Certification-Qualification Breakout Session

January 28, 2014

CAAFI®
COMMERCIAL AVIATION ALTERNATIVE FUELS INITIATIVE

Mark Rumizen
Senior Technical Specialist
Federal Aviation Administration

2008

theguardian | TheObserver

News | US | World | Sports | Comment | Culture | Business

Business › Airline industry

Fuel costs kill off a US airline every week

James Doran in New York
The Observer, Saturday 24 May 2008

$139: OIL'S BIGGEST DAY

DRUDGE REPORT

Oil's biggest day yet drags down stocks

*NEW YORK (AP) – **Oil prices made their biggest single-day leap ever Friday—clearing $139, dragging the Dow Jones industrials down nearly 400 points and raising the once-unthinkable prospect of $150 oil and even higher gas prices by the Fourth of July.***

The meteoric rise of nearly $11 for the day piled atop an increase of almost $5.50 the day before, taking oil futures more than 13 percent higher in just two days, easily a record on the New York Mercantile Exchange.

ArmyTimes
A GANNETT COMPANY

Fuel-cost worries extend to Pentagon

May. 18, 2008 - 07:27AM | Last Updated: May. 18, 2008 - 07:27AM |

WALB NEWS 10

Jet fuel prices hurt local businesses and airports

Posted: Jun 06, 2008 6:12 PM EDT
Updated: Jun 11, 2008 2:25 PM EDT

The New York Times
By MICHELINE MAYNARD
Published: September 1, 2008

For Airlines, No End in Sight to Fuel-Cost Struggles

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2011-2013

AIRLINE STOCKS Archives | Email alerts

Feb. 22, 2011, 7:13 p.m. EST · CORRECTED

Airline stocks slide as jet-fuel prices rise

Orient aviation

The No.1 commercial aviation magazine in the No.1 market

March 2011 > Main Story

Jet fuel costs rise 33.1% in a year

Bloomberg SUSTAINABILITY

How High Oil Prices Will Permanently Cap Economic Growth

By Jeff Rubin | Sep 23, 2012 6:30 PM ET | 0 Comments Email Print

RT QUESTION MORE.

Syria sends oil to 2-year high, $150 spike feared

Published time: August 28, 2013 11:01

Edited time: August 29, 2013 11:06

ft.com/frontpage US All times are London time

FINANCIAL TIMES

January 15, 2014 6:31 pm

US still vulnerable to oil shocks, say generals

By Ed Crooks in New York

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AGENDA

* Pathway Status/Overview
* Break (3:10PM – 3:30PM)
* Challenges, Lessons Learned, Process Improvements
  * OEM Review Panel Proposal: *George Wilson, SWRI*
  * FAA R&D Initiatives: *Mark Rumizen*
  * Round Table Discussion: Producers & OEMs
  * Q&A From Audience
  * Go-Forward Discussion/Recommendations
  * Conclusions

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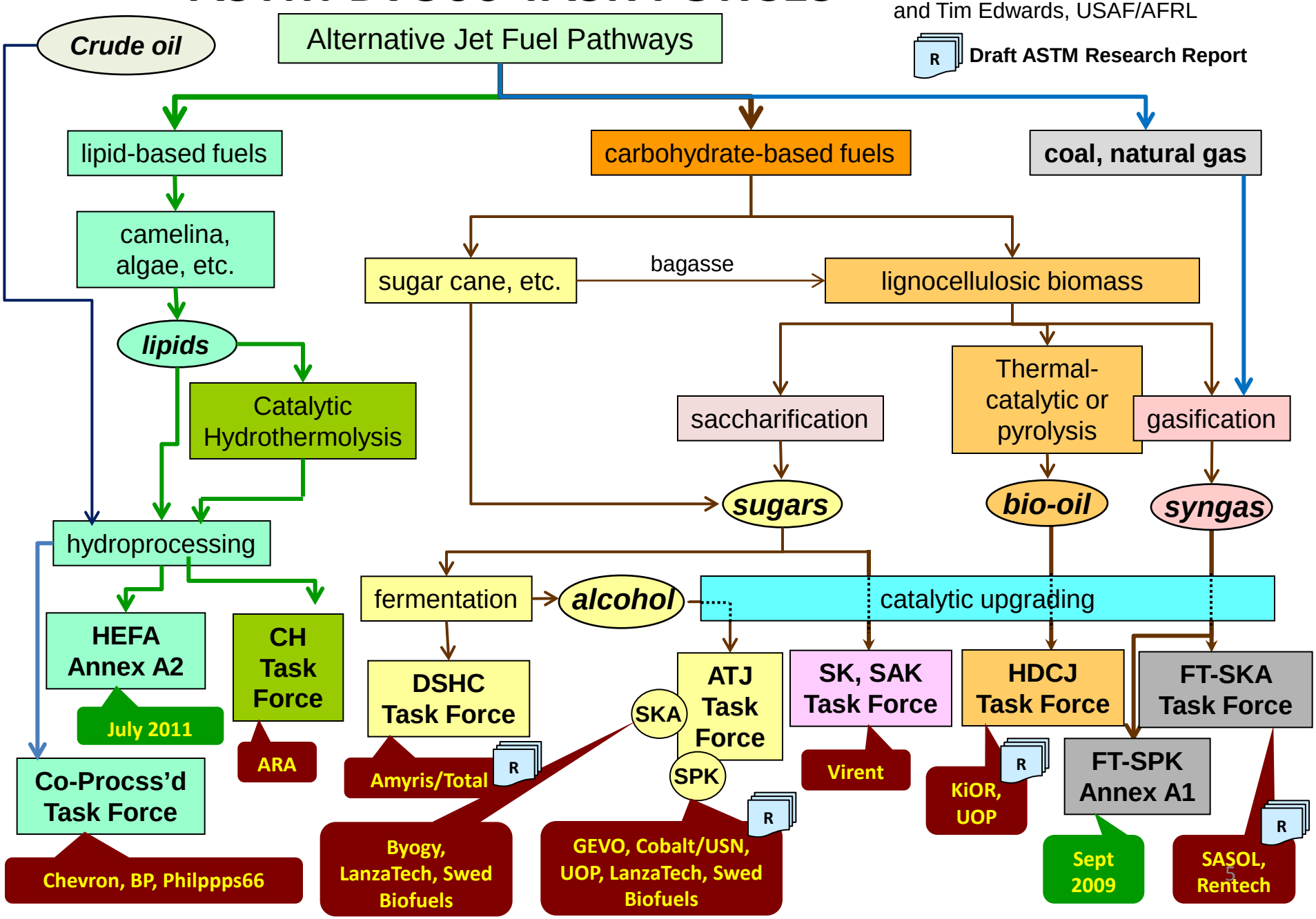
ASTM D7566 TASK FORCES

