United States Marine Corps' CH-53E Super Stallion Modernization: Necessary Victim of Transformation?

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PREFACE

The genesis for this research project was the perceived continual delay in determining the necessity and the composition of the Service Life Extension Program (SLEP) for the Marine Corps' fleet of CH-53E Super Stallion heavy lift helicopters. CH-53E SLEP funding has been approved, however, exactly what the future SLEP is to entail has not been determined.

I would like to thank my mentors Doctor Donald F. Bittner, Professor of History and Lieutenant Colonel Kevin F. Frederick, USMC for their assistance in this project particularly their patient guidance, encouragement, and recommendations.

Additionally I would like to express my deepest appreciation and gratitude to my wife for her tolerance, understanding, and encouragement. To my son, thank-you for the time you gave up so this project could be completed.

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EXECUTIVE SUMMARY

Title: UNITED STATES MARINE CORPS' CH-53E SUPER STALLION MODERNIZATON: NECESSARY OR NECESSARY VICTIM OF TRANSFORMATION?

Author: Major Paul G. Sichenzia, United States Marine Corps

Thesis: A Service Life Extension Program (SLEP) is necessary to prolong the operational capability of the CH-53E in support of Marine Corps' expeditionary capabilities.

Discussion: Is modernization of the CH-53E Super Stallion necessary, or should it be retired as a necessary victim of transformation? Will the current and future Marine Corps doctrine and concepts be executable without the heavy lift capability provided by the CH-53E?

Specifically, if the CH-53E is a concept enabler, the Service Life Extension Program (SLEP)/Modernization needs to be defined, approved, and procured quickly in order to allow continuation of the Marine Corps as a force in readiness in support of the nation's military strategy and the Combatant Commanders.

As prescribed by the 82nd Congress, the Marine Corps is to be a "versatile, fast-moving, hard-hitting" force.[1] "Moreover, we remain the most ready when the nation generally is least ready."[2] Current competition for new systems and programs has necessitated the reevaluation of all existing and future weapon systems by each of the armed services. Under the moniker of Transformation, new programs must provide a significant advance in technology and capability to be in line with the Secretary of Defense's guidance driving effects based operational capabilities. Those programs that do not conform to this concept face cancellation.

Presently, due to recent accidents and reduced confidence in the MV-22 Osprey program and its technology, the Osprey is again required to justify its relevance, capability, and survivability. However, even if the Osprey program is approved, a significant gap in future capabilities will still exist. Specifically, the heavy lift capabilities will be deficient. Currently the increased use of the CH-53E Super Stallion has made up for the delay in the MV-22's arrival. However, increased use and aging airframes will only expedite the retirement of the CH-53E. With no replacement aircraft planned for, the loss of this heavy lift platform will require a major revision of Marine Corps future warfighting strategies.

Conclusion: Conscious neglect or inadvertent oversight has resulted in a CH-53E replacement not being investigated. Without timely implementation of the SLEP, there will be no airframe capable of fully executing Marine Corps Strategy 21 (MCS 21) or Expeditionary Maneuver Warfare (EMW). Therefore, the most expeditious and cost effective solution is the immediate initiation of a CH-53E Service Life Extension Program.

[1] Lieutenant General Martin Steele, USMC, DCS PPO, "21st Century Marine Corps Tactical Sealift and Tactical Airlift." Statement to the Senate Seapower Subcommittee of the Senate Armed Services Committee, 10 March 1999, p. 3.
[2] Steele 1999, 3.

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CH-53E Super Stallion Helicopter

Primary function: Transportation of heavy equipment and supplies during the ship-to-shore movement of an amphibious assault and during subsequent operations ashore.
Manufacturer: Sikorsky Aircraft
Power plant: Three General Electric T64-GE-416 turboshaft engines producing 4380 shaft horsepower each.
Length: 99 feet 5 inches (30.32 meters)
Height: 28 feet 4 inches (8.62 meters)
Rotor diameter: 79 feet
Speed: 172.5 miles per hour (150 knots)
Maximum takeoff weight:
Internal load: 69,750 pounds (31,666 kilograms)
External load: 73,500 pounds (33,369 kilograms)
Range:
without refueling: 621 miles (540 nautical miles)
with aerial refueling: indefinite
Armament: Two XM-218 .50 caliber machineguns.
Crew: 3-5 (Mission Dependent)
Introduction date: June 1981
Unit Replacement Cost: $26,100,000

Mission: As the Marine Corps' heavy lift helicopter designed for the transportation of material and supplies, the CH-53E is compatible with most amphibious class ships and is carried routinely aboard LHA (Landing, Helicopter, Assault: an amphibious assault ship), LPH (Landing Platform, Helicopter: an amphibious assault ship) and now LHD (Landing, Helicopter, Dock: an amphibious assault ship) type ships. The helicopter is capable of lifting 16 tons (14.5 metric tons) at sea level, transporting the load 50 nautical miles (57.5 miles) and returning. A typical load would be a 16,000 pound (7264 kilogram) M198 howitzer or a 26,000 pound (11,804 kilogram) Light Armored Vehicle. The aircraft also can retrieve downed aircraft including another CH-53E. The 53E is equipped with a refueling probe and can be refueled in flight giving the helicopter indefinite range.

Features: The CH-53E is a follow-on for its predecessor, the CH-53D. Improvements include the addition of a third engine to give the aircraft the ability to lift the majority of the Fleet Marine Force's equipment, a dual point cargo hook system, improved main rotor blades, and composite tail rotor blades. A dual digital automatic flight control system and engine anti-ice system give the aircraft an all-weather capability. The helicopter seats 37 passengers in its normal configuration and has provisions to carry 55 passengers with centerline seats installed. With the dual point hook systems, it can carry external loads at increased airspeeds due to the stability achieved with the dual point system.

Background: Derived from an engineering change proposal to the twin-engine CH-53D helicopter, the CH-53E has consistently proven its worth to the Fleet commanders with its versatility and range. With four and one half hours' endurance, the Super Stallion can move more equipment over rugged terrain in bad weather and at night.

CHAPTER 1

PROLOGUE

Transformation and Other Ideas

History is filled with militaries that have undergone major reorganization and doctrinal changes with enhanced capability in response to new technologies. Some have been successful, for example the German Army's development of *Blitzkrieg* warfare before World War II, while others were not, such as the French development of the *Maginot Line* and use of tanks as defensive mobile pillboxes. Transformation is the latest operative term being used by and applied to today's military.

What is transformation? One dictionary definition of this term is, "*to change completely or dramatically.*"[1] Transformation, as applied to military institutions, is centered on effects based operations, expeditionary warfare, and ultimately to be able "to do what it was unable to do before."[2] This is in response to the Secretary of Defense's belief that warfighting will be vastly different in the future than it is today. Therefore, the military needs to change (i.e. transform). No longer will "large cumbersome military forces be necessary."[3] New technology and information systems will equip a much smaller, lighter, but more lethal expeditionary force to execute effects based operations. This transformation is designed to make the force more expeditionary, flexible, and self-sufficient.

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[1] Microsoft Encarta Dictionary, St Martins Press, NY, 2002, under the term "transformation."
[2] Lieutenant Colonel Scott Moore, USMC (Ret) "Transformation may be on the wrong path," *Marine Corps Times,* 18 November 2002.
[3] Moore, "Transformation."

Transformation applied to Marine aviation not only includes skipping a generation of platforms and weapons systems in order to field more technologically advanced and capable systems in the future, but also a reduction in the types and numbers of different systems. A "Neck-Down Strategy" is how the Marine Corps will achieve aviation transformation (Figure (1)). A difficulty today is how to achieve tomorrow's force.

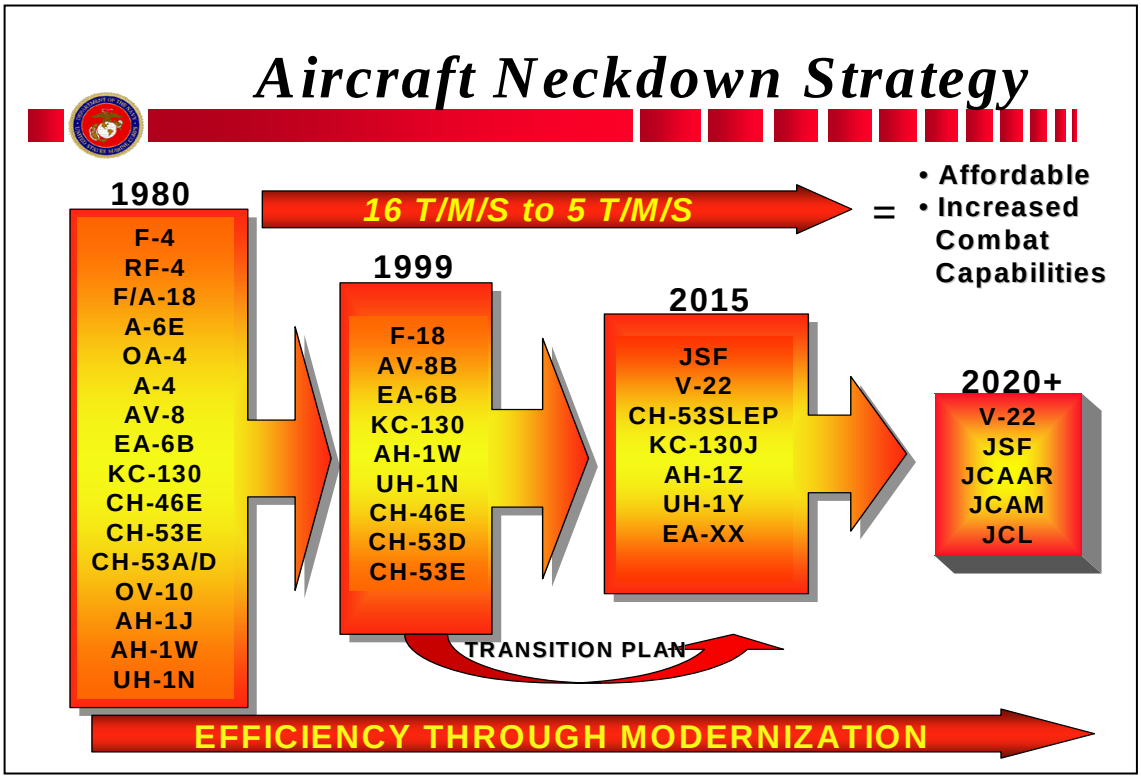

Figure 1. Marine Aviation Transformation

Source: Captain Vince Martinez, USMC, Assault Support Requirements Branch, Marine Corps Combat Development Command, November 2002.

Specifically, a fighting force that is sized, trained, and equipped with appropriate technology to conduct tomorrow's engagements, while simultaneously being prepared to

respond to today's conflicts. This "bridge to tomorrow" is the first major hurdle to overcome.

The Sikorsky CH-53E Super Stallion, currently the Marine Corps' heavy lift helicopter, is a prime example of the "bridge."[4] Originally designed to execute heavy lift externals of weapons and equipment, now it is more frequently sought as the primary long-range assault support platform.[5] Long-range assault and re-supply are two of the missions the Super Stallion executes in an exemplary manner. It has performed these worldwide, from the tropics of the Pacific region to the high deserts and mountains of Afghanistan.

The Super Stallion is, however, starting to show its age, particularly in the airframe and engines. The first CH-53Es entered operational service in 1981. Without a program to provide for the repair and remanufacture of the airframe and engines, the Marine Corps will suffer a significant degradation in capabilities. The capabilities reduction is directly attributable to the delays in fielding of the MV-22 Osprey, the increasing age, and decreasing capability of the CH-46E fleet. Is it necessary to ignore the CH-53E in the name of transformation, or is the institution of a program to ensure the continued performance of the CH-53E in support of the Marine Air Ground Task Force (MAGTF) required? It is accepted that change is necessary, as no system will last forever. However, two issues arise: (1) when will the change occur, and with what, and (2) in the process of change, is it necessary to neglect current programs and systems?

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[4] Marine Aviation Implementation Plan, Deputy Commandant for Aviation, Headquarters United States Marine Corps, Washington D.C. 2002, B-5. Cited hereafter as MAIP 2002.

[5] Assault Support is defined as the use of aircraft to provide tactical mobility and logistical support for the MAGTF within the immediate area of operations.

