



*AeroTEC flight tested a magniX500 engine on a Cessna Caravan.*

Photo courtesy of magniX

# ELECTRIFYING CARAVANS AND BEAVERS

*Harbour Air's DHC-2 Beaver takes off with a battery powered electric engine.*

Photo courtesy of Harbour Air



**A**n electric engine designed to retrofit the venerable Pratt & Whitney Canada PT-6 on de Havilland Canada DHC-2 Beavers and Cessna Caravans may be operating in commercial service by 2024.

The Seattle-area-based magniX has developed an electric engine that is being tested for use on long certified aircraft being used in commercial service. It has already performed initial flight tests on what is known as an eBeaver and an eCaravan.

The same 750-horsepower magni500 propulsion system is being tested on both airframes. The 560-kilowatt engine only weighs 293 pounds and delivers 2,075 foot-pounds of continuous torque with a base speed of 1,900 rpm and a maximum speed of 2,600 rpm. It is being developed to run on either a lithium-ion battery or a hydrogen fuel cell.

The magniX company started business in Australia in 2009 to develop electric engine technology for multiple uses before deciding to focus on developing electric engines for commercial aviation service. In January, it moved into a new 40,000-square-foot manufacturing facility and headquarters located just north of Boeing's Everett, Washington, plant. This consolidates its two facilities in Australia and Redmond, Washington.

"In the next 40 to 50 years, the internal combustion engine for aircraft will be a collector's item," said Roei Ganzarski, magniX chief executive officer, who worked at Boeing for 13 years and rose to be the chief customer officer for Boeing's Flight Services division.

magniX is starting with smaller aircraft (the Caravan and Beaver) that can be powered by existing types of batteries. magniX doesn't have to worry about battery development because there is an entire industry improving the technology for a variety of applications, including automobiles. Aviation is not the driving force behind battery R&D.

### **magniX targets middle-mile aircraft**

Initially, magniX wants to equip short-haul aircraft based on the state-of-the-art of batteries. "We are focused on aircraft flying the middle mile on flights from 60 to 1,000 miles," Ganzarski said.

magniX has formed partnerships with two seaplane companies: Harbour Air in Vancouver, Canada, flying the Beaver; and Sydney Seaplanes in Sydney, Australia, flying the amphibious Caravan.

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The reason magniX is partnering with seaplane operators is simple – because they make short-haul flights, and their leaders are interested in the proposition of no emissions operations in the pristine areas they fly over.

You might not think of a company providing airline service with Beavers and Otters and Twin Otters in British Columbia and the state of Washington would pioneer the electrification of commercial aircraft, but that is just what Harbour Air is doing.

The airline was founded in 1982 by Greg McDougall using two Beavers to fly loggers to camps in British Columbia. Today, the airline operates 14 Beavers, 22 single-engine Otters, three twin Otters and one Caravan. It is the largest seaplane operator in North America. The plan is to electrify the whole fleet starting with the Beavers. Harbour Air flies about 450,000 passengers per year. As with all other commercial aviation operators, its traffic flow has declined during the COVID-19 pandemic, but McDougall is not giving up on the electrification project.

McDougall is a hands-on manager with 10,000 flying hours in his logbook. He likes disruptive technology and attends a local discussion group on the topic. As far as he knows, he was

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the first person in Vancouver to drive a Tesla. He loves the fact that the car has so few moving parts it never needs service. And it is second nature now to plug the car in to be recharged every time he pulls in the driveway at his residence.

Somehow magniX heard about the forward-thinking owner of the seaplane operation nearby when it had an office in Redmond, Washington. McDougall was willing to form a partnership funded in part by the engine company and by government grants. Harbour Air contributed its maintenance overhaul and repair expertise on the Beaver to modify it with the magni500 engine and a lithium-ion battery. The retrofit was

led by Shawn Braiden, vice president of maintenance, and Erika Holz, the engineering and quality manager. The test pilot is Eric Scott, vice president of flight operations and safety at Harbour Air.

### Aiming for an eBeaver STC

McDougall took the Beaver up on its first all-electric test flight on Dec. 10, 2019. The battery used in this test was a heavy one qualified to fly in outer space, and it put the aircraft at maximum gross weight with McDougall aboard. Even so, he said the instantaneous acceleration of the electric engine allowed the aircraft to “leap into the air and climb like crazy.”

The first seven hours of flight testing documented the takeoff thrust efficiency and cruise performance of the aircraft while also checking out

electromagnetic interference and battery management software. Flight tests are about to resume after battery and motor modifications.

