Bell Boeing V-22 Osprey

Flying Schizophrenic

Strikingly strange, incredibly versatile

BY BARRY SCHIFF

"Operation Eagle Claw" was an attempt on April 24, 1980, to rescue 53 Americans held hostage by Islamist militants in Iran. Although unsuccessful, this seminal event gave impetus to the development of a revolutionary new aircraft better suited for such operations, the Bell Boeing V-22 Osprey (designated a CV-22 by the U.S. Air Force).

There is no way to prepare for your first encounter with an Osprey even after seeing photographs of one. Unlike most other aircraft, it is neither beautiful, nor sleek, nor handsome. It has a strikingly strange appearance that seems to belie its versatility. On the one hand, it is a heavy-lift helicopter; on the other, a turboprop airplane with really huge propellers (called *proprotors*), an example of form following function.

Contrary to common belief, the Osprey is not a tilt-wing aircraft; its wings are fixed. Instead, the engine nacelles on the wing tips rotate in unison from horizontal (airplane mode) to vertical (helicopter mode). The Osprey is the world's first production tilt-rotor aircraft.

Part helicopter, part airplane, the Osprey literally is in a category of its own

PHOTOGRAPH COURTESY OF BELL

and is designated by the FAA as a powered-lift aircraft (as distinguished from the other categories: airplane, rotorcraft, glider, and lighter-than-air). And it requires unique piloting skills.

Obtaining an invitation to visit the Air Force's Seventy-First Special Operations Squadron at Kirtland Air Force Base in Albuquerque was challenging, but once the red tape had been cut, I was offered training in a Level-D simulator and an actual flight designated as "Dusty 65" (including landing in a remote pasture in the Sangre de Cristo Mountains).

One of the first things you notice after climbing into one of the two front seats is that there is only one throttle (called a *thrust control lever*) to vary the power output of both FADEC-controlled, turboshaft engines. It and the control stick bristle with buttons and switches. This was my first experience with HOTAS, or "hands on throttle and stick," a style of aircraft control that allows a pilot to keep his hands on the controls while operating important systems, a concept becoming increasingly popular on the steering wheels of new automobiles.

Heart and soul of the Osprey is an innocuous-looking, knurled thumbwheel (spring-loaded to center) on the throttle. It is used to rotate the nacelles between horizontal and vertical. Moving the switch forward tilts the nacelles downward (horizontal), while moving it aft rotates the nacelles upward (vertical). Rather than thinking in terms of moving nacelles, visualize instead that the thumbwheel controls the direction in which proprotor thrust is vectored. This is what makes the Osprey different than any other aircraft (with possible exception of the Harrier "Jump Jet").

After starting the engines, the thumbwheel is moved forward to position the nacelles at 75 to 80 degrees of tilt (10 to 15 degrees forward of vertical). Add a little power and the aircraft begins to taxi, a result of the forward component of thrust. Nosewheel steering is conventional through the rudder pedals, which have toe brakes. What is not conventional is that the thumbwheel can be moved rearward to tilt the nacelles 7.5 degrees aft of vertical to assist in slowing or to taxi backwards. (A small gauge on a multifunction display shows current nacelle position.)

Wing flaps are extended to 73 degrees in preparation for liftoff. This seems excessive but is not done to increase lift. Instead, it reduces the area of the wing so that it interferes less with downwash generated by the rotors. Most Osprey pilots prefer the flaps to operate automatically, retracting and extending incrementally as airspeed changes during departure and arrival, which is why they will no longer be mentioned.

The nacelles are set to 86 to 88 degrees with the thumbwheel in preparation for lifting into a hover. The throttle is then moved slightly forward with a gentle, practiced wrist action. Full throw of the throttle is only four inches, so a little movement goes a long way. The throttle replaces what ordinarily would be the collective control in a helicopter.

If done correctly, the Osprey lifts into a hover and fine throttle adjustments are made to stay there. If you are too heavy-handed and apply too much power, the CV-22 jumps off aggressively and power must be adjusted to return to the desired hovering height. At this point, the control stick operates as a cyclic control in a helicopter. Move it in the direction you would like to go, and the Osprey obeys.

A pleasant surprise is that the rigid, nonflexing, counterrotating rotors generate no net torque, so there is no tendency to yaw one way or the other as do single-rotor helicopters. Hence, there is no need

CV-22 pilots must learn to shift mental gears and go back and forth between being a helicopter pilot or an airplane pilot. For brief periods, however, they are both.

