V-22 Osprey
Pocket Guide

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**Introduction**

The V-22 Osprey is the world’s first production tiltrotor aircraft. Unlike any aircraft before it, the V-22 successfully blends the vertical flight capabilities of helicopters with the speed, range, altitude, and endurance of fixed-wing transports. This unique combination provides an “unfair advantage” to warfighters, allowing the conduct of current missions more effectively, and the accomplishment of new missions, heretofore unachievable with legacy platforms.

Comprehensively tested and approved for full rate production, the V-22 provides strategic agility, operational reach, and tactical flexibility - all in one survivable, transformational platform.
Background/History

Both Bell and Boeing have over 50 years of experience in V/STOL aircraft design. In 1956, Boeing began development of the world’s first tiltwing aircraft the VZ-2. Its maiden flight was in 1958.

VZ-2 (1958)

Concurrently, Bell’s research had focused on tilting the transmissions to achieve the conversion to conventional flight. Bell’s XV-3 tiltrotor (begun in 1954) successfully achieved full conversion from helicopter to airplane mode in 1958. It continued in flight test until 1966 and did much to demonstrate the feasibility of tiltrotor technology.

XV-3 (1958)

In the 1960s and 1970s, Boeing completed over 3,500 hours of wind-tunnel testing of tiltrotor models. These models included a full-scale rotor system. 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. Its first flight occurred in 1977 and full conversion occurred in 1979. The two XV-15s demonstrated the maturity of tiltrotor technology and were directly responsible for the birth of the Joint Services Advanced Vertical Lift Aircraft (JVX).

XV-15 (1977)

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 U.S. Navy selected the Bell-Boeing team as the prime contractor to develop the JVX aircraft – now known as the V-22 Osprey.

The V-22 was approved for full-rate production in 2005, with initial operational capability in 2007. Projected production quantities are 360 for the U.S. Marine Corps, 50 for U.S. Special Operations Command (operated by the Air Force Special Operations Command), and 48 for the U.S. Navy.

V-22 (1989)
Program Events

<table>
<thead>
<tr>
<th>Activity</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>JVX Program Commenced</td>
<td>1981</td>
</tr>
<tr>
<td>Bell-Boeing Team Formed</td>
<td>Apr 82</td>
</tr>
<tr>
<td>Bell-Boeing Awarded 24-Month JVX</td>
<td></td>
</tr>
<tr>
<td>Preliminary Design Stage I Contract</td>
<td>Jun 83</td>
</tr>
<tr>
<td>Bell-Boeing Awarded JVX Preliminary Design Stage II Contract</td>
<td></td>
</tr>
<tr>
<td>FSD Contract Award</td>
<td>May 86</td>
</tr>
<tr>
<td>V-22 First Flight</td>
<td>Mar 89</td>
</tr>
<tr>
<td>Awarded Collier Trophy</td>
<td>1990</td>
</tr>
<tr>
<td>EMD Contract Award</td>
<td>Oct 92</td>
</tr>
<tr>
<td>ADM Signed for MV-22/CC-22 Program</td>
<td>Feb 95</td>
</tr>
<tr>
<td>Authorized to Proceed with CC-22 EMD</td>
<td>Dec 96</td>
</tr>
<tr>
<td>LRIP Lots I, II, III Contract Award</td>
<td>Jun 96</td>
</tr>
<tr>
<td>EMD V-22 First Flight</td>
<td>Feb 97</td>
</tr>
<tr>
<td>Completed Sea Trials</td>
<td>Feb 99</td>
</tr>
<tr>
<td>V-22 Pilot Team Wins AHS Feinstein Award</td>
<td>Apr 99</td>
</tr>
<tr>
<td>Receives 1999 DoD Defense Value Engineering Award</td>
<td></td>
</tr>
<tr>
<td>Operational Flight Training Simulator</td>
<td>Apr 99</td>
</tr>
<tr>
<td>Delivered to VMNT-204</td>
<td></td>
</tr>
<tr>
<td>Lightweight 155mm Howitzer Lifted Externally</td>
<td>May 99</td>
</tr>
<tr>
<td>First Production V-22 Delivered to USMC</td>
<td>May 99</td>
</tr>
<tr>
<td>VMNT-204 (MV Training Squadron)</td>
<td>Jun 99</td>
</tr>
<tr>
<td>V-22 Completes Initial OPEVAL (pre Block A)</td>
<td>Sep 00</td>
</tr>
<tr>
<td>Live Fire Test and Evaluation</td>
<td>Nov 00</td>
</tr>
<tr>
<td>Operational Pause</td>
<td>Dec 00</td>
</tr>
<tr>
<td>Return to Flight</td>
<td>May 02</td>
</tr>
<tr>
<td>VMX-22 Standup (MV Operational Test and Evaluation Squadron)</td>
<td>Aug 03</td>
</tr>
<tr>
<td>V-22 ITT Wins AHS Grover Bell Award</td>
<td>Jun 04</td>
</tr>
<tr>
<td>71st SOS Standup (CV Training Squadron)</td>
<td>May 05</td>
</tr>
<tr>
<td>V-22 Completes Final OPEVAL (Block A)</td>
<td>Jun 05</td>
</tr>
<tr>
<td>V-22 Approved for Full Rate Production</td>
<td>Sep 05</td>
</tr>
<tr>
<td>VMM-263 Standup (1st MV Combat Squadron)</td>
<td>Mar 06</td>
</tr>
<tr>
<td>75th MV-22 Delivery</td>
<td>Jun 06</td>
</tr>
<tr>
<td>VMM-162 Standup (2nd MV Combat Squadron)</td>
<td>Aug 06</td>
</tr>
<tr>
<td>1st Transatlantic Flight</td>
<td>Jul 06</td>
</tr>
<tr>
<td>8th SOS Standup (1st CV Operational Squadron)</td>
<td>Oct 06</td>
</tr>
<tr>
<td>VMM-266 Standup (3rd MV Combat Squadron)</td>
<td>Mar 07</td>
</tr>
</tbody>
</table>

