

# AVIATION WEEK

## & SPACE TECHNOLOGY

## UTC's Dash 8 Hybrid-Electric X-Plane Targets Commercial Market

By Graham Warwick Washington



**L**everaging its breadth as an aerospace supplier, United Technologies Corp. (UTC) is modifying a Bombardier Dash 8 Q100 regional aircraft into a hybrid-electric flight demonstrator and may offer the conversion commercially after the X-plane flies in 2022. UTC is projecting energy savings of at least 30%.

The demonstrator is the first project to be undertaken by the new United Technologies Advanced Projects (UTAP) organization. The effort's name, Project 804, comes from the straight-line distance in miles between the two UTC units involved: Pratt & Whitney Canada (P&WC) in Longueuil, Quebec, and Collins Aerospace in Rockford, Illinois. United Technologies Research Center (UTRC) is also participating.

While targeting the same 2-megawatt power class as Airbus' E-Fan X program to convert an Avro RJ regional jet into a hybrid-electric demonstrator, Project 804 differs in being aimed at developing a propulsion conversion that can be certified and produced.

The launch of UTAP follows UTC's acquisition of Rockwell Collins, its combination with UTC Aerospace Systems to create Collins Aerospace Systems, and the announcement of plans to spin off Carrier and Otis in 2020, leaving UTC as a \$50 billion aerospace company focused on Collins and Pratt & Whitney.

"This is an important time in the company's history," says Paul Eremenko, UTC chief technology officer. "It is going

through the biggest change in portfolio since United Aircraft," he says, referring to the company that was formed in 1934 by the breakup of Boeing and Pratt and renamed UTC in 1975.

"With the standup of Collins and the spinoff of the businesses, we are reshaping the company into something fundamentally new," he says. "And an important part of that is having a 'Skunk Works' organization to more rapidly mature bundles of technology."

Project 804 is the first to be launched by UTAP because "the most pressing, most obvious need is for UTC to lead in the electrification of propulsion," Eremenko says. "We already have the best aerospace-certified electrical system capability at the former Hamilton Sundstrand in Rockford, where they developed the [Boeing] 787 power system. We also have a propulsion company covering small to big engines."

The hybrid-electric propulsion project brings the two together, with UTAP providing a startup-like environment in which to develop a product demonstrator at scale. "UTAP can move at the speed of a startup but do it at the heart of the business," Eremenko says, adding that, to move quickly, "We had to redo all our processes to be compliant but as lean as possible."

There is no UTAP headquarters. Instead, projects are co-located with the businesses—Collins and P&WC in the case of Project 804. Team members have been recruited at both locations. "They have different color badges, a different culture and processes, and a different speed to operate at," he says. UTAP also recruits internally, from across UTC and UTRC, and externally, bringing new talent into the company.

UTAP was created to take on challenges that span multiple UTC units or are too risky for a business—"804 meets both criteria and was the obvious first project," says Eremenko. Although much of the technology for hybrid-electric propulsion exists within the company, UTAP projects are not intended to be 100% UTC. "The goal is one-third existing employees and know-how, one-third new people and one-third external partners," he says. "That's an aspiration. It's not clear if 804 will hit it spot on."

Under Project 804, a Dash 8 will be reengineered—on one side only for safety—with a 2-megawatt hybrid-electric propulsion system comprising a 1-megawatt gas turbine and 1-megawatt electric motor. The flight demonstrator will act as both a “technology pull” and an integration platform for UTC.

“One megawatt on the electrical side is hard enough to pull technology versus the 250-500-kW we have today. But 1 megawatt is doable in a couple of years in a certifiable way,” says Eremenko. “What 804 does differently is it creates something that can be produced and makes sense for regional airlines.”

The 39-seat Dash 8 Q100 is powered by P&WC’s PW121 turboprop, rated at 2,150 shp for takeoff. In the hybrid system, this is replaced by a new 1-megawatt (1,300-shp) turbine engine under development at P&WC. This turbine, or “thermal,” engine drives a gearbox that powers the propeller.

