

Federal Alternative Jet Fuels R&D Strategy

Research, Development, Demonstration, & Deployment (RD3)

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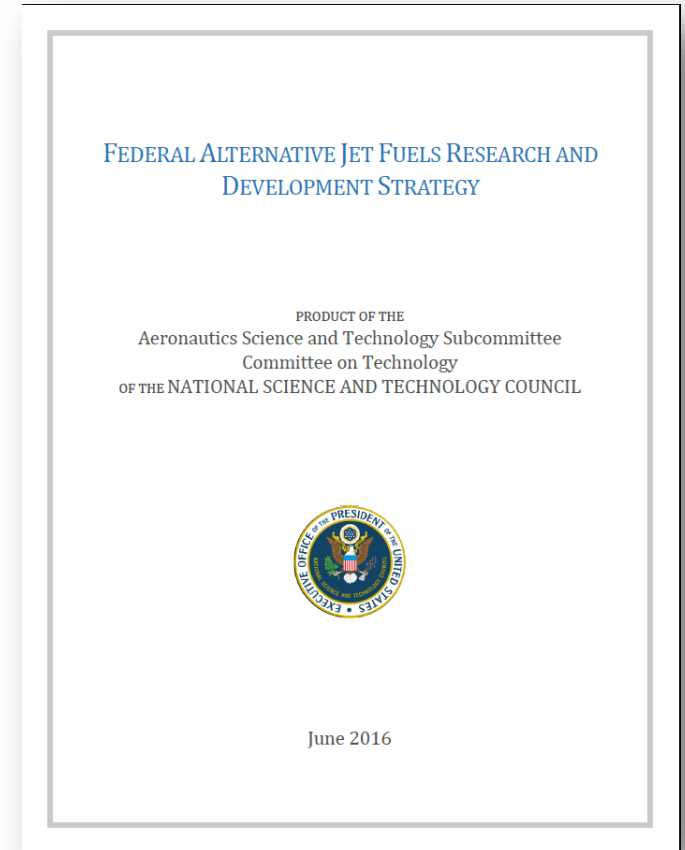
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CAAFI Biennial General Meeting 2016
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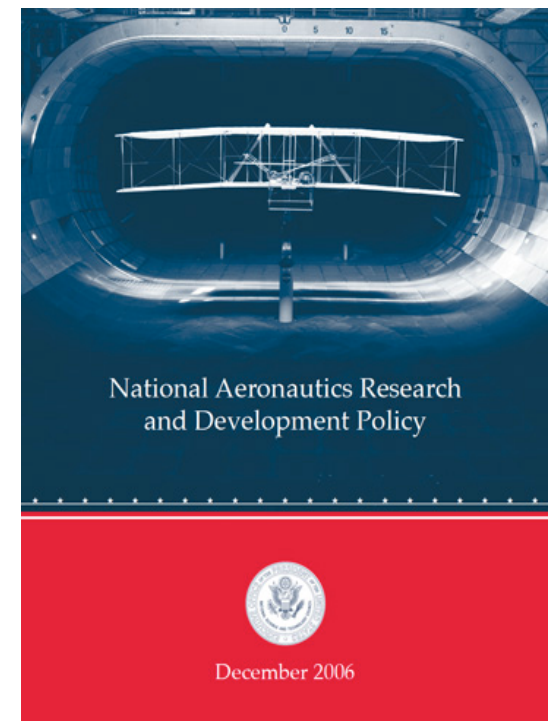
Genesis for Strategy

National AERO R&D Plan focuses on 17 aeronautics goals in four areas –

- “Mobility, Security, Safety and Environment & Energy”
- Energy Availability, Efficiency & Environmental Protection
 - Goal 1: “Enable new aviation fuels derived from diverse & domestic resources to improve fuel supply security & price stability”

Federal AJF R&D Strategy - Intended Purpose

Identify opportunities and strategically address RD3 challenges along the development path of alternative jet fuels.



An undertaking by the Aeronautics Science & Technology Subcommittee (ASTS) of the NSTC with input from stakeholders community.

Idea to develop Strategy was seeded in 2010.

