It can vary in size from a small aviation detachment of specifically required aircraft to one or more Marine aircraft wings. The ACE itself is not a formal command.

Deck Crew: Aboard USN vessels, enlisted members of the ship who work outside of the ship's superstructure.

Fast Rope: An insertion technique used to rapidly insert heliborne personnel into areas where a landing cannot be made. Building tops, ship decks, gas and oil platforms, and small or fouled landing zones are but a few examples of where Fast Rope would be used.

Fleet Marine Force: The Fleet Marine Force (FMF) is a balanced force of combined ground and air arms primarily organized, equipped, and trained for offensive amphibious or expeditionary employment.

Government Furnished Equipment (GFE): Property in the possession of or acquired directly by the government, and subsequently delivered to or otherwise made available to the contractor.

Loiter: In aviation terminology, a term meaning to fly an aircraft at a power setting and configuration to provide maximum endurance.

MAGTF: Marine formations deploy as integrated Marine Air-Ground Task Forces (MAGTFs) of various sizes: Marine Expeditionary Unit (MEU) commanded by a colonel, Marine Expeditionary Brigade (MEB) commanded by a brigadier or major general, and Marine Expeditionary Force (MEF) commanded by a lieutenant general. Each has a Command Element (CE), a Ground Combat Element (GCE), an Aviation Combat Element (ACE), and Combat Service Support Element (CSSE).

Key Performance Parameters (KPPs): Those attributes or characteristics of a system that are considered critical or essential to the development of an effective military capability and those attributes that make a significant contribution to the key characteristics as defined in the Joint Operations Concept. KPPs are validated by the Joint Requirements Oversight Council (JROC) for JROC Interest documents, and by the DoD Component for Joint Integration or Independent documents. The Capability Development Document (CDD) and the Capability Production Document (CPD) KPPs are included verbatim in the Acquisition Program Baseline (APB).

Objective: The desired operational goal associated with a performance attribute, beyond which any gain in utility does not warrant additional expenditure. The objective value is an operationally significant increment above the threshold. An objective value may be the same as the threshold when an operationally significant increment above the threshold is not significant or useful.

Sea State: Refers to the height, period, and character of waves on the surface of a large body of water. The large number of variables involved in creating the sea state cannot be quickly and easily summed, so simpler scales are used to give a rough description of current conditions, primarily for reporting in a ship's log or similar record.

Threshold: Minimum acceptable operational value below which the utility of the system becomes questionable.

SECTION I
INTRODUCTION

1.1 BACKGROUND

The current UH-1N in service is unable to exploit emerging intelligence and operational changes as the fight emerges, and is incapable of being redirected or tasked to perform immediate mission requests due to its short mission radius without proper ground or ship based refueling sites. Therefore, the installation of an AAR capability on the UH-1Y would be a tremendous force multiplier.

1.1.1 Marine Light Attack Helicopter Squadrons (HMLAs)

HMLAs are scheduled to attain an initial operational capability (IOC) of the UH-1Y utility helicopters and AH-1Z attack helicopters in March 2008, PMA-276 (1). These upgraded aircraft will replace the UH-1N and AH-1W legacy utility and attack aircraft, respectively, currently in operational use in the Fleet Marine Force (FMF). An HMLA is organized to conduct operations as either an entire squadron or as detachments operating under the control of another command element. The mission of the HMLA squadron is to provide offensive air support (OAS), utility support, armed escort, and airborne supporting arms coordination during naval expeditionary operations or joint and combined operations, USMC (2). The legacy and the upgrade H-1 aircraft are not configured for an Air-to-Air Refueling(AAR) capability and therefore are forced to rely on shipboard refueling, Forward Arming and Refueling Points (FARPs), or use of existing air bases to sustain operations beyond the initial fuel capacity of the aircraft.

1.1.2 AAR as a Ground Combat Element (GCE) Force Multiplier

AAR is a GCE force multiplier. AAR would reduce requirements to support the aircraft, subsequently freeing assets that would otherwise be tasked to support the UH-1Y to reach beyond it's mission radius, enabling those assets to support the GCE instead. AAR would require less coordination within the MAGTF and beyond the MAGTF (Host Nation Support) as well as intra-service coordination and across theater level areas of operation. An additional benefit to equipping the UH-1Y with an AAR system is a reduction in the drain on the already limited organic material and manpower of the Marine Air Ground Task Force (MAGTF), imposed by the requirements of FARP operations.

AAR configured UH-1Ys would provide greater flexibility to MAGTF Commanders because it would allow a redirection or allocation of assets that would normally be used to support non-AAR equipped aircraft. An AAR equipped UH-1Y would require less equipment to be stored aboard United States Navy (USN) shipping assets or at storage depot facilities across the globe. The space once occupied by excess FARP gear could be made available to hold other necessities for the GCE warfighters. Such items could include, but are not limited to, consumables (food, ammunition, medical supplies) and repairable items (weapons, radios, tents).

Excess FARP gear stored apart from shipping assets requires strategic airlift to transport it to where it is needed. Shortfalls in strategic airlift are not going to be overcome without great expense in the foreseeable future. Budgetary struggles become more exasperated with the ongoing fight against terrorism. Existing strategic airlift assets could serve a higher purpose of moving supplies and equipment for the GCE warfighter directly, instead of moving gear that supports the Aviation Combat Element (ACE) of the MAGTF, in order to then support the GCE of the MAGTF. AAR gives the various Type/Model/Series (T/M/S) aircraft that possess an AAR capability the ability to self-deploy. That is a huge benefit when one considers the reduction in stratlift requirements—both sealift and airlift that is no longer required to haul our aircraft all over the world. A benefit of AAR can be summarized as expeditionary enhancement.

1.1.3 AAR Exploits and Enhances the Expeditionary Capability of the MAGTF

An increase in Time on Station (TOS), loiter and mission radius (via installation of AAR on UH-1Y) facilitates the projection of the MAGTF Commander's forces deeper into enemy territory. AAR will serve to counter the enemy's anti-access capabilities. It allows freedom to strike from anywhere, remain unpredictable, and adhere to the basic tenet of warfighting…go where the enemy is weakest instead of trudging ashore into the teeth of his strength. Flexibility to react and exploit situations in flight will be limited by where a non-AAR equipped UH-1Y can get refueled. As the CH-46E is replaced with the MV-22B Osprey, the UH-1Y (and AH-1Z) will be the only organic MAGTF assets incapable of AAR (CH-53E has AAR capability). The MAGTF Commander must then develop and execute his plans around the limitation of his own intrinsic assets. Any operation executed by the MAGTF will require additional assets to compensate for its current force tasking and allocation, or increase the number of missions (sorties) flown. Should the UH-1Y be fielded without AAR, CH-53E or MV-22B aircraft would be tasked to first lift fuel to establish FARPs for the H-1 aircraft to fly beyond their limited mission radius in order to get into the fight. After establishing the FARP, the MV-22B and CH-53E would have to return to reconfigure and embark the GCE, then go back to insert them at the objective.

Reliance upon auxiliary fuel to increase mission radius is prohibitive. External auxiliary fuel tanks must be installed upon the single point of the UH-1Y's Improved Defensive Armament System (IDAS). The UH-1Y has one IDAS on each side. Installation of the external auxiliary tank then prohibits carrying either the LAU-68 (7-shot) or the LAU-61 (19-shot) 2.75 inch rocket pods. The current external auxiliary fuel tank has a 77-gallon capacity. If two 77-gallon auxiliary fuel tanks were installed on the IDAS (one tank on each side), approximately 40 minutes of flight time are gained, NAVAIRSYSCOM (3). This is in contrast to the capability to remain airborne for up to 12 hours via AAR (due to crew day restrictions) freeing the two IDAS stations to carry up to 38- 2.75 inch rockets.

Undoubtedly, AAR potential unequivocally increases and exploits the expeditionary nature of the MAGTF.

1.1.4 Mission Essential Task List (METL)

The missions of the UH-1Y aircraft include: airborne command and control for assault support operations; control, coordination, target acquisition, and terminal guidance for supporting arms; assault transport and maritime special operations; aerial reconnaissance; aeromedical evacuation; local search and rescue operations; tactical recovery of aircraft and personnel; suppressive weapons capability against ground-to-air threats; and a defensive capability against air-to-air threats, Performance Specification (4).

1.1.4.1 Command and Control (C&C)

During C&C missions, an AAR configured UH-1Y would have persistent time on station, allowing GCE commanders to establish, maintain and exploit superior Situational Awareness (SA). Digital connectivity, which is provided by the ASC-26U communication package, exponentially increases the value of the UH-1Y for the MAGTF Commander. Potentially, AAR UH-1Ys could further extend their sphere of influence by embarking Marines who can control Unmanned Aerial Vehicles, via remote control terminals from within the cabin of the UH-1Y. AAR equipped UH-1Ys would add to the strategic applications and the capability to shape the battlefield at the tactical level.

1.1.4.2 Aerial Reconnaissance

Strike Coordination and Armed Reconnaissance (SCAR) is a form of Aerial Reconnaissance assigned to H-1 aircraft (UH and AH) performing missions against enemy targets. The primary purpose of SCAR is to locate and attack targets of opportunity at such a distance from friendly forces that detailed integration is not required. The MAGTF must be able to wage war beyond the combat mission radius of the non-AAR equipped UH-1Y. It is here –beyond the reach of non-equipped AAR UH-1Y aircraft- that the UH-1Y's utility to help shape the fight far beyond the most forward line of friendly forces fails. SCAR enables targets to be detected; recognized, identified and marked for tactical jets, strategic bombers or so the MAGTF's own assets may destroy them. The UH-1Y's small size and low altitude terrain flight profile make detection by enemy forces difficult at best. The UH-1Y can provide real time intelligence to the MAGTF or to higher headquarters units as targets are detected. An excellent example of this mission is in scenarios similar to the SCUD missile hunting missions that were flown during Operation Desert Storm. UH-1Ys equipped with AAR kits could have up to twelve hours of on-station time. During Desert Storm, A-10s were the platform of choice to be tasked for SCUD hunting missions. Had UH-1Ys equipped with AAR been available, the A-10s could have been used to support the multiple requests for Close Air Support (CAS) while the UH-1Ys searched for SCUDs. The UH-1Y is equipped with a Forward Looking Infra Red (FLIR) system capable of laser range finding and designating targets out to 20 km. The FLIR also provides 10-digit Global Positioning System information (used for targeting) of any target lased. This targeting information can then be passed via radio to ground attack aircraft, strategic bombers and indirect fire weapons systems (artillery, naval gunfire). Should a friendly aircraft on a SCAR mission go down, the UH-1Y could be on hand to perform an immediate Tactical Recovery of Aircraft or Personnel (TRAP) mission. One of the most recent examples of a TRAP mission was the (then Captain) Scott O'Grady mission, 02 June 1995, in Banja Luka, Bosnia.