General Characteristics

Performance @ 47,000 lb
Max cruise speed (MCP) Sea Level (SL), kts (km/h) . . . . . 250 (463)
Max RC, A/P mode SL, fpm (m/m) . . . . . . . . . . . . . . . . 3,200 (975)
Service Ceiling, ISA, ft (m) . . . . . . . . . . . . . . . . . 25,000 (7620)
OEI Service Ceiling ISA, ft (m) . . . . . . . . . . . . . . . 10,300 (3139)
HOGE ceiling, ISA, ft (m) . . . . . . . . . . . . . . . . . . . 5,400 (1,646)

Weights
Takeoff, vertical, max, lb (kg) . . . . . . . . . . . . . . . . . 52,600 (23859)
Takeoff, short, max, lb (kg) . . . . . . . . . . . . . . . . . . . 57,000 (25855)
Takeoff, self-deploy, lb (kg) . . . . . . . . . . . . . . . . . . 60,500 (27443)
Cargo hook, single, lb (kg) . . . . . . . . . . . . . . . . . . . 10,000 (4536)
Cargo hook, dual, lb (kg) . . . . . . . . . . . . . . . . . . . . 15,000 (6804)

Fuel Capacity
MV-22, gallons (liters) . . . . . . . . . . . . . . . . . . . . . . . 1,721 (6513)
CV-22, gallons (liters) . . . . . . . . . . . . . . . . . . . . . . . 2,037 (7710)

Engines
Model . . . . . . . . . . . . . . . . . . . . . . . . AE1107C (Rolls-Royce Liberty)
AEO VTOL normal power, shp (kW) . . . . . . . . . . . . . . . 6,150 (4586)

Crew
Cockpit – crew seats . . . . . . . . . . . . . . . . . . . . . . . . . 2 MV/3 CV
Cabin – crew seat/troop seats/litters . . . . . . . . . . . . . . . 1/24/9
Airframe

A key enabling technology for the development of the V-22 was the use of composite materials to reduce cost and weight, improve reliability, and increase ballistic tolerance. The past two decades of extensive research and development on composite materials in the aerospace industry has directly benefitted the V-22 structural design.

Design Features

The V-22 has been designed to the most stringent set of design requirements of any rotary wing aircraft ever built, including safety, reliability, readiness, all-weather operations, survivability, crash worthiness, and performance.

The ability to rapidly carry large payloads over long distances and its self-deployability make the V-22 capable of supporting numerous missions worldwide.

Top Level V-22 Design Requirements

Airframe

A key enabling technology for the development of the V-22 was the use of composite materials to reduce cost and weight, improve reliability, and increase ballistic tolerance. The past two decades of extensive research and development on composite materials in the aerospace industry has directly benefitted the V-22 structural design.

Structural Features

More than 43 percent of the V-22 airframe structure is fabricated from composite materials. The wing is made primarily with IM-6 graphite/epoxy solid laminates that are applied unidirectionally to give optimum stiffness. The fuselage, empennage, and tail assemblies have additional AS4 graphite fiber materials incorporated during their fabrication. Many airframe components (such as stiffeners, stringers and caps) are co-cured with the skin panels. This technique provides subassemblies with fewer fasteners, thus fewer fatigue effects.

