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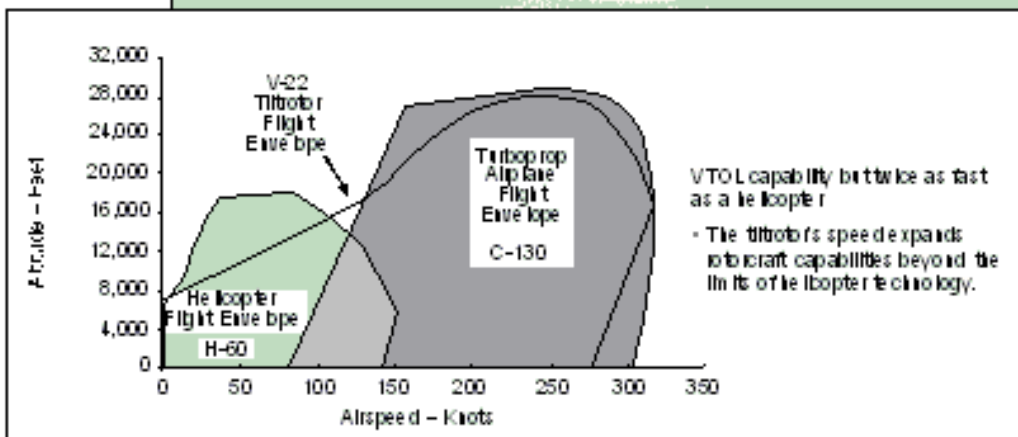
◆ EXECUTIVE SUMMARY

INTRODUCTION

The V-22 tiltrotor is a revolutionary, advanced technology, vertical and short take-off and land (V/STOL), multi-purpose aircraft with excellent high-speed cruise performance. It performs a wide range of VTOL missions as effectively as a conventional helicopter while achieving the long-range cruise efficiencies of a twin turboprop aircraft.

The V-22 will revolutionize military air transport capabilities in a manner not seen since the introduction of helicopters more than 40 years ago.

The V-22 has been designed to a very demanding set of requirements and has demonstrated its ability to perform its missions and functions during more than



V-22 Osprey

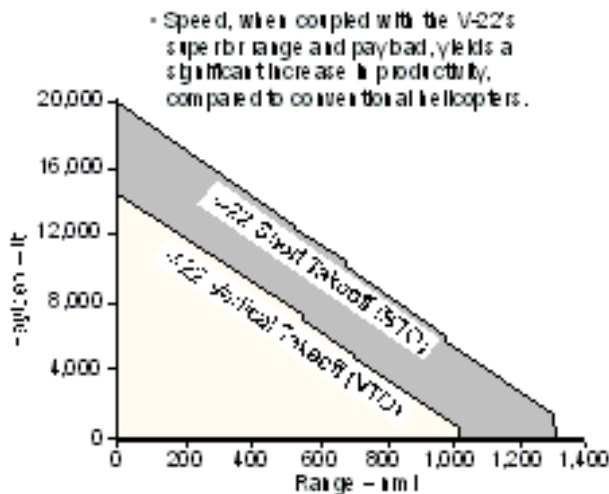
1,300 hours of flight testing. Four prototype aircraft, built during the full scale development (FSD) program, have successfully met technical and operational flight test objectives.

- | | | | |
|---|---|--|--|
| <ul style="list-style-type: none"> - Sustained cruise speed: 230 knots - Self-deploy worldwide - Unrefueled radius of action: 500 nm | } | <p>Fixed-wing
tactical
transport</p> | <ul style="list-style-type: none"> - Cockpit and cabin overpressure to protect against NBC warfare agents - High level of infrared suppression, ballistic protection |
| <ul style="list-style-type: none"> - Operate from amphibious ships - Hover not at all high - Carry 10,000 lb external payload - Fly low level, counter flight, and nap of the earth (NOE) | } | <p>Helicopter
assault
transport</p> | <ul style="list-style-type: none"> - Cockpit life grade color displays, avionics to navigate worldwide, civil and military fields - Fold/stow and corrosion protection to meet shipboard compatibility |

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Top Level V-22 Design Requirements

Other design considerations include meeting guarantees for weight and performance, graceful handling of engine failures, crashworthiness, emergency egress, and maintenance or repair accessibility. The V-22 meets all of these requirements and more.



Self-Deployable Worldwide

- The V-22 can self-deploy anywhere in the world without the need for strategic airlift or sealift.



JB-009

The ability to carry large payloads over long distances, and its self-deployability make the V-22 capable of supporting numerous missions worldwide. When combined with increased speed, these capabilities yield significant increases in productivity when compared to conventional helicopters.

Capitalizing on the speed, range, and payload capability, the U.S. Military services are purchasing the V-22 to accomplish the operations shown at right. These varied missions show the versatility of the tiltrotor in support of the Marine Corps, Special Operations Forces (SOF), and Navy Operations.



U.S. Marine Corps
(360 MV-22)

- Combat assault from ships
- Assault support



U.S. Special Operations
Command (50 CV-22)

- Long-range special operations
- Night/all weather



U.S. Navy
(48 HV-22)

- Combat search and rescue (CSAR)
- Special warfare
- Fleet logistic support

V-22 Osprey

The Bell-Boeing team has built an additional four aircraft for the Engineering and Manufacturing Development (EMD) program phase, which will culminate in Marine Corps Operational Evaluation (OPEVAL) in 1999. Low rate initial production began in 1996, with Marine Corps Initial Operating Capability (IOC) planned for mid-2001.

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	
EMD	Design, fabricate and test aircraft										JS-016
EMD/operational tests			□ OT	□ OT	□ OT	□ OT	□ OT	□ OPEVAL			
Production					Low rate initial production			5 A/C	7 A/C	9 A/C	
								Deliveries		USMC IOC ▽	
									△		
										Full rate production decision	

V-22 Program Schedule

Operational testing under EMD will be a continuation of flight testing already being conducted on the FSD aircraft. With over 1300 hours already flown, of which over 200 hours have been flown by EMD aircraft, Bell-Boeing is anticipating a very successful EMD flight demonstration and operational evaluation program.



The V-22 Converting Between Helicopter and Airplane Modes

Missions that cover large distances and that require vertical takeoffs and landings have challenged aeronautical pioneers since helicopters first proved their worth. The challenge has been to devise a vehicle that is faster, has more range, and is more cost effective than conventional helicopters.

Within this challenge, the Joint Services (USMC, USN, USAF, USA) specified in detail the operational requirements of the V-22. The joint requirement defined missions, airframe size constraints, payload handling, and other operational capabilities required to meet the U.S. needs.

