How the V-22 Osprey Works

It has long been a dream of aircraft designers to create an airplane that not only can fly long ranges at high speeds and carry heavy cargo, but can also take off, hover and land like a helicopter. Such a plane would have the flexibility to handle many different types of military missions and would also have civilian and commercial uses.

The V-22 Osprey can fly like a helicopter (left) or an airplane (right).

The **V-22 Osprey** is such a vehicle. This versatile craft has been developed for the military by Bell-Boeing aircraft. Through the use of a tilt rotor, the Osprey can take off and land like a helicopter, but convert to a turboprop airplane while in flight. The aircraft's rotors can fold, and the wings can rotate so it can be stored on an aircraft carrier.

How does this unique aircraft work? In this article, we will take you inside this aircraft to examine its systems and design.

Fly Like a Bird, Hover Like a Bee

The Osprey is a type of **vertical takeoff and landing** (VTOL) aircraft with a tilt-rotor design. The VTOL concept is an old idea stemming from the German air force at the end of World War II. After the war, the U.S. Navy developed two experimental VTOL fighter aircraft, the Pogo and the Salmon. However, the programs were cancelled because of technical difficulties. In 1958, the U.S. Air Force developed the Bell XV-3, which was the first successful VTOL to hover (it was not tested in airplane flight).

Photo courtesy NASA
Tilt-rotor aircraft: Bell XV-3 (left) and Bell XV-15 (right)

After the XV-3 program proved that the tilt-rotor concept was feasible, Bell developed the XV-15 tilt-rotor that was tested by NASA. In July 1979, the XV-15 became the first aircraft to tilt from helicopter to airplane and back. It was also capable of traveling 346 miles per hour (557 kph) in airplane mode. The success of the tests lead to the expansion of the program, which was subsequently renamed the **V-22 Osprey**. There are three configurations of the Osprey depending upon what it's being used for, such as search-and-rescue, medium-range assault or long-range special operations. While three branches of the U.S. Armed Forces -- the Marines, Navy and Air Force -- will use the Osprey, Bell is also exploring its design for possible civilian uses.

V-22 osprey transitioning from helicopter to airplane mode

The Osprey has two, large, three-bladed rotors that rotate in opposite directions and produce lift. Because the rotors turn in opposite directions, there is no need for a tail rotor to provide stability as in a helicopter. The wing tilts the rotors between airplane and helicopter modes and generates lift in the airplane mode. The Osprey can convert smoothly from helicopter mode to airplane mode in as few as 12 seconds.

The major advantages of the Osprey over a helicopter are:

- Longer range - The Osprey can fly from 270 to 580 miles (453 to 933 km).
- Higher speed - The Osprey's top speed is 315 mph (507 kph), which is twice as fast as a helicopter's top speed.
- Increased cargo capacity - The Osprey can carry 10,000 pounds (4,536 kg) of cargo or 24 troops.

The advantage of the Osprey over an airplane is that it can take off, hover and land like a helicopter. This makes is more versatile than an airplane for such missions as moving troops to remote areas, especially those without landing strips, or conducting long-range rescue operations at sea.

In the next section, we'll take a look at the Osprey's systems.

Inside the Osprey

Like any aircraft, the Osprey has the following systems:

- **Propulsion** - generate power and lift to propel the aircraft
- **Fuel**
- **Cockpit controls**
- **Communications** - allow for communication with air controllers and military operations
- **Payload** - carry cargo
- **Stowage** - especially important when it's stored on an aircraft carrier