Harbour Air is working with Transport Canada and with the Federal Aviation Administration with a goal of obtaining a supplemental type certificate in about two years. Because the Beaver is a well-established, certified airframe, the only thing Harbour Air has to concern itself with is the electric propulsion system and the battery. A key certification issue is what happens when an 800-volt battery gets wet, and Harbour Air will have to demonstrate to regulators that this issue has been dealt with along with battery crash worthiness.

The current-generation lithium-ion battery to be used now in flight test will allow the Beaver to fly 20 minutes with a payload, and by the time the STC is complete, McDougall expects the plane to be able to fly 48 minutes with an improved battery. The longest trip Harbour Air flies is an hour or less in scheduled airline service. It also flies short sightseeing tours above the Canadian wilderness and charter flights.

### Boosting range and payload as batteries improve

“Battery technology is improving rapidly,” Ganzarski said. “There is a huge investment and push forward in batteries.” A battery that produced 145 watt-hours per kilogram in 2019 has been improved to deliver twice that output today. This will allow the Beaver to “deliver more payload and range without changing anything in the future,” Ganzarski added. “That doesn’t exist anywhere else in aviation.”

The busiest route the airline flies is from the Vancouver harbor to the one in Victoria.

McDougall describes this as urban air mobility because a passenger steps aboard from one downtown and steps off in the other downtown – without ever having to deal with the hassle of

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walking through a crowded airport and its security checkpoints. The Harbour Air route from downtown Vancouver to downtown Seattle is considered by some to be the easiest way to clear customs in the United States. When a Beaver passenger steps onto the dock, he enters a line with the other seven passengers from his plane to see a U.S. customs inspector.

McDougall notes several advantages in operating a Beaver powered by an electric motor rather than a turboprop. The Pratt & Whitney Canada PT-6 operates at 850 degrees Celsius, a level of heat that causes wear and tear and requires maintenance. The electric engine designed to replace it operates at a small fraction of that temperature. With no gearbox and few moving parts in the electric power system, including the engine and an inverter, there is much less need for maintenance. In addition, the battery-powered motor produces no emissions, and the only noise passengers hear in the cabin is from the prop, according to McDougall.

McDougall is constantly getting calls about the electric engine project, and the first question everyone asks is, when will it be certified? "That's the \$24 million question," he said. "When we are finished, we will be happy to provide guidance and support for other industry efforts toward the electrification of aircraft."

### **eCaravan has Asia Pacific potential**

The magniX company has several other important projects on the books including testing and certifying the same magni500 engine on the Cessna Caravan. The company conducted the first flight of a Caravan 208 B at Moses Lake, Washington, in May 2020 working with AeroTEC, a full-service aerospace testing, engineering and certification company. Moses Lake is an airport used by Boeing for flight testing large commercial jets. Lee Human, president and CEO of AeroTEC, said at the time

of this flight test "there is no roadmap for testing and certifying electric aircraft, so this is a new frontier."

In December 2020, magniX formed a partnership with Sydney Seaplanes of Australia to pursue an STC for an amphibious Caravan (that can land on water or on a runway) with the Australian Civil Aviation Safety Authority. Flight testing may begin this fall.

Sydney Seaplanes not only conducts scheduled, charter and sightseeing operations with amphibious Caravans based in Sydney Harbor, but it also works in Asia consulting with customers in Vietnam, Indonesia, Malaysia and China as they set up seaplane operations.

The idea of obtaining an STC for an eCaravan with a magniX engine is to not only equip Sydney Seaplanes' small fleet but to offer the STC to customers in Australia, New Zealand,

the Pacific Islands and to customers it has consulted with in the past. Once the STC is secured, the seaplane company will be able to help other companies electrify their airplanes. Aaron Shaw, Sydney Seaplanes managing director, said retrofitting a Caravan with an electric engine will cost about 1 million Australian dollars (\$760,000 U.S.).

Sydney Seaplanes has operated scheduled service in the past on VFR days between Sydney and other airports, but it would like to operate IFR in the future. The idea would be to have aircraft fly a GPS approach descending to about 600 feet over the harbor entrance and then have the pilot land visually from there. Flying with pristine electric power would also allow emissions-free service from downtown Sydney taking off from the harbor to

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the nation's capital, Canberra, 200 miles away where a water landing puts the passenger right downtown.