Helicopter pilots transitioning to the Osprey prefer sitting on the right, but airplane pilots prefer sitting on the left.

PHOTOGRAPHY BY MIKE FIZER

for a tail rotor, and hovering an Osprey is not as challenging. The aircraft nevertheless is as maneuverable as other helicopters. It can back up, move sideways, pivot on a spot, and so forth.

Yawing in a hover is done the same way it is done in a conventional helicopter. Moving the right rudder pedal, though, causes the left rotor to tilt forward and the right rotor to tilt rearward, which results in a right yaw or pivot. The reverse occurs during left pedal movement.

The process of becoming an airplane is called *transition* (the reverse process is inexplicably called *conversion*) and is accomplished in as little as 16 seconds. While hovering, add power with the throttle and move the nacelles to about 75 degrees. The Osprey will move forward and begin to climb. You don't have to lower the nose to accelerate as in a conventional helicopter. Forward speed increases as a result of tilting the thrust vector. At 40 knots, raise the landing gear and lower the nacelles farther

SPECSHEET

Bell Boeing CV-22 Osprey

Specifications

Powerplants (2) ..... Rolls-Royce Liberty AE1107C, 6,150 shp ea
Proprotors (2).....three-blade, 38 ft 1 in dia
Length.....57 ft 4 in
Height ..... 22 ft 1 in
Total span (between outer proprotor tips)... ..... 84 ft 7 in
Wingspan ..... 45 ft 10 in
Wing area..... 382 sq ft
Wing loading .....158 lb/sq ft
Proprotor disc area (total).....2,278 sq ft
Disc loading (52,600 lb) ..... 23.1 lb/sq ft
Power loading.....4.9 lb/shp
Crew seats ..... 2+jump seat
Cabin seats (fully-equipped troops).....24
Cabin length.....20 ft 10 in
Cabin width .....5 ft 8 in
Cabin height .....5 ft 6 in
Empty weight (with crew).....37,500 lb
Max gross weight (rolling takeoff) ...60,500 lb
Max gross weight (vertical takeoff) ..52,600 lb
Useful load .....23,000 lb
Internal cargo .....20,000 lb
External cargo .....15,000 lb
Max rolling takeoff weight .....60,500 lb
Max rolling landing weight .....60,500 lb
Max vertical takeoff .....52,600 lb
Fuel capacity, std .....2,025 gal (13,568 lb)
Fuel capacity, with aux fuselage tanks..... .....3,315 gal (22,210 lb)
Oil capacity, ea engine..... 12 qt

Performance

Max crosswind component ..... 30 kt
Rolling takeoff (STO, nacelles @ 60 degrees) ..... 700 ft
Rate of climb, sea level, 47,000 lb.. 3,200 fpm
Rate of climb, sea level, engine-out, 52,000 lb .....600 fpm
Max level speed, sea level ..... 250 kt
Max level speed, 20,000 ft..... 300 kt
Cruise speed/endurance w/45-min rsv, max fuel (fuel consumption, ea engine), 10,000 ft
@ 82% power ..... 245 kt/5.0 hr (1,575 pph/235 gph)
Unrefueled mission radius of action (std fuel) .....430+ nm
Ferry range (aux tanks, no payload) ....1,800 nm
Service ceiling.....25,000 ft
Single-engine service ceiling.....10,300 ft
Hover ceiling..... 7,000 ft
Hover out of ground effect .....5,400 ft

Limiting and Recommended Airspeeds

V_X (best angle of climb, conversion mode).. .....68 KCAS
V_Y (best rate of climb, airplane mode) ....154 KCAS
V_{FE} (max flap extended) .... operate automatically
V_{LE} (max gear extended) ..... 150 KCAS
V_{LO} (max gear operating)..... 140 KCAS
V_{NE} (never exceed) ....280 KIAS/Mach 0.48
V_R (rotation, rolling takeoff) ..... 61 KCAS
V_{S1} (stall, power on, airplane mode)..... .....126 KCAS
V_{SO} (stall, power off, airplane mode) ....136 KCAS
Max touchdown speed..... 100 KCAS

Note: Because indicated airspeeds for the V-22 are derived from air-data computers, indicated and calibrated airspeeds are identical. All specifications are based on manufacturer's calculations.

All performance figures are based on standard day, standard atmosphere, sea level, gross weight conditions unless otherwise noted.

