Bell Helicopter Doubles Down on Innovation

The FCX concept is just the tip of the iceberg in Bell’s mission to reinvent itself and vertical flight.

By Mike Hirschberg, AHS International Executive Director

Bell Helicopter’s new Model 505 Jet Ranger X — a 21st century update of the iconic Bell 206 JetRanger — began deliveries in March. When the JRX received its type certificate from Transport Canada in December, it was the only the third new type certificate for Bell in two decades civil aircraft, following the 427 in 1999 and the 429 in 2009.

During this time span, significant resources were devoted to developing and fielding the UH-1Y/AH-1Z, the V-22 Osprey and the (then) Bell/Agusta BA609 civil tiltrotor (in addition to supporting the urgent and high operational tempo of overseas operations). Since selling its 609 interest to AgustaWestland, however, Bell has increasingly devoted resources to research and development of new civil products.

The recent 505 and 525 Relentless helicopters reflect disciplined efforts to re-enter the market segments once occupied by the 206 JetRanger and the 214ST, respectively, with innovative new generation designs. Notably, neither the 505 nor the 525 utilize rotors or dynamics developed from military programs.

Now, Bell is investing in innovative technologies and concepts to broaden its product line and recapture market share. In March, Bell unveiled its FCX-001 (“Future Concept X”) mock-up — but this is just the tip of the iceberg. Bell has a number of innovative initiatives underway that they plan to reveal regularly as they get more mature, Bell Helicopter’s new director of innovation, Scott Drennan, told Vertiflite. “Bell is dreaming big again. We’re getting back to our roots and dreaming big.”

Bell has a long history of innovation. Whereas the military and civil tiltrotors, as well as the 505 and 525, are all innovative in their own way, Drennan said, they are more incremental and generational innovations. “The new innovation team has been given the mission to do radical innovation ... look 10 to 15 years out ahead of the business [and] illuminate the future for the business,” by raising technology readiness levels (TRLs) and manufacturing readiness levels (MRLs), and showing the art of the possible. And not just for traditional rotorcraft: Bell is “actively working designs in the on-demand mobility space and electric VTOL.”

With innovative new civil and military aircraft designs advancing, Bell is now exploring radical technologies and designs that could become future products. “We are flying several subscale prototypes right now of different aircraft,” Drennan reported. Large scale testing of innovative technologies is also being conducted.

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Innovative Research & Development

505 Jet Ranger X

The 505 and 525 have been developed in parallel, and were once described as being “neck and neck” as to which would fly first. (It ended up being the JRX, by about eight months.)

With a speed of 125 kt (230 km/h), a range of 340 nm (630 km) and a useful load of 1,500 lb (680 kg), the 505 is designed to be safe and easy to fly. Bell said that the “customer-driven design of the aircraft places safety, performance and affordability at the forefront,
**525 Relentless**

When Bell’s 525 Relentless super-medium twin was unveiled in 2012, it set the bar for the world’s most technologically advanced civil helicopter.

The 525’s cockpit features noteworthy innovations including an advanced flight deck, fly-by-wire flight controls, side-stick controllers and sliding “J-Track” pilot and copilot seats. The new five-bladed main rotor system, also with LIVE, powered by two advanced GE CT7-2F1 engines, is matched with a canted tail and lift assist tailboom design (LATD) for additional lift.

With its ARC Horizon flight deck, the Relentless is the first commercial helicopter to incorporate the Garmin G5000H, a touchscreen avionics suite for enhanced situational awareness and improved pilot integration due to fewer hand/eye movements in the flight deck. Helicopter Synthetic Vision Technology (HSVT) gives pilots a 3D depiction of terrain, obstacles, traffic and more in any condition.

The Relentless will be the world’s first civil helicopter certified with a fly-by-wire control system (though the AW609 may be certified first to become the first civil rotorcraft with fly-by-wire). Bell said it planned to resume 525 flight testing this summer, pushing the program’s completion back one year to the end of 2018. The company continues working with the US National Transportation Safety Board (NTSB), FAA and General Electric Aviation to investigate the fatal crash of Flight Test Vehicle 1, which broke up southwest of Bell’s Arlington, Texas, facility on July 6, 2016, killing both pilots.

