NASA Aeronautics Research

Alternative Fuel Focus & Inter-Agency Coordination

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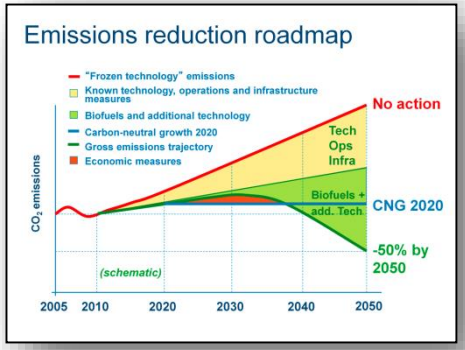
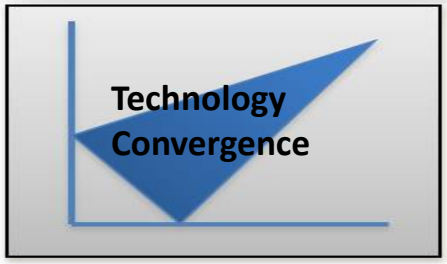
Graphic: NASA/Maria Werries

NASA Aeronautics

Research is organized into six relevant themes.

3 Mega-Drivers





6 Strategic Research & Technology Thrusts

Safe, Efficient Growth in Global Operations

- Enable full NextGen and develop technologies to substantially reduce aircraft safety risks

Innovation in Commercial Supersonic Aircraft

- Achieve a low-boom standard

Ultra-Efficient Commercial Vehicles

- Pioneer technologies for big leaps in efficiency and environmental performance

Transition to Low-Carbon Propulsion

- Characterize drop-in alternative fuels and pioneer low-carbon propulsion technology

Real-Time System-Wide Safety Assurance

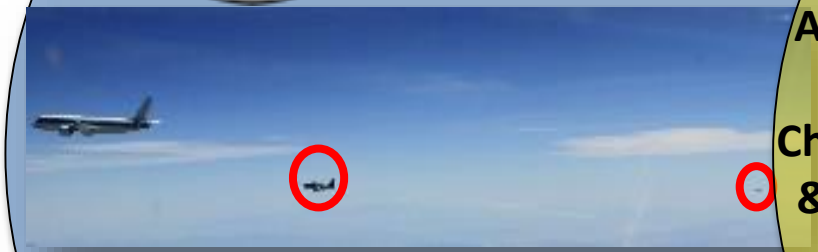
- Develop an integrated prototype of a real-time safety monitoring and assurance system

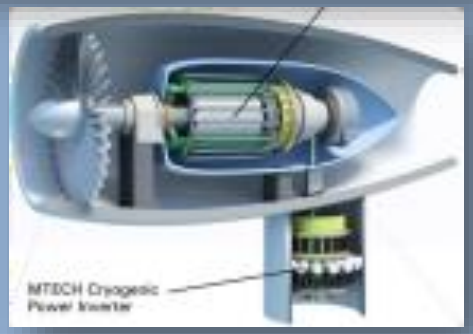
Assured Autonomy for Aviation Transformation

- Develop high-impact aviation autonomy applications

Overlapping Interests: NASA & the Alternative Jet Fuel Enterprise

NASA Strategic Thrust: Transition to Low-Carbon Propulsion





Alternative Jet Fuel Characterization & Combustion Science

National Alternative Jet Fuel Enterprise → Strategy

Alternative Jet Fuels

Part of the Solution – along the path of Low Carbon Propulsion

- Sustainable Alternative Fuels are key to meeting environmental goals of the future global Aviation System
- Significant interest & investment in alternative fuels as a viable substitute or complement to existing petroleum resources.
- 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
  - Fund research
  - Share information
  - Support transition from development to deployment
- Address the whole supply chain - broad array of agencies and stakeholders need to be involved
- Leverage expertise and programs of other government agencies and other countries
- Work through Public-Private Partnerships--industry must drive effort
- **United States FAA Goal: 1 Billion gallons of renewable jet fuel by 2018**

Bottomline:

