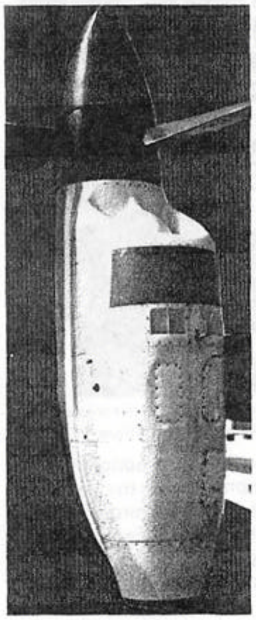

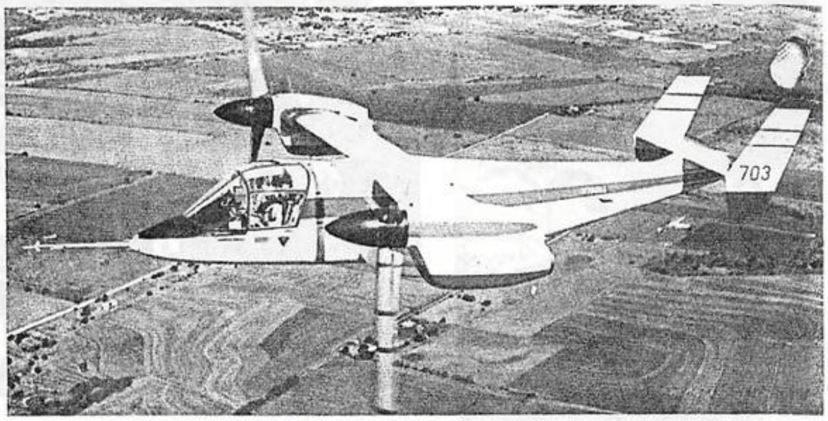

XV-15: Tilt-Rotor Technology

Half plane, half helicopter

by Lieutenant Colonel Alan D. York
Supervising Editor

"Roger, tower, we're the airplane that's about to turn into a helicopter."

The airfield manager was monitoring tower frequency on his "brick" as a couple of us *TMF* staffers joined a small group of onlookers who were trying to spot one of the most unusual aircraft flying today. Along with the airport officials, there were transient crews off corporate jets, aircraft maintenance folks and the usual assortment of aviation buffs, all waiting to get a glimpse of Bell Textron's XV-15 tilt-rotor aircraft as it arrived at Bi-State Parks Airport, Illinois, just across the river from St. Louis. It was a perfect afternoon for the short hop up from Kentucky, and if the sunny and warm weather continued, the flight demonstration planned for the next day would draw a sizeable crowd.

I had heard of the tilt-rotor and must admit, as a former helicopter pilot, I looked toward the south with a skeptical squint. After all, this XV-15 wasn't a true helicopter and it wasn't a true fixed wing either. And I wondered about the capabilities of such an unlikely compromise.

"There it is," called someone, and I watched as the speck in the brilliant blue sky quickly grew. Strange, I remember thinking, I don't hear it yet. Your average helicopter would have announced its approach with the familiar "wap-wap" of the main rotors, or at least the buzz-saw noise of the tail rotor. Finally, I picked up a faint sound from the prop-rotors. But the most striking part of the XV-15's arrival was just then revealing itself. On downwind, the "props" began to rotate from a standard fixed-wing-type configuration back toward the vertical, or helicopter mode. By the time it was on base leg, I could clearly see the "props" had become "rotors" and the aircraft was slowing for a run-on landing down the active. Making the first turn off the runway, I was still struck by its quietness. What sound there was seemed soft, almost muffled.

After the marshalling crew got the XV-15 parked, I got a chance to chat with Dorman Cannon and Jim Arnold, Bell Textron Helicopter experimental test pilots. I asked Dorman about the transition from the helicopter

Bell Textron test pilots Jim Arnold, left, and Dorman Cannon, right, discuss the unique capabilities of the XV-15 Tilt-Rotor with *TMF* editors. Photo by Capt Buzz Howard.

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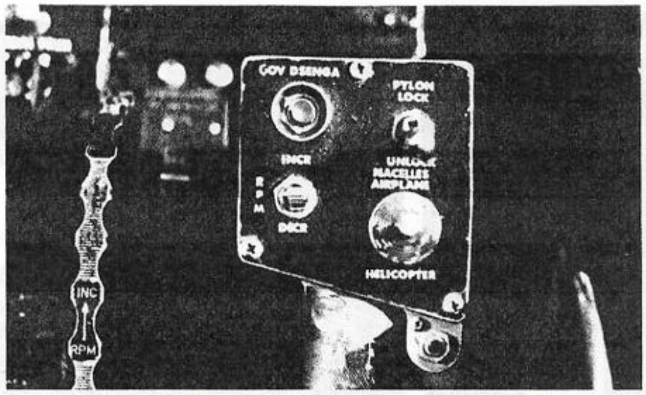


Box at top of power control lever. "Coolie hat" beep switch at lower right rotates engine nacelles and rotors forward for "airplane" flight, or backward to vertical for "helicopter" flight.

mode to the fixed wing or airplane mode. "You can take off as a helicopter from a stationary hover," he began, "and the pylons (engine nacelle and rotor) will move from the helicopter to the airplane mode in 12 seconds. During that time, you'll have gone from zero airspeed and will be accelerating past 130 knots by the time the pylons get down to the airplane or full-forward position. Because the airplane stall speed is around 98 knots, and you're already at 130 knots, you have an extremely wide safety margin built into the transition maneuver. And, of course, the same margins are there for transition from the airplane to the helicopter mode.

