Alternative Jet Fuels: Testing, Analysis & Coordination

Update to FAA REDAC E&E Subcommittee

To: E&E REDAC Subcommittee

By: Nate Brown

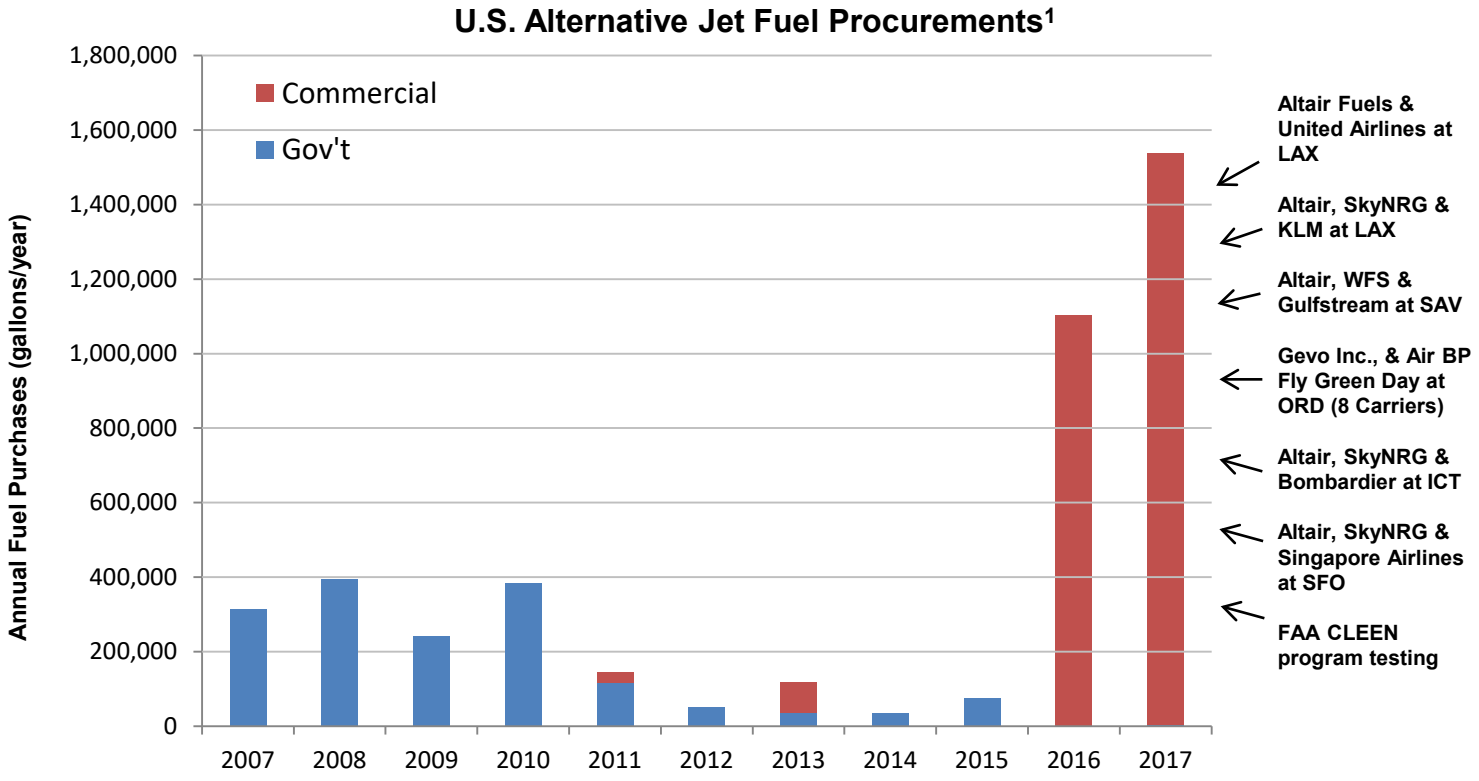
Date: March 7, 2018

FAA's AJF R&D Program

- **What have we achieved?**
- **How have we achieved it?**
  - Coordination
  - Testing
  - Analysis
- **What would we do next if funding were not a constraint?**

What have we achieved?

- Commercial flights on alternative jet fuels are expanding
- 1.5 million gallons in 2017 from two commercial producers, many commercial user, multiple U.S. airports



Notes:
1. Includes procurements of fuel by U.S. government, U.S. airlines, manufacturers, and foreign carriers delivered to U.S. airports

What have we achieved?

Potential for 250 million gallons/year in five years

Achieving AJF Production

FAA Alternative Jet Fuel Investments:

Coordination

- Public-Private
- Interagency
- State & Regional
- International

Testing

- Support certification testing
- Improve certification process
- Emissions measurements

Analysis

- Environmental sustainability
- Techno-economic analysis
- Future scenarios

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Overview of FAA Coordination Activities

Support alignment of efforts and cooperation among all key stakeholders to enable AJF deployment

