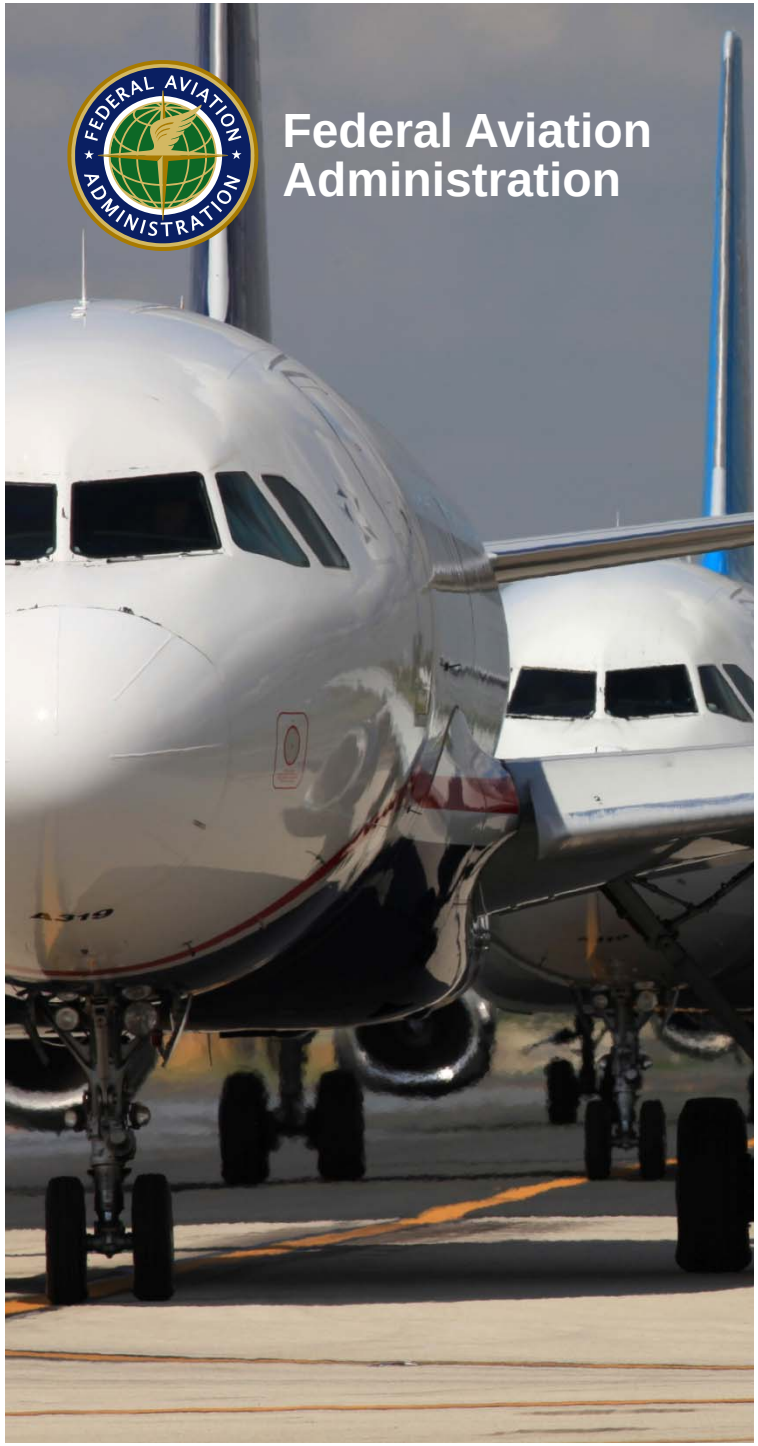
Sustainable Alternative Jet Fuels U.S. Experience

FAA Overview: R&D Activities and Coordination Efforts



Presented to: Japan Aviation Environmental Workshop

By: Dr. James I. Hileman
Office of Environment and Energy
Federal Aviation Administration

Date: November 5, 2014

Outline

- **U.S. Vision & Approach**
- **U.S. Activities**
- **Alt Fuel Developments**
- **Summary**