Adapted from Brown, Iowa State, 2012
and Tim Edwards, USAF/AFRL

R Draft ASTM Research Report



ATJ: Alcohol to Jet
CH: Catalytic Hydrothermolysis
DSHC: Direct Sugar to Hydrocabons
FT: Fischer-Tropsch
FT-SKA: FT Synthetic Paraffinic Kerosene with Aromatics
FT-SPK: FT Synthetic Paraffinic Kerosene
HDCJ: Hydroprocessed Depolymerized Cellulosic Jet
HEFA: Hydroprocessed Esters and Fatty Acids
SAK: Synthetic Aromatic Kerosene
SK: Synthetic Kerosene
SPK: Synthetic Paraffinic Kerosene
SKA: Synthetic Paraffinic Kerosene with Aromatics

ASTM Alternative Jet Fuels

January 28, 2014

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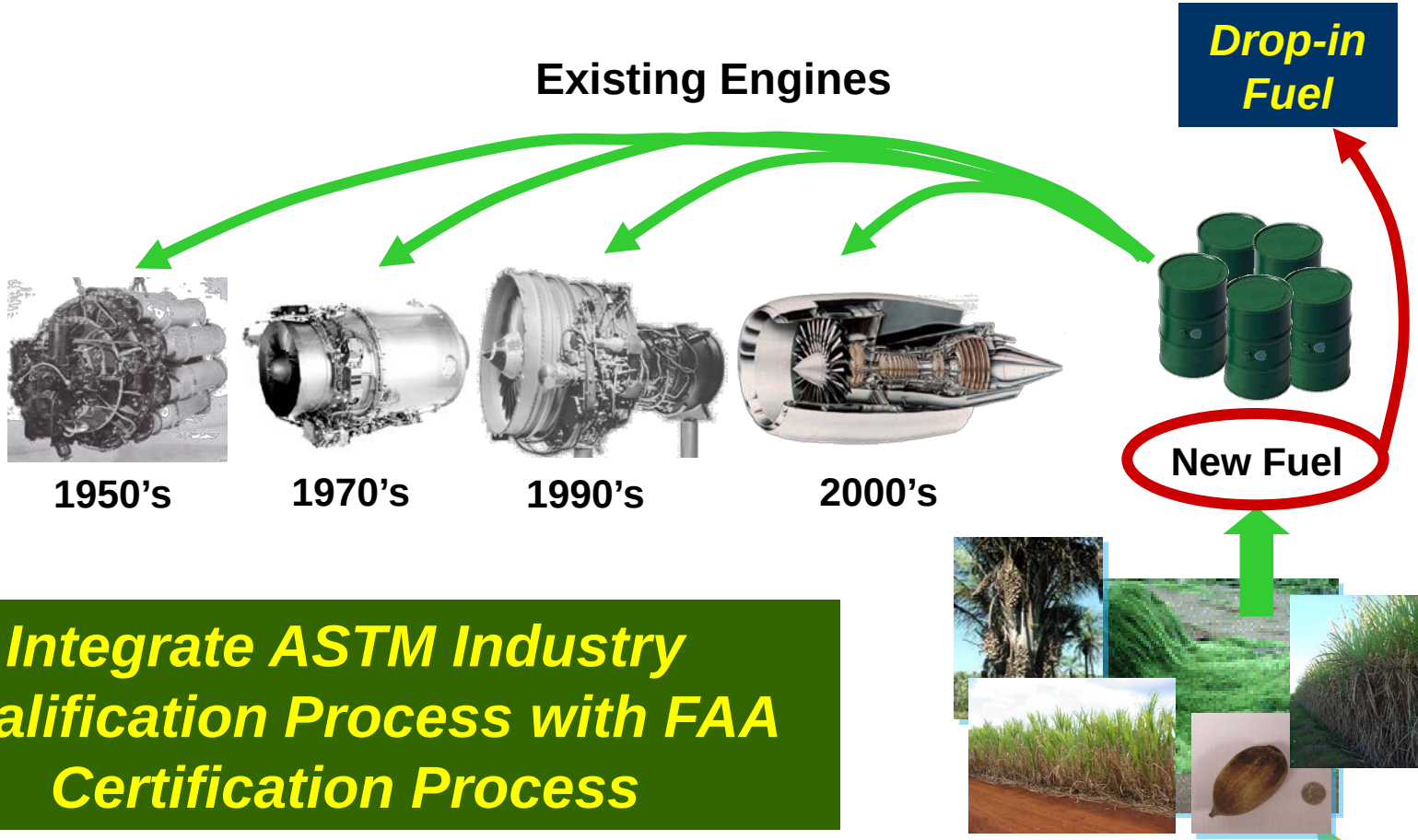
Mark Rumizen
Senior Technical Specialist
Federal Aviation Administration

How to Work Backwards to Prove New Fuel Is Acceptable for Existing Fleet of Engines?



Integrate ASTM Industry Qualification Process with FAA Certification Process

Integrated ASTM/FAA Approval

ASTM Qualification (D4054)

D7566 New Annex Drop-In Fuel

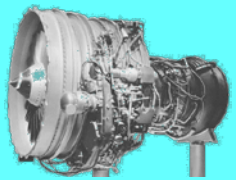
New Spec Non-Drop-In Fuel

Unchanged Operating Limitation

Approved for Commercial Operations

New Oper Limitation

Airworthiness Certification



Re-Certify All Engines

Re-Certify All Aircraft

Approved for Airline Operations

ASTM D4054 Process

TIER 1

Specification Properties

TIER 2

Fit-For-Purpose Properties

TIER 3

Component/Rig/APU Testing

TIER 4

Engine/APU Testing

ASTM Research Report

OEM Review & Approval

ASTM Balloting Process

ASTM Specification

ASTM Specification

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Thank You

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FAA/OEM Review Panel

George R. Wilson, III
Principal Scientist
Southwest Research Institute

FAA/OEM Review Process

Is Not Participation in Task Force Efforts

- TF Participation is a Personal Involvement
- Provides Insight Into Important Topics

FAA/OEM Review Process

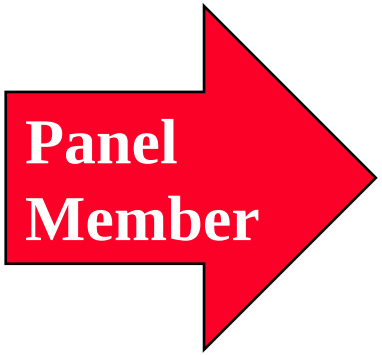
Is a Formal Effort to Achieve OEM Consensus for FAA to Proceed

- FAA Sponsored Advisory Group
- Comprised of Members with Known Fuel Expertise
- Expressed Corporate Opinion

FAA/OEM Review Process

Research Report

- Spec Results
- Fit-for-Purpose Testing
- Component Testing
- Engine Testing
- Process Control



