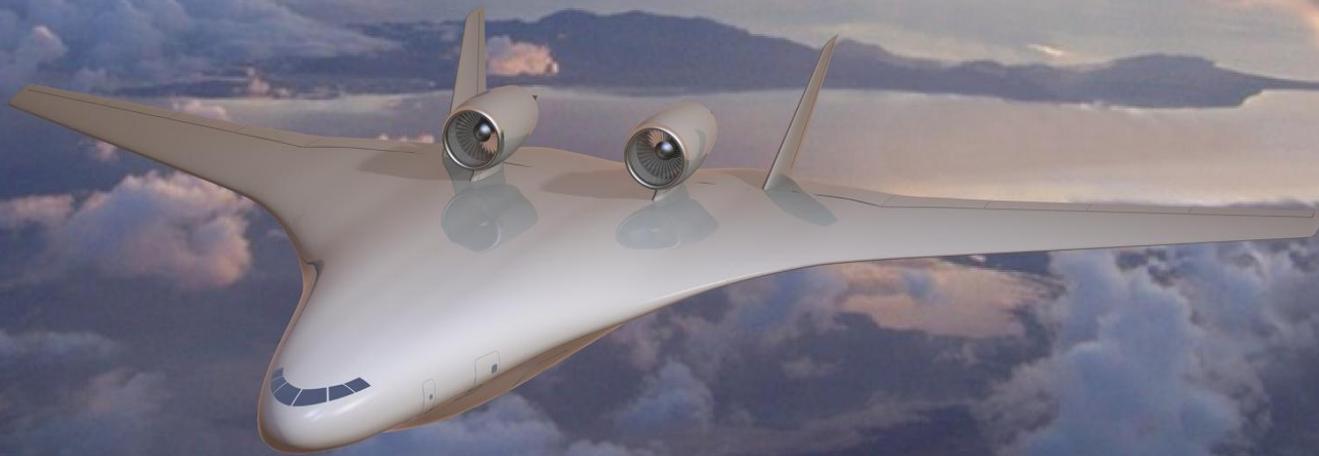


Aeronautics Committee Report to the NASA Advisory Council

Ms. Marion Blakey (Chair)
March 8, 2012





- Members:
 - Ms. Marion Blakey (Chair)
 - Dr. Ilan Kroo
 - Dr. Mark Lewis**
 - Dr. R. John Hansman**
 - Mr. Mark Anderson
 - Mr. Paul Adams**
 - Dr. Harry McDonald**
 - Dr. John Langford
 - Mr. John Borghese
 - Dr. Ray Colladay (ex-officio)
- Plans for next meeting: Face-to-face Committee Meeting at NASA Headquarters, June, 2012.

FY 2013 President's Budget Request

Program Funding

Budget Authority (\$M)	FY 2011	FY 2012	Outyears are notional				
	Actual	Estimate	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
Aeronautics	\$533.5	\$569.4	\$551.5	\$551.5	\$551.5	\$551.5	\$551.5
<u>Aeronautics Research</u>	<u>533.5</u>	<u>569.4</u>	<u>551.5</u>	<u>551.5</u>	<u>551.5</u>	<u>551.5</u>	<u>551.5</u>
Aviation Safety	67.3	80.1	81.1	81.0	81.4	81.9	82.5
Airspace Systems	87.2	92.7	93.3	92.6	91.9	91.2	90.5
Fundamental Aeronautics	206.3	186.3	168.7	171.3	173.3	175.3	177.1
Aeronautics Test Program	76.4	79.4	78.1	78.0	78.0	78.1	78.2
Integrated Systems Research	75.9	104.2	104.0	102.3	101.2	100.1	98.8
Aero Strategy and Management	20.4	26.7	26.4	26.2	25.7	25.0	24.4

Areas of Interest Explored at Current Meeting

Topics covered at the Aeronautics Committee meeting held on October 13, 2011 at NASA Headquarters:

Aeronautics Green Aviation Research Portfolio*

Interagency Relationships for Alternative Fuels*

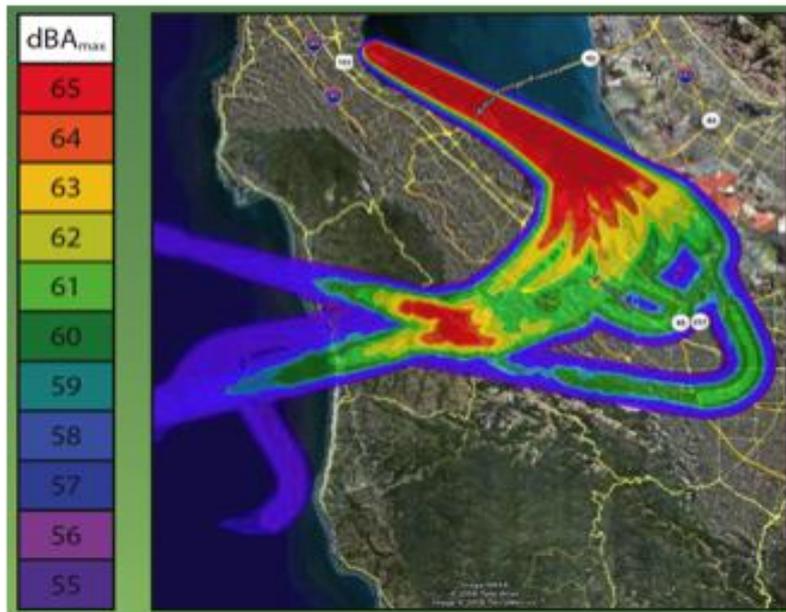
Unmanned Aircraft Systems (UAS) Subcommittee Status

Aeronautics Committee 2012 Work Plan

* This topic has a related finding provided by the Aeronautics Committee

Fundamentals of Green Aviation

- Minimize the energy required to achieve the mission
- Minimize the impact of energy use
- Minimize noise



Green Aviation Goals

- From a National Perspective and NASA Strategic Plan:
 - National Aeronautics R&D Policy (2006) and Plan (2010) identify **energy and environmental goals as central**
 - Revolutionary transformation of the airspace, the vehicles that fly in it, and their operations, safety, and **environmental impact**
- NASA Program:
 - Research to reduce fuel consumption, noise, and emissions for subsonic fixed wing aircraft and to enable revolutionary vehicle concepts and tools
 - Characterize and understand the effects of alternative fuels on jet aircraft systems and develop technologies to enable fuel flexible jet engines
- From an International Perspective:
 - International Air Transport Association's (IATA) represents approximately 240 airlines comprising 84% of total air traffic.
 - The environment is one of IATA's top priorities, along with safety and security.
 - Vision is to achieve carbon neutral growth (medium term) and to build a plane that produces no emissions (longer term)

Time Phased NASA Goals

	TECHNOLOGY GENERATIONS (Technology Readiness Level = 4-6)		
TECHNOLOGY BENEFITS*	N+1 (2015)	N+2 (2020**)	N+3 (2025)
Noise (cum below Stage 4)	- 32 dB	- 42 dB	- 71 dB
LTO NOx Emissions (below CAEP 6)	-60%	-75%	-80%
Cruise NOx Emissions (rel. to 2005 best in class)	-55%	-70%	-80%
Aircraft Fuel/Energy Consumption [‡] (rel. to 2005 best in class)	-33%	-50%	-60%