Aviation Environmental Challenges

- Aviation impacts community noise, air quality, water quality, energy usage, and climate change
- Environmental impacts from aviation emissions could pose a critical constraint on capacity growth
- Alternative jet fuels could reduce the environmental impact of aviation:
  - Carbon neutral growth by 2020 compared to 2005
  - Absolute reduction of significant air quality impacts, notwithstanding aviation growth
  - 1 billion gallons of renewable jet fuel in use by aviation by 2018

U.S. Climate Action Plan for Aviation

The U.S. is pursing a multipronged approach to address green house gas emissions from aviation

- Aircraft and engine technology improvement
- Operational improvements
- Alternative fuels development and deployment
- Policies, environmental standards, and market based measures
- Scientific understanding through research, modeling and analysis

Alternative Fuels Principles – U.S. Vision

- **Alternative Jet Fuels must be drop in, have equivalent safety and better environmental performance than petroleum Jet fuel**
- **Enable all possible fuels that meet criteria**
- **Government role to address key barriers**
- **Work through Public-Private Partnerships**
- **Address the whole supply chain**
- **Leverage expertise and resources of other government agencies and other countries**
- **Aviation should be a lead user of alternative fuels**

Challenges for Sustainable Alternative Fuels

- Feedstock availability
- Competitive cost for alternative fuel
- Approved for performance/safety
- Environmentally sustainable
- Commercially produced

U.S. Government Efforts Across the Supply Chain







Feedstock Production	Feedstock Logistics	Fuel Conversion	Conversion Process Scale-up/Integration	Fuel Testing / Approval Fuel Performance | Environment Assmt	Enable Production	End User/ Buyer

Agriculture: Biomass Crop Assistance Program & Crop Insurance Program

Agriculture: Feedstock Development Center Grants

Energy: R&D

Energy & Defense: R&D grants

Agriculture & Energy: R&D grants

FAA & Defense: C/Q Fuel testing

FAA, Defense, & NASA: Enviro Analysis

Agriculture, Navy, & Energy: Defense Production Act and Biorefinery Program

EPA: Renewable Fuel Standard

Defense & Airlines: fuel purchase

FAA: Guidance for Airports

FAA Alternative Jet Fuel Activities

- **Testing**
  - Support Cert/Qual testing
  - Improve Cert/Qual process
  - Emissions measurements
- **Analysis**
  - Environmental sustainability
  - Techno-economic analysis
  - Future scenarios
- **Coordination**
  - Interagency
  - Public-Private
  - State & Regional
  - International

FAA Alternative Jet Fuel Activities

- **Testing**
  - Support Cert/Qual testing
  - Improve Cert/Qual process
  - Emissions measurements
- **Analysis**
  - Environmental sustainability
  - Techno-economic analysis
  - Future scenarios
- **Coordination**
  - Interagency
  - Public-Private
  - State & Regional
  - International

Aviation Fuel Qualification (ASTM D4054 Process)