Public-Private
- CAAFI

Interagency
- R&D and program leveraging

State & Regional
- Farm to Fly 2.0

International
- Best practices

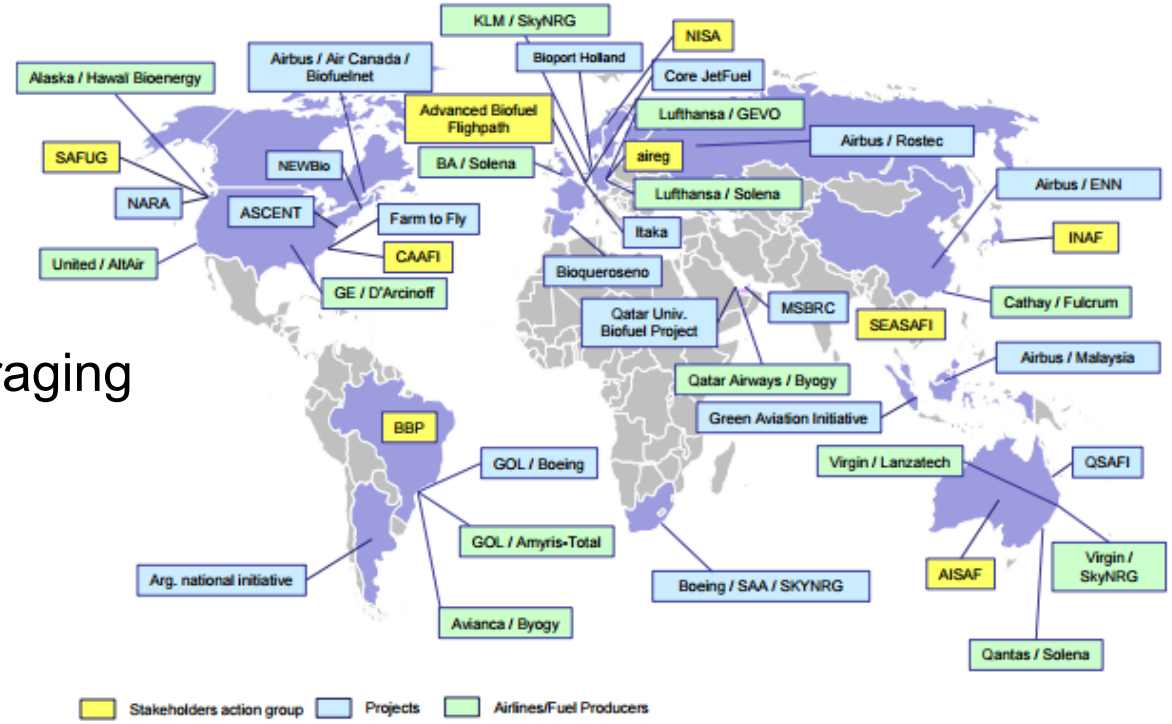


Image Credit: IATA Alternative Fuels Roadmap

Coordination Activities:

Commercial Aviation Alternative Fuels Initiative

- **Communicate the Value Proposition of SAJF**
- **Enhance the Fuel Qualification Approach**
- **Implement Frameworks & Share Best Practices**
- **Develop the U.S. SAJF Supply by Aligning Efforts to Enable Commercial Deployment**

CAAFI®
COMMERCIAL AVIATION ALTERNATIVE FUELS INITIATIVE

CAAFI Administrative Leadership Team:

- Steve Csonka, CAAFI Executive Director
- Chris Tindal, CAAFI Assistant Director
- Kristin Lewis, Volpe
- Peter Herzig, Volpe
- Nate Brown, FAA
- Rich Altman, CAAFI Executive Director Emeritus

CAAFI Team Leads:

- C/Q: M. Rumizen, C/Q
- Sustainability: J. Hileman & N. Young,
- Business: J. Heimlich
- R&D : M. Lakeman, S Kramer, & G. Andac

CAAFI Steering Group: AIA, ACI-NA, A4A, GE, Boeing, P&W, ASCENT, DOE, USDA

Coordination Activities:

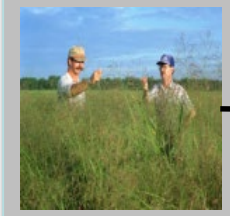
Supporting AJF Purchase Agreements

Guidance for Selling Alternative Fuels to Airlines

Available at:
http://www.caafi.org/files/CAAFI_Business_Team_Guidance_Paper_060413.pdf

Coordination Activities:

U.S. Agency Efforts Across the Supply Chain







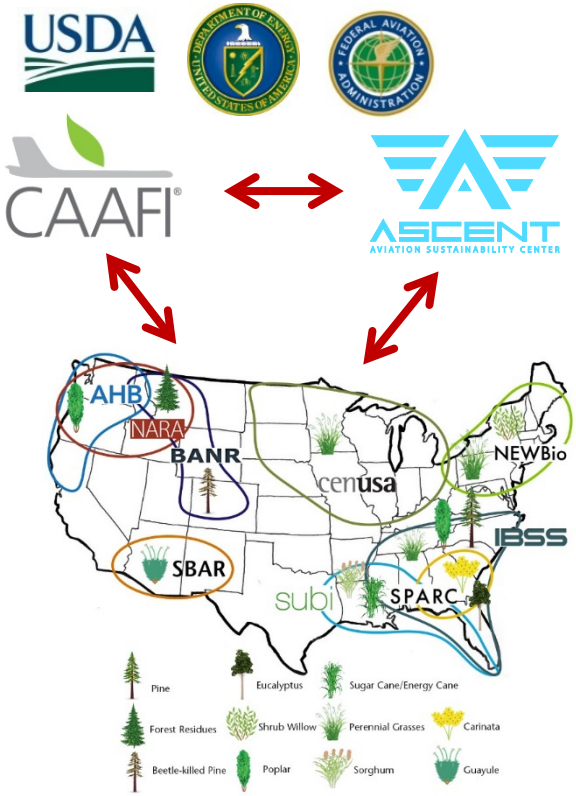
Feedstock Production	Feedstock Logistics	Fuel Conversion	Conversion Process Scale-up/Integration	Fuel Testing / Approval (Fuel Performance; Environment Assmt)	Enable Production	End User/ Buyer
Agriculture: Biomass Crop Assistance Program & Crop Insurance Program		Energy & Defense: R&D grants	Agriculture & Energy: R&D grants	FAA & Defense: C/Q Fuel testing	FAA, Defense, & NASA: Enviro Analysis	Agriculture, Navy, & Energy: Defense Production Act and Biorefinery Program	Airlines: fuel purchases
Agriculture: Feedstock Development Center Grants				ASTM INTERNATIONAL			Agriculture & Defense: Farm to Fleet
	Energy: R&D					EPA: Renewable Fuel Standard	FAA: Guidance for Airports
All: Federal Alternative Jet Fuel R&D Strategy						Agriculture, Energy, FAA: Farm to Fly 2.0	

