FAA CENTER OF EXCELLENCE FOR ALTERNATIVE JET FUELS & ENVIRONMENT

# Alternative Jet Fuel Test and Evaluation

## Project 31a

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Project manager: C. Shaw, FAA

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Alexandria, VA

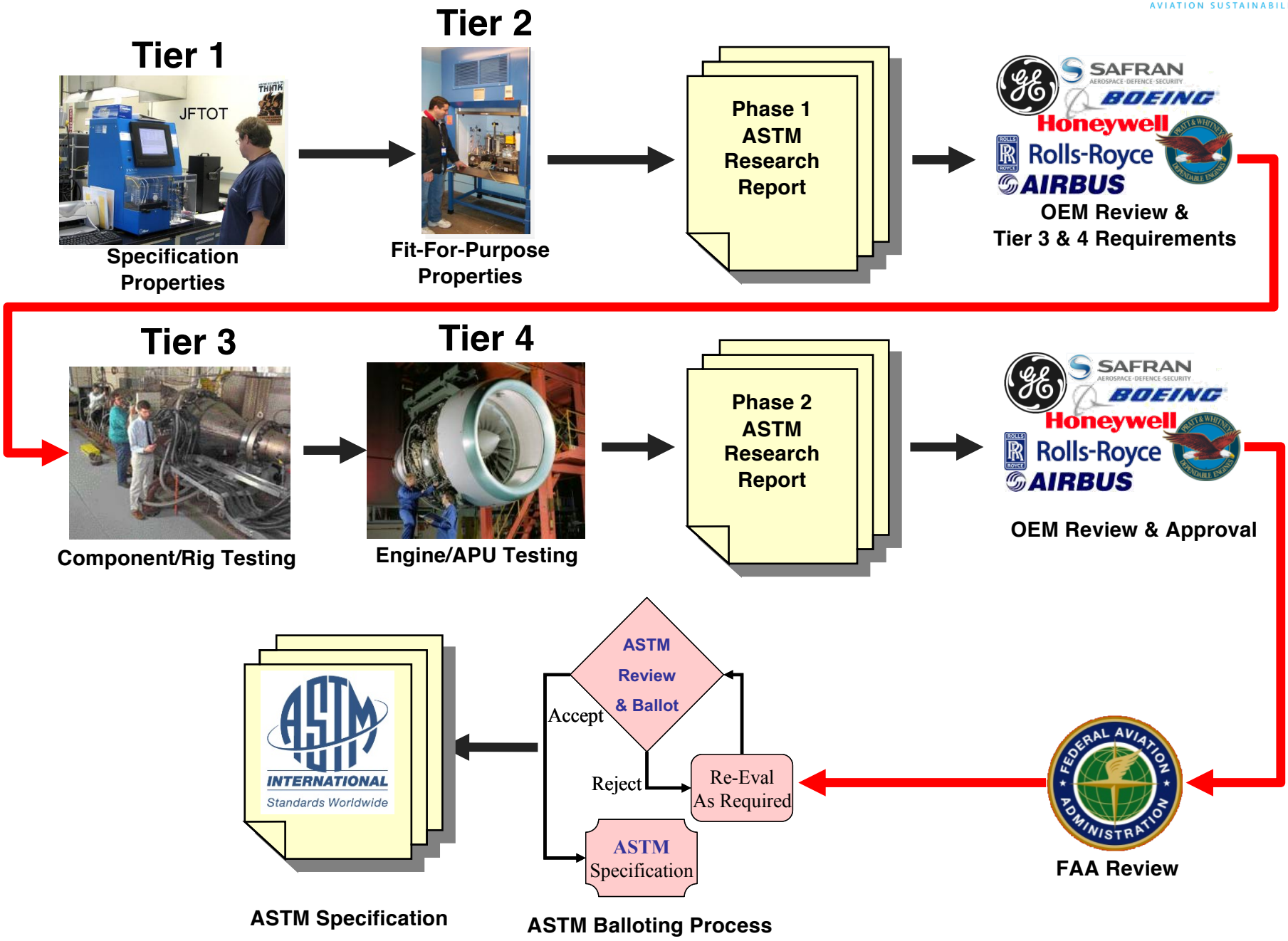
# Introduction

- Motivation – Establish a centralized facility to support continued approval/certification of candidate alternative jet fuels through the ASTM process
- Objectives
  - Fuel property and composition testing
  - Support for rig/engine evaluations
  - Coordination of OEM approval process
- Outcomes and practical applications
  - ASTM research reports for OEM approval
  - Creation of D7566 annex
  - Recognized focal point for management of D4054 qualifications process
  - Increased supply of secure, safe alternative aviation fuels