Specification Properties

Fit-For-Purpose Properties

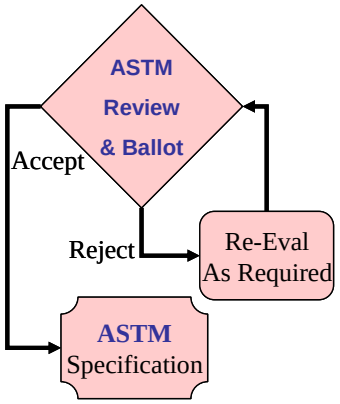
Component/Rig Testing

Engine/APU Testing

ASTM Research Report

EMBRAER
BOEING
Honeywell
Rolls-Royce
AIRBUS

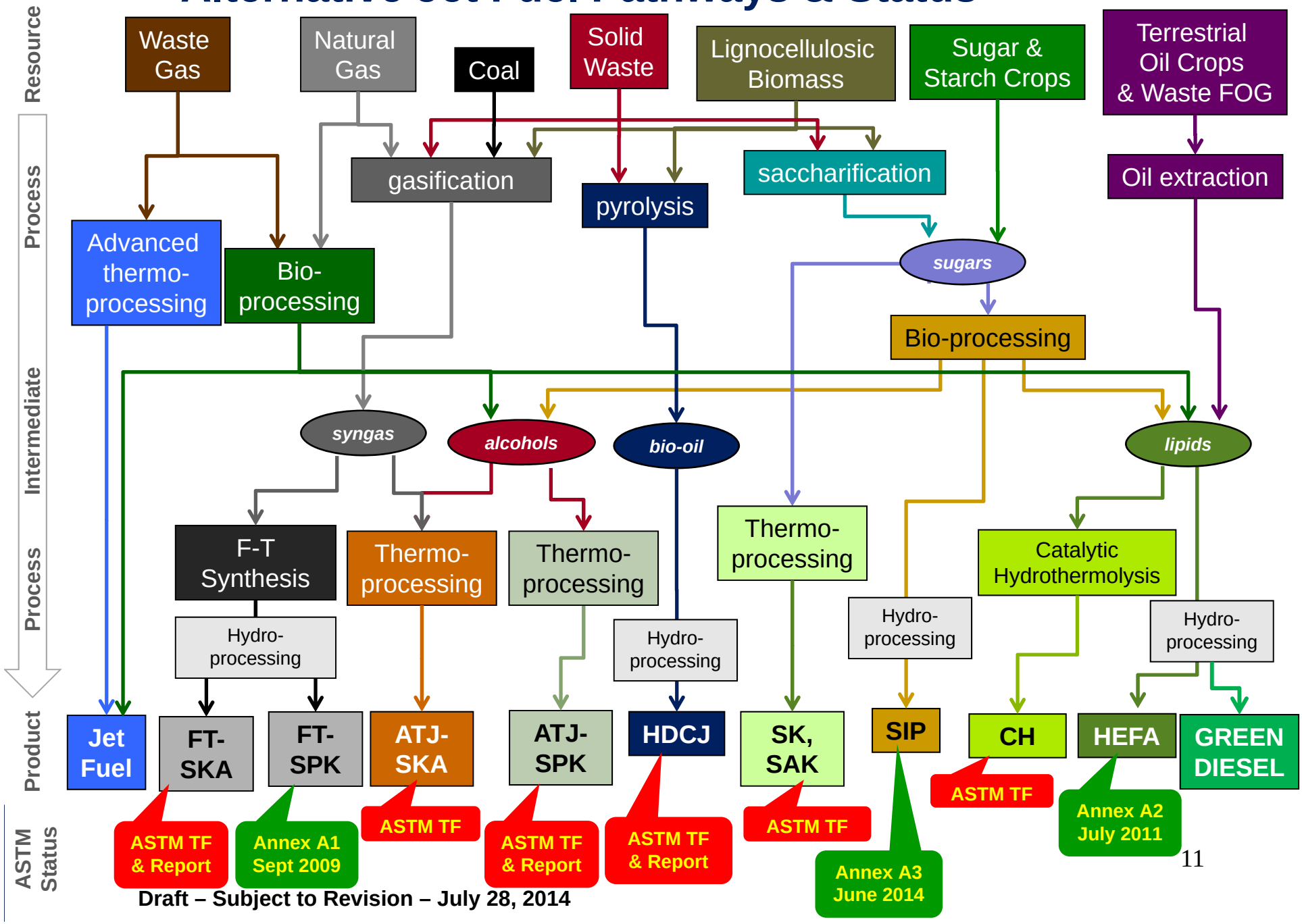
FAA & OEM Review & Approval



ASTM Balloting Process

ASTM D7566 Revision

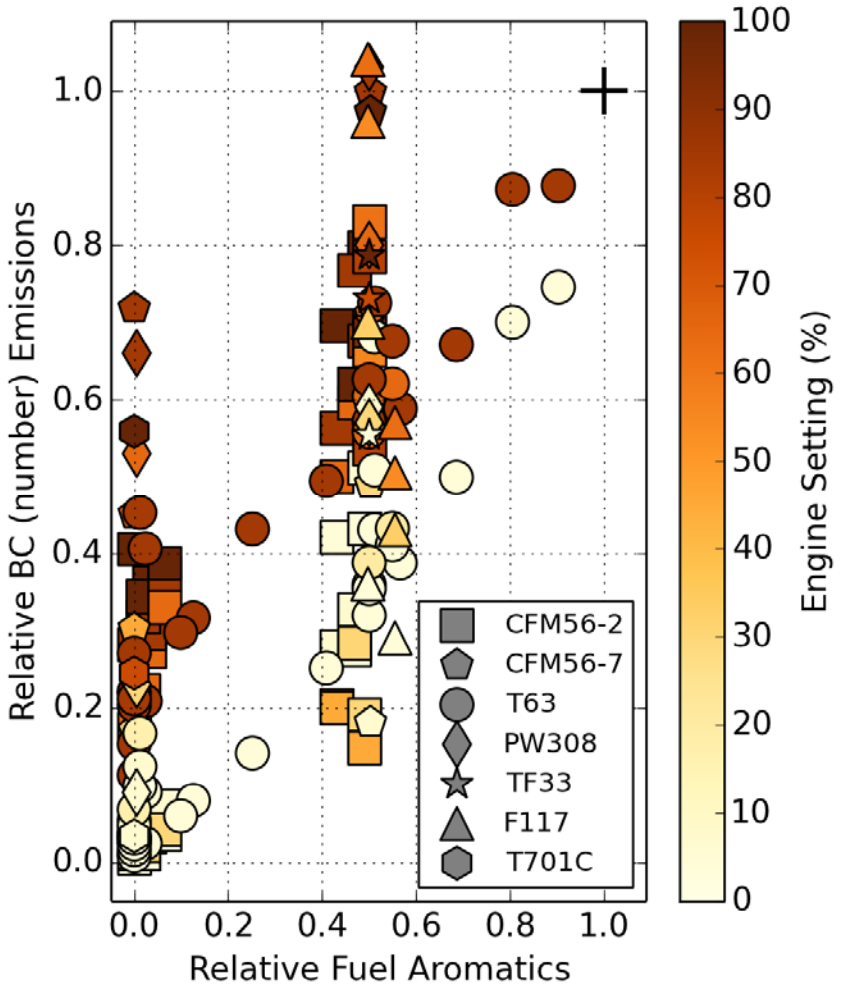
Alternative Jet Fuel Pathways & Status



Draft – Subject to Revision – July 28, 2014

Emissions Measurements

