Project 002 Understanding Changes in Aviation Emissions Due to SAF with New Combustor Technology

Missouri University of Science and Technology, Aerodyne Research Inc., and The Boeing Company, and Gulfstream

Project Lead Investigator

Philip D. Whitefield
Professor Emeritus of Chemistry
Department of Chemistry
Missouri University of Science and Technology
400 W 11th Street, Rolla, MO 65409
573-465-7876
pwhite@mst.edu

University Participants

Missouri University of Science and Technology (MS&T)

- P.I.: Prof. Philip D. Whitefield
- FAA Award Number: 13-C-AJFE-MST, Amendments 002, 003, 005, 008, 010, 012, 019, 030 and 033
- Period of Performance: September 18, 2014, to December 31, 2026
- Tasks:
  1- 3. Perform the ground testing associated with an in-flight emissions study on a wide-body airframe and a business jet
    3.1. Plan the test matrices for up to a 3-week deployment to a ground testing venue to be provided by the sponsoring original equipment manufacturer (OEM)
    3.2. Prepare the MS&T and Aerodyne® instrument packages housed in mobile laboratories, including calibration of the individual particulate matter (PM) mass number and compositional systems
    3.3. Transport and set up the MS&T and Aerodyne instrument packages
    3.4. Execute the test matrices defined in Task 1 – 3.1
    3.5. Tear-down and transport the mobile laboratories and test personnel to their home locations
    3.6. Conduct post-test data reduction and analysis including participation in post-test
    3.7. Prepare and deliver interim and final reports
    3.8. Coordinate the procurement, fuel properties analysis, delivery, handling, and loading logistics for various fuels in support of emissions testing

Project Funding Level

Project	Funding	Matching	Source
13-C-AJFE-MST-002	$1,288,836.34	$1,288,836.34	EMPA letter
--	$284,613.66	$284,613.66	Transport Canada
13-C-AJFE-MST-003	$500,000.00	$500,000.00	EMPA letter
13-C-AJFE-MST 005	$500,000.00	$500,000.00	EMPA letter
13-C-AJFE-MST-008	$579,234.00	$579,234.00	EMPA letter
13-C-AJFE-MST-010	$725,500.00	$725,500.00	EMPA letter
13-C-AJFE-MST-012	$1,217,221.00	$1,217,221.00	EMPA letter

® Aerodyne is a registered trademark of Aerodyne Research, Inc., Billerica, Massachusetts.

Project	Funding	Matching	Source
13-C-AJFE-MST-019	$521,246.00	$521,246.00	GE letter
13-C-AJFE-MST-030	$3,050,812.00	$3,050,812.00	Boeing letter
13-C-AJFE-MST-033	$2,513,003.00	$2,513,003.00	Boeing letter

EMPA = Swiss Federal Laboratories for Materials Science and Technology
GE = General Electric

Investigation Team

Missouri University of Science and Technology Prof. Philip Whitefield, (P.I.)
Prof. Klaus Woelk, (co-P.I.)
Steven Achterberg, (research technician)

Aerodyne Research, Inc.
Dr. Richard Miake-Lye, (subcontractor)

The Boeing Company (Boeing)
Dr. Steven Baughum, (subcontractor)
Dr. William Griffin, (subcontractor)

Gulfstream Aerospace Corporation
Dr. Brian Cook, (subcontractor)

Project Overview

Objectives

In the last quarter of 2022, a decision was made to re-target the ASCENT Project 002 to focus on emissions impacts measurements resulting from the adoption of sustainable aviation fuels (SAF) by current and future anticipated global commercial fleets. Funds were de-obligated and re-obligated to underwrite the cost of these new emissions measurements. The ASCENT Project 002 MS&T team, with the guidance of emissions specialists at Boeing,® Pratt and Whitney® (P&W), and Gulfstream,® proposed to make three high-priority ground-based field measurement campaigns of nonvolatile particulate matter (nvPM) and combustion gas emissions from engines on a commercial widebody transport, a business jet aircraft, and a new technology combustor burning both conventional fuels and candidate SAF. These measurements were scheduled to occur in three 21-day test campaigns in the fourth quarter (Q4) of 2023 (Boeing/ecoDemonstrator; see Link 1 below), and in 2024 Q4 (Gulfstream; see Link 2 below). The third field campaign with a novel combustor technology at P&W after being delayed due to test cell access was eventually cancelled and was replaced by a follow-up ground-based and airborne campaign with Gulfstream, scheduled to take place in April 2026. The analysis and reporting of the data arising from the Boeing and first (ground-based) Gulfstream studies are underway. Each campaign has or will be preceded by test design, planning, and preparation, beginning in the second quarter of 2023. The cost to ASCENT Project 002 has been, and will be, to (a) support the MS&T team's participation in and management of the three ground-based emission studies and (b) defray some of the costs incurred for the fuels (i.e., SAFs and conventional jet fuels) that has or will be burned to conduct both ground-based and in-flight emissions testing. During this reporting period, the ecoDemonstrator and the first ground-based Gulfstream subprojects are in the post-test analysis stage. Planning and preparation for the follow-up ground-based and airborne with Gulfstream are underway.

