



Supportability for the V-22 Osprey

Title	Supportability for the V-22 Osprey
Item Type	Thesis
Authors	Torres, Angela S. Stanmore
URI	https://hdl.handle.net/10945/10006
Publisher	Monterey, CA; Naval Postgraduate School
Date Issued	2005-12
Download date	2026-04-14 10:43:47
Link to Item	https://hdl.handle.net/10945/10006

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MBA PROFESSIONAL REPORT

**Supportability Requirements for the
V-22 Osprey**

**By: Angela S. Stanmore Torres
December 2005**

**Advisors: Nayantara Hensel
Carmelita Troy**

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REPORT DOCUMENTATION PAGE			<i>Form Approved OMB No. 0704-0188</i>
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington DC 20503.			
1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE December 2005	3. REPORT TYPE AND DATES COVERED MBA Professional Report	
4. TITLE AND SUBTITLE: Supportability for the V-22 Osprey			5. FUNDING NUMBERS
6. AUTHOR Angela S. Stanmore Torres			8. PERFORMING ORGANIZATION REPORT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000			10. SPONSORING / MONITORING AGENCY REPORT NUMBER
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A			10. SPONSORING / MONITORING AGENCY REPORT NUMBER
11. SUPPLEMENTARY NOTES The views expressed in this report are those of the author(s) and do not reflect the official policy or position of the Department of Defense or the U.S. Government.			
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.			12b. DISTRIBUTION CODE
13. ABSTRACT (maximum 200 words) The purpose of this MBA Project was to investigate and provide a comprehensive analysis of the supporting requirements for the V-22 Osprey from the perspective of the United States Navy and Marine Corps. The primary objective was to assist in determining the specifics that will be necessary to support the successful fielding of the weapons system. Various analysis techniques help identify and document specific requirements including training, spares, and the contracting options that will be necessary to support the overall weapons system from "tip to tail".. This report also includes potential outliers or issues related to the current plan. The benefit of choosing a commercial support plan in the form of Performance Based Logistics versus a traditional government supportability plan is measured in readiness. Impacts to cost over the lifecycle of the weapons system are measured in flying hours per dollar.			
14. SUBJECT TERMS Performance Based Logistics, Program Management, Performance Contract Management, Major Force Programs			15. NUMBER OF PAGES 81
			16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UL

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SUPPORTABILITY FOR THE V-22 OSPREY

Angela S. Stanmore Torres, Lieutenant, United States Navy

Submitted in partial fulfillment of the requirements for the degree of

MASTER OF BUSINESS ADMINISTRATION

from the

NAVAL POSTGRADUATE SCHOOL

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SUPPORTABILITY REQUIREMENTS FOR THE V-22 OSPREY

ABSTRACT

The purpose of this MBA Project was to investigate and provide a comprehensive analysis of the supporting requirements for the V-22 Osprey from the perspective of the United States Navy and Marine Corps. The primary objective was to assist in determining the specifics that will be necessary to support the successful fielding of the weapons system. Various analysis techniques help identify and document specific requirements including training; spares and contracting options that will be necessary to support the overall weapons system from “tip to tail”. Also included in this report are potential outliers or issue related to the current plan. The benefit of choosing a commercial support plan in the form of Performance Based Logistics versus a traditional government supportability plan is measured in readiness. Impacts to cost over the lifecycle of the weapons system are measured in flying hours per dollar.

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LIST OF ACRONYMS AND ABBREVIATIONS

AFCAIG

Air Force Cost Analysis Improvement Group

AFSOC

Air Force Special Operations Command

APOD

Aerial Port of Debarkation

BIT

Built in Test

CDT

Contract Depot Team

CLS

Contractor Logistics Support

CONUS

Continental United States

CPFH

Cost Per Flight Hour

DLR

Depot Level Repairable

DMMH/FH

Direct Maintenance Man-hour per Flight Hour

DO

Director of Operations

DOD

Department of Defense

DON

Department of Navy

DPEM

Depot Purchased Equipment Maintenance

FOC

Full Operational Capability

FSL

Full System List

GSD

General Support Division

HQ

Headquarters

HD/LD
High Demand Low Density

IMPAC
International Merchant Purchase Authorization Card
IOC
Initial Operational Capability

JORD
Joint Operational Requirement Document

KPP
Key Performance Parameters

LSA
Logistics Support Analysis

MESL
Mission Essential Systems List
MC
Mission Capable
MFHBA
Mean Flight Hours between Abort
MFHBCF
Mean Flight Hours between Critical Failure
MFHBFlog
Mean Flight Hours between Failure Logistics
MMH/FHOrg.
Maintenance Man-hours per Flight Hour Organizational
MRSP
Mobility Readiness Spares Package

NCA
National Command Authority
NMC
Not Mission Capable
NMCS
Not Mission Capable Supply

OCONUS
Outside of the Continental United States
ORD
Operational Requirements Document

PBA
Performance Based Agreement
PMC
Partial Mission Capable

R&M
Reliability and Maintainability

SOF
Special Operations Forces

TAI
Total Aircraft Inventory
TBD
To Be Determined
TNMCS
Total Non Mission Capable Supply

USAF
United States Air Force
USSOCOM
United States Special Operations Command
UTC
Unit Type Code

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GLOSSARY

Abort

A failure of an aircraft system, required during the ground airborne phases of a mission that precludes the aircraft from completing its scheduled mission.

Aircraft Availability

The percent of possessed time that a system is capable of performing at least one of its assigned missions.

Cost Per Unit Usage

The total operating costs divided by the appropriate unit of measurement for a given weapon system. The measurement unit could be flight hour, steaming hour, launch, mile driven, etc.

Depot Purchased Equipment Maintenance (DPEM)

Refers to programs consisting of depot level maintenance services purchased from contract, inter-service, and organic repair sources.

Director of Operations (DO)

Inputs as to what usefulness/effectiveness a PMC aircraft has in an operational unit. The full systems list (FSL), basic systems list (BSL), and mission essential systems list (MESL) will be used to determine an aircraft's status.

DMAG

DMAG is the purchasing agent, and uses funds provided by DMAG customers. DMAG also refers to the process by which budgetary information about these maintenance services is exchanged between the DMAG customers who need them and the ALCs who supply them.

Forward Operating Base (FOB)

A base usually located in friendly territory or afloat that is established to extend command and control or communications, or to provide support for training and tactical operations.

Forward Operating Locations (FOL)

A temporary base of operations for small groups of personnel established near or within the Joint Special Operations Area (JSOA) to support training of indigenous personnel or tactical operations.

Full Operational Capability (FOC)

The full attainment of the capability to effectively employ a weapon, item of equipment, or system of approved specific characteristics, which is manned and operated by a trained, equipped, and supported military unit or force.

Initial Operational Capability (IOC)

The first attainment of the capability to effectively employ a weapon, item of equipment, or system of approved specific characteristics, which is manned or operated by an adequately trained, equipped, and supported military unit or force.

Logistics Footprint

The government/contractor size or “presence” of logistics support required to deploy, sustain, and move a weapon system. Measurable elements include inventory/equipment, personnel, facilities, transportation assets, and real estate.

Logistics Response Time

This is the period of time from logistics demand signal sent to satisfaction of that logistics demand. “Logistics Demand” refers to systems, components, or resources, including labor, required for weapon system logistics support.

Mean Flight Hour Between Abort (MFHBA)

The total number of flight hours divided by the total number of aborts.

Mean Flight Hour Between Critical Failure (MFHBCF)

MFHBCF measures the average flight hours between failure of mission essential systems/functions, as referenced in the MESL, which renders the aircraft Non-Mission Capable (NMC). MFHBCF is computed by the number of flight hours divided by the number of code three landings and aborts.

Mean Flight Hours Between Failure-Logistics (MFHBFLog).

The ability of the system to operate under operational and support concepts, utilizing planned logistics resources (manpower and spares). This metric is calculated by the total flight hours flown divided by the total number of all failures. The purpose of this metric is to drive substantive increases in system reliability resulting in less overall failures.

Mission Capable

The Mission Capable (MC) rate is the sum of the Full Mission Capable (FMC) and Partial Mission Capable (PMC) rates. Rates are reported via the status reporting system outlined in service specific guidance.

Mission Capable (MC) Rate

The percent of possessed time that a system is capable of performing at least one of its assigned missions. Rates are reported via the status reporting system outlined in service specific guidance. Mission Capable (MC) Rate will be based on number of hours the aircraft is in a mission capable status, divided by total hours possessed. The MC rate is the sum of the Full Mission Capable and Partial Mission Capable (PMC) rates. Rates are reported via the status reporting system outlined in AFI 21-103.

Mobility Readiness Spares Package (MRSP)

An MRSP is an air-transportable package of spares, repair parts, and related maintenance supplies required to sustain a weapons system for a specified period of planned wartime or contingency operations.

Mobility Readiness Spares Package (MRSP) Fill Rate

The minimum level that any individual CV-22 MRSP kit is allowed to reach.

Non-Mission Capable

An aircraft cannot do any assigned mission.

Not Mission Capable Supply

The aircraft cannot do any assigned missions because of supply. The aircraft cannot fly (restricted from use), or a part(s) that needs to be installed on the aircraft in order to meet assigned missions.

Operational Availability

The percent of time that a weapon system is available for a mission, or the ability to sustain operations tempo.

Operational Reliability

The measure of a weapon system in meeting mission success objectives (percent of objectives met, by weapon system). Depending on the weapon system, a mission objective would be a sortie, tour, launch, destination reached, capability, etc.

Partial Mission Capable (PMC) Rate

PMC rate defines the maximum amount of the MC rate which can be met with PMC aircraft. The PMC percentage is based on the AFSOC.

Stockage Effectiveness

A customer support measurement identifying a supply account's ability to satisfy a customer demand with items the supply system is authorized to stock (based on Air Force Stockage Policy).

Total Not Mission Capable Supply (TNMCS) Rate

This monthly/annual metric is the average percentage of possessed aircraft that are unable to meet primary missions for supply reasons.

Urgency Justification Code 1A

The aerospace vehicle cannot fly any of its assigned missions due to lack of parts for subsystems on the MAJCOMs basic lists.

Urgency Justification Code JA

The aerospace vehicle can fly at least one of its assigned missions based on a basic systems list, but not all missions due to lack of parts for systems on other mission essential subsystem lists.

ACKNOWLEDGMENTS

I am indebted to Dr. Nayantara Hensel and Dr. Carmelita Troy for their support and patience. We all started with something we knew very little about and developed a deeper understanding of the federal acquisition system, major procurements, and the restraints of the PPBES. Thanks to various members of NAVAIR who offered their support in helping develop a final product, but especially Mr. Steve Bernard who unselfishly offered time, something that is priceless to all of us.

Thanks to my husband Major Javier A. Torres, USMC, who is currently serving in Afghanistan supporting America's effort to spread freedom. He has sacrificed many things to support my studies. He is always a source of strength for me and for that I am forever grateful. Finally, a special dedication to those who made the ultimate sacrifice to see this program succeed, to them we are all eternally grateful.

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I. INTRODUCTION

The Osprey is one of the latest and most complex joint weapons systems ever developed by the United States military. At the beginning of this paper it was in the Low Rate Initial Production phase, however just prior to completing the manuscript it was awarded approval to enter the full rate production phase. Chapter II not only walks through inception and refinement of the V-22, but in a detailed technical overview, it compares and highlights many of the Osprey's key system advantages over those of the traditional helicopter. It also notes some of the risk involved in fielding such high-tech, complex weapons systems.

Chapter III introduces the current plan for training pilots and maintainers. It offers an outline of the requirements and format for the training facilities. It also includes some of the concerns in the current training regiment that may require extra effort to resolve. One situation involves the inability to rotate the nacelles while the aircraft is inside the maintenance hangar. Another key concern is not just training, but also meeting the need to train the aircraft maintenance crew to support the variations in Osprey configurations.