If the future of the CH-53E is not provided for either through airframe and engine remanufacture or via a full Service Life Extension Program (SLEP), then not only will the capabilities of today's Marine Corps be impacted but key future concepts such as Operational Maneuver from the Sea (OMFTS) and Ship to Objective Maneuver (STOM) will become untenable and invalid. OMFTS and STOM were designed to be supported by aircraft such as the CH-53E and the MV-22.[6] The MV-22 is still in the operational test phase and has yet to enter operational service. The venerable CH-46E Sea Knight is by definition and reality less capable than the Osprey. In addition to age, it lacks the capacity and range necessary to execute the envisioned missions both today and in the future. For these reasons, the CH-53E's have seen an increase in utilization rates. This notoriety is good for the heavy lift community as it highlights the diverse capabilities of the platform and its aircrews. It is at the same time detrimental, as the increased usage rates are hastening the approach of the airframe's end of service life. According to Aviation Programs Weapons (APW)-51, the utilization rates for the CH-53E have gone down despite increased tasking and increased support of the Marine Expeditionary Units (MEUs).[7] This is true, provided the complete inventory of aircraft is sampled. For specific units, however, the utilization rate per airframe in reporting status has increased significantly. There are some squadron aircraft routinely exceeding 20 to 30 hours per month of utilization vice the planned rate of 18.8 hours per month.[8] This increased rate without a defined and established program to provide for the future reliability of the CH-53E will result in a decrease in the helicopter's availability due to over use. The rate of

[6] MAIP 2002, B-5, 6.
[7] Major John Celigoy, USMC, Former Assault Support Programs, APW-51 email to author, subject: "CH-53 Modernization," dtd 22 October 2002.
[8] Captain Vince R. Martinez, 7 November 2002. Author's first hand observations and personal experience as a Maintenance Officer for two CH-53E squadrons.

reduction in availability will not necessarily be proportional to the increase in utilization. In order to realize the operational concepts of STOM and OMFTS, and be a viable heavy lift platform until 2025, the future of the CH-53E must be provided for.

The Concepts

The concept of transformation is being applied to more than just weapons systems and programs in the Marine Corps. According to the former Commandant of the Marine Corps, General James Jones, "the Marine Corps has a history of continuous innovation and adaptation… that makes us transformational by design."[9] In addition to technology, transformation requires a review of not only the organization, but also the concepts and principles defining force employment. As the then Commandant stated, "Expeditionary Maneuver Warfare (EMW) is the Marine Corps' capstone concept for its employment in the 21st century."[10]

Expeditionary Maneuver Warfare

> EMW is designed to exploit Marine Corps' core competencies, history of maneuver warfare, and the application of emergent technologies to achieve optimized forces ready for employment in support of the combatant commanders.[11]

The two enabling concepts of EMW are Operational Maneuver from the Sea (OMFTS) at the operational level, and Ship to Objective Maneuver (STOM) at the tactical level.

[9] United States Marine Corps Concepts & Programs 2002. Headquarters U.S. Marine Corps Programs and Resources Department (Code RPA): The Pentagon, Washington D.C. 2002, 2. Cited hereafter as Concepts & Programs 2002,12.
[10] Concepts & Programs 2002, 12.
[11] Concepts & Programs 2002, 12.

Operational Maneuver From The Sea

OMFTS is defined in Marine Corps Warfighting Publication (MCWP) 3-24 as "a concept for the projection of naval power ashore, based on innovations in military systems and equipment that diminish the natural barriers of the sea and the shoreline."[12] The world's seas and oceans comprise the majority of the earth's available maneuver space. OMFTS will provide commanders the freedom and flexibility of maneuver without the restrictions related to traditional land warfare or the amphibious assaults of old.

Ship-to-Objective Maneuver

At the tactical level, STOM is the concept by which amphibious operations will be conducted in support of OMFTS.[13] Specifically stated in MCWP 3-24, "STOM emphasizes tactical mobility, operational speed, and operational flexibility to counter enemy strengths and exploit enemy weaknesses."[14] One of the most important facets of OMFTS and STOM is the direct movement of the landing force to the objective without the necessity of first seizing and securing a beachhead from which to assault the actual objective.[15] The large logistics centers on the shore will no longer be required before or immediately following the commencement of initial offensive action. Instead, all necessary support will be retained and metered from naval shipping to the Ground Combat Element (GCE) via air or sealift. These concepts are considered to be more than just an expansion and maturing of the Marine Corps' previous operational and tactical concepts of

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[12] Marine Corps Warfighting Publication (MWCP) 3-24. *Assault Support*. Headquarters Marine Corps Washington DC, 2 August 1999, 6-1. Cited hereafter as MCWP 3-24 Assault Support.
[13] MCWP 3-24 Assault Support, 1999, 6-1.
[14] MCWP 3-24 Assault Support, 1999, 6-1.
[15] Lieutenant General Paul K. Van Riper, USMC, *Ship-To-Objective Maneuver*, United States Marine Corps Emerging Operational Concepts, Department of the Navy, MCCDC Quantico, Va., 25 July 1997, II-4. Cited hereafter as *Ship-To-Objective Maneuver*.

fire and maneuver, maneuver warfare, and amphibious assault. They are deemed transformational due to the inherent innovation and the adaptation of existing and emergent systems to support them. The objective of these concepts is, "to be able to do something previously unachievable or exponentially better than before."[16] The enablers for each of these concepts are the capabilities provided by the Aviation Combat Element's (ACE) Assault Support assets. "The Marine Aviation Implementation Plan (MAIP) provides the blueprint for how Marine Aviation, but more specifically how Assault Support Aviation, will support each of these concepts as an ever increasingly capable expeditionary force."[17] The assets serving as the foundation of these concepts are the MV-22 Osprey and the CH-53E Super Stallion.

[16] Concepts & Programs 2002, 3. Original STOM concept paper generated by Lieutenant General Paul K. Van Riper, MCCDC Quantico, Va., 25 July 1997.
[17] MAIP 2002, 1-1.

CHAPTER 2

HELO LIFT REQUIREMENTS

Mission Statements and Capabilities

Medium Lift

According to MCRP 5-12D, *Organization of Marine Forces,* the CH-46 Sea Knight's primary mission is:

> To provide assault transport of combat troops in the initial and follow-on stages of amphibious assault operations and subsequent operations ashore. A secondary function is the movement of supplies and equipment during amphibious and subsequent operations ashore.[18]

As a direct replacement for the CH-46, the MV-22 is intended to not only execute but also enhance the medium lift mission. However, the MV-22, "with in-flight refueling, a 2,100 nautical mile range, and high speed capability combined with its tilt-rotor technology will allow it to expand the medium lift, assault support missions and tasks."[19]

Heavy Lift

The CH-53E mission is to provide assault helicopter transport of heavy weapons, equipment, and supplies during amphibious operations and subsequent missions ashore.[20] Its fully articulated rotor head and impressive engine power make it extremely maneuverable despite its large size.[21] External transport of cargo is often the most expedient method of

[18] Marine Corps Reference Publication (MCRP) 5-12D, *Organization of Marine Forces,* MCRP 5-12D, Marine Corps Combat Development Command, Quantico VA. 13 October 1998. pg 3-29. Cited hereafter as MCRP-5-12D.
[19] MCRP-5-12D. 1998, 3-30.
[20] MCRP-5-12D. 1998, 3-28.
[21] MAIP 2002, B-5.

moving equipment and supplies in a combat environment and typically is the preferred method of cargo transport for the CH-53E. The CH-53E has both a single and a dual point external capability, each rated up to 36,000 pounds.[22] With a secondary mission of combat assault of troops (exclusive of the initial assault wave), the CH-53E is also capable in theory of seating up to 55 combat loaded troops with centerline seating installed.[23] The CH-53E is thus highly versatile and capable of long duration and/or range flight.[24] With aerial refueling, the CH-53E's range can be extended even further. A summation and comparison of aircraft capabilities is provided in table (1).

Table (1): Aircraft Capabilities Comparison[25]

Acft Type	Initial DoS	AirSpeed (KIAS)			Range (NM)			Pax Load		Weight (lbs)			
		Cruise	External	Max	Combat	Max	W/Ext	Avg	Max	Basic	Int	Ext	Max
MV-22	TBD	240	150-210	305	200	2100[a]	50[b]	24	24	33,140	10,000	10,000	60,500
CH-53E	1981	130	110-130	150	200	540[c]	50[b,c]	24	55	37,000	20,000	36,000	73,500
CH-46E	1963	100	80	145	100	450[e]	25[f]	10-12	18	18,000	3,000	4,300	24,300

[a] Maximum range with 1 Aerial Refueling is 2135 nm.
[b] External range given is for a maximum lift capability of: 10,000 pounds (MV-22) and 36,000 pounds (CH-53E).
[c] Range is unlimited with Aerial Refueling.
[d] HQMC administrative peacetime passenger restriction.
[e] Range with 1 internal range extension tank installed.
[f] External lift is not frequently executed. Range is dependent upon ambient condition, load weight and aircraft load.

A Heavy Lift History in Brief

Throughout the history of war, commanders and their troops have desired increased fire support via larger and more effective and efficient weapons with which to inflict the

[22] Naval Air Training and Operating Procedures Standardization (NATOPS) Manual. Navy Model CH-53E Helicopter, Washington, DC: Department of the Navy. March 31, 2000, I-2-81. Cited hereafter referred to as the CH-53E NATOPS.
[23] CH-53E NATOPS March 31, 2000, I-1-1.
[24] MAIP 2002, B-5.
[25] Table compiled from multiple sources; CH-46E and CH-53E NATOPS, MV-22 and Assault Support Requirements Program Managers.

maximum amount of damage and destruction on their enemy. The challenge has always been not only how to make these weapons available, but also how to move them on the battlefield in support of the troops. As weapons systems became larger, logistical support requirements correspondingly increased.

Over the millennia, everything used or consumed on the battlefield was carried on the backs of the soldiers, then pack animals, and finally by vehicle - both ground and air. By the close of World War II, a new element in aviation had appeared: nearly 400 helicopters were in service providing utility or rescue functions.[26] With the Korean Conflict came the desire for a means to move large amounts of equipment and supplies in rugged and unimproved areas. With a concept and a requirement identified, a means remained to be developed. This was not to receive significant attention for nearly 15 years. In 1965, two things transpired: The Soviet Union fielded a helicopter that lifted in excess of 55,000 pounds to an altitude of 9,318 feet,[27] and the United States Navy formally identified the requirement for the Heavy Lift Helicopter (HLH).[28]

The concept of rotary wing heavy lift in support of amphibious assaults in the United States Marine Corps can be traced to two roots: General Roy Geiger's observations during the first atomic tests at Bikini Atoll, from which he concluded that a World War II type amphibious Fleet with embarked Marines was extremely vulnerable to a nuclear attack; and the experiences of the Marine Corps in Korea.[29] However, the Navy and the Marine Corps' specified requirements were different. The Navy desired a means of effecting

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[26] Major Archibald M. McLellan, USMC. U. S. Marine Corps Command and Staff College Masters of Military Studies Paper, *Strategic and Operational Relevance of Heavy Lift in the United States Marine Corps: CH-53E Program.* Academic Year 2002, 7. Cited hereafter as McLellan, CH-53E Program MMS.

[27] CH-53E Program History, HQMC, APW-51, n.p. n.d.

[28] McLellan, CH-53E Program MMS 2002, 7.

[29] Major James D. Barich, USMC. U. S. Marine Corps Command and Staff College Masters of Military Studies Paper, *The History of Heavy Lift: Can the 1947 vision of an all heavy lift helicopter force achieve fruition in 2002?* Academic Year 2002, 4.

aircraft recovery, while the Marine Corps desired both an aircraft recovery capability and the ability to expeditiously execute the vertical lift of men and equipment from ship to shore.

The result of the Navy and Marine Corps' studies was a defined need for a heavy-lift rotary wing aircraft. The first attempt at a true heavy-lift aircraft resulted in the HR2S (CH-37 Mojave) in 1955, which was replaced in 1966 by the CH-53A and in 1977 the more powerful CH-53D, the Sea Stallions. In 1979, Sikorsky Aircraft Corporation forwarded a design improvement of the CH-53D Engineering Change Proposal (ECP) to the Department of the Navy for consideration and subsequent approval. The ECP called for an improved, more powerful, and more capable helicopter, one suited to the external lift and movement of the Marine Corps' M-198 howitzer, its gun crew and ammunition. The result of the ECP was the CH-53E Super Stallion: A 3-engined, 7-bladed, 100-foot long helicopter capable of lifting 16 tons.

