Tiltrotor Trials, Tribulation and Tragedy

Leonardo believes the AW609 could give it decade-long market lead among high-speed civil rotorcraft

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Tony Osborne

There is something undeniably alluring about the prospects of tiltrotor flight. The ability to fly long distances at turboprop speeds without the need of a runway at either end presents an attractive proposition for people whose time really is money.

Yet, 14 years after its first flight, and more than two decades since program launch, the Leonardo Helicopter (formerly AgustaWestland) AW609 commercial tiltrotor has yet to achieve certification, let alone enter operation. Its development has swallowed hundreds of millions of dollars, resulted in two joint-venture divorces and cost the lives of two test pilots.

The first prototype, AC1, is now flying in Italy after being transferred from the U.S. following the crash of the second prototype in October 2015.

But certification of the pressurized, nine-passenger aircraft boasting a 275-kt. max speed — now targeted for mid-2018 — could be game-changing for the world of rotary-wing flight and give the Italian manufacturer as much as a decade-long lead against any future high-speed vertical-lift competition.

Born initially as a joint venture between Bell and Boeing in 1996, the Model 609 was to be a 16,000-lb. civilian spinoff from that partnership's V-22 Osprey military tiltrotor and Bell's XV-15 test aircraft that preceded it. Bell took a leading share of the civil program, and company

officials forecast sales of up to 1,000 aircraft over 20 years. But in March 1998, Boeing withdrew as a partner, forcing Bell to find another company to share the risk. Its search took it to Europe, where Italy's Agusta, a company that had worked closely with Bell for decades, was willing to invest.

The new partnership was announced at the 1998 Farnborough Airshow and a new company, the Bell/Agusta Aerospace Co. (BAAC), was created to push the renamed BA609 program forward, and slightly trailing that of the V-22.

But it was never supposed to take this long.

When the program was launched in 1996 first flight was envisaged for 1999, and deliveries planned for 2001. But the BA609 didn't take to the air until March 2003, and another two years passed before the aircraft finally flew in airplane mode. And even with those milestones achieved, Bell was having doubts about the market for the civil tiltrotor. Indeed, executives at Textron, Bell's corporate parent, had reportedly tried to pull the plug on the program before first flight. With enthusiasm cooling in the Bell camp, friction developed between the two partners.

AW609 CHARACTERISTICS

Propulsion		
Powerplant	2 x PWC PT6C-67A	
Weight		
MTOW	8 ton class	18,000 lb class
Useful load	up to 2,860 kg	up to 6,300 lb
Capacity		
Crew /Passengers	2/9	2/9
Fuel		
Fuel Load (std tank)	1,166 kg	2,571 lb
Performance		
Max Cruise Speed	510 km/h	275 kt
Hover OGE (ISA)	1,828 m	6,000 ft
Service Ceiling (ISA)	7,620 m	25,000 ft
Maximum range - std/aux fuel tanks	1,389 km/1,852 km	750 nm/1000 nm

Primary certification Authority: FAA /Federal Aviation Administration
Powered Lift Category - Tiltrotor Class Aircraft

Concurrently, problems with the more important V-22's development were also weighing heavily on the BA609 project. By 2008, and with the global financial crisis biting hard, development work on the civil tiltrotor was grinding to a standstill, and managers at Bell in particular were growing increasingly convinced that the aircraft would not be a commercial success, a view arguably held by the American firm's management to this day.

Unwilling to see the program slip further, Agusta, then AgustaWestland and now Leonardo Helicopters, began negotiating with Bell to take the program off the latter's hands. Details of

the early negotiations slipped out in 2009, but it was not until 2011 when the then-CEO, Giuseppe Orsi, revealed at Heli-Expo that the two companies were in final negotiations for the Italian firm to purchase the program outright, something that Bell was not keen to disclose. A deal was finally inked at that year's Paris Air Show and cleared all regulatory hurdles five months later.

The sale gave Bell the option to use the proceeds to improve the V-22, which has since become a key platform of U.S. Marine Corps aviation, and the Fort Worth manufacturer is now firmly invested in tiltrotor as the solution to the U.S. Army's Future Vertical Lift needs with the development of the V-280 Valor. In addition, Bell continues to be a supplier to the AW609 program and will take a limited royalty from sales. Notably, as part of the agreement, Leonardo cannot produce an armed military version of the aircraft.

Protytype 3 is seen here being assembled in Italy. It is due to begin flight testing in Philadelphia, Pennsylvania, shortly.

Today, the commercial tiltrotor is Leonardo's flagship product. In a May 2016 presentation to the Italian government, CEO Mauro Moretti revealed that the company was set to spend more than €400 million ($419 million) on the program between 2016 and 2020. The next closest investments by the company were for its M345 jet trainer and production improvements on composite structures for Boeing 787 production, each priced at just over €150 million ($157 million).