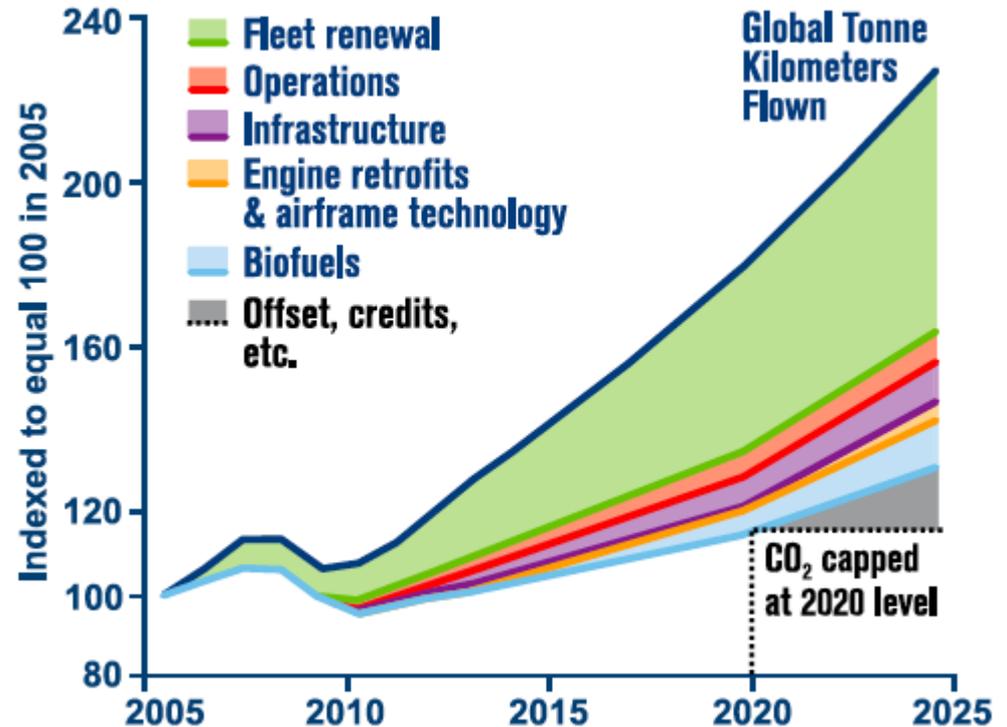
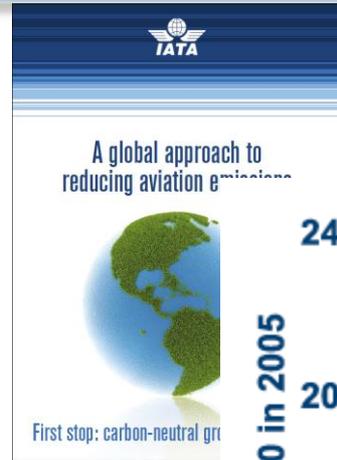
* Projected benefits once technologies are matured and implemented by industry. Benefits vary by vehicle size and mission; N+1 and N+3 values are referenced to a 737-800 with CFM56-7B engines, N+2 values are referenced to a 777-200 with GE90 engines

** ERA's time phased approach includes advancing "long-pole" technologies to TRL 6 by 2015

‡ CO₂ emission benefits dependent on life-cycle CO_{2e} per MJ for fuel and/or energy source used