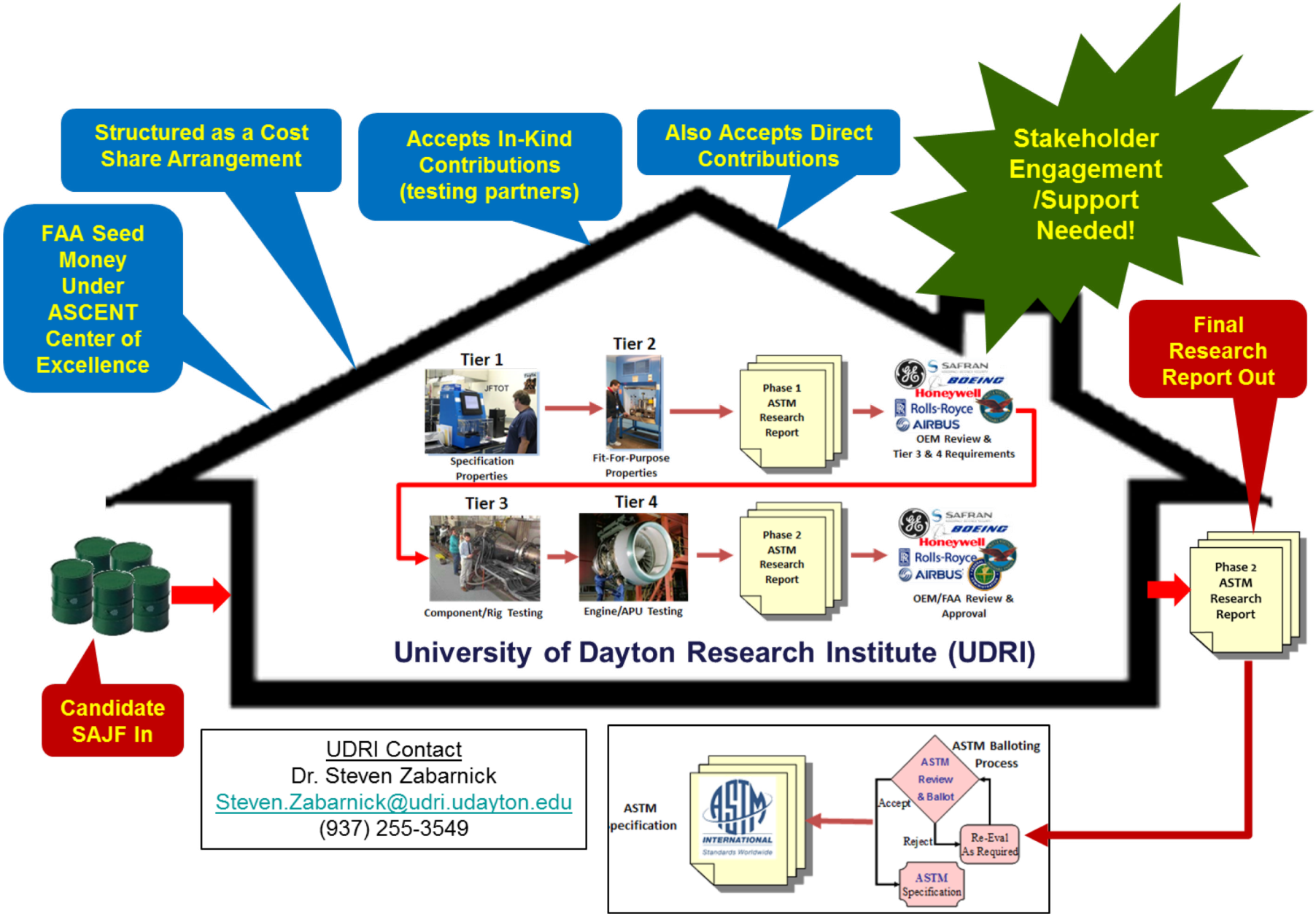
# Primary Tasks

- Alternative Fuel Candidate Evaluation
  - LanzaTech ATJ approved, Shell IH2, IHI Bb-oil
- Coordination of Research Report Review Process
  - LanzaTech ATJ approved, Boeing HFP-HEFA, ARA CHJ, Virent SAK, Shell IH2, IHI Bb-oil
- Development of Generic Annex Fast Track Process
  - D4054 Annex with stringent requirements/fast approval
  - Chemical composition methods – trace oxygen analysis
- GCxGC Method Development – hydrocarbon type and trace polars methods
  - Replace D2425 mass spec method
  - Method documentation, precision determination, comparison with other labs/GCxGC columns/modulators