The composite airframe delivers the necessary stiffness and light weight for V/STOL. It also provides additional resistance to environmental corrosion caused by salt water. The composite airframe is fatigue resistant and damage tolerant – a feature particularly desirable for ballistic survivability.
Landing Gear

The retractable tricycle landing gear is a crashworthy design that allows routine operations over field conditions consisting of rocks, sand, dust, dirt, grass, brush, snow, rain, and ice. Its clearance for boulders and stumps is up to 30.5 cm (12 in).

Design highlights include:
• Main landing gear
  - Two hydraulically activated main landing gear located in the left and right sponsons
  - Hydraulic master braking cylinders
  - Manually-activated, cable-operated parking brake

• Steerable nose landing gear
  - Hydraulically activated located under the cockpit floor
  - Hydraulic power steering unit provides 75 degree left and right steering authority, which is controlled by the rudder pedals.
• A 19.3 mPa (2800 psi) nitrogen bottle provides emergency extension power.

• Descent conditions
  - 3.7 m/s (12 ft/s) for normal operations
  - 7.3 m/s (24 ft/s) during a crash landing

• Landing gear loading
  - Designed for a California Bearing Ratio (CBR) of 4.0

<table>
<thead>
<tr>
<th>Weight distribution</th>
<th>kg</th>
<th>lb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main landing gear (ea)</td>
<td>5,595</td>
<td>12,337</td>
</tr>
<tr>
<td>Nose gear</td>
<td>4,202</td>
<td>9,264</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Footprint area, per tire</th>
<th>sq cm</th>
<th>sq in</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two mains, (ea)</td>
<td>348</td>
<td>54</td>
</tr>
<tr>
<td>Nose wheels</td>
<td>116</td>
<td>18</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Footprint pressure</th>
<th>kPa</th>
<th>psi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main landing gear (ea)</td>
<td>827</td>
<td>120</td>
</tr>
<tr>
<td>Nose gear</td>
<td>1,860</td>
<td>270</td>
</tr>
</tbody>
</table>

Landing gear loading at the aircraft empty weight in helicopter mode at the one g static condition

Propulsion System

Two Rolls-Royce AE1107C Liberty engines provide the propulsion for the V-22. The AE1107C is a 6,150 shaft horsepower, two-spool, turboshaft, gas-turbine engine. The engines are located within the nacelles. The interconnect driveshaft provides safe one-engine-out flight in all modes of operation.

An Engine Air Particle Separator (EAPS) is integral to the engine installation, and can be selected to manual pilot control or automatic.

Fire detection and extinguishing systems are provided in the engine compartments, wing bays and mid-wing areas.

A rotor brake assembly is integral to the mid-wing gearbox.
Payload Systems

The V-22 is designed to fulfill the multimission role, with its large open cabin, rear loading ramp, and a variety of cabin and cargo systems.

Personnel transport

- Crashworthy seats
  - Crew chief and 24 troops
  - Folding, removeable seats for loading flexibility
  - Inboard facing
- Medevac litter stanchions
  - Up to three stations of (3) litter positions each

Cargo

- External
  - (2) external cargo hooks
    - 10,000 lb single hook (forward or aft hook)
    - 15,000 lb dual-hook
    - Cabin accessible
  - Air-drop capability
- Internal
  - 300 lb/ft² floor loading capacity for up to 20,000 lb of internal cargo
  - Floor tie-down fittings within cabin and ramp
  - Flip, roller rails for cargo loading
  - 2,000 lb cargo winch, 150 ft cable
  - (2) 463L half-pallets, (4) 40 in x 48 in warehouse pallets, and other loading as available
  - Light Tactical Vehicles - Several vehicles can be loaded internally, including the M151 Jeep (top cover removed and windshield folded), and the M274 Mechanical Mule. The U.S. Marine Corps and The U.S. Special Operations Command are designing a family of Internally Transportable Vehicles (ITV) sized to be carried inside of the V-22.
Cargo envelope

All dimensions are in inches.

Note: Dimensions define the shape that must be clear from sta. 309 to sta. 559, and from sta. 559 to 701.5 in the aft fuselage, with the ramp floor level with the cabin floor.

Cabin Volume

Vertical insertion/extraction
- Rescue hoist at rear ramp
- Electric hoist, 250 ft usable cable
- 600 lb capacity, > 250 fpm speed
- Emergency cable cutting system
- Two fast rope attachments in cabin area
- Parachute static lines
Flight Control System

The V-22 incorporates both fixed-wing and rotary-wing flight controls in the electronic, fly-by-wire system. The Flight Control System (FCS) provides control throughout the flight envelope, as well as a smooth transition between helicopter and airplane flight modes.