Table (2): Evolution of Heavy Lift[30]

Acft Type	Years in Service	Airspeed (KIAS)		Range	Pax	Weight (lbs)	
		Cruise	Max	(NM)	Load	Basic	Max
CH-37	1955 to 1966	100	115	145	26	20,831	33,000
CH-54	1964 to1972	95	145	690	N/A	20,650	42,000
CH-47D	1962 to Present	140	155	613	44	23,401	50,000
CH-53A	1966 to 1991	120	130	257	36	22,444	40,000
CH-53D	1977 to Present	120	130	600	36	23,485	42,000
CH-53E	1981 to Present	130	150	540	37	37,000	73,500

30 *Jane's All the Worlds Aircraft 1961-1962*. John W. R. Taylor, Ed., (The McGraw-Hill Book Company, Inc., New York, 1961), pg 318; *Jane's All the Worlds Aircraft 1969-1970.* John W. R. Taylor, Ed., (The McGraw-Hill Book Company, Inc. New York, 1969), pp 436-437, *Jane's All the Worlds Aircraft 1993-1994.* Mark Lambert, Ed., (Jane's Information Group, Inc., Alexandria, Va., 1993), pp 455-457.

Since the fleet introduction of the CH-53E to HMH-461 in 1981, the Super Stallion has assumed other missions in addition to its primary one of heavy lift. It has been adapted to and assumed the additional roles as the primary aircraft for use during non-combatant evacuation operations (NEO), and the tactical recovery of aircraft and personnel (TRAP) missions. In its assault support transport role, the CH-53E is capable of carrying up to 37 combat loaded Marines 400 miles, or on longer missions by means of in-flight refueling. No other Marine helicopter has this capability, and only the U.S. Army's CH-47 comes close to matching it.

Recent History

The diverse capabilities of the CH-53E were demonstrated in 1995 in Bosnia, with the successful rescue of Captain Scott O'Grady, USAF, by two Marine Corps CH-53E's, escorted by AH-1W Cobras and AV-8B Harriers. Then in 1997 and 1998, the Super Stallion was in use on humanitarian assistance and peacekeeping operations in East Timor. More recently, it has demonstrated its extended range capability in the global war on terrorism. Six CH-53E's from two different Marine Expeditionary Units (MEU's), the 15th and the 26th:

> Joined forces, flew nearly 400 nautical miles inland from two different ships, under cover of darkness, conducted Night Vision Goggle (NVG) aerial refueling to insert 2 interim fast attack vehicles (IFAV) and 161 Marines into an austere and extremely dusty landing zone (LZ) that later became Camp Rhino, Afghanistan.[31]

This introduction of Marines into Afghanistan was made possible because of the diverse capabilities inherent in the CH-53E, specifically, long-range and large capacity. Five days

[31] Captain Jay M. Holterman, USMC, "The 15th Marine Expeditionary Unit's Seizure of Camp Rhino." *The Marine Corps Gazette*, Vol. 86, No. 6, June 2002, pp. 41- 43. Cited hereafter as Holterman "The 15th MEU".

after this insert, the forward operating base (FOB) of Camp Rhino was capable of sustaining an entire MEU.[32]

However, long-range insertion and extraction is not the primary mission of the CH-53E. Rather, the originally intended role and prescribed mission of the Super Stallion is for the execution of heavy lift, via internal or external transport ship to shore and around the battlefield. The movement of personnel is a secondary mission, one primarily assigned to the CH-46E, Sea Knight, and eventually to the MV-22 Osprey once it joins the operating forces. However, the Super Stallion has been executing this secondary mission with increasing frequency. This is due to two factors: the increasing inability of the engines to produce acceptable power to conduct external lift operations, and the consistently decreasing capabilities of the Sea Knight.

These detractors have led some senior commanders to institute local changes in their CH-53E's mission statement and standard operating procedures (SOP). Specifically, they have begun to focus on development and refinement of the long-range, over-the-horizon (OMFTS, STOM-like), tactical and operational procedures.[33] While it is good to exploit a particular capability, it should not be done to the detriment of the aircraft's primary mission. One result of this local change is the potential for creating a generation of heavy lift pilots lacking the proficiency and confidence in the execution of heavy lift external missions.

[32] Holterman, "The 15th MEU," 43.

[33] MAG-16 developed and executed two missions in 1996 and 1997, referred to as Desert Punch and Desert Thunder respectively. These missions consisted of an over the horizon airlift of a Marine Regiment. The purpose was to expose and familiarize aircrews to the challenges presented when operating in large helicopter flights, over long distances with different performance characteristics.

CH-53E Relevance

The CH-53E Super Stallion is currently the helicopter platform of choice for long range missions be it a raid, an insert, or the rapid build up or removal of personnel, supplies and equipment, such as in a Non-combatant Evacuation Operation (NEO) or Humanitarian Assistance (HA). The Marine Expeditionary Unit (MEU) and Marine Expeditionary Brigade (MEB) commanders regularly call for and rely heavily upon the Super Stallion's speed, range, and payload should a NEO situation develop. The heavy lift mission can still be executed in support of the NEO or another independent mission, if needed.

The CH-53E is an extremely capable platform. Its flexible means of employment is an asset to the Marine Corps and the Joint Force Commander. Routinely, Marines will employ their CH-53E's in support of Army, Navy, Air Force and Allied counterparts to execute missions that cannot or will not be executed by their own service air arms. For example, in Operation ENDURING FREEDOM (OEF), Marine CH-53E's flew numerous resupply and relocation missions in support of Army Special Operations Forces (SOF) in remote and mountainous locations. Army Task Force 160 and Air Force Special Operations aircraft did not normally operate during daylight hours.[34] High demands were placed on their limited helicopter resources, resulting in the SOF helicopters being unable to execute the daylight logistic missions.[35] Thus if the Marines were not executing these missions, soldiers would have been in the field in need or potentially left in harm's way.

Air movement of aircraft, weapons, equipment and supplies was the genesis for developing and procurement of the Super Stallion. Heavy lift was the CH-53's original mission statement, but due to the necessity to compensate for the aging CH-46 and delayed

[34] Captain Vince R. Martinez, USMC, MARCORSYSCOM Assault Support Requirements Program Manager, interview by the author, 15 January 2003. Cited hereafter as Martinez interview 15 January 2003.
[35] Martinez interview, 15 January 2003.

arrival of the MV-22 the Super Stallion has assumed much of the medium lift and troop transport roles as well. This trend will not only continue, it will increase until the majority of the 348 MV-22's enter operational service.[36] During the transition from CH-46's to MV-22's, the CH-53E will be relied upon even more. The Marine Corps and the CH-53 crews will be able to do this. However, without new life for the H-53, via new engines and remanufactured airframe, a serious problem will arise for the Air Combat Elements (ACE). Without a full or partial modernization program, the CH-53 will not survive to 2015 and the abilities of the MAGTF will thus decline. Even with a full MV-22 force, the previous capabilities of the MAGTF cannot be restored without the presence of the CH-53E.

The planned procurement of the MV-22 is far less than a direct one for one (MV-22 to CH-46E) replacement ratio. Budget cuts, program delays, mishaps, and ever increasing program costs, have seen the original 1989 planned procurement of 552 MV-22's suffer gradual reduction to 348 airframes as of 2002.[37] This reduction in the number of Ospreys to be purchased by the Marine Corps is due primarily to the rising program costs. The price of the MV-22 has risen from $34 million in 1994 to a current per copy estimate of $60 million or more.[38] Some estimates forecast the final production cost to be around $80 million.[39]

[36] Major Scott Harris, USMC, MARCORSYSCOM MV-22 Requirements Program Manager, interview by the author, 15 January 2003. Cited hereafter as Harris interview, 15 January 2003.
[37] Christopher Bolkcom, "V-22 Osprey Tilt-Rotor Aircraft." CRS Issue Brief for Congress IB86103. (Washington, DC: Congressional Research Service, Library of Congress, updated 5 November 2001), CRS-3.
[38] Harris interview, 15 January 2003.
[39] Harris interview, 15 January 2003.

CHAPTER 3

DOCUMENTING A NEED

Marine Aviation Requirements Study

The CH-53E is the only helicopter in the U.S. inventory that has not received a service life extension program (SLEP).[40] However, this is necessary if this aircraft is to execute the current and future Marine Corps concepts of OMFTS, STOM, and EMW.[41] Until the MV-22 Osprey enters full rate production (scheduled to begin at the earliest in FY2008), the CH-53E is the only rotary wing asset available to provide full or partial realization and validation of the ACE's aspect of these operational concepts.

The Marine Corps is mandated to be the force in readiness capable of responding to any global crisis that arises. As such, it is necessary to maintain the warfighting assets in a commensurate state of readiness and capability. The Marine Corps will fight in the near future with what is in the inventory today. In an attempt to determine the future needs of Marine Corps aviation, the Deputy Commandant of the Marine Corps for Aviation and the Commanding General of the Marine Corps Combat Development Command (MCCDC) sponsored the Marine Corps Aviation Requirements Study (MARS).[42]

The study, completed in August 2001 by the Center for Naval Analysis (CNA), attempted to identify the Marine Corps' complete aviation requirements across the spectrum of operations. Four major scenarios were investigated in the MARS: Peacetime,

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[40] Major David J. Dowling, USMC, "The future of heavy lift in support of expeditionary maneuver warfare." *Vertiflite*, Vol. 48, No. 2, Spring 2002, pp 44. Cited hereafter as Dowling 2002.
[41] Dowling 2002, 44.
[42] Dr. Gary Phillips, and others, Marine *Aviation Requirements Study: Summary Report*, August 2001. (Center for Naval Analysis Research Memorandum D0003922.A2/Final). Washington D.C., 1. Hereafter cited as CNA MARS 2001.

Major Theater War (MTW), Small Scale Conflict (SSC), and MEU. This study asked two questions,

> What aviation support is required for joint and combined MAGTF operations in peacetime, wartime and combinations thereof and how do these fiscally unconstrained air support requirements translate into numbers of aviation systems required?[43]

The analysis also updated a previous CNA study of 1989 and increased the period of observation out to 2015.[44] Simply stated, the CNA study was done to determine the correct numbers of aircraft and squadrons required for the Marine Corps to complete its assigned roles and missions.

The MARS concluded that a force structure consisting of 17 to 19 medium and 6 to 8 heavy lift squadrons could support peacetime requirements.[45] Therefore, today's present force structure is sufficient to support the anticipated peacetime requirements out to and beyond 2015.[46] The study assumed that the CH-46E and CH-53D would be replaced by the MV-22 on a one for one basis and that the current CH-53E would still be in service.[47] CNA also investigated the benefits of modernizing the CH-53E.[48] A summation of CNA findings of the aviation requirements to support the four different scenarios is provided in table (3).[49]

[43] CNA MARS 2001, 1.
[44] CNA MARS 2001, 1.
[45] CNA MARS 2001, 4.
[46] CNA MARS 2001, 1.
[47] CNA MARS 2001, 2.
[48] CNA MARS 2001, 2.
[49] CNA MARS 2001, 10.

Table (3). Future Squadron Requirements[50]

Current Structure		Future Requirement: Active + Reserve (deployable) Squadrons					
Aircraft Type	**Active + Reserve Squadrons**	**Future Aircraft**	**Peacetime Active + Reserve**	**MTW**	**MTW + MEU**	**Peacetime + SSC**	**MTW + SSC + MEU**
CH-46E	17	MV-22[a]	21	21.7	22.9	26.0	27.9
CH-53D[b]	3						
CH-53E	8[c]	CH-53E	8	8.3	8.7	9.8	10.5

a. Current Transition plan is for 17 active and 4 reserve MV-22 squadrons.
b. CH-53D squadrons to be phased out and replaced by MV-22's.
c. Two Reserve CH-53E squadrons are slated for be transition to MV-22's.
Source: Center for Naval Analysis Marine Aviation Requirements Study, 2001.

Certain assumptions were made by CNA in attempting to determine tomorrow's aviation requirements. The study's findings were based on the application of these assumptions. According to one unofficial assessment, the MARS made several questionable assumptions:[51]

-The current force structure is correct for the future.
-The baseline metric was the MV-22 fleet, meaning alternative aircraft were critiqued against the MV-22 and not the Marine Corps' optimal needs.
-Artificial limitations imposed on comparison aircraft.
-Performance parameters were incorrect for the CH-53E.

The following assumptions should be included and do have an impact on the results of the study since both result in fewer CH-53E's being available:

-Reserve CH-53E squadrons planned conversion to MV-22's.
-Reduction in CH-53E fleet.

First, MARS did not take into account that both of the CH-53E reserve squadrons are slated to convert to MV-22's. This will reduce the total number of CH-53E squadrons and in turn decrease the number of heavy lift assets available to the Marine Corps.

[50] CNA MARS 2001, 12.
[51] McLellan CH-53E Program MMS, 2002, 22.