Although Bell and the NTSB have both kept quiet throughout the investigation, Rotor & Wing International reported in March that the 525 “experienced rotor system vibration and frequency resonance in its airframe and flight control system seconds before the aircraft broke up in flight” — the rotor speed dropped and the blades hit the nose and tail. It is believed that the aircraft was conducting a unique test at the time: it was flying at close to 200 kt (370 km/h) and 2,000 ft (600 m) when the pilots began a one engine inoperative (OEI) high-speed descent.

Before the accident, the first three aircraft racked up nearly 200 hours in the air. Although Bell has kept FTV 2 and FTV 3 grounded, extensive hardware and software simulations have continued with the Relentless Advanced Systems Integration Lab (RASIL), and ground testing recently began again. The third and fourth aircraft are nearing completion and will begin flight testing this summer/fall.

**V-280 Valor**

In March, Bell completed the ground vibration testing (GVT) of its V-280 Valor; the company’s “third generation tiltrotor” is its Joint Multi-Role (JMR) Technology Demonstrator focused on the US Department of Defense (DoD) Future Vertical Lift (FVL) acquisition program. [See our resource page at www.vtol.org/FVL for more information on the program and the other companies involved.]

In an interview with Vertiflite, Vince Tobin, vice president for advanced tiltrotor systems at Bell, reported that the testing was a success. “We didn’t discover anything that’s a major issue. Everything was generally within the models and what was not is minor and correctable. So, we’ll have those fixed and it won’t impact the schedule or the opportunity to get to first flight” in September.
Some of the gearboxes used just for GVT are now being replaced with flightworthy components before the rotors are installed in May and ground runs begin in July. After the Valor has “air under the tires,” Bell expects a two-to-three month envelope expansion flight test program to demonstrate the transition to airplane mode and 280 kt (520 km/h) airspeed.

Eagle Aviation Technologies in Newport News, Virginia, is fabricating the rotor blades with an innovative new process. They “start with a one-piece spar — real different from the way we do it on the V-22,” explained Tobin. Eagle then attaches core to either side and wraps the blade skin around it. “It’s a relatively simple construction — as simple construction as a tiltrotor rotor blade can be,” given the fact that the cross-sectional area, the airfoil and the twist change along the blade length. “It’s a relatively complex geometry, but we’ve simplified the process as much as possible on how to put it together.” Bell then machines the molded assembly, including the pitch change link supports and other details, to make the complete rotor blade.

“If five years ago when we started this you would’ve asked me ‘what are you most concerned about to get to first flight?’ I would have told you ‘flight control software, gearboxes and rotor blades,’” said Tobin. “And here we are six months from first flight, and we’re making good progress, but the things that are left to get done are flight control software, gearboxes and rotor blades.”

After it completes all the required flight test points on V-280, Bell is considering whether to fly the aircraft “unmanned” — an autonomous flight with a safety pilot. “We want to explore that and make sure that any aircraft that we build from now on would have an unmanned flight capability. We have a big head start because this is our third fly-by-wire aircraft: we’ve got V-22, 525 and now V-280. Once you have the flight control inputs going into a flight control computer … whether it’s manned or unmanned is the same. While it’s not trivial to figure out how to get the flight control inputs into the flight control computer, it’s a much shorter leap to get from manned flight to unmanned flight … with a fly-by-wire aircraft than with a mechanically controlled aircraft.”

The FVL Family of Systems includes six “Capability Sets” from Light (CS1) to Heavy (CS5). The JMR studies focused the V-280 Valor on what was called FVL-Medium, which now roughly corresponds to CS3. “We think it’s scalable from CS1 to 5, and the Army is talking about a 6,” which would be the Joint Future Theater Lift program, said Tobin. “We’re pretty confident that once we determine the requirement, tiltrotor technology is scalable to meet it.”