The V-22 Osprey is a revolutionary change. It brings capabilities not found in any helicopter -- twice the speed, range and altitude capability. These capabilities, recognized in the over 17 COEAs performed to date by various agencies and governments, have shown that the Osprey is more cost effective than any helicopter or compound helicopter. The Osprey will bring interoperability and vastly increased mission effectiveness to armed forces.

The V-22 has been designed to the most stringent set of design requirements of any rotary wing aircraft ever built.

Safety, reliability, readiness, all-weather, survivability, crashworthiness, performance. Nothing has been left out or compromised to achieve this revolutionary performance capability.

The Osprey is in production *today* and deliveries start in 1999. Projected production quantities are 360 for the USMC, 50 for SOCOM, and 48 for the USN.

Osprey was designed from inception for shipboard and in-the-field use. It offers unprecedented built-in reliability and maintainability features. There is no honeycomb in the primary structure, no magnesium in the aircraft and no composites, such as Kevlar, that are prone to long term deterioration from water.

The modern avionics suite of communication, navigation and penetration aids are fully integrated and redundant, where necessary, to ensure successful mission completion. Survivability is designed in, not added on.

The Osprey will be operated by the US military for a period of 25 to 50 years and therefore a very comprehensive training and support system is being developed by Bell-Boeing. We plan to expand this support system worldwide as we add customers, and to develop a Contractor Logistics Support (CLS) approach that meets our customer's needs and minimizes cost.

WHAT IS A TILTROTOR?

Definition

A "tiltrotor" is a unique type of aircraft which can fly fast and efficiently in forward flight like a turboprop airplane and also takeoff, hover, and land vertically like a conventional helicopter.

A tiltrotor has a wing with lift/propulsive proprotors at each wing tip. These proprotors are designed with a high degree of twist and careful aerodynamic design to function effectively both as propellers and as rotors. The proprotors, along with their engines and reduction gearboxes, are typically mounted in



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wingtip nacelles which rotate from a horizontal position (airplane or cruise mode) to the vertical one (helicopter or hover mode).

In helicopter mode, the proprotors provide all lift and attitude control. Required engine power is highest when hovering. As the aircraft converts to airplane mode, power and thrust are reduced as the wing takes on more of the lift. As a result, the tiltrotor can achieve very efficient cruise performance.

A Tiltrotor is not a Helicopter

Although a tiltrotor can hover and has excellent maneuverability and handling qualities in vertical flight like a helicopter, a tiltrotor has other capabilities which greatly exceed those of a helicopter. It is misleading and technically incorrect to refer to a tiltrotor as a helicopter.

A helicopter's wing is its rotor (or rotors). The rotor blades are rotated about a shaft above the aircraft. As the rotors pass through the air, they create lift so the aircraft can remain stationary over the ground. This process is called hovering.

Control of the helicopter is provided by varying the pitch of the rotor blades as they rotate. The helicopter can move vertically up and down by increasing or decreasing pitch on all rotor blades simultaneously, a process called collective pitch control.

The helicopter can control its movement over the ground by varying the pitch of individual blades, increasing or decreasing lift at selected points during blade rotation, a process called cyclic pitch control. The combination of collective and cyclic pitch control gives the helicopter its excellent control characteristics in the hover.

The helicopter's thrust is nearly always pointed upward. The helicopter achieves forward flight by tilting the plane of its blade rotation forward, thus slightly tilting its thrust in the desired direction of flight. Tilting the thrust direction is an inefficient method for generating forward thrust. Consequently, it requires a great deal of power to achieve high speeds while sustaining level flight.

This characteristic of the helicopter, along with the high drag of its rotor system and the problem of retreating blade stall at higher speeds, accounts for the helicopter's speed limitation.

The tiltrotor achieves its lift and control in hovering flight in exactly the same way as a helicopter: proprotor system lift, and collective and cyclic pitch control. This gives the tiltrotor its excellent hover and slow flight handling characteristics.

However, the tiltrotor can tilt its proprotors from vertical to horizontal for providing thrust while relying on its wing for lift. In this way, the tiltrotor overcomes many of the helicopter's weaknesses:

- High rotor system drag
- High fuel consumption at higher airspeeds
- Retreating blade stall
- High vibratory loads

A tiltrotor has characteristics uncommon to conventional single rotor helicopters, other tandem rotor systems, or conventional airplanes. Of particular significance are the following:

- Counter-rotating proprotors eliminate the yawing moment due to torque which is prominent in single rotor helicopters.
- The interconnecting driveshafts automatically deliver power to both rotors following the loss of one engine, eliminating asymmetrical thrust during single engine operation.

A Tiltrotor is not a Tiltwing

In the tiltwing configuration, the aircraft's engines and propellers are rigidly mounted to the wing and the entire propulsion system is tilted between the vertical and horizontal positions. Propulsion is provided by propellers, not proprotors, and cyclic pitch control is not used in the vertical flight mode. Because of problems with wing stall during conversion, the envelope of safe tilt angles for different airspeeds is very small. The tiltwing flies well in the airplane mode, but is very inefficient at low speeds and during hover. Tiltwings do not typically hover for long periods due to their high hovering fuel consumption.

A Tiltrotor is not an Airplane

An airplane only has a wing to produce lift. An airplane creates lift by moving its wing through the air fast enough to generate enough lift to overcome the aircraft's weight. An airplane uses propellers or jet engines to maintain the speed necessary to sustain flight. At low speeds the airplane wing stalls and can no

V-22 Osprey

longer maintain lift. The airplane controls its direction of flight through the use of ailerons, elevators, and rudders.

In airplane mode, the tiltrotor functions exactly the same as a typical airplane. In forward flight, the tiltrotor is supported by the lift of its wing. Its speed is sustained by its turboshaft engines driving the proprotors. Its controls are ailerons, elevators and rudders, function exactly like a conventional airplane. However, for low speed or hovering flight, a tiltrotor can rotate its nacelles (i.e., its thrust direction) from the horizontal to the vertical position — something an airplane cannot do.

Finally, a tiltrotor's proprotors are much larger than an airplane propeller or jet, consequently the proprotors can generate the same amount of thrust as an airplane at a much slower RPM. The lower tip speed of the tiltrotor makes it very quiet in cruise flight, even at high speeds.

Flying a Tiltrotor

The tiltrotor is easy to fly. The pilot controls both flight modes with a single set of controls. The conventional airplane stick, rudder pedals, and thrust lever automatically function like a cyclic stick, yaw pedals, and collective control in a helicopter. The flight control system is designed to change the flight control functions automatically and transparently as aircraft speed increases or decreases during conversion.

In a tiltrotor, the pilot also controls nacelle angle. Using nacelle controls provides an additional method to translate forward and aft and turn, completely independent of fuselage attitude or cyclic pitch.

See *Flight Controls and Cockpit Management System* for details of how the various pilot controls control the aircraft in each flight mode.