Second, the MARS requirement for the CH-53E is for three more squadrons than exist in the Marine Corps today. This shortfall will increase based on the number of CH-53E's projected to complete SLEP. Of the 163 aircraft in the inventory, the proposed SLEP Operational Requirements Document (ORD) is planning to provide for 111 aircraft.[52]

The CNA study contains additional errors. The Marine Corps' planned purchase of MV-22's is 348 airframes. This is six squadrons worth of aircraft short of the 26 squadrons delineated in the MARS (Peacetime + SSC).[53] The number of medium lift squadrons presently maintained in the Marine Corps is one less than that recommended by the MARS. CNA further noted that a difference in squadron composition exists. A reserve squadron has only eight aircraft vice the 16 in a regular squadron.

Finally, the MARS was completed using two key planning assumptions:

-Increased aircraft availability.
-Higher sortie capability.[54]

These are ambitious given the present uncertainty associated with the CH-53E's future and the reliance on the untried MV-22. If sortie rates or aircraft availability percentages do not increase, more aircraft will be required than table (3) depicts. Second, if the scope of the CH-53E SLEP is not defined and implemented immediately, the number of available aircraft will be reduced. This reduction in availability will not support increased sortie rates.

In the MTW scenario, a Marine Expeditionary Brigade's GCE, a Regimental Landing Team (RLT) requires movement of its forces ship-to-shore and around the battlefield.[55]

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[52] Bonholtzer 2002, 2.
[53] CNA MARS 2001, 12. Peacetime and SSC were considered to constitute the majority of the missions and roles. If sufficient aircraft existed in PT+SSC then adequate support would be available in/for the remaining two scenarios.
[54] CNA MARS 2001, 13.
[55] CNA MARS 2001, 24.

The MARS findings determined that CH-53Es were necessary to complete the initial and subsequent movements. However, the study failed to take into account actual CH-53E capabilities and the current manner of employment. The CH-53E maximum passenger load is 32 (without centerline seating installed), but peacetime constraints limit the maximum capacity of the Super Stallion to 24 passengers.[56] In the event of a MTW, it is doubtful that the maximum combat load would not be used. In Afghanistan, for example the standard load is 30-Marines. MAGTF commanders are empowered to, and routinely do, deviate from the 24-passenger restriction.

The movement ashore of an RLT will require 388 sorties, 264 by MV-22 and 124 by CH-53E.[57] To ensure the tactical mobility and readiness of the RLT daily sustainment is necessary. This is where the lift capability of the CH-53E will be necessary, specifically in the ship-to-shore movement of supplies and equipment outlined in STOM. To support the 3045 troops and 225 vehicles of an RLT, a total daily requirement of 3 million pounds of supplies in all classes will be required.[58] The Osprey is not capable of supporting this requirement alone, as the number of sorties required will exceed those available from the supporting aircraft. Without this capability, other options must be considered. The amphibious shipping supporting the MEB must either move closer to the shore and secure a beach-landing site for air cushioned landing craft (LCAC's) and LCU's, or go forward without the necessary equipment and logistics support. Neither of these options is in keeping with the objectives of STOM.

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[56] Advertised passenger loads range from 37 to 55; however, this HQMC restrictions set the maximum peacetime capacity at 24. Centerline seats must be installed to carry 55 Marines and severely restricts loading and unloading evolutions. Seats and seatbelts must be provided for each passenger, limiting passenger loads to 32.

[57] CAN MARS, 2001, 26

[58] "Assault Support Lift Requirements: Preliminary Requirements Analysis." Information Brief. Assault Support Requirements, Marine Corps Combat Development Center. Provided January 2003 by Capt Vince Martinez, USMC.

Future Possibilities

To be truly transformational, the Marine Corps should consider establishing its future acquisition requirements based on defined capabilities. Then it must procure those systems or aircraft which provide those capabilities in sufficient quantities to allow the respective force providers to tailor their forces to achieve the desired end state (Figure (2)).

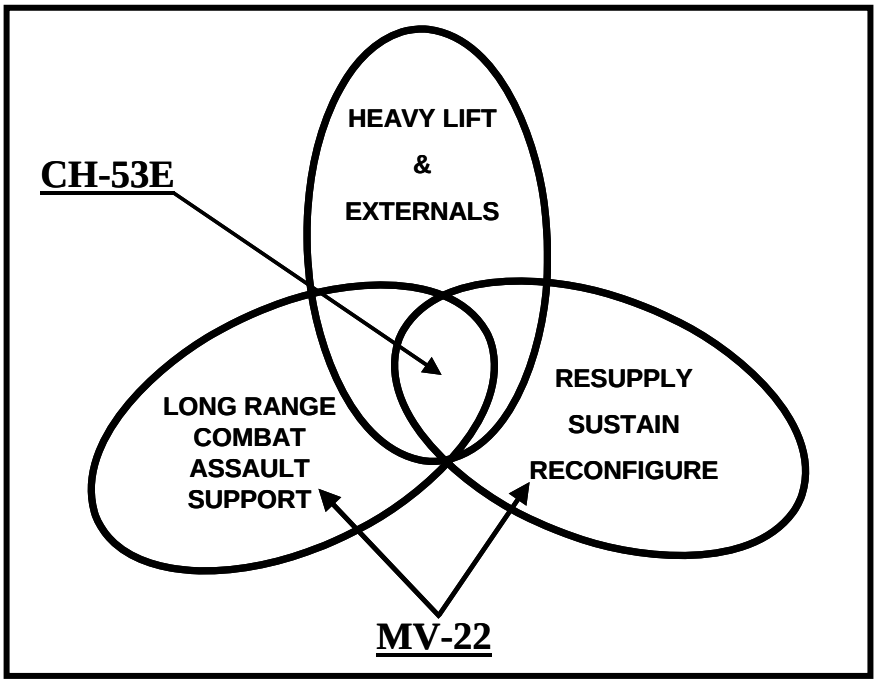


Figure 2. Capabilities required to support OMFTS/STOM.

One way to ensure this would be mirror composite MAGs, each containing the same number and distribution of aircraft types or an "Assault Support Group."[59] It would consist of a MAG comprised of one squadron of each type of aircraft in equal and sufficient numbers to support its associated MEU, similar to the Air Force's Air Expeditionary Wing concept.

[59] McLellan CH-53E Program MMS, 2002, 39.

Another possible solution might be three very diverse, but *Task Focused*, MAGs or MAWs. In each Marine Aircraft Wing (MAW), the same types of aircraft would be present, but in different numbers based on the most commonly executed mission profiles of each. In 1st MAW, for example, MAG-36 might consist of primarily heavy lift helicopters (CH-53Es) and long-range transports (C-130s) with an equal mix of medium lift (MV-22s) and attack (AH-1Zs) platforms.

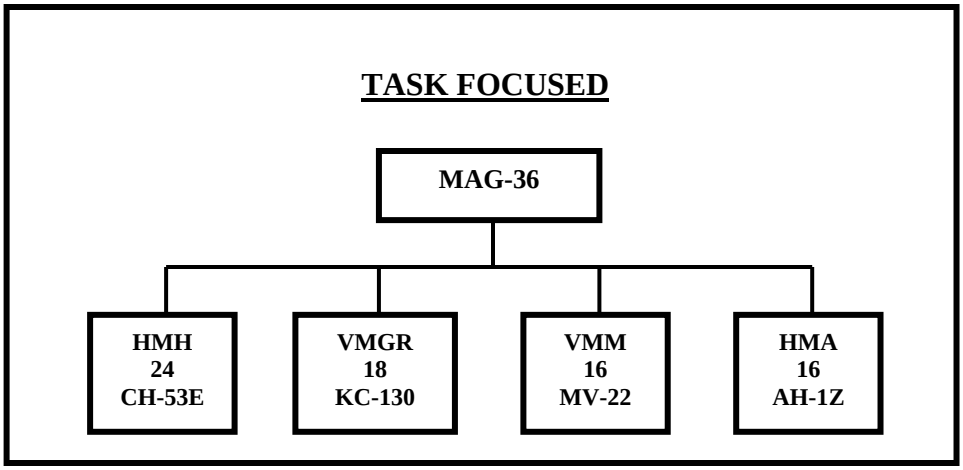


Figure 3. Notional Assault Support Group (ASG).

ASG composition would be based on geographic constraints/requirements. Composition allows execution of all necessary assault support functions.

While 3rd MAW and its subordinate MAGs might be comprised mostly of F/A-18 or JSFs, MV-22's, AH-1Zs and a only a single CH-53 squadron. This is similar to present MAG organization, but does not require duplicate squadrons or mirror MAGs.

CHAPTER 4

CH-53E CAPABILITIES

Why is the CH-53E SLEP Needed?

The Super Stallion is entering a stage in its service life that all other Marine Corps helicopters have been through: the need for an engine upgrade. The current engines (T64-GE 416 and 416 A) are showing signs of fatigue and age. On average the power output, while still sufficient to safely sustain flight, routinely fails to produce acceptable minimum power to conduct external or heavy lift operations. Every other aircraft in the Marine Corps' inventory has received either upgraded engines, overhaul of their airframes, or both. The CH-53E has received neither.[60]

In 1992, NAVAIR commissioned a Service Life Assessment Program (SLAP) study to determine the actual service life limit of the CH-53E airframe. The results of the SLAP (conducted by Sikorsky Aircraft Corporation) concluded that the service life of the CH-53E is 6120 flight hours due airframe fatigue.[61] The SLAP findings detailed new structural inspections and compiled a list of components and systems that would require updating for continued reliability. It also identified specific sections of the airframe requiring redesign and/or replacement for continued safe operation of the CH-53E's assigned mission profiles. The Weapons System Planning Document (WSPD) provided a utilization rate of

[60] Dowling, 2002, 44.
[61] Captain V. R. Martinez, USMC, MCCDC Information Paper 17 June 2002, 1. Cited hereafter referred to as Martinez info paper.

18.8 flight hours per month.[62] When present aircraft utilization rates versus the in-service dates of the airframes were compared, it was projected that CH-53E inventory would drop below the Primary Aircraft Authorization (PAA) of 16 in FY2011 (Figure 4).[63]

