



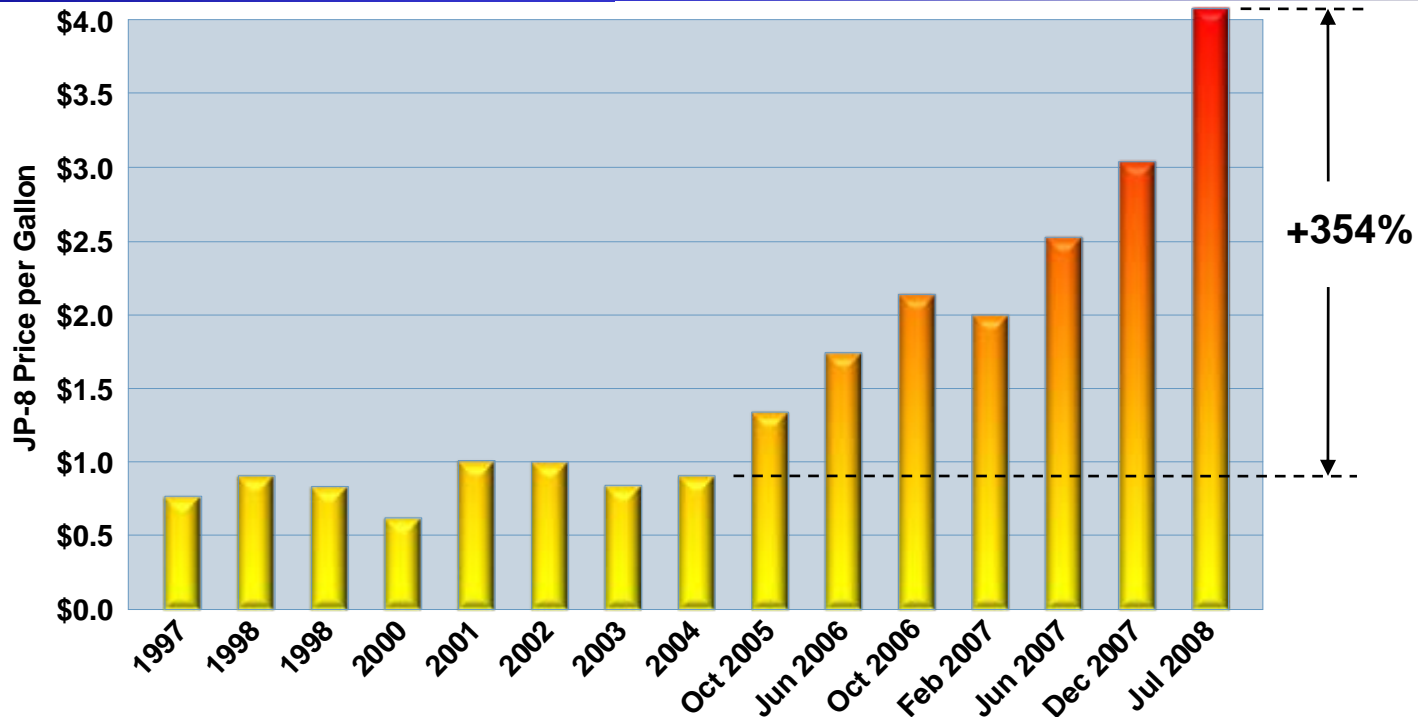
---

# **A Perspective on Joint Agency Collaboration in F-T Aviation Fuels (2006-2008)**

**Tim Edwards  
Air Force Research Laboratory  
Aug 2008**



# DOD Assured Fuels Initiative



## AF Vision

“The Air Force is committed to completing its testing and certification of our aircraft fleet for alternative fuels by 2011. Working with industry, we can accomplish this goal. Once accomplished, we look forward to buying domestically produced synfuel at competitive market prices from manufacturing facilities that engage in effective carbon dioxide capture and reuse.”