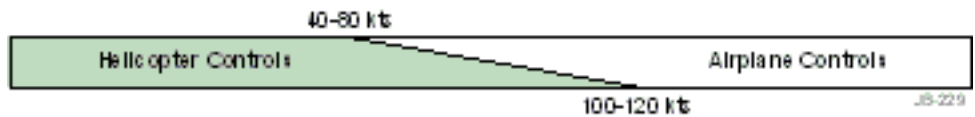
Conversion

The process of rotating the nacelles to transition between helicopter and airplane modes is called conversion.

The conversion procedure is simple, straight forward, and easy to accomplish. The amount and rate of nacelle tilt can be completely controlled by the pilot or can be performed automatically by the flight control system. (On the V-22, the minimum time to accomplish a full conversion from hover to airplane flight mode is 12 seconds.)

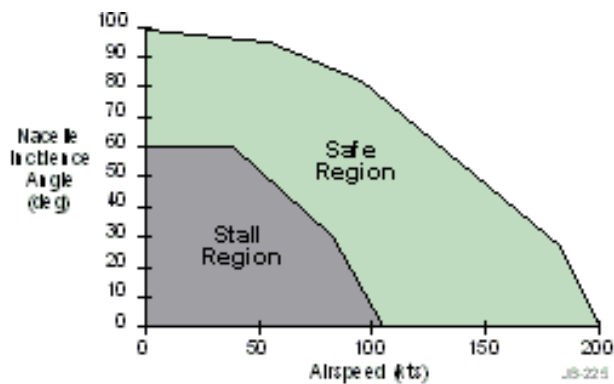
Conversion is not a dynamic maneuver - a maneuver that must be accomplished within a set amount of time. A tiltrotor can fly at any degree of nacelle tilt indefinitely.

During vertical takeoff, conventional helicopter controls are utilized. As the tiltrotor gains forward speed to between 40 to 80 knots, the wing begins to produce lift and the ailerons, elevators, and rudders become effective. At this point, rotary-wing controls are gradually phased out by the flight control system. At approximately 100 to 120 knots the wing is fully effective and cyclic pitch control of the proprotors is locked out.



The conversion from airplane flight to a hover simply reverses the process described. Since the fuselage and wing are free to remain in a level attitude during the conversion, there is no tendency for the wing to stall as speed decreases. Rotor-borne lift fully compensates for the decrease in wing lift.

Because there is great variability available between aircraft and nacelle attitude, the conversion corridor (the range of permissible airspeeds for each angle of nacelle tilt) is very wide (about 100 knots). In both accelerating and decelerating flight this wide corridor means that a tiltrotor can have a safe and comfortable transition, free of the threat of wing stall.



Conversion Corridor

Flight Safety

The engines of the tiltrotor are connected by a shaft through the wing. Under dual engine operations, the connecting shaft transmits very little power, but if power from one engine is lost the shaft naturally transfers half the power from the remaining engine to the opposite proprotor. The transfer of power is so quick and smooth that the yaw which normally accompanies loss of power on one side in a multi-engine airplane is absent in a tiltrotor and the only sensation in the cockpit is an overall reduction in thrust.

Although modern engines are very reliable and the probability of both engines failing on the same flight are extremely low, the tiltrotor can maintain the RPM of its proprotors while descending without power. With the tiltrotor, the pilot has the option of making a wing-borne or rotor-borne descent. Minimum descent angles are actually better in airplane mode and so the pilot would typically descend in airplane, only rotating the nacelles up for the final flare and landing.

TILTROTOR ADVANTAGES

Performance

The tiltrotor expands on the operational roles of both helicopters and airplanes. A tiltrotor has an exceptionally large operating envelope. It can operate effectively from a hover to airspeeds of 300 knots and altitudes exceeding 20,000 feet. A tiltrotor's envelope typically encompasses that of both a helicopter and a fixed-wing turboprop aircraft.

Tiltrotors achieve airplane-like cruise speed and range with greater flexibility and more cost effectiveness than other V/STOL concepts. Some of the advantages of tiltrotors are:

- Wide, flexible conversion corridor
- Gentle, forgivable control system
- Interconnected rotors to provide safe one-engine-out flight in all modes
- Flies backward and/or sideward easily
- Quiet cruise flight, with low acoustic signature

Flexibility

Within its payload capability, a reasonably sized tiltrotor can perform any mission currently performed by helicopters and many missions currently being performed by fixed-wing tactical transport type aircraft. The tiltrotor is best suited for those types of missions involving vertical or short field takeoffs and landings and for which time and/or distance are important mission parameters.

Quieter

Tiltrotors reduce rotor rotational speed and use very low thrust for cruise propulsion and so they are inherently more quiet than both helicopters and airplanes during cruise flight.

Better than a Helicopter

Providing similar vertical takeoff and hover performance to that of a conventional helicopter, a tiltrotor can take off from small, unimproved, or confined areas and still cover long distances at high speed. In combination with its large payload capacity, the increased speed and range mean that the tiltrotor offers a very significant increase in productivity per flight hour when compared to a helicopter.

Because the rotors do not provide lift in cruise and do not incur the retreating-blade stall penalties of conventional helicopters, a tiltrotor will have significantly less vibration at higher speeds. Because tiltrotors have only brief exposure to the vibration and oscillatory loading that occurs during helicopter flight (less than 10 percent of tiltrotor life versus 100 percent for a helicopter), tiltrotors offer significantly better reliability than helicopters, thus lowering operating costs.

Better than an Airplane

The tiltrotor has the efficiencies of a twin turboprop airplane but does not need a runway for takeoff or landing. A tiltrotor can be based from small, temporary flight facilities or platform ships, while still providing a high speed, and long range capability. With a hoist or other equipment, it can insert or remove personnel and/or equipment from areas too small to land in by hovering above the location.

The location of the engines, transmissions, and rotors at the wing tips provides higher roll and yaw inertias, resulting in a very stable platform from which to employ sensors.