Chapter III also gives an overview of the operational capabilities of the Osprey, and its capabilities when working with the U.S. Marine Corps, or Navy. In some instances the capabilities of the V-22 act as force multipliers by fulfilling tasks that are traditionally performed by other aircraft. Osprey often performs the additional tasks better, and successfully "free-up" fighter aircraft for other missions.

Chapter IV introduces the various contract options, and why the new performance based logistics contract is the contract of choice compared to the traditionally support method. It also includes an analysis of various alternatives and supporting arguments for the final choice. Chapter V introduces an overview for parts support and gives a basic introduction to the logic that led to the final decisions. Chapter VI is the conclusion, but it also notes other opportunities for research.

The Osprey has been in development for over 20 years, but the need for emerging technology supported its successful realization. The original intent in this manuscript was to use more numerical analysis, however the complexity of the project's funding eroded the option for using a purely numerical analysis method. The Osprey has simply raised the bar for technology. It was designed and fielded to meet the needs of the next generation war-fighter. Its technology has drawn a new line in the sand for performance standards and made history in aviation. This paper gives only a brief glimpse of her successes, failures and the birth of a new legacy as it enters full rate production.

II. BACKGROUND

As 1991 brought about the end of the Cold War, the latest focus of the U. S. military is now the global war on terrorism. This war has rapidly progressed since September 11, 2001 (with the Bombing of the World Trade Center in New York City and the attack at the Pentagon in Washington DC). This tragedy unveiled a new enemy of democracy and freedom whose efforts have inevitably changed the face of warfare around the world. Small and agile, this new enemy is capable of making its presence known to all countries, anytime, and almost anywhere. This enemy cannot be identified as a single sovereign or regime because it is a transformational and faceless ideology that has successfully harnessed and used one of the greatest weapons and single weaknesses of any powerful nation, and that weapon is the weakness of human nature.

In the wake of this new threat, the U.S. Military has been forced to undergo significant transformation. This effort includes the ongoing need to develop highly sophisticated weapons systems. The current presidential administration has led the way by supporting many new innovations including network-centric warfare, the F-22 Joint Strike Fighter, and the Osprey's tilt-rotor technology. All have made major advancements by successfully combining opposing capabilities.

The Osprey's tilt-rotor capability was a controversial technology that made its military debut in the late 80's. After having both a rocky research and development and low rate initial production phase, the V-22 received its approval for full-rate production. The approval of the Osprey and its tilt-rotor capability, like other major programs, has simultaneously created the requirement of joint military logistics, maintenance, and training support.

The goal of this report is to offer a comprehensive review of the military's overall plan for program supportability. This report reviews various aspects of supportability requirements, maps the options for execution, and addresses any potential outliers that may hinder the success of fielding, support, and personnel training requirements. The

methodologies used for analysis include a cost-benefit analysis of the readiness capability of civilian versus military support, and a cost analysis of the training requirements and infrastructure that may be needed after fielding.

A. TECHNICAL

Taking off and landing vertically a tremendous tactical utility that is considered as an indispensable military asset in modern warfare. However, low airspeed and altitude, which significantly adds to its vulnerability is considered a key drawback.¹ Ceiling constraints and general performance in inclement weather is also an important limitation of the helicopter when compared to its fixed-wing counterpart. The helicopter's tail rotor, especially on a single rotor helicopter, is a marked drain on engine power, and increases aircraft drag and noise. It is also considered as an ever present hazard to general operations.²

The dramatic increase in the U.S. military's operational tempo has led many to believe that the military helicopter reached its practical capabilities limit in warfare decades ago.³ The next generation of aircraft has to successfully eliminate all of the helicopter's capability limitations, while incorporating the performance advantages of a fixed wing aircraft. Combining the better of two separate technologies has been the strategy for a variety of U.S. military weapons systems. The tilt rotor was introduced and designed to fulfill this requirement.

The concept of creating an aircraft with tilting propellers was conceived early in the history of manned flight. Later the concept of refining the technology was pursued shortly after the advent of helicopter. A significant amount of world wide research yielded a variety of concepts for tilt-rotor technology. In the end, many prototypes reached construction, but very few ever successfully took flight. A key issue in developing such sophisticated technology was that many engineering challenges required decades of research, technology maturation and evolution. Prior to actual technical

1 B. Norton, Bell Boeing V-22 Osprey, (2004), North Branch, MN: Specialty Press p. 5.

2 Ibid.

3 Ibid.

realization and what could be considered a practical vehicle prototype, engineers built a few experimental aircraft specifically for data collection.⁴

The first true tilt rotor aircraft that actually was capable of flying was built by the Transcendental Aircraft Corporation with a small amount funding from the Department of Defense. The tiny aircraft only had a maximum hover gross weight (GW) of just 1750 lbs and a wingspan of 21 ft. The rotors were powered by a single reciprocating engine located within the fuselage. The prototype's first hover flight occurred on 15 June 1954. It made its first partial transition five months later and eventually flew with about 70 degrees of actual rotor tilt. After this prototype made over 100 flights and flew 23 flight hours, the aircraft crashed on June 20, 1955.⁵

Despite the unfortunate end of the original prototype, almost 30 years later the V-22 Osprey eventually began its research and development phase. Although it has taken 20 years to get it to the low rate initial production phase, the delays in program execution cannot completely be attributed to limitations in research or technical capability. Numerous key external issues such as budget cuts, changes in presidential administrations, and military strategic transformation have all had a heavy impact in program development. World events such as the end of the Cold War and China's economic boom supported the procurement "holiday" that demanded the drastic downsizing in national defense assets and the defense commercial industry. The U.S. military's current technology lag has become a critical deficiency in the global war on terrorism. The current need for balance between transformation and the joint service mandate for new weapons systems negatively impacts operational readiness at all levels of the military.

The heavy influence and current mission requirements was a key driver in the contrast between the V-22 and her and her predecessors. The tilt-rotor has successfully combined prop-rotor and engines together in a single rotating wingtip nacelle. The object

4 B. Norton,. Bell Boeing V-22 Osprey, (2004), North Branch, MN: Specialty Press.

5 Ibid.

of this design scheme was to allow the aircraft to take off like a helicopter with the nacelles at 90 degrees. After take-off, the nacelles rotate forward from 90 to 0 degrees for conversion into a high-speed airplane.⁶

Conversion begins at a speed where the wings are simultaneously gaining lift as the rotor lift decreases with tilt angle.⁷ During its minimal time in transition, the “prop-rotor blade and hub serve as a dual use helicopter blade and airplane propellers.”⁸ The counter-rotating prop-rotors located on either side of the aircraft’s fuselage naturally cancel the opposing rotor torque. This effectively eliminates the requirement for a traditional helicopter tail rotor. However, this change does have some impact on hover capability, but the impact is considered an acceptable trade-off considering the added advantage of cruise speed and distance. Despite the fact that the Osprey has a lower cruising speed than that of an airplane of comparable power and weight, it far exceeds the cruising speed of a helicopter. This was a key performance element in the development of the weapons system primarily because Osprey was specifically designed to replace the helicopter, not the airplane.⁹

The controls in the cockpit serve common functions regardless of the mode of flight. When the Osprey is in hover mode and low speed flight with the nacelles tilted near vertical, the collective or thrust control lever, and cyclic or ‘stick’ provide familiar helicopter functions. The prop-rotors employ helicopter control mechanizations. A lateral cyclic for roll and translation or sideway flight commands changes in the prop-rotor blade pitch angles that simultaneously come around during rotation. This produces a sideways tilting of the rotor disks. Due to the asymmetrical prop-rotor lift differential collective pitch is uniform but opposed to blade angle changes on each prop-rotor or differential lift. Pitch control from longitudinal cyclic displacement gives fore and aft tilting of the rotor disks.¹⁰

As the aircraft accelerates through a high speed conversion, the physical controls of the Osprey change functions. This change requires the pilot’s control strategy to

6 B. Norton,. Bell Boeing V-22 Osprey, (2004), North Branch, MN: Specialty Press.

7 Ibid.

8 Ibid.

9 Ibid.

10 Ibid.

progressively adjust until it eventually resembles that of a conventional fixed-wing aircraft. In airplane mode (APLN) the rudder pedals produce yaw while the stick becomes a climb, dive and roll rate controller by moving the ailerons, flaperons and elevator. The thrust control lever (TCL) input provides power for a simple throttle to set the longitudinal thrust. The longitudinal stick is used to manage the aircraft energy state by relatively increasing or decreasing the flight path angle, constant speed or by allowing the aircraft to accelerate and decelerate.

Ground testing played a vital role in verifying design choices and optimizing system requirements. The program successfully overcame a variety of engineering challenges and problems specifically related to the systems. As with any new development as the program progressed it had many high and low points. Often, experimental technology needs time for science to catch up with the requirements. This is always an easy accomplishment especially in lieu of the ongoing challenges and complexity of major defense programs.¹¹

The following graph, Figure 1, is a comparison of the Osprey flight capabilities compared to that of the helicopter and the fixed wing aircraft. Note the area where Osprey has successfully captured the best of both technologies.

- **Navy V-22 Performance**
 - Tilt-rotor design
 - VTOL
 - Speed/Range/Ceiling of Turboprop
 - Nominal Cruise 240Kts
 - Mission Radius 350nm
 - Service Ceiling 25,000ft
 - Normal Altitude w/pax 10,000ft
 - Ferry Range 2100nm w/ 1 refuel

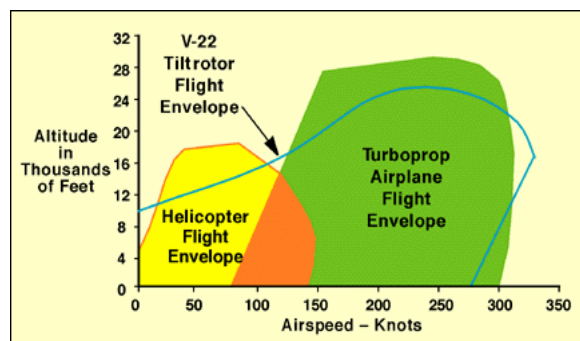


Figure 1. Flight Capabilities Comparison¹²

¹¹ B. Norton, Bell Boeing V-22 Osprey, (2004), North Branch, MN: Specialty Press.

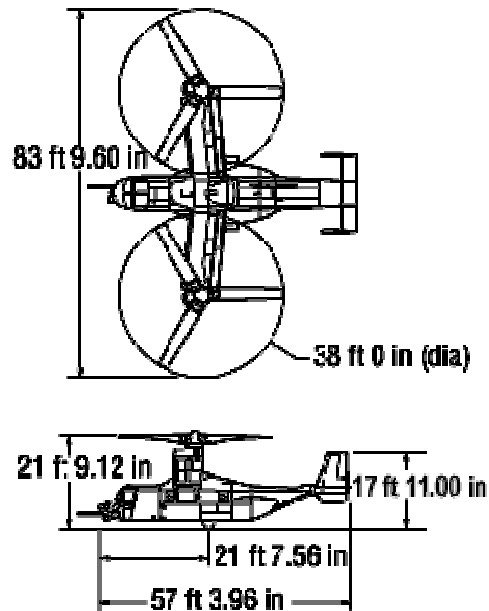
¹² A. Easterly, V-22 Business Development Bell Helicopter Textron. "Navy V-22 Concept Employment Brief, Naval Postgraduate School, January 20, 2004".