USDA · Energy · Defense · EPA · NASA · FAA · Commerce · NSF

Impact of Coordination Activities:

Farm to Fly 2.0 - Support for Supply Development

- 4 CAAFI State Initiatives funded by USDA
- 6 USDA NIFA CAPs addressing sustainable AJF supply chains
- 3 biofuel producers funded under the DPA to build and commission biorefineries ($510M)
- 25 Feedstock Readiness Level (FSRL) evaluations in the National Agricultural Library “Ag Data Commons”
- DOE funding opportunity announcements (FOAs) for jet fuel process development and feedstock
- 5 ASCENT Universities focused on AJF supply chain development

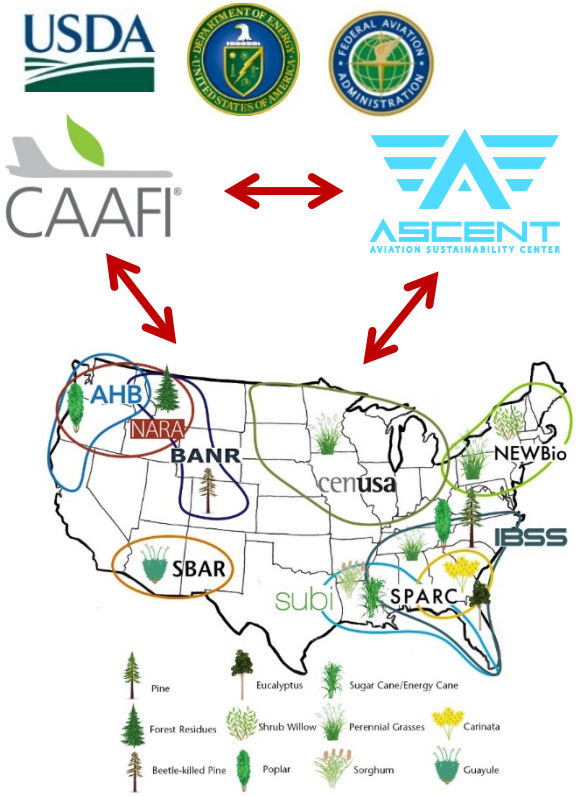


USDA NIFA AFRI Coordinated Agriculture Projects (CAPs)

Impact of Coordination Activities:

Farm to Fly 2.0 - Support for Supply Development

- 2 CAAFI Biennial General Meetings (2014, 2016)
- 4 DOE Bioenergy/Bioeconomy Meetings
- 1 DOE sponsored Alternative Aviation Fuel Workshop and Report (2016)
- Billion Ton Bioeconomy Initiative Vision & Challenges and Opportunities reports (2016)
- 1 Federal Alternative Jet Fuel Research & Development Strategy
- 1 National Academy of Sciences report on Commercial Aircraft Propulsion and Energy Systems Research: Reducing Global Carbon Emissions (2015)
- 4 chapters on AJF contributed to NASA Green Aviation book