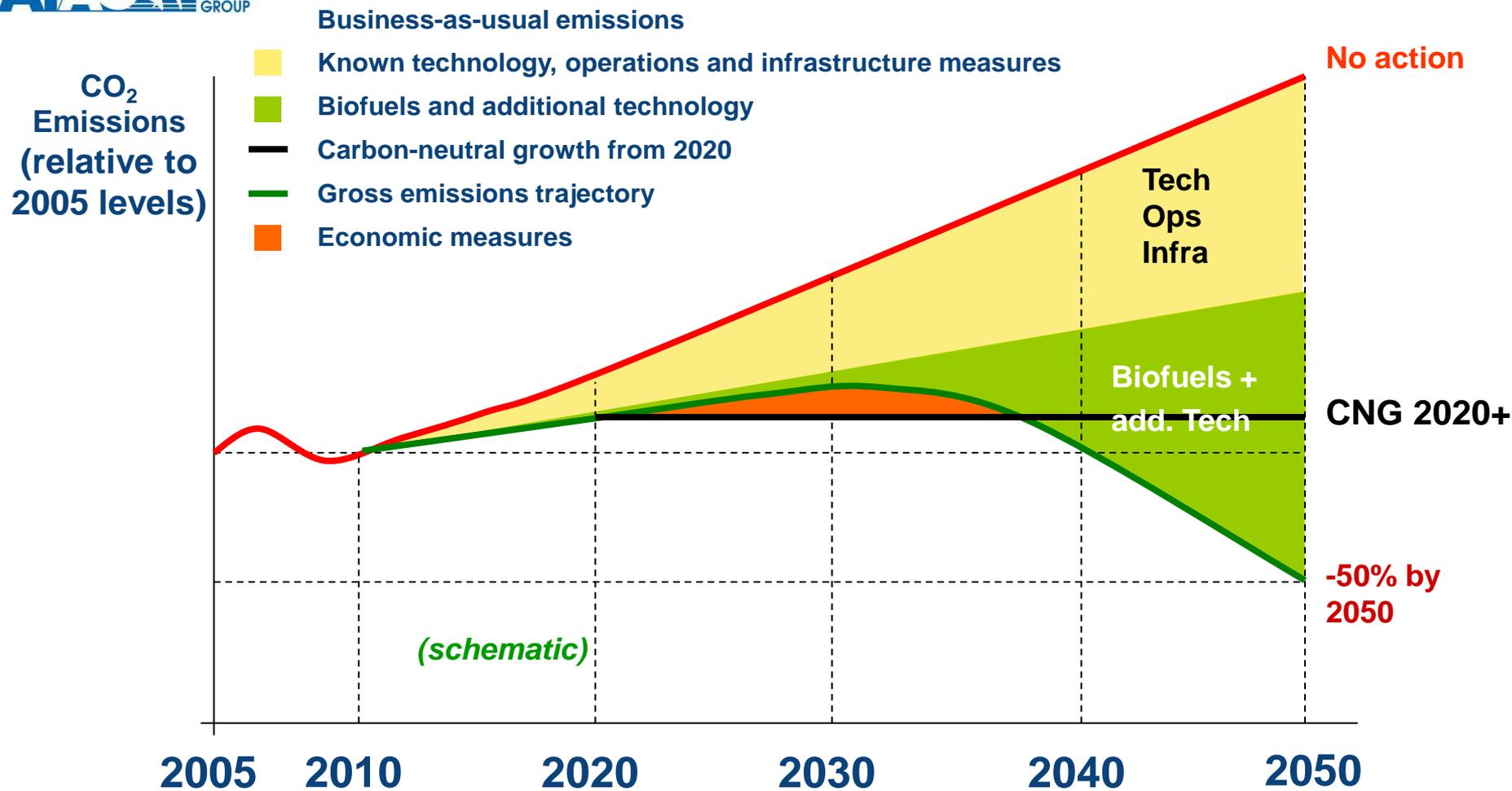
IATA Vision*

- A cap on aviation CO₂ emissions from 2020 (carbon-neutral growth)
- An average improvement in fuel efficiency of 1.5% per year from 2009 to 2020
- A reduction in CO₂ emissions of 50% by 2050, relative to 2005 levels



*A Global Approach to Reducing Aviation Emissions, November 2009

Emissions Reduction Roadmap





- Goal-driven advanced concepts and technologies to enable “green aircraft”
- Approaches to optimizing air transportation system operations to enable “green operations”
- Integrated assessments of the green aviation research portfolio

Green Aircraft

ERA Advanced Vehicle Designs and Concepts

- The project contracted with Boeing, Northrop Grumman and Lockheed Martin to develop conceptual aircraft with the goal of simultaneously reducing aircraft noise, emissions and fuel burn.
- Key technologies that were common to all include:

- Innovative flow control concepts
- Advanced composites, combustors, and Ultra High Bypass (UHB) engines
- Airframe and engine integration



Boeing
Blended Wing-Body

- Projections from NASA and contractor analysis
 - 75% reduction in NO_x is almost certain by N+2
 - 40% - 49% fuel burn reduction range is weakly dependent on configuration
 - 20 decibel (dB)- 42 dB below Stage 4 cumulative reduction range is strongly dependent on configuration



Lockheed Martin
Box-Wing



Northrop
Grumman
Flying Wing

Technical Priorities/ERA – N+2

Environmentally Responsible Aviation (ERA) Project is investigating aircraft concepts and work toward maturing technologies to simultaneously reduce fuel burn, emissions and noise.