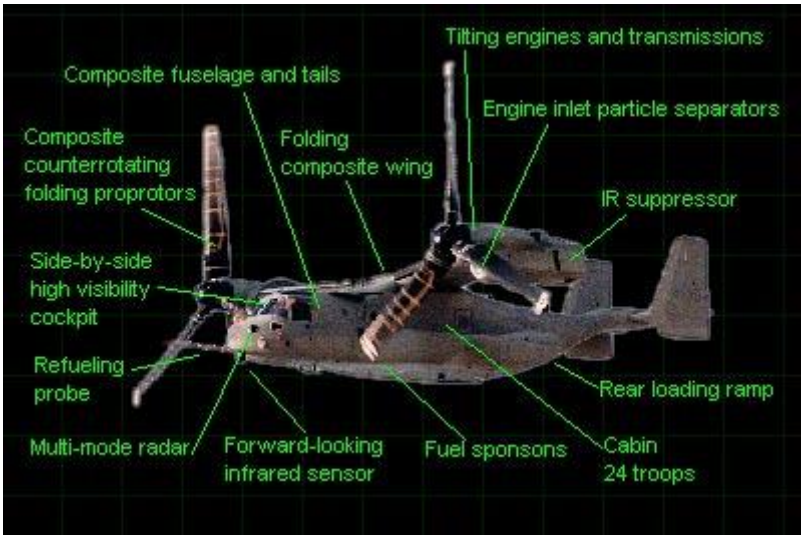


Photo courtesy U.S. Navy

Osprey's external features

Propulsion

As mentioned above, the Osprey has two rotors with three-bladed, 38-ft (11.6-m) propellers. Each propeller is driven by an Allison AE 1107C turboshaft engine that is capable of producing over 6,000 horsepower. Each engine drives its own rotor and transfers some power to a **mid-wing gear box**. This gear box drives the tilting mechanism. In the event of an engine failure, the Osprey is capable of running on only one engine. In this case, power from the remaining engine is distributed to the two rotors through an interconnecting drive shaft.

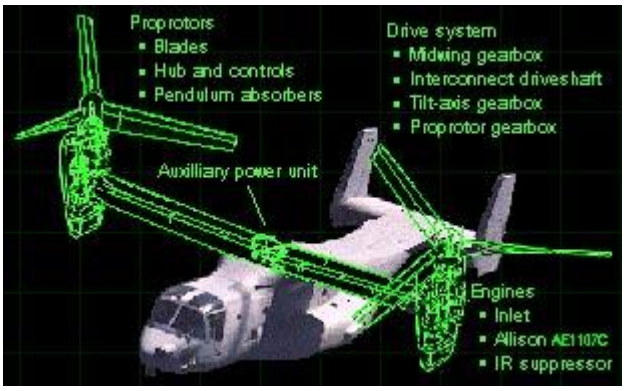


Photo courtesy U.S. Navy
Osprey propulsion

Fuel

The Osprey has 16 fuel tanks, 10 integrated into the wings and six in the fuselage. The feed tanks directly supply the engines with fuel from the other tanks, and fuel transfer is automatic. As the fuel flows from the tanks, pressurized nitrogen gas fills the tanks to reduce the possibility of fire. Depending upon the configuration of the Osprey, it can hold from 1,450 to 3,640 gallons (5,489 to 13,779 liters) of fuel.

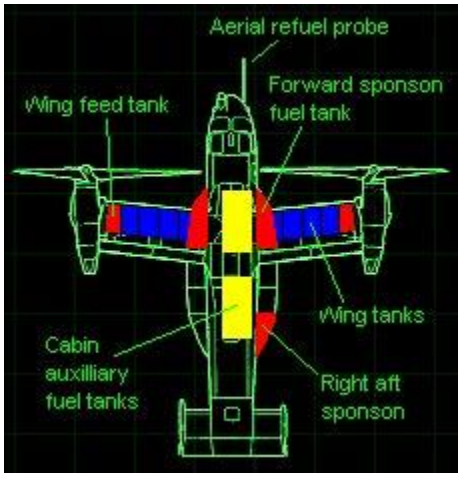


Photo courtesy U.S. Navy
Osprey fuel tanks

Cockpit Controls

The cockpit of the Osprey holds a pilot and co-pilot. In addition, there is a fold-down seat in the center behind the pilots for a flight engineer. The instrument panels have multi-functional displays, similar to the new glass cockpit of the space shuttle. The displays hold information about the engines (such as oil pressure, temperatures and hydraulic pressures) and flight (such as fuel data, attitude and engine performance). There are also keypads used to interact with the flight computer and sticks used to control the flight maneuvers.