OEM Review

- Engineering Analysis
- Proprietary and Trade Secret Analysis
- Operational Impact
- Service Impact
- Customer Impact

SwRI™

FAA/OEM Panel Member

- Convert Research Report to Internal Engineering Document
- Distribute to Key OEM Decision Makers
- Produce and Conduct Internal Presentations
  - Work with TF to Answer Questions
- Polls Company
- Provides Official Response
  - Not Recommended – Why Not?
  - More Info Needed – What Needs to be Done?
  - Recommended – OK for FAA to Proceed to ASTM Consensus Process

FAA/OEM Panel Member

- #1 Job – Provide Technical Support to Manufacturing
- Alternative Fuels May Not Be Part of the Business Plan
  - May Support Anyway
    - » A “General Good” Approach
  - May Require Funding
    - » Many Companies Require “Overhead” to Justify Efforts at All Levels
  - May Not Support
    - » De Facto Withdrawal (Pocket Veto Not Allowed)
- Funding Potential
  - Direct by Prospective Producer
  - Public/Private Funding
  - OEM by Regulation

FAA CLEEN II and COE
(FAA Alternative Fuels R&D Programs)

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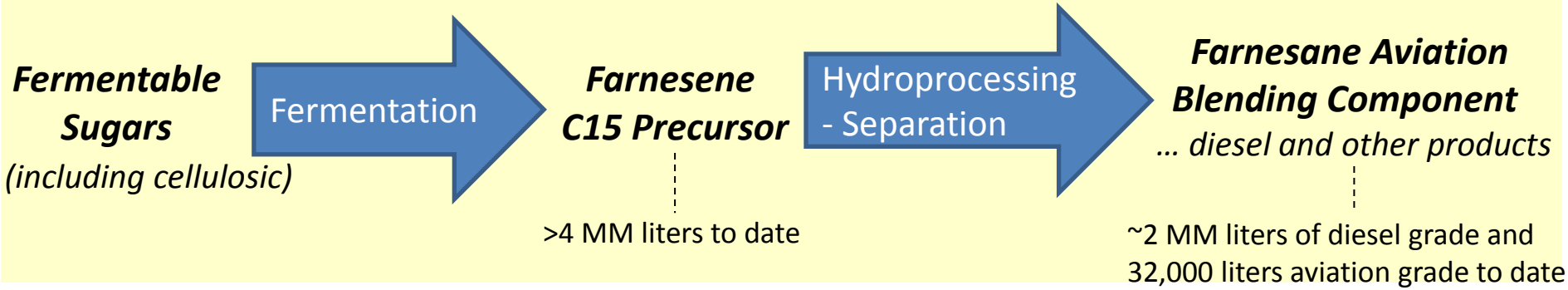
FAA Environmental/Alt Fuels R&D Support Initiatives

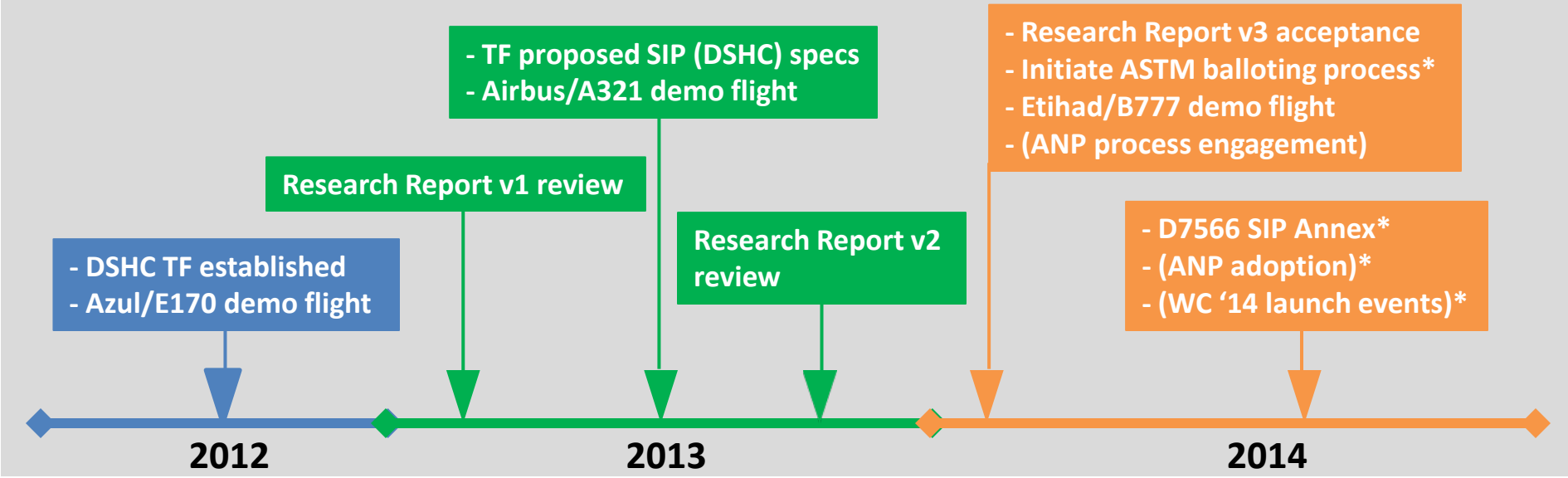
	CLEEN II	ASCENT	SEMRS
	Continuous Lower Emissions, Energy, Noise	**Aviation Sustainability Center of Excellence**	**Sustainability, Environmental Management and Research support**
What?	Advance TRL of aircraft technology and alternative fuels	Expands environment and energy research carried out by PARTNER COE	Complement Internal FAA R&D and CLEEN II/ASCENT
When?	2015 – 2020	2013 – 2023	2014 – 2019
How Much?	$100M FAA Funding with 50% industry cost share	$40M FAA Funding with 50% industry cost share	TBD as Required for FAA Support
Status	RFP mid-2014	Established Sept. 2013	RFP now open until Feb 11
Alt Fuels Elements	TBD, considering D4054 Support	Wide-Range of Research Topics Possible Including "Fuel Performance Testing"	Alternative Jet Fuel Research Support including "Conduct D4054 Testing" and "Develop Analytical Methods Based on Fuel Composition"

Synthesized Iso-Paraffins From Fermented Hydroprocessed Sugars (generically aka DSHC)