The figures below present the locations and numbers of hydraulic actuators used in controlling the V-22. It also includes the functions of the flight control surfaces.
Flight Control Mechanisms

The primary flight controls consist of:

- Cyclic sticks located in front of each cockpit crew seat
- Thrust control levers mounted to the left of each seat
- Floor-mounted directional pedals
- Proprotor nacelle angle control (thumbwheel on TCL)

The pilot and copilot controls are mechanically connected under the cockpit floor by push-pull control tubes. Sensors detect control displacements in each of three axes and relay the information directly to the digital flight control computers. These high-speed computers provide commands directly to the aircraft's flight control actuators. The rudder pedals also control the nose wheel steering and wheel brake systems.

The following figures illustrate the effect of each pilot’s control input on aircraft motions in both helicopter and airplane modes.
The V-22 can perform a complete transition from helicopter mode to airplane mode in as little as 16 seconds. The aircraft can fly at any degree of nacelle tilt within its conversion corridor (the range of permissible airspeeds for each angle of nacelle shift).

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

The conversion corridor is very wide (approximately 100 knots) in both accelerating and decelerating flight. This wide corridor results in a safe and comfortable transition, which is free of the threat of wing stall.
Hydraulic Systems

There are three independent 34.5 MPa (5,000 psi) hydraulic systems. Systems 1 and 2 are designated as primary and are dedicated to the flight control systems. System 3 is designated as the utility hydraulic system, and also powers the following equipment/functions:

- Landing gear (extend/retract)
- Ramp/door
- Main wheel brakes
- Nose wheel steering
- Engine start
- Cargo winch
- Engine Air Particle Separator (EAPS)
- Wing stow
- Rotor brake
- Retractable aerial refuel probe

In the event of failure in the primary hydraulics system (Systems 1 and 2), System 3 provides pressure to the swashplate and conversion actuators (providing additional redundancy). For maintenance and ground operations, System 3 is powered by the APU (prior to rotor spin up).

Electrical Systems

The V-22 is equipped with a redundant power generation system capable of producing up to 240 total kVA. The system consists of:

- Two 40 kVA constant frequency generators
- Two 50/80 kVA variable frequency generators
- Three AC to DC regulated converters
- One 24 ampere-hour sealed lead acid battery

Ground power may be provided by external AC power unit or by the on-board APU.

The AC power is distributed as 115/200 volt (3-phase), and 115-volt, (single phase). There are four utility electrical outlets provided in the cabin.

The V-22 DC electrical system supplies 24/28 Volts Direct Current (VDC) to the flight-essential systems, the primary aircraft DC electrical loads, the electrical components powered from the essential bus, and the electrical components powered from the battery bus.
Fuel System

The fuel system is integrated into the wing and fuselage systems and consists of:

- Two wing feed tanks – one in each outboard section of each wing
- Two sponson tanks – one in each forward sponson bay
- Eight wing tanks – 4 in each wing between the wing feed tank and the mid-wing area.
- Retractable aerial refueling probe

For extended range operations, up to (3) mission auxiliary tanks (MAT) in the cabin, or (2) MAT and an aft sponson tank can be used. Electrical, plumbing, and vent connections are provided for the installation of the internal cabin tanks.

V-22 Fuel Configuration

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Number of Tanks</th>
<th>Usable Fuel per Tank (gal)</th>
<th>Fuel Weight per Tank (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wing Feed Tanks</td>
<td>2</td>
<td>88</td>
<td>334</td>
</tr>
<tr>
<td>Fwd Sponsons</td>
<td>2</td>
<td>478</td>
<td>1,809</td>
</tr>
<tr>
<td>Wing Tanks</td>
<td>8</td>
<td>74</td>
<td>278</td>
</tr>
<tr>
<td>Total - Standard</td>
<td>All Tanks</td>
<td>1,721</td>
<td>6,513</td>
</tr>
<tr>
<td>Mission Aux Tanks</td>
<td>Up to 3</td>
<td>430</td>
<td>1,628</td>
</tr>
<tr>
<td>Aft Sponson (Optional)</td>
<td>1</td>
<td>316</td>
<td>1,197</td>
</tr>
</tbody>
</table>

Environmental Control System

The V-22 incorporates a modern Environmental Control System (ECS) to provide for crew and passenger health, safety, and comfort over a wide range of aircraft and environmental operating conditions. It also protects the avionics/mission systems during operation in extreme climatic conditions as well as under thermal stress.