V-22 Osprey

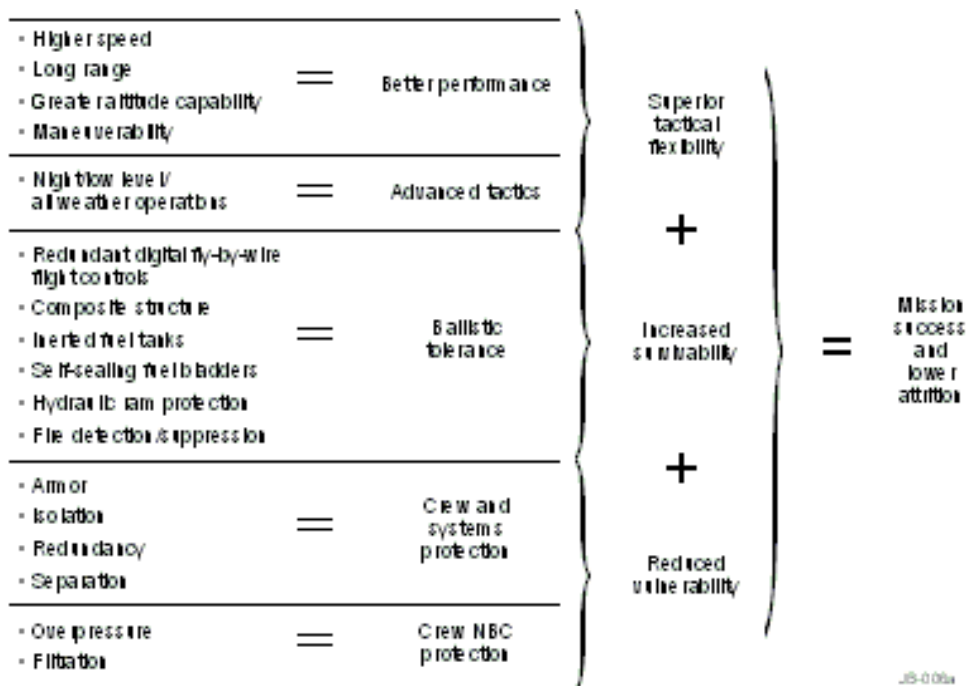
V-22 DESIGN

The V-22 incorporates all of the characteristics of a normal tiltrotor and, in addition, has been designed to a very strict set of U.S. military specifications, including reliability, crashworthiness, and shipboard compatibility. The combined military and individual service requirements that have most influenced the design of the V-22 are shown below.

<p>Combined Military Services</p> <ul style="list-style-type: none"> • VTOL and high-speed cruise • Operates in NBC-contaminated environments • Worldwide self-deployment • Advanced survivability features • Shipboard operations • Reduced operations and support costs • Efficient maintenance • Self-protection 	<p>U. S. Marine Corps</p> <ul style="list-style-type: none"> • Combat assault, ship- and land-based • 24 troop, 371 km (200 mi) radius of action • External cargo capability <p>U. S. SOCOM</p> <ul style="list-style-type: none"> • Special operations • 18 troop insertion/extraction to 927 km (500 mi) radius of action <p>U. S. Navy</p> <ul style="list-style-type: none"> • Combat Search and Rescue (CSAR) to 890 km (480 mi) radius of action • Special warfare team insertion/extraction • Logistics resupply to ships at sea <p style="text-align: right;">JIS-009</p>
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Key U.S. Military Requirements

The V-22 combines VTOL and high-speed night/all-weather capability while incorporating a series of advanced features to improve mission success rates and enhance survivability. These features will provide a significant reduction in



attrition which, when combined with the V-22's range and payload capacity, will mean fewer aircraft are required to accomplish a given mission.

Configuration Summary

The rotor system and airframe are made of advanced composite materials, fiberglass, and metal. More than 43 percent of the V-22's structure weight is fabricated from composites. The airframe structure and its seating accommodations for the passengers and crew have been systematically designed to maximize crashworthiness and safety.

The defined internal cargo requirements include crashworthy seating for up to 24 combat troops, palletized cargo, light wheeled vehicles, and up to 12 medical litters. This defined the cabin dimensions and volume as well as the ramp design. External cargo requirements up to 4,536 kg (10,000 lbs) include single or dual pendant hook-up for netted cargo and large vehicles or ordnance. The dual hook arrangement provides sufficient stability for cruise at higher speeds with loads up to 6,804 kg (15,000 lbs).

Turboshaft engines are located in nacelles at each end of the wing. The engines drive two 11.6 meter (38 foot) diameter proprotors through gearboxes that are interconnected to provide fail-safe engine power to both rotors.

The design features state-of-the-art avionics and triply redundant digital fly-by-wire flight controls. Onboard Central Integrated Checkout (CIC) and Vibration, Structural Life, and Engine Diagnostics (VSLED) systems are employed to provide continuous condition monitoring of the aircraft's structure, engines, electrical systems, and dynamic components.

The aircraft's tricycle landing gear provides for excellent ground or deck handling qualities. An aft ramp facilitates troop and cargo loading and unloading.

Flight Crew

The standard crew consists of a pilot and a copilot in the cockpit and a crew chief (or gunner) in the cabin. An observer seat is also located between the two pilots.

Shipboard and Ground Operations

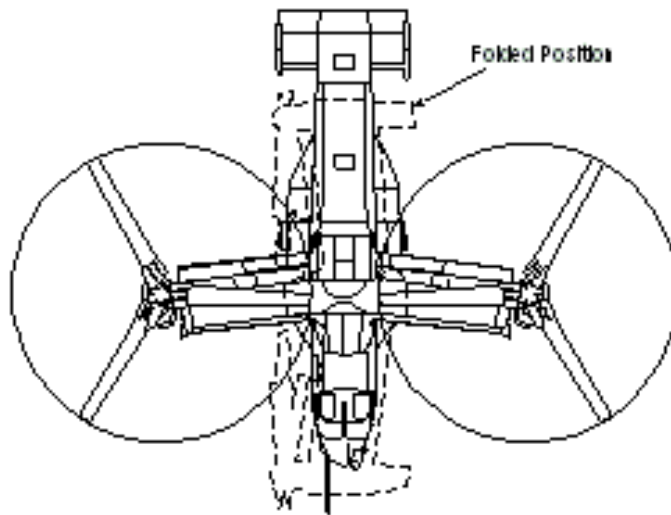
In just 90 seconds, the proprotor blades and wing can be folded and stowed automatically to accommodate deck spotting and to minimize shipboard stowage space. When folded the V-22 takes on the dimensions shown at right by the dashed lines; this compact configuration can also be used to reduce hangar space as well.

Design constraints imposed by shipboard compatibility (rotor disk size) and airplane mode operation required relatively small, stiff proprotors. Ground clearances are such that personnel and most ground support equipment are not endangered by rotor strikes, an important safety factor when compared to all helicopters.