Pathway Overview



ASTM D4054 Qualification Timeline



*projected

ATJ-SPK

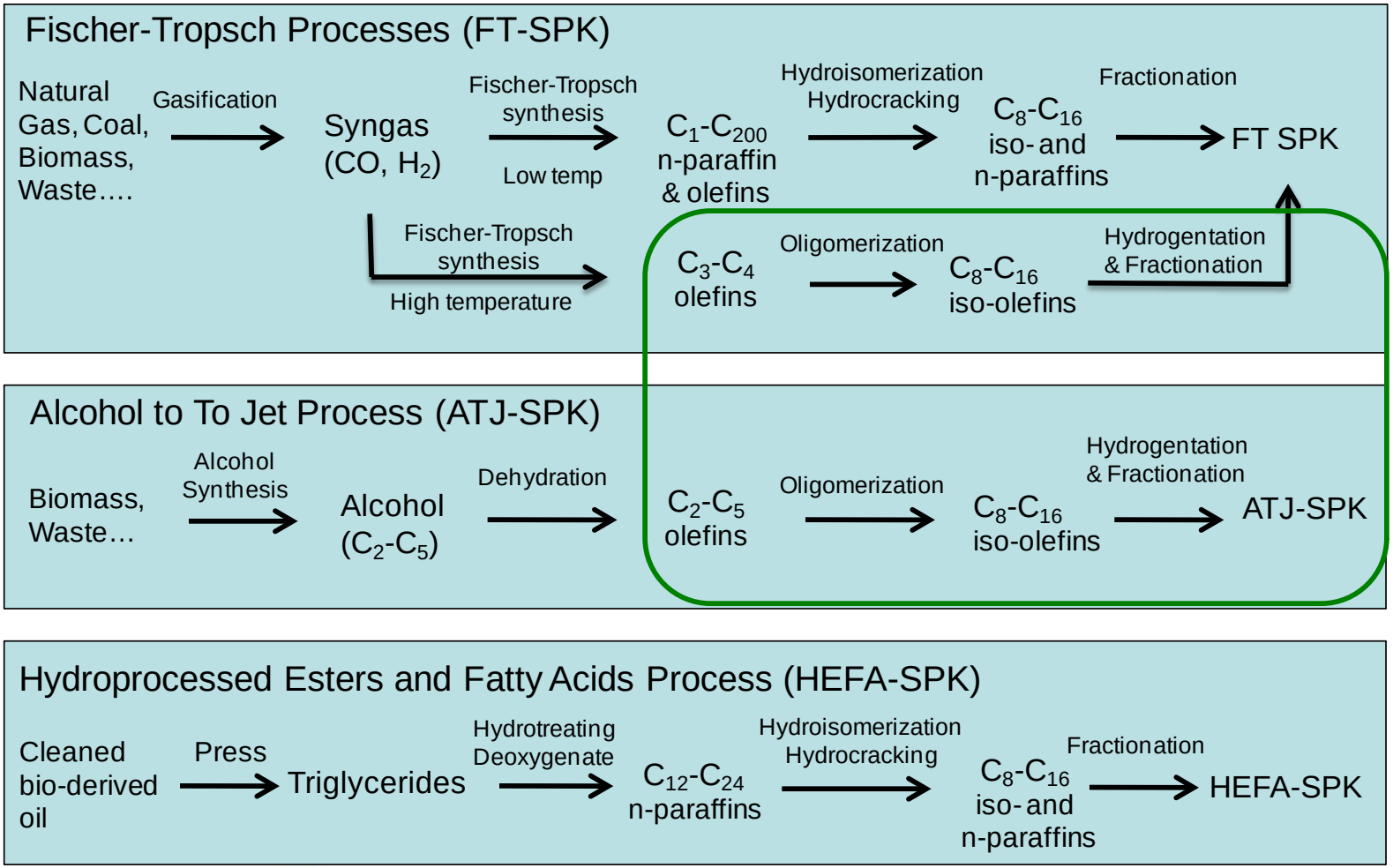
ALCOHOL TO JET

CAAFI General Meeting & Expo
Washington, D.C.