"And the transition is basically controlled by the simple 'coolie hat' beep switches installed on the pilot's and copilot's power levers (these would be called collective pitch levers in a conventional helicopter). By moving this spring-loaded switch forward, the engine pylons rotate toward the airplane position; and moving it to the rear rotates them toward the vertical or helicopter positions.

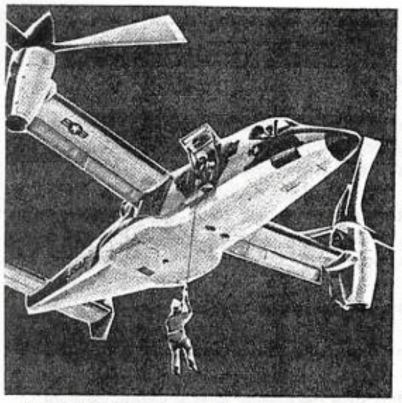
"The engines are also interconnected by a drive shaft that allows both rotors to continue operating in case of engine failure." And as Jim Arnold remarked, "There's very little indication if one engine were to fail because the other would continue driving both rotors through the interconnect drive shaft. You would simply be limited to half the power."

As we continued talking about how straightforward everything operated, I began to realize the great efforts that must have gone into solving all the challenging problems associated with such a remarkable aircraft. The XV-15 embodied successful solutions to a host of engineering and aerodynamic problems, and this brief encounter with it and the pilots who fly it, peaked my curiosity about the tilt-rotor concept and its development over the years.

The idea of an aircraft that combines the hover capability of a helicopter with the forward speed and cruise range of a fixed-wing isn't new. As a matter of fact, by the late 1940's companies like Bell Helicopter and Transcendental Aircraft Corporation were already actively engaged in engineering studies of this intriguing concept.

Although Bell's design team had concluded that development of a tilt-rotor test bed was well within the state-of-the-art capability, they also knew there would be difficulties as there are with any technology that breaks new ground; such questions as the best type rotor system, transmission and control interface, and basic stability were just a few of the problems they would have to wrestle with if the thing was ever to get off the ground. During this same period, Transcendental Aircraft Corporation was also deeply involved in the tilt-rotor and would later be the first to actually test fly a true tilt-rotor design.

In May 1951, however, the Army and Air Force awarded a



Artists conception of proposed search and rescue (SAR) tilt-rotor. Proposed aircraft has a design gross weight of 20,000 pounds and 370 nm radius of action. Courtesy of Bell Textron.

Bell XV-3 #2 over West Texas during test flight. Photo by Bell Textron.

phase I study contract to Bell Helicopter. The first of two test aircraft underwent extensive design and component testing to evaluate both concepts and hardware that would minimize the problems mentioned earlier. Now designated the XV-3, the second prototype built was actually the first to fly, making a first hover flight in August 1955. The other XV-3 was still undergoing extensive testing of the experimental three-bladed articulated rotor system.

Further flight testing continued until inflight instability of the three-bladed rotor caused the number 1 XV-3 to crash, seriously injuring Bell test pilot, Dick Stansbury. This mechanical instability problem prompted the design team to try a simpler, two-bladed rotor system, and make some significant changes and improvements in pylon-rotor-wing design. With the two-bladed rotors installed and the other modifications complete, the XV-3's test program continued amassing technical data about tilt-rotor design and operation. By the time the test program was completed in 1966, the XV-3 had flown 270 test flights, logged 125 hours in the air, during which 110 full conversions from the vertical (helicopter) mode to the horizontal (full 90° forward or fixed-wing) mode had been successfully accomplished.

Convinced of the basic soundness of the concept, Bell continued working to solve the remaining technical problems which had resisted adequate solution during the XV-3 program. Eventually, the prop-rotor dynamic stability problem which had been the most significant drawback of the previous program gave way to innovative engineering. The development and use of automatic blade flapping control, positive pitch/flap coupling, swashplate/pylon coupling, and high wing stiffness, combined to eliminate the stability problem once and for all.

An Army program for a composite capability aircraft starting in the mid-1960s resulted in Bell using these new features in the preliminary design they proposed. The aircraft was to have two turbine engines mounted in wingtip nacelles to drive their respective three-bladed prop-rotors, each 38.5 feet in diameter. This was far different from the XV-3 where a single piston-driven radial engine mounted in the fuselage powered both rotor systems. Wind tunnel tests of scale models of the design confirmed that Bell had indeed solved the rotor-pylon-wing stability problem. The test model reached a maximum cruise speed of 350 knots. Even though further funding was halted because of the war in Southeast Asia, Bell managers and engineers felt they had acquired enough tilt-rotor expertise to pay for full-scale research using in-house funds. So in 1968, Bell embarked on a verification test program of the new, post-XV-3 technology, which led directly to the XV-15.

In 1972, the Army and NASA joined to fund construction and testing of a full-sized tilt-rotor technology demonstrator. The design competition quickly narrowed to Boeing Vertol and Bell Textron. In 1973, after extensive study of both proposals, and of flight simulator comparisons of the two, an Army/NASA contract was awarded to Bell. The first flight of the XV-15 occurred on 3 May 1977, and since then, the XV-15 has been demonstrating the impressive capabilities and versatility of the tilt-rotor concept.