➢ Energy Security ➢ Environmental Sustainability ➢ Social & Economic Benefits

Source: FAA briefing at ICAO Aviation & Sustainable Alternative Fuels Workshop, October 2011

Diverse R&D Challenges

- Feedstocks
  - Varieties and geographical diversity
  - Production and yield efficiency
  - Sustainable and dependable supply
- Conversion efficiency and commercial scale production
- Jet fuel specificity and demand for byproducts
- Cost-competitiveness
- ASTM approval for performance, safety and operability
- Environmental sustainability and resource demand

Coordination Efforts

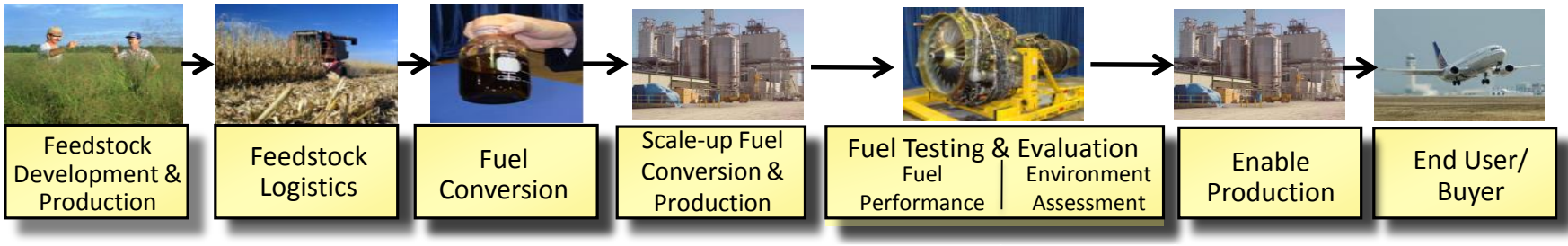
Coordination needed across all links in the development path

Alternative Jet Fuel Development Path

Economic and environmental sustainability analysis across entire development path

Feedstock Production	Feedstock Logistics	Fuel Conversion	Conversion Process Scale-up/Integration	Fuel Testing/Evaluation: Fuel Performance / Environment Assmt	Enable Production	End User/ Buyer
• R&D for feedstock options & cost • Reduce cost & risk of feedstock production • Reduce cost to finance first-of-a-kind plants	• R&D for conversion & improved conversion cost	• R&D for testing of fuels; transparent process for certification/qualification • Improve analysis of benefits & work towards converging standards for crediting	Production incentives; investment			• Fuel purchases • Guidance for airport use/handling

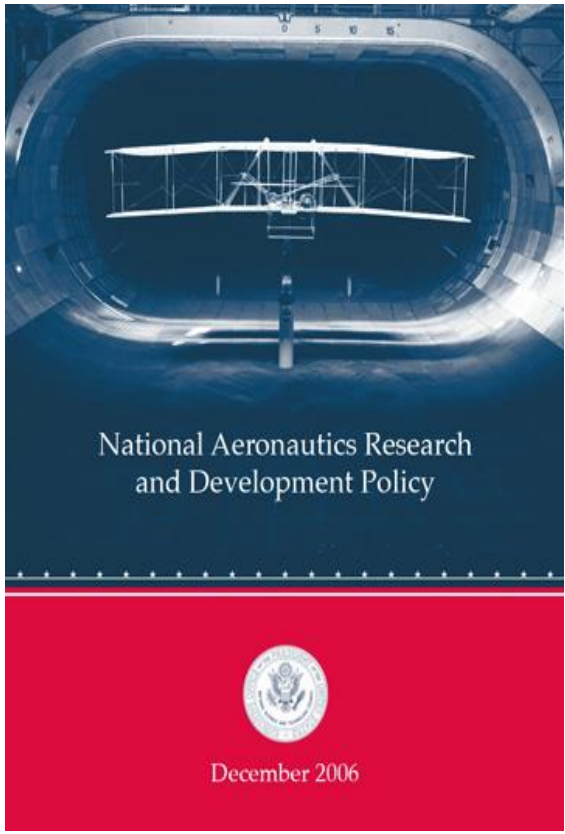
AJF Development Path: Interagency Contributions



