

Confronting Challenges, Creating Opportunities

Sustaining a Commitment to Bioenergy

Session 2-D

Aviation RJF: Are you getting on-board?

Technical Pathway Development – Expanding Supply & Reducing Cost

11Jul'12, Washington DC

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imagination at work



Jet fuel functional requirements

How do we use fuel ...

As a coolant

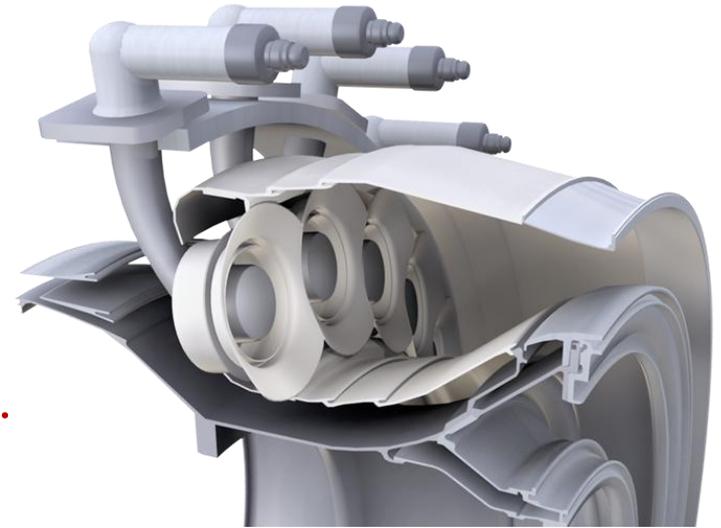
As a lubricant

As a hydraulic fluid

As a ballast fluid

As a swelling agent, conductive medium, ...

... and as an energy source



Need: Efficiency, safety, and operability paramount

High energy content: volumetric & mass

Stable: high flash point (no explosions), low freeze point (liquid at -60F)

Auto-ignition, lean-blowout, operability, flameout, control stack, cavitation, cold ignition, altitude relight, coking, fouling, emissions constituent generation, ...

Aviation fuel used for multiple purposes ... So its creation has to be carefully controlled to get the right physical and fit-for-use properties (ASTM D 1655)

RJF facilitization - why we care!

Customer alignment, as RJF can bring:

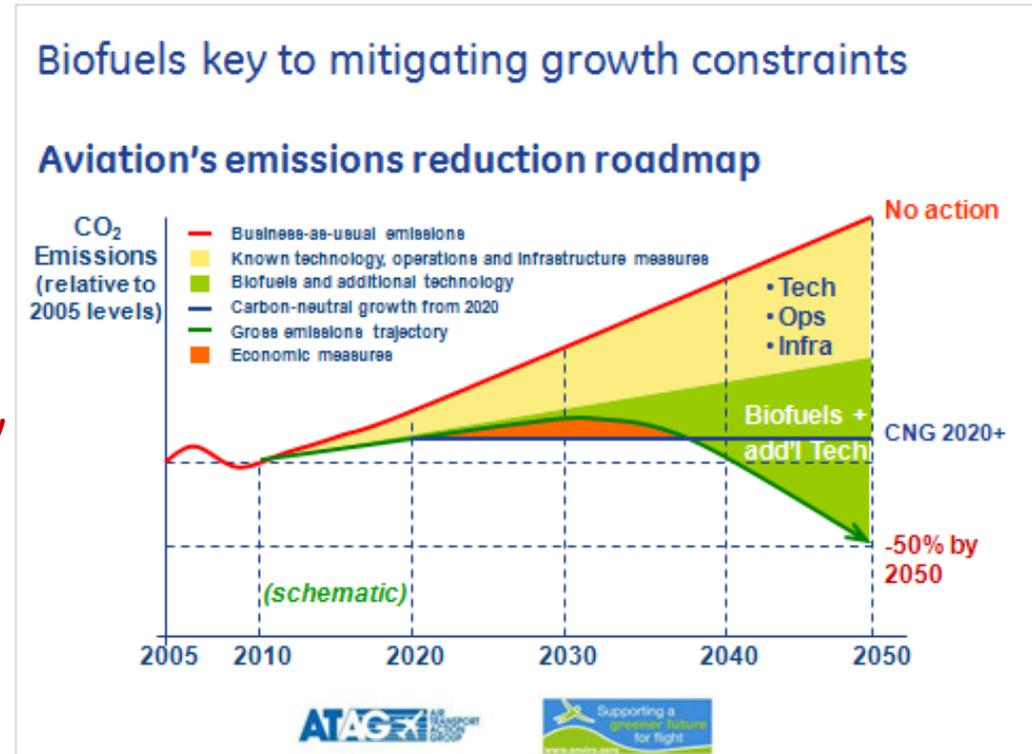
- Carbon relief
- Price stability
- Supply surety (military focus)
- Energy security
- Lowers LAQ emissions
- Improves energy mass density
- Minimal infrastructure impact