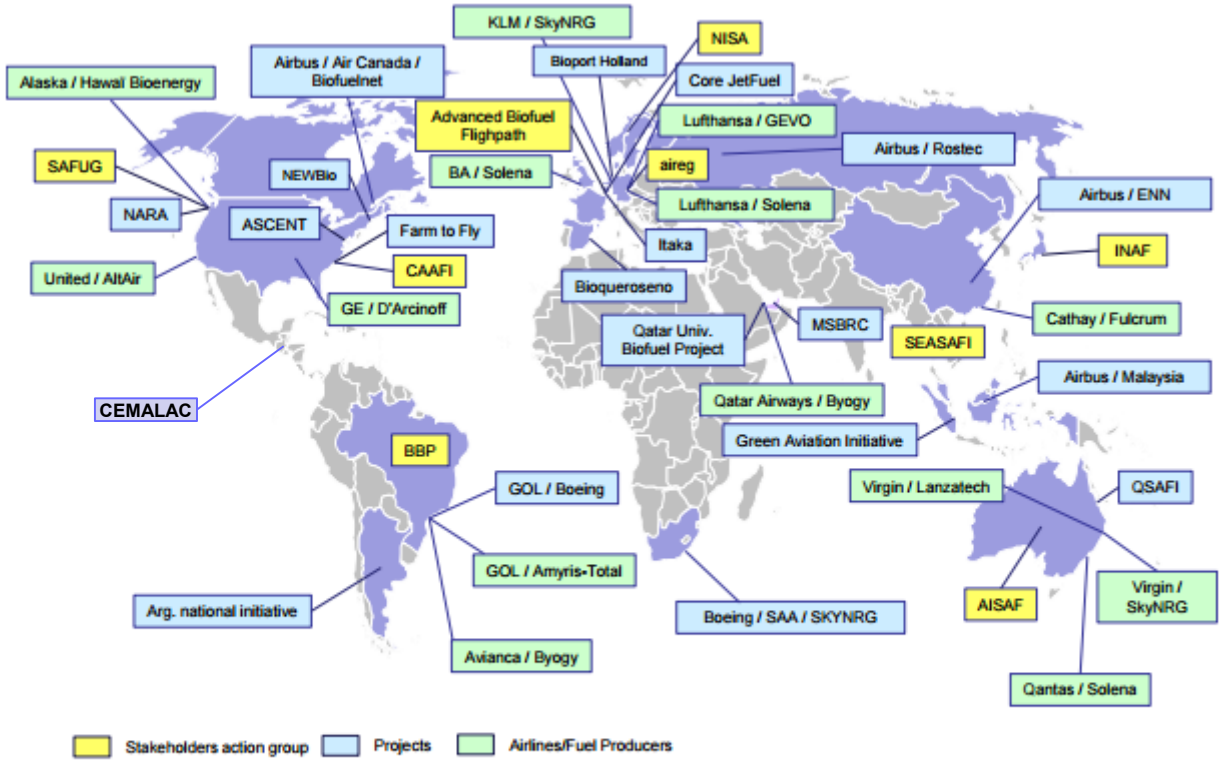


USDA NIFA AFRI Coordinated Agriculture Projects (CAPs)

Impact of Coordination Activities:

International Coordination

- 5 Bilateral agreements support AJF in other regions
- 2 ICAO Conferences on AJF (CAAF and CAAF2 in 2009, 2017)
- ICAO Alternative Fuel Seminars
- ICAO Global Framework for Aviation Alternative Fuels
- AJF inclusion in CORSIA



Credit: IATA Alternative Fuels Roadmap

Achieving AJF Production

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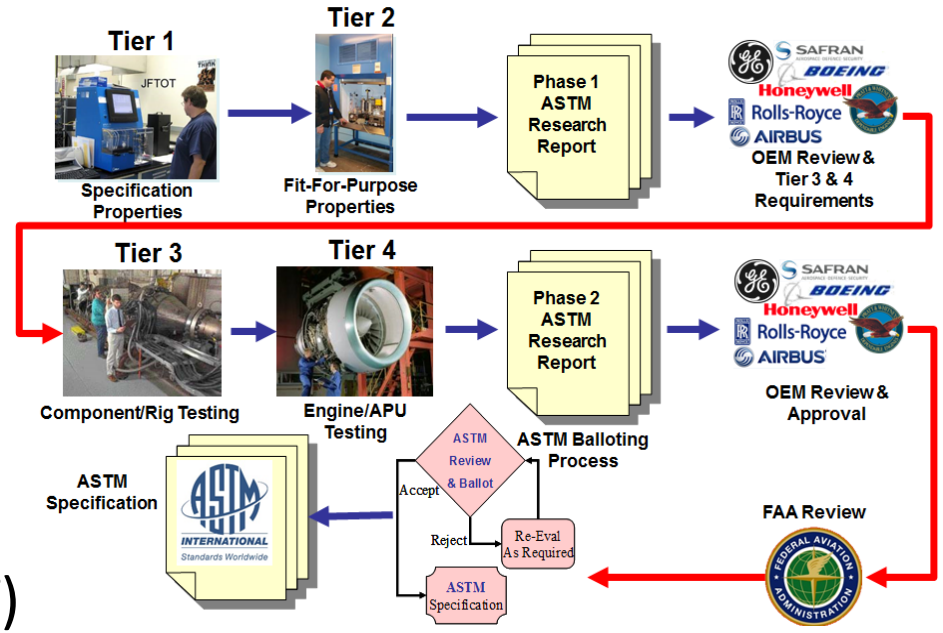
Overview of FAA Testing Activities

Support ASTM International evaluation of alternative jet fuels; improve evaluation process