Secretary of the Air Force Michael W. Wynne, July 9, 2007, Keynote Address at AIAA/SAE/ASME Joint Propulsion Conf., Cincinnati, OH



# AF Leadership Strategic Message



- The Air Force has a three-step Energy Strategy:
- Reduce Demand
  - Increase energy efficiency and reduce our energy consumption
- Increase Supply
  - Research, test and certify new domestic fuels
- Cultural Change
  - We are creating a culture where all Airmen make energy a consideration in everything we do
- *The Air Force is working our energy strategy in partnership with other government agencies and the private sector.*

**AIR FORCE ENERGY VISION:**

**MAKE ENERGY A CONSIDERATION IN ALL WE DO**



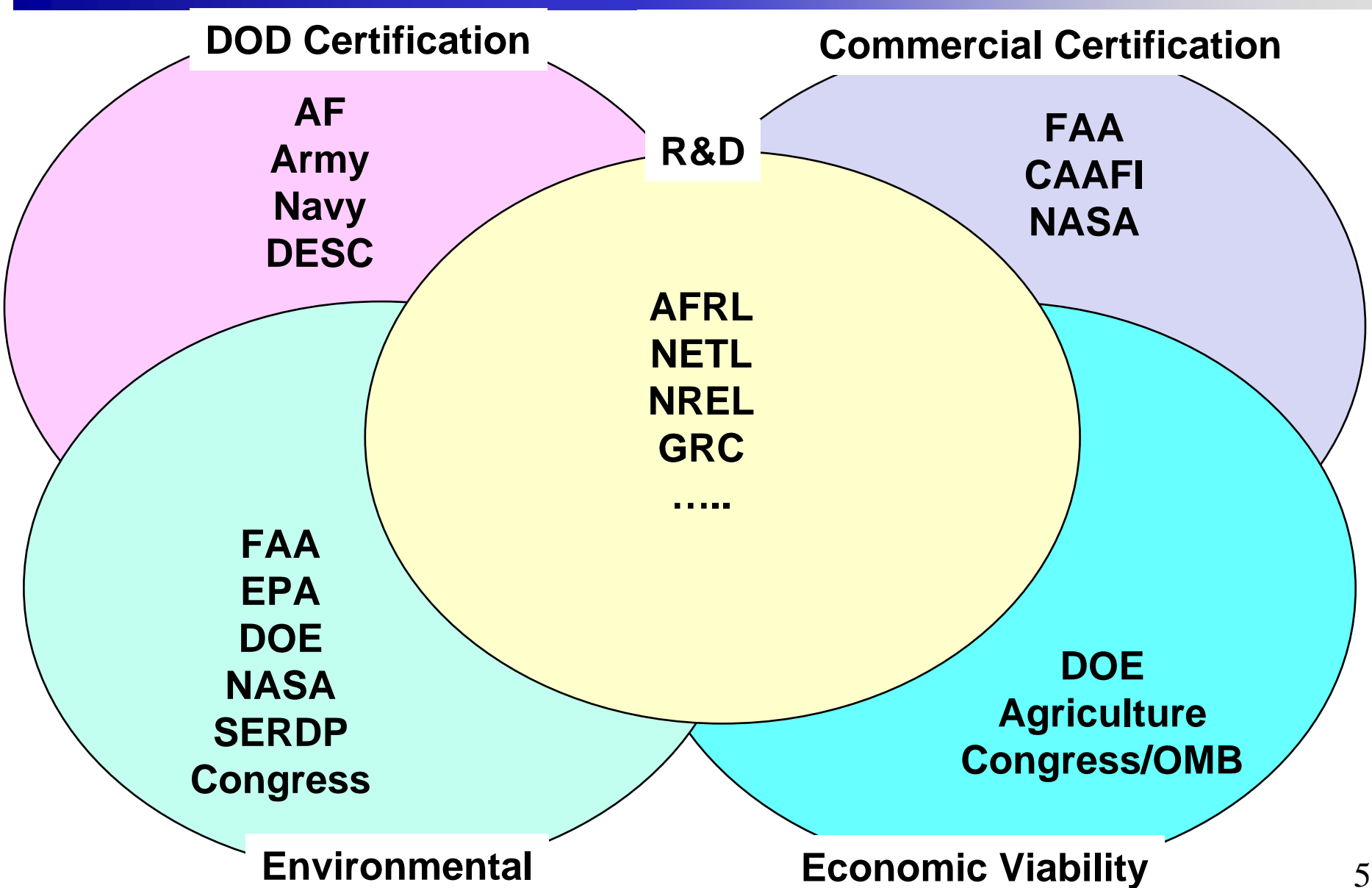
# AF Alternative Fuel Program Highlights