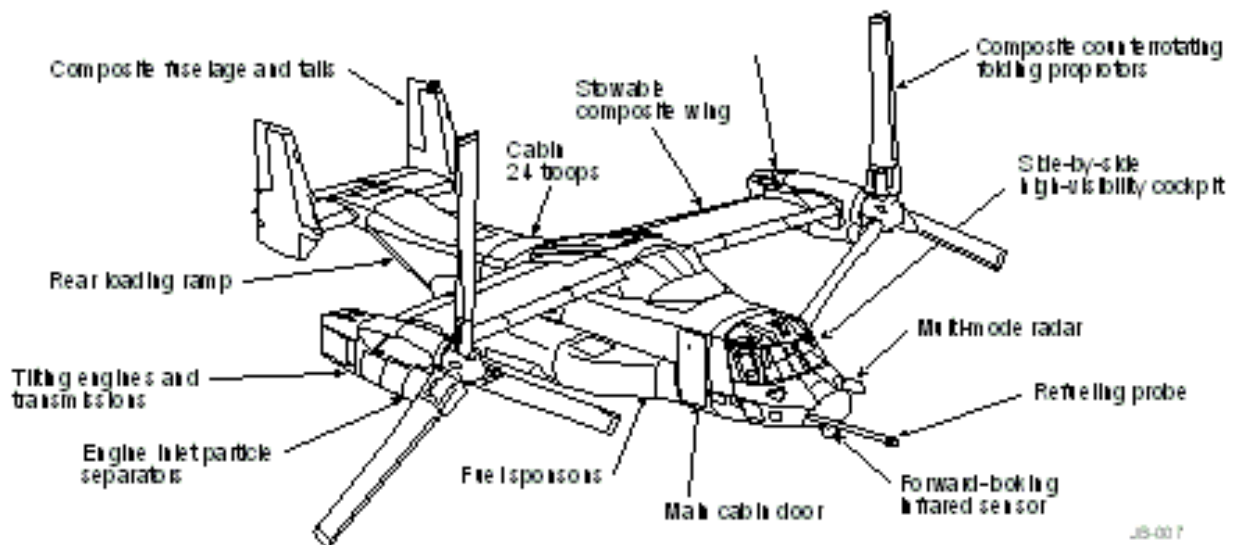
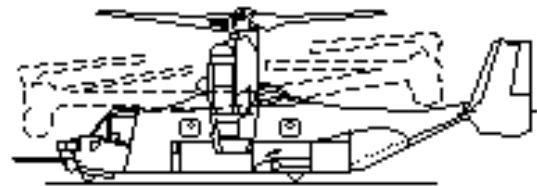
V-22 Osprey

Flight Operations

The aircraft operates as a helicopter when taking off and landing vertically. Once airborne the nacelles are rotated 90 degrees forward thus converting the aircraft into a turboprop airplane for high-speed, fuel-efficient flight.



Aircraft Characteristics	
Length	57 ft 4 in
Width	84 ft 7 in
Height	22 ft 1 in
Folded length	63 ft 0 in
Folded width	18 ft 5 in
Folded height	18 ft 1 in
Rotor diameter	38 ft 1 in
Power	2 x 6,150 shp
Empty weight	33,140 lb
Maximum VTO weight (61st)	51,400 lb
Short takeoff weight	57,000 lb
Sea-level payload weight	60,500 lb
Maximum fuel capacity	2,037 gal
Cable length x width x height	290 in x 72 in x 72 in
Cable provisions	24 troops or 12 life rafts
Rescue hoist capacity	600 lb
Cargo floor limit	300 psf
Cruise speed (3,000 ft/91.5°F)	275 kts
Maximum speed (15,000 ft/45°F)	305 kts



JB-007

The proprotors are connected by means of an interconnect driveshaft that runs through the wing between the two nacelle mounted transmissions. During normal, twin-engine operation very little power is transmitted through the shaft. The primary purpose of the interconnect shaft is to immediately transmit power to both rotors from a single engine in the case of an engine failure. It also

V-22 Osprey

provides power to the aircraft systems components located at the mid-wing area. The proprotors are not required to be synchronized.

The V-22 provides excellent air and ground taxiing capability. Nacelle tilt provides thrust control to accelerate and decelerate easily. Aft nacelle is sufficient to stop or back the aircraft for precise ground handling.

Through the use of nacelle tilt control and lateral trim mode, the V-22 has the ability to translate in any direction in a hover independent of fuselage attitude. Counterrotating proprotors eliminate torque coupling. The stability of the V-22 in airplane mode compares favorably with that of a conventional twin-engine commuter type airplane.

The V-22 is very safe and easy to fly in hover, slow flight, transition, and airplane flight regimes. In hover and slow flight, it has the maneuverability and agility of a helicopter. In fact, it is easier to fly in a hover than contemporary single-rotor helicopters. Heading control in the V-22 requires little or no pilot reaction to changes in power or wind direction or velocity. It will be very easy for both fixed- and rotary-wing pilots to transition to tiltrotor flight.

The V-22 can fly continuously at any speed from 83 km/hr (45 knots) rearward and sideward up to 584 km/hr (315 knots) in level forward flight (TAS). The maximum dive speed is 719 km/hr (388 knots) TAS. The V-22 can perform a complete conversion from hover to forward flight in 12 seconds. The pilot can stop a conversion or reconversion or reverse it at any point, and can convert or reconvert at any altitude while climbing, diving, or turning. Conversion and reconversion can be performed at any power setting from full power to no power.

At an average cruise speed of 250 knots, the V-22 can fly a 100 nm tactical troop insertion mission in approximately 24 minutes from takeoff to touch down in the landing zone. A 200 nm mission takes approximately 48 minutes.

Mission range or endurance establishes the fuel requirement, thus sizing the remainder of the physical aircraft as well as the engine power and transmission ratings. The V-22 was given mission requirements for both long and short range operations. To most effectively perform these mission, the V-22 is available in two fuel system configurations, basic and full-fuel. Additionally, the requirement to self-deploy to a distance of more than 3,335 km (1,800 nm) meant that the V-22 must also accommodate aerial refueling and internal tanks.

With its basic tactical fuel tanks (3492 kg/7700 lb capacity), the V-22 can carry its troop payload to a tactical radius of action of 200 NM and return without refueling. With additional fuel tanks in its wing and sponson, the V-22 can extend this tactical radius of action to 400 NM. Finally, with the addition of cabin auxiliary tanks, the V-22 can achieve an unrefueled, zero payload ferry flight range of over 1500 NM. For longer range missions, the V-22 can also be refueled in flight using the available refueling probe.

Because of its ability to fly like an airplane, the V-22 is well suited for missions which require a substantial sensor package to be maintained at altitude. The V-22 can perform these missions while operating from an austere site, a short landing strip, or a ship equipped with a landing pad.

The primary missions include: combat troop lift, internal and external cargo lift, combat search and rescue, special operations, and self-deployment. The secondary missions include: administrative personnel transport, light logistics/general support, tactical air control support, and aeromedical evacuation.

Flight Safety

The V-22 is powered by two Rolls-Royce/Allison T-406 turboshaft engines, each of which develop over 6,000 shaft horse power. The power of one engine is quite sufficient to sustain airplane mode (wing-borne) flight. The V-22 can hover on one engine if it is light enough; however, the recommended one engine inoperative landing procedure is a short field landing with the nacelles at 60 degrees tilt.

