Carleton University Blended Wing Body Gas Turbine Engine (CUB-GT)
Mechanical & Aerospace Engineering 4th Year Project 2025/26

BWB Aircraft

Blended **w**ing **b**ody (**BWB**) aircraft have distinct wing and body structures, but they are blended together with no clear dividing line between them. They have been, and are being, studied by numerous aerospace companies, including Airbus (as a replacement for the A320neo) and Bombardier (as a next-generation business jet), and JetZero (as a commercial mid-market model with jetliner, freighter, and military tanker applications). The fuselage of a BWB aircraft can generate a significant portion of the total lift, allowing for the use of smaller and lighter wings. This configuration allows for much improved aerodynamics, mainly resulting from reduced drag on the aircraft. Along with powerplant efficiency and other improvements, there is the potential to reduce fuel burn, and thus carbon emissions, by 50% over current aircraft.

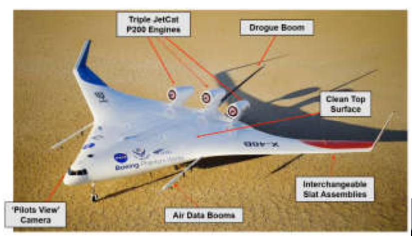
Airbus BWB Maveric prototype [Wired, February 2020]

JetZero Z4 Midmarket Model Concept [AWIN, December 2024]

Bombardier BWB EcoJet [Business Jet Traveller, August 2022]

BWB Flight Test Vehicles

Flight **t**est **v**ehicles (**FTV**) are used when one can't get data from ground-based analysis or testing. As FTVs are subscale aircraft, there are various issues to be overcome, but a best compromise is usually the goal. For example, the Boeing X-48B demonstrator was at an 8.5% scale. The Bombardier EcoJet Phase 1 FTV was at a 7% scale (8-foot wingspan) and the Phase 2 FTV is at a 20% scale (18-foot wingspan). Various technical challenges and testing are addressed, including understanding flight control complexity and developing flight control laws for these novel configurations. For the EcoJet program, initial shaping and aerodynamics were studied in Phase 1, while developing flight control laws and gathering more data by flying longer, faster, and higher are the main goals of Phase 2. A future Phase 3 might focus on a yet larger-scale FTV, with a greater focus on systems, structures, and internal configurations.

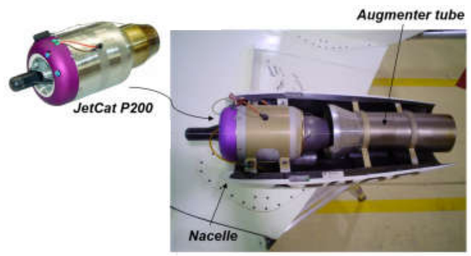


Boeing X-48B BWB demonstrator
[Cosentino, SAE AeroTech Congress and Exhibition, 2009]

Bombardier Phase 1 and Phase 2 BWB flight test vehicles
[Aerospace Testing International, January 2024]

FTV Propulsion

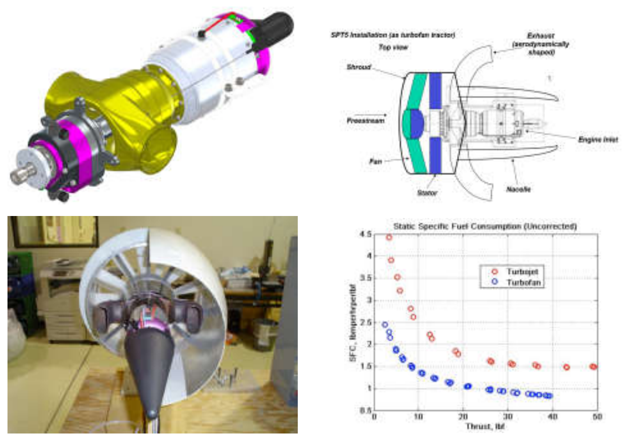
Engine choice for FTVs are quite limited and are typically very small turbojet gas turbine engines with a thrust in the range of 50-500 lbs (approximately 200-2000 N). These simple engines, with a one-stage centrifugal compressor and a one-stage axial turbine, are inefficient with relatively high fuel consumption and are very noisy. This results in limited flight endurance and thus requires many test flights to collect the necessary data. So, for more efficient testing of current and future FTVs, it would be useful to develop better very small gas turbine engines and propulsion systems. These more efficient engines would also be of interest for other flying applications like model aircraft, unmanned aerial vehicles, and remotely-piloted vehicles.