- Near-term goal: 50/50 F-T/JP-8 blend certified in all AF vehicles by 2011 (ASC Alternative Fuel Certification Office(AFCO))
  - B-52 certified Aug 2007 (Syntroleum F-T “S-8” purchased by AFRL)
  - C-17 flight test Oct 19/22, 2007; B-1 March 19, 2008 (Shell F-T purchased by Defense Energy Support Center (DESC) )
- Coordinating with Commercial Alternative Aviation Fuel Initiative (CAAFI)
  - Developing fuel certification process through AFCO, MIL-Handbook-510
  - Generating reams of physical property data on F-T and blends
- Coal expected to be first resource utilized domestically in U.S. .... however:
  - Biomass has significant CO<sub>2</sub> footprint reduction potential
  - AF supporting DARPA “biojet” program
- Desire is for 50% of AF consumption to come from alternative fuel blend by 2016 (~400M gal/yr)
  - Defense Energy Support Center Request for Information for 200M gal buy



# Federal Interactions in Alternative Aviation Fuels



# CAAFI Aviation Alternate Fuels Roadmap

## (Level 2 / Scenario 1 - Long Term)

**Draft**

Category	2005	2007	2010	2015	2030	2050				
Alternative Fuel Products	SASOL Jet Fuel	C17 FT Fuel Test	Nigeria GTL	Qatar GTL Production	US CTL Biomass Co-fired	China CTL	Bio-butanol for ground use	Either Industrial Energy or Resurgence in Nuclear Power	Solar	Future Energy Source
	Shell Bintulu GTL	Syntroleum Jet fuel in B-52	Boeing/Virgin Biojet Demo	Boeing/Air New Zealand Demo	US CTL Production	Bio-jet fuel approved	Cellulose ethanol for ground use	Start of Hydrogen Economy	Ocean Bio-fuel Factories	
Economics & Business		CTL Economics - Scully Financial	ACRP Handbook complete	DOE Step Gain in CO2 Sequestration Efficiency	50% USAF Syn fuel use					
Certification		Spec for 100% SASOL	50/50 Generic FT Blend Listed in ASTM	ASTM Lists 100% FT Generic	ASTM Bio Fuel Spec	70% USAF Domestic CTL Sourcing (2025)				Future Aircraft for Advanced Fuel
Environmental	Spec for 50% SASOL Blend	B-52 emissions	CTL & Bio-fuel Emissions Test	Operational assessment	Coal to liquids	New bio-fuel impacts	Adv bio fuel emissions			Advanced Aviation Fuel Spec
R&D	Tar Sands Online	Scoping study	HBR TF emissions assessment	Benefits assessment	Jet fuel spec revis	F-T Fuel Carbon Sequester	Low emissions Bio-fuel certified			
	GE/cruise ships burn biofuel in turbine	1st gen bio-jet Lab tested	2nd gen bio-jet Lab tested	Generic mat. Compat list	Bio-jet tests done	Bio-jet fuel approved	High energy deoxygenated bio-jet fuel from algae			
	B-52 syn-fuel flight test	C17 test	Biofuel Tested, CFM	Boeing/Virgin 747 Test	F/T swell lubricity issues solved	F-T and biojet blend tests done	Synthetic biology jet fuels developed			Advanced aviation fuel dev

# Aviation Alternate Fuels Roadmap

(Level 3 / Scenario 1, R&D Near Term Only)



Category 6/06

2006

2007

2008

2009

DoD

B-52 demo All engines F/T blend	Bio-jet tests T63 Engine	Density of FT study	N Dakota Biojet studies Research Combustor	FT seal swell etc.	Combustor operability and relight tests	Expand material compatibility	FT toxicology assessment	Analysis of DARPA biojet fuels	FT evaluation in diesel engine	FT evaluation with AC fire protection
---------------------------------	--------------------------	---------------------	--	--------------------	---	-------------------------------	--------------------------	--------------------------------	--------------------------------	---------------------------------------

Engine Companies

B-52 demo 2-engines F/T blend	100% F-T Fuel approved	SASOL	Define mat. compatibility	Fuel tank foam tests	DARPA biofuels 1/07 - 6/08 Engineering OEM protocol	DARPA biojet samples to AFRL	Design studies for other than "drop in"	FT APU evaluation	Combustor design for reduced toxics with oxygenated fuels	
-------------------------------	------------------------	-------	---------------------------	----------------------	---	------------------------------	---	-------------------	---	--