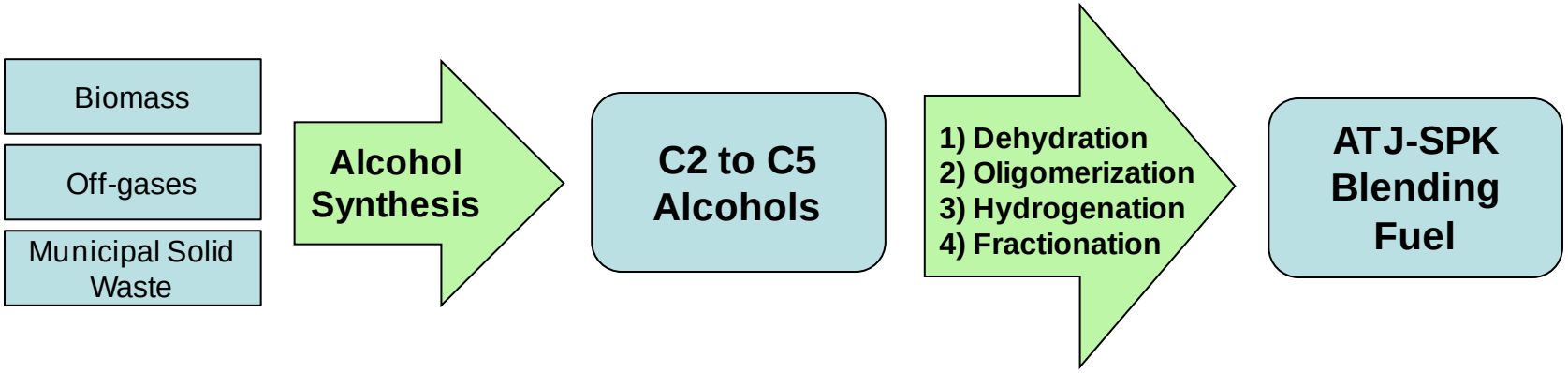
January 28th, 2014

gevo Cobalt UOP A Honeywell Company LanzaTech Swedish BioFuels

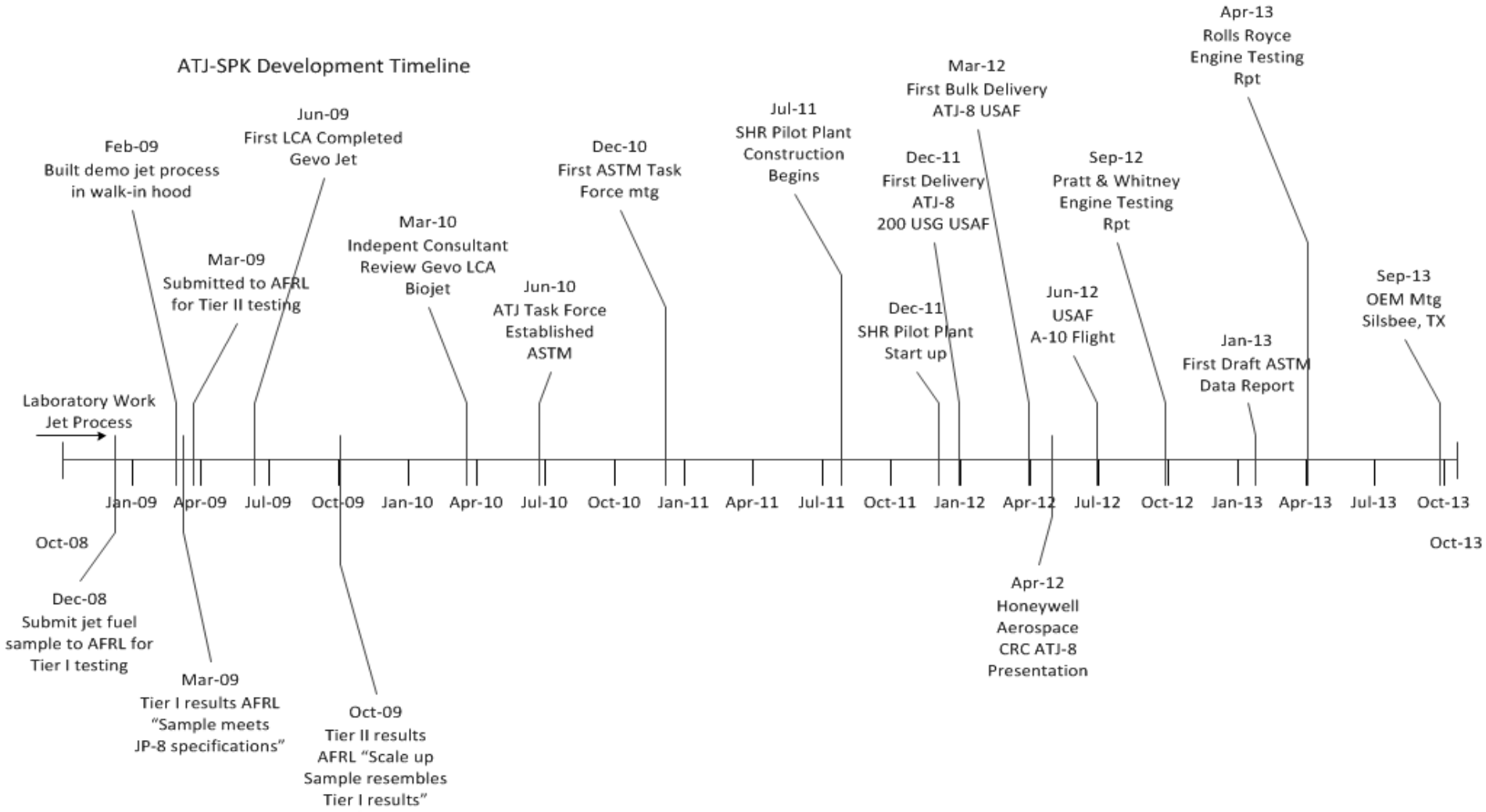
ATJ-SPK Processes Today



ATJ-SPK Feedstock-Alcohols



ASTM Timeline



gevo Cobalt UOP A Honeywell Company LanzaTech Swedish BioFuels

Catalytic Hydrothermolysis (CH) - Pathway

Biofuels ISOCONVERAION (BIC)Process = CH + Hydrotreating (Chevron Lummus Global)

Feed Stocks

- Triglycerides
- Plant oils
- Tallow
- Algal oils
- Fatty acids

Water

CH Conversion

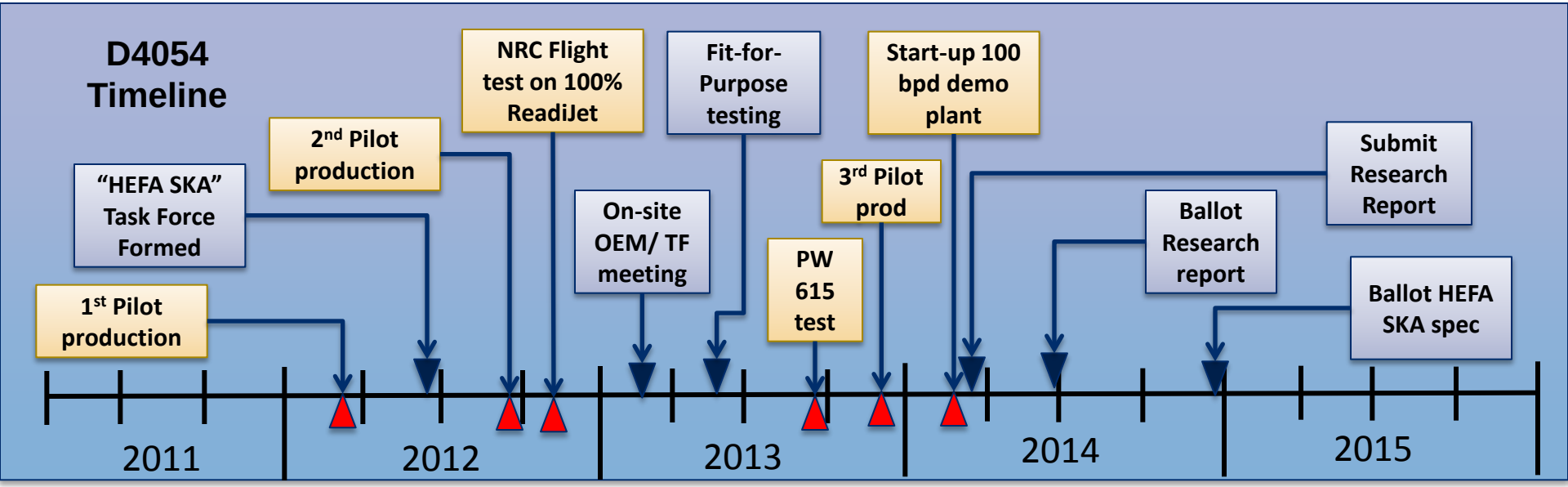
Intermediate Products

- n-paraffins
- Iso paraffins
- Cycloparaffins
- Aromatics
- Olefins
- Organic acids

Hydrogen

Hydrogenation Fractionation

Jet Fuel "Drop-in" ASTM D1655 Equivalent w/o blending



Hydrotreated Depolymerized Cellulosic Jet (HDCJ)