# D4054 Certification Process



# D4054 Clearinghouse Concept





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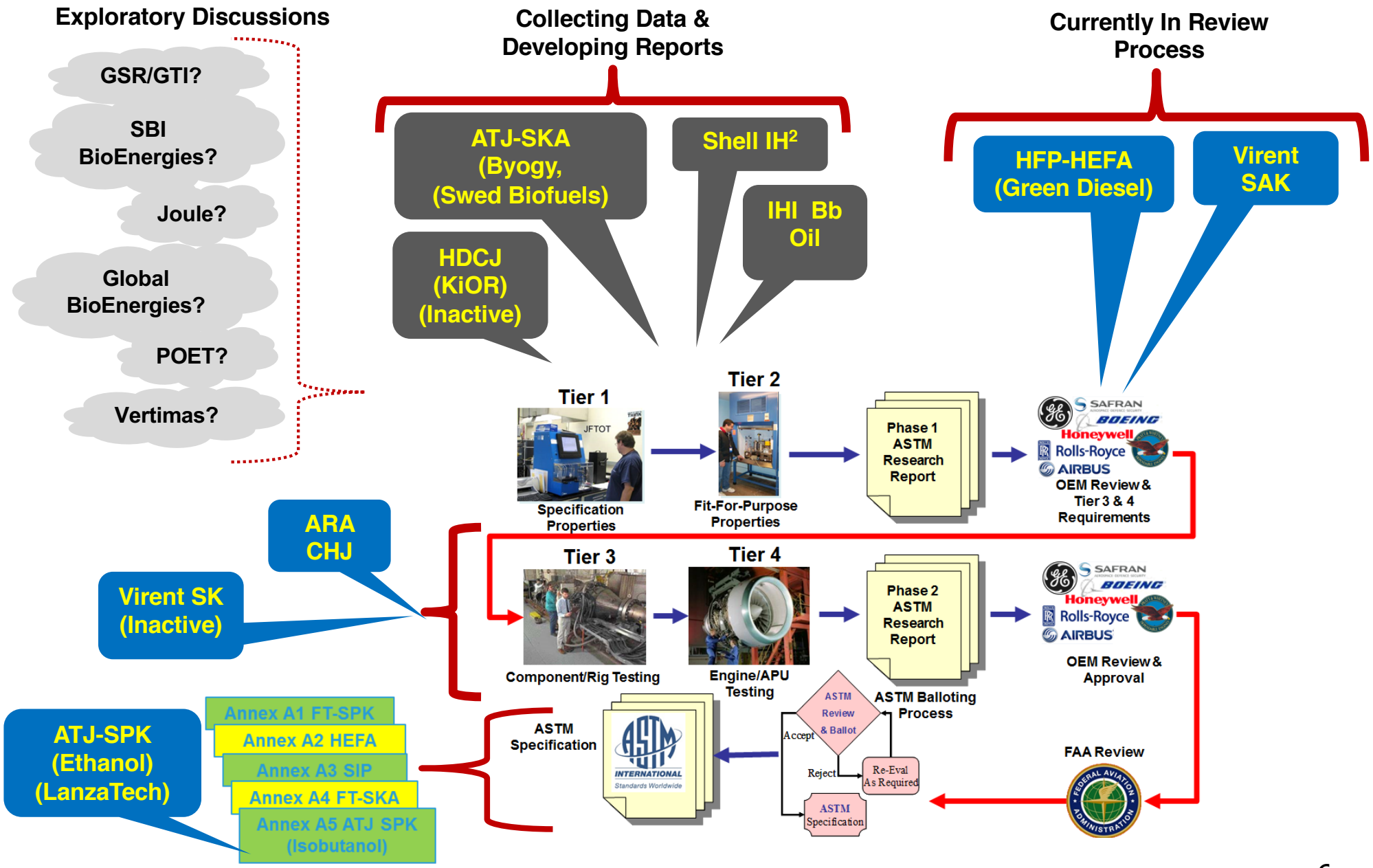
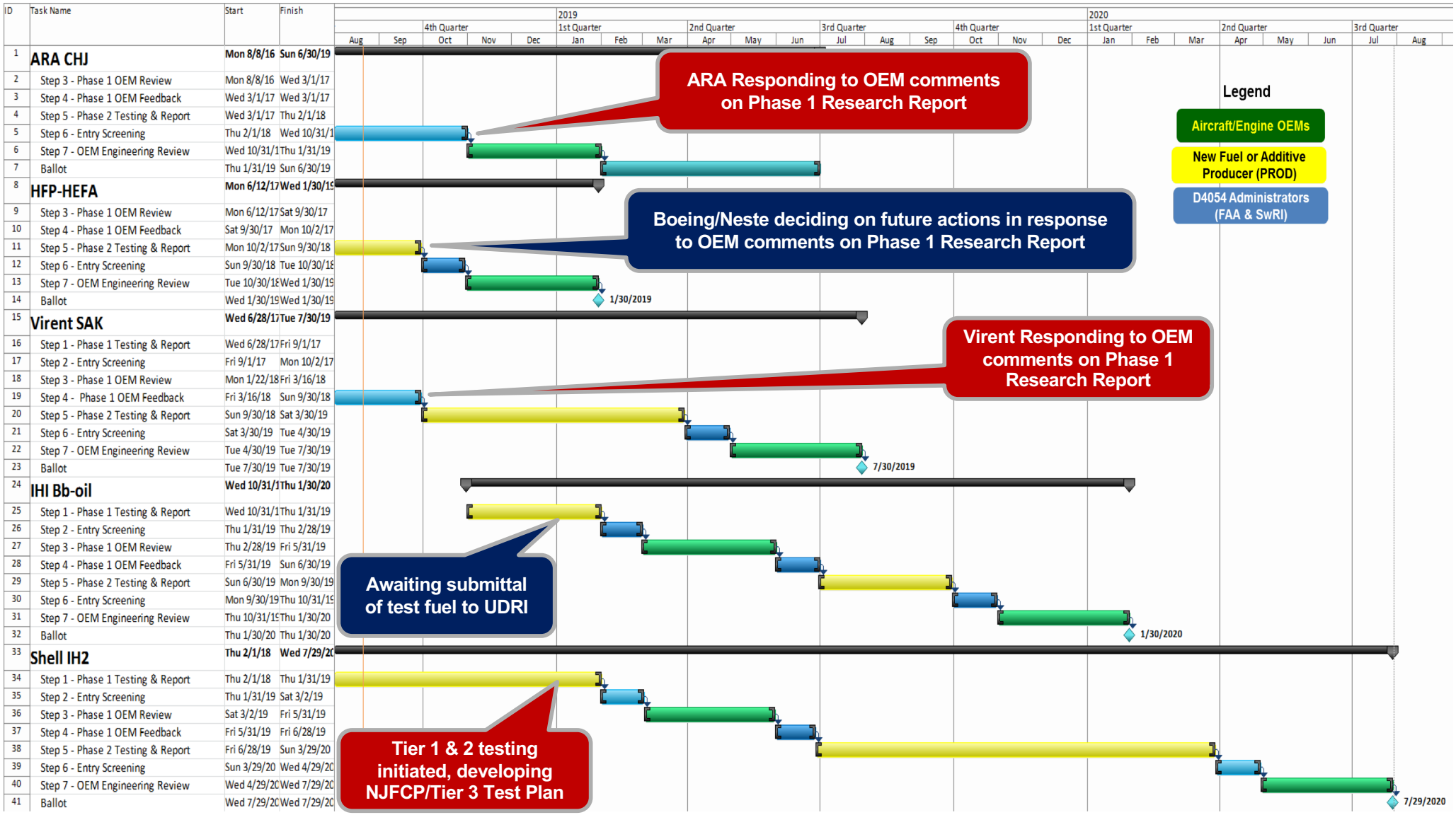
# Candidate Fuels in Queue