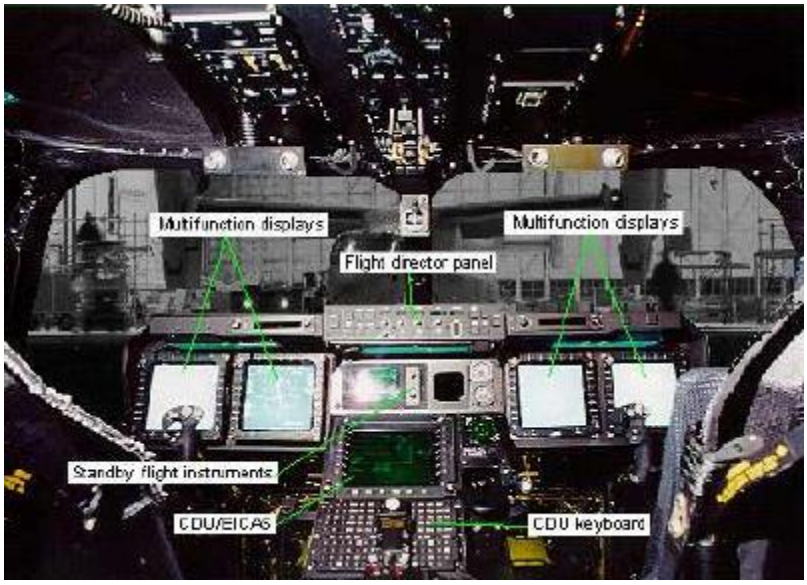


Photo courtesy U.S. Navy
Osprey control panels

Communications

The Osprey is equipped with multi-band radios (AM, FM, UHF, VHF) for voice transmission and radio reception. It also has navigational beacons and radios, radar altimeters and an internal intercom/radio system for communications among the crew and troops onboard.

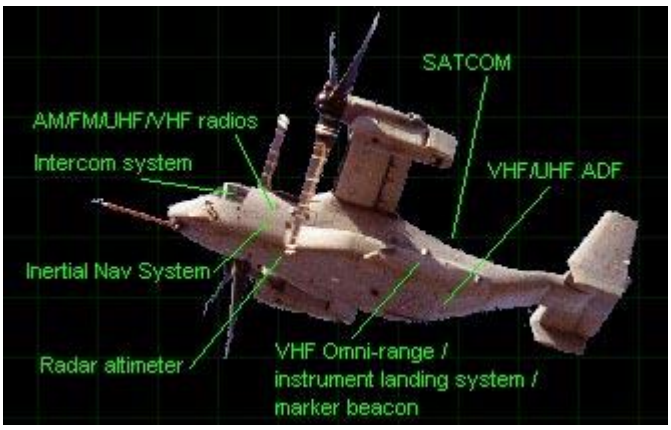


Photo courtesy U.S. Navy
Osprey control panels

Payload

The Osprey can hold up to 24 troops and carry up to 20,000 lb (9,072 kg) in its cargo bay, which is 5.7 ft wide by 5.5 ft high by 20.8 ft long (1.72 x 1.68 x 6.35 m). The cargo bay has fold-down seats along the walls and a ramp that is used to load or deploy cargo and troops. Deployment can also take place in the air by parachute. In addition to the 20,000-lb load in the cargo bay, the Osprey has an external hook-and-winch system that allows it to carry up to 15,000 lbs (6,803 kg) of cargo in tow.

Stowage

When the Osprey lands on the deck of a ship, it can be folded up for down-time. The blades and the wings are both foldable. The sequence is shown below:

Photo courtesy U.S. Navy

The blades fold inward (top left and right); the wings turn up (bottom left); the wings fold back (bottom right).

How the Osprey Flies

To understand how the Osprey flies, the basic thing to understand is that airplane wings create lift by deflecting air downward, benefiting from the equal and opposite reaction that results. Helicopters do the same thing with blades, which are rotating wing shapes like the airfoils of an airplane wing. Helicopter blades are thinner and narrower than airplane wings because they have to rotate so fast. These rotating wings are mounted on a central shaft. When the shaft is spun, lift is created.

When the Osprey is ready to take off, its rotors are in a vertical position. With the rotors mounted on the wings, it looks like a two-bladed helicopter. When the Osprey is in helicopter mode (on takeoff, landing and when hovering), the rotors generate lift. While in flight, the Osprey's rotors move down to a horizontal position. In this position, it is the wings that generate lift, like on a traditional airplane, and the rotors function as they do in a propeller aircraft. The Osprey lands like a helicopter by reversing the process, raising the rotors from a horizontal to a vertical position.

To better understand how the Osprey flies, check out How Helicopters Work and How Airplanes Work.