The 1-megawatt electric motor, powered by batteries installed under the cabin floor, also drives the gearbox. For takeoff and climb, both the thermal engine and electric motor drive the propeller. In cruise, only the thermal engine is used. On descent, the motor operates as a generator and uses excess thermal-engine power to recharge the batteries to ensure sufficient energy is available for a go-around.

By downsizing the turbine engine, and enabling it to operate at a constant, optimal full-power setting from takeoff through the cruise, UTAP expects fuel savings of about 30% over a 1-hr., 200-250-nm flight. “That’s conservative,” says Eremenko. There is a penalty from the extra weight of the hybrid system components and lower energy density of batteries versus jet fuel. Empty weight is increased and fuel capacity reduced by about 50%, cutting range to 600 nm from 1,000 nm. “We shave a little bit off the maximum range, but it is never used,” he says.

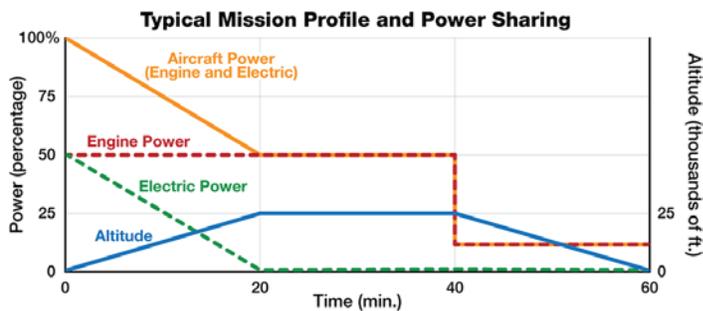
Hybridization is suited to short commuter flights on which aircraft spend a lot of time in climb and descent, says Eremenko. “With a 1-megawatt electric system, we can downsize the thermal engine and get a significant efficiency improvement,” he notes. “The economic case closes and we can productionize it in a relatively small number of years. This is a technology and a product demonstration.”

And Eremenko says it makes sense to go to production: “This is not some bright, long-term future vision. It is a unique value proposition that can make a pretty big difference in the near term.”

Aircraft developers are looking closely at hybrid-electric propulsion as a way to reduce emissions and at using architectures such as distributed electric propulsion or boundary layer ingestion to offset the weight and efficiency penalties of the additional complexity.

“All those are OEM trades we are not equipped to do,” says Eremenko. “But this is one where we can take an existing airframe and not optimize the aircraft, but instead downsize the thermal engine by a factor of two and operate it at its optimal design point for the entirety of the mission.”

The hybrid-electric system “has a pretty simple architecture,” he says. The turbine engine, electric motor and gearbox are installed in a redesigned nacelle but drive the original pro-



PELLER. Cabling for the 1-kilovolt electrical distribution system runs through the wing root.

The flight demonstration program will look at the effects of altitude on the high-voltage electrical system, including corona discharge. Although Eremenko says this “will not be a huge problem” at the Dash 8’s cruise altitude, “we will look at altitude effects and try to retire as much risk as we can” because, at the 35,000-40,000-ft. cruise altitude of jets “it will be much more extreme,” he explains.

The battery will use off-the-shelf cells with custom packaging and a custom battery management system to mitigate the risk of thermal runaway. “We are not publishing the chemistry. That is still a trade study,” he says. “We are making a significant effort to be all-certification-level design and testing.”

While UTAP will not certify the conversion, it is being designed to be producible. “We will go through this in a way that the design has all the attributes for certification,” he says. “We want to be meet certification-level safety at the system level and be able to drive the regulatory conversation.”

Building the safety case is one of the long poles in the schedule to fly the demonstrator, which has been set at three years “to drive speed as a cultural attribute and cultivate risk tolerance” within UTC, says Eremenko. “Speed is one of the more effective ways to drive risk tolerance as a behavior,” he adds.

Project 804’s goal is to enable UTC to be able to offer hybridization as a product. “We think it is a viable retrofit offering. We have a lot of work to do to prove it, but see no showstoppers,” says Eremenko. “Hybrid-electric propulsion would breathe new life into existing commuter aircraft and also enable a new generation of regionals.”

*Editor’s note: This article was revised to update the projected value of Collins and Pratt & Whitney in 2020.*