Pathway Overview

Renewable Biomass Feedstock

- ✓ **Abundant supply**
- ✓ **Non-food resource**
- ✓ Lignocellulose

Depolymerization

- ✓ **KiOR's BFCC**
- ✓ UOP's Pyrolysis
- ✓ Licella's Hydrothermal

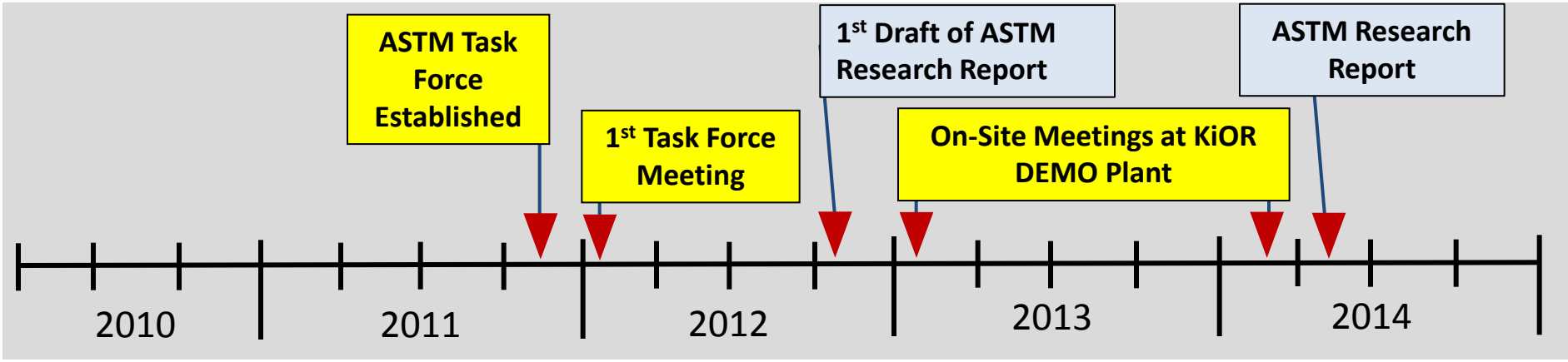
Bio-crude Hydrotreating

- ✓ **Hydrotreating**
- ✓ **Refinery proven tech.**
- ✓ Hydrocarbon product

Blendstock Fractionation

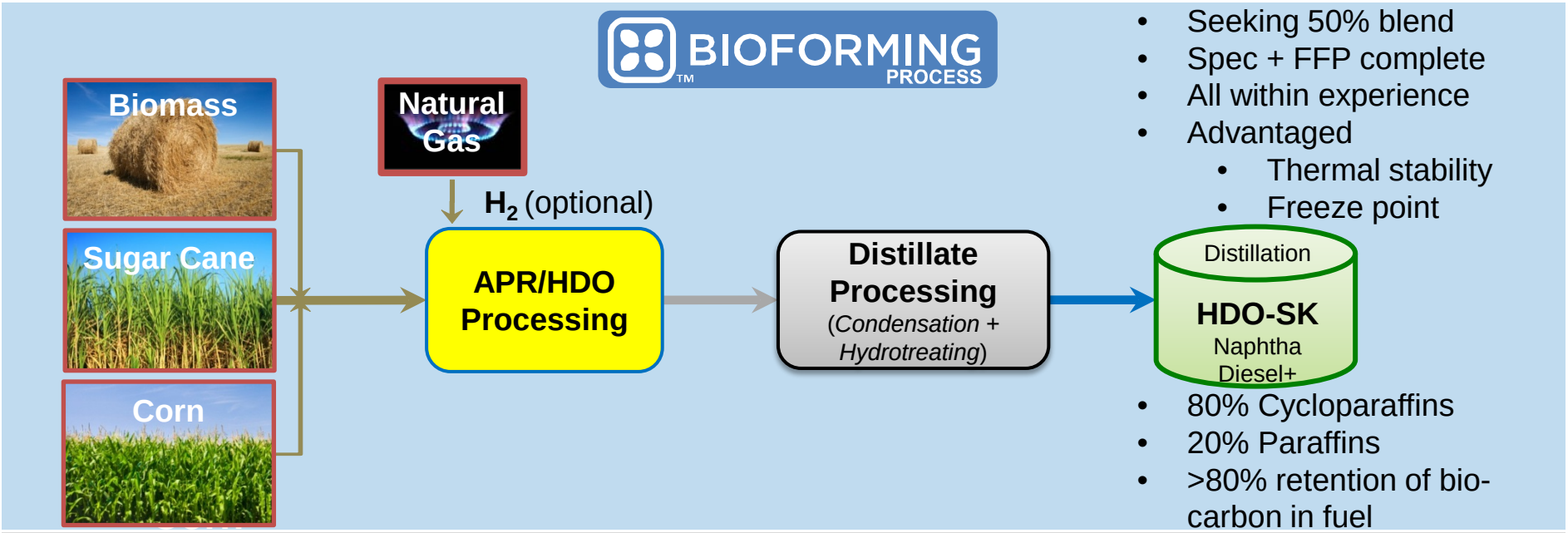
- ✓ **Fungible hydrocarbons**
- ✓ **Gasoline, Jet, Diesel**
- ✓ Aromatic rich (30-45%)

ASTM D4054 Qualification Timeline

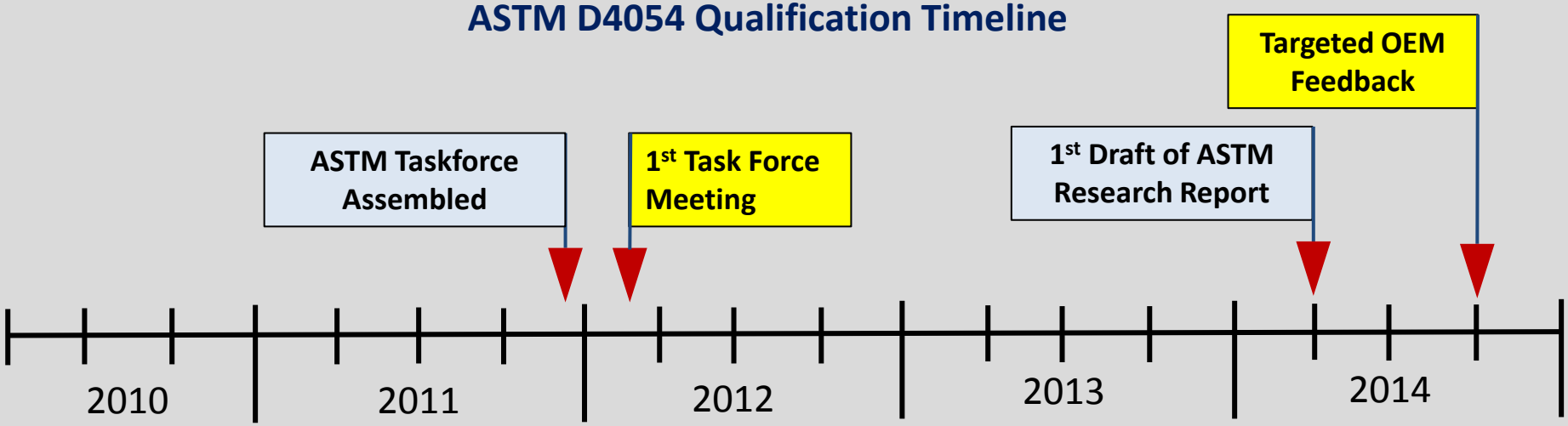


HDO-SK: Hydro-Deoxygenated Synthesized Kerosene

Pathway Overview

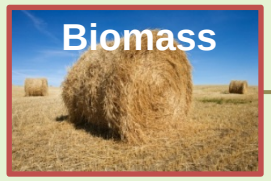


ASTM D4054 Qualification Timeline



HDO-SAK: Hydro-Deoxygenated Synthesized Aromatic Kerosene

Pathway Overview



Natural Gas

H_2 (optional)