Aviation commitments

- Improving sustainability

No near-term viable kerosene alternatives

RJF works! Lots of Options / Lots of Promise



The OEM's direct role with RJF

Supporting the Industry's agenda

Evaluation, **testing**, qualification and certification of proposed renewable fuels – **2nd and 3rd gen drop-ins**

Combustor rigs, engine ground tests, and flight demonstrations

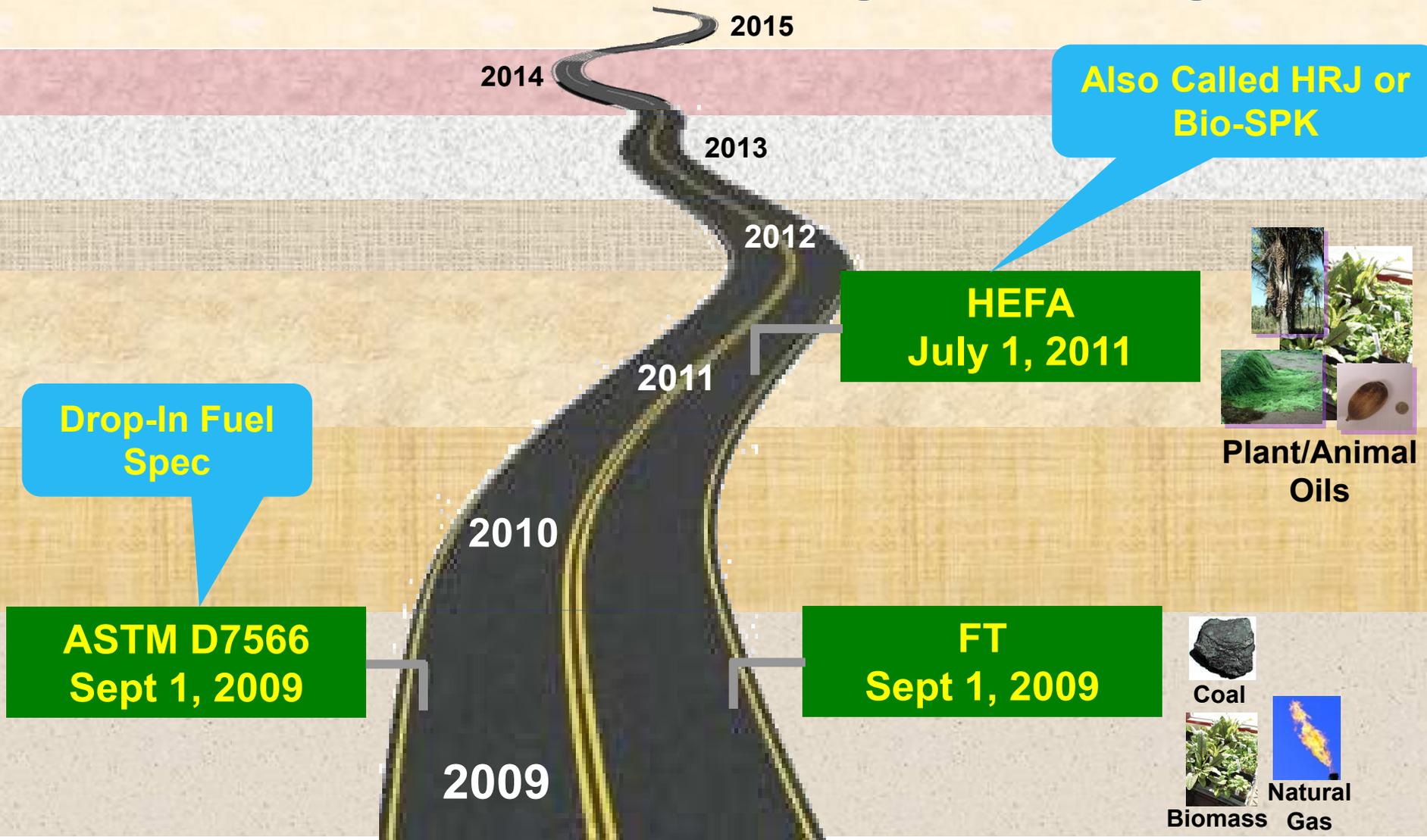
Support customers and industry to catalyze promising, renewable, sustainable jet fuel technologies