The ECS includes:
- Pneumatic power system
- Onboard Oxygen Generating System (OBOGS)
- Onboard Inert Gas Generating System (OBIGGS)
- Cockpit and cabin heating and cooling
- Avionics air conditioning
- A pneumatic wing deicing system

The pneumatic system supplies low-pressure (3.5 kg/sq cm, or 50 lb/sq in) compressed air to the ECS. The ECS distributes conditioned air to the cockpit and cabin, and partially conditioned air to the O\textsubscript{2}N\textsubscript{2} concentrator, wing deicing boots, and avionics cooling air particle separators. Compressed air for the pneumatic system is supplied by the Shaft-Driven Compressor (SDC). The SDC is mounted on the mid-wing gearbox and operates when the APU or engines are running.

Cockpit and Avionics

The V-22 Integrated Avionics System (IAS) is a fully integrated avionics suite using a combination of off-the-shelf equipment and specially developed hardware and software. The functionality integrated into this system is as follows:

- **Controls and Displays**
  Provides aircrew and maintenance personnel with the resources to monitor cockpit information and control aircraft functions.

- **Mission Computers**
  Provides for dual-redundant processing using primary and backup advanced mission computers that process and control all functions of the IAS.

Fuel System Capacities (JP-5 or JP-8)
• **Navigation**
  Provides primary navigation data. This data is gathered from the inertial navigation sensors and radio navigation sensors.

  Navigation data includes: position, heading, altitude, geographic frame velocities, radar altitude, radio navigation (data such as distance and bearing to ground stations), and marker beacon station passage.

  An optional enhanced suite can include Terrain Following/Terrain Avoidance (TF/TA) Multimode Radar and traffic collision avoidance system (TCAS).

• **Communications**
  Provides for internal and external radio control and intercommunications, VHF/UHF radio communication, SATCOM, and IFF.

• **Turreted Forward Looking Infra-Red System**
  Provides for reception of infrared energy and its conversion to video signals (to assist the aircrew in piloting and navigation).

• **Digital Map**
  Provides a real-time, color, moving map imagery on the multi-function displays. It may be operated independently by both operators. The aircraft's position is shown with respect to the display, and multiple overlay options are available.

• **Electronic Warfare Suite**
  Provides detection and crew notification of missiles, radars, and laser signals that pose a threat to the aircraft.

  The suite also includes dispensers for expendable countermeasures.

  An optional enhanced suite includes active jamming systems, additional countermeasure launchers, and other systems.

• **Interface Units (IUs)**
  Provides the capability to control and monitor the aircraft and its avionics systems that are incompatible with the MIL-STD-1553 data bus protocol.

  The IUs provide the capability to communicate with ARINC-429, RS-422, and other discrete signal devices.

• **Vibration, Structural Life, Engine Diagnostics (VSLED)**
  VSLED is an onboard system designed to capture and record vital aircraft data for enhanced safety and maintenance. An active vibration suppression system is also onboard to detect and suppress cockpit and cabin vibration.
Shipboard Compatibility

The V-22 is designed to operate within the space limitations imposed by the flight deck, hangar deck, and aircraft elevators of the U.S. Navy’s amphibious assault ships as well as compatible with the limited maintenance facilities aboard these ships.

The basic requirements, which support this capability, include:

- Operating from a launch and recovery spot located next to the island superstructure of an amphibious assault ship
- Corrosion resistant composite rotor blades, hubs, and airframe
- Marinized engines
- Electromagnetic Environmental Effects (E3) protection
- Compact airframe footprint for easy stowage
- Tiedowns incorporated for winds up to 60 knots in stowed configuration and for 100 knot heavy weather configuration
- Blade fold/wing stow in and up to 45 knot winds
- Many maintenance tasks to be accomplished in the folded/stowed configuration.
Survivability Features

The V-22 design has numerous inherent and intentionally designed survivability features, as itemized below.

Reduced Susceptibility
- Performance
  - Speed
  - Range
  - Altitude
  - Maneuverability
- Defensive Warning System
- Threat Warning and Countermeasures
- Tactics
  - Night
  - Low-level
  - All-weather
- Signature Reduction
  - Infrared - 95% reduction compared to CH-46
  - Acoustic - 75% reduction compared to CH-46
  - EMCON
  - Visual

Reduced Vulnerability
- Systems Protection
  - Redundancy
  - Isolation
  - Separation
  - Armor
- One Engine Inoperative Capability
- Dry Bay and Engine Fire Suppression
- Ballistic Tolerance
  - Composite Structure
  - Hydraulic Ram Protection
  - Self-sealing Fuel Bladders
  - Nitrogen-Inerted Fuel System

Improved Crashworthiness
- Energy Management
  - “Broomstraw” Blade Failure
  - Mass Remote Design
  - Controlled Wing Failure
  - Anti-plow Bulkhead
- Crashworthy Fuel System
- Ditching Buoyancy, Stability and Emergency Egress
- Stroking Seats and Shoulder Harness for Troops and Crew
### Operating Environment

The V-22 has been designed to operate within the specified set of environmental conditions summarized below.