Federal AJF R&D Strategy

Intended to:

- **Articulate** *Aspirational yet Achievable* Objectives, *Measurable* Performance Metrics and Timeline to achieve the goal
- **Mobilize** the federal and non-federal stakeholders community towards achieving the common goal and objectives
- **Understand** industry needs and align federal strategic R&D efforts
- **Integrate**, align and coordinate interagency activities
- **Promote** increased collaboration
- **Enhance** technology transfer
- **Help** federal agencies to make their business cases to secure funding for AJF R&D activities

FEDERAL ALTERNATIVE JET FUELS RESEARCH AND DEVELOPMENT STRATEGY

PRODUCT OF THE
Aeronautics Science and Technology Subcommittee
Committee on Technology
OF THE NATIONAL SCIENCE AND TECHNOLOGY COUNCIL



June 2016

Overarching Statement of the Strategy

Strategy sets out prioritized Federal R&D goals and objectives to address key scientific and technical challenges that inhibit the development, production, and use of economically viable alternative jet fuels that would provide environmental and social benefits relative to conventional fuels while enhancing U.S. energy security.

Emphasis is on technical challenges that can be addressed by Federal R&D activities.

Strategy acknowledges that there are policy challenges, however, they are outside the R&D scope of this strategy.

AJF Development Path, R&D Themes and Federal Role

Theme 1

R&D Goals and Objectives for Feedstock Development, Production, and Logistics

Theme 2

R&D Goals and Objectives for Fuel Conversion and Scale-Up

Theme 3

R&D Goals and Objectives for Fuel Testing and Evaluation

Feedstock Development & Production

Feedstock Logistics

Fuel Conversion

Fuel Conversion Scale-Up

Fuel Testing & Evaluation

Production & Deployment

End User

R&D Goals and Objectives for Integrated Challenges

Theme 4



Feedstock Development & Production



Feedstock Logistics



Fuel Conversion



Fuel Conversion Scale-Up



Fuel Testing & Evaluation



Integrated Challenges

DOC	X					X
DoD			X	X		
DOE	X	X	X			X
DOT					X	X
EPA						X
NASA					X	
NSF	X	X	X			
USDA	X	X	X			X

Strategy Outline

- Executive Summary
- Introduction
- Purpose and Scope
- AJF Development Path
- **R&D Goals and Objectives**
 - [3 time horizons: near-(<5 years); mid-(5-10 years); and far-(>10 years) terms]**
 - Feedstock Development, Production, and Logistics
 - Fuel Conversion and Scale-Up
 - Fuel Testing and Evaluation
 - Integrated Challenges
- Non-Technical Challenges
- Federal Coordination
- Public-Private Partnerships
- International Coordination
- Conclusions
- Appendix 1 Agency-Specific Contributions to Research and Development of Alternative Jet Fuels
- Appendix 2 Multi-Agency Activities that Contribute to Research and Development of Alternative Jet Fuels
- **Appendix 3 Federal AJF R&D Goals and Objectives**
 - R&D Goals and Objectives: Feedstock Development, Production, and Logistics
 - R&D Goals and Objectives for Fuel Conversion and Scale-Up
 - R&D Goals and Objectives for Fuel Testing and Evaluation
 - R&D Goals and Objectives for Integrated Challenges
- Available at:
https://www.whitehouse.gov/sites/default/files/federal_alternative_jet_fuels_research_and_development_strategy.pdf

Federal Coordination (per the Strategy)

To enable continued coordination of Federal AJF R&D efforts –

- AJF-Interagency Working Group (IWG) to continue under the auspices of the NSTC's ASTS.
- IWG will continue to include representatives from appropriate Federal agencies & will serve as a focal point for Federal interagency coordination
- IWG will work in conjunction with existing formal and informal interagency coordination mechanisms and public-private initiatives to augment those efforts.
- **IWG will ensure that duplication is avoided since it will have a lead role in the implementation of this Strategy, including:**
 - informing program, budgeting, and prioritization decisions;
 - coordinating activities;
 - identifying outcomes (e.g., joint competitive solicitations, joint review of proposals);
 - performing progress assessment;
 - engaging stakeholders; and
 - making recommendations to agencies toward meeting evolving R&D needs.