Flight Control System

The V-22 flight control system is a full authority, triply redundant, digital, fly-by-wire system with control laws structured within a primary flight control system (PFCS). The PFCS provides the basic control functions for flight. In addition, an automatic flight control system (AFCS) is included to provide stability and control augmentation for enhanced handling qualities. The V-22 flight handling qualities are enhanced through command shaping, rotor and engine speed governing, rate feedback, automatic flap control, and lateral side force control.

Flight on the PFCS has been demonstrated throughout the envelope and it meets all control requirements for primary flight. Flight on the AFCS has also been demonstrated throughout the envelope. The AFCS has been optimized to meet pilots' needs for a wide range of missions. The fly-by-wire architecture allows for easy tailoring of the flight control systems to incorporate changes based on pilot feedback, resulting in low pilot workloads for all tasks. With AFCS on, at 4.6 meter (15 feet) hover height, nearly hands-off hover performance is possible in low winds.

Maintenance

Under normal conditions, the V-22 can support both three [organizational (O), intermediate (I), and depot (D) unscheduled] and two level (O and D) maintenance concepts. Scheduled inspection requirements have been minimized through up-front design. Some of the enabling technologies that support this philosophy include:

- Extensive use of composites
- "Enhanced toughness" technologies
- Central integrated checkout systems
- Integrated diagnostics systems
- Composite repair development programs

In addition, the V-22 is designed to be operated for extended periods from austere sites that lack normal maintenance support. Onboard power generation, and built-in hand-holds enable field maintainers to perform all normal flight inspections without special facilities or equipment.

V-22 Osprey

The V-22 was designed with maintenance and support in mind. It incorporates some marked changes in maintenance concept and employs a substantially different scheduled maintenance philosophy, reducing maintenance manpower requirements and thus cost of operation.

Growth Potential

Multi-role capability is a cornerstone to the V-22 program. The V-22 has a basic configuration that supports the missions using standard or existing, provisioned, kits.

Flexibility in the avionics system is also a cornerstone of the V-22 program. The existing Mil-Std-1553 databus architecture means that different units can be integrated, provided they conform to V-22 command protocols. This minimizes the amount of modifications necessary to produce service-unique configurations for special performance and operational needs. This flexibility has been demonstrated within the V-22 program already with the transition from the baseline USMC mission configuration to that for the USSOCOM missions.

Additionally, the V-22 is one of the most thoroughly tested aircraft in history. By the end of the EMD program, Bell-Boeing will have a complete database of the important parameters from the Static Test Article, the Drop Test Article, vulnerability tests, flight tests, reliability growth tests, and comprehensive component qualification testing. Should changes be required over the life of the aircraft, this data will allow the careful selection of changes that minimize weight and cost while maximizing performance and capability.

Because the V-22 has sufficient performance margin for growth over an extended service life, incorporation of such items as a nose-mounted gun (already provisioned), increased computational processing and memory reserve will not require major system redesign. Such planning for the future will offer long-term payback as technology advances and new mission requirements are developed. In the area of avionics alone, it is anticipated that the future will offer greater capability, faster processing, and require less cooling, space, weight and power than the systems of today.

The V-22 stands ready to integrate the technology of tomorrow. It is this design for the future that will minimize the effort to adapt the V-22 to satisfy future mission requirements.

AFFORDABILITY

Operational Utility

Affordability versus mission effectiveness is a key issue facing aircraft operators worldwide. The tiltrotor aircraft offers the potential to significantly reduce fleet procurement and operating costs, because the tiltrotor can fulfill both helicopter and airplane roles. Having one aircraft type for most missions significantly reduces aircraft and facilities requirements, and in addition, crew and maintenance personnel training can be consolidated thus reducing total training time and cost as well.

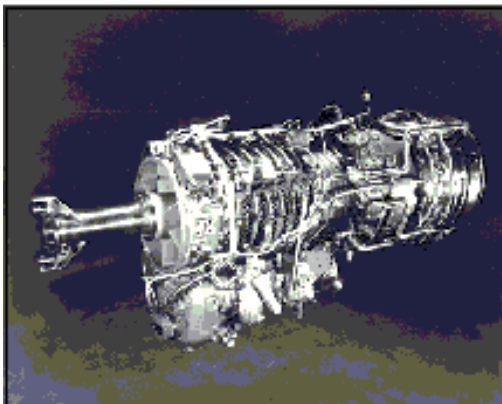
Acquisition Cost

The U.S. Navy/Bell-Boeing team has employed an aggressive cost containment program to keep the price of the V-22 affordable. Modern manufacturing processes for both composite and metal components are being demonstrated on early production prototypes. These are reducing both manhours and assembly time with the associated cost savings.

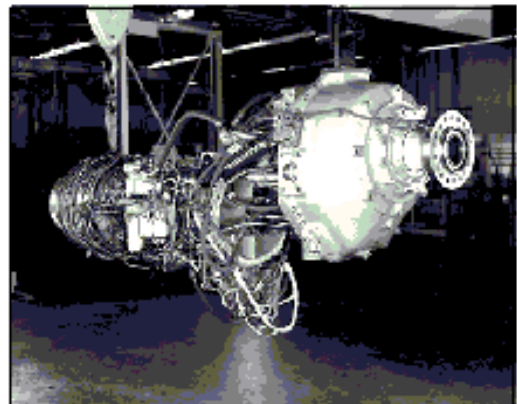
Engine Spares Commonality

The V-22 is equipped with two Rolls-Royce/Allison T-406 engines, an evolution of the proven T-58 powerplant. This engine shares many parts and functions with the AE2100 series engines found on the Lockheed-Martin C-130J, Cessna Citation, and SAAB 2000. Operators using the AE2100 series engine will benefit from the common spare parts supply, training, maintenance procedures and tools.