Boeing

Lab Test Of TecBio Biofuel	Atomiser cold flow on biojet	Tests to support F-T approval process	2 Bio-fuel Sustainability Reports	APU testing on biojet	Biofuel materials test	Bio-kerosene from Algae & palm oil created	APU cold start on biofuel	Lab test of Algae & palm oil bio-fuel	Algae & palm oil sustainability & cost report	
----------------------------	------------------------------	---------------------------------------	-----------------------------------	-----------------------	------------------------	--	---------------------------	---------------------------------------	---	--

Other Airframers

Lab Test - Purdue & TBD Biofuels	Supply bio-fuel blends to NASA & SwRI	Utilization/design range of comm. Aircraft.	Supply 2 bbl biojet to NASA	Test for lubricity and seal swell for Bio-jet / synthetic blend	Check that other companies agree with materials test protocol	Boeing/ Virgin 747 Test	Bio-thermal stability test defined	Materials compatibility test matrix	Embraer Biojet demo	
----------------------------------	---------------------------------------	---	-----------------------------	---	---	-------------------------	------------------------------------	-------------------------------------	---------------------	--

FAA/NASA

Sxnfuel+JP8 blends, TVC or other Combust.Sector, Perform+Env (NASA/AFRL/WPAFB)	CFD FT-JP8 blends, TVC Combustor	Bio Fuel & FT combustion kinetics	Breakpoint test of bio-fuel blend (NASA)	FT fuel Engine test (NASA/USA F/PW)	Hi PR test data (incl. emiss.)	Combust or Blend data	Combustor test of FT&bio-fuel blends (NASA)	Alt.Fuel Ground test performance + Emissions (NASA)		
--	----------------------------------	-----------------------------------	--	-------------------------------------	--------------------------------	-----------------------	---	---	--	--

Others

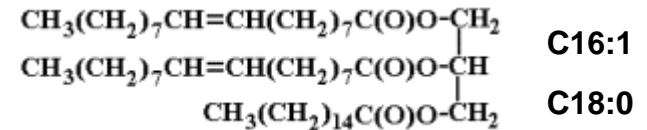
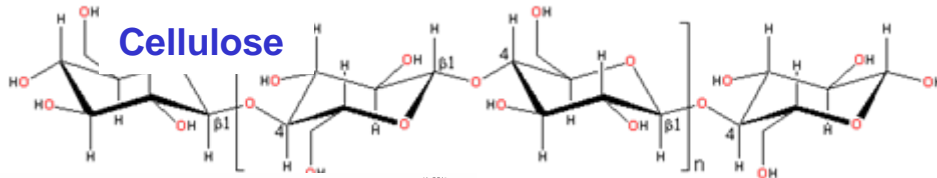
Cruise Range impact of F-T fuel, Air Canada	1 <sup>st</sup> generation Bio-fuel blend matrix performance tests (SwRI)	CTL feasibility study, Indiana	Bio-fuel therm stability in Hx	UHBypass engine test FT Fuels (NASA/PW)	Combustor test of Syn&Bio fuel blends (HPR Emissions (NASA)	Quantify deposits on ellipseometer	Swift develop. Syn+ renewable Jetfuel as chem. blend	Biofuel+JP8 blends, TVC or other Combust.Sector, Perform+Env (NASA/AFRL/WPAFB)	Indiana compl. Agreement with CTL company	Swift compl. D1655 Labtesting	PSU, coal derived JP900, check status
---	---	--------------------------------	--------------------------------	---	---	------------------------------------	--	--	---	-------------------------------	---------------------------------------



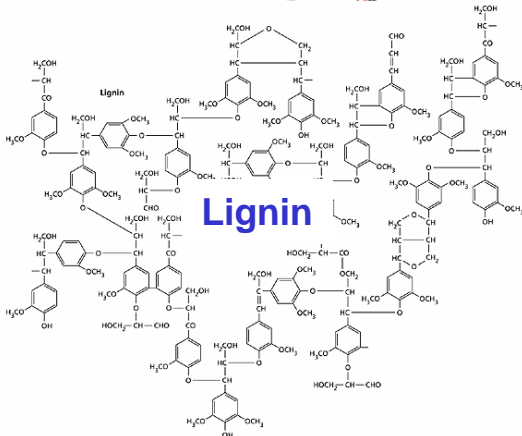
# Production of "Bio" Jet Fuel

"second generation"

"first generation"



Triglycerides (fats, oils)

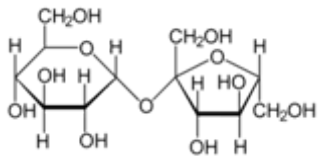


gasification  
(or co-gasification  
with coal)