Post-Release Activities

- Convened a Fed-only workshop (September 9) on strategy roll-out and to develop plans for post-release implementation activities
- Strategy roll-out at ASCENT (September 28, 2016) and CAAFI (October 25-27, 2016) meetings
- Develop and execute structured framework for IWG engagement on Strategy implementation and progress assessment

Federal Alternative Jet Fuels R&D Strategy

Feedstock Development, Production and Logistics

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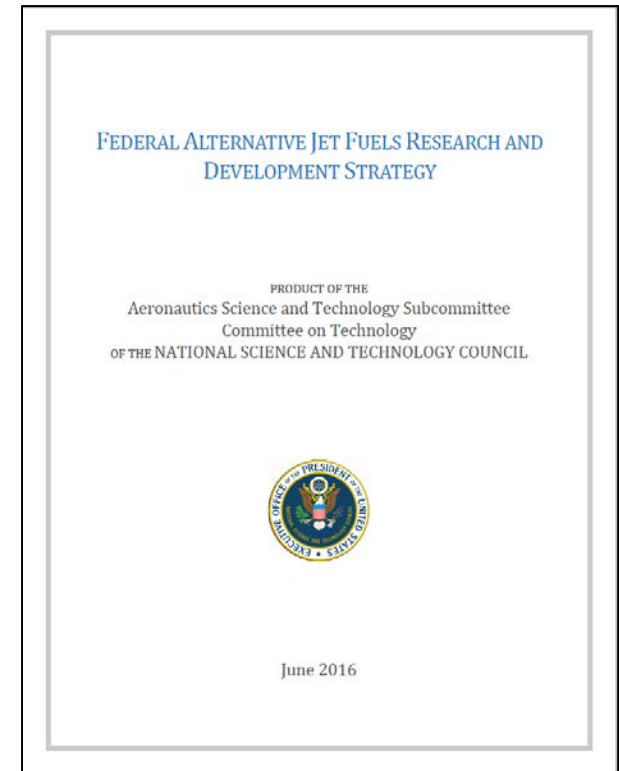
Harry Baumes, Ph.D.

Office of Energy Policy and New Uses, USDA

Theme Leads: Feedstock Development, Production,
and Logistics

FAJFS Interagency Working Group

Presented at the CAAFI Biennial General Meeting
October 27, 2016



Feedstock Development, Production, and Logistics

Challenges Identified

- Feedstock quantity (supply), quality, and cost
- Integration and optimization of feedstock/residual availability with: sustainable production and harvest/residual or MSW collection; optimized logistics (bulk density reduction, transportation, storage); preprocessing; and conversion
- Long time-frame for biomass feedstock genetic development (10-15 years)
- Need to match regionally-available feedstock with emerging/extant conversion platforms and logistics chains
- Interface logistics at biorefinery: feeding biomass into biorefinery; materials handling challenges

Feedstock Development, Production and Logistics

Goals and Examples of Agency-specific Activities Addressing Near-term Objectives

- 1. FEEDSTOCK DEVELOPMENT:** Increase crop yields (tons/acre), water and nutrient use efficiency, as well as pest and disease resistance, and improve feedstock conversion characteristics (DOC, DOE, NSF, USDA)
 - Benchmark readiness of existing and alternative regional feedstocks quantity, quality, and cost needed for extant or emerging conversion platforms (**DOE, USDA**)
 - Identify public and private sources for regional feedstock candidates and catalog characteristics to understand where research gaps exist (**DOE, NSF, USDA**)
 - Set up feedstock improvement programs/partnerships to facilitate accelerated crop improvement (**DOE, USDA**)
 - Leverage existing feedstock improvement programs, genetic/genomic information (**DOE, USDA**)
 - Develop risk management tools such as crop insurance to promote dedicated bioenergy crop production (**USDA**)

EXAMPLES:

USDA ARS & FS collaborative and intramural research

- Biomass Research Centers for bio-based renewable energy (feedstocks plus entire supply chain)

USDA's Coordinated Agricultural Projects (CAPs) within the Sustainable Bioenergy Challenge Area.

- SUBI/ARS developed cold tolerant high yielding energy cane, allowing cane production north of the Gulf Coast.