Promote fuel solutions with genuine CO₂ benefits (well-to-wake)

Share findings on renewable fuel efforts

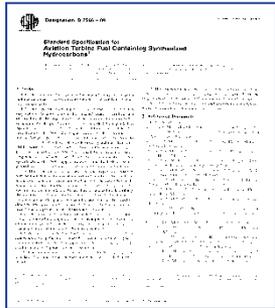


Certification: Continuing Our Progress

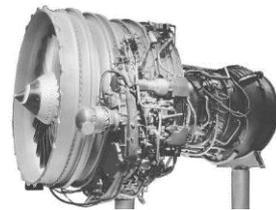


Airworthiness regulations for aviation fuel

Regulatory Authorities Do Not Certify Fuel, They Certify Airplanes and Engines to Operate on Specified Fuel



Industry/Military Fuel Specification



Engine Operating Limitations

- Fuel Specification



Aircraft Operating Limitations

- Engine limitations Used for Aircraft



Aircraft Operator (Airlines) Operating Rules

- Must Adhere to Aircraft and Engine Limitations

Content courtesy of FAA/CAAFI

Why is ASTM approval so important?

ASTM Qualification



**D7566 New Annex
Drop-In Fuel**



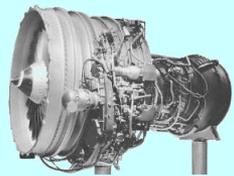
**New Spec
Non-Drop-In
