Research for the Future of Alternative Jet Fuels

What the ASCENT Center of Excellence for Alternative Jet Fuels and Environment is Delivering

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FAA CENTER OF EXCELLENCE FOR ALTERNATIVE JET FUELS & ENVIRONMENT

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ASCENT - FAA Center of Excellence for Alternative Jet Fuels and Environment

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Research Focus Areas

Alternative Jet Fuels

3.1.1. Feedstock Development, Processing and Conversion

3.1.2. Regional Supply and Refining Infrastructure

3.1.3. Environmental Benefits Analysis

3.1.4. Aircraft Component Deterioration and Wear

3.1.5. Fuel Performance Testing

Environmental

3.1.6. Aircraft Noise and Impacts

3.1.7. Aviation Emissions and Impacts

3.1.8. Aircraft Technology Assessment

3.1.9. Energy Efficient Gate-to-Gate Aircraft Operations

3.1.10. Aviation Modeling and Analysis

ASCENT Team

Lead Universities:

- Washington State University (WSU)*
- Massachusetts Institute of Technology (MIT)

Core Universities:

- Boston University (BU)
- Georgia Institute of Technology (Ga Tech)
- Missouri University of Science and Technology (MS&T)
- Oregon State University (OSU)*
- Pennsylvania State University (PSU)*
- Purdue University (PU)*
- Stanford University (SU)
- University of Dayton (UD)
- University of Hawaii (UH)*
- University of Illinois at Urbana-Champaign (UIUC)*
- University of North Carolina at Chapel Hill (UNC)
- University of Pennsylvania (UPenn)
- University of Tennessee (UT)*
- University of Washington (UW)*

Advisory Committee - 58 organizations:

- 5 airports
- 4 airlines
- 7 NGO/advocacy
- 9 aviation manufacturers
- 11 feedstock/fuel manufacturers
- 22 R&D, service to aviation sector

* Denotes USDA NIFA AFRI-CAP Leads and Participants & Sun Grant Schools

Alternative Jet Fuels Research Strategy

- While alternative fuels exist, commercial deployment is in its infancy.
- Factors such as cost and uncertain regulations have hindered large-scale adoption of new jet fuels.
- Developing a more sustainable aviation industry requires streamlining the production and facilitating certification and adoption of alternative fuels.
- To address these challenges, ASCENT researchers are working to improve the feasibility of alternative jet fuels through:
  - Production and distribution supply chain analyses, including their life cycles
  - Increasing our understanding how alternative fuels will affect emissions, air quality, and performance, and
  - Creating more concrete procedures for efficient alternative fuel certification.

ASCENT Projects Supporting Alternative Jet Fuels

Research Topic Area	ASCENT Project Numbers
AJF Supply Chain Analysis	1
Improving Climate Policy Analysis Tools	21
Worldwide LCA of GHG Emissions from Petroleum Jet Fuels	32
Emissions Data Analysis for CLEEN, ACCESS, and Other Recent Tests	24
Alternative Jet Fuels Properties & the National Jet Fuels Combustion Program	25, 26, 27, 28, 29, 30, 31, 33, 34

For project descriptions and other information see - http://ascent.aero

ASCENT Project 01
Alternative Jet Fuel Supply Chain Analysis

- Research team is:
  - Evaluating regional supply chains including feedstock production, transportation, and fuel conversion
  - Evaluating fuel production pathways, feedstock and infrastructure requirements, and commercial fuel demand to create scenarios for future production
  - Identifying potential intermediate materials and co-products for each pathway to understand potential ways to aid in making bio-refineries more economical.

ASCENT Project 01
Alternative Jet Fuel Supply Chain Analysis

- Project aims to identify key barriers throughout the alternative jet fuel supply chain that must be overcome to produce and effectively market 1 billion gallons of alternative jet fuel in the near term and 10 billion gallons in the longer term while considering technological, environmental, economic, and social elements.