The V-280 Valor is currently 95% complete, primarily waiting on installation of the rotors before ground checkout testing. First flight is planned for September.

The V-280 takes advantage of the huge investment made in the Osprey. “V-22 was a technological marvel when we design it 30+ years ago, and it’s still an awesome capability, as evidenced by how much it’s being used all over the world,” said Tobin. “The real focus for us, and what we did for V-280 and we’re doing on V-247, is applying technology to make aircraft that are more producible, cost less to build, cost less to operate — essentially we’re making the capability that V-22 provides much more affordable. And that’s where the real innovation is … to get that high-end capability, but do it for helicopter prices.”

V-247 Vigilant

In September, Bell unveiled its V-247 Vigilant to offer “game-changing tiltrotor range and speed to unmanned missions” for the US Marine Corps’ Marine Air-Ground Task Force (MAGTF). The company described the aircraft as “a low-risk, achievable approach to satisfying the USMC MUX (MAGTF Unmanned Expeditionary Capabilities) requirement for a Group 4/5 Unmanned Aerial System (UAS).”
The V-247 is designed with a modular payload system that enables flexibility, and rapid configuration changes for specific missions. With a two-aircraft system, Bell stated that the single-engine Vigilant could conduct persistent 24-hour intelligence, surveillance and reconnaissance (ISR) operations, or achieve more than 10 hours of time-on-station with 600 lb (270 kg) of payload at a 450 nm (725 km) mission radius. Bell has not yet selected an engine, but estimates performance using data from existing engines in the 5,000–6,000 shp (3,700–4,500 kW) range. The V-247’s impressive range and speed facilitates escort missions for other helicopters, tiltrotor and even fixed-wing aircraft.

The company completed the V-247 system requirements review (SRR) on March 31, based on what the team understood about the requirements. The Pentagon finalized an Initial Capabilities Document (ICD) for the MUX requirement in October. Tobin emphasized that the Marines “are very open on what the requirements are and where they’re headed on the MUX program.”

Although government funding is not expected any earlier than fiscal 2019, Bell has been proceeding on internal research and development funding: “We are proceeding on IRAD with the goal of entering the program with minimal technical risk. We’re tracking the requirements, and as the requirement changes, we’re updating our baseline and making sure that we’re designing for the requirement as we understand it.” Tobin expects to hold a preliminary design review for the Vigilant within the next 12 months.

The Capability Development Document (CDD) is expected in the next 12–18 months, which will allow the Marines to pass the DoD acquisition Milestone B and release a request for proposals (RFP) to enter the Engineering & Manufacturing Development Phase (EMD).

Tobin said that almost all of the technologies and manufacturing techniques being developed for the V-280 are transferable to V-247. “Our goal is to make sure we enter into the [MUX] program of record having mitigated as much risk as practical.” Based on the V-280 demonstration effort and the evolving V-247 design, Bell will conduct trade studies to inform the Marines of the impact of requirements decisions, so that when the CDD requirements are finalized, the Marines could move directly into a Milestone B decision if the Vigilant is selected.

Bell said that the head start on the V-247 design, and using existing engines, enables a DoD acquisition Milestone C decision (approval to enter the Production & Deployment Phase) as early as 2023.

Bell has about 250 engineers working across the V-280 and V-247 team. Tobin noted that there are a dozen partner companies, which together likely have a similar number of employees engaged on the programs.

In early April, at the US Navy League’s annual Sea-Air-Space Expo, Bell displayed a model of the V-247 that could be equipped for the Navy’s requirements for anti-submarine warfare (ASW), sensor missions, or equipped with an airborne early warning (AEW)
Thacker Leads Bell Technology and Innovation

Michael Thacker was named in February 2017 as Bell Helicopter’s Executive Vice President for Technology and Innovation, where he is responsible for leading Bell’s core engineering team and providing strategic direction for designing, developing and integrating technologies for use in current and next generation products.