Fuel**

**Unchanged
Operating
Limitation**

New Oper Limitation

**The Key to
Commercialization**

Airworthiness Certification



Re-Certify All Engines



Re-Certify All Aircraft



**Approved for Airline
Operations**

ASTM D7566 enables Drop-In Fuel

Production



Semi-Synthetic Fuel

Tighter Control of Fuel Properties

Re-Identified



D1655

Conventional Jet Fuel

Separate Tracking NOT Required

Operations



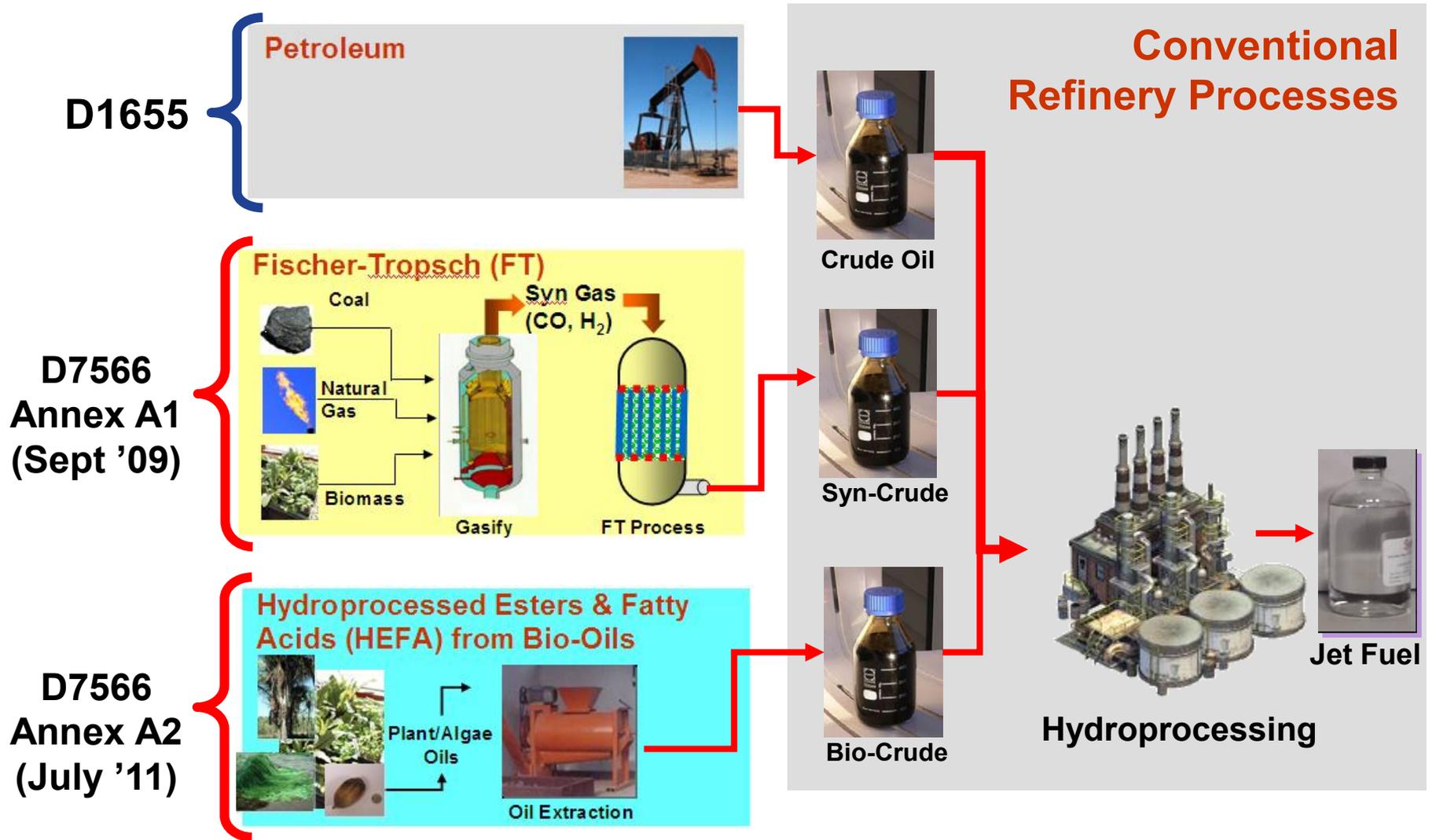
Conventional Jet Fuel

Re-Certification NOT Required

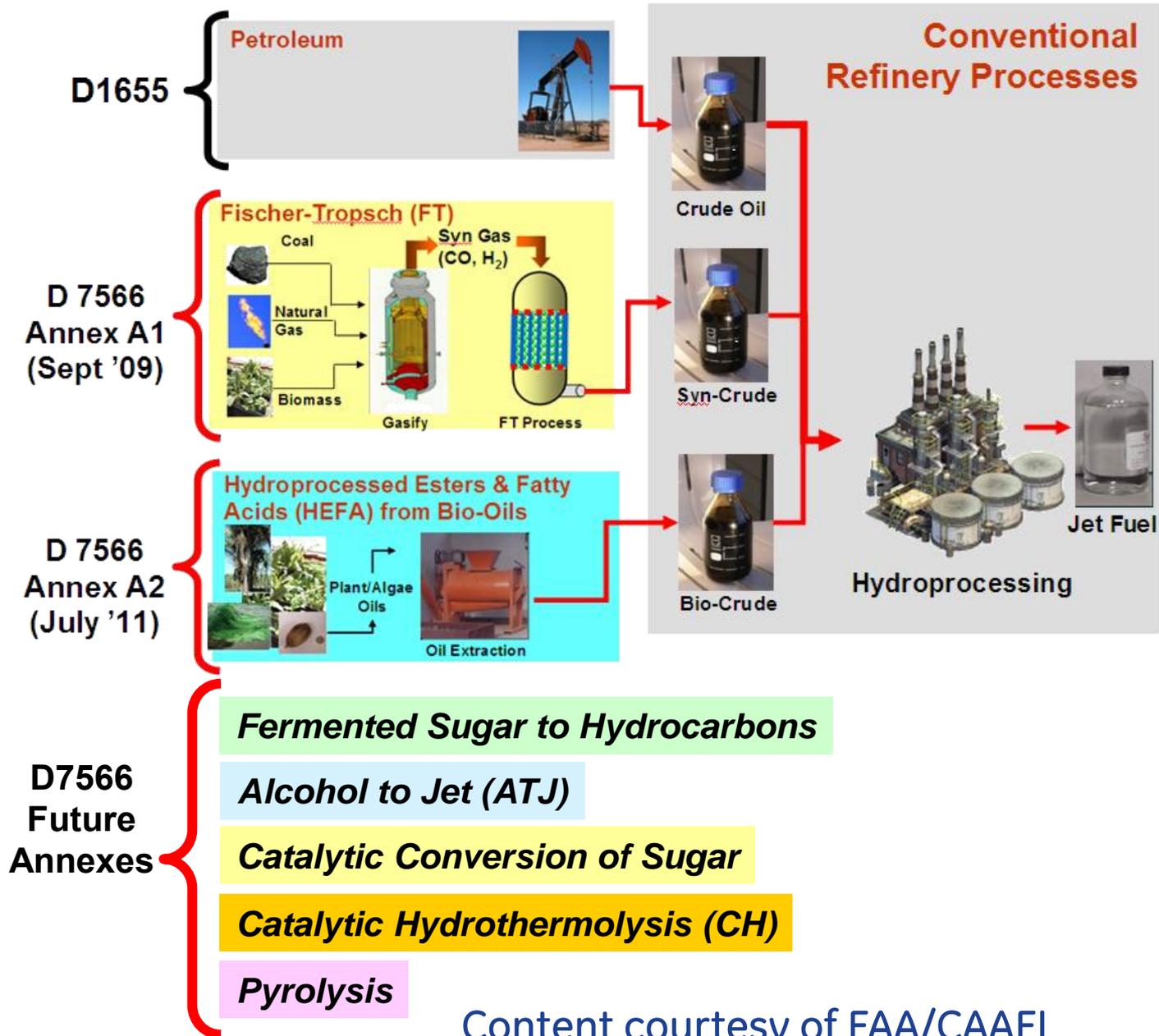
Distribution



ASTM Aviation Fuel specifications



Future alternative aviation fuels



Content courtesy of FAA/CAA/FAI

Future Fuels at ASTM

Fermented Sugar to HCs



Fermentation



Genetically Engineered Microbes



Jet Fuel Product Constituents

Alcohol to Jet (ATJ)