Leonardo Helicopters CEO Daniele Romiti claims that despite delays to AW609 certification, achieving that in 2018 could give the company a 10-15-year lead over the competition. The nearest manufacturer perhaps is Airbus with its X3 (X-cubed) technology, currently being adapted for a European Union Clean Skies 2 program called LifeRCraft.

“We have never said we would sell [the AW609] in large numbers,” Romiti said in a 2016 interview. “The market has to be made ready to accept this innovative architecture.”

He went on to note the aircraft was sized to operate out of existing helipads and landing sites — “the benefit of the dimensions.”

The general configuration of the aircraft has changed little since the first mock-ups made their trade show debuts in the early 2000s. A long, narrow pressurized fuselage with a T-tail rudderless vertical stabilizer, the AW609 has a high-set, slightly forward-swept 34-ft.-long main-wing with a Pratt & Whitney Canada PT6C-67A mounted on both wingtips, which swivel from 95-deg., or just beyond vertical, to a horizontal position for forward flight. The engines, which feature full authority digital engine controls (FADECs), are interconnected mechanically to allow either to drive the other in the event of a failure. Each engine turns a 26-ft.-diameter prop rotor with a variable-pitch system capable of pitching the blades for horizontal and vertical flight. The aircraft is roughly the same length as the company’s AW139, twin-engine medium helicopter with a maximum gross weight of 18,000 lb.

Prototype 3 undergoing ground runs before it was sent to the U.S.

The AW609 prototypes are equipped with Rockwell Collins Pro Line 21 avionics suites, but production aircraft will be fitted with the Pro Line Fusion system featuring 14-in. touch-screen displays and integrated FMS with satellite-based navigation, synthetic and enhanced vision, and head-up display interfaces.

The avionics are integrated with the aircraft's fly-by-wire (FBW) flight control system, allowing the AW609 to be flown with conventional helicopter controls even while in horizontal flight. The engine nacelles are controlled with a thumbwheel on the collective. The nacelles move at 3 deg. per second but can rotate faster — up to 8 deg. per second — in an emergency. The aircraft is designed to be flown single pilot.

The pressurized cabin can seat up to nine people comfortably but could potentially be configured for missions other than passenger transport.

Over the course of the aircraft's development, engineers have introduced a series of drag and weight reduction measures including a new vertical stabilizer with part of the trailing edge removed, as well as a new tail cone. The shape of the engine exhaust nozzles was altered to a more oval, rather than square, shape and the rotor spinners were enlarged. These changes reduced drag by 10%, the company said.

The benefits of the tiltrotor are obvious, if customers can justify the cost, now estimated at $25 million to $26 million per unit. During 2015, the manufacturer demonstrated the AW609's capability by flying between company sites in England and northern Italy, a distance of 540 nm (1,000 km), in 2 hr., 18 min. at a cruising altitude of 25,000 ft. Leonardo claims that the tiltrotor comfortably beats the combination of car, helicopter and business jet on the same journey by 30-50%. The addition of an auxiliary fuel tank system positioned on the wing near the nacelles could extend maximum range up to 1,100 nm (2,000 km) or fly six passengers over a range of 800 nm (1,482 km) in a little over 3 hr. This has been driven by the request of some customers to fly from helipads in New York to Bermuda, an overwater distance of roughly 670 nm (1,244 km).

Three organizations are now studying the practicality of the tiltrotor as a business case. Bristow, which supports the offshore oil and gas industry, was the first to sign a joint development agreement in February 2015 to examine the potential role of the AW609 as well as the larger, more advanced tiltrotors that the manufacturer wants to develop in the future. The company's internal studies, presented in London last April, showed that tiltrotors could eliminate the need to transfer passengers from fixed-wing airliners to helicopters, and fly oil workers to offshore platforms or remote locations directly from major airports.

As an example, one current contract requires a Boeing 737 to fly oil workers between Fairbanks and Deadhorse, Alaska, where they transfer to helicopters for transport to drilling facilities in the Beaufort Sea. But a tiltrotor could fly the entire journey from Fairbanks to the rigs in one hop. In addition, the studies show that tiltrotors could fly to every rig in the Gulf of Mexico directly from Houston, potentially negating the need for the numerous coastal helicopter bases that now support operations in the region.

“Flying up at 18,000 to 25,000 ft. means you are away from congestion of other aircraft flying around the platforms. This means reduced mission, costs, time and risk and enables more productive days,” Russell Gould, director of global fleet support at Bristow, told the Royal Aeronautical Society.

Although best known for its oil and gas support services, Era Group also signed a joint development agreement on the tiltrotor to look at the aircraft’s potential for providing emergency medical care to high-net-worth individuals. The review focused on markets like India where poor ground infrastructure could slow the transport to hospitals in an emergency.