Sydney Seaplanes is working with Dante Aeronautical of Spain on the eCaravan project. "We are having ongoing discussions with CASA because there are no regulations in Australia currently to certify this type of aircraft," said David Doral, Dante co-founder and CEO. The plan is to ground test the power train now to make sure it is ready for flight tests this fall. The flight tests may continue through 2023, and Doral said at that point CASA may create a new regulation to govern the certification.

### Battery recharging and the lure of hydrogen

If Caravan amphibians are powering electric engines with batteries, that provides a potential advantage in the Pacific Islands. If a stopping point is a runway in a remote area, it would be possible to set up a windmill or solar panels to recharge a stack of batteries, which could be swapped out with one on an eCaravan when it lands there. This would remove the need to truck in fuel, which is usually difficult and expensive in remote areas.

The same thing could be of benefit in Antarctica where Caravans already operate, according to Shaw. Hauling fuel to a remote ice-covered landing strip is also an expensive proposition. Shaw notes that the wind blows all the time on the frozen continent, so using wind to recharge batteries would be easy. Sydney Seaplanes already has solar panels on the roof of its facility in Sydney Harbor, and it could add more by covering the roof of its hangar to recharge batteries for eCaravans.

Shaw is also interested in the possibility of having the eCaravan powered by a hydrogen fuel cell rather than a battery as this aircraft could fly at longer ranges. He hasn't selected a partner for hydrogen power yet but is talking with ZeroAvia, a London- and California-based company.

ZeroAvia completed 10 flight tests in June 2020, with a hydrogen-fuel-cell-powered Piper M class six-seat turboprop aircraft at Cranfield airport in the United Kingdom. The aircraft's 260-kilowatt hydrogen-electric power train replaced its 350-horsepower Lycoming 540-AE2A engine. ZeroAvia is aiming for certification in 2023 and is targeting 500-mile range, 10-to-20-seat aircraft used for commercial passenger, cargo and agricultural applications.

In other projects unrelated to its Australian venture, magniX has teamed up with Universal Hydrogen, a startup company that plans to have Bombardier Dash 8 and ATR-42/72 turboprops retrofitted and flying with magniX electric engines using hydrogen in carbon-free airline service by 2025.

The technology needed to provide hydrogen to create electricity on the aircraft is mature and requires "no science research or new invention," said Paul Eremenko, CEO and co-founder of Universal Hydrogen. "We are not inventing new stuff – we're just integrating it in a really unique way." Eremenko is the former chief technology officer of United Technologies before it merged with Raytheon, and he brought several other highly experienced aerospace executives with him to start the hydrogen venture.

Eremenko said hydrogen can be created at wind farms during off-peak hours when the electricity involved would otherwise be wasted. Then Universal Hydrogen will use a container based on its proprietary design to ship hydrogen as a liquid or a gas to airports where it can be used to power the magniX engines while producing zero emissions. "It is the ideal propellant for aviation," he said. "Or expressed another way, aviation is the killer app for hydrogen. It is the most energetic propellant outside of nuclear fuels."

### A new plane called Alice

The electric engine company is not only working on retrofitting already certified aircraft like the Beaver, Caravan, Dash 8 and ATR 42/72. About 20 miles away from magniX's new facility is Eviation Aircraft, which has selected the smaller magni250 electric engine, a 375-shaft-horsepower propulsion system, for its all-new nine-passenger Alice commuter aircraft. Alice is an all-composite, fly-by-wire aircraft with three electric engines with pusher props – one in the tail and one on each wingtip. The production aircraft will be powered by a 950-kilowatt-hour lithium-ion battery weighing about 8,000 pounds. A 100-watt light bulb consumes 1 kilowatt-hour in 10 hours.

In a setback, an early prototype aircraft was damaged by a battery compartment electrical fire following ground testing in Prescott, Arizona, in January 2020. No one was injured. The company was founded in 2015 by two Israelis, and it had a prototype Alice aircraft on static display at the Paris Air Show in 2019. A redesigned prototype is expected to begin flight testing this year, and the company aims to have the aircraft certified by 2023.

Alice is being designed to carry nine passengers and a crew of two at a cruise speed of 240 knots at a range of more than 500 nautical miles plus a 45-minute IFR reserve. It has a targeted maximum takeoff weight of 14,000 pounds, and Eviation aims to deliver a \$200 per hour direct operating cost.

Honeywell Aerospace unveiled a lightweight, low-maintenance "micro vapor cycle" thermal management system in June 2020 for urban air vehicles and named the Alice as the launch platform. It generates cold air or liquid to cool cabins, electronics components and batteries. It is oil free with fewer moving parts and is practically a maintenance-free system. □





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