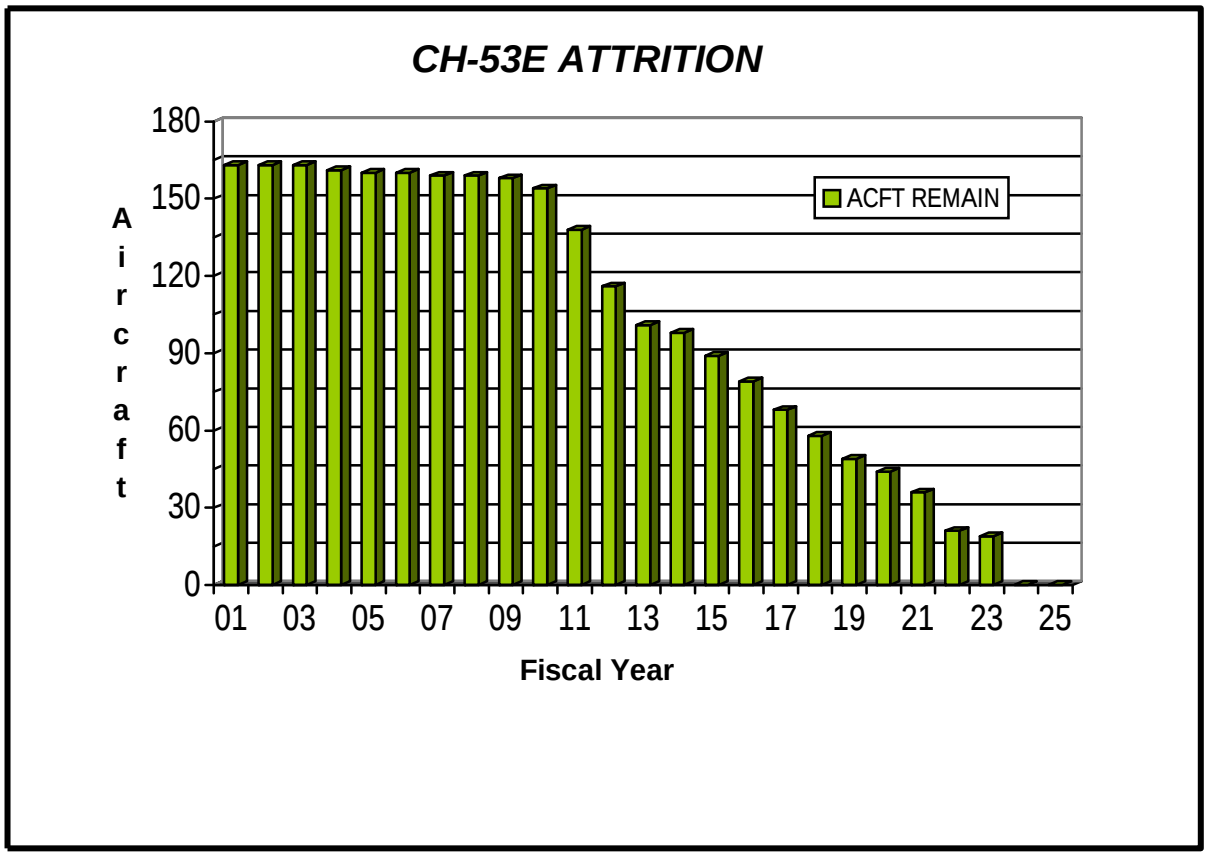
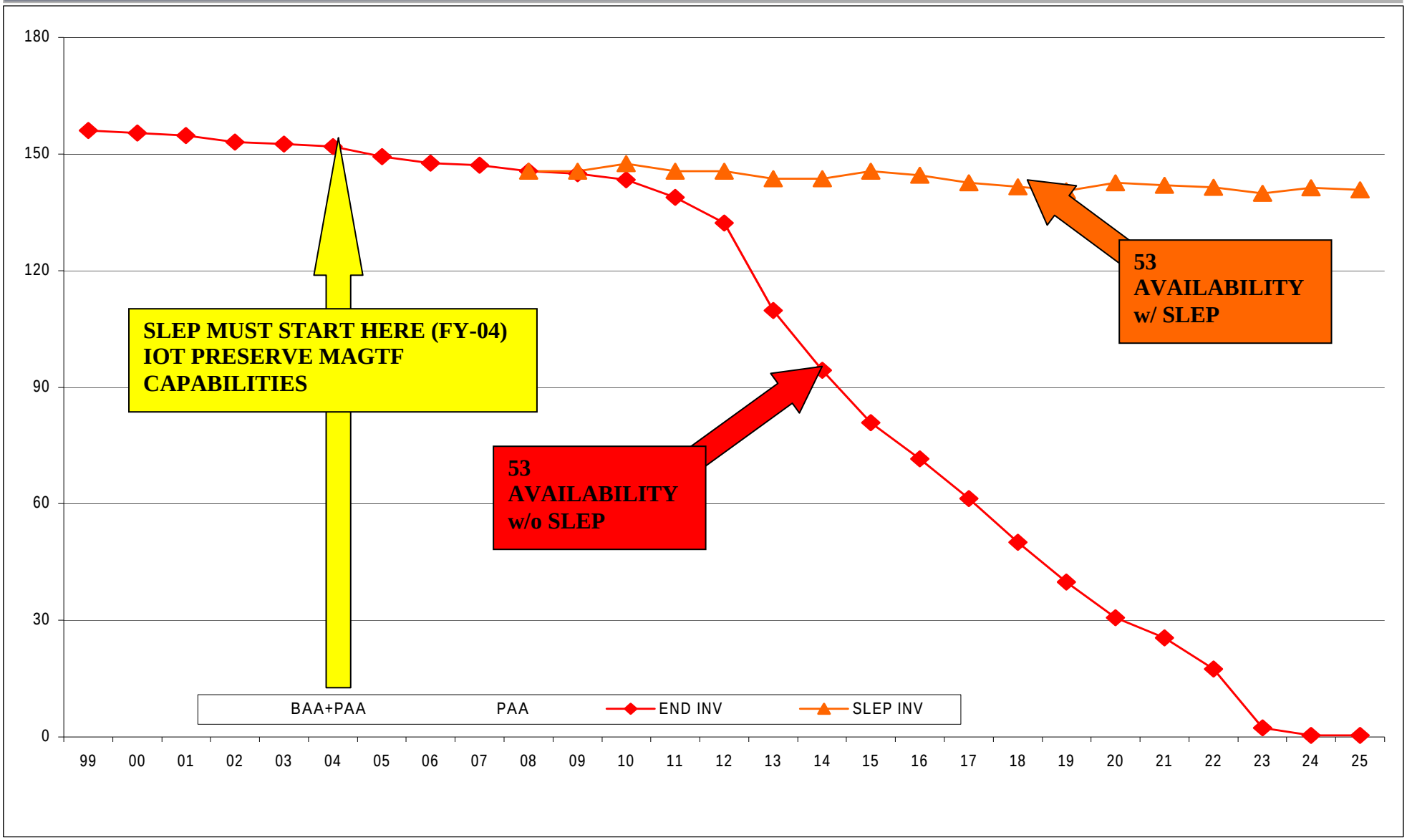


Figure 4. Anticipated Retirement CH-53E Schedule
Source: APW-51 CH-53X Information Brief

These assumptions were made before Operation's ENDURING FREEDOM and the IRAQI FREEDOM, and the subsequent increased utilization of the Super Stallion Fleet. Figure (5) is a graphic representation, generated by the APW-51 office depicting the

[62] Weapons System Planning Document (WSPD) defines the expected service life of an aircraft or system based on the anticipated use rate verses the total number of assets available.
[63] Martinez Info Paper 17 June 2002, 2.

CH-53E Fleet Inventory
(W/ & W/O SLEP)



anticipated inventory depletion date from which a no later than SLEP execution date was determined to ensure minimum impact on the MAGTF's combat assets.[64]

Engine degradation is also a key contributor for the necessity of a service life extension. A new engine or one rebuilt to original specifications should produce 4380 shaft horsepower.[65] Performance charts in the CH-53E Naval Aviation Training and Operations Procedures Standardization (NATOPS) manual are designed to account for an acceptable engine degradation of up to 7% below specification power.[66] With increasing frequency, engines installed on fleet aircraft are not producing the minimum acceptable power or failing their hourly inspections due to low power output.

In an attempt to reduce the numbers of engines being removed from aircraft and sent to the intermediate level maintenance facilities, (the Marine Aircraft Logistics Squadrons (MALS)) engines were being rebuilt to a lower specific power output equivalent to a 12% degradation.[67] This reduction in specific power was done without the knowledge of the operators and operational level maintainers.[68] The provided justification for reducing the power available (P_a) from 7 to 12 percent was to promote engine longevity vice enabling the maximum available power to be obtained.[69] As the engine performance continues to decline with advancing age, so does the lift capability of the CH-53E, (i.e. reduced carrying capacity). Figure (6) provides a graphic representation of the current system weights and aircraft capabilities.

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[64] CH-53X (CH-53E Upgrade Program)." Information Paper. Headquarters Marine Corps, Aviation Programs and Weapons-51, 18 October 2000, 2, 3. Cited hereafter as APW-51 CH-53X Brief.
[65] CH-53E NATOPS March 31, 2000.
[66] CH-53E NATOPS March 31, 2000. Specification power is the power output of a newly manufactured engine.
[67] "Assault Support Lift Requirements: Quick-Response Analysis." Information Brief. Assault Support Requirements, Marine Corps Combat Development Center. Provided March 2003 by Captain Vince Martinez, USMC. Cited hereafter as Martinez Quick Analysis Brief.
[68] Martinez Quick Analysis Brief, March 2003.
[69] Author's personal experience as Maintenance Officer, based on of an engine performance working group meeting debrief held at MCAS Miramar, Spring 2001.

Heavy Lift – Payload/ Range 35º C

MAA Branch

S & A Division

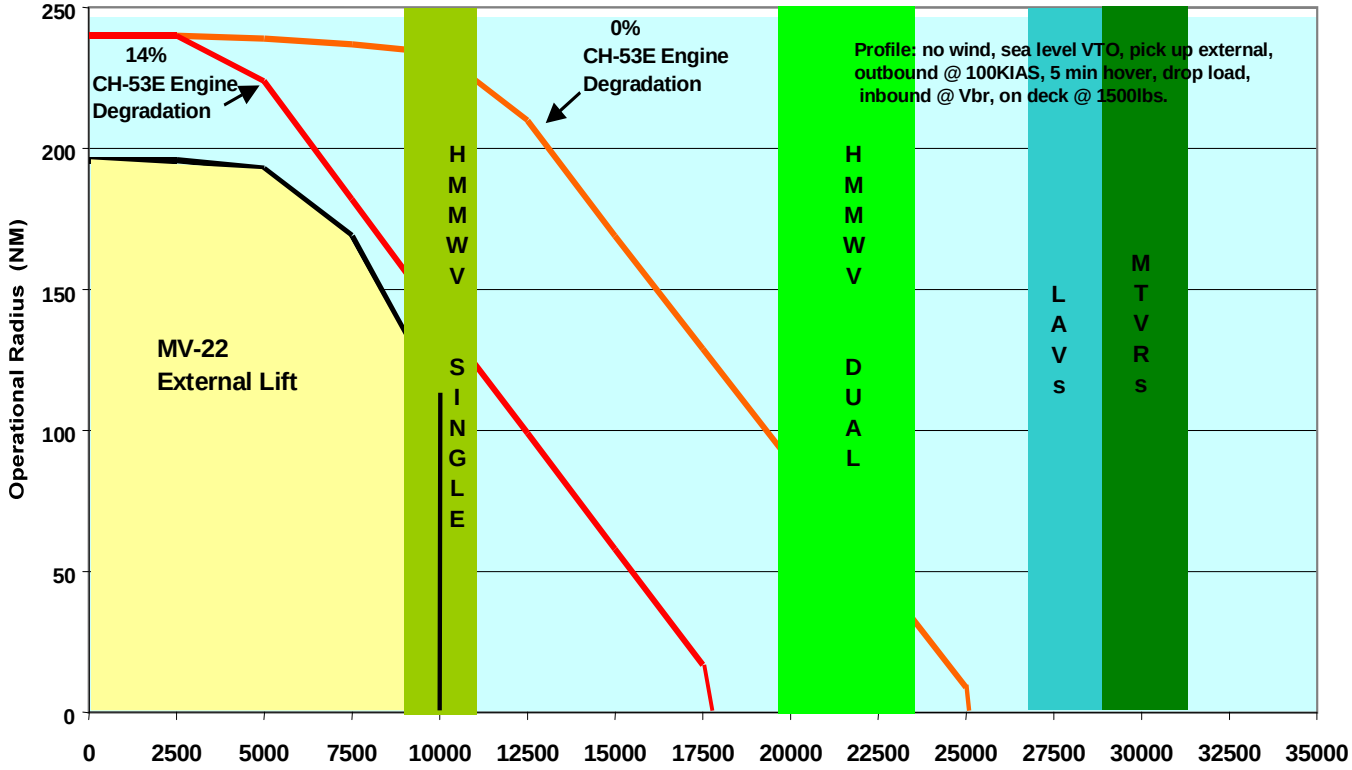

Figure 6. Heavy Lift Payload vs Range

Source: Preliminary Requirements Analysis Brief, Captain V. R. Martinez,MCCDC .

Complicating this difficult engine situation is the additional need for airframe modifications. The designed service life limit of the airframe, specifically the main transmission beams, bulkheads, and vertical pylon components, is 6200-6500 flight hours (Figure 7). As of the end of fiscal year 2001, the average age of the CH-53E fleet was 13 years with an average accumulated flight time of 3500 hours.[70] Some airframes are over 21 years old and have accumulated over 5000 hours.[71] No new engines have been procured since 1999, the delivery date of the last CH-53E to the Marine Corps. Yet most significantly, the aircraft is flying 20 percent more than last year.[72]

The implications are clear: This increased utilization has made the need for a service life extension program (SLEP) vital to ensure the continued safe operation of the Super Stallion, the safety of the Marines that fly them and fly in them, and mission accomplishment. Of the originally delivered 165 aircraft, 153 are still in service with one retired in early 2002 and two more scheduled for retirement by the end of 2003.[73] Seventy-two aircraft are presently slated for retirement on or before 2015, without implementation of some variation of SLEP. Given the setbacks and delays in the Osprey program and the decreased abilities of the CH-46, it is essential that the Marine Corps decide and execute a plan to refit, remanufacture the present aircraft, or purchase new additional CH-53E's.

The originally proposed SLEP would have resulted in the aircraft receiving new engines, and airframe rework and repairs to ensure operational service out to FY 2025. With transformation came a requirement to do things better than before, vice just

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[70] James C. Garman. "An affordable solution to heavy lift." *Vertiflite*, Vol. 48, No. 2, Spring 2002, 40.
[71] Garman, 2002, 40.
[72] Frank Colucci. "Marine Corps mulling over options for heavy lift helos." *National Defense Magazine*, 23 September 2002.
[73] Celigoy, 22 October 2002. Projected aircraft retirements based on forecasted end of service life.