Feedstock Development, Production and Logistics

Goals of Agency-specific Activities

- 2. FEEDSTOCK PRODUCTION:** Develop sustainable feedstock production systems that require minimal inputs, have a high tolerance for environmental stress, and minimize the risk of adverse environmental impacts (e.g., invasiveness, erosion) (DOE, USDA)
 - Identify/evaluate/ leverage past/current regional R&D to understand gaps/needs (DOE, USDA)
 - Leverage/build regional R&D partnerships including local communities, universities, industry, government, and non-governmental organizations (NGOs) (DOE, USDA)
 - Set up/leverage sub-commercial-scale test sites to perform R&D with existing genotypes/residuals (DOE, USDA)
 - Train regional extension/tech transfer specialists who will interface with producers (farmers/ forest landowners), processors, and communities (USDA)
 - Identify regional workforce requirements across supply chains (USDA)

EXAMPLES:

- Sun Grant/DOE Feedstock Partnerships
- USDA CAPs:
 - NEWBio (led by PSU)
 - Advanced Harwood Biofuels (led by UW)



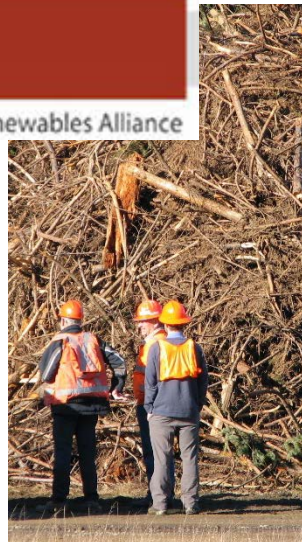
Feedstock Development, Production and Logistics

Goals of Agency-specific Activities

3. **FEEDSTOCK LOGISTICS:** Improve harvesting, collection, storage, densification, pretreatment, and transportation of physical biomass to the conversion facility (DOE, NSF, USDA)
4. **FEEDSTOCK LOGISTICS:** Improve collection, storage, densification, pretreatment, and transportation of municipal solid waste (MSW) to the conversion facility (DOE)
 - Identify/evaluate/leverage past/current regional R&D to understand gaps/needs (DOE, USDA)
 - Study the impact of changes in regional logistic scenarios on the quality of existing feedstock/residue/MSW and bio-based product/ co-product options (DOE, NSF, USDA)
 - Identify targets for reducing costs, minimizing feedstock losses, and enhancing quality at every step of the regional logistic chain (DOE, USDA)
 - Establish/leverage feedback loops from regional AJF conversion platforms (DOE, USDA)

EXAMPLE:

- USDA CAP: NARA (led by WSU) worked out the logistics to convert forest residuals to fermentable sugars to produce AJF for an Alaska Airlines commercial demonstration flight.



Federal Alternative Jet Fuels R&D Strategy

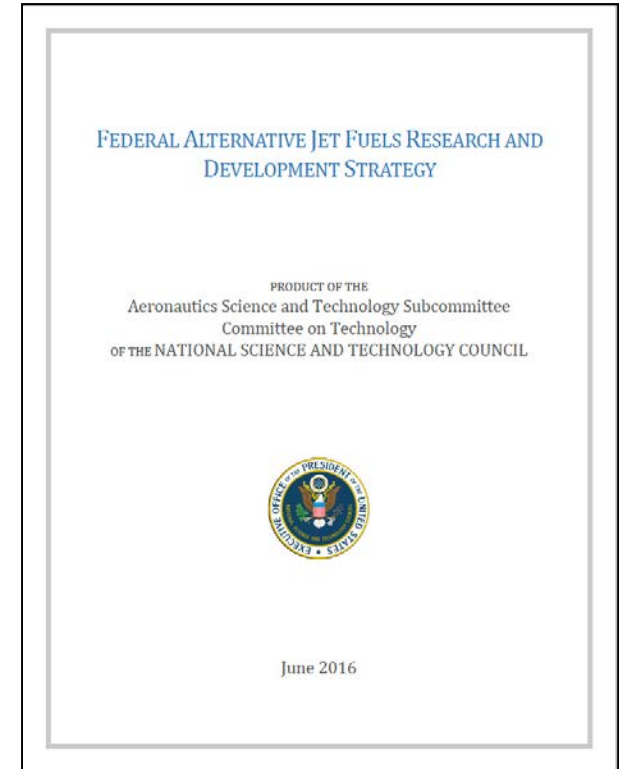
Fuel Conversion and Scale Up

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Theme Leads: Fuel Conversion and Scale Up
FAJFS Interagency Working Group