Thacker was previously the senior vice president of engineering at Textron Aviation, where he was responsible for the engineering efforts of the Beechcraft, Cessna and Hawker product lines. This included new aircraft development, certification, compliance, experimental fabrication, technical publications and product safety, as well as engineering product support for all aircraft in production and legacy models.

Thacker joined Cessna in 1993 as an engineer in propulsion integration. Since then, he has held various positions of increasing responsibility in engineering and program management. Prior to being promoted to senior vice president in July 2011, Thacker held the position of director of research and advanced technology from 2008. In that role, he managed and directed new product and technology development programs and processes. His responsibilities included product and technology strategy, and program initiation and execution.

Between 1993 and 2016, Cessna greatly expanded its product line, adding new aircraft to the bottom, middle and top of its business jet portfolio (including very light jets). Textron bought Beechcraft and its Hawker brand in 2014, adding the King Air and military turboprop trainers to its portfolio to form Textron Aviation.

Thacker brings a lot of strength in certification and innovation. Significantly, he was engaged with the re-write of the FAA’s Part 23 (Small Airplane) certification standards. According to the Aircraft Owners and Pilots Association (AOPA), the new rule has “groundbreaking new provisions that allow manufacturers to use performance-based, industry-consensus standards in place of the ‘prescriptive’ manufacturing methods that have long hindered development of new designs and technologies, and caused aircraft certification costs to soar.”

The FAA is now exploring the possibility of a re-write for Part 27 and Part 29 rules governing civil helicopters; Bell has been a proponent of revisiting the certification standards.

With Thacker’s experience in certification, Cessna’s research and advanced technologies, and product and technology strategy, plus his new found position at Bell Innovations and Technology, Thacker may be uniquely qualified to help Bell chart a path forward.

Notably, Thacker is speaking at the Uber Elevate Summit in April, focused on defining a path towards urban electric VTOL operations (see www.vtol.org/electric-vtol). Bell is the only major aircraft manufacturer presenting at the summit, and the only company to have two speakers: Thacker and Scott Drennan, who said that Bell is “actively working designs in the on-demand mobility space, and electric VTOL.”

radar to extend the capability of the fleet, as well as sonobuoys on side bays and a Mark 50 torpedo in the center bay.

The V-247 is being design for a lot of flexibility in its capability, Tobin said: “The Marines have asked us to make sure that the aircraft fits in the hangar of the DDG [guided missile destroyers] because they would like the Navy to have the opportunity to buy this aircraft as well to help them with the program.”

Asked what’s next, Tobin replied that tiltrotor technology is “eminently scalable. So the design work that we’re doing for V-280 and -247 is applicable to other size aircraft.”

Innovation & Technology
Reorganized to Innovate

With the huge downturn in civil and military sales over the past several years, Bell Helicopter made significant reductions in personnel. The company — and its engineering staff — is less than half of what it was four years ago.

After Mitch Snyder took over as Bell Helicopter’s President and CEO in November 2015, the company conducted a reorganization in early 2016. As part of it, the company transitioned from a matrixed engineering department — under an executive vice president of engineering — to an integrated product team (IPT) structure — with a much smaller “Innovation and Technology” department. “We went from a functional model to a deployed model that included changing what was named ‘Engineering’ at Bell to “Technology and Innovation,’ with our engineers deployed out to the programs,” said Drennan. Thus, most engineers at Bell are now assigned to one or more products, e.g. reporting to the program managers for 525, 429, V-22, V-280, etc.

Drennan has about 40 personnel under him in the Bell Innovation group — as it is being temporarily called, pending an official name to replace the former “XworX” moniker. Also under Technology and Innovation are the organizations for flight test, safety, certification, the technical fellows, and the laboratories.

Snyder listed the company’s emphasis in driving innovation: advanced VTOL designs, hybrid and clean propulsion, assisted and autonomous flight, flexible avionics, cutting edge materials technology, and unrivaled safety. The advanced VTOL designs include not only traditional helicopters and tiltrotors, but also transformative vertical flight approaches. The company is believed to be working on a new hybrid electric VTOL design. Although he wouldn’t clarify further, Drennan said that the company is “actively working several designs” related to on-demand mobility.