(1) Innovative Laminar Flow Control Concepts for Drag reduction

Technical Challenge (TC) – Reduce fuel burn by 6 percent while minimizing maintenance issues

(2) Advanced Composites for Weight reduction

TC – Reduce aircraft weight by 10 percent over state of the art composites while maintaining safety margins at the aircraft system level

(3) Advanced UHB Engine Designs for Specific Fuel Consumption reduction

TC – Reduce fuel burn by 20 percent while reducing engine system noise and while minimizing weight, drag and integration penalties at aircraft system level

(4) Advanced Combustor Designs for Landing Takeoff (LTO) Nitrogen Oxides (Nox) reduction

TC – Reduce LTO NOX by -75 percent while lowering fuel burn at the aircraft system level

(5) Airframe and Engine Concepts for Community Noise Reduction

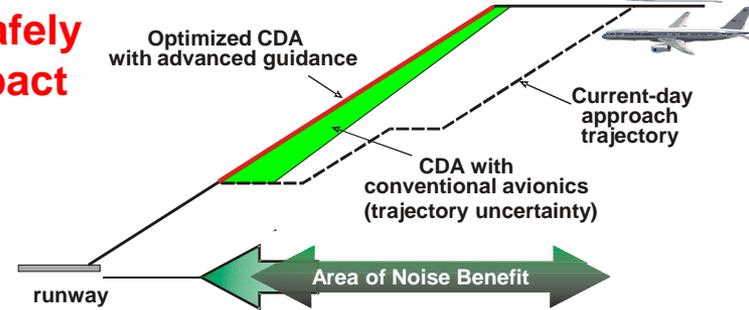
TC – Reduce component noise signatures while minimizing weight and integration penalties at aircraft system level

Green Operations

Develop & demonstrate novel operation concepts to safely increase throughput while reducing environmental impact

Today:

Continuous Descent Approaches (CDA's) only flown at off-peak hours or in low-congestion airspace



San Francisco trials indicate fuel savings of up to 3000 pounds (10,000 lb CO₂ reduction) per flight for large aircraft during peak traffic conditions

Tailored Arrivals & Enroute Descent Advisor (EDA)

- EDA combines scheduling with CDA to generate green solutions that maximize runway throughput and avoid conflicts
- Tailored Arrivals optimize CDA's to individual aircraft performance capability

UPS claims Merging and Spacing operations with Continuous Descent Arrivals (CDAs) will enable savings of 1 million gallons of fuel per year

Airborne Merging and Spacing

- Merging and spacing will be delegated to the flight deck instead of current ground-based process
- Will enhance EDA through closer spacing and eliminating missed slots

Development Partners:

FAA, Boeing, United Airlines, US Air, UPS

Early Adapters of Tailored Arrivals:

United Airlines, Quantas, Air New Zealand, Japan Airlines

Energy navigation concept (eNAV)

- Optimized fuel burn, noise, and emissions reduction by commanding pilots when to deploy flaps, gear, engine power settings, etc.

Integrated Portfolio Approach

- Technological improvements must be implemented in the system to achieve green impact
- Performance improvements from new aircraft designs have broad impact – reduced fuel burn, lower emissions, lower noise – but long fleet transition timeframes
- Other improvements that don't require new aircraft designs – operations, fuels – have more targeted improvements, but can be more rapidly implemented across the fleet

Green Investments must also be considered in the context of projected needs based on global drivers and constraints, transportation trends and demand drivers

Investment

	Integrated Systems Research Program / Environmentally Responsible Aircraft (ERA) Project	Fundamental Aeronautics Program (FAP)	Airspace Systems Program (ASP) FY11 \$87.2M
Minimize Energy Required	\$21.5	\$51.6M	
Minimize Impact of Energy Utilization	\$7.8M	\$12.4M	
Minimize Noise	\$18.0M	\$14.2	