Presented at the 2016 CAAFI General Meeting

October 27, 2016



Conversion and Scale-up Challenges

- High cost of production such that alternative fuels cannot compete without subsidies
- Lack of sufficient volume of fuels produced at commercial scale
- Competing markets for renewable diesel and jet fuel
- Conversion processes have to be robust enough to handle heterogeneous nature of feedstocks
- Testing at bench, pilot, and demonstration scales are essential to debug the process which translates into cost

Fuel Conversion and Scale-up

- 1. New conversion technologies** - Discovery, development, and scale-up of conversion processes with improved yield, efficiency, and energy requirements that lead to cost-competitive alternative jet fuels (DOD, DOE, NSF, USDA)
 - Increasing catalyst lifetime
 - Removing oxygen efficiently
 - Producing pre-cursors that can be easily converted to jet fuel
- 2. Production of jet fuel at distributed scale** - Develop conversion technologies that can produce jet fuel from multiple feedstocks in a distributed manner (DOD, DOE, NSF, USDA)
 - Co-feeding biomass, wastes, other feedstocks
 - Utilizing stranded resources (flared natural gas, biomass, industrial waste gases)

New Conversion Technologies, Distributed Scale - DOE

- Near term - Ongoing effort, need more technology diversity, currently focused on pyrolysis
- Mid-term – Research and investment needed in process intensification, improved separation processes
- Feedstocks – lignocellulosic biomass, algal biomass
- Conversion processes – Fast pyrolysis, catalytic conversion
- Production of jet fuel at distributed scale – Requires investment, new funding opportunity needed



Federal Alternative Jet Fuels R&D Strategy

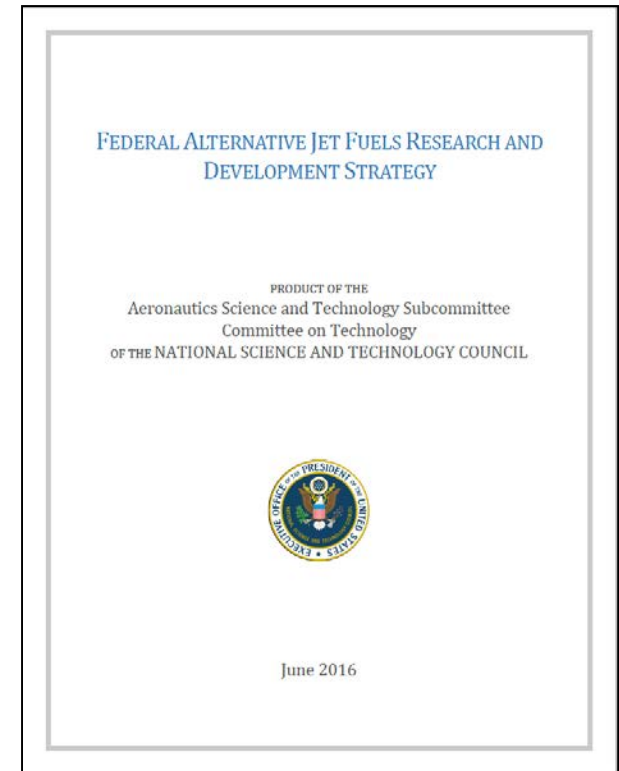
Fuel Testing and Evaluation

Nate Brown (DOT), Tim Edwards (DOD)
& Angela Surgenor (NASA)

Theme Leads: Fuel Testing and Evaluation
FAJFS Interagency Working Group

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CAAFI Biennial General Meeting

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Fuel Testing and Evaluation

Challenges Identified

- Cost, time & uncertainty of civil and military approvals of AJF is burdensome
- Limited understanding how composition of AJF impacts operability of the gas turbine engines
- Limited understanding how fuel composition and emissions impact the environment