Fermentation



Alcohol

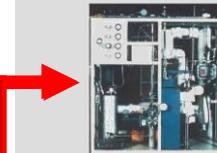


Dehydration

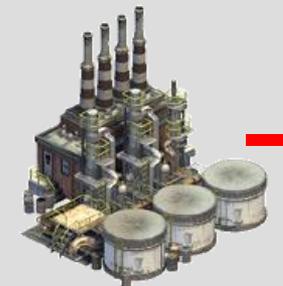


Olefins

Conventional Refinery Processes



Oligomerization



Hydroprocessing



Jet Fuel

Catalyzed Sugar to HCs



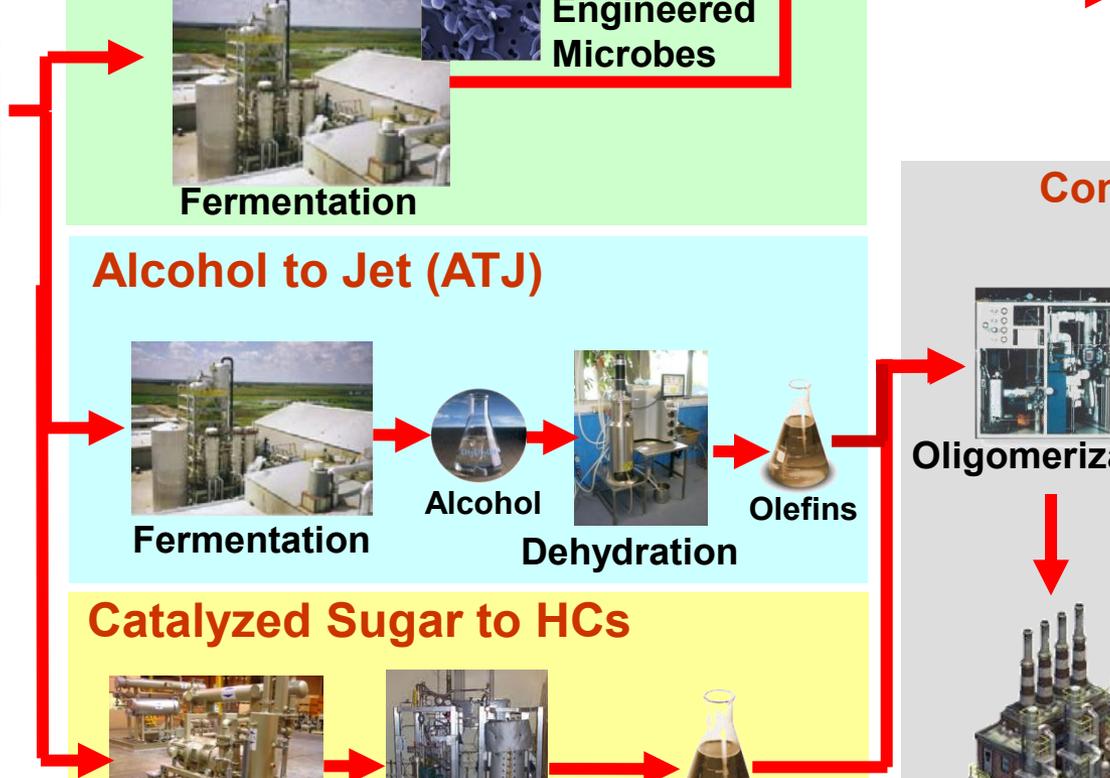
Pretreatment



Catalysis



Olefins



sugarcane
Sugar



switchgrass



corn stover



forest waste
Lignocellulose

Future Fuels at ASTM (cont'd)

Catalytic Hydrothermolysis (CH)



Plant/Animal Oils



Oil Extraction



Catalytic Hydrothermolysis



Bio-Crude

Conventional Refinery Processes



Hydroprocessing & Fractionation



Jet Fuel

Pyrolysis



Lignocellulose



Pretreatment



Pyrolysis