1.1.4.3 Combat Search and Rescue (CSAR) vs. TRAP

CSAR is defined as the *specific* task performed by rescue forces to affect the recovery of distressed personnel during war or military operations other than war (Joint Publication 1-02, Department of Defense Dictionary of Military and Associated Terms, 12 Apr 2001). Each Service and US Special Operations Command (USSOCOM) is responsible for performing CSAR in support of their own operations, consistent with their assigned functions. Successful CSAR operations enhance a Joint Force Commander's (JFC's) capabilities by returning valuable resources to friendly control, by denying adversaries the opportunity to exploit the intelligence and propaganda value of captured personnel, and by maintaining force morale. The potential complexity and scale of CSAR operations dictate the need for *theater level planning* and properly organized, trained, and *equipped* forces as well as clear guidance for command and control, Joint Publication (5).

TRAP is a subcomponent of CSAR missions, but it is only executed once the location of survivors is confirmed. It does *not* involve *dedicating* aircraft assets *to locating survivors*. Tactical recovery occurs once the general location of survivors is confirmed. A TRAP mission may also include personnel to conduct a local ground search, if required. Marine Corps tactical aircraft are not normally equipped to conduct the search portion of CSAR or the over-water portion of search and rescue missions, USMC (6). TRAP missions involve the rescue or extraction, by surface or air, of downed aircraft, personnel, or equipment. *TRAP should not be confused with combat search and rescue (CSAR).* USMC rotary wing assets *are not equipped* nor are their aircrew trained to perform search and rescue, and will execute a TRAP only when the location and condition of the survivor or mechanical asset is known, USMC (7).

In each of these afore mentioned missions, the UH-1Y would realize in most cases, an increase in mission performance and operational capability enhancement with the incorporation of an AAR system. Mission performance enhancement would be gained via an increase of Time on Station (TOS) and combat mission radius. This performance enhancement translates into allowing an increase in the length of time an aircraft could continue to perform a task without having to temporarily cease operations in order to return to a ship, air base, or FARP for fuel before continuing.

The implication of installing an AAR capability is not to eliminate the need for FARPs, ships, or air bases (although the reliance on terrestrial refueling locations is significantly reduced). Rather, at the tactical level of operations, an AAR capability would allow greater mission radius, decrease dependence upon sister service assets and capabilities, and reduce dependence on foreign governmental consent for staging a FARP on foreign soil. Reliance upon using existing air bases also entails capturing the base, securing the base, and supporting the base, none of which is expeditionary in nature. An AAR capability would reduce the vulnerability of USN vessels by increasing their distance from the shore when launching the UH-1Y.

AAR equipped UH-1Ys would enhance the strategic and operational capability of the MAGTF by eliminating the logistical footprint required to secure, establish, maintain and defend refueling stations needed to simply get to an area of operations. Freedom of movement from the point of projection relieves some burden on strategic sealift and strategic airlift. The amount of FARP equipment stored aboard Maritime Prepositioning Ships (MPS) may be reduced and replaced with more consumable supplies or warfighting assets (main battle tanks, etc.) if fewer FARPs are required.

1.1.5 USMC 21

In November 2000, then Commandant of the Marine Corps (CMC), General James L. Jones, outlined his vision for how the Marine Corps should be organized, equipped, and prepared to fight and win conflicts. "As the premier expeditionary Total Force in Readiness, the Marine Corps was to be tailored to answer the nation's call, at home or abroad. Opportunities and challenges in the world's littoral regions would only increase America's reliance on the continuous forward presence and sustainable maritime power projection of Naval Expeditionary Forces (the Marines Expeditionary Unit, or MEU; or Marine Expeditionary Brigade, or MEB). These expeditionary capabilities were to provide the geographic combatant commanders with scalable, interoperable, combined-arms Marine Air-Ground Task Forces (MAGTFs) to shape the international environment, respond quickly to the complex spectrum of crises and conflicts, and gain access or prosecute forcible entry operations. Critical to achieving these goals would be the optimization of the Corps' operating forces, support and sustainment basing, and unique capabilities. Additionally, the Corps would continue to sustain their enduring relationship with the U.S. Navy as well as reinforcing their strategic partnerships with sister services. Finally the Corps was to "capitalize on innovation, experimentation, and technology." (Gen. J.L. Jones, 2000).

1.1.6 SEA POWER 21

In October 2001, then Chief of Naval Operations (CNO), Admiral Vernon Clark, outlined his vision for how the USN and USMC should work together to organize, integrate, equip, and transform their forces to meet the emerging threats of the future. "The events of 11 September 2001 tragically illustrated that the promise of peace and security in the new century is fraught with profound dangers: nations poised for conflict in key regions, widely dispersed and well-funded terrorist and criminal organizations, and failed states that deliver only despair to their people. These dangers will produce frequent crises, often with little warning of timing, size, location, or intensity. Associated threats will be varied and deadly, including weapons of mass destruction, conventional warfare, and widespread terrorism. Future enemies will attempt to deny us access to critical areas of the world, threaten vital friends and interests overseas, and even try to conduct further attacks against the American homeland. These threats will pose increasingly complex challenges to national security and future warfighting. Previous strategies addressed regional challenges. Today, we must think more broadly. Enhancing security in this dynamic environment requires us to expand our strategic focus to include both evolving regional challenges and transnational threats. This combination of traditional and emerging dangers means increased risk to our nation. To counter that risk, our Navy must expand its striking power, achieve information dominance, and develop transformational ways of fulfilling our enduring missions of sea control, power projection, strategic deterrence, strategic sealift, and forward presence." (ADM Clark, Oct 2001). The three fundamental concepts that are the foundation of the Navy's Sea Power 21: Sea Strike, Sea Shield, and Sea Basing, which are described below.

1.1.6.1 Sea Strike

Sea Strike is defined as the ability to project precise and persistent offensive power from the sea. "When operational objectives from over the horizon are not achievable, the Navy-Marine Corps team moves ashore. Using advanced vertical (rotary wing aircraft) and horizontal (Amphibious Assault Vehicles) envelopment techniques, ground forces will maneuver throughout the battlespace, using speed and precision to generate combat power. Supported by sea bases, those forces will exploit superior situational awareness and coordinated fires to create shock, confusion, and chaos within the enemy's ranks. Sea Strike capabilities will provide Joint Force Commanders (JFCs) with a swift insertion of ground forces from rotary wing aviation assets. Sea Strike operations will be fully integrated into joint campaigns, adding the unique independence, responsiveness, and on-scene endurance of naval forces to joint strike efforts. Combined sea-based and land-based striking power will produce devastating effects against enemy strategic, operational, and tactical pressure points—resulting in rapid, decisive operations and the early termination of conflict" (ADM Clark, Oct 2001).

The integration of AAR would increase the projection (range) of the UH-1Y providing JFCs greater utility in completion of assigned missions. This can be accomplished by releasing the full potential of an expeditionary force, free from short range limitations requiring dependency on FARPs.

1.1.6.2 Sea Shield

Sea Shield would enhance international stability, security, and engagement through sea and littoral superiority. "Sea Shield would also assure access to contested littorals, and allow defensive and offensive power projection deep inland. The importance of Sea Shield is clearly evident since the proliferation of advanced weapons and asymmetric attack techniques places an increasing premium on the value of deterrence and battlespace dominance. Sea Shield capabilities- deployed forward from staging areas, ships or bases- will help deter aggressors before the onset of conflict. Additionally, Sea Shield will complement Sea Strike efforts by ***releasing*** aviation assets assigned the mission of force *defense*, allowing them to concentrate on *offensive strike* missions and generate far greater *offensive* firepower farther from the fleet" (ADM Clark, Oct 2001). An AAR capability on the UH-1Y would enable the UH-1Y to provide USN vessels and forces ashore forward protection, enabling them to operate at increased ranges from USN vessels, reducing the need to return to shipping or FARPs for refueling.

1.1.6.3 Sea Basing

Sea Basing would serve as the foundation from which offensive and defensive fires are projected. "As enemy proliferation of weapons of mass destruction grows, and the availability of overseas bases declines, it is sensible both militarily and politically to reduce the vulnerability of U.S. forces through expanded use of secure, mobile, networked sea bases. Afloat positioning of these capabilities strengthens force protection and frees Rotary Wing assets and Amphibious Landing Craft, which ease the complex and critical logistics efforts to support forces ashore. These concepts build upon the solid foundation of the Navy-Marine Corps team, leverage U.S. asymmetric advantages, and strengthen joint combat effectiveness" (ADM Clark, Oct 2001). An AAR capable UH-1Y would allow sea based forces to remain offshore and eliminate reliance on establishing FARPs ashore, protecting valuable assets from many threats.

Both USMC 21 and Sea Power 21 outline the basic requirements to provide forward presence, sustainable maritime power projection, protect valuable aviation assets and reduce the logistical support footprint. The UH-1Y will meet these requirements handily with the addition of an In-Flight Refueling capability.

1.2 AMPHIBIOUS ASSAULT SHIPS

For the purpose of this discussion, a premise of operation for the UH-1Y is forward deployment from an Amphibious Ready Group (ARG). The flagship of the ARG is the Amphibious Assault Ship (L class Ship). Amphibious Assault Ships are designed to embark, land and support Marine expeditionary forces for extended periods of time. These ships resemble small aircraft carriers and are capable of supporting Marine aircraft and landing craft. The U.S. Navy currently operates two classes of "big deck" Amphibious Assault Ships: the LHA Tarawa Class and the LHD Wasp Class. See figures 1 and 2. Within the ARG are other Air-Capable ships. The LPD and LSD Air-Capable class ships are also capable of refueling rotary wing aircraft. See figures 3 and 4.

Figure 1. LHA Class Ship

Source: USS Peleliu Official US Navy website photograph archives.

Figure 2. LHD Class Ship

Source: USS Bataan Official US Navy website photograph archives.

Figure 3. LPD Class Ship

Source: USS Denver Official US Navy website photograph archives.

Figure 4. LSD Class Ship
Source: USS Comstock Official US Navy website photograph archives.