- Project supports the Alternative Fuel Task Force (AFTF) within the International Civil Aviation Organization (ICAO) Committee on Aviation Environmental Protection (CAEP) in efforts to evaluate the potential of alternative jet fuels to help meet aviation environmental goals and to assess the life cycle CO_2 emissions from the use of these fuels.

ASCENT Project 1
Alternative Jet Fuel Supply Chain Analysis

Project Coordinator: Michael Wolcott, Washington State University

Participants

- Argonne National Laboratory
- Pacific Northwest National Laboratory
- Massachusetts Institute of Technology
- Pennsylvania State University
- Purdue University
- University of Hasselt
- University of Hawaii
- University of Illinois
- University of Tennessee
- Volpe Transportation Center
- Washington State University

ASCENT Project 21
Improving Climate Policy Analysis Tools

- Project focuses on continued development of tools to assess how different aviation policy scenarios at the global, zonal, and regional scales could affect the climate.
- FAA will use the tools to inform its strategic vision on sustainable aviation growth.
- Researchers continue developing a rapid model that uses the latest literature and scientific understanding for fast results. They also will work toward creating and validating a more complex model that can examine effects at finer scale.

Lead Investigator: Steven Barrett

Participant: Massachusetts Institute of Technology

ASCENT Project 24
Emissions Data Analysis for CLEEN, ACCESS, and Other Recent Tests

- Project gathers and analyzes data about aircraft engine non-volatile particulate matter (nvPM) emissions in order to better understand the air quality and climate effects of alternative jet fuels.
- Researchers use data from emission measurement tests such as CLEEN and ACCESS to develop improved models showing the relationships among fuel composition, engine power levels, and nvPM emissions.
- Project will guide more accurate measurements and estimates of nvPM from alternative fuels for jet aircraft.

Lead Investigators: Randy Vander Wal and Steven R.H. Barrett

Participants:

General Electric Aviation

Massachusetts Institute of Technology

Pennsylvania State University

ASCENT Project 31
Alternative Jet Fuels Test and Evaluation

- Project 31A provides the capability to evaluate the suitability of candidate alternative fuels via performance of engine, component, rig, or laboratory tests.
- Candidate alternative fuels must meet the ASTM International requirements, which involve evaluation of specification and fit-for-purpose fuel properties. Evaluations may include chemical analysis; thermal stability; low-temperature performance; seal swell compatibility; metal/non-metallic materials compatibility; combustion and emissions performance.
- Evaluations will be coordinated with DoD and other government agencies as well as with engine and aircraft manufacturers.
- Data will be shared with the FAA and the broader alternative fuel qualification community, including ASTM International.

Project Coordinator: Steven Zabarnick

Participant: University of Dayton

ASCENT Project 31
Alternative Jet Fuels Test and Evaluation

- Project 31B focuses on testing alternative jet fuels for properties and combustion performance; specifically, what is the effect of minor amounts of residual oxygen that might remain in the alternative jet fuel after processing.
- Researchers address two questions.
  - What kind of oxygenated functional groups are left after partial hydrogenation?
  - How do these oxygenates influence fuel properties and combustion performance that are important to the ASTM specifications, such as water content, acidity, viscosity, flash point, cloud point, flame lean blow-out point, NOx emissions from combustion, and soot emissions from combustion?

Participants: University of Washington and Washington State University
Lead Investigators: Manuel Garcia-Perez and John Kramlich

ASCENT Project 32
Worldwide LCA of GHG Emissions from Petroleum Jet Fuel

- This project calculates greenhouse gas emission estimates for petroleum jet fuels for the recent past and future scenarios.
- Researchers break out results by world regions, quantifying the potential effect of changes in future demand and crude oil properties, and estimate opportunities for reductions in greenhouse gas emissions along the petroleum supply chain.
- The results from this work will be used as a petroleum baseline for future alternative jet fuel analyses both within the U.S. Government and in support of U.S. efforts at the International Civil Aviation Organization's Committee on Aviation Environmental Protection (CAEP).