- PARTNER developing relationship for black carbon emissions based on engine thrust and fuel aromatic content[1]
- Intend to further expand alt jet fuels emissions knowledge using measurements from CLEEN Program and NASA tests
- Expanding knowledge to include alt jet fuels that have aromatic content (e.g., HDCJ)



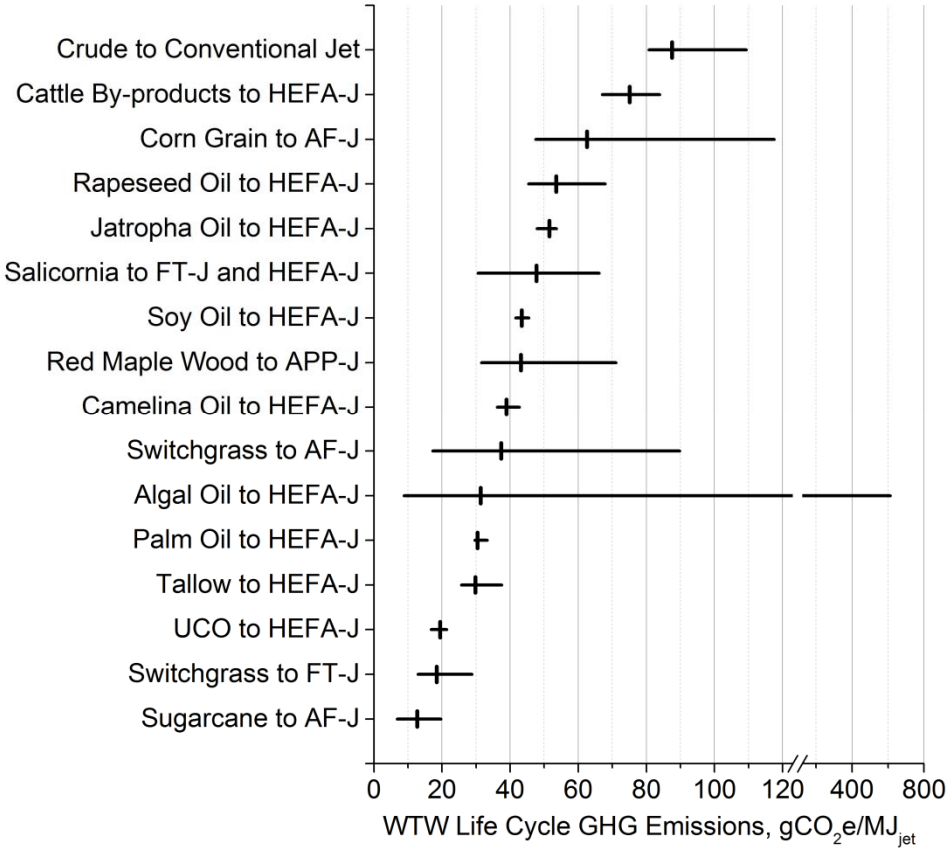
Preliminary PARTNER Project 47 research results (http://partner.aero) – DO NOT CITE OR QUOTE