	Feedstock Development & Production	Feedstock Logistics	Fuel Conversion	Scale-up Fuel Conversion & Production	Fuel Testing & Evaluation: Fuel Performance	Fuel Testing & Evaluation: Environment Assessment	Enable Production	End User/ Buyer
USDA	✓	✓	✓	✓	---	✓	✓	✓
DOC	✓	---	✓	✓	✓	✓	---	✓
DoD	---	---	---	---	✓	✓	✓	✓
DOE	✓	✓	✓	✓	---	✓	✓	---
EPA	---	---	---	---	---	✓	✓	---
FAA	---	✓	---	✓	✓	✓	---	✓
NASA	---	---	---	---	✓	✓	---	---
NSF	✓	✓	✓	---	---	---	---	---

US Aeronautics R&D Policy

National Aeronautics Research & Development Policy and Plan



The Plan focuses on 17 aeronautics goals in four areas –

- Mobility,
- Security,
- Safety
- Environment and Energy

Energy Availability, Efficiency & Environmental Protection

- Goal 1: "Enable new aviation fuels derived from diverse & domestic resources to improve fuel supply security & price stability"

National Alternative Jet Fuel Strategy being developed under the sponsorship of:

National Science & Technology Council;
Aeronautics S&T Subcommittee (ASTS)

National Alternative Jet Fuels R&D Strategy

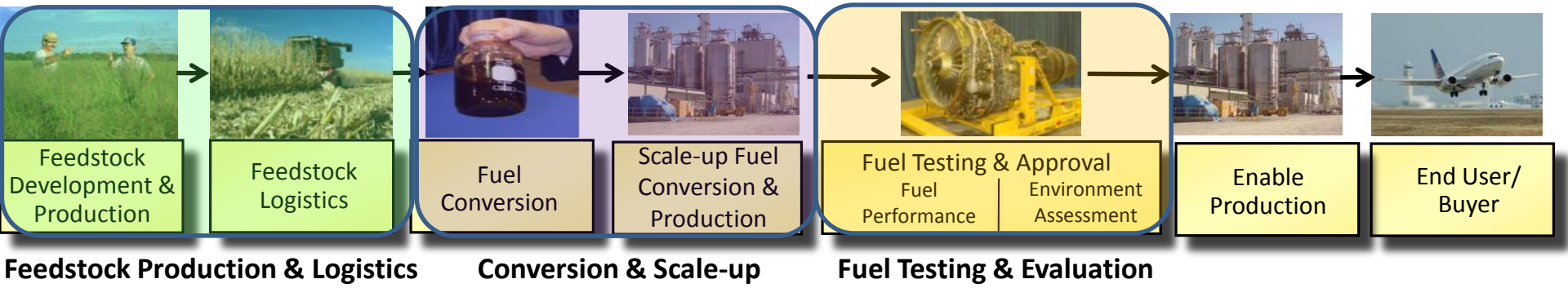
Intended Purpose

Identify opportunities and strategically address challenges associated with Research, Development, Demonstration, and Deployment (RD3) along the development path of alternative jet fuels.

National AJF R&D Strategy – A mechanism 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 to address RD3 challenges along the alternative jet fuels supply-chain
- **Integrate**, align and coordinate interagency activities
- **Promote** increased collaboration
- **Enhance** technology transfer