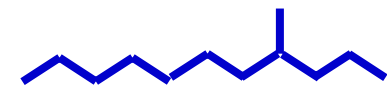
pyrolysis/  
hydroprocessing



**"HXO"**  
**"HFO"**  
**"HAL"**



**"direct fermentation"**



Typical jet fuel molecule

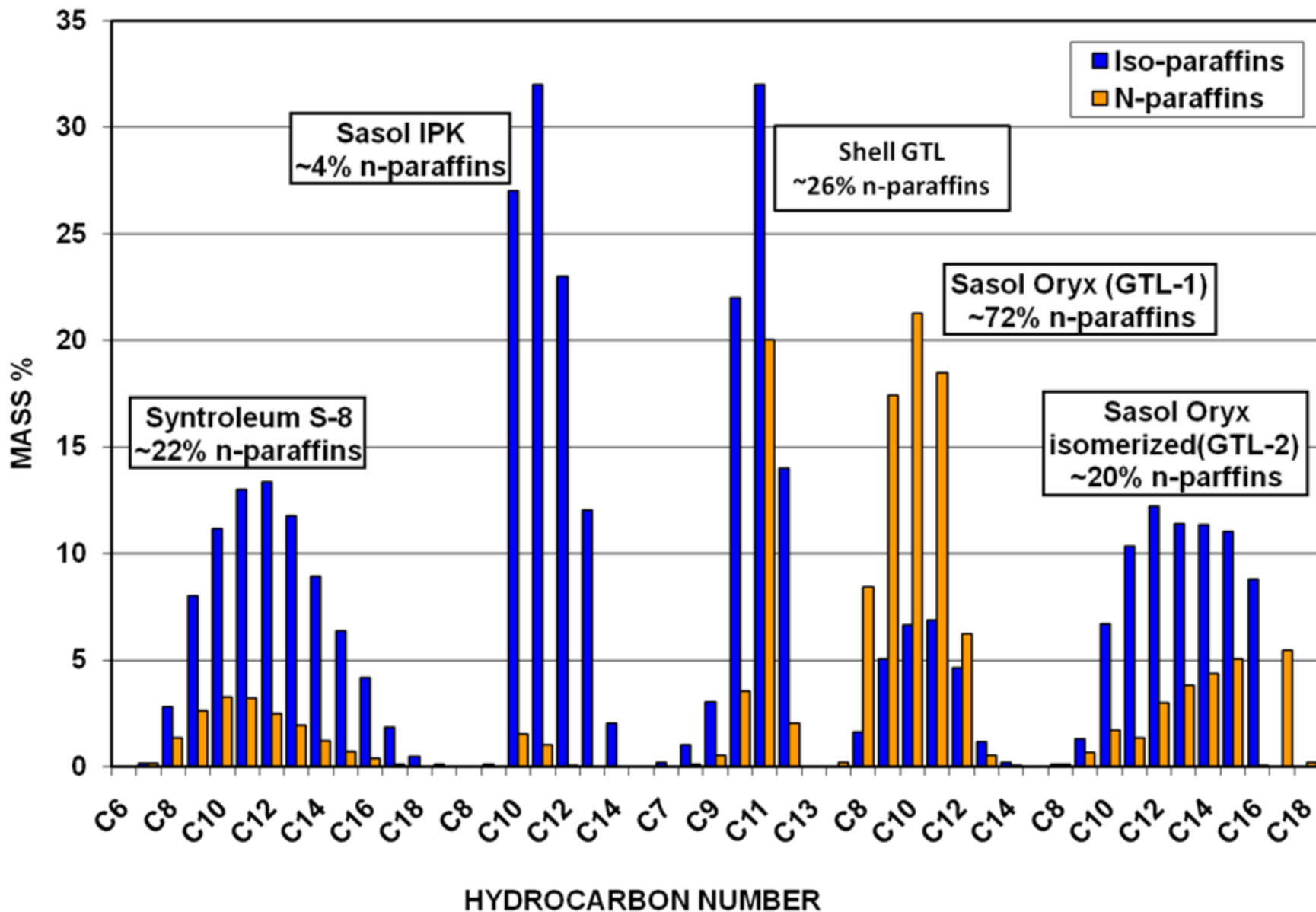


# Product Variability

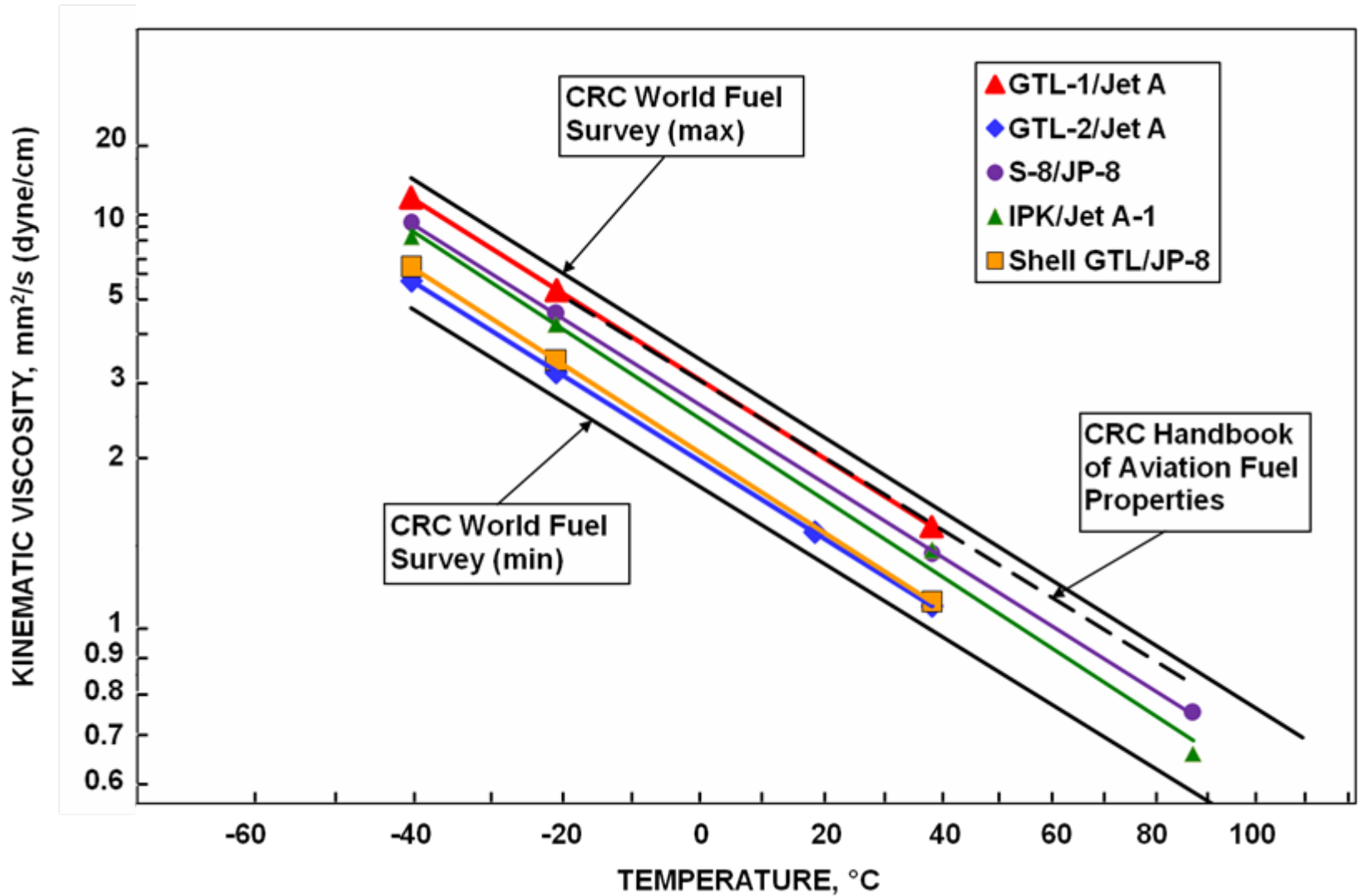


- **What does certifying “F-T” mean?**
- **Have substantial data on Sasol and Syntroleum fuels**
  - **Large delivery of Shell fuel in Sep 07**
    - **Extensive property measurements underway**
  - **Test quantities of F-T fuels, biofuels available**
    - **How consistent?**
    - **How to specify?**
- **How should F-T be obtained? DESC is the procurement agency for all federal agencies & DOD.**
  - **Incorporate in MIL-DTL-83133? Current proposal is Appendix with specification for “synthetic” (non-petroleum) component, with blend to meet Table I in main spec**
  - **Specialty procurement? (either blend or pure F-T)**