Note: ERA seeks concepts and technologies for simultaneous impact

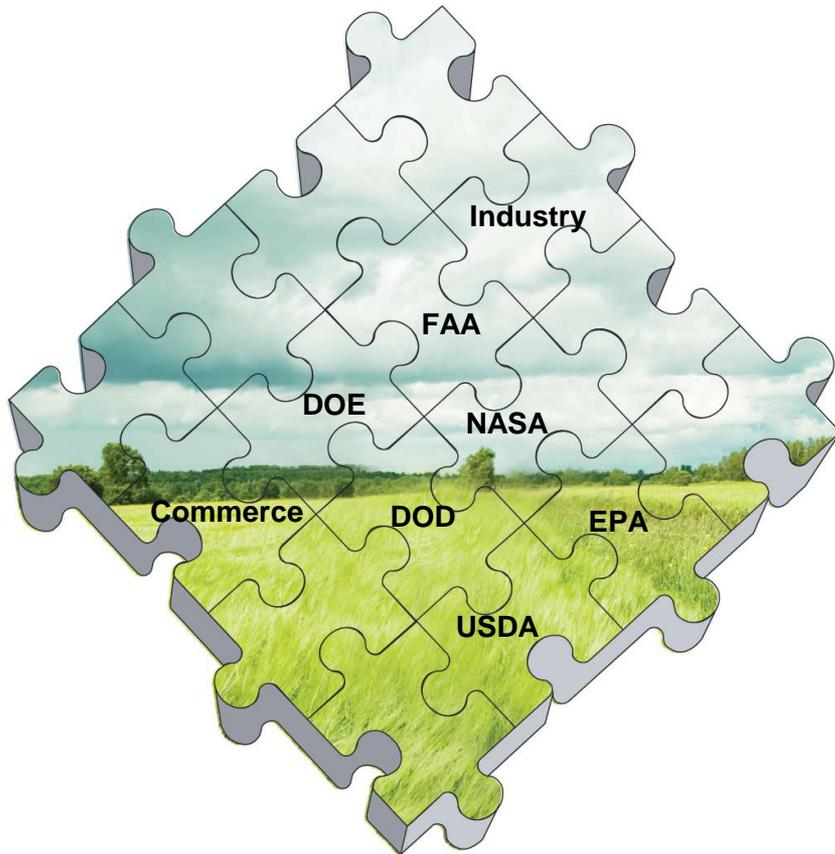
Note: Primarily investments in materials that can be utilized in lighter weight structures

Note: Many concepts also help achieve lower noise impacts

Committee Finding

The Committee fully supports the research NASA's aeronautics program is conducting in the area of Green Aviation. The Committee understands the challenges related to noise reduction and reduction in emissions (CO₂, NO_x, and other harmful particulates) and compliments ARMD's approach to address the challenges from a system wide perspective that considers both vehicles and operations. The Committee is encouraged by the efforts to capture the results of systems analyses and trade studies/sensitivity analysis. Understanding the market space and economics are key to identifying the correct technology barriers that need to be addressed. To help demonstrate and test potentially high risk technologies that are developed, it is important to establish strong collaborative partnerships with other government agencies and industry. NASA Aeronautics is continuing with its portfolio review and assessment, which the Committee fully supports and looks forward to the results as the assessment progresses, particularly in relation to investments in green aviation research. Additionally, the Committee was briefed on NASA's research on Hybrid Wing Bodies. Given their efficiency and noise reduction potential, the Committee sees any future N+2 research in this area as promising.

Inter-Agency Coordination Efforts on Alternative Jet Fuels



Key Points:

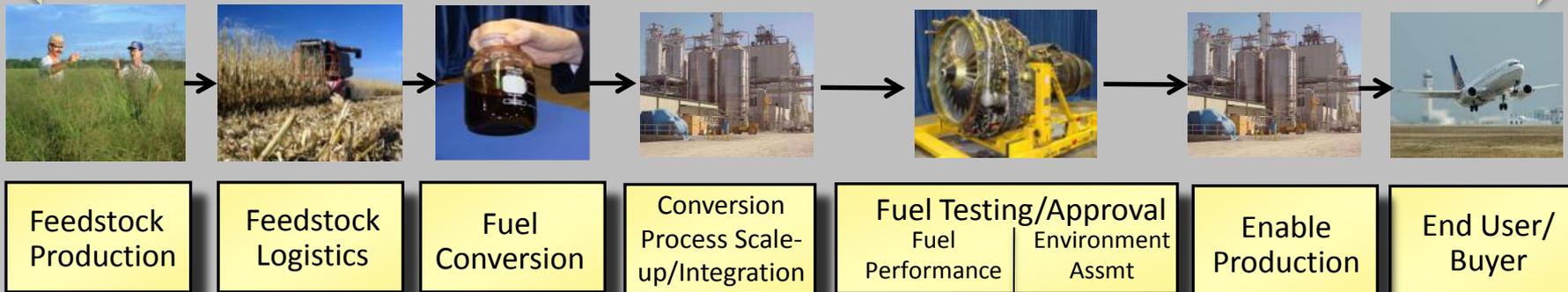
- Complementary efforts of multiple government Agencies in support realization of alternative jet fuels.
- While no one Agency has “carte blanche” exclusive responsibility to support a given step in the supply chain, each agency has specific focus areas.
- Communication and coordination is necessary and valuable at all levels – HQ, program, researcher levels.
- **NASA efforts focused on use of alternative fuels with respect to engine performance and emissions. Other agencies support this role.**

Purpose: Identify and articulate the efforts of government Agencies with respect to enabling alternative jet fuels.