T406-A-D-400



AE2100

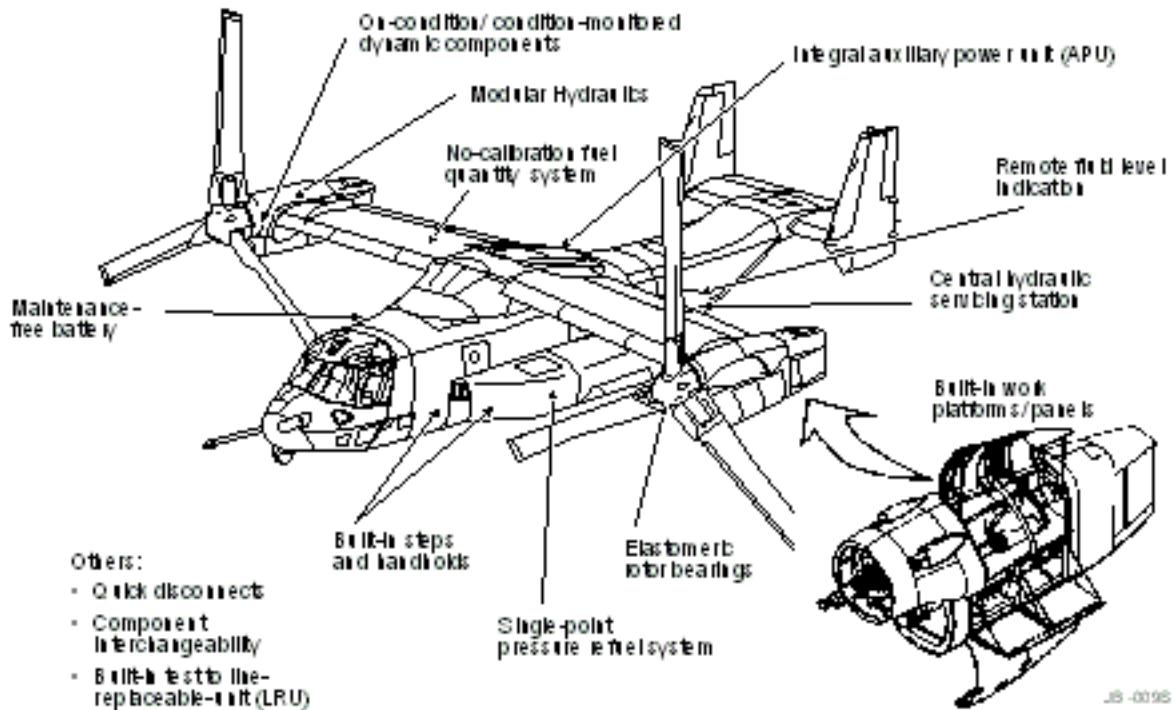


- Engines common to V-22 (T406) and C-130J (AE2100)
 - 80 percent common on part number basis
 - 70 percent common on dollar basis

V-22 Osprey

Maintenance

Working with the U.S. military, Bell-Boeing has developed a maintenance concept that reduces maintenance hours per flight hour by building in maintainability features. From pre-flight inspection to component replacement and ease of servicing, maintenance cost reductions are being proven in operational tests. For example, engine removal and replacement can be completed in only five hours by three people.



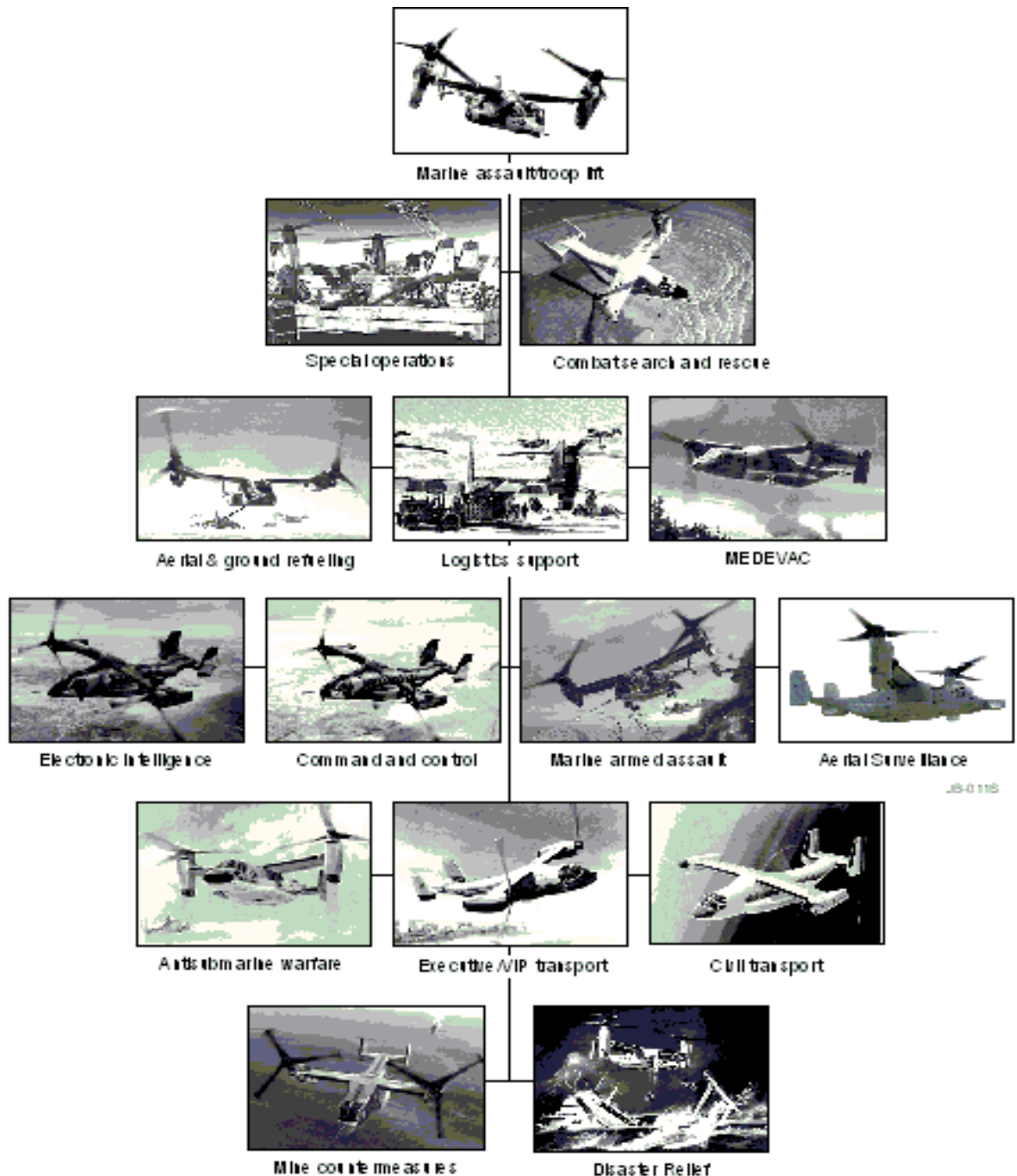
Built-in Maintainability Features

Increased Production Rates

As the number of V-22 aircraft increases internationally, all operators will benefit from cost reductions arising from increased production rates, as well as from interoperability and multi-service operational utility that will enhance operational effectiveness.

MULTIMISSION CAPABILITIES

The V-22 tiltrotor design can be adapted to missions not specified by current customers. Bell-Boeing has developed numerous design upgrades and configuration improvements to suit alternate missions. Highlighted here are the most prominent of the configurations conceived to date. With its speed, range, and internal cargo capacity, it makes an excellent platform for Aerial Refueling, Search and Rescue, or Command and Control.



V-22 Osprey

The V-22 is a highly flexible, multipurpose aircraft capable of performing many missions. The U.S. Government, Bell-Boeing, and commercial analysis companies have evaluated the suitability and effectiveness of V-22 variants for over 30 different missions, which are summarized below.