The V-22

The V-22 is being developed to perform United States Marine Corps (USMC), United States Navy(USN), and United States Special Operations Command (USSOCOM) combat missions. The V-22 design, incorporating advanced but mature technology proven in the XV-15 tiltrotor demonstrators, V-22 Full Scale Development (FSD) models, and V-22 Engineering and Manufacturing Development (EMD) models, takes advantage of proven technology in composite materials, digital fly-by-wire flight controls, and advanced survivability and crashworthiness. A tiltrotor combines the speed, range and fuel efficiency normally associated with turboprop aircraft with the vertical take-off/landing and hover capabilities of helicopters. The tiltrotor aircraft represents a major technological breakthrough in aviation that meets long standing military needs.

V22 Characteristics

Engines

- Two Rolls-Royce Liberty AE1107C
- AEO VTOL Normal Power, shp (kW) : 6,150 (4,586)
- AEO VTOL Interim Power, shp (kW) : 6,830 (5,093)
- OEI VTOL, shp (kW) : 6,830 (5,093)

Transmission

- AEO VTOL Max Cont., rhp (kW) : 4,570 (3,408)
- AEO VTOL Takeoff, rhp (kW) : 5,183 (3,865)

Dimensions (External)

- Length, fuselage, ft (m) : 57.3 (17.48)
- Width, rotors turning, ft (m) : 84.6 (25.55)
- Length, stowed, ft (m) : 63 (19.20)
- Width, stowed, ft (m) : 18.4 (5.61)
- Width, horizontal stabilizer, ft (m) : 18.4 (5.61)
- Height, nacelles fully vertical, ft (m) : 22.1 (6.73)
- Height, vertical stabilizer, ft (m) : 17.9 (5.46)
- Height, stowed, ft (m) : 18.3 (5.56)

Dimensions (Internal)

- Length, max, ft (m) : 24.17 (7.37)
- Width, max, ft (m) : 5.92 (1.80)
- Height, max, ft (m) : 6.00 (1.83)

Proprotor 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

Performance

- Max Cruise speed (MCP), SL, kts (km/h) : 241-257 (446-476)
- Max R/C, A/P Mode, SL, fpm (m/m) : 3,200 (975)
- Service ceiling, ISA, ft (m) : 24,700 (7,529)
- OEI Service ceiling, ISA, ft (m) : 10,300 (3,139)
- HOGE ceiling, ISA, ft (m) : 5,400 (1,646)

Mission radius with aft sponson tank

- Land-Assault Troop Mission (24 Troops), nm (km) : 242 (448)
- Pre-Assault Raid, nm (km) : 267 (495)

Mission radius with wing tanks

- Land-Assault Troop Mission (24 Troops), nm (km) : 233 (432)
- Pre-Assault Raid, nm (km) : 306 (567)

Accommodation

- Cockpit - crew seats : 2 MV / 3 CV
- Cabin - crew seat/troop seats/litters : 1/24/12

Weights

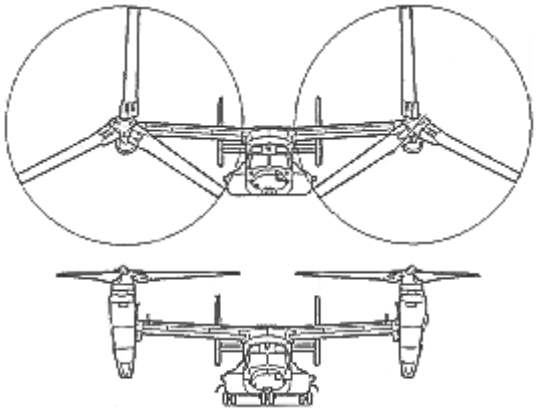
- Empty, lbs (kg) : 33,459 (15,177)
- Takeoff, verical, max, lbs (kg) : 52,600 (23,495)
- Takeoff, short running, max, lbs (kg) : 57,000 (25,909)
- Takeoff, self-deploy mission, lbs (kg) : 60,500 (27,443)
- Cargo hook, single, lbs (kg) : 10,000 (4,536)
- Cargo hook, dual, lbs (kg) : 15,000 (6,804)