# Gantt Schedule for Current Fuels



# Status of Subcontracts for ASTM Research Report Review

- SwRI – coordination of ASTM approval & research report review
- Honeywell –
- Rolls Royce –
- GE Aviation –
- Pratt & Whitney
- Boeing –
- Airbus – in negotiation

Research report review

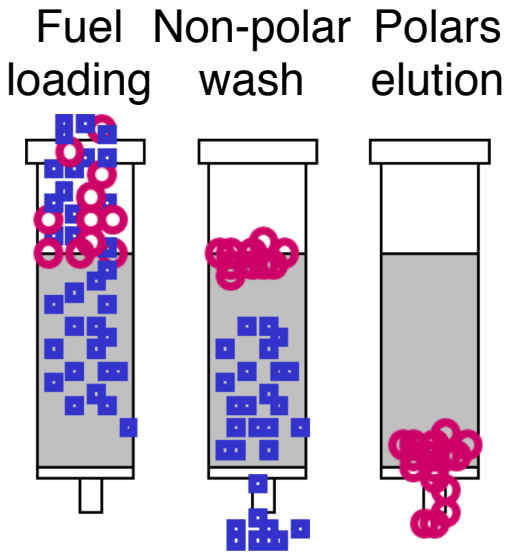
# Generic Annex → Fast Track Annex

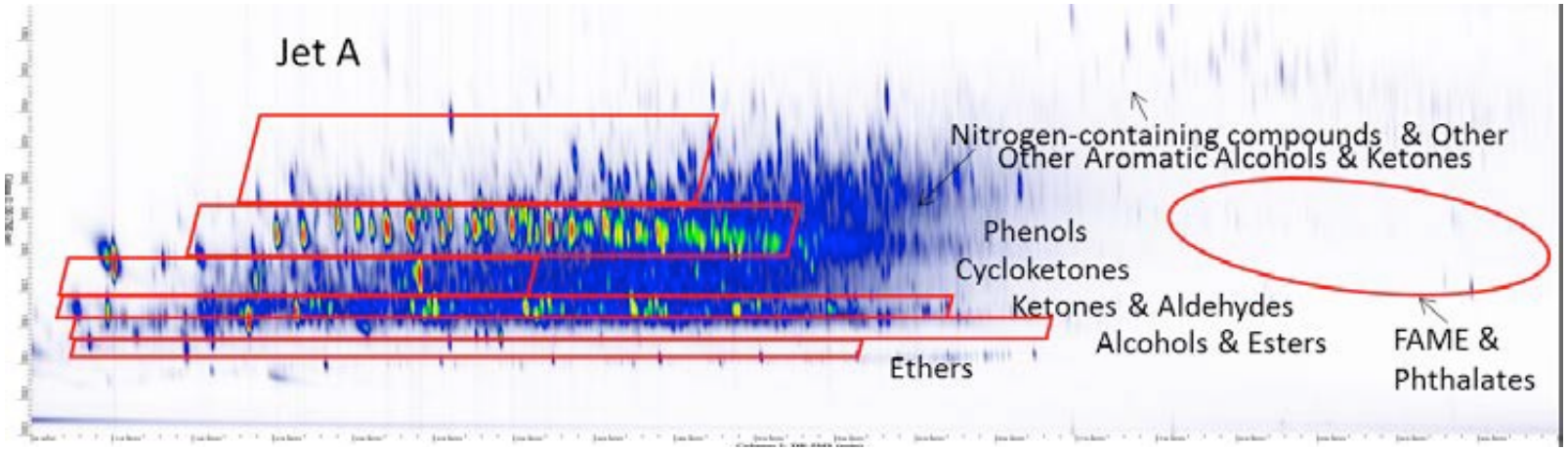
- Generic Annex D7566 – no OEM review process
  - Stringent property requirements
  - Feedstock and process not defined
  - Push back from OEMs on approval without OEM review
  - Abandoned in Spring/Summer 2018
- Fast Track Annex for D4054 – defines new streamlined approval process
  - *Stringent property requirements*
  - *More detailed Table 1 (composition, C# distribution, etc.)*
  - *Feedstock and process defined*
  - Includes OEM review requirement
  - D7566 annex produced – lower blend limit?

*Research report*

# Chemical Composition for the Fast Track Annex

- Need to limit non-hydrocarbon species & select limits
- Sulfur, nitrogen, oxygen, and metals
- ASTM methods exist for S, N, and metals
- GCxGC with SPE for polar oxygenates/N