All of these ships are capable of cold and hot fueling aircraft. Cold fueling requires the aircraft engines and rotor systems to be shutdown and static while taking on fuel. Hot fueling allows engines and rotors to be operating. There are several limitations to these four classes of ships that may prohibit aircraft fueling operations. Limitations include but are not limited to: sea state (as it influences ship's pitch and roll), deck cycle (e.g., AV-8B Harrier aircraft departures prohibit other aircraft from being on the flight deck), proficiency of deck crew (certain crewmembers must be qualified to refuel aircraft), ordnance loadout of aircraft (normally operating procedures prohibit hot refueling of aircraft if ordnance is loaded) and number of aircraft in the ship's pattern. Each ship must also be refueled at regular intervals while underway with aviation fuel.

1.3 FORWARD ARMING AND REFUELING POINT (FARP)

The objective of a FARP is to provide fuel and ordnance for highly mobile and adaptable helicopter operations. Both hot and cold fueling operations are possible at a FARP. The size of the FARP varies with the mission and the number of aircraft to be serviced. Normally, FARPs are short-term, transitory facilities established for a specific duration and mission. The scope of flight operations in a FARP area should include (but not be limited to) individual aircraft, sections, or divisions of aircraft requiring ordnance and refueling. Minimizing flight time to and from a FARP and reducing the refueling and rearming time within the FARP achieves this objective, USMC (7).

1.3.1 Types of FARP Operations and Procedures

The objective of a FARP is to minimize response time and decrease turnaround time in support of sustained operations (ashore). There are two varieties of FARPs commonly used: ground refueling from storage bladders and rapid ground refueling (RGR) provided from an aircraft. RGR can be provided by both the KC-130 and the CH-53E. The KC-130 can use up to three different on-board fueling systems, while the CH-53E utilizes the tactical bulk fuel delivery system (TBFDS). KC-130 and CH-53E aircraft normally provide only hot refueling services. Ground FARPs use ground-refueling systems (either fuel trucks or static fuel bladders as fuel storage and dispensing points) and provide both hot and cold refueling, USMC (7).

1.3.1.1 Ground Cold FARP

The ground cold FARP allows aircraft to land at a single point conducting all FARP operations. Arming or de-arming, uploading or downloading of ordnance, and fuel operations are conducted as separate evolutions. Normally, cold FARPs are linearly arranged, with spots numbered away from where the FARP officer in charge (OIC) is located. Aircraft ingress or egress is directly to or from the spots; therefore, taxi directors would not be used during cold refueling procedures, USMC (7). See figure 1, appendix A.

1.3.1.2 Ground Hot FARP

Except when using the static FARP layout, all ground hot FARPs share layout features of a pre-staging area and a post-staging area regardless of the refueling asset used to support the FARP (i.e., ground, KC-130, or CH-53E RGR). Typically, de-arming of on-board ordnance is conducted in the pre-staging area. Often refueling is conducted in the fueling area, and ordnance uploading and arming is conducted in the post staging area (or appropriately designated space). Taxi directors are normally used to guide aircraft into and out of the fueling area, USMC (7). See figures 2 and 3, appendix A.

1.3.1.3 Static Forward Arming and Refueling Point

The static FARP allows aircraft to land at a single point conducting all FARP operations to include de-arming, refueling, ordnance uploading, and arming with the receiving helicopters rotors turning, USMC (7). See Figures 4 and 5, appendix A.

1.3.1.4 Forward Arming and Refueling Point Equipment and Manning

There are six basic formats to equip a FARP. There is the CH-53E Rapid Ground Refueling (RGR) which requires five crew and can operate two refueling points at 45 gallons per minute (gpm) from three 800 gallon internal fuel tanks. The KC-130 RGR requires five crew, which can operate four points at 60 gpm. The amount of fuel that can be carried internally for refueling rotor wing aircraft depends on the distance the KC-130 must fly to get to a FARP site and then fly back to a base. Additionally, each FARP must have manpower to coordinate and execute the duties at the FARP. To operate four refueling points requires seven personnel. Four taxi directors are the minimum requirement for the smallest size FARP configurations. In order to arm or de-arm, load or download one aircraft, four aviation ordnancemen are required. To oversee and supervise overall operation of the FARP and provide liaison between aircrew and FARP personnel, one Airboss and one Officer in Charge (OIC) are required. If the RGR equipment is not available, there are four configurations that may be used. First is the Helicopter Expedient Refueling System (HERS), which may consist of up to eighteen 500 gal fuel pods (9,000 gals total) that is capable of 125 gpm from four refueling points. Second is a six container (SIXCON) consisting of five mobile fuel storage modules of 900 gallons each. The SIXCON is capable of 125 gpm from one point. Another format is the M970 fuel truck, which is capable of carrying 5,000 gallons (over paved roads) or 3,800 gallons (cross country-not over rough terrain). The M970 can refuel aircraft at 240 gpm from a single point or 200 gpm from two points simultaneously. Lastly is the Aviation Refueler Capability (ARC). This vehicle replaces the M970 and holds 5,000 gallons over paved roads or 4,200 gpm (cross country-not over rough terrain). The ARC can dispense fuel at 250 gpm from a single point or 200 gpm from two points simultaneously, USMC (7).

As described above, the logistics footprint of any FARP evolution requires a detailed planning effort, may involve host nation support, and requires vast amounts of manpower and material. Sustained operations will more than likely require FARP operations. The implementation of an AAR system in the UH-1Y will not relieve the necessity for FARP operations; rather, the addition or installation of an AAR kit would alleviate the additional burden of establishing a FARP between the point of departure and the objective area as well as eliminating the restriction placed upon the aircraft's freedom of movement that being tied to a FARP for refueling operations creates. This is a prime example of facilitating the achievement of the goals established in the CNO's and CMC's visions of *Sea Power 21* and *USMC 21*.

SECTION II
AIRCRAFT & SYSTEMS DESCRIPTION

The purpose of this section is to present the current UH-1Y and it's fuel system and examples of Aerial Refueling equipment that may be used or modified to provide the UH-1Y with an AAR capability.

2.1 AIRCRAFT DESCRIPTION

The UH-1Y could be modified to incorporate an AAR system. The UH-1Y is a tactical utility helicopter manufactured by Bell Helicopter Textron. It is a twelve-place helicopter capable of operating from prepared or unprepared landing areas, from amphibious shipping, other floating bases, and austere shore bases, day or night, in Visual Meteorological Conditions or Instrument Meteorological Conditions. Two General Electric T700-GE-401C turbo shaft engines are installed to provide power to the drive train system. Each engine is rated (uninstalled) at 1,800 shaft horse power (intermediate power). The maximum gross weight for takeoff is 18,500 pounds. See figure 5.

2.1.1 UH-1Y Fuel System

The UH-1Y fuel system could be readily adapted to allow AAR. The fuel system is composed of eight subsystems: fuel storage, fuel feed, fuel quantity gauging, On Board Inert Gas Generating System, fuel system venting, refueling and de-fueling, auxiliary fuel, and fuel system control and management. Figure 6 is a schematic of the fuel system, NAVAIRSYSCOM (3).

2.1.1.1 Fuel Storage

Fuel storage consists of five interconnected, self-sealing fuel cells. Their primary function is to store fuel to be delivered to the engines or Auxiliary Power Unit. Total fuel

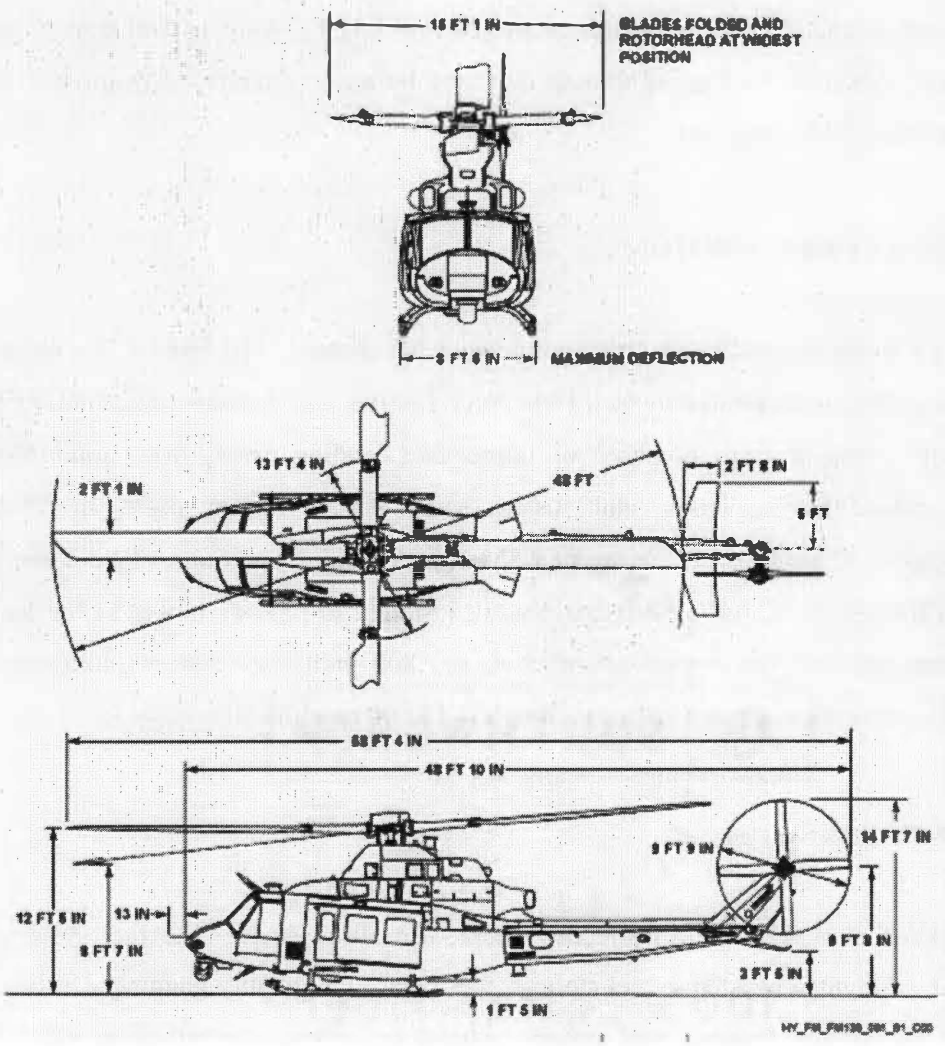
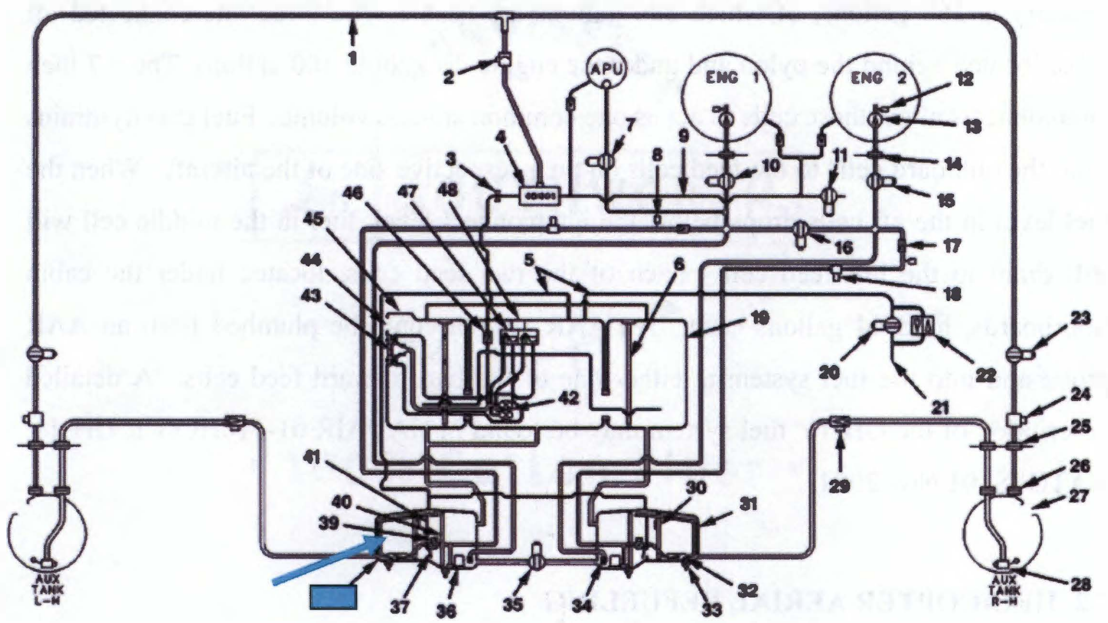