Power plant

- Two Allison T406-AD-400 engines
- Max and Intermediate, SHP(kW) - 6,150 (4,586)

Rotor System

- Blades per hub - 3
- Construction - graphite/fiberglass
- Tip speed, fps (mps) - 661.90 (201.75)
- Diameter, ft (m) - 38.00 (11.58)
- Blade area, ft² (m²) - 261.52 (24.30)
- Disc area, ft², (m²) - 2,268.00 (210.70)
- Blade folding - automatic, powered



Transmissions

- Takeoff [USMC], ship (kW) - 4,570 (3,408)
- Takeoff [USN], ship (kW) - 4,970 (3,706)
- Takeoff [USAF], ship (kW) - 4,970 (3,706)
- 1 engine inoperative, ship (kW) 5,920 (4,415)

Performance

- Max speed, SL, Kits (km/h) - 275 (510)
- Vert rate of climb, SL, fpm (m/m)
1,090 (332)
- Max rate of climb, SL, fpm (m/m)
2,320 (707)

Range

- Amphib assault, nm (km) - 515 (954)
- Max, self-deployment, nm (km)
2,100 (3,892)

Crew

<ul style="list-style-type: none"> • Service ceiling, ft (m) - 26,000 (7,925) • Service ceiling, one engine inop, ft (m) 11,300 (3,444) • HOGE, ft (m) - 14,200 (4,328) 	<ul style="list-style-type: none"> • Cockpit - crew seats - 2 • Cabin - troop seats/litters - 24/12
<p>Dimensions - Internal</p> <ul style="list-style-type: none"> • Length, max, ft (m) - 24.17 (7.37) • Width, max, ft (m) - 5.92 (1.80) • Height, max, ft (m) - 6.00 (1.83) <p>Weights</p> <ul style="list-style-type: none"> • Empty, lbs (kg) - 33,140 (15,032) • Takeoff, vertical, max, lbs - 47,500 (21,546) • Takeoff, short running, max, lbs (kg) 55,000 (24,948) • Takeoff, self-deploy mission, lbs (kg) 60,500 (27,443) • Cargo hook, single, lbs (kg) 10,000 (4,536) • Cargo hook, dual, lbs (kg) - 15,000 (9,221) 	<p>Dimensions - External</p> <ul style="list-style-type: none"> • Length, fuselage, ft (m) - 57.33 (17.48) • Width, rotors turning, ft (m) - 83.33 (25.55) • Length, stowed, ft (m) - 62.58 (19.08) • Width, stowed, ft (m) - 18.42 (5.61) • Width, horizontal stabilizer, ft (m) - 18.42 (5.61) • Height, nacelles fully vertical, ft (m) - 21.76 (6.63) • Height, vertical stabilizer, ft (m) - 17.65 (5.38) <p>Fuel Capacity</p> <ul style="list-style-type: none"> • Sponsons, gals (liters) - 1,228 (4,649) • Wings, gals (liters) - 787 (2,979) • Aux, self-deployment, gals (liters) - 2,436 (9,221)

Figure 2. Osprey Characteristics¹³

B. OPERATIONS

In support of the latest joint requirement, the Osprey has a configuration that is slated to meet the operational requirements for all military services. It is especially

¹³ CV-22 Osprey, "Overview of the Osprey's and its Role in the Future of the U.S. Special Operations". Retrieved on July 26, 2005 from <https://wwwmil.seymourjohnson.af.mil/tenant/360trs/cv-22%20Osprey.htm>.

designed to support to the Navy's transformational shipboard operational requirement. Osprey offers such supporting features as a 90 second rapid wing and blade fold, corrosion resistance and a system that supports resistance to electromagnetic interference. This was a key issue during production because of shipboard space constraints and the significant number of electronic systems onboard U.S. ships. Additionally, navy ships typically have weight limitations and launch speed requirements that are key drivers in the success of a many evolutions. This would be vital in the ship's ability to perform search and rescue operations at sea.¹⁴

The Navy's current plan is to certify the Osprey for operation onboard all classes of U.S Navy amphibious ships and aircraft carriers. Any Logistic ships that are capable of launching and recovering the CH-53E Sea Stallion should also receive full certification for the Osprey. Additionally, this aircraft should have a better fore and aft rotor obstruction clearance than that of the traditional MH-60. Certification for navy ships will still be required prior to commencing operations using the Osprey, but Osprey should offer increased flexibility and support for operational readiness.

The Osprey offers numerous improvements over her predecessors that support emerging requirements of sea operations. One advantage is that in airplane mode it has a reduced acoustic signature as well as infrared engine suppressors. Osprey also has the advantages of an increase in speed/range and an advanced threat warning systems that has a reduced susceptibility to synergistic manner. Engineers chose to use composites in the prop-rotor and airframe in order to provide a certain level of ballistic tolerance that allows the Osprey to continue flight after sustaining impacts from projectiles up to and including a 23mm Armor Piercing Incendiary(API) round.¹⁵

Cockpit seats are armored to withstand 7.62mm small arms rounds and the aircraft fuel tanks are self-sealing and contain nitrogen gas to reduce the possibility of vapor ignition after they have taken a hit. Engineers noted that nitrogen has a lower flash point than oxygen therefore it reduces the

¹⁴ Proprietary Source 1, December 2003.

¹⁵ Proprietary Source 1, December 2003 p. 2-4.

possibility of explosions. Additionally, the flight control system has triple redundancy and both the hydraulic and electrical systems have dual redundancy.¹⁶

The Osprey was designed to support any future requirements or needs of the military. It has also been designed with a focus on the requirements outlined in the Defense Planning Guidance and Sea Power 21. Sea Power 21 is the lead document for the Navy's transformation. Its strategy is based on the three fundamental concepts defined as Sea Strike, Sea Shield, and Sea Basing. FORCE-net integrates all three concepts and is hailed as the backbone for successful execution. FORCEnet unites the warrior, sensors, networks, control, platforms and weapons into a network distributed combat force.¹⁷ The Osprey's versatility and various configurations are the key design elements that support the successful execution of service specific and congressional strategies.

Osprey's range, speed, payload, and basing options are critical to achieving the objectives specified by Sea Power 21. First, there has to be an increase in the logistics capability for the Expeditionary Strike Force to sustain a sea-based striking force. Inter-theater transfers of mission-critical equipment, personnel, and supplies are continuous critical capabilities that have to be met prior to and during hostilities. As a key player in sustaining logistics support, the Osprey fulfills a variety of requirements including tanker refueling, search and rescue missions, and high-speed troop transport.¹⁸

The Osprey's diverse capabilities increase the overall effectiveness and operational readiness of any carrier or Expeditionary Strike Group by acting as a force multiplier. The V-22 tanker configuration has 10,000 lbs of "give-way" fuel for a full cycle. This is a 67% increase in capability when compared to the existing S-3 refueling aircraft that only has a fuel capacity of 6,000 pounds. Operationally, Osprey's refueling capability translates into four strike fighters individually, which gains an additional 20 minutes of flight time. This also presents a significantly greater safety margin than the one that is currently available with the S-3 tanker. The Osprey's tanker configuration also

¹⁶ Proprietary Source 1, December 2003 p. 2-4.

¹⁷ Ibid.

¹⁸ A. Easterly, V-22 Business Development Bell Helicopter Textron. "Navy V-22 Concept Employment Brief, Naval Postgraduate School, January 20, 2004".

acts as a “force-multiplier by giving the Carrier Air Group (CAG) the option of uploading F/A- 18 Hornets with additional ordinance to support the force mission versus the old requirement that typically included the use of Hornets for tankers.”¹⁹

The diagrams Figure 3 and Figure 4 show the strategic location and make-up of the Osprey fuel system.

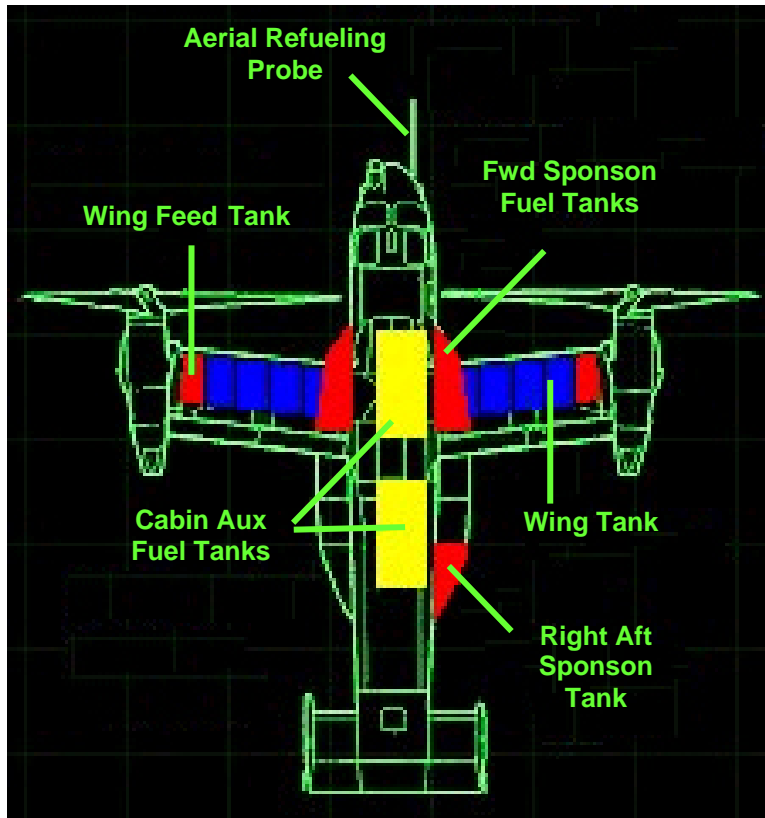
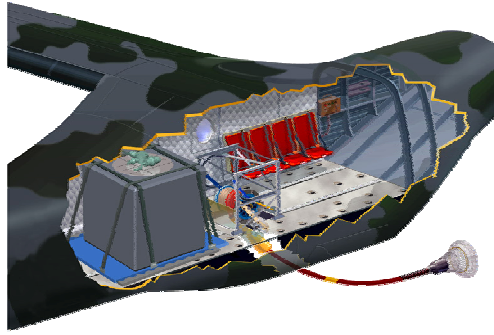


Figure 3. Osprey Fuel System²⁰

19 A. Easterly, V-22 Business Development Bell Helicopter Textron. “ Navy V-22 Concept Employment Brief, Naval Postgraduate School, January 20, 2004”.

20 Ibid.



- **Navy V-22 Aerial Refueling**
 - Auxiliary Tanks: 2 x 430 gal (5590 lbs.)
 - Internal Fuel: 11,700 lb/1720 gal
 - Fuel Giveaway: Auxiliary + Internal (17,290 lbs.)
 - Kit Weight: 660 lbs
 - Fuel rate: 120gpm
 - Reconfigure time: < 1.5 hours
 - V-22, CH-53E, AV-8, F/A-18, JSF, etc.
 - 230kts
 - 80-91 ft hose length

Figure 4. Osprey Fuel System, Part 221

The Navy's Sea Power objective is shown in Figure 5.

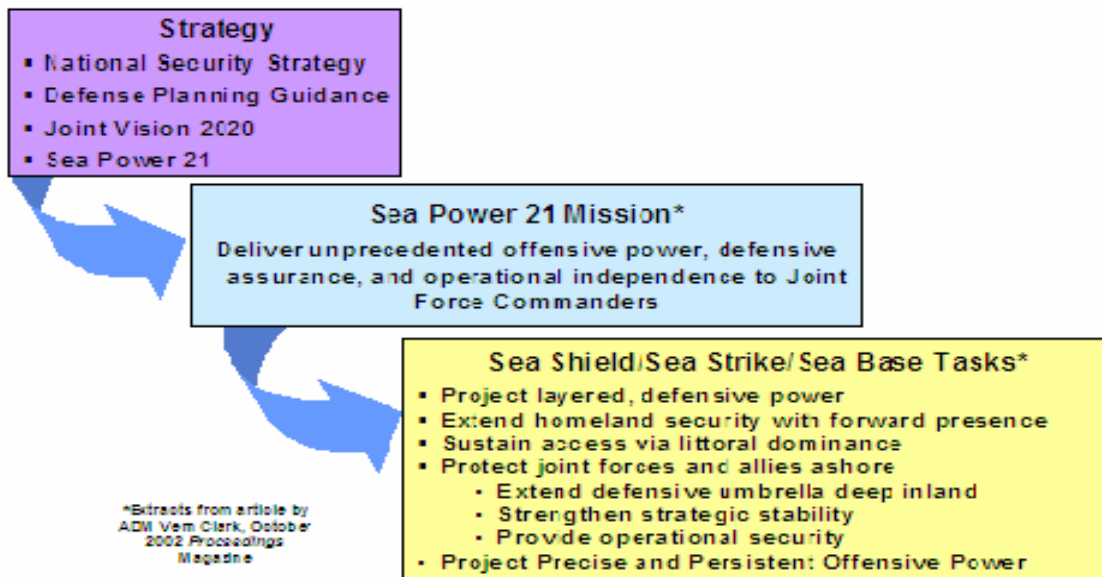


Figure 5. Navy's Sea Power Objective²²

²¹ A. Easterly, V-22 Business Development Bell Helicopter Textron. "Navy V-22 Concept Employment Brief, Naval Postgraduate School, January 20, 2004".