	Mission Applications
Special Warfare	Special Operations Electronic Warfare Antisubmarine Warfare Mine Warfare
Theater Operations	Assault Medium Lift Tactical Mobility Advanced Rotary Wing Attack Gunship/Close Air Support Aerial Refueling
Recovery	Search and Rescue Combat Rescue Medical Evacuation Joint Emergency Evacuation of Personnel
Communications	Forward Air Control Surface, Subsurface, Surveillance Coordination Over-the-Horizon Targeting Surface Combatant Airborne Tactical System
Intelligence	Observation Armed Reconnaissance Airborne Early Warning-Surface Combatants Signal Intelligence Battle Group Surveillance-Intelligence
Transport	Fleet Logistics Carrier/Surface Ship On-Board Delivery Operational Support Airlift Mid-Air Retrieval System Light Intratheater Transport National Executive Transport
Support	Missile Site Support Range Support

For each mission, the V-22's high-speed flight and hover capabilities provide the large area of operations and rapid responsiveness of a fixed wing turboprop aircraft while retaining a helicopter's capability to operate from confined areas. To cover a given territory or ocean zone, fewer bases, V-22 aircraft and crews are required versus conventional aircraft and crews. In addition, self-

deployability, improved reliability, and reduced maintenance will significantly reduce the cost of military deployments and operations.

The V-22 has been designed with space, weight, and power provisions for various electronic and other equipment upgrades. The two mission computers and the triple MIL-STD-1553B digital data buses afford significant growth potential for additional avionics systems or operator consoles in the aircraft cabin. Under normal conditions (non-icing), the V-22 electrical system (240 kVA total from 4 generators) can deliver over 100 kilowatts of power over that required for flight. Even under icing conditions, over 50 kilowatts remain available.

The large, unobstructed cabin area, high take-off gross weight limits, and large electrical power capacity facilitate the addition of a wide range of mission equipment and systems. All V-22 aircraft can be fitted with additional fuel tanks in the wings and sponsons. With some development, auxiliary fuel and/or weapons can be added using an external stores arrangement.

V-22 Osprey

DEVELOPMENT HISTORY

Both Bell and Boeing have extensive experience in V/STOL aircraft design. In 1956, Boeing began development of the world's first tilt-wing aircraft, called the VZ-2, which made its maiden flight in 1958. Earlier, Bell's research had focused on tilting the transmissions to achieve conversion to conventional flight. Bell's XV-3 tiltrotor, begun in 1954, achieved full conversion in 1958 and continued in flight test until 1966.

Bell and Boeing continued to design and test tiltrotor configurations during the 1960s and competed in the early 1970s for the next tiltrotor program. Based on its experience with the XV-3, Bell was awarded a NASA-U.S. Army contract in 1973 to develop two XV-15 tiltrotors. First flight occurred in 1977 and full conversion occurred in 1979. The two XV-15s were the stepping stones toward the future of tiltrotor flight and were directly responsible for the birth of Joint Services Advanced Vertical Lift Aircraft (JVX).

The V-22 Osprey development was begun by the U.S. Department of Defense as the JVX program in 1981. Drawing upon the strengths of their respective research efforts during the preceding 30 years, the Bell-Boeing team was officially formed in April 1982. In April, 1983, the Bell-Boeing team was selected by the U.S. Navy as the prime contractor to develop the JVX aircraft, now known as the V-22 Osprey.



VZ-2 1958



XV-3 1958



XV-15 1977

J8-2095



V-22 1989

Evolutionary Development of a Revolutionary Aircraft

The Navy awarded the Bell-Boeing Team, in April 1983, the 24-month Preliminary Design contract. This PD Stage I contract included 4,800 hours of wind tunnel model testing, flight control simulation testing, supportability analysis, trade studies, design analysis, design reviews, critical structural testing, and mockups. In addition, the program was augmented with approximately 500 hours of applicable XV-15 flight testing.

The PD Stage II add-on modification to the Preliminary Design contract, awarded in June 1984, augmented the PD Stage I effort. It permitted the start of the detail design of major components and procurement of critical long-lead items in preparation for V-22 system testing to be conducted under FSD.

The FSD contract awarded in May 1986 included detail design, manufacture, and flight testing of six aircraft. First flight was 19 March 1989, and flight test continued through July 1992.

In October 1992, the EMD contract was awarded to design, manufacture, and flight test four aircraft in a production-representative configuration, and to perform Design Support Flight Test on two of the FSD aircraft (#2 & #3). The EMD aircraft (#7 through #10) were designed and manufactured at the Philadelphia and Fort Worth facilities of the Bell-Boeing team. Flight test activities are managed by the Integrated Test Team (Government and Bell-Boeing) at Naval Air Warfare Center, Aircraft Division, Patuxent River (NAWCADPAX), Maryland, the principal flight test site. The flight test program is currently in the EMD phase with four MV-22 aircraft flying at NAWCADPAX.

On 10 February 1995 a DoD Acquisition Decision Memorandum (ADM) was signed documenting decisions made in late 1994 by the Defense Acquisition Board and the Defense Resources Board concerning the V-22 Program. The ADM authorizes the Navy, Air Force and Special Operations Command (SOCOM) to proceed with an integrated MV-22/CV-22 program..

On 24 December 1996, Bell-Boeing were authorized to proceed with EMD for the CV-22 special operations. After completion of MV-22 flight testing, Aircraft #7 will be modified to support CV-22 EMD risk reduction and design efforts. Aircraft #9: After completion of MV-22 flight testing, it will be re-manufactured as necessary to meet the required CV-22 configuration.

To date, there has been over 1300 flight hours accumulated on the V-22 aircraft. Bell-Boeing has received the first Long Range Initial Production (LRIP) contract from NAVAIR for 16 production aircraft scheduled for first delivery in May 1999.

V-22 Osprey

SUMMARY

The Osprey has extremely low external noise and very low inherent vibration characteristics since the rotors are in symmetric flight rather than edgewise flight throughout most of the flight regime.

IR-suppressed engine exhaust does not bathe the fuselage of the V-22 and create a large IR target. Active countermeasures provide additional protection from attack by IR missiles.

Cockpit and cabin overpressure delivers Nuclear, Biological, Chemical protection throughout the aircraft. An airtight door between cockpit and cabin provides the possibility of multiple missions in an NBC environment without contamination of the cockpit crew.

The U.S. Government is proceeding with production of the V-22. The production quantities for the U.S. Marine Corps, and Special Operations Forces are firm, with a U.S. Navy procurement planned.

The Bell-Boeing team has made the personnel, facilities, and equipment investments necessary to achieve a low-risk transition from the development phase to production of an affordable aircraft.

The V-22 Osprey tiltrotor is in production.