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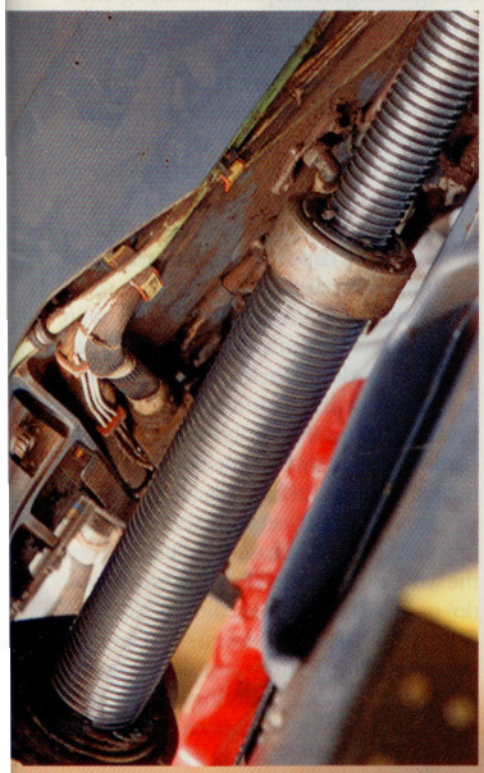

to 60 degrees, which increases airspeed even more.

Now for the magic that is made possible by the Osprey's triple-redundant flight-control computers and fly-by-wire control system. At between 40 and 80 KCAS, flight-control computers begin to electronically and gradually phase out the cyclic function of the control stick while simultaneously enabling the stick to begin moving the flaperons (combination flaps and ailerons) and elevator. Similarly, the rudder pedals are given increasing control of the twin rudders. (Osprey rudders are small because they are not used at low speed.)

This smooth transition from helicopter to airplane is transparent to the pilot and is complete at between 100 and 120 KCAS. The control stick and rudder pedals have full command of the flight controls just as they do in other airplanes. They no longer have any helicopter functions.

When the aircraft reaches 110 KCAS, the nacelles are lowered all the way to zero degrees (horizontal). Acceleration improves dramatically. Those huge propellers really pull hard.

If a takeoff needs to be made at heavy weights and high density altitudes, Osprey pilots make a rolling takeoff (called a STO, or short takeoff). The brakes are held while the nacelles are rotated to 60 degrees. Maximum power is gradually applied and then the brakes are released. The aircraft will roll for a short distance while forward pressure is applied to the cyclic control (the stick) to prevent premature liftoff. At rotation speed, forward

The Osprey in helicopter mode (below). This nacelle is in the 90-degree position (left) and a jackscrew is used to position each nacelle.

stick pressure is relaxed and the CV-22 levitates. If liftoff occurs prematurely, the Osprey will wallow and stagger a little because the wing is not yet developing enough lift to assist significantly with the takeoff. Also, the conventional flight controls are somewhat mushy, not yet fully effective. After gaining altitude following a STO, the pilot reverts to the departure profile used following a vertical takeoff.

A helicopter is relatively inefficient in cruise flight because only a small portion of the lift developed by the rotors is used for forward speed—most rotor lift combats gravity to keep the aircraft airborne. Once the Osprey's short, thick wing has sufficient airspeed to provide all needed lift, all of the proprotors' thrust can be directed horizontally to achieve high forward speed. Helicopters also are speed-limited by retreating-blade stall and have high vibratory loads; the Osprey has no such problems.

Once the nacelles are horizontal, the CV-22 is a conventional turboprop airplane. There are no differences worthy of note except for looking out a side window and seeing a truly huge propeller disc. Its 38-foot diameter makes it the world's largest airplane propeller. The blades are so long that each requires a twist of 42 degrees from root to tip. They also turn slowly, 333 rpm in cruise flight and 397 rpm in helicopter mode. You can almost count the blades as they swing by. Slow-turning propellers are relatively quiet, too, a significant advantage when operating in urban or high-threat environments.

An engine failure in airplane mode is not as traumatic as in a conventional twin. That's because there is no accompanying yaw following failure. The Osprey's engines are interconnected with a long shaft that immediately transfers half the power from the operating engine to the opposite proprotor. This occurs automatically and the only effect in the cockpit is a noticeable power reduction. The effect is the same as losing half of the power in a single-engine airplane. During such an emergency, power from the remaining engine can be increased to 6,830 shp from its normal maximum of 6,150 shp.