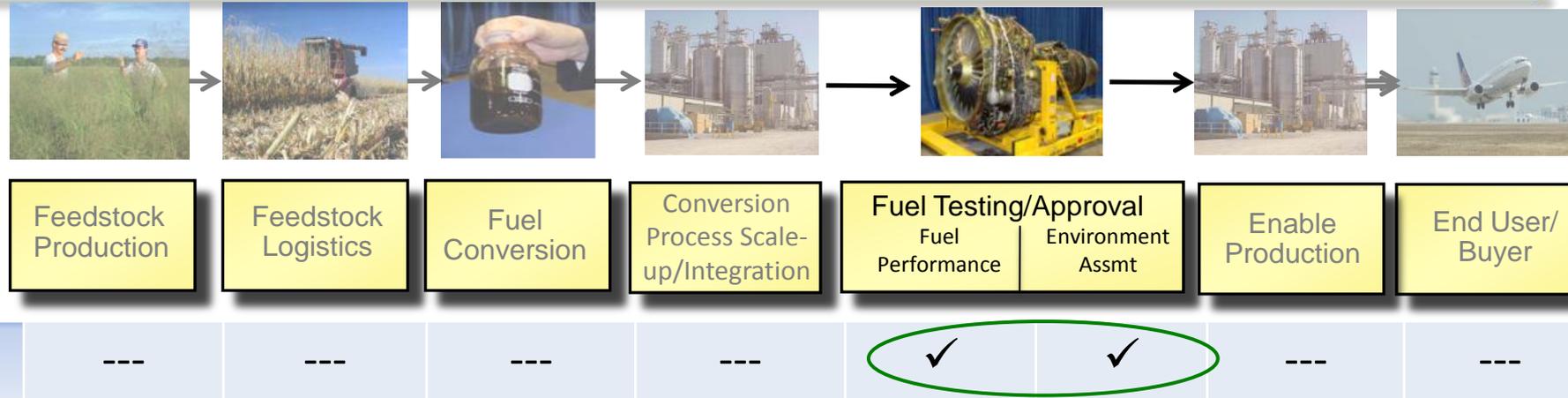
Approach: Achieve concurrence on a representation of the full “well-to-wake” process against which primary agency investment areas can be identified. Work with designated officials from various agencies at the HQ level to “self-declare” Interest, Role, & Goal as well as primary investment areas.

Alternative Jet Fuel Supply Chain

Economic and environmental sustainability analysis across entire supply chain



NASA Investment in Alternative Fuels



• NASA efforts include:

- Fundamental tests in combustion flametubes (conventional & alternative fuels) - to obtain model validation data
- Physics-based combustion modeling tools to improve predictive capabilities for flowfields, reactions, & emissions
- Engine testing using alternative fuels to establish related emissions and engine performance
- Exhaust plume experiments at sea level and altitude conditions including for establishing the links between exhaust particle properties & contrail formation
- N+2 combustor sector tests with industry using currently available alternative fuels and blends
- N+3 low emissions combustion concepts capable of operation on alternative fuels

Aviation Alternative Fuel Experiment (AAFEX)-2 Completed

PROBLEM

Need to determine effects of alternative fuels on aircraft emissions

OBJECTIVE

Perform static aircraft engine testing using Hydrotreated Renewable Jet (HRJ) and other fuels to determine effects on engine performance and emissions. A second objective was to examine methodologies for particle sampling to assist the SAE – E-31 Aircraft Particle Measurement Subcommittee in developing a standard particle sampling technique.