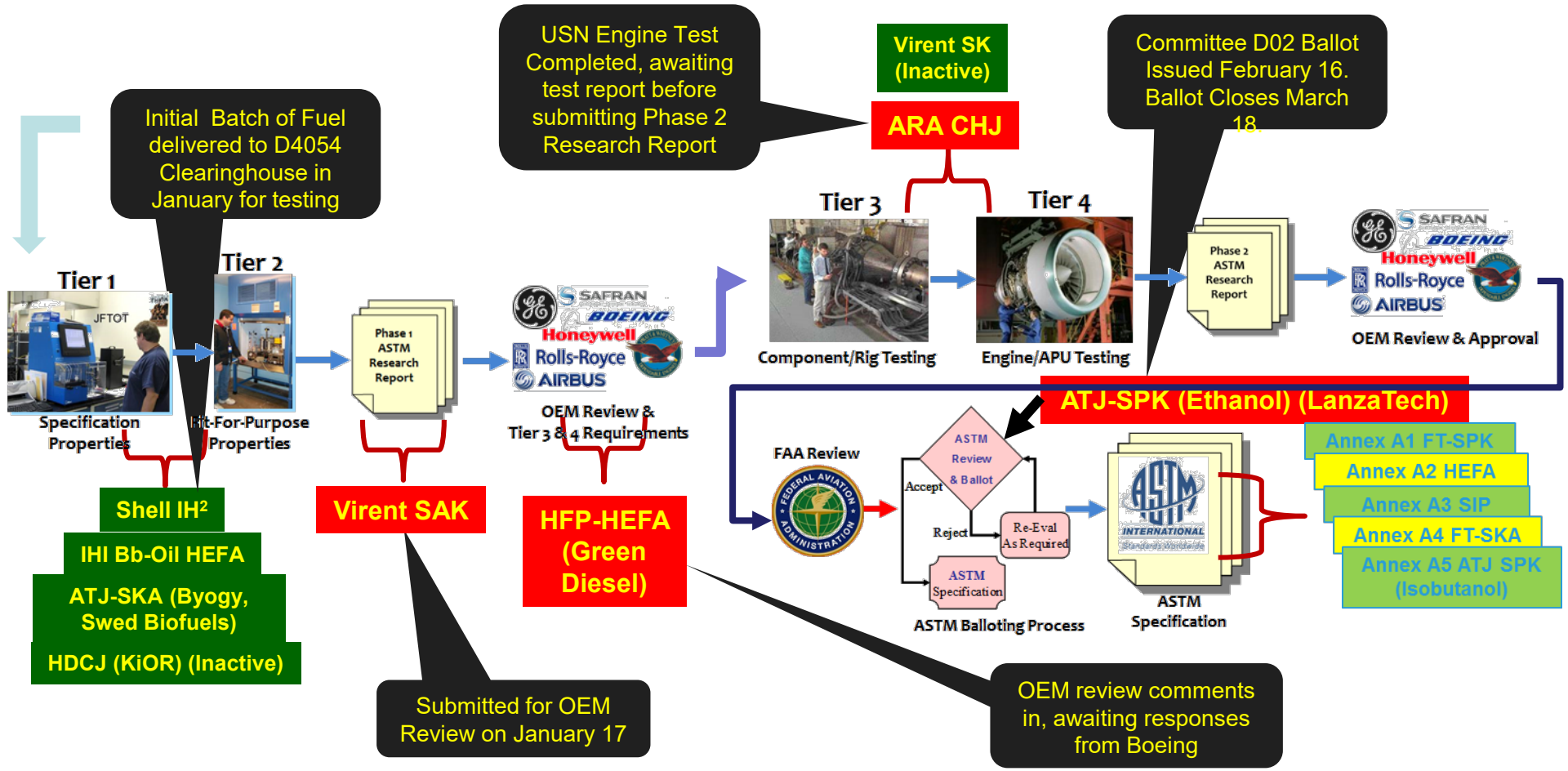
- **Support ASTM certification & qualification testing activities to develop data for new approvals**
  (CAAFI, CLEEN, & ASCENT)
- **ASTM Clearinghouse**
  (CAAFI & ASCENT)
- **OEM Review Process**
  (ASCENT)
- **Data Gathering & Library**
  (ASCENT)
- **Streamline approval process via the National Jet Fuels Combustion Program** (ASCENT)

D4054 Alternative Jet Fuel Approval Process



Testing Activities:

Status of Alternative Jet Fuels within D4054



Testing Activities:

ASTM D4054 Clearinghouse Concept

Structured as a Cost Share Arrangement

Accepts In-Kind Contributions (testing partners)

Also Accepts Direct Contributions

Stakeholder Engagement / Support Needed!

FAA Seed Money Under ASCENT Center of Excellence

Final Research Report Out

University of Dayton Research Institute (UDRI)

Candidate AJF In

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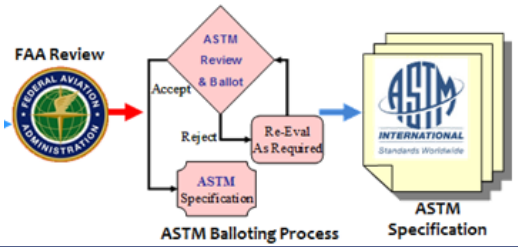
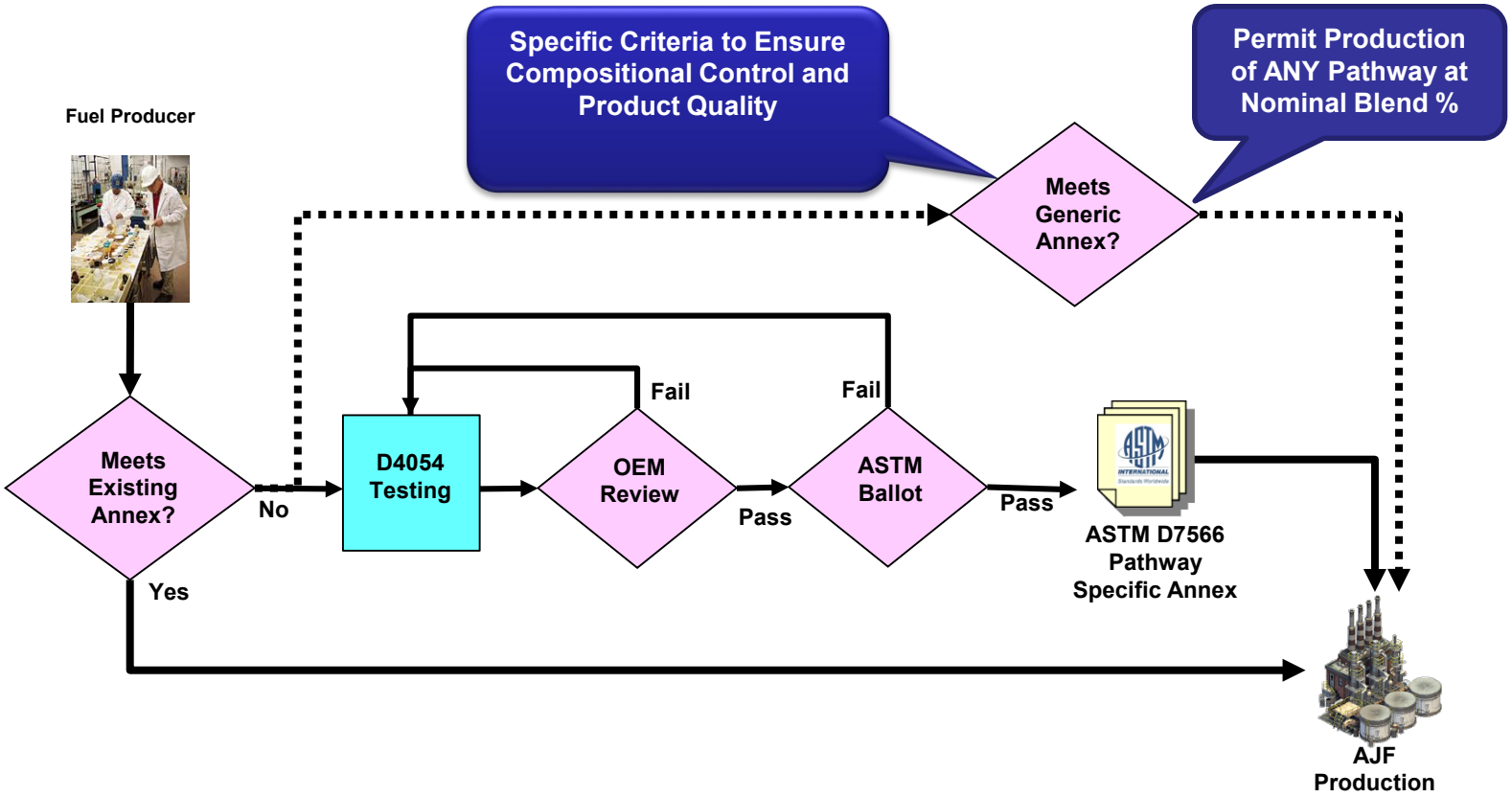