Figure 5. UH-1Y Aircraft

Source: NAVAIR 01-110HCG-1, UH-1Y NATOPS, 01 Nov 2004.



1. AUXILIARY FUEL AIR PRESSURE LINE
2. PRESSURE REGULATOR
3. ORIFICE ASSEMBLY
4. OBIGGS GENERATOR
5. VENT LINES
6. AFT FUEL QUANTITY PROBE
7. APU FUEL SHUTOFF VALVE
8. PRESSURE SWITCH
9. BLEED AIR
10. ENGINE NO. 1 FUEL SHUTOFF VALVE
11. HEATER CONTROL VALVE
12. PRESSURE SWITCH
13. ENGINE-MOUNTED SUCTION BOOST PUMP
14. FORWARD FIREWALL QUICK DISCONNECT
15. ENGINE NO. 2 FUEL SHUTOFF VALVE
16. CROSSFEED VALVE
17. CHECK VALVE
18. ENGINE PRIME SOLENOID VALVE
19. AFT RIGHT FUEL CELL
20. BYPASS VALVE
21. OVERBOARD VENT
22. CLIMB/DIVE VALVE
23. AUXILIARY FUEL SHUTOFF VALVE
24. PRESSURE RELIEF VALVE
25. AIRFRAME SKIN PENETRATION
26. TANK-MOUNTED JETTISON DISCONNECTS
27. GRAVITY FILL PORT
28. TANK EMPTY FLOAT SWITCH AND SHUTOFF VALVE
29. FLOW INDICATING CHECK VALVE
30. FORWARD FUEL QUANTITY PROBE WITH LOW LEVEL DETECTOR
31. FORWARD RIGHT FUEL CELL
32. EJECTOR PUMP
33. FUEL SAMPLE VALVE
34. CHECK VALVE
35. INTERCONNECT VALVE
36. ELECTRIC PRIME/TRANSFER PUMP
37. FLAPPER CHECK VALVE
38. FORWARD LEFT FUEL CELL
39. FLOW SWITCH
40. AFT FUEL QUANTITY PROBE
41. BAFFLE
42. PRESSURE FUELING SHUTOFF VALVE
43. PRESSURE FUEL PORT
44. GRAVITY FILL PORT
45. AFT LEFT FUEL CELL
46. OBIGGS CHECK VALVE
47. DUAL PILOT VALVE
48. AFT CENTER FUEL CELL

HY-FM-FM019-001-01-C00

Figure 6. UH-1Y Fuel System

Source: NAVAIR 01-110HCG-1, UH-1Y NATOPS, 01 Nov 2004.

capacity is 388 gallons, of which 386 gallons are usable. The three interconnected aft cells, located behind the pylon and under the engine deck, hold 300 gallons. The 4.7 inch interconnects allow these cells to act as one common storage volume. Fuel gravity-drains from the outboard cells to the feed cells on their respective side of the aircraft. When the fuel level in the aft cells drops below the interconnect level, fuel in the middle cell will still drain to the left feed cell. Each of the two feed cells, located under the cabin floorboards, hold 44 gallons each. An AAR system could be plumbed from an AAR probe and into the fuel system at either one of the two forward feed cells. A detailed description of the UH-1Y fuel system may be found in NAVAIR 01-110HCG-1, UH-1Y NATOPS, 01 Nov 2004.

2.2 HELICOPTER AERIAL REFUELING

As the air war was waged in South East Asia (SEA), HH-3 (the primary CSAR platform then) rescue innovators were hard at work back in the United States. The idea of refueling a helicopter in flight was being conceptualized. Helicopter air refueling was urgently needed in SEA, since straight-line distances from forward operating lines to many of the target areas in North Vietnam were approximately 150–190 miles. Search and Rescue (SAR) helicopters rarely flew straight lines to downed airmen. Circuitous routes were flown to avoid enemy air defenses. The actual flight distance was frequently as much as three times that of a straight line. Many missions exceeded the 350-mile radius of the HH-3.

United States Air Force (USAF) Major Harry P. Dunn had spent his entire Air Force career flying helicopters. He believed it was possible to air refuel a CH-3 from a KC-130. Headquarters Air Rescue Service authorized him to test the concept. On 15 December 1965, Major Dunn coordinated a test flight flown by two Sikorsky test pilots, Mr. Don Eastman and Mr. Dick Wright, in which a USAF CH-3 took off to attempt an air-refueling linkup with a KC-130 owned by the USMC (see figures 7 and 8). The H-3

Figure 7. The First Helicopter to Plug Into a Refueling Basket

Source: Air Force Historical Research Agency Photo.

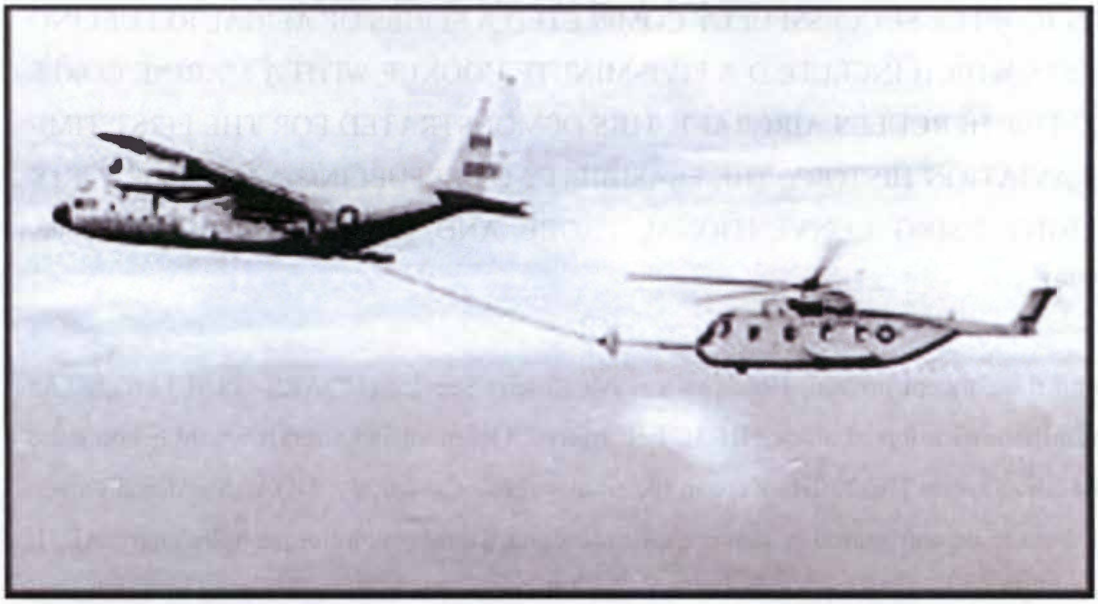


Figure 8. C-130 and the First Helicopter to Plug Into a Refueling Basket

Source: Air Force Historical Research Agency Photo.

was configured with an AAR probe which was not plumbed to the aircraft. The probe was installed to prove the concept of plugging into a refueling basket. Skeptical engineers from the USAF Engineering Test Center at Wright-Patterson Air Force Base believed that the vortices shedding from the propellers and aircraft wake turbulence that occurred behind a KC-130 would destroy the helicopter (LaPointe, 1999). Doubt was heightened by the fact that neither pilot had ever participated in an air refueling operation. Despite this disbelief, the test took place with results far better than expected. Major Dunn's theory was proven to be correct when the H-3 flew up behind the KC-130, slipped into refueling position, and on their first attempt plugged the dummy probe into the refueling basket (LaPointe, 1999).

At the completion of the air refueling, the following message was transmitted to HQ Air Rescue Service:

SUBJECT: HELICOPTER AERIAL REFUELING

ON 15 DEC 65, AT MCAS CHERRY POINT, N.C., AN AIR FORCE CH-3 HELICOPTER SUCCESSFULLY COMPLETED A SERIES OF AERIAL REFUELING TESTS WHICH INCLUDED A FIVE-MINUTE HOOKUP WITH A MARINE CORPS KC-130F HERCULES AIRCRAFT. THIS DEMONSTRATED FOR THE FIRST TIME IN AVIATION HISTORY THE FEASIBILITY OF REFUELING A HELICOPTER IN FLIGHT USING CONVENTIONAL PROBE AND DROGE SYSTEM (LaPointe, 1999).