FAA Alternative Jet Fuel Activities

- Testing
  - Support Cert/Qual testing
  - Improve Cert/Qual process
  - Emissions measurements
- **Analysis**
  - Environmental sustainability
  - Techno-economic analysis
  - Future scenarios
- Coordination
  - Interagency
  - Public-Private
  - State & Regional
  - International

Environmental Analyses

- Environmental analyses
  - Focus on well-to-wake (WTW) life cycle GHG emissions
  - Results incorporated into ANL GREET model[1] and EPA analysis
  - Examining climate impacts from change in combustion emissions
- Recent life cycle GHG work[2]
  - Tallow and waste oils for HEFA
  - Advanced fermentation of sugars, starches, and switchgrass
- Water footprint analysis[3]
  - Examined water footprint of all fuels considered for LC GHG emissions
  - Fuel use on same order of magnitude as conventional jet fuel unless irrigation is used



1. ANL GREET model available at http://greet.es.anl.gov/files/aviation-lca
2. PARTNER Project 28 and 47 research: (partner.aero): Stratton et al. 2010, Staples et al. 2014, Bond et al. 2014, and Seber et al. (forthcoming)
3. PARTNER Project 47 (partner.aero): Staples et al. 2013

Economic Analyses

- Techno-Economic Analysis
  - Computing minimum selling price (MSP) for n^{th} plant
  - Using discounted cash flow rate of return method
- Effort is focused on identifying ways to reduce production costs
- Lower feedstock costs
  - HEFA production from rotation crop such as pennycress[1]
  - Advanced fermentation using sugar cane[2]
- Modify product slate
  - For HEFA, maximizing jet fuel production requires $0.25 to $0.30 per gallon more than maximizing diesel fuel to break even[3]
  - Maximizing biochemicals makes certain jet fuel production pathways economical[4]
- Utilizing brownfield facilities reduces production costs[2,3]

Research results can be found at http://partner.aero/:

1. Project 31 – Winchester et al. 2013
2. Project 47 – Staples et al. 2014
3. Project 28 – Pearlson et al. 2013
4. Project 47 – Bond et al. 2014

FAA Alternative Jet Fuel Activities

- Testing
  - Support Cert/Qual testing
  - Improve Cert/Qual process
  - Emissions measurements
- Analysis
  - Environmental sustainability
  - Techno-economic analysis
  - Future scenarios
- **Coordination**
  - Interagency
  - Public-Private
  - State & Regional
  - International

Commercial Aviation Alternative Fuels Initiative (CAAFI)

- Public-Private coalition for commercial aviation to engage the emerging alternative fuels industry
- Enable development of alt jet fuels:
  - Equivalent safety/performance (drop-in)
  - Comparable cost
  - Environmental improvement
  - Security of Energy supply
- Four teams for key issues:
  - Environment Team
  - Certification-Qualification Team
  - R&D Team
  - Business Team
- State and Regional Support
- International Cooperation

Coordinate USG Efforts Across the Supply Chain







Feedstock Production	Feedstock Logistics	Fuel Conversion	Conversion Process Scale-up/Integration	Fuel Testing / Approval Fuel Performance | Environment Assmt	Enable Production	End User/ Buyer