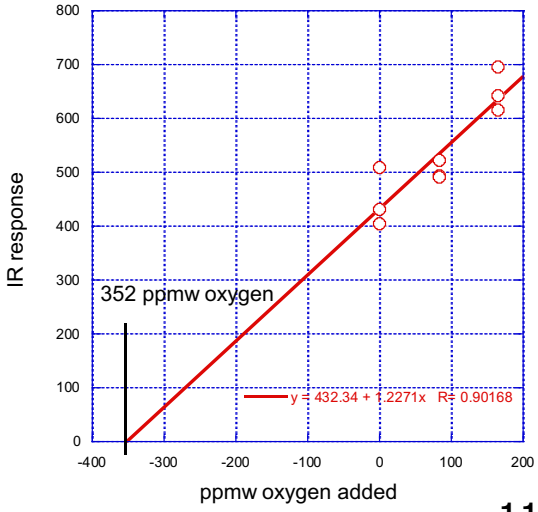


# Trace Oxygen Analysis

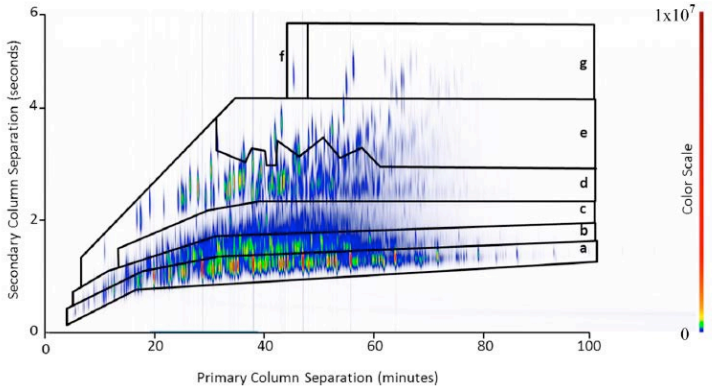
- OEM's concerned with unknown trace oxygenate contaminants
  - No current ASTM method to measure total oxygen at ppm levels
- Evaluation of Elementar Oxycube with IR detector
  - Reductive pyrolysis of O to CO
  - Address interferences
    - $O_2$ from air – $N_2$ sparge
    - Dissolved/free $H_2O$ in fuel – mol sieve
  - Evaluate sensitivity, LOQ in fuel
- 10 ppm limit currently not promising
- Determine usefulness and need for in Generic Annex
  - May no longer be needed for Fast Track Annex