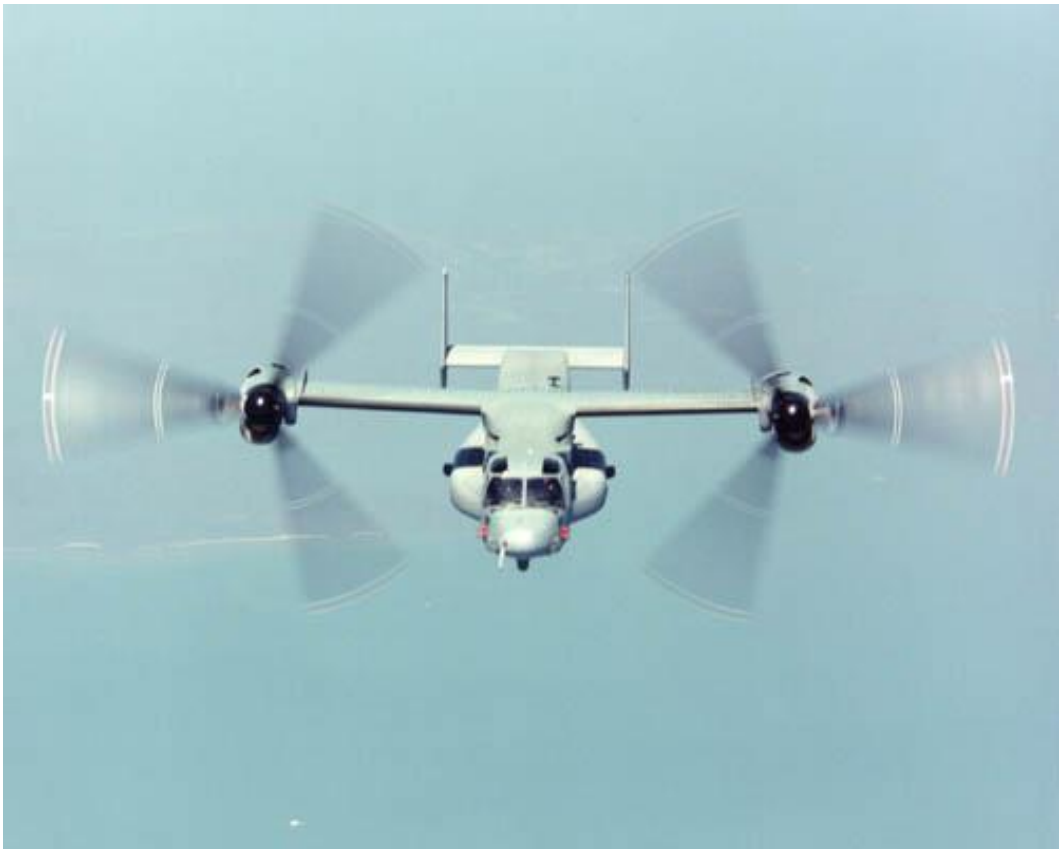
Fuel Capacity

- MV-22 (including aft sponson tank), gallons (liters) : 1,448 (5,481)
- CV-22 (including aft sponson tank), gallons (liters) : 2,040 (7,722)

Fuel Capacity with wing tanks

- MV-22 (including wing tanks, no aft sponson tank), gallons (liters) : 1,724 (6,526)






Bell Boeing

The Bell Boeing V-22 Osprey is the first aircraft designed from the ground up to meet the needs of all four U.S. armed services. The tiltrotor aircraft takes off and lands like a helicopter. Once airborne, its engine nacelles can be rotated to convert the aircraft to a turboprop airplane capable of high-speed, high-altitude flight.

The V-22 Osprey provides unique capabilities offering:

- increased speed because it's twice as fast as a helicopter.
- much longer range resulting in greater mission versatility than a helicopter.
- multi-mission capability: amphibious assault, combat support, long-range special ops infiltration and exfiltration, transport, search and rescue, medevac, and, in the future, tanker capability.

The V-22 Osprey aircraft:

- can transport 24 combat troops or up to 20,000 pounds of internal or external cargo using its medium lift and vertical takeoff and landing capabilities
- meets U.S. Navy requirements for combat search and rescue, fleet logistics support, and special warfare support
- matches the U.S. Special Operations Command's requirement for a high-speed, long-range, vertical lift aircraft
- can be stored aboard an aircraft carrier because the rotors can fold and the wing rotate
- has air-to-air refueling capability, the cornerstone of the ability to self-deploy

Boeing is responsible for the fuselage and all subsystems, digital avionics, and fly-by-wire flight-control systems. Boeing partner Bell Helicopter Textron, Inc., is responsible for the wing, transmissions, empennage, rotor systems and engine installation.

The V-22 provides a significant increase in operational range over the legacy systems it will replace and is the only vertical platform capable of rapid self-deployment to any theater of operation worldwide.