Agriculture: Biomass Crop Assistance Program & Crop Insurance Program

Agriculture: Feedstock Development Center Grants

Energy: R&D

Energy & Defense: R&D grants

Agriculture & Energy: R&D grants

FAA & Defense: C/Q Fuel testing

FAA, Defense, & NASA: Enviro Analysis

Agriculture, Navy, & Energy: Defense Production Act and Biorefinery Program

EPA: Renewable Fuel Standard

Defense & Airlines: fuel purchase

FAA: Guidance for Airports

Farm to Fly 2.0

… "THEREFORE, AS OUR GOAL, we the undersigned, jointly signify our intent to continue working together over the next five years in an expanded collaboration entitled "Farm to Fly 2.0", to enable commercially viable, sustainable bio-Jet Fuel supply chains in the U.S. that are able to support the goal of one billion gallons of bio-Jet Fuel production capacity and use for the Aviation Enterprise by 2018"

CAAFI State & Regional Deployment

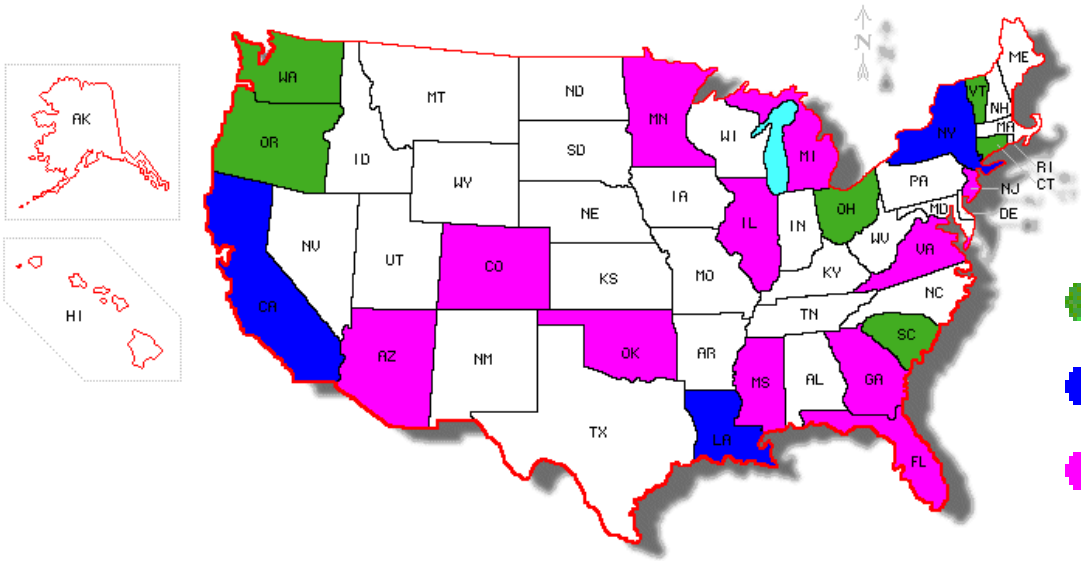
- **Working with local lead organizations/POCs**
- **Provide context, advice, strategy, benchmarking**
- **Facilitate networks & links between stakeholders**
- **Link to Farm to Fly 2.0**

CAAFI®
COMMERCIAL AVIATION ALTERNATIVE FUELS INITIATIVE

MASBI

Georgia® Centers of Innovation

WASHINGTON AIRPORTS TASK FORCE



"Farm to Fly" projects in process

Commercial Execution Initiated

"Farm to Fly" project dialogue

* Does not include Dept. of Energy Pilot Projects, Defense Production Act Projects, map credit to diymaps.net.

International Engagement

- Bilateral Cooperation Agreements
- Informal coordination with counterpart organizations
- International Civil Aviation Organization

New FAA Programs

Aviation Sustainability Center (ASCENT)

- New Center of Excellence for Alternative Jet Fuels and Environment

Continuous Lower Energy, Emissions and Noise (CLEEN) II

- Reduce aircraft fuel burn, emissions and noise through technology & advance alternative jet fuels