²² Proprietary Source 2, September 2004.

C. MISSION/OBJECTIVE

The V-22 is being developed to perform for the U.S. Navy, U.S. Marine Corps, and the U.S. Special Operations Command combat mission. Its highest priority is the U.S. Marine Corps aviation because of the critical requirement to replace the CH-46E, which is used by the Marine Corps, Navy and the Special Operations forces in hostile areas. The acquisition of this medium-lift aircraft represents a revolutionary leap in the ability of U.S. forces from over the horizon to inland objectives. It flies twice as fast, significantly further, and with a heavier payload which is often key to the successful execution of maneuver warfare. In essence, successfully capitalizing on this capability greatly enhances the survivability of the war-fighters.

The Air Force Special Operations Forces and U.S. Special Operations Command missions are the most stringent missions of the V-22 because of the potential anticipated extended exposure to high threat environments. The CV-22 variant for special operations will travel five hundred nautical miles while flying 500 feet above ground level, locate a small landing zone, infiltrate and ex-filtrate a team of 18 special operations ground forces and return to base. The capability for these operations must extend at least as far as being done covertly, at night and in adverse weather. The CV-22 special operations configuration will have an enhanced survivability by virtue of the electronic warfare suite specifically designed to meet the Special Operations mission as well as meeting the survivability standards identified for the basic V-22 weapons system.²³

The Osprey is also slated to meet a variety of joint requirements with a diversity that is unmatched by any other military or civilian aircraft. It has been designed for in-flight refueling as well as search and rescue at sea, and can successfully insert and extract troops during amphibious operations. It has been tested for a variety of uses that meet the ever-changing needs for covert special operation and joint operability among the services. The design of the Osprey surpasses the helicopters in range, speed, and payload capacity. It has been built as a response to the changing needs of the future military, and is a key element in the success of future global military operations.

²³ CV-22 Osprey, "Overview of the Osprey's and its Role in the Future of the U.S. Special Operations". Retrieved on July 26, 2005 from <https://wwwmil.seymourjohnson.af.mil/tenant/360trs/cv-22%20Osprey.htm>



Figure 6. New Defense Challenge²⁴

²⁴ Proprietary Source 1, December 2003.

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III. TRAINING REQUIREMENTS

A. PILOTS

The cornerstone in the efforts to field the Osprey is laying the groundwork for a successful training program. This may seem difficult considering that weapons systems require the skills of both fixed and rotor pilots. In January 1999, the U.S. Marine Corps Aviation Department issued an order to “organize, train and equip MV-22 forces in an effort to support the fielding phase of the Osprey. The results included the development of a five phase course of action that was designed to “train the trainer.”²⁵ Lee and Dell in their thesis titled Planning Flight Training for the Transition to the V-22 Osprey, which specifically talks about the development of the Osprey training program, noted that the transition began with determining the optimum location that would provide the best opportunity for implementing a joint training plan.²⁶ Additionally, this location had to have the ability to meet the training requirements for all military services.

The initial plan included the first phase of training that would be necessary to transition Ch-46 and other pilots into the pipeline and that would support full fielding of the V-22. The USMC has dedicated a proportional amount of time to incorporating lessons learned from previous aircraft transitions and to consolidating lessons learned specifically attributed to experience with the Osprey.

A syllabus was developed for training a Fleet Replacement Squadron (FRS). The initial plan was category of training that would ultimately lead each student through a progressively more difficult stage of training as he advanced through the program. Each stage includes interactive media instruction, flight simulators, and actual aircraft flights in the latest prototypes.²⁷

“One key difference in the Osprey when compared to past aircraft training was that more emphasis would be placed on simulator training due to the cost of the

²⁵ Proprietary Source 1, December 2003.

²⁶ Ibid.

²⁷ R.M. Lee and R.F. Dell, Thesis, Planning Flight Training for the Transition to the V-22 Osprey. NPS.

aircraft.”²⁸ Certain simulator and actual aircraft flights would have to be flown at night, both with and without night vision goggles (NVGs) to support the pilot’s requirement to maintain proficiency in flying night operations. Additionally, the early stages of training could be considered more regimental, while later the program’s schedule becomes more flexible as students approach the later stages of their program.²⁹

After FRS training, pilots begin tactical training with their perspective fleet units. The most advanced training could be conducted by fleet squadron instructors; however other training may require specific levels of certification. Some key concerns for the transition plan included the potential for the bathtub effect. In essence, this is a situation where pilots return from a deployment, transfer for various reasons to other commands, and are replaced gradually during the 18-month period between deployments. Typically this has been permitted with minimal concern, but considering the demands imposed by a shortening of deployment cycles, the V-22 units may experience progressive deficiencies that may be difficult to eliminate. Over a short period of time the stability of the unit may be gravely affected by this shortfall.³⁰ The increasing requirements of the military may escalate the overall effect of this deficiency.

In June 1999, the Helicopter Squadron (HMT-204) was officially re-designated as VMMT-204 with a mission of providing Osprey training for both Marine and Air Force pilots as well as maintenance personnel. This training facility is located at Marine Corps Air Station in New River, North Carolina. In April 1999, the squadron received a new motion-based operational flight trainer to train instructors to fly the Osprey. The Operational Flight Trainer (OFT) provides the pilot with computer-generated horizontal and vertical visual scenes all inside of a 24-foot dome. It also provides a full range of motion that gives pilots the “feel” of both acceleration and deceleration. It also presents students the opportunity to train in a broad spectrum of simulated environments.³¹

28 Steve Bernard, NAVAIR, August 2005.

29 R.M. Lee and R.F. Dell, Thesis, Planning Flight Training for the Transition to the V-22 Osprey. NPS p.6-13.

30 R.M. Lee and R.F. Dell, Thesis, Planning Flight Training for the Transition to the V-22 Osprey. NPS.

31 Ibid.

1. Pilot Training Devices

The following operator devices have been identified as requirements to support the V-22 training facility. Currently, most are being utilized by both the USMC and the Air Force Special Forces.

a. Integrated Cockpit Learning Environment (ICLE)

The ICLE consists of a full-size replica of the V-22 cockpit, mounted on a fixed base, and used to provide instruction on aircraft systems and procedures. The ICLE was procured in FY02 and is scheduled for delivery in FY04.

b. Full Flight Simulator (FFS)

The FFS is a flight deck replica of the MV-22, representative in appearance, flight performance characteristics, and system operation. The simulator is equipped with a six degrees of freedom motion base, tactical/threat environment, and a full field of view visual simulation system. MV FFS 1 and 2 were ready for training (RFT) in FY01 and FY02. MV FFS 1 and 2 Block A upgrade was completed in FY03. MV FFS 3 with Block A will be RFT in FY04. It is planned to procure MV FFS 4 in FY05, with RFT in FY07. CV FFS 1 was RFT in FY03. CV FFS 2 is planned for procurement in FY05, with RFT in FY07.

c. Flight Training Device (FTD)

This is a flight deck that is identical to the FFS, but without the motion system. MV FTD 1 was RFT in FY01. FTD 1 Block A upgrade was installed in FY03, with the Block B upgrade planned for installation during FY05. It is planned to procure 13 additional MV FTDs between FY07 and FY15. CV FTD 1 was RFT in FY04.

d. CV-22 Cabin Part Task Trainer (CPTT)

The CPTT is a replica of the interior cabin of the CV-22, including cargo-handling equipment. One Air Force unique CPTT will be procured for the Flight Engineer (FE)/Loadmaster training course. The device was procured in FY04 for delivery in FY06. The CPTT will be located at Kirtland AFB.

B. MAINTAINERS

The Marine Corps maintainers will also employ a phased strategy for the transition of the Marine Corps medium-lift fleet to the Osprey. Upon transition, each squadron will maintain an aircraft inventory of 12 aircraft. The essential time-to-train for

a squadron transition is approximately 24-30 months. This period consist of a Stand-down, Post-Transition, and a Pre-Deployment Training phase. Initial training for fleet personnel or maintainers will also be conducted at Marine Corps Air Station (MCAS) in New River, North Carolina. Similar to the pilots training, service and mission unique training will be developed to support each service's unique mission requirements.³²

Marine Medium Tilt-Rotor Training Squadron 204, located at MCAS in New River, will be designated the Fleet Readiness Squadron for V-22 aircrew and the Fleet Replacement Enlisted Skills Training for maintenance training.³³ The current program is designed to reduce the hours of maintenance required in conjunction with the military's ongoing effort to decrease the need for support personnel.

The Manpower Engineering Program (MEP) consist of five sub-programs used in planning, programming, and budgeting for manpower resources to support the Navy's operating forces and shore establishments. The Preliminary Squadron Manning Document implemented the program and lists the following subprograms: Shore Manpower Document Program, Commercial Activities Program, and Navy Manpower Mobilization Systems. Skill levels and the number of personnel needed are being determined by various support elements. Documents providing the skill levels and personnel numbers include the Joint Training Systems Plan and the prime contractors Training & Equipment Plan.

The Navy planning process is pertinent in documenting new developments. These developments include new aviation, equipment, system, subsystems, and non-hardware. It also tracks aircraft squadrons transferred to the Naval Reserve, reserve program components, area training requirements, and mission continuum. New weapons systems always require a transition period that can be long or short, depending on the previous capability. The requirement to man the new weapons system at a similar level as the system it replaces always presents a resource constraint that affects all participating

³² R.M. Lee and R.F. Dell, Thesis, Planning Flight Training for the Transition to the V-22 Osprey. NPS.

³³ NASA Research Center. Tilt Rotor Aeroacoustic Model. Tilt Rotor Aeroacoustic Model (TRAM) as a National Research Facility. Retrieved August 23, 2005 from <http://rotocraft.arc.nasa.gov/facilities/tram.html>

services. Manpower requirements for weapons systems that are not a one for one replacement for older systems must be identified and included in the manpower budget. Risk involving manning shortfalls must be mitigated to minimize its impact to fielding the supportability phase of the program. In this case, the Osprey will replace Marine Corps aircraft on a one-for-one basis.

The Marine Corps has also created a new set of Military Occupational Specialties (MOS's) specifically for the V-22 program. The training program objectives are designed by the contractor with a focus on complimenting and maximizing the skills of those new to the MOS. The V-22 Maintenance Training System identifies a comprehensive solution for the maintenance training resources necessary for the training. Those resources reside at an inter-service schoolhouse located at MCAS in New River. A Memorandum of Agreement between HQAET and HQ Marine Corps was put in place to set up this training process. The training media and CV-22 unique maintenance training devices are a subset of MV-22 resources at the school. The normal sustainment process for the Navy and Marine Corps maintenance personnel will be used to maintain training resources.³⁴

Currently, courses and training are underway to support the Osprey's low rate initial production phase. Courses offered include a Crew Chief Initial Skills Course which is designed to provide training to members of the U.S. Air Force. It includes basic skills and knowledge necessary to perform maintenance on all CV-22 systems. The Crew Chief Familiarization Course provides transitional training for maintainers who are presently qualified on the H-53 and H-60 helicopters. Personnel chosen to take this course are typically level 5 or 7 and will be trained specifically on the differences between the old and new weapons system. Other courses include training that focuses on the Avionics Systems Specialist, which is geared toward level 5 and 7 personnel. Among other aspects of the training, this course will include an Aircraft and Cockpit familiarization section.