Figure 7. Service Life Extension Airframe Modifications

Source: APW-51 CH-53X Information Brief

continuing with the status quo. To validate the cost of the SLEP, or a modernized 53E, with transformation the desired performance parameters have been altered. The modernized 53E is to have an increase in lift capacity of 5,000 lbs from 73,500 to 78,500 pounds, with a new emphasis placed on operations conducted in high, hot, and heavy conditions. These conditions are defined as a pressure altitude of 3,000 ft and an ambient temperature of 91.5 degrees Fahrenheit.[74] In these conditions, the present CH-53E is only able to lift a 7,000-pound load to a maximum range of 200 nautical miles.[75] However, with the new Rolls-Royce/Allison engine and improved rotor blades will enable the 53 SLEP to be capable of transporting a 28,000-pound load from amphibious shipping to a distance of 200 nautical miles under nearly all ambient conditions (Figure (8)).[76]

The improvement of the Super Stallion is necessary. From the perspective of the GCE, there presently exists a shortfall in its warfighting ability. While the CH-53E can make the rapid build up of combat power on or near the objective feasible, it can presently only accomplish this by inserting Marines. The most lethal and significant fire support asset that can be inserted with the assault force is the Interim Fast Attack Vehicle (IFAV) or armored High Mobility Multi-purpose Wheeled Vehicle (HMMWV). The improved or modernized 53E will allow the GCE to have the option of having their 28,000-pound, Light Armored Vehicles (LAV) inserted as part of the assault force.

Additionally, over time the weight of the GCE's equipment has increased (Table (4)). While some new systems were designed to reduce weight, the Light Weight 155mm (LW155) Howitzer for example, most systems are getting markedly heavier.

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[74] APW-51 CH-53X Information Brief, 2000, 2.
[75] APW-51 CH-53X Information Brief, 2000, 2; Martinez Information Paper, 17 June 2002, 3.
[76] Ambient conditions are those atmospheric variables of air temperature, pressure altitude, and relative humidity present at the time the aircraft is operating in a given area

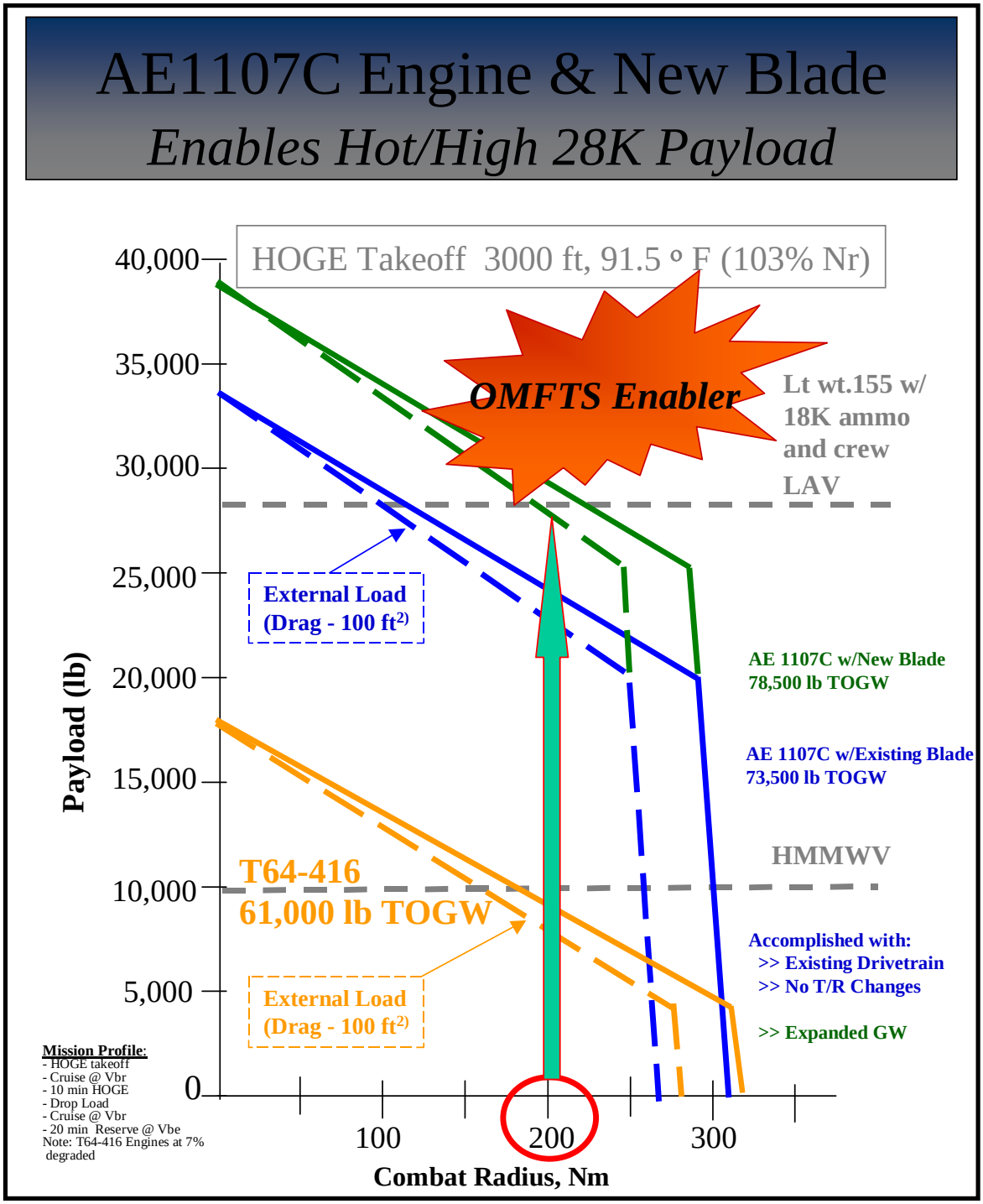

Figure 8. Performance Increase
Source: APW-51 CH-53X Information Brief.

Table (4): USMC System Weights

CURRENT SYSTEM	WEIGHT (Lbs)	FUTURE/IMPROVED SYSTEM	WEIGHT (Lbs)	DELTA (Lbs)
M939/M809 (5-Ton Truck)	23,000	MTVR (7-Ton Truck)	29,500	6,500
M-198	17,500	LW-155	9,500	-8,000
HMMWV	5,400 to 8,500	H-HMMWV	Up to 10,300	1,700 to 4,900
CH-46E	15,537	MV-22	33,150	17,613
AV-8B	14,900	JSF	22,500	7,600
N/A	----	HIMARS	28,000	28,000
LTVP-7 AAV	46,314	AAAV	62,880	16,566

The M-198 howitzer's prime mover was the 5-ton truck weighing 23,500 pounds. However, its upgraded prime mover, the MTVR, is a 7-ton capacity vehicle weighing 29,500 pounds. A proposed fire support asset, the High Mobility Artillery Rocket System (HIMARS) currently has a design weight of 28,000 pounds. Equipped in this manner, the GCE will be able to get to the fight quickly via the MV-22 or in mass via the CH-53E, but it will be under armed. Unless the fire support and transport systems get lighter or a new lift platform is procured, the GCE will no longer be able to expeditiously get to the fight with adequate fire support or battlefield mobility.

Planned GCE transformation is to include the procurement of a new "fire support triad" comprised of the LW-155 towed system (FY2003), the HIMARS, and the expeditionary fire support system (EFSS).[77] If this new fire support triad is not air-mobile due to the lack of a suitable air capable platform or reduced sealift, the GCE's combat effectiveness will be severely diminished. The MV-22's designed external lift capability is 10,000 pounds,

[77] According to MCCDC Requirements Branch, the LW-155 Howitzer is scheduled for delivery to the operating forces in FY2003, followed by the HIMARS , a tracked multi-tube rocket artillery system in FY2007. The specific composition of the EFSS has yet to be determined; one variation is a towed or vehicle mounted 120mm mortar system.

allowing only the LW-155 howitzer to accompany the GCE to the fight. Additional aircraft will have to be provided to move the 7,500 pounds of ammunition and the 8 to 12 man gun crew. However, the LW-155 must be inserted before or after the assault force since the MV-22's speed advantage is negated during the conduct of externals. Maximum airspeed is a function of the aerodynamic properties of the load being transported, not the platform conducting the lift. The maximum airspeed of a majority of the air transportable loads is at or below 130 knots airspeed.

Service Life Extension Program (SLEP)

Many questions arise when discussing the options of modernization or SLEP for the CH-53E. These include:

What will the SLEP entail?
What should it include?
What performance benefits will be realized?
How many airframes should be modernized?
Why should new money be spent on old technology?
Is the CH-53E modernization/SLEP affordable?

The last question is perhaps the most contentious issue. It is accepted Marine Corps-wide that the CH-53E SLEP is absolutely necessary. It has also been recommended by the Center for Naval Analyses (CNA) and further endorsed by the key leadership of the Marine Corps.[78] However, programs that are perceived as in competition with or can be considered as posing a threat to the MV-22 generally are ill received and thus quickly cast aside. This is even more relevant in these times of reduced budgets and competing

[78] Dr. Gary Phillips, Major Eric Damm USMC, Dr Tom Bowditch, Mr Anton Jareb and Mr Robert Benbow. *Marine Aviation Requirements Study: Summary Report.* (Center for Naval Analysis Research Memorandum D0003922.A2/Final). Washington D.C., August 2001, 1,12. Cited hereafter as CNA MARS 2001.

programs. When the discussion turns to cost and competition, then the composition of the SLEP program is questioned because of expense and not necessity or purpose.

In accordance with recommendations specified in the two CNA studies, MARS and MEB 2015, which were endorsed by the Deputy Commandant of the Marine Corps for Aviation and requested by operators at the user level, concurrence existed at all levels that a service life extension program (SLEP) for the CH-53E was necessary.[79] However, major differences existed as to what the exact scope of the SLEP was to include.

Regrettably, the delay in program implementation comes directly from what an approved SLEP will include. All involved with the program desire a more capable aircraft that will continue to provide heavy lift and flexibility to the operating forces. However, the program cost remains as the major hurdle. One of the key benefits of SLEP is to be the reduction in operating and sustainment (O&S) costs. CH-53s are an expensive aircraft to operate and maintain. They currently have the highest cost per hour of any aircraft in the Marine Corps.[80] Comptrollers and supply officers desire lower O&S costs, but hesitate when confronted with the proposed component costs associated with the airframe improvement.

The fleet needs an aircraft capable of performing to its advertised parameters, while the appropriations committees desire a capabilities increase in return for the investment. The operational forces top priorities were engine improvements (new and more powerful engines, or remanufacture of existing power plants to original specifications), selected airframe overhaul and improvement and upgraded avionics. Notably, these would not represent an improvement of the current capabilities of the Super Stallion; rather, they

[79] CNA MARS 2001, 22.
[80] Celigoy, 22 October 2002.

would only be the minimum improvements necessary to ensure the ability of the aircraft to perform its specified and assumed roles and missions.

At the 2002 Assault Support Operational Advisory Group (OAG)[81] annual meeting, representatives from the operating forces assembled to present their priorities for funding to the program office as a united single voice. The OAG resulted in the establishment of the seven pillars of the CH-53E SLEP. These are:[82]

Structural Life Extension (SLE) – modification and repair of the airframe.
Common Engine (Performance Enhancer) – more power, program cost reduction.
Improved Cargo Handling System – enhanced on/off-load capability.
Elastomeric Rotor Head – increase performance, operating cost reduction.
Improved Main Rotor Blades (Performance Enhancer) – increase in lift and performance.
Common Cockpit – reduce pilot workload, increase situational awareness.
Combat Survivability – modernize aircraft protection systems.

Based on an analysis of alternatives consolidated by MCCDC's Requirements Branch, three proposed alternatives for the CH-53E SLEP now exist: SLEP Lite, SLEP Remanufacture, and SLEP New Manufacture. Each addresses or includes portions of or all of the seven pillars defined by the OAG.[83]

SLEP Lite

SLEP Lite would consist of four key elements:

Tail section replacement.
Improved T64 engine reliability.
Improved cargo hook handling system.
Critical survivability upgrades.

[81] The Operational Advisory Group is an annual meeting sponsored by the Aviation Programs and Weapons (APW) Branch of HQMC. Its purpose is to review the status of current aircraft systems, modifications and improvements. An additional function is to sample all the operators to refine current issues and address any new requirements.
[82] Martinez Info Paper 17 June 2002, 1.
[83] Martinez Info Paper 17 June 2002, 4.