<table>
<thead>
<tr>
<th>Environment</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient Temperature</td>
<td>-65°F (-54°C) to 125°F (+52°C)</td>
</tr>
<tr>
<td>Pressure Altitude</td>
<td>Method 520.0, Procedure III, MIL-STD-810; Temperature, Humidity, Vibration, Altitude</td>
</tr>
<tr>
<td>Humidity</td>
<td>Method 507.3 of MIL-STD-810; Humidity 45% RH at 21°C 95% RH at 35°C 80% RH at 52°C 20% RH at 71°C</td>
</tr>
<tr>
<td>Tropical Exposure</td>
<td>Combination of Temperature, Humidity, Rain, Solar Radiation, and Sand/Dust requirements allow the V-22 to operate in a Tropical Environment.</td>
</tr>
<tr>
<td>Vibration</td>
<td>Method 514.3, Procedure I, MIL-STD-810; Vibration</td>
</tr>
<tr>
<td>Shock Method</td>
<td>516.3, Procedure I &amp; V, MIL-STD-810; Shock</td>
</tr>
<tr>
<td>Sand and Dust</td>
<td>Method 510.1, Procedure I, MIL-STD-810; Sand and Dust Particle concentrations of $1.32 \times 10^{-4}$ pounds per cubic foot in multidirectional winds of 45 knots. The upper nacelle blower will withstand particle concentrations of $4.0 \times 10^{-6}$ pounds per cubic foot.</td>
</tr>
<tr>
<td>Water Resistance</td>
<td>Method 512.3 of MIL-STD-810; Leakage (Immersion)</td>
</tr>
<tr>
<td>Mold Growth</td>
<td>Method 508.4 of MIL-STD-810; Fungus</td>
</tr>
<tr>
<td>Salt Mist</td>
<td>Method 509.2, MIL-STD-810; Salt Fog</td>
</tr>
<tr>
<td>Salt Spray</td>
<td>Sea salt fallout up to 200 parts per billion. The aircraft’s components operate reliably after exposure to Method 510.1, Procedure I, MIL-STD-810</td>
</tr>
<tr>
<td>NBC</td>
<td>Power, wiring, and connections provided for seven stations for NBC protective garments and masks (three are located in the cockpit and four located in the cabin).</td>
</tr>
<tr>
<td>Exposure to Solar Radiation</td>
<td>Radiant energy at a rate of 355 BTU per square foot per hour or 104 watts per square foot (1120 W/M²).</td>
</tr>
<tr>
<td>Bird Strike</td>
<td>The windshield is capable of resisting the impact of a three pound bird at 275 knots.</td>
</tr>
<tr>
<td>Rain and Wind</td>
<td>8 inches per hour minimum. The aircraft is designed to withstand damage in winds of: up to 60 knots with wing ready for flight and blades folded; up to 100 knots with both wing and blades ready for flight; up to 60 knots from any direction with blades folded and wing stowed.</td>
</tr>
<tr>
<td>Hail Strike</td>
<td>Able to withstand 1 inch hail stones in multiple aircraft conditions - in-flight, take off and landing, taxi and hover, and parked.</td>
</tr>
<tr>
<td>Snow</td>
<td>Snowload capability of 20 pounds per square foot on horizontal surfaces. This is assuming aircraft is not operating and will be cleared of snow between storms.</td>
</tr>
<tr>
<td>Icing</td>
<td>Operation at full mission capability in icing conditions, ice fog, and hoarfrost up to moderate intensities down to -20°C ambient temperatures.</td>
</tr>
<tr>
<td>Lightning</td>
<td>No Category 1 effects due to damage to or temporary upset of Category 1 CFE and GFE from a severe lightning attachment with a 200 kAmp first return stroke with a peak rise time of $1.4 \times 10^7$ Amp/sec to the air vehicle. No Category 2 effects due to damage to or permanent upset of category 2 CFE or due to damage to Category 2 GFE from a lightning attachment with a 50 kAmp first return stroke with peak rise time of $3.8 \times 10^7$ Amps/sec to the air vehicle.</td>
</tr>
</tbody>
</table>
V-22 Flight Performance

The V-22 is capable of sustained cruise speeds in excess of 275 ktas and an unprecedented V/STOL aircraft mission radius. Standard day capabilities are shown in the figures below.