APPROACH

Utilize the NASA DC-8 aircraft at the Dryden Operational Facility in Palmdale, CA to perform emissions testing using various alternative fuels and a JP-8 reference fuel and obtain gaseous, solid, and aerosol samples for analysis at 1, 30, and 150 meters downstream of the aircraft engine exhaust.

RESULTS

- Over 30 hours of engine testing conducted.
- Participants from NASA LaRC, DFRC, and GRC, AFRL, AEDC, MST, NAVY AESO, EPA, P&W, GE, RR, UTRC, PSU, as well as several particle instrument measurement companies.
- Gaseous and particulate emissions obtained for neat HRJ, HRJ/JP-8 blend, JP-8, Fischer-Tropsch (F-T) low sulfur, and F-T high sulfur fuels. Preliminary results indicated that the neat HRJ fuel showed reductions in black carbon emissions greater than 90% at idle and approximately 50% reduction at takeoff thrust compared to the standard JP-8 fuel.

SIGNIFICANCE

Results will be used for to determine effects of several alternative fuels and fuel sulfur on engine performance and emissions. Particle sampling methodology experiments will directly support SAE E-31 subcommittee development of a standard for particulate sampling and data from this testing should reduce the time that it takes to develop the standard.



AAFEX-II Test

Committee Finding

The Committee is very pleased to see NASA ARMD's proactive leadership to help form strong coordination and collaboration in research between NASA and other government agencies concerning the use of alternative fuels for aviation and hopes that coordination and collaboration will continue. The Committee believes the coordination effort to date is re-affirming NASA's role in conducting research to characterize alternative fuels including emissions characterization and to develop fuel-flexible combustor technologies.



- The Aeronautics Committee, in conjunction with the ARMD Associate Administrator, discussed and approved the draft terms of reference (TOR) establishing a UAS Subcommittee to provide advice and recommendations on a wide range of UAS issues
- First meeting was held on Dec 20th, 2011 at NASA Headquarters.
- UAS Subcommittee Membership:
 - Dr. John Langford, Chair (member of the NAC Aeronautics Committee)
 - Dr. Brian Argrow, University of Colorado
 - Dr. Eric Johnson, Georgia Institute of Technology
 - Ms. Rose Mooney, AAI Corporation
 - Mr. David Vos, Athena Technologies
 - Mr. Steve Sliwa, Insitu Inc.
 - Mr. Nicholas Sabatini, Nick Sabatini and Associates
 - Col. Dean Bushey, USAF
 - Ms. Lynn Ray, FAA

CY 2012 Work Plan

- 1) Review specific research and development activities within NASA Aeronautics that are directed at mitigating the environmental impact of aviation, including reduced emissions, lower noise, and better fuel efficiency. Specifically, the Committee will advise on the depth and breadth of NASA research related to green aviation including assessing cross-agency collaboration and the inclusion of emerging technologies Initial implementation of the key FY11 research initiative Unmanned Aircraft Systems Integration in the NAS.
- 2) Review deliberations and initial activities of the Unmanned Aircraft Systems Subcommittee (UASS). The Committee will assess initial work plan and advise on areas of improvement.
- 3) Examine the current process for the transfer of NextGen technologies to the implementation and user communities, and advise on ways to improve the timeliness and effectiveness. In particular, the Committee will assess differing parameters of technology transfer (single technology versus integrated technologies, narrow NAS domain impact versus system-wide impact, near-term versus mid-term impact) and advise on value and improvement. The Committee will also assess NASA's NextGen R&D activities relative to those being conducted by other government organizations (or government supported organizations) and advise on potential areas of synergy and collaboration. This should include major simulation, test and evaluation, and flight research capabilities.



- 4) Assess implementation by the Programs of the agreed upon Directorate level international collaborations strategy and advise on ways to improve strategy. The Committee will also provide advice on the strategy for dealing with non-traditional partners such as Brazil, Russia, India, and China.
- 5) Review results and progress of the National Research Council-led Flight Research Study. The Committee will provide advice on ARMD planning efforts in regards to the study outcomes and further flight research.
- 6) Provide advice and feedback on ARMD contribution to a national aeronautics research agenda aimed at achieving a broad consensus on federal aeronautics research. The Committee will also provide advice on the formulation of a decadal survey for NASA Aeronautics if NASA decides to do a decadal survey for aeronautics.