JetCat P200 turbojet engine used on the Boeing X-48B BWB demonstrator and its location in the nacelle [Cosentino, SAE AeroTech Congress and Exhibition, 2009]

Improved Efficiency FTV Propulsion

During the Boeing X-48 BWB demonstrator project, researchers at NASA and Boeing worked on developing a more fuel-efficient very small gas turbine. Turbofan engines, where part of the flow bypasses the core of the engine (compressor, combustor, turbine, and propelling nozzle) were originally developed to increase the propulsive efficiency and reduce the emitted noise of gas turbine engines. So, NASA and Boeing examined the possibility of modifying an available turboshaft engine, the JetCat SPT5. Instead of being used to turn a propeller, the engine was modified to turn a fan. The fuel consumption was much improved over the previously-used P200 JetCat turbojet engine. Unfortunately, for this modified turbofan design, the fuel consumption was higher, and the thrust lower, than the original turboshaft design turning a propeller. However, the feasibility of developing a very small turbofan engine was successfully demonstrated.



CW from top left: JetCat SPT5 turboshaft engine [JetCat]; re-design of SPT5 as a turbofan; nearly fully assembled SPT5 turbofan; improved fuel consumption of SPT5 turbofan vs. P200 turbojet – a 44% reduction at maximum thrust condition
[Cosentino, SAE AeroTech Congress and Exhibition, 2009]

CUB-GT for 2025/26 – Design of a More Efficient Gas Turbine

For the current academic year, and beyond, the **C**arleton **U**niversity **B**lended Wing Body **G**as **T**urbine Engine (**CUB-GT**) fourth year project team is designing an efficient, very small gas turbine engine. The target will be to develop an engine more efficient than a JetCat P500, which is used to power the Bombardier BWB FTV. A list of accomplishments from the current year, and a plan for the next two is provided below. In general, this project will appeal to students interested in gas turbine engines and propulsion technology, with specific interests in:

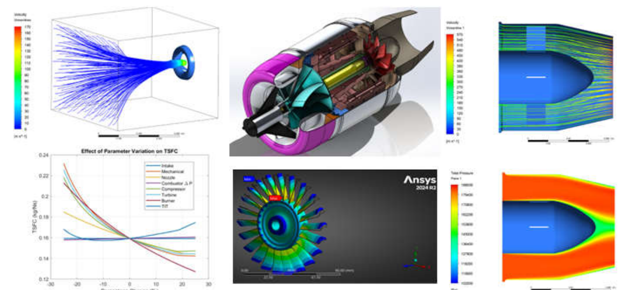
- Thermodynamic cycle calculations
- Turbomachinery aerodynamics
- Mechanical design and structural analysis
- Engine testing and performance

The team is led by:

Professor Henry Saari, Project Manager and Lead Engineer (henry.saari@carleton.ca)
Professor Hamza abo el Ella, Lead Engineer (hamza.ella@carleton.ca)

Year 1 (2024/25) - Accomplishments

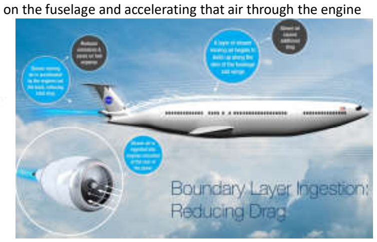
- Studied and reverse engineered JetCat P500
  - Thermodynamics
  - Aerodynamics
  - Mechanical design
- Developed tools and methods to analyze and design gas turbines
- Determined that a turbofan is the best route for an improved engine



Year 2 (2025/26)

- As done in the NASA/Boeing project, a turboprop engine (KingTech K-100TPG4+) will be modified into a turbofan
- Work for the year will include
  - Install engine in test cell and perform baseline testing
  - Design fan stage (thermodynamic, aerodynamic, mechanical design)
  - Plan for fan stage manufacturing and testing of modified engine in Year 3
- Study potential of **b**oundary **l**ayer **i**ngestion (**BLI**) to further reduce fuel consumption
  - BLI can reduce total drag on an aircraft by the engines ingesting part of the boundary layer on the fuselage and accelerating that air through the engine

Turboprop engine [KingTech]



BLI mechanism and advantages [NASA]

Year 3 (2026/27)

- Install fan stage on engine Design and develop demonstration article
- Testing of turbofan version for validation of fan design and performance improvement
- Further study of BLI installation effects