With the concept proven, Headquarters Air Rescue Service (HQARS-USAF) ordered an initial modification of a few HH-3C helicopters. The modified aircraft would become the HH-3E. Several HC-130Hs were in the final stages of assembly. HQARS ordered eleven of them to be configured as tankers. Air refueling would revolutionize helicopter SAR. It would prove to have a profound effect on SAR operations in the war raging in South East Asia.

2.2.1 Aerial Refueling Equipment

For the purpose of this thesis, consideration should be given to the current primary tanker of the USMC, the KC-130, see figure 9. The KC-130 uses a Probe and Drogue system, see figure 10.

2.2.1.1 KC-130 Hercules

The KC-130 has two drogue equipped refueling stations, one mounted on each wing outboard of the engines. Each refueling station consists of a Sargent Fletcher 48-000 refueling pod, 85 ft of hose, MA-2 coupling and a 27 in. diameter high-speed (fixed-wing aircraft) or 54 in. diameter low-speed (helicopter) drogue. Fuel flows when the hose is pushed in 5 ft; flow continues, provided the hose is maintained in the refueling position of 20 to 80 ft of hose extension. Hydraulic pressure provides 90% of the force required to rewind the hose during refueling to reduce hose slack and whip. The hoses are marked at 10-ft intervals to visually identify and confirm the length of the hose when extended. The MA-2 coupling requires 140 lb of force to connect (2 to 5 kt closure) and 420 lb of force to disconnect. Air-to-Air Refueling (AAR) altitude band is from 500 ft to 23,000 ft; speed range for the low speed helicopter drogue is 110 to 130 KIAS. Maximum hose extension or extraction speed is 120 KIAS, NAVAIRSYSCOM (11).

The maximum useable fuel load is from 29,036 lbs to 58,466 lbs. Transferable fuel is dependent on sortie duration. At maximum useable fuel capacity, around 34,000 lbs is available for transfer during a 4 hr flight, assuming a fuel burn rate of 6,000 lb/hr. With the removable fuselage fuel tank fitted, transfer rate is about 4,080 lb/min with the two AAR pump configuration or 2040 lb/min with the single AAR pump configuration. Without the fuselage tank, the transfer rate is about 1,020 lb/min. The lower transfer rate can be selected on request according to the receiving aircraft system requirements and/or limitations. Regulated fuel pressure is 50 psi at the drogue, NAVAIRSYSCOM (12) and NATO (13).

Figure 9. KC-130 Aerial Refueling CH-53Es

Source: Official USMC Website Photo Archives.

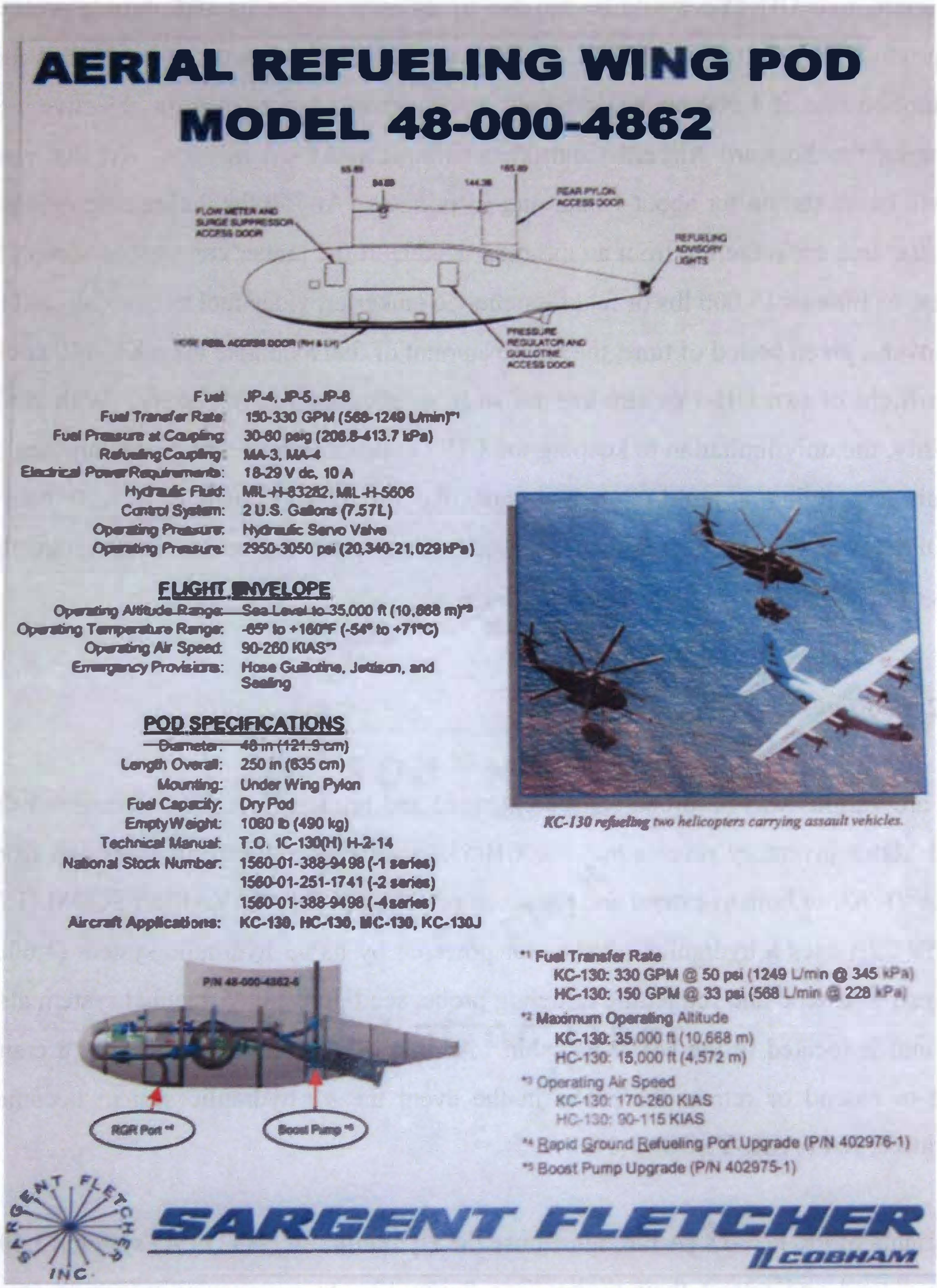


Figure 10. Sargent Fletcher Refueling Pod 48-000

Source: Air-To-Air Refueling Manual, NAVAIR 00-80T-110, Oct 1992.

AAR configured UH-1Ys would be capable of flying at airspeeds and altitude profiles appropriate to tanking from KC-130s. As an example, a flight of two UH-1Ys with a fuel consumption rate of 1,000 pounds-per-hour (each aircraft) loiters over an objective area performing the Forward Aircraft Controller-Airborne (FAC-A) mission. At that rate, they will be on station for about 1 hour and 45 minutes. At 750 lbs fuel remaining, they depart the area for refueling from an airborne tanker. If the tanker can stay on station to dispense as little as 15,000 lbs of fuel (assume the tanker provides fuel to other aircraft as well), over a given period of time, the ample amount of fuel available via a KC-130 could keep a flight of two UH-1Ys airborne for over an additional seven hours. With AAR capability, the only limitation to keeping the UH-1Y airborne would be by the amount of time aircrew flying a multi-piloted aircraft like the UH-1Y, which is 12.0 hours, NATOPS (14). Overall, increases in mission radius, loiter and on station time are the results of installing AAR systems in the UH-1Y.

2.2.1.2 In-Flight Refueling Probes

There are various ways a probe can be extended and retracted. A look throughout the United States inventory reveals that the CH-53E uses engine bleed air (220 psi) from engines #1, #3, or both to extend and retract its refueling probe, NAVAIRSYSCOM (15). The MV-22B uses a hydraulic drive motor powered by its #3 hydraulic system (4,600-5,250 psi) to extend and retract the refueling probe, see figure 11. A manual system also exists and is located in the MV-22B cabin. Additionally, a crewman may use a crank handle to extend or retract the probe in the event the #3 hydraulic system becomes inoperative, NAVAIRSYSCOM (16).

All variants of the F/A-18 (A through F) use the Hydraulic 2A (HYD 2A) system (3,000 psi) to extend and retract their probes, see figure 12. In emergency extension cases (HYD 2A not available), the Auxiliary Power Unit (APU) accumulator is used to extend the probe, NAVAIRSYSCOM (17) and NAVAIRSYSCOM (18). Similarly, the AV-8B uses hydraulic pressure from its #1 system (3,000 psi) to extend and retract the refueling

Figure 11. MV-22 Aircraft Performing AAR Operations

Source: Official USMC Website Photo Archives.

Figure 12. F/A-18 Aircraft Performing AAR Operations

Source: Official USMC Website Photo Archives.

probe, NAVAIRSYSCOM (19). These aircraft demonstrate that there are numerous means to extend and retract AAR probes. Determination of which method would be best for implementation of the UH-1Y would depend on an analysis by NAVAIR engineers, developmental test pilots and operational test pilots.

The UH-1Y could use currently proven methods such as engine bleed air, aircraft hydraulics, aircraft electrical systems or the Auxiliary Power Unit (as a source of power or bleed air) to extend and retract an AAR probe. Another option would be a probe that had a self-contained hydraulic unit to extend and retract the probe.

SECTION III
TECHNICAL SPECIFICATIONS & DEVELOPMENT

This section identifies the current specification requirements and draws out proposed specifications modifications for an AAR equipped UH-1Y.