³⁴ R.M. Lee and R.F. Dell, Thesis, Planning Flight Training for the Transition to the V-22 Osprey. NPS. p. 6-19

Graduates will be awarded certification upon completion of the courses. Courses that are currently being offered include the CV-22 Crew Chief's Course, which individually are close to 10 weeks in duration; the CV-22 Avionics Systems Course, which is a little over nine weeks in duration; and the CV-22 Electro-Environmental Systems, which is a transitional course that focuses on electrical systems, environmental control systems and wire repair as well as other systems applicable to the CV-22 aircraft. This course is also just over nine weeks in duration. The Hydraulic Systems Course and the Propulsion Systems Course are both five weeks and similar to the other courses and are geared towards a level 5 or 7 technician.

In essence, the current courses cater to personnel who are transitioning from other aircraft and already have a working knowledge of aircraft maintenance. This decision bodes well for the future success of the current training programs and the overall fielding of the Osprey.

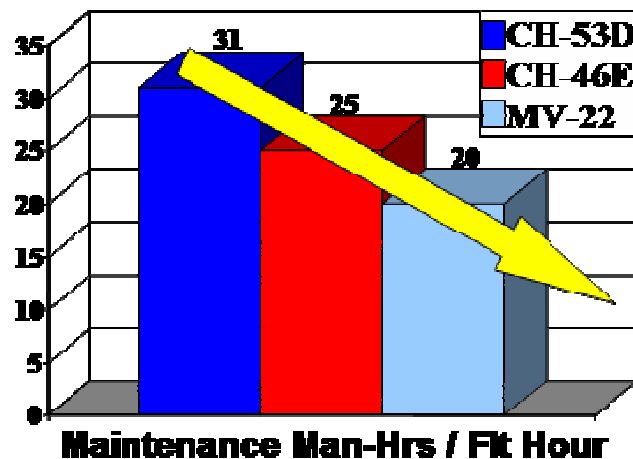


Figure 7. Maintenance Man-Hrs/Flt Hour³⁵

C. MAINTAINER TRAINING EQUIPMENT

The following maintenance trainers have been procured or delivered to the V-22 joint schoolhouse in New River, NC. These trainers will support O-level courses conducted by the V-22 Maintenance Training Unit.

³⁵ A. Easterly, V-22 Business Development Bell Helicopter Textron. "Navy V-22 Concept Employment Brief, Naval Postgraduate School, January 20, 2004".

Part-Task Trainers (PTT)

The Part-Task Trainers have been developed based on the LSA data, the IETM, and the Instructional Systems Development (ISD) process. Seven PTTs have been delivered to the MTU.

Landing Gear PTT (LGPTT)

The Landing Gear PTT consists of two devices and replicates the Landing Gear System. It provides O-level maintenance personnel with realistic training in the servicing and repair of the landing gear strut, wheel, and brake system. The LGPTT RFT was October 1, 2002.

Mechanic PTT (MPTT)

This is a replica of a wing (60%), from just beyond the mid-wing area through the nacelle, and it includes gearboxes, drive train, engine, prop-rotor components, and flight control surfaces. It provides O-level maintenance personnel with realistic training in the servicing and repair of the engine, drive-train, selected flight control systems, and associated subsystems. The MPTT RFT was October 1, 2002. It is currently being upgraded to a V-22 Block A configuration and RFT with an intended fielding date of February 2005.

Airframe PTT (AFPTT)

This is a replica of a wing (60%), from just beyond the mid-wing area through the nacelle, and it includes gearboxes, drive-train, engine, prop-rotor components, and flight control surfaces. It provides O-level maintenance personnel with realistic training in the servicing and repair of the engine, drive-train, selected flight control systems, and associated subsystems. The AFPTT RFT was October 1, 2002. Upgrade to Block A/B configuration is planned to be RFT in April 2006.

Sponson PTT (SPTT)

This is a replica of the Left-Hand Sponson and includes the selected Environmental Control Unit (ECU) and fuel system components. It provides O-level

maintenance personnel with realistic training in the servicing and repair of selected tasks involved with the ECU, fuel system, and subsystems. The SPTT RFT was October 1, 2002.

Power Plants Trainer Article (PPTA)

This trainer is comprised of a full wing with nacelles and engines in a Block A configuration. It provides O-level maintenance personnel with realistic training in the servicing and repair of the engine, drive-train, selected flight control systems, and associated subsystems. The PPTA was RFT in September 2003.

Consolidated V-22 Electronic Maintenance Trainer (CVEMT)

This trainer will provide USAF O-level maintenance personnel with training associated with selected CV-22 unique systems. The CV-EMT was procured in FY03 for delivery to the MTU at MCAS in New River during FY04.

Aircraft Maintenance Trainer (AMT)

Aircraft Bruno 165433 was re-designated as a training device during the 3rd quarter of FY01 and is located at the MTU, which is at MCAS in New River, NC. The AMT was upgraded to a Block A configuration, with an RFT date of November 2004. The AMT provides O-level maintenance personnel the training necessary to service, troubleshoot, repair, or remove and replace the aircraft's major systems and subsystems. Current planning is to acquire two EMD aircraft after completion of flight testing, estimated to be during FY06. These aircraft will also be designated as AMTs and will support the projected training throughput. The second AMT is planned to be upgrade to Block A/B configuration.

Trainer Fault Insertion System (TFIS)

TFIS will allow the instructor to insert and remove selected avionic and electrical faults into the AMT to enhance and reinforce system troubleshooting training. TFIS will be used in conjunction with the AMT. TFIS (LRIP) was RFT in December 2003. A second TFIS in a Block A configuration was scheduled for delivery in December 2004.

Avionics Functional V-22 Trainer (AFVT)

The AFVT provides realistic training in the operation and troubleshooting of the V-22 Cockpit Management System. The AFVT is comprised of four student stations and one instructor operator station (IOS). The student stations will replicate the V-22 cockpit, utilizing touch screens in place of the actual cockpit controls. Incorporation of aircraft mission computers allow the student stations to be reconfigured to either an MV or CV configuration. The AFVT has been upgraded to a Block A configuration. A Block B upgrade is planned to be incorporated during FY05.

The above systems, in concert with the courseware, comprise the VMTS, which will be used by all services. The Enlisted Crew Training is to provide crew members with the skills and knowledge necessary to safely and effectively perform pre-flight, post-flight, turnaround, and daily inspections. Training will also allow crew members to perform ground and flight duties during training.³⁶

³⁶ Proprietary Source 6, Logistics.

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IV. PARTS SUPPORT REQUIREMENTS

A. PARTS REQUIREMENTS

Various elements of the military have worked diligently to determine the future requirements of the Osprey. The overwhelming decision to use Performance-Based Logistics (PBL) is a decision that has slowly made its way to the forefront of weapons system supportability. Considering that each service and Special Operations Command will have a modified configuration of the original, it appears that the idea of parts support should be as simple as the availability of a sister military service. Also, considering the increased amount of redundancy in the system, the Osprey is designed to eliminate significant system failures.

The Performance Based Logistics effort includes awarding a long term contract to Bell-Boeing to provide wholesale logistics support with effectiveness measured using parameters such as parts availability. Past Boeing PBL contracts have used a combination of incentives to insure that contract and readiness requirements were being met. Considering Aircraft availability or readiness is directly tied to parts availability, the concept of parts availability has several external factors including the effectiveness of the supply chain, design reliability, maintainability, and obsolescence of parts resources that present notable challenge in supporting readiness.³⁷

Outliers that are beyond anyone's control include war-time support and surges in demand that are not driven by historical data or foreseeable factors such as increases in hostilities. In some of the past PBL contracts, Boeing has successfully accounted for small surges in demand. However, when parts allowances are set and fleet requests exceed 200 percent or greater of the initial allowance, it creates a ripple effect in support. In essence, the contractor is forced to pull future requirements forward to meet the unexpected demand. This typically causes an increase in cost, and in some instances may negatively impact the contractor's performance incentive, despite the fact that many events are outside the scope of the contract.

Contrary to popular belief, many defense contractors make notable sacrifices to meet the military's need. This historical government-contractor relationship supports the

³⁷ Proprietary Source 6, Logistics.

efforts that are currently being made to improve not only the methodology for performance incentive awards for PBL contracts, but to also improve the procedures that track awards for performance. The Department of Defense (DOD) is working to improve its mechanism for forecasting so that unexpected increases in initial allowances can be decreased, eliminated, or addressed with the appropriate amount of urgency. An effort is also being made to accurately document a surge in requirements and adequately reflect that surge as it relates to contractor responsiveness and the relationship of that responsiveness to fee and profit.

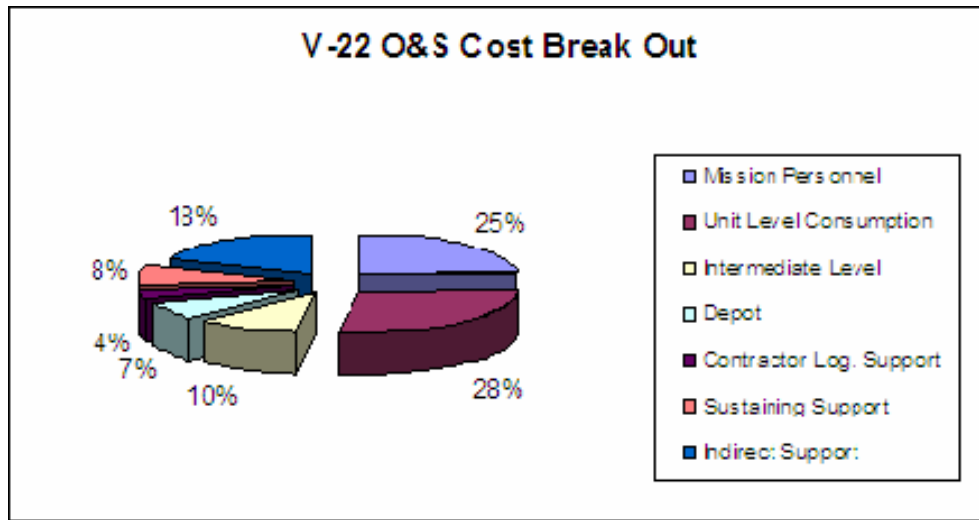


Figure 8. V-22 O&S Cost Break Out³⁸

Contractor Responsibilities
Managing and Conducting a Continuous reliability improvement program
Managing and conducting A continuous maintainability improvement program
Managing and conducting a parts/component obsolescence mitigation program
Control of configuration Changes in support of the initiatives above
Control of engineering Changes in support of the initiatives above
Control of technical data changes in support of the initiatives above.

Table 1. Contractor Responsibilities³⁹

³⁸ From Proprietary Source 7, Budget.

³⁹ Performance Based Logistics. “Contracting and Performance Agreement Management for PBL. University of Alabama Center for Science & Technology.

B. JUSTIFICATION FOR COMMERCIAL SUPPORT

R= Readiness

FH= Flying Hours

T= Total System

The objective of total system support is to maximize flight hours per dollar. Total System support includes all elements of cost both tangible and intangible. In short, how long can the V-22 fly, how much is it going to cost, and where is the balance that maximizes the equation? Additionally, is there a greater benefit in dollars per flight hour with government total system support versus the benefit in dollars per flight hour for commercial industry total system support? A constrained optimization exists between the marginal benefit of readiness over the marginal cost of readiness versus the marginal benefit of flying hours over the marginal cost of flying hours and the marginal benefit of total system support over the total cost of system support. The key constraint or resource is program funding.

$$\frac{MBR}{MCR} = \frac{MBFH}{MCFH} = \frac{MBTS}{MCTS}$$

MBR=Marginal Benefit of Readiness

MBC=Marginal Cost of Readiness

MBFH= Marginal Benefit of Flying Hours

MCFH= Marginal Cost of Flying Hours

MBTS= Marginal Benefit of Total System

MCTS= Marginal Cost of Total System.