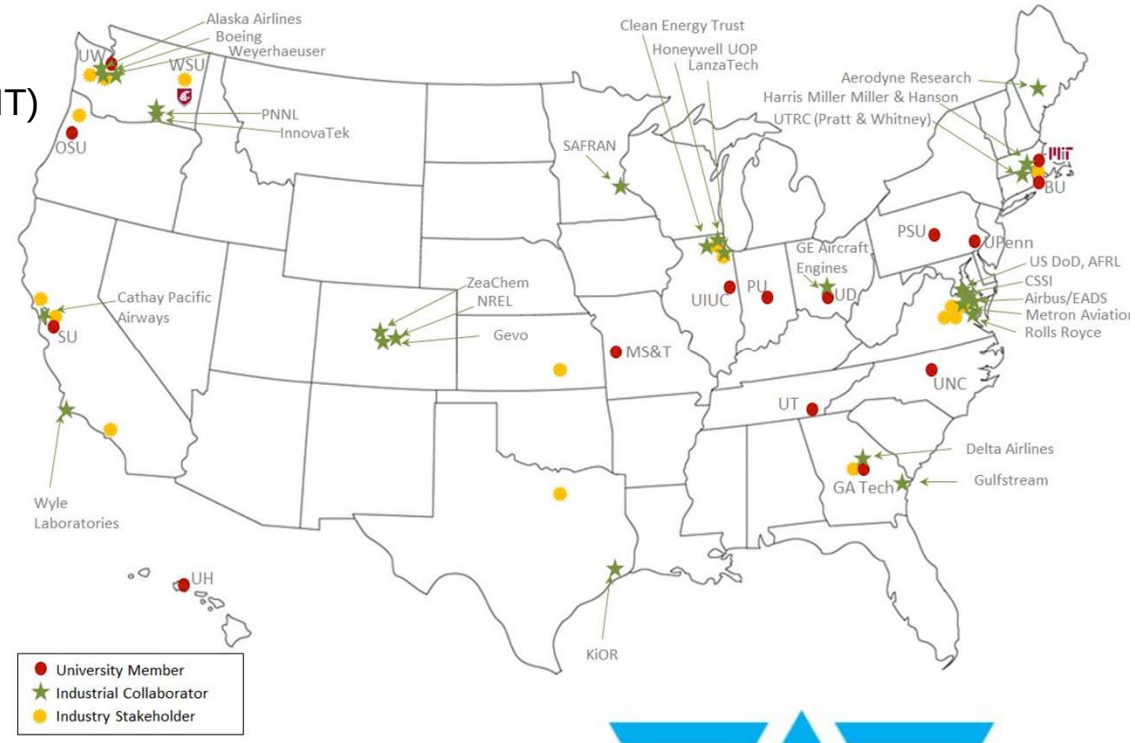
FAA CENTER OF EXCELLENCE FOR ALTERNATIVE JET FUELS & ENVIRONMENT

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)*



ASCENT
AVIATION SUSTAINABILITY CENTER

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

Continuous Lower Energy, Emissions and Noise (CLEEN) Phase II

NextGEN

- **FAA R&D Program:**
  - Reduce aircraft fuel burn, emissions and noise through technology & advance alternative jet fuels
  - 1:1 minimum cost share requirement
- **CLEEN I: 2010-2015 ($125M FAA Funding)**
  - Alternative Jet Fuel Projects with Boeing, Rolls Royce, Pratt & Whitney, and Honeywell
- **CLEEN II: 2015-2020 ($100M FAA Funding)**
  - Industry Day - December 3, 2013 in Washington DC
  - Solicitation open now until January 23, 2015
  - More information available at: https://faaco.faa.gov/index.cfm/announcement/view/18077

Alt Fuels Development Progress 2014

- ASTM approval of SIP fuels (June 2014), additional ballots under preparation
- Engine tests of novel fuels continue
- ASCENT analysis projects established
- Continued domestic and international engagement

Alt Fuels Progress Anticipated in 2015

- Continue support to ASTM approval of additional fuel pathways
- Continue Certification / Qualification testing of fuels with current methods (D4054) to support ASTM approval
- Continue work to improve testing methods to reduce cost and time of Certification / Qualification over longer term
- Continue analysis in support of deployment
- Continue domestic and international engagement

Summary

- Alternative jet fuels are a key component of U.S. strategy for meeting aviation environmental goals
- FAA efforts are directed to overcoming key challenges via testing, analysis and coordination
- Multiple programs and activities focus on different aspects of the challenge
- Partnerships across technical areas are a key focus
- Strong domestic and international coordination necessary for success

Dr. Jim Hileman

Chief Scientific and Technical Advisor for Environment and Energy

Federal Aviation Administration
Office of Environment and Energy

Email: james.hileman@faa.gov