3.1 UH-1Y PERFORMANCE SPECIFICATIONS

The current Performance Specification for the UH-1Y is as follows. The UH-1Y shall have a mission radius, with a utility payload, of 110 NM (Key Performance Parameter-KPP Threshold) and 200 NM with auxiliary fuel (KPP Objective). V_{Cruise} shall be guaranteed to be 142 Knots True Air Speed (KTAS) at 3,000' Standard Day Pressure Altitude (PA)/ 91.5° F at mission configuration and V_H shall be guaranteed to be 157 KTAS at 3,000 ft Standard Day Pressure Altitude (PA)/ 91.5° F at mission configuration. Mission radius environmental conditions are defined as takeoff at sea level, 103° F with a utility payload. An in-flight segment shall be flown at 3,000 ft PA, 91.5°F. Mission radius profile is defined as: Takeoff with full internal fuel, and Hover In Ground Effect (HIGE) at sea level, 103° F with a utility payload. Remaining mission segment shall be measured on a standard day. Flight profile shall be defined as aircraft start-up, 5 minutes at flight idle, takeoff, 1 minute at intermediate power and climb to 3,000 ft PA, 91.5° F. Cruise to mission radius at long range cruise speed (99% best max specific range), HOGE for 5 minutes. Offload eight combat loaded Marines via FAST ROPE. Loiter 10 minutes at max endurance airspeed for emergency extract, if required. Return at long range cruise speed (99% best maximum specific range). Aircraft will return with reserve fuel of 10% fuel remaining or fuel for 20 minutes at maximum endurance speed (whichever is greater), Performance Specification (4).

3.2 PROPOSED UH-1Y SPECIFICATION MODIFICATIONS

An AAR capable UH-1Y would increase the performance of most missions such as, Airborne Command and Control, Air Mission Commander, Forward Air Controller (Airborne) and FLIR Reconnaissance. Performance gains would be realized in an increase in mission radius, loiter and time on station because a tanking aircraft could more rapidly reposition to meet the refueling need of the UH-1Y in a dynamic environment. Conversations with LtCol Anderson, Deputy Program Manager for the H-1 program, assisted in determining the following recommendations.

3.2.1 AAR Provision

A proposed Test an Evaluation Master Plan (TEMP) may read as follows: A Provision shall be made for an in flight refueling probe kit. This kit shall be Government Furnished Equipment (GFE) and is considered Special Mission Equipment. The probe itself is recommended to be installed on the port side of the aircraft. Cockpit controls, indicating systems and internal fuel lines shall be provided to allow the kit to be run directly into the left forward feed cell via plumbing permanently installed under the cabin flooring, located on the port side of the aircraft. See the blue arrow in figure 16. The probe portion itself shall be quick disconnect in nature, requiring minimal time to install or remove the probe and requires no special tools. When the probe is detached from the aircraft a cap or plug should be installed (as part of the kit) to maintain the integrity of the plumbing and ensure the system remains debris and contamination free. Such plumbing could run from the aft end of the probe along the port side of the fuselage in such a manner that it will not interfere with cockpit or cabin ingress or egress. Additionally, the plumbing could run from the aft end of the probe along the port side of the fuselage in such a manner that it will not interfere with cockpit or cabin ingress or egress.

3.2.2 Shipboard Compatibility

The AAR kit, when installed, shall meet all requirements of shipboard operating procedures as outlined in NAVAIRSYSCOM (21) and NAVAIRSYSCOM (22).

3.2.3 AAR Compatibility

The UH-1Y, when configured with the AAR kit, shall be compatible with US and NATO tanker aircraft equipped with a hose and low speed drogue refueling system and associated procedures as outlined in NAVAIRSYSCOM (11). The primary tanker aircraft shall be the KC-130. The flight envelope for AAR operations should be from 110 KIAS to 130 KIAS.

3.2.4 Aerial Refueling Flow Rates

Fuel flow rates from a tanker aircraft shall not exceed the internal UH-1Y fuel system limitation of 75 gpm at 55 psi.

3.2.5 AAR Equipped UH-1Y Flight Envelope

The operating flight envelope shall permit defensive air combat maneuvering turns up to 60° Angle Of Bank at speeds up to 130 KIAS up to the maximum gross weight of 18,500 lb both at sea level, 103° F and at 3,000' PA, 91.5°F.

3.2.6 Other Considerations

This kit shall generate no Electro Magnetic Interference when installed and operating on the aircraft. A powered or manual auxiliary means to extend and retract the probe shall be installed in the aircraft. Such auxiliary means shall be independent and separate from the primary means. AAR operations shall be executable in day or night, aided and unaided, in VMC. Operating temperature range shall be between –32°C and +52°C. The aircraft shall be controllable in One Engine Inoperative and autorotation flight profiles.

SECTION IV
CONCLUSIONS

Throughout the Department of Defense (DoD), Rotary Wing (RW) aircraft are equipped with AAR capability, thereby increasing their TOS and mission radius. Examples in the United States Army (USA) include the MH-60K and the MH-47D/E. Currently, in the USAF, the MH-53J and the MH-60G are AAR capable and, in the near future, the CV-22 will contain this enhanced capability. In the USMC, the only helicopter equipped for AAR operations is the CH-53E. The MV-22B also is configured with a retractable AAR probe. Each of these services has implemented AAR capability to their aircraft to allow the aircraft to fly longer distances and decrease dependence on refueling on the ground or aboard ship. The concept is combat-proven and viable.

4.1 PAST PERFORMANCE AND FUTURE FLEXIBILITY

With the events of September 11th 2001, military planners began planning operation Swift Freedom, designed to be the opening move in the overarching Operation Enduring Freedom. The initial objective was to seize and defend a Taliban stronghold that allied forced code-named Camp Rhino. Camp Rhino was in Afghanistan- a land locked country that was 300 NM from the Indian Ocean and the Gulf of Oman at its closest point. The 15th MEU began to plan the execution of this mission as the ARG waited 25 NM off the coast of Pakistan by the seaport village of Pasni. The plan to get the 2,500 embarked Marines into Camp Rhino required multiple CH-53E flights from the ship, using AAR. The UH-1Ns and AH-1Ws were tasked to provide CAS and reconnaissance prior to, during and post insertion of the infantry Marines from the CH-53Es. The short range of the H-1s required establishing a FARP at a Reserve Pakistani Air Force base. Once this host nation support was established and permission granted to commence, a FARP was built. The logistic train required to establish a FARP 250 NM into Pakistan taxed the capabilities of the MEU Service Support Group. With all the pieces in place, Swift Freedom was scheduled to commence on the last Thursday in November 2001. On the morning of Thanksgiving Day, the 15th MEU Commander learned that the 20,000 gallons of fuel that had been established at the FARP for their mission had been nearly depleted by a British SAS aviation support regiment performing priority missions inside Afghanistan the night before. Operation Enduring Freedom was delayed for 36 hours until the fuel could be replaced. The total route length flown by the H-1 crews was just over 500 nm from the ship to Camp Rhino, requiring almost eight hours of elapsed time to get from the boat to the FARP and then into position to seize Camp Rhino. The extreme amount of man-hours required to plan, establish the FARP in Pakistan, and resupply the fuel there could have been avoided or reduced dramatically, had the UH-1N had longer range or an AAR capability.

In the future, missions such as this will be conducted by the UH-1Y. The enroute time to the FARP could be reduced to less than two hours given the UH-1Ys increased speed over the UH-1N. The total time from ship to objective could be reduced by more than half, if the UH-1Y were equipped with AAR capability. Threshold and Objective Mission Radii would be more than doubled with the inclusion of AAR capability. The CH-53Es that launched from the ship to Camp Rhino performed AAR once from KC-130s and were able to successfully get the infantry Marines into the objective in the shortest amount of time possible.

Now that USSOCOM has established a Marine force, MARSOCOM, future operations will most likely include long-range missions where no host nation support may be available to establish FARPs for USMC rotary wing assets. Future Areas of Operation may include North Korea, Iran, and China. As of the writing of this paper, the Marine aviation assets assigned to MARSOCOM have yet to be determined. Potentially, it will include the UH-1Y. Acquisition and installation of an AAR capability for the UH-1Y will increase the capability of the MARSOCOM contingent, meeting the goals established by the CNO and CMC in their visions for their branches role in the DoD.

The scope of this paper addresses the increase in capability an AAR system would provide the UH-1Y. Each HMLA squadron is comprised of both AH and UH aircraft. Beginning in the Viet Nam war, UH and AH aircraft have worked together in combat. Recent combat operations in Iraq have proven that the AH and UH aircraft of the HMLA draw upon each other's strengths when working together to defeat the enemy and return to base together at the end of each mission. The absence of proposing the installation of an AAR capability to the AH-1Z is not meant to imply it should not also be researched, developed and implemented. On the contrary, all of the benefits gained in the UH-1Y would be negated because the AH-1Z would still be tied to an intermediate FARP for refueling. More importantly not equipping the AH-1Z also with AAR capability would be ignorant and only serve to handicap the MAGTF Commander. Both the AH-1Z and UH-1Y should have an AAR capability.

The scope of this paper addresses the increase in capability [illegible] provide the UH-1Y. Each HMLA squadron is comprised of [illegible] AH-1Z [illegible] UH-1Y [illegible]. Beginning in the Viet Nam war, the AH-1 and UH-1 have worked [illegible]. Recent combat operations in Iraq have proven [illegible] the AH and UH [illegible] rely upon each other's strengths when working together to [illegible] to have [illegible] at the end of each mission. The [illegible] of procuring the capability of an AAR capability to the AH-1Z [illegible] would not also be [illegible] developed and [illegible] all of the benefits gained to the UH-1Y would be negated because the AH-1Z would still be tied to [illegible] FARP for refueling. [illegible] not equipping the AH-1Z also with AAR capability would be [illegible] and only [illegible] the HMLA [illegible]. Both the AH-1Z and UH-1Y should have AAR capability.

SECTION V
THE PATH AHEAD

The path ahead is a rough outline of the events that must occur in order for the USMC to acquire and implement AAR capability.

5.1 ACTION TASKS

The acquisition process will begin with a full and open competition under Title 10 U.S.C 2304(c) (1), once the Mission Need Statement is approved. A System Development and Demonstration contract shall be written to include procurement of the spares and support necessary to conduct Developmental Test and Evaluation, as well as early Operational Assessments. Competition for spares and repair of non-consumables shall be sought, promoted and sustained through the development of documentation and provisions for the data rights necessary to ensure the implementation of Performance Based Logistics during the Production and Deployment phase of this mission kit.

5.1.1 Marine Corps Combat Development Command

MCCDC's mission is to develop Marine Corps warfighting concepts and determine associated required capabilities in the areas of doctrine, organization, training and education, equipment, and support and facilities to enable the Marine Corps to field combat-ready forces; and participate in and support other major processes of the Combat Development System. MCCDC will utilize two branches to determine the usefulness of an AAR capability on the UH-1Y, the Marine Corps Warfighting Laboratory (MCWL), and the war-gaming branch. To procure an AAR mission kit for the UH-1Y, MCCDC must write an Operational Requirements Document (ORD), which will outline the intent the AAR system is to fill as well as to what standards of performance the system shall meet, based on the info from the MCWL and war-gaming branch.