Any increases in readiness are constrained by the budget. Therefore, it is important to determine the maximum amount of readiness in flying hours that can be purchased with each fiscal year's budget.

Considering DOD has a decreasing budget that is set by Congress, this could be viewed as a weighted outlier. The relationship between readiness and Congress can be measured by making Congress a factor that is inversely proportional to the budget or cost for readiness, yet directly proportional to the demand for readiness measured in flying hours.

Congress = X

Demand = D as related to demand for readiness or deployment of troops

$$\frac{MBR}{MCR} = 1 \text{ over the } \frac{MBX}{MCX}$$

$$\frac{MBR}{MCR} = \frac{MBXD}{MCXD} = \frac{1}{MBX / MCX}$$

At what point can there be a balance that will increase the number of flying hours while simultaneously decreasing the total system cost of life cycle supportability? The marginal benefit of readiness would have to be measured in reference to the number of mission-capable (MC) flying hours versus the number of non-mission-capable flying hours, or flying hours that were lost due to an aircraft being in the non-mission capable (NMC) status.

Mission capability can be reflected as a direct cost of the additional amount of supportability required to reach the mission-capable status. What does it cost to maximize the number of mission-capable flying hours and at what point does cost and support reach a balance that maximizes readiness without increasing budget requirements and directly impacting demand?

Although there are certain fixed costs that can be considered up front, including infrastructure that is in place to support manufacturing facilities, transportation, and ongoing technology improvements, there are specific outliers to the program's flying hours that historically vary significantly enough to offset budget goals. Items that include ongoing technology improvements, the rising cost of fuel, the increasing cost of qualified engineers, and the ongoing global demand for U.S. military support are just some of those factors.

Eliminating extenuating factors leaves the basic equation for readiness defined as it was initially. However, it is difficult to mitigate risk related to demand variances. The

current plan is to simply contract for support over the lifecycle of the program which should meet the ever-changing requirements for a new technology.

Levels of readiness can be determined by a readiness function when:

$$R = \frac{FH}{Dollars} * \frac{S}{Dollars}$$

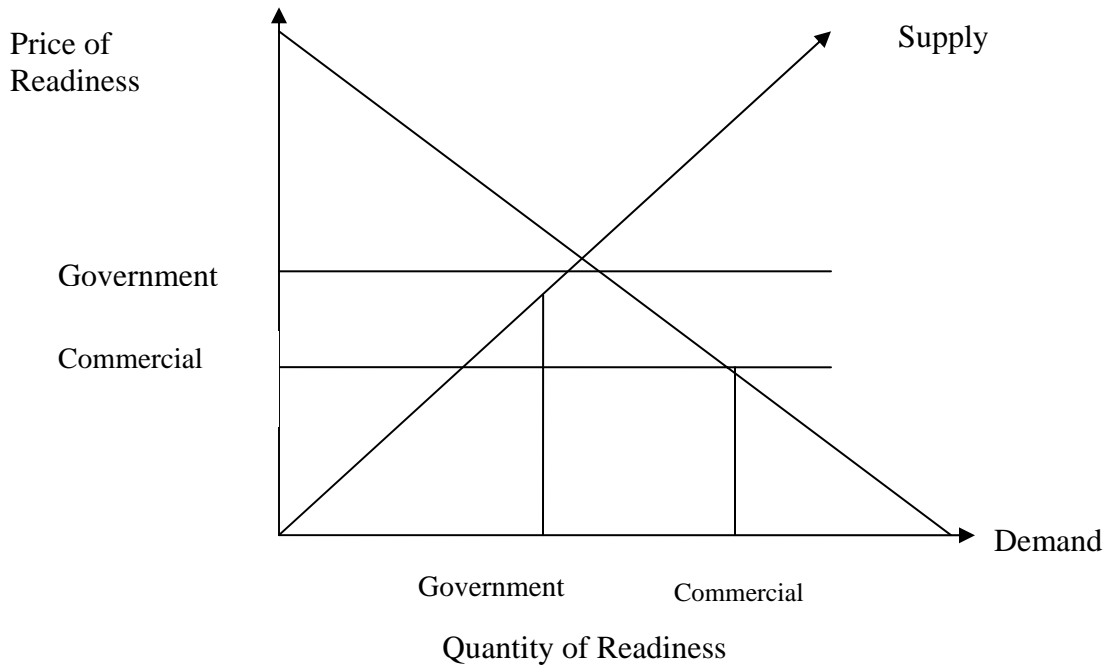


Figure 9. Quantity of Readiness by Price of Readiness

C. TRANSITIONAL SUPPORT

Naval Air Depot, North Island intends to use the successful implementation of the F/A-18 E/F Integrated Readiness Support Team (FIRST) Program as the guide for incorporation of the V-22 VIGIL Program. The Performance Based Logistics (PBL) strategy was established to target war-fighter performance based goals for weapons systems, subsystems and components.⁴⁰

⁴⁰ Proprietary Source 5, Analysis.

This strategy ensures that cradle-to-grave or life-cycle support responsibilities are assigned for the overall life management of the reliability, supportability, and total ownership cost (TOC) of a system. It also translates to war-fighter specified levels of operational performance that are directly related to sustaining the program at a level that meets system readiness requirements. Finally, the strategy focuses on reducing long-term operating and support costs.

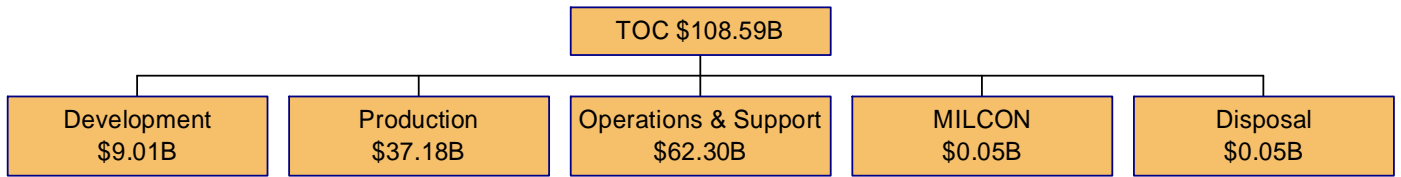
"Depot North Island is hailed as being the center of excellence for both electronic/electrical systems, and all instruments related to those systems. They have the technical expertise to help the Osprey program maintain the highest levels of readiness."⁴¹ The PBL strategy, in conjunction with North Island's expertise, not only encourages contractor innovation via performance incentives, but it also empowers to improve system deficiencies that increase system effectiveness. The outlier for the successful implementation of performance-based logistics is finding a way to exceed requirements while simultaneously reducing life-cycle cost. Most have determined that the most effective way to reduce cost over the life of a weapons system is by using a total life-cycle management approach.⁴²

Figure 10 indicates planned Total Ownership Costs:

41 Proprietary Source 5, Analysis, p 8-15.

42 Proprietary Source 6, Logistics p 8-15.

Acquisition Program Baseline (APB 26 July 2004) (TY\$B)



PB-06 Budget Submission (Feb 2005) (TY\$B)

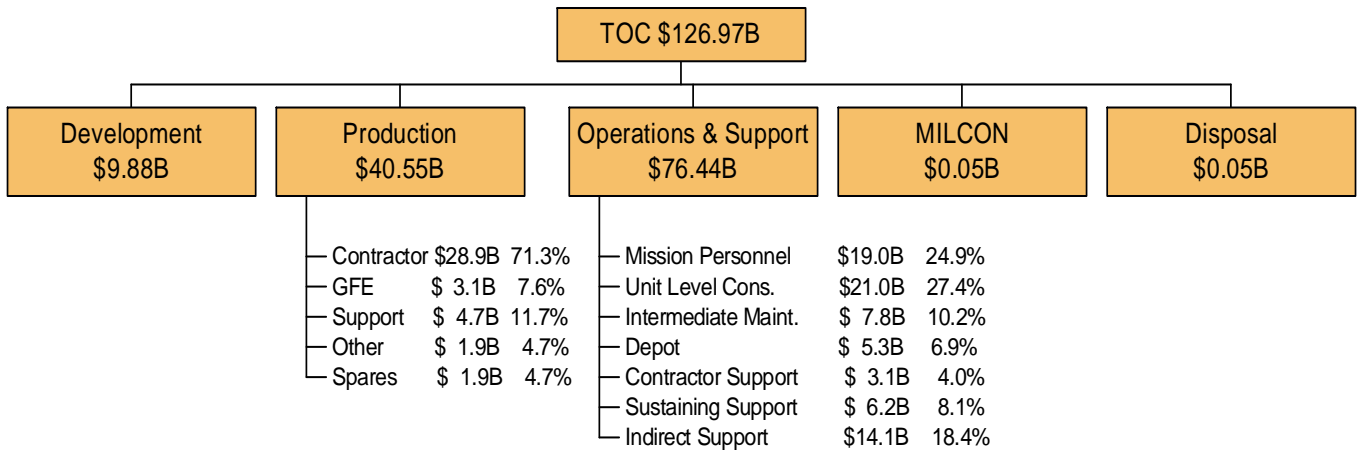


Figure 10. Planned Total Ownership Costs⁴³

DIRECT CONTROL	DIRECT INFLUENCE	MINIMAL INFLUENCE	MINIMAL INFLUENCE	NO CONTROL
MOD KIT	DEPOT MAINTENANCE	EMERGENCY REPAIRS	SOFTWARE MAINTENANCE	TAD/TDY
PROCUREMENT	CONTRACTOR SUPPORT	A/C SUPPORT SVCS	TECH PUBS MAINTENANCE	PCS
SUSTAINING ENG	AVDLRS	MISSION PERSONNEL OPS	FRS PERSONNEL	MEDICAL SUPPORT
	SIMULATOR OPERATIONS	OTHER MISSION PERSONNEL	CNET TRAINING	BASE OPS SUPPORT
		I- LEVEL MAINTENANCE	MAINTENANCE TRAINING	
		POL	CONSUMABLES	
		TRAINING	O-LEVEL MAINTENANCE	
		MUNITIONS	MALS AUGMENT	
		PURCHASED SERVICES		

Table 2. Influence and Control Lists⁴⁴

⁴³ Proprietary Source 7, Budget

⁴⁴ Ibid.

D. COMPARISON/CONTRAST

The Performance-Based Logistics strategy is the chosen mechanism for meeting the Osprey's supportability requirements. However, there are a variety of options for executing this strategy. A comparison of the various options for support will help determine the optimum or best value for the V-22 sustainment strategy. Several PBL options were considered, but the best five options are included in this analysis. The analysis took into consideration all elements of logistics/sustainment and only included the options that would meet the requirements in the original statement of work. (The following is a brief summary of a study that helped determine the most feasible alternative for fielding Osprey's PBL strategy.)

The first alternative is the option of Status Quo which implies that future sustainment will mirror the current operating environment support plan. This includes a three-tiered maintenance concept comprised of an organizational, intermediate and a depot level of maintenance. The Naval Inventory Control Point will function as the program system integrator as well as acquire the initial common V-22 spares. They will also provide replenishments for spares throughout the life of the program.

The second alternative is the alternative that utilizes a single long term sustainment strategy contractor as the program systems integrator to manage all V-22 sustainment requirements. Initial spares will be acquired by Naval Inventory Control Point and supplied to the Program System Integrator as Government Furnished Equipment (GFE). Organizational and intermediate maintenance will be completed by military maintenance personnel for their perspective aircraft configurations.