Link 1 – https://aviationweek.com/special-topics/sustainable-aviation-fuel/boeing-737-10-ecodemonstrator-tackles-saf-contrail-study
Link 2 - https://www.gulfstreamnews.com/en/news/?id=c106d3c5-ffa0-4cf1-adc7-292e3a56dfea&utm

® Boeing is a registered trademark of The Boeing Company, Seattle, Washington.
® Pratt & Whitney is a registered trademark of RTX Corporation, Farmington, Connecticut.
® Gulfstream is a registered trademark of Gulfstream Aerospace Corporation, Savannah, Georgia

Work Schedule

- Task 1– 3 describes the work required to successfully perform the ground testing associated with an in-flight emissions study on a wide-body airframe (potentially the Boeing-sponsored ecoDemonstrator study), a business jet (the Gulfstream studies)
- Task 1 – 3.1: Plan the test matrices for up to a 3-week deployment to a ground testing venue to be provided by the sponsoring OEM (Boeing, Seattle, WA; Gulfstream, Savannah, GA). This planning exercise has been undertaken in coordination with the National Aeronautics and Space Administration Mobile Aerosol Laboratory team who are participating in the Boeing and Gulfstream ground tests.
- Task 1 – 3.2: Prepare the MS&T and Aerodyne instrument packages housed in mobile laboratories, including calibration of the individual PM mass number and compositional systems.
- Task 1 – 3.3: Transport and set up the MS&T and Aerodyne instrument packages (mobile laboratories). This task includes deployment of test personnel to the test site and the interconnection of the instrument packages to the communal sampling probe assembly. During this setup activity, sampling system loss analyses will be performed.
- Task 1 – 3.4: Execute the test matrices defined in Task 1 – 3.1
- Task 1 – 3.5: Tear down and transport the mobile laboratories and test personnel to their home locations.
- Task 1 – 3.6: Conduct post-test data reduction and analysis including participation in post-test workshops whose locations and times are yet to be defined.
- Task 1 – 3.7: Prepare and deliver interim and final reports.
- Task 1 – 3.8: The OEMs, with the assistance of the Federal Aviation Administration (FAA), through this effort, have or will coordinate the procurement, fuel properties analysis, delivery, handling, and loading logistics for various fuels in support of the 2023–2025 emissions testing.

  In the case of the ecoDemonstrator subproject, the fuels burned are as follows:
  - Fuel 1: Low-sulfur Jet A, per ASTM D1655 (ASTM, 2023), total percentage by mass maximum objective of 0.0001 (maximum total sulfur target of 1 ppm)
  - Fuel 2: 100% hydroprocessed esters and fatty acids (HEFA)-straight paraffinic jet fuel (SPK), per ASTM D7566 (ASTM, 2022), Tables 1, A2.1, and A2.2
  - Fuel 3: Approved SAF blend (e.g., 30% HEFA-SPK), per ASTM D7566, Table 1

  In the case of the first Gulfstream subproject, the fuels burned are as follows:
  - Fuel 1: 100% HEFA- SPK
  - Fuel 2: 30%/70% HEFA-SPK/Jet A Blend
  - Fuel 3: 100% Conventional Jet A

Milestones

- Task 1 – 3.1: COMPLETED for Boeing, first and second Gulfstream
- Task 1 – 3.2: COMPLETED for Boeing, first and second Gulfstream
- Task 1 – 3.3: COMPLETED for Boeing and first Gulfstream
- Task 1 – 3.4: COMPLETED for Boeing and first Gulfstream
- Task 1 – 3.5: COMPLETED for Boeing and first Gulfstream

Major Accomplishments

- Reconfigured ASCENT Project 002 objectives, with new configuration in action.
- Successfully completed planning and preparation phase for SAF studies with Boeing and Gulfstream,
- Successfully completed ground tests with Boeing and first Gulfstream, with data deposited in appropriate archives.

Publications

Whitefield, P. (2025, October). *Understanding Changes in Aviation Emissions due to SAF with New Combustor Engine Technology* [Oral presentation]. ASCENT Advisory Board Meeting, Alexandria, Virginia.

Achterberg, A, Whitefield, P., & Woelk, K. (2025, October 8). *Gulfstream Ground Test Campaign October 2024* [Oral Presentation]. ICAO CAEP WG3 Meeting.

Outreach Efforts

Currently in negotiation with Aerodyne, Carnegie Mellon University, Gulfstream, P&W, Airbus America,® and Embraer® for future follow-on or new SAF focused studies

Awards

None.

Student Involvement

One graduate student (Lauren Kehoe) was employed in this project and four undergraduate research assistants (Justin Patek, Joshua Carpenter, Zane and Zachary Achterberg) were employed in pre- and post-test activities, including individual component testing and calibration, and data reduction.

Plans for Next Period

- Complete Task 1 – 3.4: For Second Gulfstream Study.
- Complete Task 1 – 3.5: For Second Gulfstream Study.
- Complete Task 1 – 3.6: For Boeing, and both Gulfstream studies.
- Complete Task 1 – 3.7: For Boeing, and both Gulfstream studies.
- Complete Task 1 – 3.8: For Second Gulfstream Study.
- Negotiate, plan, and prepare with Gulfstream, P&W, Airbus America, and Honeywell® for future follow-on or new SAF-focused studies.
- Communicate results and conclusions from the three field campaigns with publications and presentations.

References

ASTM International. (2022). *ASTM D7566-22: Standard Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons*. https://doi.org/10.1520/D7566-22

ASTM International. (2023). *ASTM D1655-22a: Standard Specification for Aviation Turbine Fuels*. https://doi.org/10.1520/D1655-22A

® Airbus is a registered trademark of Airbus Operations GmbH, Hamburg, Germany.
® Embraer is a registered trademark of Embraer S.A., San Jose Dos Campos, Brazil.
® Honeywell is a registered trademark of Honeywell International, Inc., Charlotte, New Jersey.