Bio-Crude

Summary:

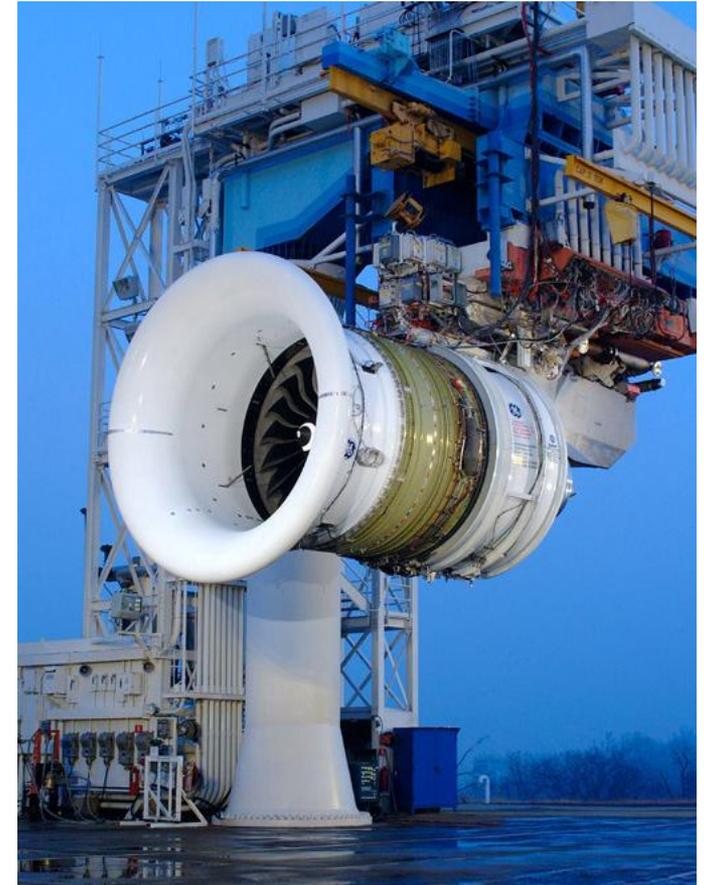
Industry is working in concert to catalyze promising, renewable jet fuel technologies

Many parties working to **expand supply and reduce cost**, within multiple socio-economic and geo-political paradigms

- Not just with scale and learning curve
- Looking at optimization of all elements of the vertical
 - New/Improved: agronomy, feedstocks, processing/handling, conversion technologies, system efficiencies

As new conversion technologies are proven, new pathways to be added to ASTM D 7566

Got a pathway, technology or good idea?
Please come on-board!





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