MCWL's purpose is to improve current and future naval expeditionary warfare capabilities across the spectrum of conflict for current and future operating forces.

The war-gaming branch provides a highly flexible exploratory and assessment methodology that can apply to a broad range of situations outside of "war" proper. War-gaming is particularly suitable for generating, refining, and assessing concepts, plans, issues, and technologies; assessing alternative courses of action; identifying capabilities and deficiencies; replicating conditions difficult to reproduce in peacetime; and reducing surprises. It is here at the war-gaming division, that the application, benefits and potential usefulness can be considered and a recommendation can be made to the Marine Acquisition leadership.

5.1.2 Program Manager Air 276

With an approved MNS from MCCDC, PMA-276 may begin engineering liaison with industry to determine the technical requirements for installation of an AAR mission kit. Testing, data reduction, recommendations for refinement, manufacturing and distribution to the Fleet Marine Force should be accomplished in such a manner that can be accomplished with Initial Operation Capability of the UH-1Y, or shortly thereafter.

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APPENDICES

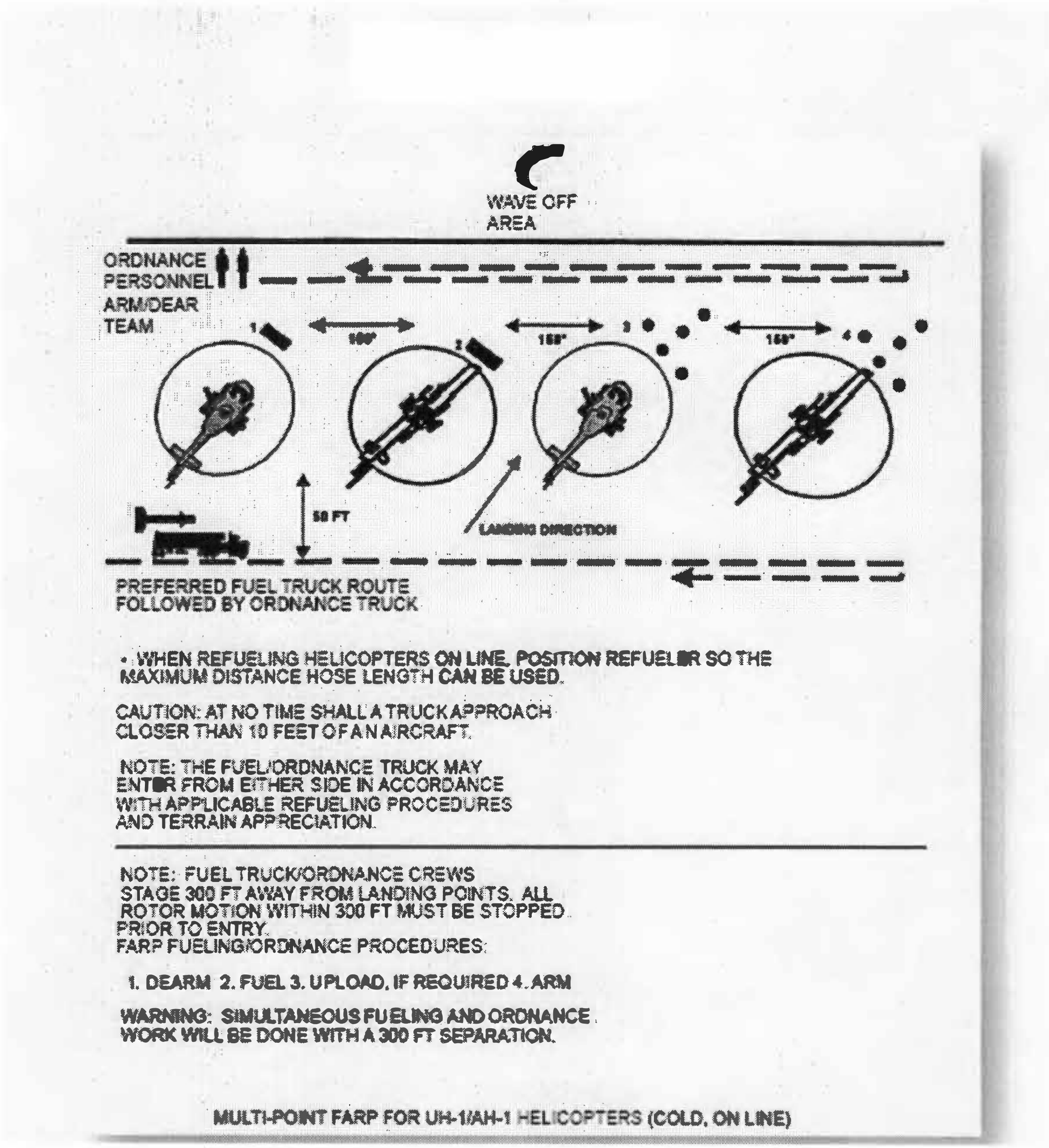


Figure A-1. Ground Cold FARP for UH-1/AH-1 Helicopters

Source: Naval Tactics Techniques and Procedures 3-22.3-UH-1N, Jun 2003.

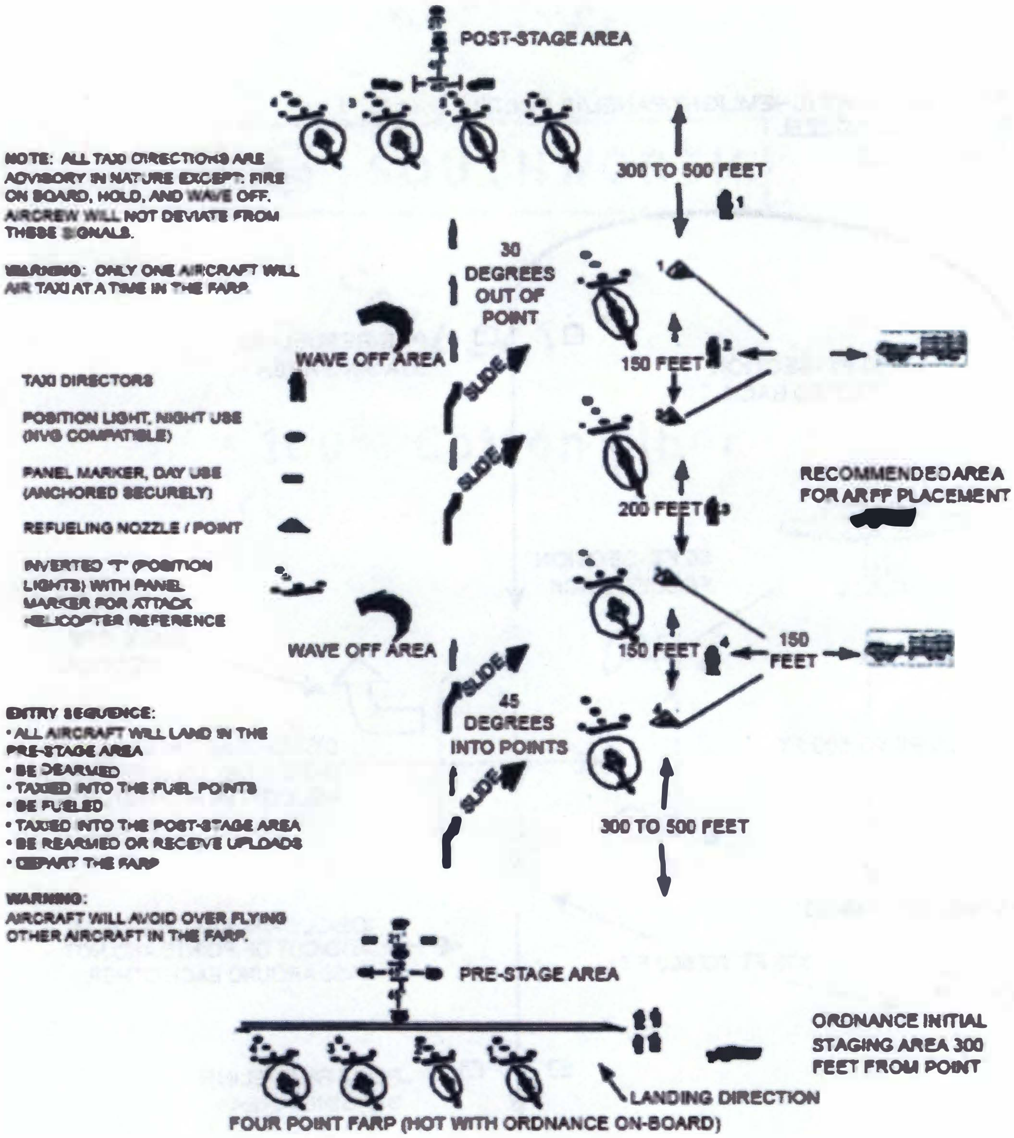


Figure A-2. Ground Hot FARP Layout

Source: Naval Tactics Techniques and Procedures 3-22.3-UH-1N, Jun 2003.