The Osprey is not pressurized because of the manufacturing difficulty in pressurizing a cabin with a square cross-section. The aircraft has an on-board oxygen-generating system and an aerial refueling probe, so it is capable of long-range and high-altitude operations.

For real excitement, fly the Osprey in low level over mountainous terrain to avoid detection. During terrain-following and terrain-avoidance operations, multi-mode radar sends computed and blended commands to the flight director but not the autopilot. This allows you to smoothly hand-fly as low as 200 feet over mountainous terrain without looking out the window (although it is more fun if you do) or in instrument conditions. You also can fly the Osprey as low as 100 feet agl over relatively flat or gently rolling terrain. A little practice flying low level in the Osprey rapidly builds confidence in the system.

All good things must come to an end. When about three miles from landing, retard the throttle fully. The huge propellers suddenly become giant air brakes and deceleration is incredible. You feel that without a shoulder harness, you'd wind up with a face full of glass panel. Simultaneously raise the nose and increase the wing's angle of attack to temporarily maintain altitude. When airspeed decreases from above 250 KCAS to 160, gradually rotate the nacelles to 88-89 degrees and simultaneously begin descent. In the meantime, the throttle and stick transparently and automatically convert from airplane to helicopter mode—you are once again a helicop-

ter pilot. If approaching with too much speed, raise the nose, but the work can be done by rotating the nacelles to 97.5 degrees, which provides some rearward thrust for deceleration. When airspeed has been reduced sufficiently, move the nacelles to 86 to 88 degrees (depending on wind), drop the landing gear, enter a hover, and lower yourself gently onto the tarmac by "squeezing" the throttle slowly aft. Unlike a helicopter, there is no flare or pitch-up required.

A very steep approach can be made with the nacelles 7.5 degrees aft of vertical, but you must lower the nose about 5 degrees or the Osprey will stop in midair. This is counterintuitive to a helicopter pilot who is accustomed to nose-high attitudes during landing approaches.

After parking, a rotor brake can be used to arrest proprotor rotation in 20 seconds. Because the blades can be folded and the wings rotated 90 degrees in only two minutes, the Osprey is easily hidden under camouflage netting or stored on the deck of a ship.

In the extremely unlikely event of a double engine failure, the Osprey will glide in airplane mode at a steep 4.5:1 glide ratio (about half that of a typical lightplane). If you land as an airplane, though, you are going to destroy the proprotors that extend far below the belly of the aircraft. The graphite/fiberglass blades are designed to "broomstraw" with debris flinging outboard. If double failure occurs in helicopter mode, a descent while autorotating is very steep and because of the low-inertia blades, the landing is said to be challenging.

CV-22 pilots must learn to shift mental gears and go back and forth between being a helicopter pilot or an airplane pilot. For brief periods, though, they are both. Maj. David Millett, one of the highest-time Osprey pilots in the Air Force, says that the CV-22 is neither a perfect airplane nor a perfect helicopter but is a combination of both. "The Osprey fleet has been averaging 10,000 hours per year for the last six years without any serious problems," he adds.

"We've never had an aircraft that combines such cruise speed and range with vertical-lift capability. The Osprey substantially widens our operational envelope and the missions we can perform," says Millett. "An added advantage is that we can approach a landing area with a low noise footprint and not be heard until we are there."

How will the Air Force use its Ospreys? By definition, the missions of "Special Ops" are unspecified, so one can only imagine. The Marines, however, will soon be deploying an MV-22 squadron to Afghanistan where the Osprey's unique ability to fly high and fast from remote areas will greatly improve mission capability.

For civilians?

Is there a future for a civilian tilt-rotor aircraft? Bell Helicopter thinks so and has teamed with Agusta, the Italian helicopter maker, to develop the Bell/Agusta BA609 for the corporate market. Two prototypes of the aircraft have been flown as high as 25,000 feet and as fast as 310 KTAS. They have also been flown in rearward and sideward flight at 35 knots. The 609 will be pressurized and carry nine passengers plus a crew of two. Certification in both the United States and Europe of the 16,800-pound (maximum gross weight) tilt-rotor is expected in early 2012. AOPA

With gratitude to and respect for Lt. Col. Michael McKinney, Maj. David Millett, and the men and women of the Seventy-First Special Operations Squadron who so graciously shared their time and expertise. —*Barry Schiff*