FCX

At Heli-Expo in March, Bell unveiled a mock-up of a concept helicopter called the FCX-001. Not intended to enter production or even undergo flight testing, the FCX-001 was instead built to showcase potential technologies that could eventually work their way into Bell products.
“Six months ago we created a dedicated team to focus on emerging technologies and how we could incorporate them into our products,” Snyder said. “Among that team’s first tasks was to display visually the technologies and innovations that present a roadmap that we envision bringing to market.”

Within the Innovation team, a core group of engineers working with graphic designers proved to be a highly collaborative team of problem solvers, Bell stated. It was through this process that the FCX-001 was constructed to physically demonstrate a new way of thinking. Bell’s descriptions of the technology suite on the FCX-001 concept mock-up are provided in the sidebar.

Bell explained that the company was not planning to build and fly the aircraft, even as a demonstrator, but was rather advanced actuation or materials, or both, to push beyond the enhancements that we originally created.

**Virtual Cockpit:** One pilot seat. Removing the traditional Multi-Function Display (MFD) flight deck for enhanced visibility from the pilot seat creating an entirely new experience. We see pilots of the future controlling the aircraft with the aid of augmented reality and an artificial intelligence computer assistance system. This takes us from computer augmented piloting, much like we have today with Fly-By-Wire systems, to optionally piloted vehicles where the pilot assumes the role of safety and mission officer aboard the aircraft while the computer flies with him. This is the stepping stone to the fully autonomous unpiloted VTOL air vehicles.

**Enhanced Cabin Design:** A concept modular flooring systems allows for rapid seating configuration changes so that the cabin can be customized for many types of passenger, cargo or mission based requirements. LED lighting in the overhead canopy can be fully customized in color and brightness depending on passenger preference. 360-degree pop-down air ventilation systems to allow for increased comfort on demand.

**Advanced Landing Gear:** There is an important design aesthetic to this gear but we are exploring how non-traditional geometries, including wheels, tires and support structures can facilitate function when combined with advanced materials. As an example, actuation can improve maneuverability and absorb landing energy for improved safety and comfort in ground operations.

**Flight Control Technology:** At the heart of the fly-by-wire system are three separate and independent flight control computers. Upon receiving digital commands from the pilots, the system evaluates and calculates the optimal method to achieve the order, assuring the aircraft is not compromised and is supported by extra system redundancy.
a mockup of different technologies that could be incorporated for future aircraft.

Drennan clarified that it “wasn’t a product release, a product reveal, or a next platform reveal…. It’s us sharing a part of our vision for future technology that would either be on helicopters or VTOL aircraft.” For example, the electric anti-torque approach could be applied to different models; the company has been testing sub-scaled versions in the laboratory, and plans to test the concept in full-scale later this year. Whereas the powerplant associated with the FCX approach is “thermal based” (e.g. turbine or diesel), the power for the anti-torque system is electric: “we are looking at hybridized, more electrified, vertical takeoff and landing,” Drennan said.

What’s Next?

At the Bell press briefing at Heli-Expo, Snyder reported that 36% of the company’s $3.2B in 2016 revenue was commercial and 64% government/military, with the stated desire to reach a 50:50 split. With the 505 and 525 bookending Bell’s commercial product range, it begs the question of where the company’s next commercial helicopter product will be.

The FCX-001 concept aircraft was stated as being about the size of a Bell 412 — which is about 12,000 lb (6,000 kg) — so perhaps the technologies being demonstrated might be well sized for a new medium twin to renew the company’s product line.

Drennan noted: “We have created a culture of innovation at Bell Helicopter and will continue to test new concepts, ideas and technologies that will enable us to design, build and provide the most modern products to our customers.”

“Being a pioneer in the aircraft industry is in our DNA and we want to share this renewed passion with the world. The FCX-001 points the way for our future — a renewed focus on innovative solutions and technologies. When the time is right, we look forward to sharing more of what we’re doing behind closed doors,” added Snyder.

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