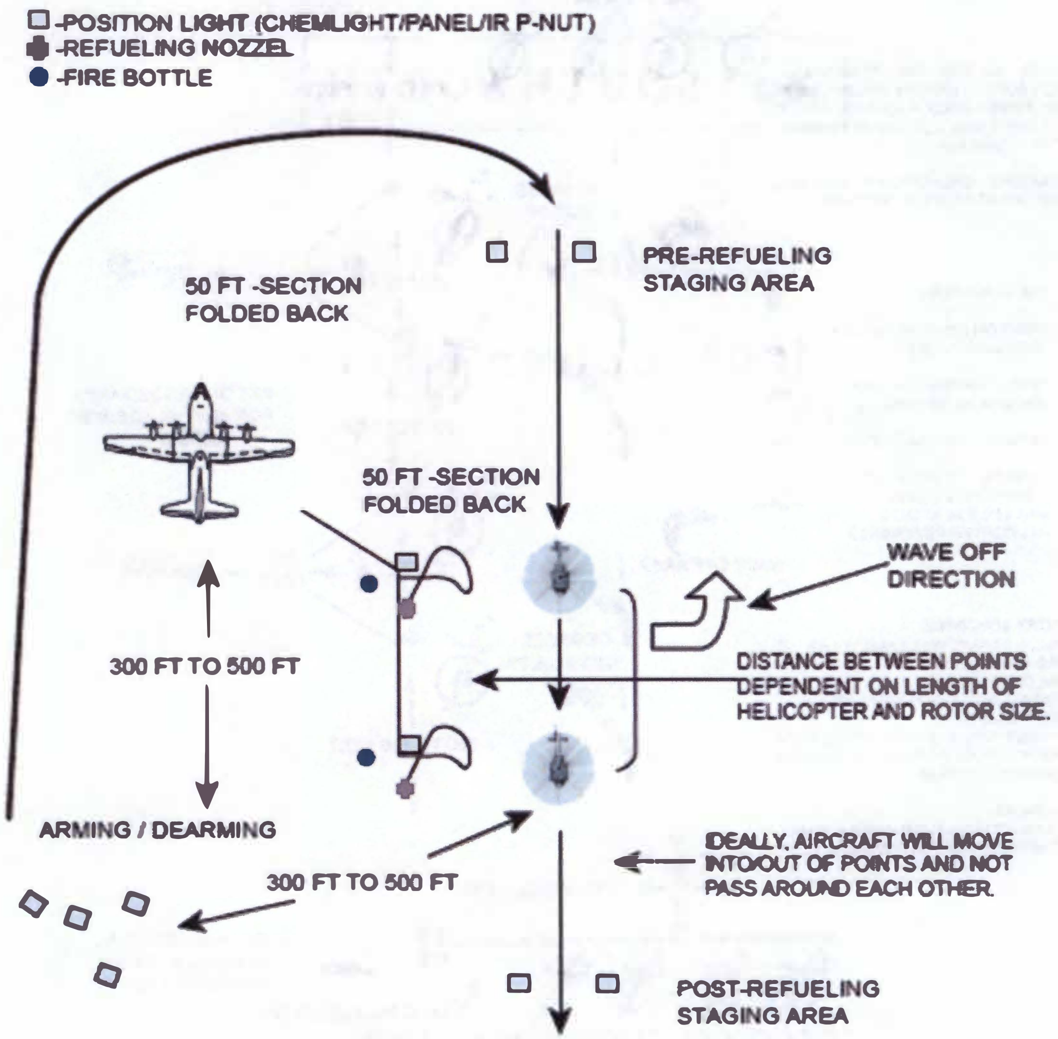
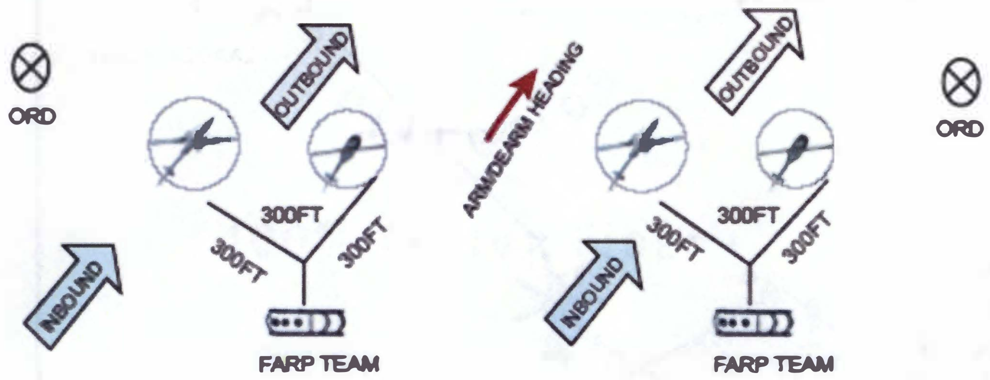


Figure A-3. KC-130 Hot FARP Layout

Source: Naval Tactics Techniques and Procedures 3-22.3-UH-1N, Jun 2003.



WARNING: FUELING AND ORDNANCE OPERATIONS CAN NOT BE CONDUCTED SIMULTANEOUSLY

NOTE: 1 AIRCRAFT LAND DIRECTLY ONTO THEIR ASSIGNED POINTS.

NOTE: 2 THERE IS TYPICALLY 300 FEET OF SPACE BETWEEN FUELING ASSIGNMENT, FUEL POINTS AND ORDNANCE SITE ALLOWING BOTH FUELING AND ORDNANCE OPERATIONS TO BE CONDUCTED AT THE FUEL POINTS. EXACT DISTANCE REQUIRED BETWEEN THE REFUELING POINT AND THE FUEL SOURCE CAN BE COMPUTED UTILIZING QUANTITY DISTANCE TABLES FOUND IN NAVSEA OP 5 VOL 1 *AMMUNITION AND EXPLOSIVES ASHORE* AS WELL AS QUANTITY DISTANCE FORMULAS FOR THE HAZARD CLASS OF MUNITIONS (K FACTOR).

NOTE: 3 EACH POINT WORKS AUTONOMOUSLY FROM THE OTHER SO YOU CAN DEARM, FUEL, UPLOAD AND ARM AIRCRAFT AT ONE POINT WITHOUT BEING IMPEDED BY ACTIVITIES OCCURING ON THE ADJACENT POINT.

Figure A-4. Static FARP Layout

Source: Naval Tactics Techniques and Procedures 3-22.3-UH-1N, Jun 2003.

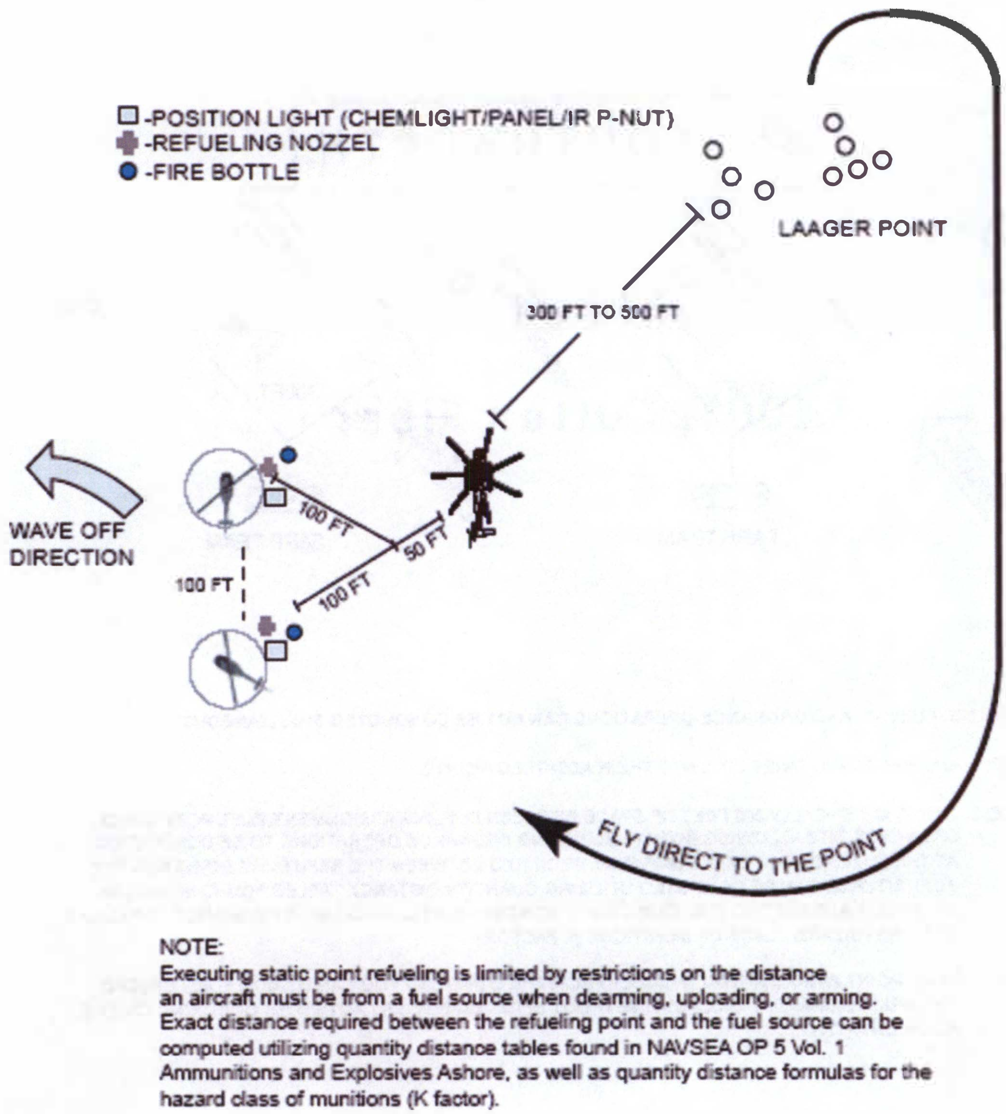


Figure A-5. CH-53 RGR Static FARP Layout

Source: Naval Tactics Techniques and Procedures 3-22.3-UH-1N, Jun 2003.

VITA

Scott Paul Suckow was born in Minneapolis, Minnesota, on 13 July 1966. Upon graduating from Coon Rapids Senior High School, he enlisted in the United States Marine Corps. He completed basic training at Marine Corps Recruit Depot, San Diego CA, in November 1984. He was assigned to Marine Light/Attack Helicopter Squadron Three Six Seven (HMLA-367), Marine Corps Air Station Camp Pendleton, CA, where he worked on AH-1J/T/W model Cobras as an avionicsman and UH-1Ns as an avionicsman/Crew Chief/Aerial Gunner. On September 10th 1988, Sergeant Suckow was Honorably Discharged and attended the University of Minnesota-Duluth. In June 1993 he graduated with a B.A. in History. After completing Fleet Replacement Training Squadron Three Zero Three (HMT-303) in 1996, First Lieutenant Suckow was assigned to HMLA-169 as a UH-1N pilot where he served in various squadron billets to include a combat tour in Afghanistan with the 15th Marine Expeditionary Unit (15th MEU) in 2001. Captain Suckow graduated from Weapons and Tactics Instructor (WTI) Course prior to his deployment with the 15th MEU. After returning from Operation Enduring Freedom (OEF) in 2002, Captain Suckow attended the United States Naval Test Pilot School (USNTPS) and graduated in June 2003. Major Suckow was then assigned to Air Test and Evaluation Squadron Two One (HX-21) as the UH-1N Platform Coordinator and project pilot. He is still serving as the UH-1N Platform Coordinator and project pilot as well as performing test pilot duties on the AH-1W, AH-1Z, UH-1Y, TH-57 and VH-3D aircraft. Major Suckow will be returning to the Fleet Marine Force in April, where he will be assigned to HMLA-367 and deploying to Iraq in September.