# Composition



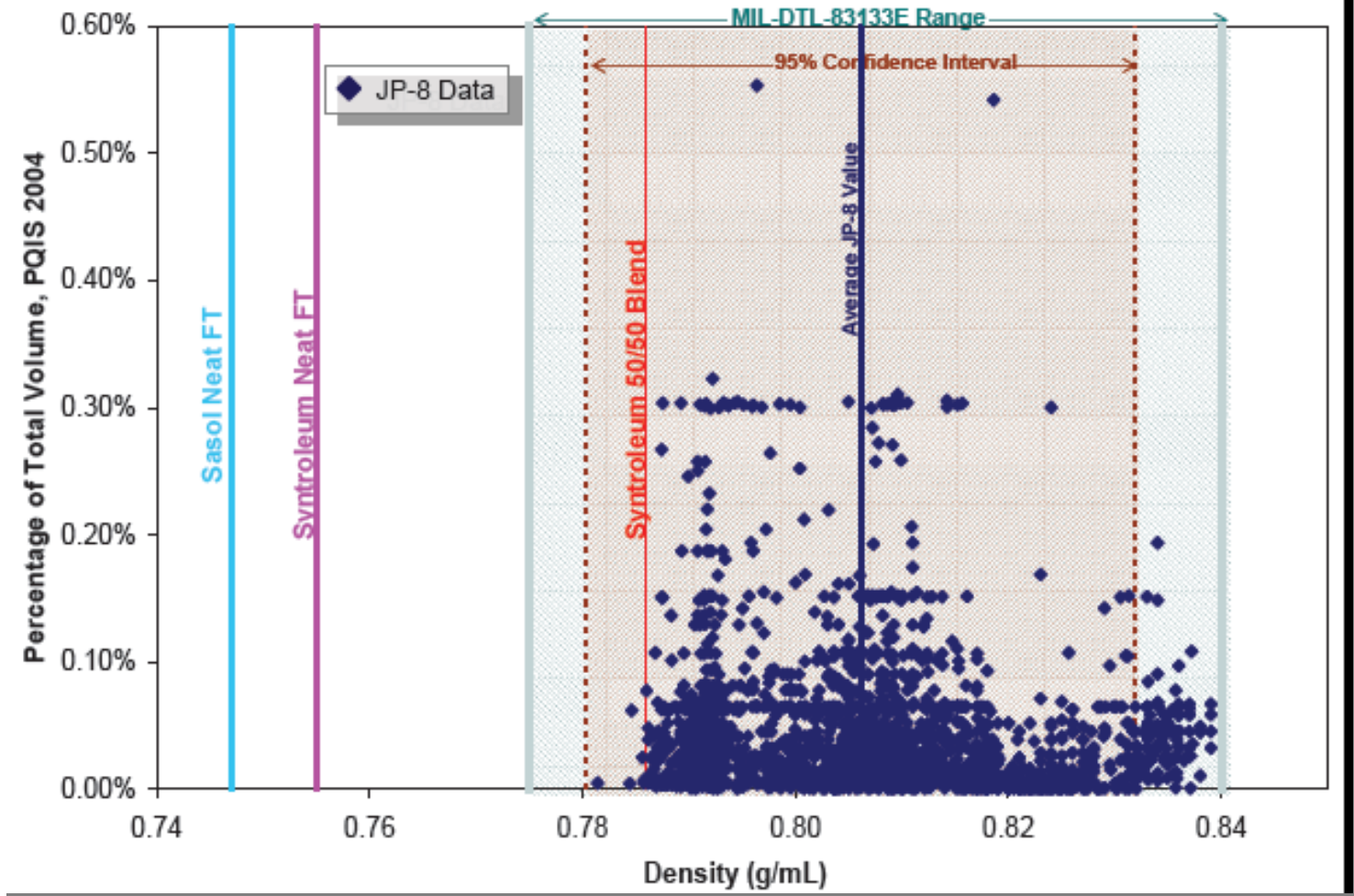
# Viscosity (50/50 blends)



- Viscosity of SSJF has typical temperature characteristics



# Property “Experience Base”





# Bringing “Biojet” into the Process



- Experience with submitted samples
- Bringing in as blend or 100%?
- Potential technical issues:

## “BTL”

---

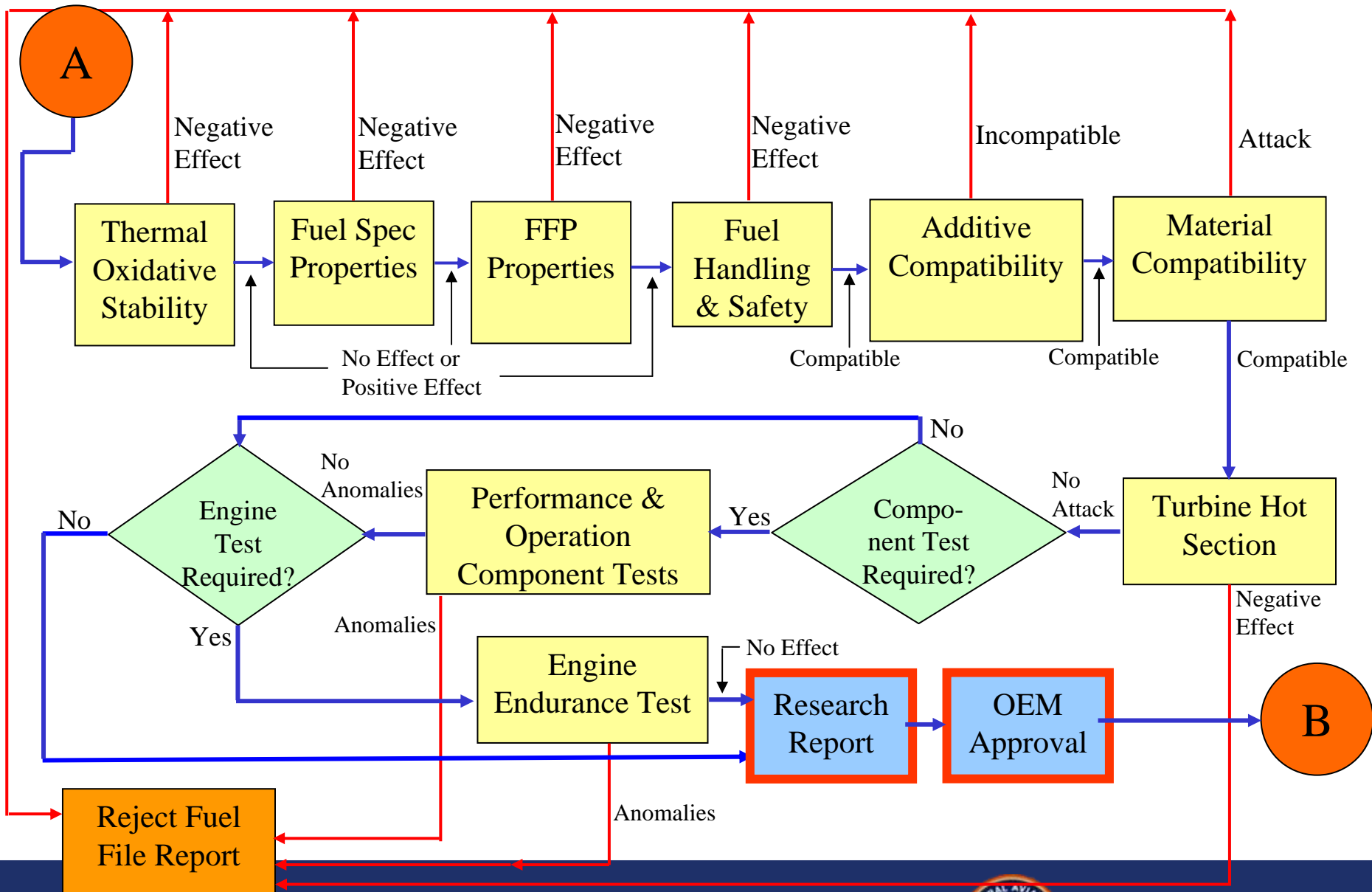
- Same as other FT fuels

## Biojet / green jet/ biokerosene

---

- Storage stability/bio growth
- Trace oxygenates, non HC species

# Phase 2: Technical Evaluation of Fuel/Additive





# Summary



- **Evolving U.S. alternative fuels program a true multi-agency effort**
  - **R&D – DOE, DOD, NASA, FAA, Agriculture, ...**
  - **Certification – FAA, DOD**
  - **Environmental – FAA, EPA, DOE, NASA, DOD**
  - **Economic Viability – DOE, Agriculture, OMB, Congress...**
- **Current close collaboration with industry also a key aspect of program**