Testing Activities:

ASTM D7566 Generic Annex



Impact of Testing Activities:

Alternative Jet Fuels are being Certified

- **Created ASTM D7566 Specification (2009)**
- **5 fuels added to the ASTM specification (2009-present)**
  - Sixth approval Q2 2018
  - 6+ additional fuels under evaluation
- **Created ASTM D4054 Process and D4054 Users Guide**
- **Filled "testing gap"**
  - FAA funded testing of 7 fuels via first phase of CLEEN program
  - FAA funded testing of 4 fuels via second phase of CLEEN program
- **D4054 Clearinghouse established via ASCENT to simplify and accelerate approval process (2016)**
  - Facilitate funding from non-US government sources
  - Research report review support
  - Tier 1 & 2 testing for two fuels
  - EU, UK clearing houses in development

Impact of Testing Activities:

Estimated Requirements for Approval of AJF

As a result of the investments made by FAA and others, time and fuel requirements for AJF approval have fallen dramatically over time

Lanzatech ATJ-SPK (ethanol)	09/2016	07/2017	Expected 04/2018	50 [4]	

[1] USAF fuel purchases in 2007 and 2008 for fleetwide qualification
[2] USAF & Navy fuel purchases in 2009-11 for fleetwide qualification
[3] USAF, Navy and CLEEN fuel purchases in 2012-2014
[4] Only tier 1 & 2 testing needed for Lanzatech due to existing knowledge base and similarity to previously approved fuels.

Achieving AJF Production

FAA Alternative Jet Fuel Investments:

Coordination
- Public-Private
- Interagency
- State & Regional
- International

Testing
- Support certification testing
- Improve certification process
- Emissions measurements

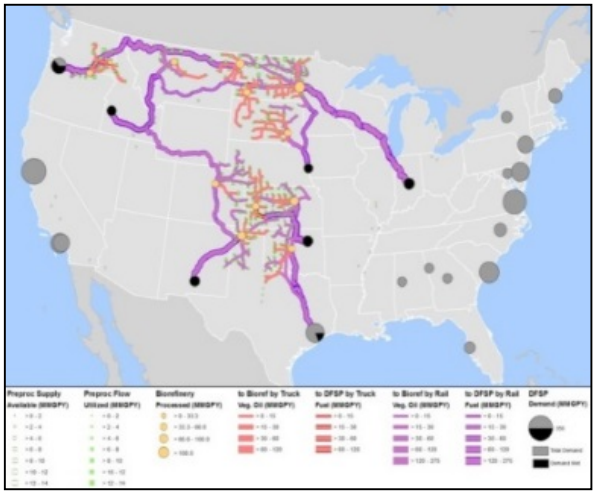
Analysis
- Environmental sustainability
- Techno-economic analysis
- Future scenarios

Overview of FAA Analysis Activities

Support better understanding of the environmental sustainability, economic costs and potential supply of AJF

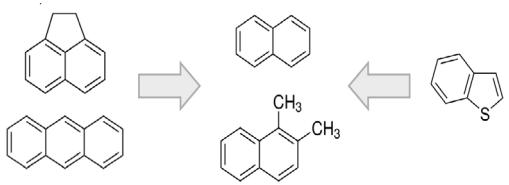
AJF Supply Chain and ICAO AFTF Support (ASCENT 01)

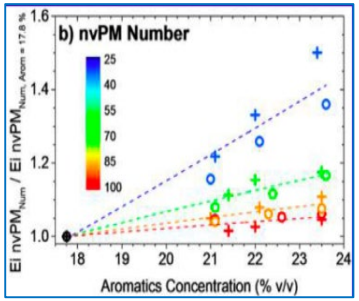
- GHG life cycle analysis (LCA) and ILUC
- Techno Economic Analysis
- Production potential
- Opportunities & challenges for U.S. production
- Regional supply chain projects
- Policy impacts



Future Scenarios/Supply Potential (ASCENT 01, Volpe, DOE NREL)