Lead Investigator: Steven R.H. Barrett
Participant: Massachusetts Institute of Technology

ASCENT Project 33
Alternative Fuels Test Database Library

- Project establishes database of information about current and newly emerging alternative jet fuels, with the goal of eventually acting as the comprehensive and centralized knowledge-base for use in fuels research and policy development.
- With oversight from the FAA, researchers integrate and analyze existing data from various government agencies and research groups.
- The database will be useful for screening and comparing emerging fuels to conventional petroleum fuels and already certified alternative.
- Data gathered will be beneficial to the effort of approving novel fuels and will inform the design and optimization of new systems including next-generation engines, fuel delivery systems, and pollution mitigation technologies.

Participants: University of Dayton and University of Illinois
Project Coordinator: Tonghun Lee
Lead Investigators: Steven Zabarnick

ASCENT Projects 25-30 & 34 National Jet Fuels Combustion Program

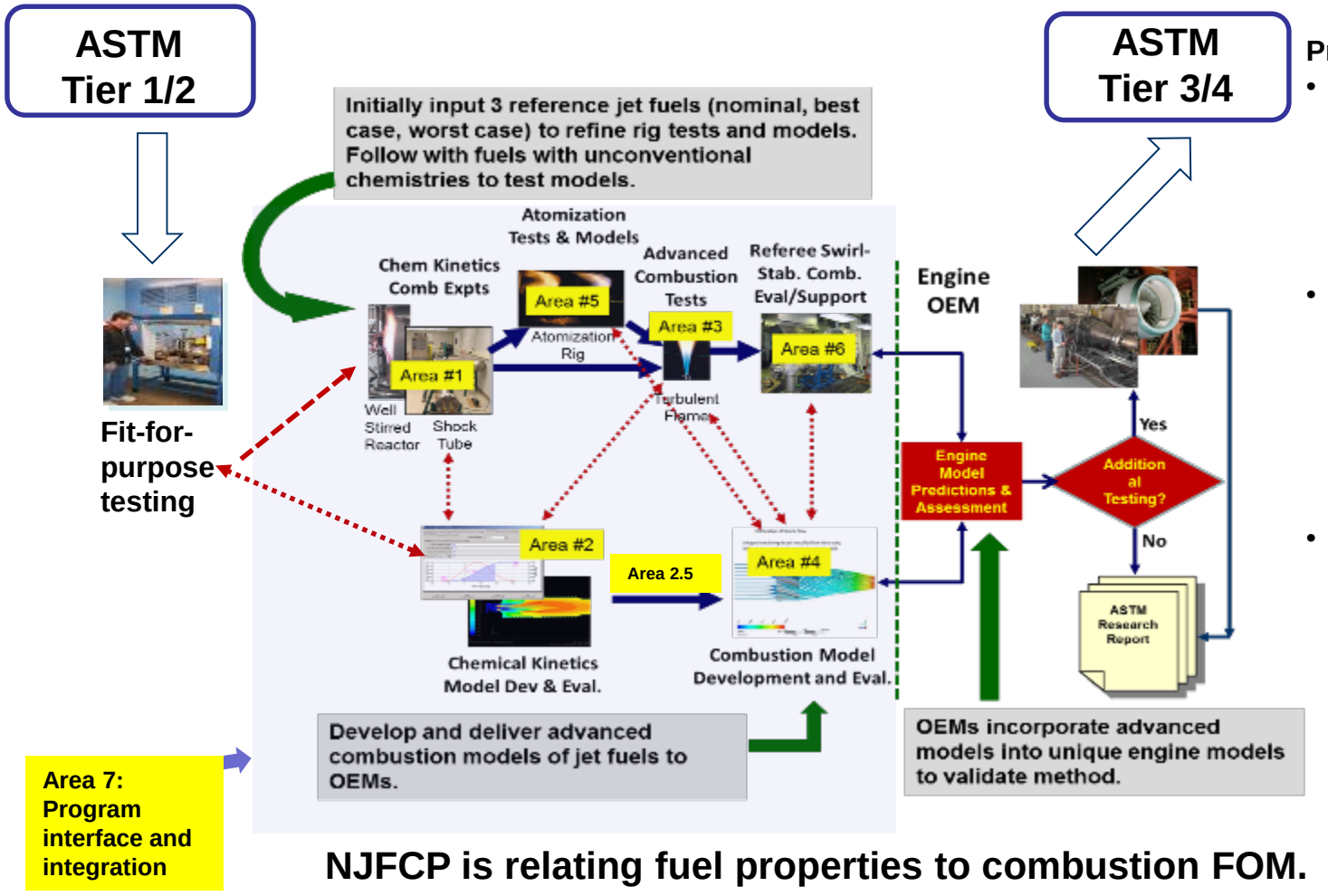
Vision: Develop an experimental and analytical capability to facilitate OEM's evaluation of physical and chemical properties of fuels on engine operability and to streamline ASTM fuels approval process.