BIOFORMING™ PROCESS

APR/HDO Processing

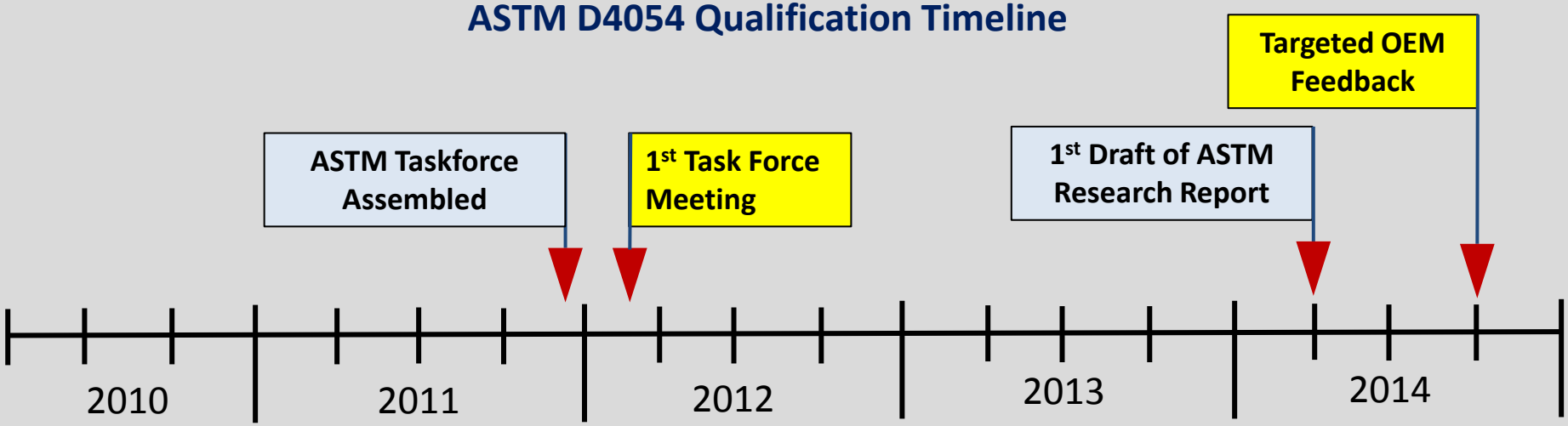
Aromatics Processing
(*Modified ZSM-5*)

Distillation

HDO-SAK
Gasoline
Diesel+

- Seeking blend up to aromatics limit
  - Balancing blendstock
- Spec + FFP complete
- All within experience
- Advantaged freeze point
- 95% Mono-Aromatics
- 5% Indans/Tetralins
- >80% retention of bio-carbon in fuel

ASTM D4054 Qualification Timeline



Synthesized Kerosene with Aromatics, SKA

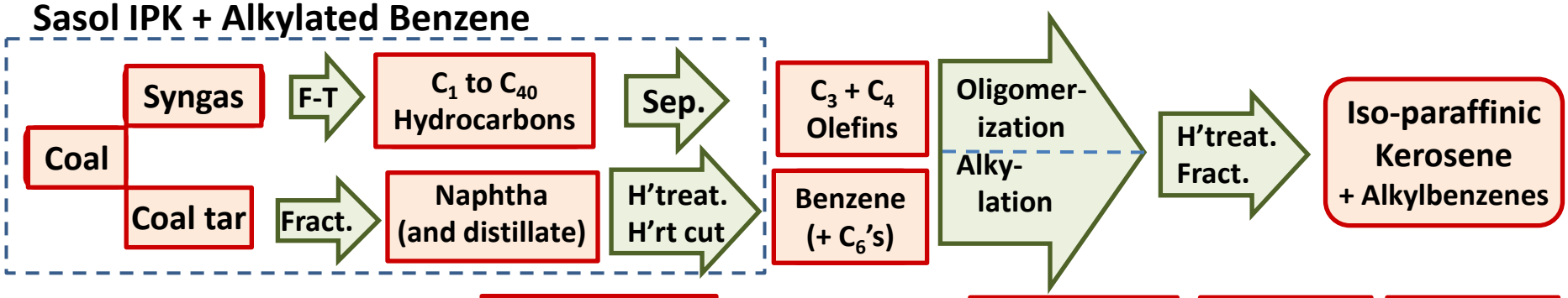
SKA Task Force Objective: Develop D7566 Annex defining synthesized kerosenes with aromatics

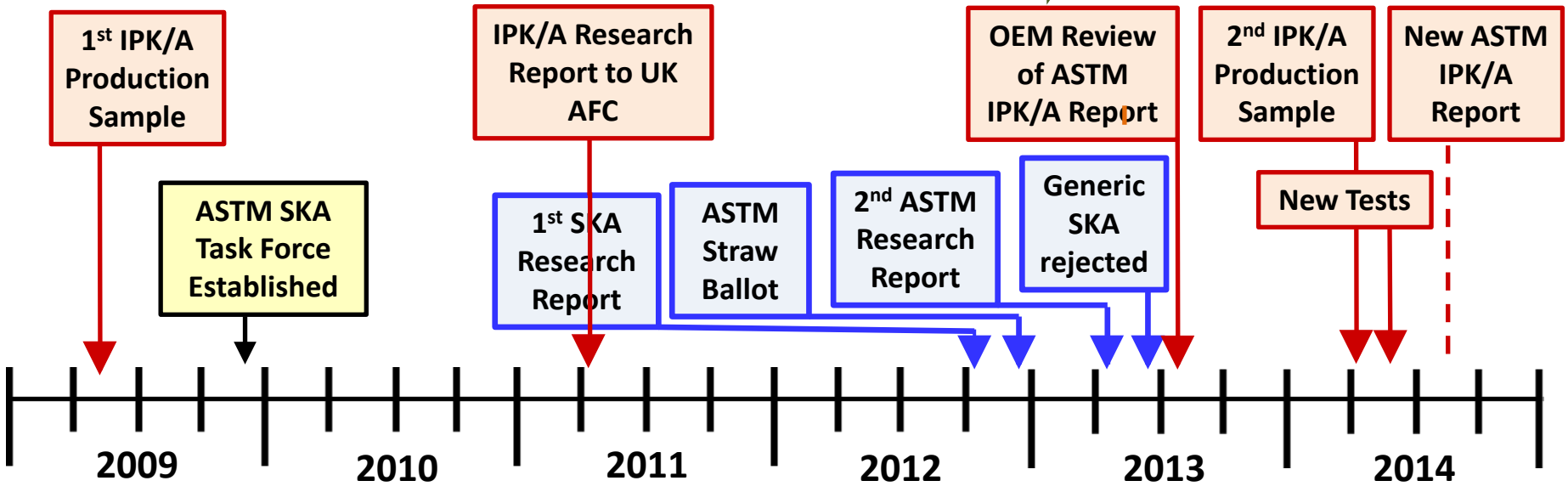
Scope: 3 methods of synthesizing aromatics
- F-T product
- Hydrocracked F-T wax
- Alkylated benzene

Approach: 3 Phases
- F-T kerosenes
- Renewable kerosenes
- Uni-molecular products

Results:
- Successful D4054 eval.
- Successful def'n of arom.