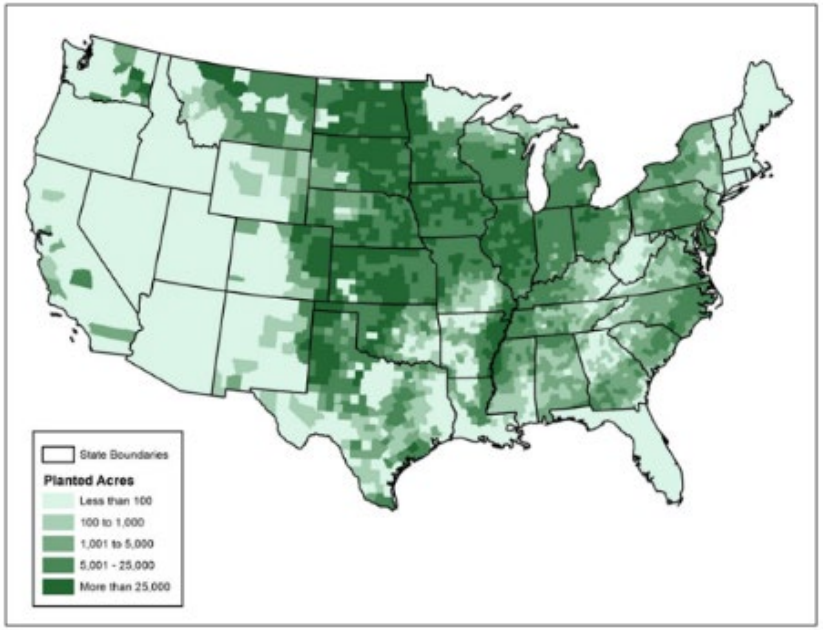
Emissions Impacts of AJF (ASCENT 39)





Pennycress Techno Economic Analysis

- University of Tennessee Knoxville examined Pennycress grown in rotation with Corn and Soybeans (using fallow land in winter)
- Provides oil and biomass
- POLYSYS and IMPLAN modeling
- Results suggest that pennycress has potential to supply approximately 800 million gallons of jet fuel



- **Economic impact ~ $19 billion and 66,000 jobs**
- Many of these jobs would be in rural areas and would enhance rural American economies.
- Results are conservative estimate and could be higher
- Additional benefits of pennycress not included in calculation

ICAO CAEP Alternative Fuels Task Force Support

CORSIA Support

- Determine appropriate GHG LCA values for feedstock to fuel pathways (MIT, DOE Argonne National Labs)
- Calculate land use change factors to be added to LCA values (Purdue)
- Determine non GHG sustainability criteria to which AJF must adhere (Volpe Center, MIT, Purdue)

Additional AFTF Efforts

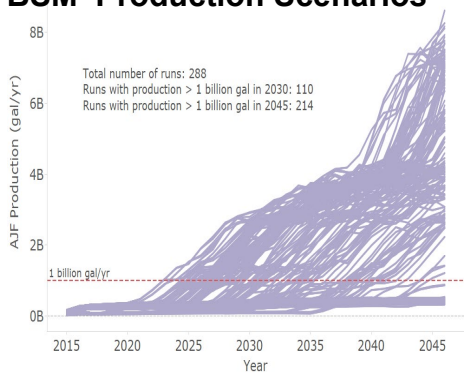
- Provide policy guidance to member states on how to facilitate uptake of sustainable AJF (MIT, Purdue)
- Develop range of scenarios for future alternative jet fuel production to support 2050 trends assessment (MIT)

Analysis Activities:

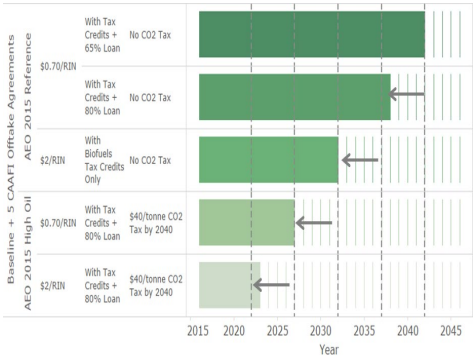
Volpe FTOT & NREL Biomass Scenario Model

- NREL and Volpe asked (with DOE and FAA funding):
  1. How much AJF can be produced and how soon? (2017-2045)
  2. What is the likely geospatial distribution of feedstock and fuel production and AJF delivery? (for the year 2030)
- 38% of scenarios result in 1+ billion gallons by 2030
- Combined incentives needed to get 1 billion gallons by 2030
- Waste feedstocks (crop residues) likely drawn from Midwest first if existing ethanol facilities can be repurposed to ATJ

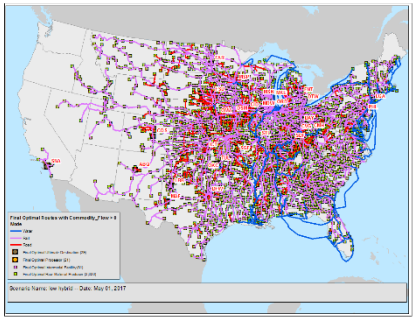
BSM Production Scenarios



BSM Incentive Scenarios



FTOT Geographic results



FAA AJF Analysis

- **Inclusion of AJF in Argonne National Lab GREET model**
- **Renewable Fuel Standard (RFS) "opt in" for AJF from HEFA**
- **California Low carbon fuel standard (LCFS) "opt in" for AJF (expected 1/2019)**
- **Inclusion of AJF within CORSIA**
  - LCA methodology agreed
  - Sustainability criteria being developed
  - Core values for AJF GHG LCA and LUC being developed
- **AJF production forecasts widely used by ICAO**
- **Informing DOE funding activities for conversion process development**
- **Economic analyses being used by industry (e.g., HFP-HEFA)**
- **Increasing understanding of bottlenecks to production**
  - Leveraging/Complementing USDA regional activities