The third Alternative is a deviation of alternative 2 that includes a modified version of the second and utilizes a single long term sustainment strategy contractor as the program system integrator to manage all sustainment requirements. Initial spares will be acquired by the Navy Inventory Control Point and supplied to the PSI as GFE while organizational and intermediate maintenance will be completed by the respective service specific maintenance personnel. However, all funding will utilize the Navy Working Capital Fund (NWCF).

Alternative four utilizes the Naval Inventory Control Point as the Program System Integrator to manage all V-22 sustainment. This is the typical sustainment method chosen by many Navy programs. Military personnel

will conduct organizational and intermediate maintenance while the wholesale inventory management remains as part of the program system integrator's responsibility.

Alternative five combines the best attributes of Alternatives three and Alternatives four. In analyzing alternative four, the focus is on the strengths, weaknesses and risk of a single performance based agreement that supports all war fighters.

Various weights were placed on specific aspects of program success. Deviations between alternatives were quite small, and in some cases almost negligible. However, the final determination was that Alternative three which was a modified version of alternative two is the option that provides optimal support. Primarily this alternative creates a sustainable support structure that provides support to the war-fighter by maximizing the government/contractor logistics strength while maintaining affordability.

The program manager retains overall management and responsibility however the contractor is responsible for the daily tooth to tail support of the weapons system for the operational forces. This includes material management, supply chain management, technical data management, engineering support, obsolescence management, reliability managements, availability management and other support functions as required. Additionally, the government has significant experience in awarding and executing the performance based logistics service contracts. Combine this effort with financing and sustaining program efforts via the Navy Working Capital Fund and results yield a mechanism that support financial a high degree of flexibility.

The NWCF it is a non-appropriated account that does not carry the risk of expiring funds. It also enables the contractor to mitigate risk by allowing an investment in long-term support at reduced costs. Implementation has historically been approximately 20-24 months, but for this analysis, 22 months is accepted. The organization responsible for this effort should have a working knowledge in supply support management and planning with an overall objective of satisfying war fighter requirements while reducing total ownership cost.⁴⁵

The results of this study offer overwhelming support for the current program strategy. NAVICP has a long-running history for providing parts support, and has helped sustain the Navy and Marine Corps through many ongoing and ever-changing demands.

⁴⁵ Proprietary Source 6, Logistics

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V. CONTRACTS

A. BACKGROUND

The needs of the future joint military have introduced a variety of initiatives that are designed to meet the ever-changing requirements. Performance-Based logistics is one element whose primary objective is to reduce the life-cycle cost of major weapons systems. Its focus is on the integrity of the relationship between the customer and the contractor versus a traditional more definitive focus on the details of the contract. Its goal is to offer more autonomy to the contractor for technology insertion while sustaining maximum levels of performance. In the PBL contract, negotiations can be re-opened by either party at any time, but typically resolution is sought at much lower levels.

Contractor profit is driven by performance while oversight is provided by the dwindling members of the government's contracting world. As with many new initiatives, a number of questions remain unanswered, but the most pressing question is this: will Performance-Based Logistics withstand the change of political power and a dwindling budget?

B. CONTRACTING FOR PERFORMANCE-BASED LOGISTICS

Performance-Based Logistics is gradually becoming a key element in the Department of Defense procurement strategy for major weapons systems. In many cases, its popularity as a supportability mechanism is due to its ability to offer a perceived balance in risk, technology integration, and cost that benefit both the government and contractor. The focus of this particular strategy is quite the contradiction to the prior adversarial relationship that existed between the government and its major contractors. The key difference is that the success of this strategy is based on the "relationship" versus the "contractual agreement" between the two entities. Today's Integrated Product Teams consist of key players for both the government and the contractor. ⁴⁶

⁴⁶ Performance Based Logistics. "Contracting and Performance Agreement Management for PBL. University of Alabama Center for Science & Technology.

C. THE CONCEPT

Performance-Based Logistics is defined as an “alternative logistics support solution that transfers traditional Department of Defense inventory, supply chain management and technical support functions to the supplier for a guaranteed level of performance at the same or reduced cost.”⁴⁷ The intent is to transfer significant decision and control aspects of the contract that are traditionally the role of the Department of Defense, from the government to the contractor. In essence, “total system support responsibility” as well as a perceived equilibrium of risk is shared between the government program manager and the contractor program manager.

Advantages include faster response times for support, less red tape for engineering change proposals, and a projected lower overall life-cycle cost. Theoretically, the contractor has more authority to use his best judgment regarding technology insertion, including the use of newer technology, performance-enhancing technology, and other options that may increase performance or decrease the overall life-cycle cost. The contractor also has the right to make specified engineering changes to a weapons system with minimal government oversight. This level of autonomy should create efficiencies that improve timelines and contract execution.

D. PBL STRATEGY PROBLEMS/ISSUES

Specific problems and issues are addressed in this portion of the analysis. Solutions and potential options are included at the end as part of the analysis.

- Rate of Technology-As with many new initiatives, flaws and oversight are prevalent. In the PBL plan, a key concern is the “disconnect” in the expectations between key stakeholders in regards to the life of a program. The government often extends the life of a weapons system even in circumstances where the overall system is obsolete and the life-cycle costs are starting to increase. The necessity of the government’s ongoing use of obsolete technology, commercial contractors, and subcontractors typically results in unplanned and extremely high startup costs to build or re-design support elements for obsolete systems. Contrary to the commercial industry, these issues have not been enough

⁴⁷ D. Oliver, Performance Based Logistics Program Brief, June 4, 2001. Retrieved August 21, 2005 from www.dtic.mil/indices/2001system/oliver.html.

of a deterrent to the government to abandon outdated technology. In the long run, the PBL ideology should be cheaper, however if technology continues to move at the current rate, despite the best intentions, the contract will start to increase in cost to the contractor, thereby decreasing his bottom line.

- *The American Taxpayer*-Another issue is the increasing demand from constituents to decrease cost, specifically in relation to defense spending. The long-term success of this plan seems to be based on the idea that DOD will continue to buy new weapon systems to replace those that no longer meet the needs of the future military. If the government and contractor maintain a solid working relationship, then the key obstacle will be convincing Congress to spend more money on new weapons systems. However, historically, changes in the presidential administration as well as changes in the power of the Congressional political party have a significant impact on the life-cycle funding of such programs.

- *Realistic Contractor Capability*-Finally, there is the issue of a contractor's capability of meeting the same, or improving upon, delivery dates. Most contractors "quietly" agree that they cannot successfully meet operational tempo demands during contingencies. This fallacy has led some members to suggest that incentives for contractors be tied directly to weapon system readiness levels. Unfortunately, Readiness levels have many other variables that impact the aggregate metric. Some of these include human resources, training, operational tempo, world events, and the specific mission of the weapon system. In reality, there are too many variables to hang a contractor's profit solely on meeting a metric that in many cases may be unrealistic and unattainable.

E. THE CONTRACT

"The development of a successful partnership and service level agreement requires a balance of power and incentive to make it work."⁴⁸ The results of such an agreement can be surprising because of the synergies and increased level of creativity that directly fuels the level of accomplishment. Contracting officers are offered a variety of mechanisms to protect the government and reward the contractor. Specifically noted

⁴⁸ D. Oliver, Performance Based Logistics Program Brief, June 4, 2001. Retrieved August 21, 2005 from www.dtic.mil/indices/2001system/oliver.html p. 2.

options include fixed- price or cost-reimbursable contracts that contain award fees, graduated award fees, award terms, fixed fees, fixed terms, and in many cases a combination of various profit based awards. Typically, using either a cost-reimbursable or fixed- price contract with any of the abovementioned options is based on how the government wants to measure contractor performance. Success or failure is often defined in an evaluation period and focuses on general procedures to determine if the award fee has been earned.

If the objective is to measure specifically designated performance categories, criteria, or performance over an indicated evaluation period, then a simple award fee may suffice. The benefit is that this element has flexible revision and change options that can be distributed to individual workers as bonuses, thereby making them more personal to those actually performing on the contract. The disadvantage is that it requires a “constant review of the statement of work and an additional investment of time in administration due to the consistent need to for performance documentation.⁴⁹ Additionally there is the ongoing need to focus on end-item performance and successfully striking a perfect balance between cost, schedule and actual task performed.⁵⁰

Using a cost or fixed-price contract in conjunction with a graduated award fee has a somewhat different effect. This contract type has what is considered competing areas of focus within the program. Specifically noted are areas where ‘macro levels of overriding’ performance is required. It has a strong focus on cost as an independent variable (CAIV) and is a heavily milestone- focused vice, having all profit and fee based solely on performance. In essence, the primary focus of this contract is tradeoffs.⁵¹ "One noted weakness in using this type of incentive is the drain on resources that are required to

49 Performance Based Logistics. “Contracting and Performance Agreement Management for PBL. University of Alabama Center for Science & Technology.

50 D. Oliver, Performance Based Logistics Program Brief, June 4, 2001. Retrieved August 21, 2005 from www.dtic.mil/indices/2001system/oliver.html p. 13.

51 D. Oliver, Performance Based Logistics Program Brief, June 4, 2001. Retrieved August 21, 2005 from www.dtic.mil/indices/2001system/oliver.html p. 13.

manage this type of contract. Additionally, the impact on award-fee incentives can be magnified negatively if the government uses the incorrect higher-level performance element."⁵²

Performance-Based Incentives work in “measurable, mission related terms that include performance standards, quality assurance plans and financial incentives/penalties based on performance. It is suggested that this type of contract incentive be applied selectively to discourage inefficiencies and to motivate contractor efforts that might not otherwise be emphasized.”⁵³ Benefits include the fact that profit is tied to specific technical performance objectives, delivery schedule, and cost control objectives. Once again, the weakness is the increase in resources that are required for oversight, and delays in any area would directly impact contractor profit.

F. CONTRACT PROBLEMS/ ISSUES

- *Oversight Requirement*- The primary issue with the contract for performance-based logistics is that it is based on performance. Therefore, regardless of the type of contract used, all will require oversight by the contracting officer that ranges from micro to the macro level. The limited number of personnel available and the magnitude of visibility required often results in some of the similar concerns raised in the Engagement vs. Disengagement paper written by Professor Cory Yoder, Naval Postgraduate School. The government has been given a tool that has the sole intent of effectively reducing the personnel requirements and overall system cost as well as simplifying the supportability requirements for a variety of weapons systems. Contradicting the potential for success is the increase in requirement for extensive oversight by the government to ensure that incentive and award fees are actually awarded within the scope of the contract.

Solutions

- *Option 1* -Raise the stakes for contractor performance and lower the incentive fee. If the relationship is the most important portion of a contract, and

⁵² D. Oliver, Performance Based Logistics Program Brief, June 4, 2001. Retrieved August 21, 2005 from www.dtic.mil/indices/2001system/oliver.html p. 13.

⁵³ Ibid.

according to the studies at the University of Alabama, the contract only becomes a concern when there is a disagreement, then this is a viable option. Additionally, Mr. Steve Bernard, Logistics Manager at NAVAIR, stated that the contractor makes money on spares, not the developing of weapon systems. Therefore, simply lower the award fee while strategically maintaining a balance between what the government is willing to pay and the area on the scale where the contractor believes that he is still benefiting from the agreement. Incidentally, the more prevalent a method becomes, the more proficient a contractor becomes at implementing that methodology. PBL costs for overall support should decrease after a contractor, his suppliers, and other infrastructure are in place. This efficiency should especially be realized when a contractor supports 4 or 5 weapon systems using this contracting strategy.

- **Option 2** - Make the contract type FFP from the beginning vice the cost plus for contractors who have had prior major performance-based logistics contracts, while maintaining the current award fee structure. Experience significantly reduces the initial start-up costs for major contractors. Typically they have a better understanding of the scope of contract requirements and can execute a contract much faster than a contractor who is starting from scratch (e.g., KBR in LOGCAP contracts).