Sasol IPK + Alkylated Benzene





Round Table Discussion
CAAFI CQ Breakout Session

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D4054 Process

Producers	OEMs
Timing/Volume Req'ts/Logistics not clear	Generally positive comments
How to account for co-processing?	
Composition-Based approval, not feedstock/process based	Should be subject to improvement based on experience
Better up-front involvement and coordination relative to test requirements/results	Who pays for engine and aircraft analysis?
Difficult to find lab to perform some tests	Test fuel not from full-scale production facilities
OEMs may not fully accept some test methods	
High cost, need FAA/DOD support	
Can testing not being used be removed from requirements?	
OEM/FAA Review step outside of normal ASTM procedures	
Specific rationale for rejection should be communicated	

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Fit-For-Purpose Testing

Producers	OEMs
Is World Survey/CRC Handbook acceptable pass/fail criteria?	Upcoming revision addresses scope of experience of some FFP properties
Need OEM Feedback on Test Methods/Results	Lack of definition of acceptable difference from reference properties
Involvement of Smaller OEMs (Cessna, Embraer)?	Same issues each time with some properties
OEMs always seem to find additional test requirements beyond D4054	Some variability in how data is presented
Evaluation of bulk physical properties for hydrocarbon, kerosene type fuels is not necessary – results always the same. Remove unnecessary tests.	Producers with minimal contact with OEMs may have incomplete/inappropriate data
Lack of or poorly defined pass/fail criteria • Water separation • Toxicology • API 1581 Filter testing	Some data lacks specific details

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Materials Compatibility Testing

Producers	OEMs
How many of these materials actually need to be soak tested?	Upcoming revision will address subjectivity.
How to move to more real-world testing such as dynamic testing?	Need to incorporate ultra-short materials list
How to harmonize different dynamic methods?	
Need to make sure OEMs are engaged up front rather than after testing completed	
Complex list of materials, pass/fail requires expert knowledge	Some problems if baseline fuel not run at same time as test fuel
Not necessary for hydrocarbon fuels in kerosene range, base on materials technical requirements, aromatics only issue	Test data and reports have improved over time, now can quickly review and make determination
Testing of metallics unnecessary	
Test fuels differ only in trace materials, which don't impact materials compatibility	Test data is variable depending on fuel producers engagement with OEMs
Need initial testing to determine if more extensive testing necessary	Often need to do testing ourselves on specific materials
Base on chemistry in lieu of testing	

Component/Rig/Engine Testing

Producers	OEMs
Are we maximizing read-across based on composition and properties?	Lack of clearly defined pass/fail criteria
HW testing is well-defined, but other rig testing is not (pass/fail criteria)	Some OEMs only report general information due to proprietary concerns
Pass/fail criteria needs to be defined	
Pass engine test but have issues on components test; doesn't make sense	When producers fully engaged, test is well defined and results usable
Some tests not being done, need better up-front criteria for need for performing tests; difficult to plan	Often component tests required by OEM without technical basis to support a need for the test (not considering fuel chemistry or FFP results)
Need standardized rigs to only test once	
Why need to wait until FFP done before rig/component test begins?	Too engine focused, process needs to be clear that airframe testing is equally important
Is HW testing enough? Most demanding environment? Why test at other OEMs?	

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Pathway/Process Definition

Producers	OEMs
Can we broaden feedstock/process definitions and focus on final composition/properties?	Should now direct focus on certifying a fuel based on final properties with less emphasis on process
If a number of process variations involved, may need to adjust definition detail depending on criticality to product composition	
Need to ensure production batches give the same composition/performance as test batches	Should be defined such that controls do not allow unforeseen deviations
Approving fuel by process OK for now, but ATJ limitations on alcohol feedstock seems too restrictive	As an OEM, don't have process expertise, can't comment except that end product needs to fit current fuel property distribution
Need to move toward more generic pathways and away from company specific approvals	Should we require documentation of conventional petroleum fuel processes?
Process should be controlled via product quality specs, not process conditions	

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Use of Compositional Characteristics to Guide D4054 Process

Producers	OEMs
Knowledge of acceptable range for hydrocarbons and trace materials would improve approval process	Compositional characteristics can be used to define testing, if fuel properties the same, should consider not testing
Should require carbon number distribution, then only concern is oxygenates and inorganic contaminants	Compositional controls should cover both bulk composition and trace materials
Fuel performance is a function of composition, should understand performance differences based on composition, not run same tests repeatedly	Broad distribution of hydrocarbons should result in fewer tests, need detailed rig and engine data to predict based on composition
Ultimately a composition-based D7566 makes sense	Airframers don't have expertise to link composition to D4054 process
Streamline process to only FFP for similar compositions	
Replace rigs/engine testing with compositional models	

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How Can D4054 Process be Improved?

Producers	OEMs
No guidance on based on composition	Shorten list materials
No guidance on reference petro-Jet	Require technical basis for determining need for component/rig/engine testing
How to overcome OEM "cartel" approach?	Discourage redundant or non-standard testing, select representative component/engine tests
Economize test matrix to what is only necessary	Better definition of FFP properties and materials (where to get them)
Ensure timely OEM response, stop adding additional requirements	Decision matrix to determine component testing requirements
Process lost credibility with FAME project, need clear pass/fail criteria	Provide airframer input/requirements
Gov't sponsored testing best way to go	Need to project management to avoid log jams
Est. stage gate process with periodic reviews	Need to make it clear airframe fuel system testing may also be required
Remove subjectivity, base on FDA's process	
OEMs who don't participate should not be able to hold-up approval at last minute	

Other Questions/Comments?

Producers	OEMs
Concern if D4054 process not improved, producers will move away from jet fuels or start selling unapproved streams	Lengthy/costly process necessary to ensure airworthiness/safety
How can we continue with fuel approvals with defunding of USAF/AFRL/AFCO?	OEMs need to make sure there is no impact on flight safety
CAAFI should screen candidate processes to ensure commercial viability before proceeding down D4054 process	OEMs must have veto to block processes not technically acceptable for the safety/performance of their products
	When's lunch?

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