### Hover Performance

**V-22 Standard Day Hover Envelope (OGE)**

- Hover out of ground effect ≥ 50 ft
- 5% bridge margin
- Auto Flaps
- Zero wind

### Cruise Flight Envelope

**V-22 Airplane Mode Flight Envelope (Standard Day)**

- Cruise speed for 99% best range
- 20 min landing fuel reserve
- 37,000 lb max OGE

### Internal Payload Mission

- Mission Auxiliary Tanks:
  - (1) MAT
  - (2) MAT
  - (3) MAT
- Maximum continuous power
- 104% Nr
- 95% maximum engine power
- Auto Flaps
- Zero wind

### External Payload Mission

- Mission Auxiliary Tanks:
  - (1) MAT
  - (2) MAT
- Cruise speed for 99% best range
- 20 min landing fuel reserve
- 57,000 lb max GW

### Self-Deployment Mission

- 15,000 max altitude cruise
- 60,500 lb max self-deploy GW
- Takeoff Limits:
  - Sea Level/Std: 51,688 lb
  - 3000 ft/ISA +20C: 48,418 lb

### Mission Definition:

- Warmup: 10 min at Idle Power
- Takeoff: 1 min at 95% max power (HOGE)
- Outbound Cruise: V99br, airplane mode
- Hover to Drop PL: 5 min at 95% max power (HOGE)
- Drop External Load
- Return Cruise: V99br, airplane mode
- Land: 1 min at 95% max power (VTO HOGE or STO)
- Reserves: 20 min at Vbe at 10,000 ft
Multiservice Configurations

MV-22 U.S. Marine Corps
The V-22 is being developed and produced utilizing incremental, time-phased upgrades ("Blocks").

- Block A - safe and operational
- Block B - combat capability improvements plus enhanced maintainability
- Block C - mission enhancements and upgrades

Block B will be the first Block to deploy.

Inherent features
- Composite/aluminum airframe
- Triple redundant fly-by-wire flight controls
- Rolls-Royce AE1107C engines
- Interconnect drive shaft
- 5000 psi hydraulic system
- 240 kVA electrical capacity
- Blade fold/wing stow
- Anti-ice and deice systems
- Vibration, structural life, and engine diagnostics
- Engine air particle separators
- Loading ramp
- Aerial refueling probe
- 5.7’ W x 5.5’ H x 20.8’ L cabin
- Onboard oxygen and inert gas generating systems (OBOGS/OBIGGS)

Mission equipment
- Single and dual point external cargo hooks
- Advanced cargo handling system
- Fast rope
- Rescue hoist
- Parachute static lines
- Ramp mounted defensive weapon system
- Up to (3) mission auxiliary fuel tanks

Avionics
- Dual avionics MIL-STD-1553B data buses
- Dual 64-bit mission computers
- Night Vision Goggle (NVG) compatible, multifunction displays
- Inertial navigation system (3)
- Global positioning system
- Digital map system
- SATCOM
- VOR/ILS/ marker beacon
- Radar altimeter
- FM homing system
- Dual VHF/UHF/AM/FM radios
- Digital communications system
- Turreted Forward Looking Infra-Red (FLIR) system
- Identification, Friend or Foe (IFF) transponder
- Tactical Air Navigation (TACAN) system
- Troop commander’s communication station
- Flight incident recorder
- Missile/radar warning and laser detection
CV-22 U.S. Special Operations Command

The CV-22 is being developed and produced in parallel with the MV-22 configuration in incremental upgrades ("Blocks")

- Block 0 - MV-22 Block A plus basic special operations capabilities
- Block 10 - MV-22 Block B plus improved special operations capabilities
- Block 20 - MV-22 Block C plus mission enhancements and upgrades

MV-22 Block B and CV-22 Block 10 have the same propulsion system, and 90% common airframe. The primary differences are in the avionics systems.