Funded by the FAA through ASCENT with additional funding from NASA and the Air Force Research Lab and participation by a large number of national and international government, industrial, and university research labs

Program Leader: Mohan Gupta

Overview of NJFCP Program

Vision: Develop an experimental and analytical capability to facilitate OEM's evaluation of fuel physical and chemical properties on engine operability and to streamline ASTM fuels approval process.



NJFCP is relating fuel properties to combustion FOM.

Program uniqueness:

- Integrated systemwide approach involving all stages of testing and modeling areas for identical conditions
- Real-time communication and share of info among all 6 areas (experimentalists and modelers) and OEMs
- Brings state of the art knowledge, computer capabilities, and engineering experience together

ASCENT Project PIs and Key Contributors

- Area 1: Ron Hanson (Stanford), Tom Bowman (Stanford), Dave Davidson (Stanford), **Shock Tube and Flow Reactor Studies.**
- Area 2: Hai Wang (Stanford), **Chemical Kinetics Model Development and Evaluation**.
- Area 2.5: Tianfeng Lu (U. Conn), Wenting Sun (Georgia Tech), Stephen Zeppieri (UTRC), **Computational Acceleration.**
- Area 3: Tim Lieuwen (Georgia Tech), Jerry Sietzman (Georgia Tech), David Blunck (Oregon State), Fred Dryer (Princeton), Tonghun Lee (Illinois Urbana-Champaign), **Advanced Combustion.**
- Area 4: Suresh Menon (Georgia Tech), Matthias Ihme (Stanford), Venkat Raman (U. Michigan), **Combustion Model Development and Evaluation.**
- Area 5: Robert Lucht (Purdue), Paul E. Sojka (Purdue), Scott Meyer (Purdue), Carson Slabaugh (Purdue), Jay Gore (Purdue), **Atomization Tests and Models.**
- Area 6: Scott Stouffer (Dayton), Steven Zabarnick (Dayton), Tonghun Lee (Illinois Urbana-Champaign), **Referee Combustor.**
- Area 7: Josh Heyne (Dayton), Med Colket (contractor), Alex Briones (Dayton), **Coordination.**

FAA, NASA, and AFRL Funded Activities

Summary of Integrated Program

1. Year 1 Accomplishments
   - Demonstrated fuel effects in engine rigs on Lean Blow Out ✓
   - Created kinetic models for different fuels ✓
   - Demonstrated fuel effects in burner rig simulations ✓

2. Year 2 Objectives
   - Develop and demonstrate capabilities for alt. ignition experiments (i.e. cold fuel-air and/or low pressure capabilities)– *in progress*
   - Demonstrate fuel-dependent CFD and chemistry models towards FOM sensitivity - *in progress*
   - Develop and demonstrate physics-based fuel-dependent spray models for CFD- *in progress*

3. Overall Program Goals
   - Develop an experimental and analytical capability to enable OEMs to evaluate fuel physical and chemical properties on engine operability primary Figures of Merit towards the streamlining of fuels through the ASTM approval process

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