And then at the 2015 Dubai Airshow, the United Arab Emirates Joint Aviation Command (JAC) signed for three aircraft to support the country’s new National Search and Rescue Center. The goal is to provide critical healthcare within the so-called “Golden Hour,” the short period of time when a patient’s chances of survival are greatest if given care after a severe injury.

In addition, Leonardo has been studying the potential of a search and rescue capability for the AW609 for several years. Despite the aircraft’s relatively small cabin, the company has looked at developing a two-panel door operable in flight, with the upper part containing the hoist needed for rescues over water or inhospitable terrain. The AW609’s speed and radius of action means it can respond faster and at longer distances than conventional helicopters, flying over the weather and then descending to the rescue area. The tiltrotor’s productivity would also be higher, which means fewer would be required to provide the same coverage as multiple helicopters.

Of the development partners, only the UAE Joint Aviation Command is known to have signed a firm purchase agreement for the aircraft, with options for another three. But little is known about the other customers who have signed up. As far back as 2001, Bell/Agusta Aerospace Co. was claiming 80 agreements had been signed, but that number has dropped to 60, according to Leonardo. Several have been ordered by wealthy individuals, with reports that one is destined to service a mega-yacht. Strategy documents by the Italian armed forces and its public agencies have also listed tiltrotors as a capability high on their shopping lists.

“This is the new frontier . . . and the number of people believing in this is increasing,” Romiti said.

But there are still many hurdles for the AW609 to overcome, the tallest being certification, and the nature of the aircraft demands a new category of oversight: the FAA’s Powered Lift category, which calls for the AW609 to meet elements of both FAR Part 25, the airworthiness standards for fixed-wing aircraft, and Part 29, which governs rotorcraft. These requirements have put significant pressure on the development program, forcing test pilots to explore areas of the flight envelope that even after more than 50 years of tiltrotor experience — involving the V-22, XV-15 and the XV-3 —are full of unknowns.

This examination has included recovery from the phenomenon of vortex ring state, or settling with power where the rotor system no longer generates lift, as well as autorotation, and one-engine- and all-engine-inoperative flight states. Leonardo made several requests to the FAA to exempt the aircraft from various requirements to reflect the tiltrotor's unique design.

Then in October 2015, tragedy hit the program when the second prototype, AC2, crashed near the town of Varese in northern Italy, claiming the lives of veteran test pilots Herb Moran and Pietro Venanzi. Eyewitness reports claimed the aircraft was on fire before it hit the ground. The manufacturer immediately halted flight testing. A full and final report from the Italian air accident investigation board, the ANSV, is yet to be published.

An interim report posted in June 2016 by the ANSV revealed that the aircraft had begun experiencing oscillations as it entered a high-speed flight regime, required as part of the certification testing. When the pilots attempted to correct the oscillations, the AW609's flight control system tried to compensate and inadvertently generated a phenomenon that investigators called "divergent Dutch roll." The investigators found that the company's simulator was unable to reproduce the phenomenon, and so the condition could not have been predicted. They also urged the manufacturer to review the AW609's flight control laws.

There were other challenges, too. The investigators struggled to recover flight data off the aircraft's combined cockpit voice recorder and flight data recorder, which had been seriously damaged and failed to record some key parameters. However, the recorders' data was confirmed through telemetry sent by the aircraft during the fatal test flight. Early in the investigation, the third prototype, AC3 (whose first flight occurred on Jan. 30 in Philadelphia), was briefly impounded by the authorities.

After flight testing re-commenced at the end of July 2016, the first prototype, AC1, was moved from Arlington, Texas, to Leonardo's facility in Philadelphia where it manufactures the AW119Kx Koala and some AW139s for the North American market. Subsequently that aircraft was transferred to Italy, while AC3 was sent to Philadelphia for flight testing. AC3 will play a critical role in the development of the deicing system and will head for the cold of Minnesota in the coming winter. Part of those tests will involve the AW609 flying behind the U.S. Army's Helicopter Icing Spray System (HISS) CH-47 Chinook test helicopter.

Meanwhile, AC4 is being assembled in Philadelphia and will be the closest to the production standard of the three prototypes, equipped with the Pro Line Fusion avionics, and will ultimately be used for function and reliability tests, maintenance flight and customer demonstrations.

The assembly of AC4 in Philadelphia is giving technicians and engineers there a better idea of how the aircraft will come together when production begins, probably at the end of 2018. A second assembly line will be created later, if needed, at Leonardo's Vergiate, Italy, production facility.

As the AW609 nears its entry into commercial service, the manufacturer is already envisioning a 20-seat civil tiltrotor for delivery in the 2030 timeframe. In addition, it plans to fly a demonstrator to validate five new, evolved tiltrotor technologies in 2023 as part of the European Union's Clean Sky II aerospace technology development program. For Leonardo, the future clearly tilts toward tiltrotors.