CV-22 unique equipment

- Multimission Advanced Tactical Terminal (MATT) integrated with digital map, survivor locator equipment, and the electronic warfare suite
- Multimode Terrain Following/Terrain Avoidance (TF/TA) radar
- Advanced, integrated defensive electronic warfare suite
  - Suite of Integrated RF Countermeasures (SIRFC)
  - Directed IR Countermeasures (DIRCM)
- Additional tactical communications with embedded communication security
- Upgraded intercommunications
- Computer and digital map upgrades
- RF interference canceller system
- Flight engineer seating accommodation
- Crash position indicator

V-22 Top Tier Suppliers

<table>
<thead>
<tr>
<th>Supplier</th>
<th>System</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAE</td>
<td>Flight control system</td>
</tr>
<tr>
<td>EFW</td>
<td>Digital map, MFD, DEU</td>
</tr>
<tr>
<td>Engineering Fabrics</td>
<td>Fuel cells</td>
</tr>
<tr>
<td>General Dynamics</td>
<td>Mission computer</td>
</tr>
<tr>
<td>Honeywell</td>
<td>ECS system and components, LWINS, VF generator, CDS, FDP, TCAS, SDC, IR suppressor, heat exchanger</td>
</tr>
<tr>
<td>ITT</td>
<td>AN/ALQ-211 (SIRFC)</td>
</tr>
<tr>
<td>Moog</td>
<td>Flight control actuators, vibration suppression actuators</td>
</tr>
<tr>
<td>MRA</td>
<td>Structural components</td>
</tr>
<tr>
<td>Northrup Grumman</td>
<td>DIRCM</td>
</tr>
<tr>
<td>Raytheon</td>
<td>FLIR, MMR, MAGR, IFF, mission planning, maintenance system</td>
</tr>
<tr>
<td>Rolls Royce</td>
<td>Engines</td>
</tr>
<tr>
<td>Smiths</td>
<td>Standby alimeter, AIU, rudder actuator, CF generator, flight incident recorder, lighting controllers, forward cabin control station, transmission blowers</td>
</tr>
<tr>
<td>Vought</td>
<td>Empennage, fiber placement skins</td>
</tr>
</tbody>
</table>
Studies and Analyses
Numerous major studies and analyses have shown that the V-22 is more cost and operationally effective than any helicopter (including compound helicopter designs), or any combination of helicopters.

Compared to a range of current and advanced helicopter designs:
- The V-22 has superior speed, range and survivability:
  - Increases the tactical options available to the operational commander
  - Dramatically reduces friendly force casualties in post-assault ground operations
- When equal lift capability aircraft fleets are considered:
  - Significantly fewer V-22 were required to accomplish the specified missions.
  - Likewise, proportionately fewer support assets and personnel were required.
- When equal cost aircraft fleets are considered:
  - The V-22 fleet is more effective than any of the helicopter alternatives.
  - Lower through-life costs of the tiltrotor

V-22 offers best value for the money.

For example, in a recent V-22 in GWOT Scenario, the disparity in required mission resources was evident. The V-22 needed about one-quarter of the resources required of conventional helicopters. Specifically, the asset requirements were:
- 3 V-22s, 1 strategic airlift aircraft, 1 strategic tanker, 3 combat service support aircraft, and 1 support base

VS
- 5 helicopters, 7 tactical tankers, 9 strategic airlift aircraft, 12 combat service support aircraft, and 4 support bases

Reduced complexity increases the probability of success, while decreasing requirements and total mission cost. The V-22 significantly reduces the logistical complexity to accomplish the mission.
Flight Crew and Maintenance Mechanic Training

The V-22 Training System is comprised of fully integrated aircrew and maintainer training and training devices. Safety, proper procedures, and effectiveness are stressed within all training courses. They are designed to meet the needs of initial entry and transition personnel. The Bell-Boeing training strategy takes advantage of a full suite of training services and equipment developed specifically for the V-22. These include:

- A Federal Aviation Agency (FAA) Level-D equivalent full flight simulator (FFS),
- Level 7 equivalent Flight Training Device (FTD),
- Suite of Part Task Maintenance Trainers
- Interactive audio/video computer-based training (CBT) devices, and
- Computer-based presentation system supporting instructor-led training.
Multimission Capabilities

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 tiltrotor variants for over 30 different potential missions. These potential missions are summarized in the following list:

- **Special Warfare**
  - Special Operations
  - Electronic Warfare

- **Sea Control**
  - Anti-Submarine Warfare
  - Anti-Surface Ship Warfare
  - Maritime Interception Operations
  - Mine Warfare

- **Theater Operations**
  - Assault Medium Lift
  - Tactical Mobility
  - Advanced Rotary Wing Attack
  - Gunship/Close Air Support
  - Aerial Refueling
  - Combat Rescue

- **Recovery and Civil Support**
  - Search and Rescue
  - Medical Evacuation
  - Joint Emergency Evacuation of Personnel
  - Civil Disaster Response

- **Communications**
  - Forward Air Control
  - Surface, Subsurface, and 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 Onboard Delivery
  - Operational Support Airlift
  - Mid-Air Retrieval System
  - Light Intratheater Transport
  - National Executive Transport

- **Support**
  - Missile Site Support
  - Range Support