This option could be implemented the soonest, with a forecasted initial operational capability (IOC) of FY 2009.[84] It would consist of the remanufacture of the airframe to refurbish the high fatigue areas of the main gear box (MGB) platform, bulkheads, and the vertical stabilizer. These areas have the shortest service life and have been frequently found to have fatigue and stress fractures. Additionally, the existing engines would be upgraded to the MV-22's AE1107C engine manufactured by Rolls-Royce/Allison. Adaptation of the MV-22's engine would result in a gain of 1320 to 1820 shaft horsepower (depending on ambient conditions).[85] A second benefit of adapting the Rolls Royce engine to the CH-53E is parts commonality. Future maintenance activities would have fewer engines and related components to stock and service. Engine commonality also decreases the purchase price of the engine for the Marine Corps and in turn decreases SLEP costs.

Initially, SLEP Lite appears as the least expensive and thus the most attractive solution to the appropriations officers. It would return modified aircraft back to the operating forces approximately one year from the date of induction. However, over the long-term it would be more costly and subject to piecemeal implementation, budgetary attacks, and program compromises, all eventually resulting in additional expenditures with minimal returns. Also, if this level of SLEP is implemented, another engine replacement or upgrade would be required to ensure availability out to FY 2025 due to continual degradation of the existing engine.[86]

[84] Martinez Info Paper 17 June 2002, 2.
[85] APW-51CH-53X Information Brief 18 October 2000,3.
[86] Martinez Info Paper 17 June 2002, 4.

SLEP - Remanufacture

SLEP Remanufacture would consist of a seven-step upgrade:[87]

Structural Life Extension (SLE).
Common Engine (Performance Enhancer).
Improved Cargo Handling System.
Elastomeric Rotor Head.
Improved Main Rotor Blades (Performance Enhancer).
Common Cockpit.
Improved Survivability.

This second, and more involved option, consists of the addition of new rotor blades, advanced avionics, and rotor head in addition to the SLEP Lite improvements. This option would include an all titanium, elastomeric rotor head. The addition of this new and improved rotor head would be the most significant contributor to a reduction in the operating and sustainment costs over the current CH-53E. However, this new rotor head is the single most expensive component and becomes the focus of the pro-transformation, anti-legacy, cost reduction committees. The long term operating and sustainment cost savings are missed when compared to the price of the new rotor head. This version of the SLEP is forecasted IOC for FY 2012 and would result in the loss of each airframe from service for over a year.

SLEP - New Manufacture

The third proposal for SLEP is the SLEP New Manufacture.[88] This version would entail the reopening of the assembly line as well as the following improvements:

New Structure/Airframe.
Expanded capabilities of existing dynamic components.
Increased gross weight capability.
Common engine.

[87] Martinez Info Paper 17 June 2002, 2.
[88] Martinez Info Paper 17 June 2002, 3.

Common cockpit.
Improved rotor head.
Improved blade.
Improved cargo handling system.
Improved aircraft survivability.

This third CH-53E SLEP option is the most involved and the most expensive. It consists of the procurement of additional new aircraft and the full remanufacture of existing airframes. The full remanufacture portion would require two different periods. The first, Block A with a potential IOC of FY 2008, would include upgrade, repair, or installation of all the listed items except the main rotor head and the improved blades.[89] The second portion, Block B, would consist of the retrofit of the new main rotor head and main rotor blades. Block B would have the potential for IOC in FY 2011.[90] Completion of both upgrade blocks would return a fully capable and enhanced heavy lift asset to the operating forces.

Commensurate with this option is a proposal to reopen the assembly line and acquire more CH-53E's to ensure continued availability of the aircraft to the Marine Corps while the older aircraft are completing the SLEP cycle. This is not only the most expensive option; it is also the most involved of the three. It does ensure, however, that a fully capable enhanced heavy lift or long-range rotary wing assault platform would exist in support of the MAGTF and the various combatant commanders out to FY 2025.

The Costs

The reservations and arguments against either the remanufacture or new purchase is cost justification. The reported cost of a new-build aircraft, a new aircraft with limited

[89] Martinez Info Paper 17 June 2002, 3.
[90] Martinez Info Paper 17 June 2002, 3.

additional new technology (a modern glass cockpit, new radios, navigational aids and engines), is between $50 and $60 million dollars per aircraft.[91] This increase in cost per aircraft from $26 million results from the need to reconstitute the CH-53E assembly line that has been closed for almost four years. The planned improvements also contribute to the higher per aircraft cost.

The estimated cost to execute either SLEP Lite or SLEP Remanufacture is between $25 and $60 million dollars per airframe.[92] The final figure will depend upon the level of remanufacture approved and the number of aircraft to complete the SLEP.

A driving force behind the modernization of the CH-53E is its present operating costs. For the majority of the CH-53E's operational history, the average cost per hour (CPH) was $3300.[93] This changed drastically in 1996, when the entire CH-53E fleet was grounded by NAVAIR in response to a series of swashplate failures and subsequent investigations as to the causal factor. Due to the high maintenance time with no associated flight time accrual, the CPH rose to $6000. The fleet was grounded again in 1999 for additional swash-plate modifications and upgrades to the tail rotor disconnect coupling; this resulted in an increase in the CPH to $11,500 by FY00.[94] At the close of fiscal year 2002, the CH-53E CPH had risen to $13,500.[95] As the Super Stallion continues to age, the operating cost will continue to rise.

The SLEP was additionally designed to reduce the operations and support (O&S) costs and the maintenance man-hour (MMH) per flight hour costs. The top 10 (O&S) costs associated with the CH-53E are listed below:

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[91] Celigoy, 22 October 2002.
[92] Celigoy, 24 October 2002.
[93] Based on author's personal experience as a Wing Level Rotary Operations Officer, Squadron, and Group level Operations and Maintenance officer. Historical average of $3,300 CPH spans the years from 1981 to mid-1995.
[94] Dowling, 2002, 45.
[95] Major John Celigoy, USMC, former APW-51, e-mail interview, 24 October 2002.

1. Nacelles.
2. Main Rotor Head.
3. Swash-plate.
4. Main Rotor Blade.
5. General Relay Panel.
6. Engine Starter.
7. AFCS Computer.
8. #2 Engine Inlet Duct.
9. Pylon Hinge Pin Cylinder.
10. Disconnect Coupling.

*SLEP only addresses #2 and #4 of the top 10 O&S cost drivers listed above.[96]

Reducing the MMH per flight hour would result in an immediate decrease in the 53E's CPH. The CH-53E is a labor-intensive aircraft and age is increasing the number of hours of maintenance that must be performed. To keep the CH-53E flying, currently 46 MMHs per flight hour are required.[97] The engine nacelles have been identified as a major, if not the most, significant man-hour intensive component on the aircraft. Due to several reasons (their location on the aircraft, composition, mishandling, and aircraft induced stress) the nacelles (more commonly referred to as engine cowlings) crack frequently and occasionally fail completely.

The main rotor head assembly is the next most labor-intensive component. The Super Stallion's rotor assembly relies on heavy weight oils and hydraulic fluid to function and is referred to as a *wet head.* This design has performance benefits, but it is also more labor intensive than the *dry* or elastomeric rotor heads installed on the older CH-46 and CH-53D.

During an initial SLEP briefing by Sikorsky representatives in 2002, the full modernization plan was presented. This brief emphasized the increased lift capabilities of 28,000 pounds to 200 nautical miles, in high pressure altitudes (PA) and hot temperatures.[98] 3000ft PA and 91.5 deg F and 28,000 pounds are referred to as the high,

[96] Martinez Info Paper 17 June 2002, 1.
[97] Capt Vince Martinez, USMC. "Assault Support Lift Requirements: Preliminary Requirements Analysis." Information Brief. Assault Support Requirements, Marine Corps Combat Development Center. January 2003.
[98] APW-51 CH-53X Information Brief, 2000, 2,3.

hot, and heavy domain. This has been determined to be a key performance parameter (KPP) by Marine Corps Systems Command's (MARCORSYSCOM) Assault Support Requirements Branch.[99] More importantly, a modernized CH-53E would only be able to perform to this standard if the complete proposed SLEP components were installed. A partial or piecemeal installation would provide only minor improvements over current capabilities. This is a concern to operators as historically new programs and systems frequently experience concessions due to reductions in funding. The result is system implementation without full program support. This is done to get the product into the operating forces with the assumption that follow-on funding for the system or program can be recouped or increased later. Some of the systems introduced to CH-53E in this manner have included the Global Positioning System (GPS), Forward Looking Infra Red (FLIR), Ground Proximity Warning System (GPWS), and Night Vision Device Heads-Up-Display (NVD HUD). Without the necessary program support, the full benefits of a modernized CH-53E will not be achieved and the future of the Super Stallion will degrade into a liability vice a MAGTF combat multiplier.

The issue is the need to provide for the CH-53E's future. This has been successfully identified and for the first time in aviation program history funding has been provided for a program without an approved Operational Requirements Document (ORD).[100] What remains to be determined is the SLEP composition. Delays in implementing the SLEP for the CH-53E will in no way benefit the Marine Corps in the future and could result in this aircraft's SLEP losing its funding to other programs.

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[99] Captain Vince R. Martinez, USMC. Assault Support Requirements Branch, Marine Corps Combat Development Center, interview by author, 11 October 2002.

[100] Martinez, Info paper 17 June 2002, 2. The CH-53E SLEP has had funding allocated for the Research, Design, Test and Evaluation (RDT&E) program in increasing amounts from $3 million in FY-03 to $336 million dollars in FY-07.

Logistics Enabler

A service life extension program is necessary to prolong the operational capability of the CH-53E in support of the Marine Corps. However, an existing issue must first be addressed. Specifically, is there a valid heavy lift mission for the CH-53E? Under the current administration, forces and systems must be justified. The basis of justification is what capabilities are required and are they transformational?

Loads in excess of 10,000 pounds will have to be transported via other means, surface or air. Presently, the other means of ship-to-shore mobility are via landing craft utility (LCU), air cushioned landing craft (LCAC), or by CH-53E. The CH-53E allows the ship-to-shore movement of both men and equipment. Sea and surface movement require a safe and secure landing beach or harbor to disembark their cargo, and are not in the spirit of the current and future Marine Corps concepts. Specifically OMFTS, STOM, and Sea-Basing are designed to negate the necessity of establishing a secure beach landing area or port for off-load, thus allowing for maximum maneuverability by the assault force.[101]

Despite claims that the Marine Corps is a light force, the force is actually getting heavier. Reports from both Army and Marine Corps units supporting Operation ENDURING FREEDOM state that combat troops are taking more gear into the field in order to sustain themselves there. The more remote the location, the more the soldiers load.[102]

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[101] *Ship-To-Objective Maneuver*, 25 July 1997, II-4.

[102] Based on author conversations with recent participants in OEF. The GCE, CSSE and ACE representatives all reported that the previous planning figure for combat loaded infantry personnel has increased from a generic 200lbs to 285 to 300 lbs.

The Super Stallion is more suited as a logistics enabler. The cargo capacity (both total weight and size) available in the CH-53E is a significant benefit and it is for this very reason logisticians prefer the CH-53E as a cargo transport platform. With the future of Marine Corps operations relying on sea-basing and over the horizon (OTH) operations, resupply, and sustainment necessitate the CH-53E in the inventory. The MARS study included in its baseline assumptions that the CH-53E or an improved version would be available.[103] Unless a suitable replacement for the Super Stallion is identified and fielded in the near term, the tenets of Expeditionary Warfare, OMFTS, STOM, and Sea-basing are not possible. Additionally, it is reported that the heavy lift external mission constitutes seven percent or less of all the external lifts.[104] However, based on the current trend of increasing weights and a recurrent necessity to move cargo containers and bridging equipment, logisticians will still require and seek out the Super Stallion's capabilities.[105]

An emergent challenge for the combat commander will be not only how to get his heavier loaded Marines to the fight in vehicles (air, land, and sea) with smaller capacities, but how to sustain them. The MV-22 and the Advanced Amphibious Assault Vehicle (AAAV) both have reduced troop capacities compared with those systems they are replacing. If only personnel are required to be air transportable, an all-medium lift force might be appropriate and CH-53E's would then be no longer necessary. However, the combat troops constituting the assault force would have only their organic weapons and equipment that is configurable into loads of 10,000 pounds or less.

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[103] CNA MARS 2001, 12.

[104] Martinez, interview December 2002.

[105] During an interview with a MEU logistician, one of the questions fielded was, "How would the MEU be impacted if no CH-53Es were available?" The response: "it would be next to, if not totally, impossible to efficiently and effectively complete administrative or tactical offloads."