Impacts of FY19 Budget and FY20 Target

- Alternative jet R&D to be zeroed out started in FY19
- Testing Efforts in FY18
  - Prioritize efforts to support near-term fuel approval
  - Focus on ASTM Process with emphasis on work in ASCENT Project 31 (UDRI Clearinghouse) and CLEEN projects (with GE and RR)
  - National Jet Fuel Combustion Program will be zeroed out
- Analysis Efforts in FY18
  - Prioritize efforts to ensure alternative fuels included in CORSIA
  - Dramatic reduction in work on supply chain development / CAAFI Support
- **Even if Congress were to provide funding for alt fuels in FY19, we have lost the ability to do long-term planning**

	FY16 Actual	FY17 Enacted	FY18 President Budget	FY18 Congress Reports	FY19 President Budget	FY20 Target
Testing						
Coordination						
Analysis						

Additional Research Needs

AJF development, commercialization and production growth

- **Coordination**
  - CAAFI Biennial General Meeting & ASCENT research review in Washington, DC in December 2018
  - Leverage USDA Community Agriculture Projects awarded in Arizona and Florida
  - Support additional off-take agreements and fuel production
  - Align R&D with goals and objectives of federal agency partners
- **Testing**
  - Implement clearing house to establish robust/sustainable process
  - Maintain momentum on testing and review - Support 6+ new ASTM fuel approvals
  - Further the generic annex and other approaches to accelerate approvals
- **Analysis**
  - Ensure ICAO CAEP inclusion of alternative jet fuels within the ICAO global market based measure
  - Support the information needs of regional supply chains utilizing tools and data developed
  - Focus ASCENT research efforts in cooperation with USDA, DOE and private sector

Impact of Alternative Jet Fuel Activities

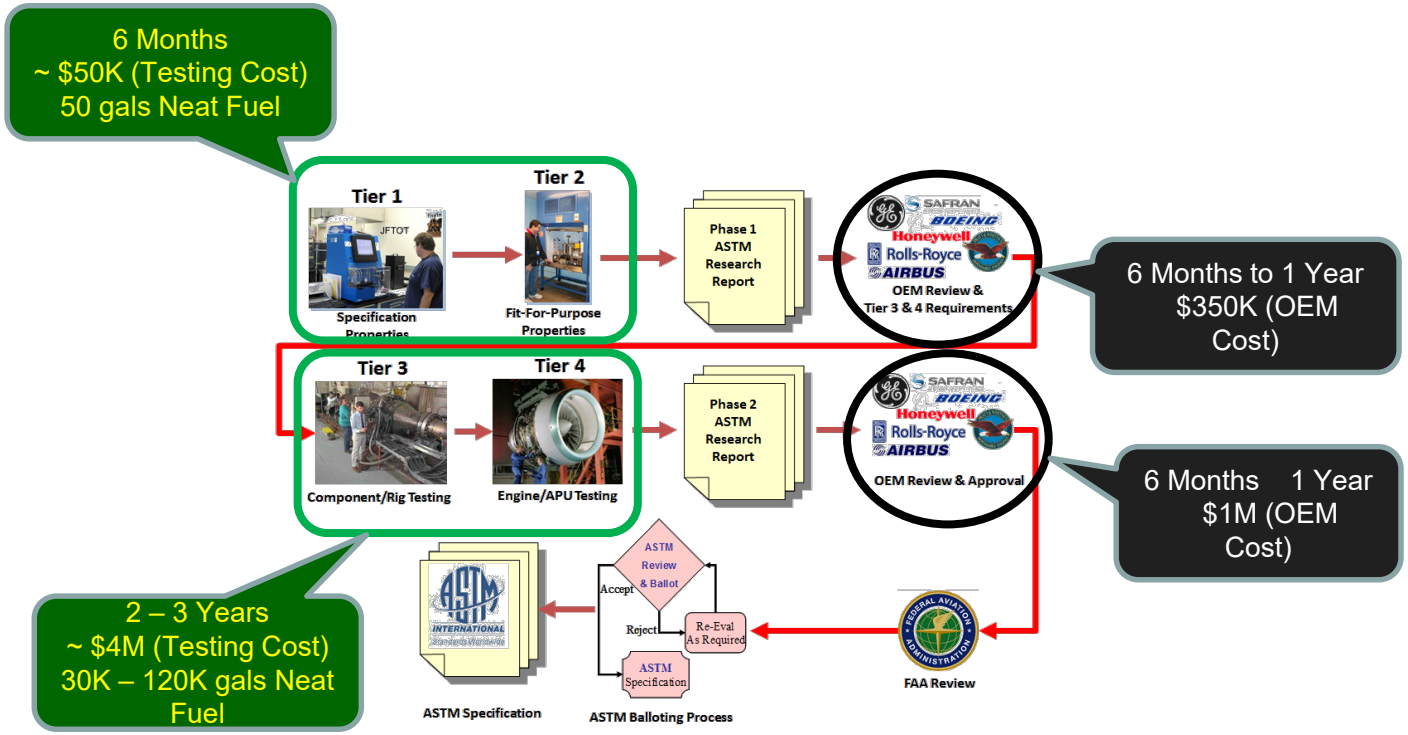
- Aviation will be the last user of petroleum and biofuels for aviation are not feasible…
  - Widely held view in 2006 – but not one that was held by the aviation industry that created CAAFI

- Commercial production of HEFA fuel begins at Alt Air facility in 2016

- Potentially more than 250 million gallons per year of production in 2025

Back up slides

D4054 Typical Costs & Time Requirements



Notes:

- Assumes 50% blend ratio
- Does not include OEM or producer overhead/admin costs
- Time duration does not include inactive waiting periods