National Alternative Jet Fuels R&D Strategy

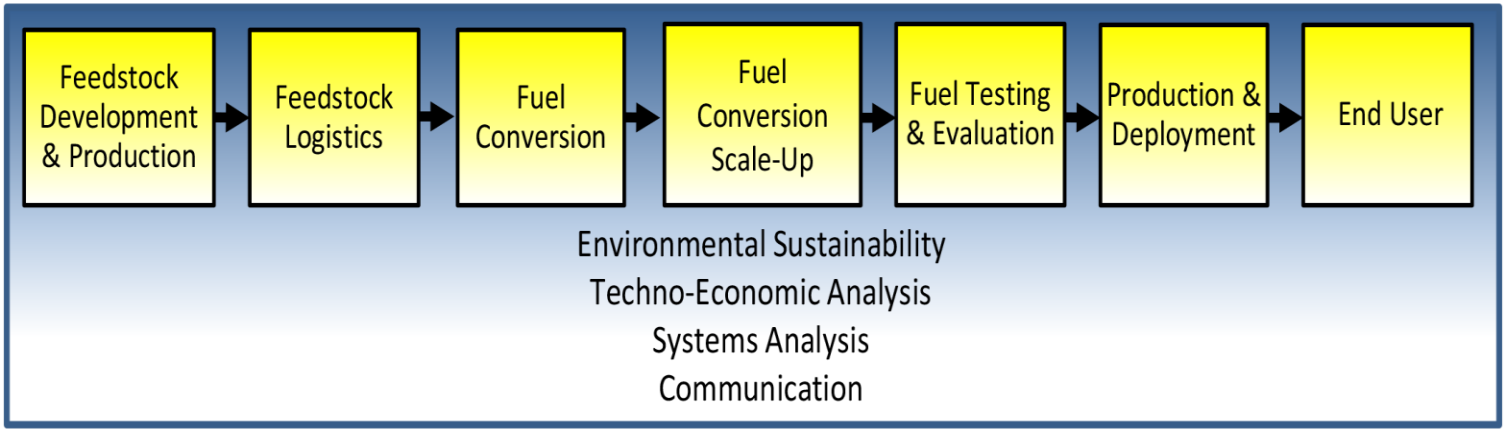


Organization of Strategy Goals and Objectives

- Three thematic topic sections
  - Feedstock Development, Production and Logistics
  - Fuel Conversion and Scale-up
  - Fuel Testing & Evaluation (including certification and qualification)
- Section on Integrated Challenges – considerations that span entire development path and the interfaces
- Categorized objectives along three time horizons: Near- (<5 years), Mid- (5-10 years) and Far- (>10 years) term - similar to National Aeronautics R&D Plan
- Acknowledge non-R&D context of policy (e.g., RFS), economic factors/challenges, & international considerations

Alternative Jet Fuels Development Path: System-Wide Challenges & Non-Linearities

A complex enterprise in which the elements of the Development Path are inter-related.



- Strategy document utilizes the linear model of the Development Path.
- However, each of the elements of the Development Path are influenced by other elements. Examples:
  - Current and projected demand by End Users directly affects the desirability of investment in Feedstock Development & Production and Fuel Conversion & Scale-Up.
  - Perceptions about the complexity and amount of fuel required to succeed in the fuel certification process (part of Fuel Testing and Approval) directly affect the desirability and investment needed in Fuel Conversion Scale-Up.
- Strategy recognizes these interactions and provides rationale for cross-cutting efforts that integrate multiple elements of the Development Path.

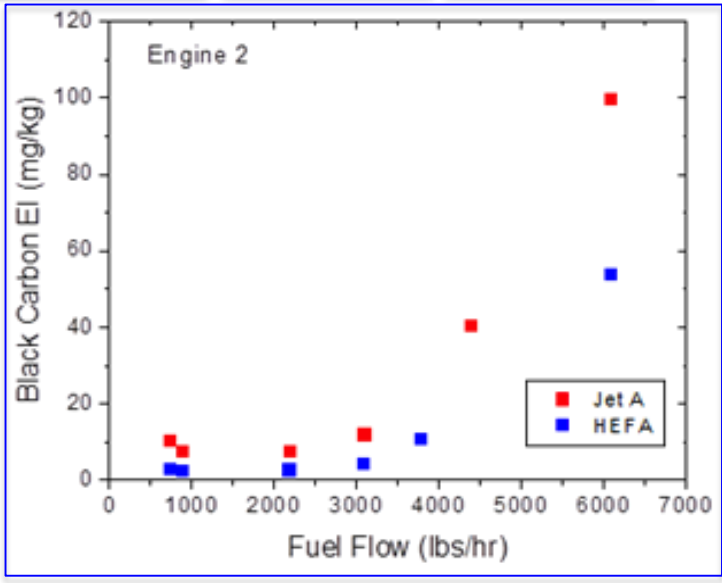
NASA Alternative Fuels Research

Environmental Assessment

Feedstock Production → Feedstock Logistics → Fuel Conversion → Conversion Process Scale-up/Integration → Fuel Testing/Evaluation (Fuel Performance | Environment Assmt) ✓ → Enable Production → End User/ Buyer