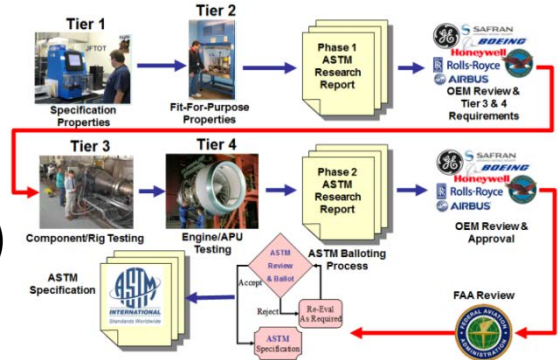
Fuel Testing and Evaluation: Goals and Sample Near-term Objectives

- 1. Facilitate civil and military approval of additional AJF pathways by enabling efficient evaluation for performance and safety through advancement of certification and qualification processes and collection and analysis of data (DOD, DOT, NASA)**
 - Support capability to perform all testing required by ASTM D4054 and military specifications, including fuel property testing, component/rig testing, and aircraft engine testing to complete evaluation for viable alternative jet fuel pathways **(DOD, DOT)**
 - Advance fuel composition and combustion performance modeling, experimentation, and analysis **(DOD, DOT, NASA)**
 - Develop improved test methods for certification and qualification that allow for more rapid, efficient and less costly fuel evaluation to support approvals **(DOD, DOT, NASA)**
- 2. Improve scientific understanding of how AJF composition impacts gas turbine combustion emissions and operability (DOC, DOD, DOT, NASA)**
 - Establish national databases of alternative jet fuel engine operability testing and combustion emissions data and analyses **(DOC, DOT)**
 - Support AJF turbine engine combustion emissions measurements and analysis **(DOD, DOT, NASA)**
 - Examine dependence of variations in jet fuel composition on magnitude and types of combustion emissions **(DOD, DOT, NASA)**

Fuel Testing and Evaluation: Examples of federally funded activities

Goal 1:

- CLEAN Testing, USAF & Navy Testing & ASCENT Project 31 "Alternative Jet Fuel Test & Evaluation" (DOD, DOT)
- Jet Fuel Property Tracking Project (DOT)
- CAAFI and ASTM "quick start" approach (DOD, DOT)
- National Jet Fuel Combustion Program (NJFCP) (DOD, DOT, NASA)



Goal 2:

- ASCENT Project 33 "Alternative Fuels Test Database Library" & NIST thermophysical properties experimental, modeling, and data activities.
- DOD emissions measurements during combustion testing of alternative fuels and DOD modeling efforts through SERDP.
- ASCENT Projects 13 "Micro-Physical Modeling & Analysis of ACCESS 2 Aviation Exhaust Observations" & 24 "Emissions Data Analysis for CLEAN, ACCESS, and Other Recent Tests"
- NASA's AATT, ACCESS2 and ECLIF-2 programs on contrails
- NASA's Low NOx Combustion Tests with the capability of real-time Alternative Fuel blending;



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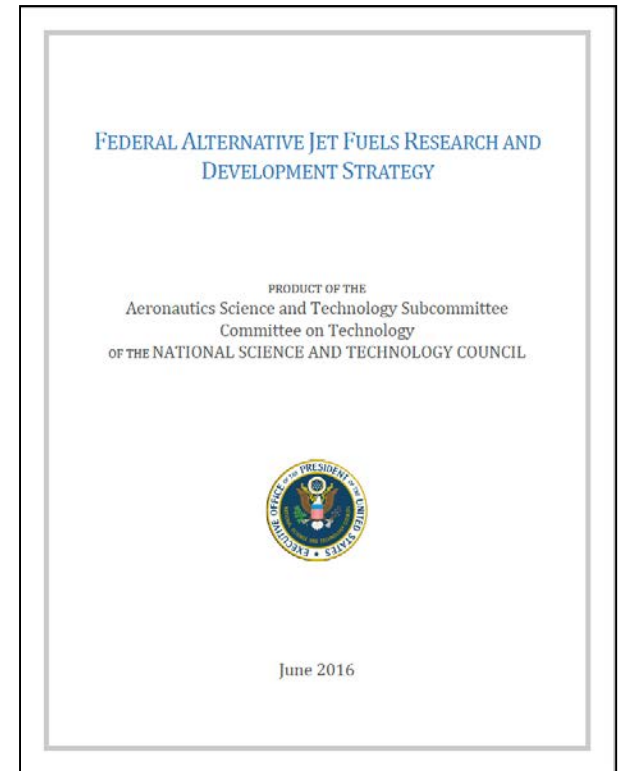
Integrated Challenges