Today, the HMMWV inventory is being upgraded and improved. These improvements equate to a heavier vehicle. Only one HMMWV is external lift transportable by the Osprey. Super Stallions have the ability to external a dual-HMMWV load and their associated crews. In this configuration, the load weight is 17,000 pounds. A similar package lifted by Ospreys would require one aircraft making three separate trips or three aircraft executing the lift. This example reveals a 3:1 MV-22/CH-53 ratio required to insert the same force and is reflected in the present CH-46 to CH-53 distributions. The MEU ACE also maintains this ratio in the 12 to 4 distribution of the “46” to “53” mix. This distribution becomes invalid if the GCE scheme of maneuver requires M-198 or the newer LW-155 howitzers to be lifted and inserted as part of the assault wave. The characteristics of the CH-53E are the epitome of "do more with less"; when compared to the Osprey, however, the reverse is not applicable. More MV-22’s would still not enable the air movement of the howitzers due to the weight of the loads. More aircraft cannot make up for the lack of a heavy lift platform. It is simple: to lift a heavy load you need a heavy lift platform.

Tactical Recovery of Aircraft and Personnel

Without a heavy lift asset, the Marine Corps will also be without a platform capable of executing the tactical recovery of aircraft and personnel (TRAP). The CH-53E can lift and recover all current Marine Corps aircraft in its inventory with the exception of the KC-130 (Figure (9)). Exclusive of the larger transport and bomber aircraft, nearly all U. S. military fighter, attack, and helicopter aircraft are retrievable by the CH-53E. The MV-22 is not

even able to retrieve another Osprey. No service can afford to write-off recoverable and repairable aircraft, particularly in today's environment of billion dollar systems and limited budgets.

Figure 9. Tactical Aircraft Recovery.
Source: Unknown

For example, one of the first missions in support of Operation ENDURING FREEDOM for the CH-53E was the successful retrieval of an U.S. Army UH-60 Black Hawk helicopter in October 2001.[106] Had the 15th MEU (SOC) not been in theater or if its Aviation Combat Element had deployed without CH-53's, the special operations H-60 would have required destruction.

Another reason for providing for the longevity of the CH-53E fleet is to ensure that force commanders have an airlift capability, heavy or other. Budget cancellations,

[106] Laurence McQuillian and Andrea Stone. "Mystery Attackers Fire at U. S. Forces in Pakistan." *USA Today*, 24 October 2001, 7.

program delays, and a series of accidents have all contributed to shifts in the Osprey's introduction into the operating forces, now scheduled for FY 2008. Even if future Osprey pilots are front-loaded soon enough to be deployable commensurate with the MV-22's operational debut, a lapse in assault support available to the fleet will exist. A combination of limited MV-22 squadrons and the reduced CH-53E availability associated with the SLEP will contribute to an overall decrease in available helicopter support to a MAGTF. As such, the remaining operational CH-53s and CH-46s will have to assume the burden of support. The result: During the transition from CH-46 to the MV-22, there will be insufficient medium lift assets in the fleet. To provide for this pending shortfall, the CH-53E needs to be ready and capable of assuming its assigned share of assault support missions in support of the Marine Corps and the Nation.

Summary

It is necessary to finalize the composition of the CH-53E SLEP to start the immediate refurbishment of the aircraft. Should the MV-22 Osprey program experience further delays or be cancelled, the CH-53E will be relied upon even more for the execution of both its primary mission of heavy lift, while also assuming the missions of medium lift assault support aircraft. However, an increase in one mission profile will only serve to expedite the demise of the other. Full production or cancellation of the Osprey does not alleviate the requirement to expedite the implementation of the CH-53E's SLEP as both aircraft have been identified as essential to achieve the objectives established in the Marine Corps' future tactical and operational concepts. Continued delays in beginning SLEP serves to decrease the future capability of the Super Stallion to perform its heavy lift mission due to

engine degradation. Increased utilization associated with increased operational tempo is contributing to the acceleration of the programmed retirement schedule of the airframe. Without the CH-53E the Marine Corps' future concepts of OMFTS, STOM, and ultimately EMW will be unexecutable, as each was based upon the capabilities of the CH-53E. Additionally, even if a suitable and more capable replacement for the CH-53E was identified, current acquisition cycles are not conducive to the timely procurement and fielding of it. For example, the MV-22 has spent nearly 20 years in the cycle. The Marine Corps cannot afford either the time or money to repeat this while determining the follow-on for the CH-53E. Our adversaries will not wait for the Marine Corps to be ready.

CHAPTER 5

CONCLUSION

The CH-53E SLEP must be provided for immediately. While the usefulness of the CH-53E until 2025 could be questionable due to unforeseen and rapid technological advances, there is a definite need for its capabilities today and in the near future. Without the flexibility, range, and capacity the Super Stallion provides, Marines will not have a viable means with which to get to the fight. Present and future Marine Corps' operational concepts will not be supportable with the MV-22 alone. OMFTS, STOM, and Sea-basing require the capabilities that both the Osprey and the CH-53E Super Stallion provide.

The CH-53E SLEP composition must be finalized and funded immmediately to ensure the continued availability of the aircraft in support of OMFTS and STOM through 2025. Three SLEP varaints have been proposed and are being evaluated. SLEP Lite is the least costly and impacts the operating forces the least, but while revitalizing the CH-53E airframe it does not result in a performance increase. SLEP Lite returns the present advertised capabilities and will require further future engine improvements. The second version, SLEP Remanufacture, provides for the longevity of the airframe, increases the range and capacity, and modernization of the instrumentation and avionics. The third version, SLEP New Manufacture, is the most expensive and most intensive. However, it does more than ensure the longevity of the aircraft to support the operating forces. This version is transformational, the performance increases associated with new engines and an upgraded airframe will allow the CH-53E to lift more and go farther than is presently

possible. Reopening the assembly line to produce and procure additional aircraft will ensure CH-53E availability to the operating forces during the modification of the older aircraft.

Further impediments in program approval and execution will result in the Marine Corps' inability to be a force in readiness, unable to ensure the nation's security and stability in the world. The CH-53E was the solution to an identified lack of capability in the Department of the Navy, specifically heavy lift. Range, flexibility, and adaptability are but a few of the beneficial by-products of the CH-53E. The Super Stallion and its heavy lift mission must be provided for today to ensure the capabilities of the Aviation Combat Element and the readiness of the Marine Corps to properly perform its role in an increasingly uncertain and troubled world.

APPENDIX A: List of Acronyms

AAV	Amphibious Assault Vehicle
AAAV	Advanced Amphibious Assault Vehicle
ACE	Aviation Combat Element
ACFT	Aircraft
AOA	Analysis of Alternatives
ANVIS	Aviator Night Vision System
APW	Aviation Programs and Weapons
AR	Aerial Refueling
ASP	Assault Support Program
CMC	Commandant of the Marines Corps
CNA	Center for Naval Analysis
CNO	Chief of Naval Operations
CPH	Cost Per Hour
COE	Concept of Employment
DoD	Department of Defense
DoN	Department of the Navy
EBFL	Extended Boom Fork Lift
EMW	Expeditionary Maneuver Warfare
Ext	Externals
FAV	Fast Attack Vehicle
FLIR	Forward Looking Infrared
FOC	Full Operational Capability
FTR	Future Tilt Rotor
GAO	Government Accounting Office
GCE	Ground Combat Element
GPS	Global Positioning System
HAR	Helicopter Aerial Refueling
H-HMMWV	Heavy Variant High Mobility Multipurpose Wheeled Vehicle
HIMARS	High Mobility Artillery Rocket System
HLR	Heavy Lift Replacement
HMH	Marine Heavy Helicopter Squadron
HMLA	Marine Light Attack Helicopter Squadron
HMM	Marine Medium Helicopter Squadron
HMMWV	High Mobility Multipurpose Wheeled Vehicle

HMT	Marine Heavy Helicopter Training Squadron
HQMC	Headquarters Marine Corps
HUD	Heads-Up Display
IFAV	Interim Fast Attack Vehicle
IGB	Intermediate Gear Box
IOC	Initial Operational Capability
JCAAR	Joint Common Attack
JCL	Joint Common Lift (Medium & Light)
JCAM	Joint Common Assault & Multi-Role (Heavy)
JSF	Joint Strike Fighter
JTF	Joint Task Force
JTR	Joint Tilt Rotor
KIAS	Knots Indicated Airspeed
KPP	Key Performance Parameters
KTS	Knots
LAV	Light Armored Vehicle
Lbs	Pounds
LCAC	Landing Craft Air Cushioned
LCU	Landing Craft, Utility
LHA	Amphibious Assault Ship – General Purpose
LHD	Amphibious Assault Ship – Multipurpose
LPD	Amphibious Transport Dock (Ship)
LPH	Amphibious Assault Ship – Helicopter
LW155	Light Weight 155mm Howitzer
MACP	Marine Aviation Campaign Plan
MAIP	Marine Aviation Implementation Plan
MAG	Marine Aircraft Group
MAW	Marine Aircraft Wing
MAGTF	Marine Air-Ground Task Force
MARDIV	Marine Division
MARFORLANT	Marine Forces Atlantic
MARFORPAC	Marine Forces Pacific
MARFORRES	Marine Forces Reserve
MARS	Marine Aviation Requirements Study
MARCORSYSCOM	Marine Corps Systems Command
MAWTS-1	Marine Aviation Weapons and Tactics Squadron-1
MCAS	Marine Corps Air Station
MCCDC	Marine Corps Combat Development Command
MEB	Marine Expeditionary Brigade

MEF	Marine Expeditionary Force
MEU	Marine Expeditionary Unit
MGB	Main Gear Box
MMH	Maintenance Man Hour
MTW	Major Theater War
M198	155mm Artillery Piece (Towed)
NATOPS	Naval Aviation Training and Operational Standardization
NEO	Non-combatant Evacuation Operation
NGB	Nose Gear Box
Nm	Nautical Mile
NVD	Night Vision Devices
NVG	Night Vision Goggles
OAT	Outside Air Temperature
O&S	Operating and Sustainment
OMFTS	Operational Maneuver from the Sea
OPEVAL	Operational Evaluation
OPLAN	Operational Plan
OPTEMPO	Operational Tempo
ORD	Operational Requirements Document
OSD	Office of the Secretary of Defense
OT&E	Operational Test and Evaluation
OTH	Over-the-Horizon
P_A	Power Available
PA	Pressure Altitude
PAA	Principle Aircraft Authorization
PMA	Program Management Activity
P_R	Power Required
QTR	Quad Tilt Rotor
RDT&E	Research Development Test and Evaluation
RGR	Rapid Ground Refueling
SLAP	Service Life Assessment Program
SLEP	Service Life Extension Program
SOC	Special Operations Capable
SOF	Special Operations Forces
SOW	Statement of Work
SPMAGTF	Special Purpose Marine Air-Ground Task Force
SSC	Small Scale Contingency
STOM	Ship to Objective Maneuver

TBFDS	Tactical Bulk Fuel Dispensing System
TERF	Terrain Flight Regime
TGB	Tail Gear Box
T/M/S	Type Model Series
TOR	Terms of Reference
VMM	Marine Medium Tiltrotor Squadron
VMMT	Marine Medium Tiltrotor Training Squadron
WSPD	Weapon System Planning Document
WTI	Weapons and Tactics Instructor

APPENDIX B: Definitions

Ambient Conditions – those atmospheric variables; air temperature, pressure altitude, and relative humidity present at the time the aircraft is operating in a given area

Assault Support – the movement of high-priority cargo and personnel within the immediate area of operations, in-flight refueling, and the evacuation of personnel and cargo.

Bureau Number (BUNO) – BUNO's are numbers that are assigned to an airframe during production for identification and record keeping purposes. Aircraft of a specific type/model and series are routinely referred to by this term (number).

Nacelle – a housing attached to an airframe or wing in which the engine assembly is mounted.

Primary Aircraft Allocation (PAA) – The number of aircraft authorized to be held at the Squadron level. A CH-53E squadron's PAA is 16.

Power Available (P_a) – that specific power produced by an engine under a given set of atmospheric (ambient) conditions. Those conditions in which the engine is operating.

Power Required (P_r) – the minimum necessary power necessary to sustain or execute a flight maneuver, such as takeoff or external lift.

Rotor head – Main component of a helicopter, where the rotor blades are attached.

Swash Plate – a component of the helicopter drive train that transmits pilot control inputs into movements of the rotor head and rotor blades.

Sortie – a single flight evolution, usually consisting of one take off and one landing.

Weapons System Planning Document (WSPD) – defines the expected service life of an aircraft or system based on the anticipated use rate verses the total number of assets available.

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