AAFEX-1 & AAFEX-2 – Ground Experiments Engine Exhaust Measurements

1. Characterize the effects of alternative fuels on engine emissions
2. Fuels tested: JP-8, F-T, F-T blends, HRJ, HRJ blends, high-sulfur F-T
3. Volatile & non-volatile particulates substantially reduced.



ACCESS2 – Flight Experiment; Engine Exhaust Measurements

1. Multiple chase aircraft in situ measurements
2. Evaluate fuel effects on engine performance, cruise-altitude gas & particle emissions
3. Investigate the role of soot concentrations/properties and fuel sulfur content in regulating contrail formation & microphysical properties

Laboratory Experiments; Altitude Simulation of Aircraft Cruise & Emissions

1. Simulate gas turbine particle emissions & cruise altitude for Jet-A & alternative fuels
2. Evaluate role of soot physical properties on the formation of contrail ice particles

NASA Alternative Fuels Research

Fuel Performance



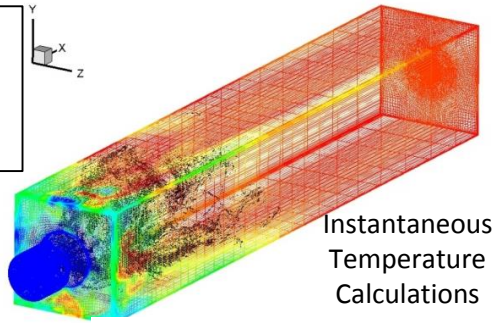




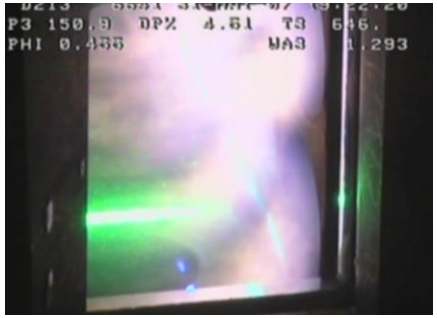
Feedstock Production → Feedstock Logistics → Fuel Conversion → Conversion Process Scale-up/Integration → ✓Fuel Testing/Evaluation (Fuel Performance | Environment Assmt) → Enable Production → End User/ Buyer

Develop Combustion Models – JP-8 & Alternative Fuels

Calculations include two-phase flow physics, fuel chemistry/reactions, & emissions



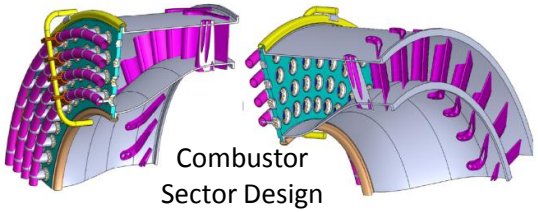
Instantaneous Temperature Calculations



Flametube Test with Laser Diagnostics

Fundamental Combustion Lab Experiments - Validation Data Using JP-8 and Alternative Fuels

1. Detailed temperature & pressure distribution measurements
2. Combustion emissions measurements
3. Compare against calculations



Combustor Sector Design

Develop Combustion Concepts taking Advantage of Alternative Fuels Properties

1. Predict performance & emissions using combustion models & simulation
2. Validate performance & emissions with flametube experiments

→

Develop Combustor Concepts

1. Design advanced combustors
2. Predict performance & emissions using combustion models & simulation
3. Validate performance & emissions with sector & full annular experiments

Summary

- US Agencies recognize the complex, inter-related nature of the alternative jet fuel enterprise.
- The complexity of the enterprise warrants close, inter-agency communication and coordination.
- Federal Agencies have self-organized to not only more closely coordinate but also codifying their coordination and common goals in an actionable National strategy.