Dan Friend (NIST), Bret Strogon (DOD),
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Theme Leads, Integrated Challenges
FAJFS Interagency Working Group

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Integrated Challenges

Challenges Identified

- Availability, accessibility, integration, and quality of required **data** across the development/supply chain.
- Clear understanding of **indices and metrics** for environmental, economic, and social measures of AJF sustainability across the development/supply chain.
- Comprehensive appreciation of **regional, National, and global** aspects of the AJF enterprise across the development/supply chain.

Integrated Challenges: Goals and Sample Near-term Objectives

1. Advance understanding of and improve environmental sustainability of AJF production and use (DOC, DOT, EPA, USDA)

- Advance the scientific understanding of environmental impacts of AJF production and use on all relevant scales, including those related to life-cycle emissions that impact climate change and environment (DOC, DOT, EPA, USDA)
- Improve capabilities to assess natural resource requirements for AJF production and use on regional and national scales (DOC, DOT, USDA)

2. Develop and validate a comprehensive systems model to support viable AJF deployment (DOD, DOE, DOT, EPA, USDA)

- Identify and quantify the elements and interactions among elements that are required to develop a systems model that can be used to create regional and national scenarios for AJF deployment that reflect criteria for environmental, economic and social sustainability (DOT, EPA, USDA)
- Advance techno-economic and regional development path analyses of AJF (DOE, DOT, EPA)

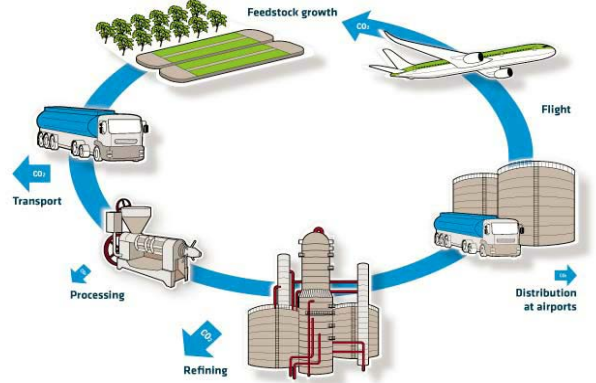
3. Promote communication, as well as, scientific and technical R&D best practices for the National enterprise (DOC, DOE, DOT, USDA)

- Facilitate the dissemination of scientific & technical information via improved access to Federally funded research results. (DOC, DOE, DOT)

Integrated Challenges: Examples of federally funded activities

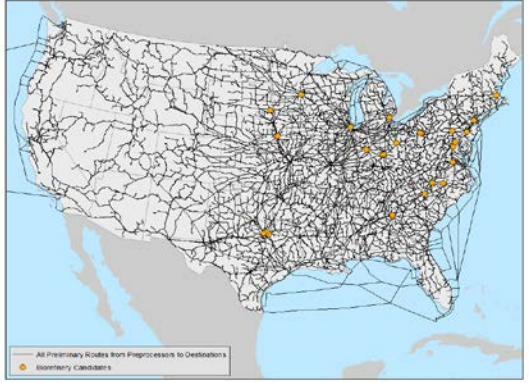
Goal 1:

- Integrate USDA and DOE efforts to advance analytical understanding of feedstock and fuel production, respectively (e.g., *Farm to Fly*, *CAAFI*)
- ASCENT Projects: "Supply Chain Analysis" (LCA) & "Worldwide LCA of Petroleum Fuels"
- Argonne National Labs GREET model



Goal 2:

- NREL Biomass Scenario Model
- ASCENT Projects: "Supply Chain Analysis" (scenarios, techno-economics, and social sustainability) & Volpe Alternative Fuels Transportation Optimization Tool)



Goal 3:

- Commercial Aviation Alternative Fuels Initiative (CAAFI)
- ASCENT Center of Excellence (e.g., *AJF Test Database Library*, *Supply Chain Analysis*)