| rapid OXY cube + IR detector |
| --- |
| 10 ppm |
| ±0.001 - 0.1% |



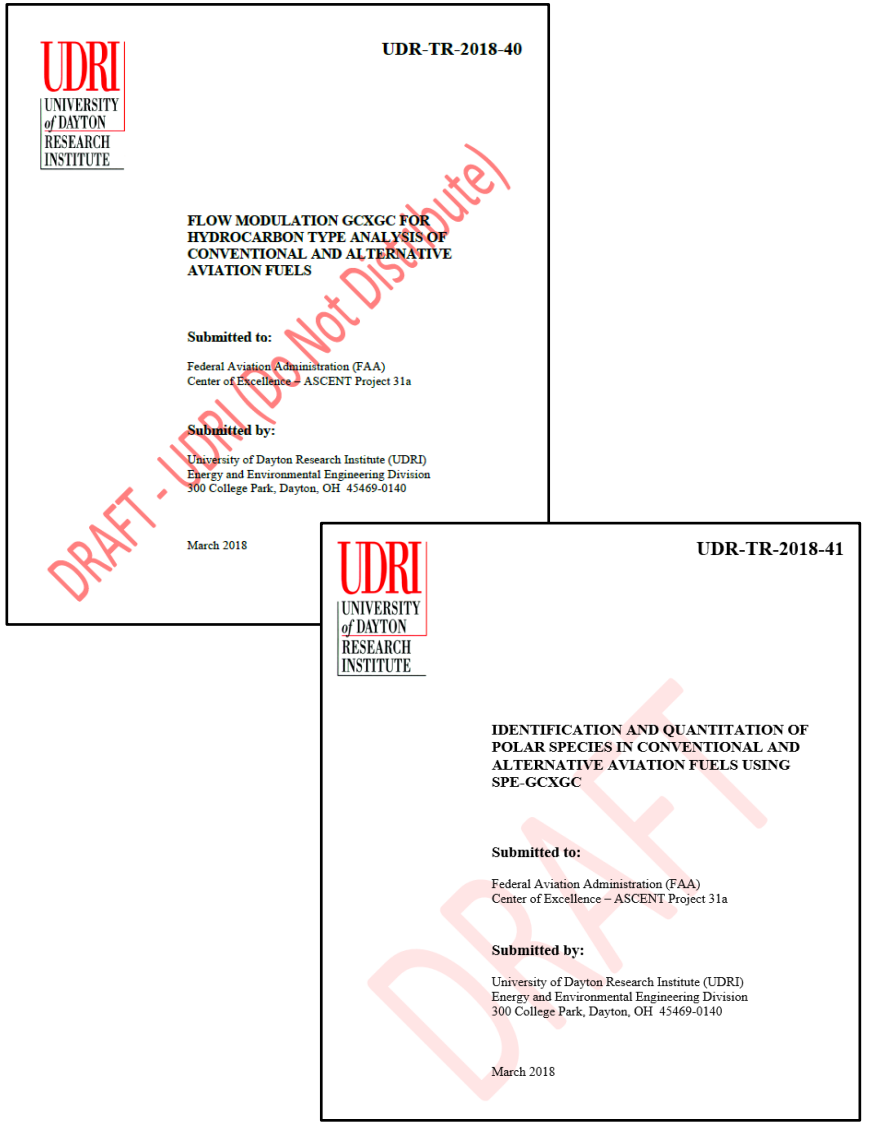
# GCxGC Method Documentation & Analysis

- Two phase project
  - Phase I
    - Document current hydrocarbon-type GCxGC method used for ASTM research reports to date – draft in final stages
    - Develop reference fuels/materials for template registering
    - Investigate precision and repeatability
  - Phase II
    - Work with external organization to determine reproducibility
    - Identify other GCxGC techniques
    - Correlation studies of GCxGC techniques
      - Document two additional methods
      - Determine bias between methods
- Funding received Sept 25, 2018



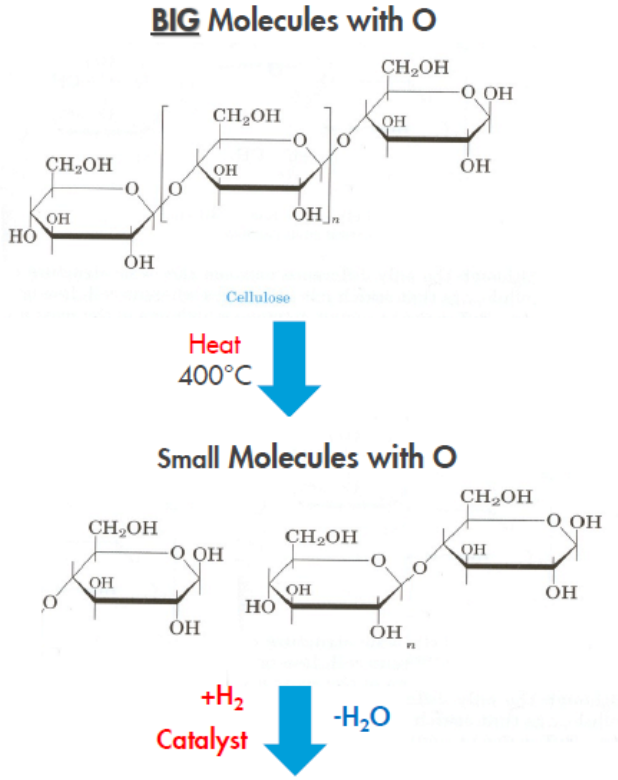
# GCxGC Method Development & Documentation

- UDRI Method FC-M-101, "Flow Modulation GCxGC for Hydrocarbon Type Analysis of Conventional and Alternative Aviation Fuels," UDR-TR-2018-40
- UDRI Method FC-M-102, "Identification and Quantification of Polar Species in Conventional and Alternative Aviation Fuel Using SPE-GCxGC," UDR-TR-2018-41



# Shell IH² Technology

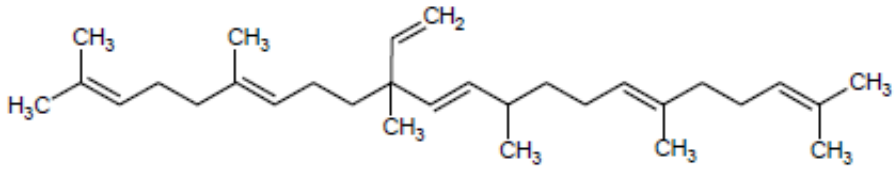
- Hydropyrolysis & hydrotreating of biomass
- Woody biomass, MSW, Ag residue, etc.
- ~95% cycloparaffins (5% other paraffins)
- Existent gum - initial sample showed oxidation degradation – hydroperoxides & oxygenates
- New sample being generated
  - Avoiding oxidation
  - Recommended early antioxidant addition
- High cycloparaffin content – likely requires Tier 3-4 evaluations – combustor rig/APU
  - NJFCP!