- **Options 3** - Design software that is similar to EVMS that tracks the entire cost of a PBL contract. The program parameters should start with the initial C-17 PBL contracts and move forward to include the current V-22 contract. Use this information to track the actual cost, including the award and incentive fees paid to contractors. Later use the data to determine if past prices been fair and reasonable and if experienced contractors are adequately capturing realistic cost in the initial negotiation of the contract, or is the contractor simply taking advantage of the government's need and choosing to meet that need at a cost that is disproportionately above the "Actual?" If this is the case, then the government should seek some form of resolution, including re-opening negotiations and/or contract termination.

G. RECOMMENDATION FOR CONTRACT EXECUTION

This analysis suggests a gradual implementation of all options, beginning with the development of the software and ending with the implementation of FFP type contracts

for commercial entities that have had at least two past PBL contracts. Most companies maintain lessons learned on past execution, expect to receive additional government business, and in many cases, immediately correct deficiencies to improve profit. Contracts would typically be awarded via competition versus sole source in order to take advantage of the market opportunities and to raise the stakes for contractors. Contract visibility should include higher levels of oversight so that key players can monitor the contractor's success at meeting the requirements. If the user and congressional staffers are aware of the requirements, then contractor performance will be monitored by two key but diverse elements that are capable of influencing profit.

H. SUMMARY

PBL represents the transition in focus from the contract to the relationship between the customer and the contractor. It is no longer the “strength of the contract,” but the strength of the relationship that drives the success of war-fighter support. In a combined effort to keep a weapon system operating at its highest level of reliability, many contractor options for engineering changes, requirement modifications, and authority are granted in the original contract. However, the significant decrease in personnel, defense spending, and diversity in operational requirements threatens the success of this new initiative.

COMPARISON OF CULTURE EXAMPLES	
New Culture	Old Culture
The C-17 aircraft is the focus of a Boeing - Air Force partnership. They do joint off sites and work specifically on their relationship. They have joint weekly, monthly, block, etc., meetings and reviews. Every employee who works on the C-17 wears a plastic card the size of their badge, imprinted with the partnership agreement signed by Boeing and Air Force leaders.	<ul style="list-style-type: none"> ◆ Arms length, adversarial relationship between government and contractor. ◆ All communications in writing to create an audit trail. ◆ Interact as little as possible, conduct bi-annual performance reviews. ◆ Maintain objectivity <i>don't get too close to the contractor.</i> ◆ Contractor driven by <i>profit motive</i> vs. nation's defense. ◆ Government close holds information.
NAVSEA established an e-marketplace using a one-page flowchart showing what it wanted its electronic services procurement system to look like. The five steps represented the full operating capability (FOC) of the desired system, with the extensions and clouds being areas for future scalability in the eventual system. The Navy simply handed the flowchart to potential vendors and asked them, "How much of this picture can you deliver and at what price?" (IBM - Seaport Study, p. 18)	<ul style="list-style-type: none"> ◆ Lengthy statements of work developed by government requiring office—with an attempt to document every possible situation, process, regulation, milspec, service, and government expectation for the bidders. ◆ Independent government estimates. ◆ Elaborate processing of Statement of Work through technical data, system engineering, legal, etc., all with organization-specific word requirements.
Air Force Joint Surveillance Target Attack Radar System (JSTARS) Total System Support Responsibility (TSSR) partnership has multiple agreements in place supporting the sustainment of JSTARS. In most cases, these agreements stand alone—they are not part of the contract between Northrop Grumman Corporation (NGC) and the Air Force. The Partnering Agreement (PA) between NGC and the Warner Robbins Air Logistics Center (WR-ALC) has been incorporated into the prime TSSR contract as the guiding basis for the Air Force providing the depot-performed workloads to the contractor.	<ul style="list-style-type: none"> ◆ Finger pointing between government and suppliers over delays and cost increases. ◆ Request for Proposal describes services and scope of work in great detail. ◆ Numerous change orders as soon as work starts and RFP omissions are identified. ◆ Government defines service delivery means and process through inclusion of government regulations and directives. ◆ Contract administration role vs. partner role. ◆ Only acceptable relationship is a contractual one.
Sikorsky Aircraft Corporation (SAC) is working side-by-side with Corpus Christi Army Depot (CCAD) to reduce repair/overhaul turnaround time for the H-60. This joint collaboration has improved business processes, depot repair methodology, and more responsive product support, with only four contractor jobs directly attributable to the partnership.	<ul style="list-style-type: none"> ◆ <i>Expert</i> role assigned to government employee. ◆ Use of design specifications where the government tells the contractor <i>how</i> to provide the service. ◆ Contractors in the government workplace viewed as personal service. ◆ Quality assurance processes defined by government specialists. ◆ Government employee relies on <i>guidance</i> from HQ.
The Navy Inventory Control Point (NAVICP) has an F/A-18E/F Integrated Readiness Support Teaming (FIRST) prime contract with Boeing under which Naval Air Depot (NADEP) North Island performs depot repair services to Boeing as a <i>subcontractor</i> . Boeing provides funding, repairable units, repair parts, obsolescence management, and shipping. The NADEP North Island provides touch labor, facilities, technical data, equipment, production engineering, and packaging. Fifty-seven government jobs were created or sustained by this partnership.	<ul style="list-style-type: none"> ◆ Contractors are taking jobs away from government workers. ◆ Government is buyer of services, not seller. ◆ All payments to government are deposited in the U.S. Treasury account. ◆ Private sector cannot use government facilities and equipment to perform work.

Table 3. Comparison of Culture Examples⁵⁴

⁵⁴ From Performance Based Logistics. "Contracting and Performance Agreement) Management for PBL. University of Alabama Center for Science & Technology.

VI. CONCLUSION

The Marine's experimental tiltrotor squadron completed more than a month of simulated combat mission in California and Nevada and has returned to North Carolina for a crucial set of operations at sea. The operations at sea will involve multiple aircraft flying on and off amphibious assault ships. The squadron of eight aircraft flew more than 600 hours during the rigorous trials which were designed to duplicate the demanding Afghanistan and Iraqi mountain and desert conditions where Marine helicopters are currently in operation. Current simulated operations included combat assault missions with troop insertion. The last time Osprey demonstrated troop transport was in April 2000 when the MV-22 crashed at Mirana, Arizona killing 19 Marines. This crash and the crash in North Carolina eight months later killing four Marines prompted an 18 month grounding of the aircraft.⁵⁵

The new requirements are not so much the issue, as downsizing, transformation, and "jointness," are all necessary, whether combined or independent of one another. However, execution in lieu of so many technology gaps and the increasing world demand on the U.S. military has almost created a drag effect on the military's ability to support demand. The concern is not that all mandates for new technology, jointness and transformation will be unsuccessful, because the U.S. military historically achieves success even in perceived failure. However, the trickle effect at the operational level has left many gaps that will widen, not close, as the operational tempo continues to rise.

The Osprey has recently been approved for full rate production. The successful fielding of this new technology still has many obstacles to overcome. Included in this struggle is the ongoing desire for balance in spending and contractor profit. The results often tip in favor of the contractor when the government's decisions appear to support what the public perceives as contractor cash cows. These results occasionally happen despite the best efforts of negotiators.

Transformation or change is not only required, but necessary, and the future success of the Osprey, the Joint Strike Fighter, and the Performance-Based Logistics

⁵⁵ NAVAIR, V-22 Osprey Web. "Tilt-Rotor Osprey Faces Crucial Test at Sea After Rigorous Land Trials" Retrieved July 6,,2005 from http://pma275.navair.navy.mil/index.cfm?fuseaction=news.detail&news_id=116.

strategy, as does everything else, lies gently in the hands of the local user, engineer, program manager, congressman and taxpayer. Strangely enough, this is a group as diverse as the stars.

A. OPTIONS FOR FUTURE RESEARCH

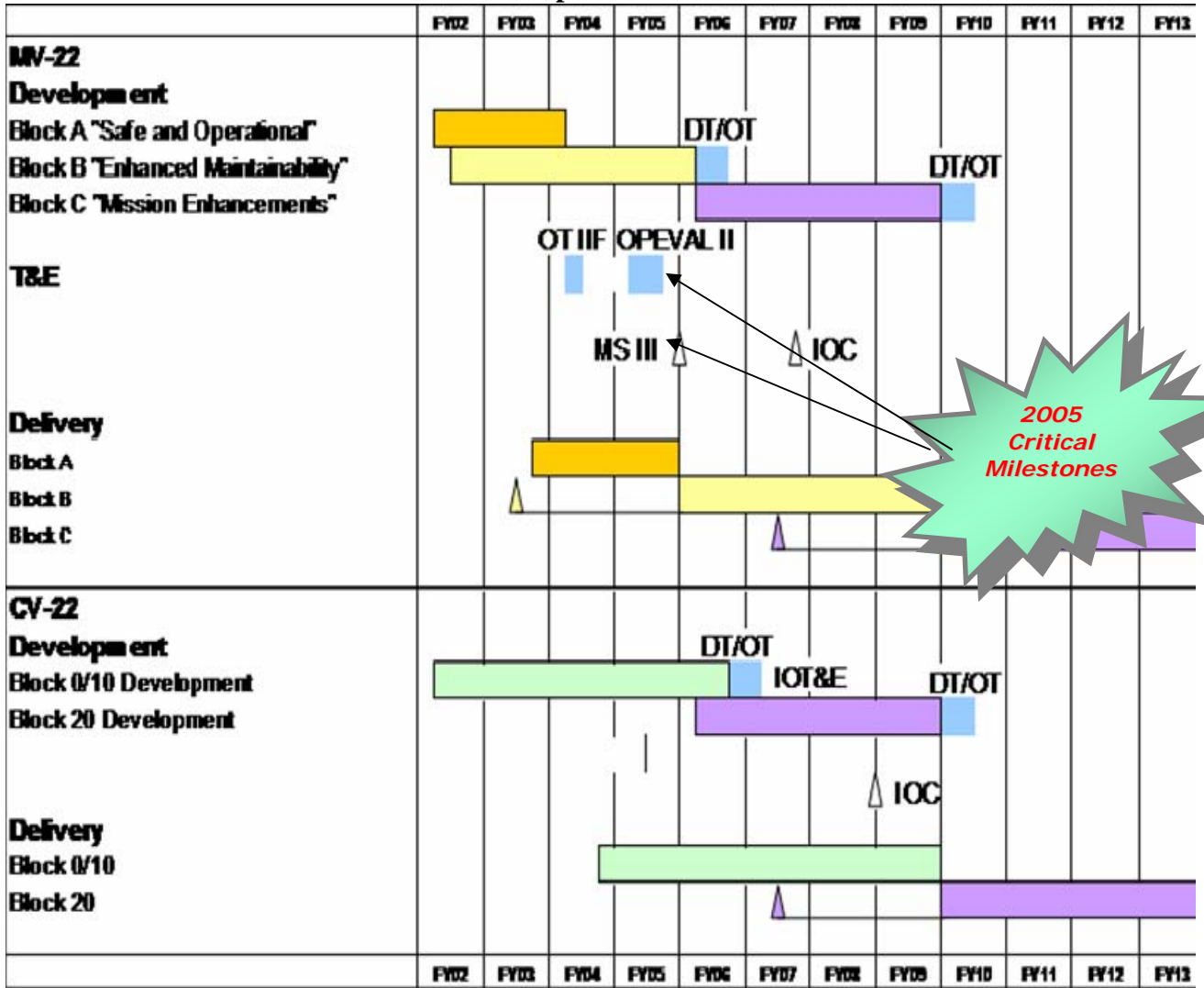
Option 1 - Numerical Cost Analysis of actual long term cost savings with performance based contracts versus traditional contracts that are supported by the government.

Option 2 - Five year capabilities review of the Osprey. Did it actually accomplish its initial goals and if so was it a higher price than originally forecasted.

Option 3 - Complete a 7 year analysis determining Osprey's impact on current and future war-fighting capabilities of future conflicts

APPENDIX

Total Ownership Cost Forecast



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