# IHI Bb-oil Technology

- Open pond algae cultivation – algae strain selected and bred to maximize hydrocarbon production

- 80-90% hydrocarbon, 10-20% free fatty acids
- Hydrocarbon isomers $C_{32}$-$C_{34}$ – 6 double bonds
  - Botryococcene, typical structure

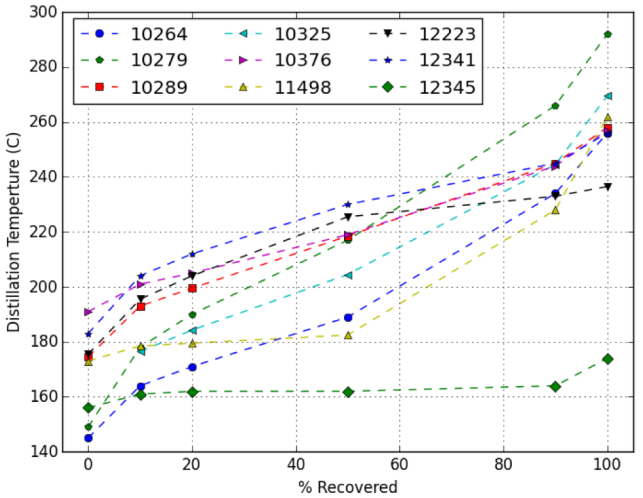


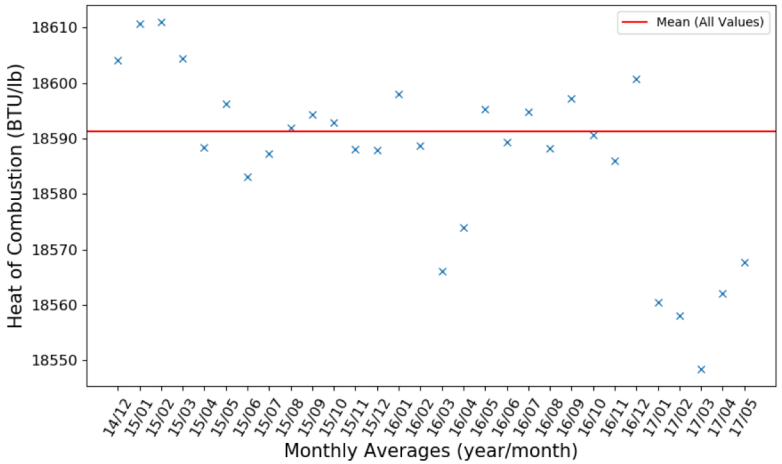

- Typical algal processing
  - Cultivation, dewatering, drying, extraction, conversion
- Deoxygenation, hydroisomerization/ hydrocracking similar to HEFA processes

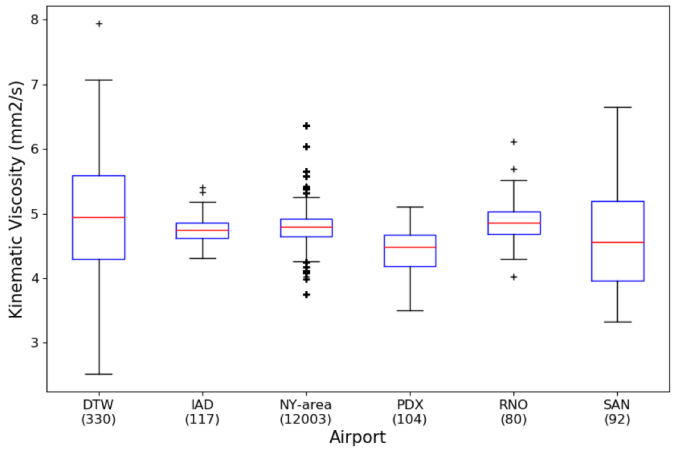
- Composition similar to HEFA except for high cycloparaffins – ~30-50%
  - high density 0.778, above HEFA SPK limit

# Alternative Jet Fuels Test Database (AJFTD) Updates

- ***Extend data compilation*** on AJFs (new fuels, GCxGC, NJFCP)
- ***Support research & certification*** through fuel property analyses
- ***Increase accessibility*** to recent testing data
- Database provides 400+ documents covering ~300 POSFs
- Processed fuel data into JSON format
  - Improve **access** to compiled fuel data
  - Provide **flexible** data storage structure
  - Facilitate **data analysis** with search tools
  - Enable faster **data query**




***Top***: NJFCP fuels distillation curve data

***Left***: Monthly averages of airport fuel heat of combustion data

***Right***: Fuel kinematic viscosity distributions by airport (# values reported)

# 2019 FY New Tasks

- Combustion rig & APU evaluations of Shell IH$^2$
- Database (Project 33) support
- Continued OEM research report review support
- GCxGC method development/documentation

# Acknowledgements


- We ❤ our cost share partners:





- Thanks to Cecilia Shaw, Levent Ileri, Jim Hileman, Mark Rumizen, and FAA AEE team