Sustainable Aviation Fuels (SAF)

Update to FAA REDAC E&E Subcommittee

To: E&E REDAC Subcommittee
By: Nate Brown & Anna Oldani
Date: March 10, 2021
FAA SAF Program Focus

**Testing**
- Accelerate SAF development
  - Test fuels
  - Improve testing methods
  - Conduct evaluation
  - Streamline approval

**Analysis**
- Environmental and economic sustainability
  - Lifecycle emissions
  - Cost reduction
  - Supply potential
  - Supply chain opportunities

**Coordination**
- Support SAF integration
  - Public-private partnership – CAAFI
  - U.S. interagency cooperation
  - International cooperation – ICAO
SAF Funding Levels

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<tr>
<th>Year</th>
<th>FY2018 Actual</th>
<th>FY2019 Actual</th>
<th>FY2020 Actual</th>
<th>FY2021 Enacted (Proposed)</th>
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Benefits of Sustainable Aviation Fuels (SAF)

- SAF are “drop-in” liquid aviation fuels – same infrastructure, engines & aircraft
- SAF reduce GHG and air quality emissions substantially – best near term path to aviation de-carbonization
- Viable technologies exist - seven alternative fuels currently approved for use, more under evaluation for approval
- Scalable feedstocks – wastes & residues, biomass, sugars, oils and energy crops can all supply SAF
- Widely accepted by airlines, business & general aviation
- Broadly supported among federal agencies as meeting critical goals - climate, energy security, rural economic development
- Critical to international efforts to address aviation emissions
Challenges to SAF to be addressed

- Timely certification for aviation use of SAF solutions
- Increasing blend limits to greater than 50%
- Reducing the costs of production
- Expanding scale of production
- Availability of conversion infrastructure
- Availability of feedstock supply
Agenda

Testing
- Qualification Process
- ASTM Status

Analysis
- Supply Chain Tools & Analysis

Coordination
- ICAO CAEP FTG & LTAG
- Federal
- Commercialization
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Fuel Qualification – ASTM D4054

Multi-tiered qualification process involves stakeholders across industry and government

- **ASTM International** manages jet fuel specification
- **Does not determine sustainability** of fuel, only safety, performance
- **FAA and Defense** support evaluation of alternative fuels through:
  - *Clearinghouse*: certification & qualification testing
  - Data gathering & review
  - New test method development
D4054 Clearinghouse

FAA Center of Excellence – ASCENT – facilitates centralized jet fuel testing through UDRI Clearinghouse

- Coordinating with EU and UK efforts to support and develop additional evaluation capabilities
- EU funding will support Clearinghouse testing (cost-share)

UDRI Contact
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(937) 255-3549
Agenda

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ASTM D4054 SAF Qualification Status

Through FAA support, seven SAF categories have been annexed in ASTM D7566

- Exploratory Discussions
  - OMV Re-Oil
  - Forge?
  - Brightmark Energy?
  - CSIIIP
  - Juniper?
  - REVO?
  - Vertimass

Met with OEMs on Nov 2 to review plastics to fuel process

Gathering more data to support ASTM ballot to increase HEFA cycloalkane limit

- Virent SK (inactive)
- Virent SAK (inactive)

Tier 3
- Component/Rig Testing

Tier 4
- Engine/APU Testing

- Reclassified as “inactive” due to lack of engagement

**Tier 1**
- D4054 testing initiated
- Reviewed with OEMs on Aug 24, D4054 testing initiated
- Initiated compositional testing on C3 and C5 alcohol feedstock blends
- Developing Tier 3 & 4 test program with Clearinghouse

**Tier 2**
- Specification Properties
- FR-For-Purpose Properties
- ATJ-SKA (inactive)
- CSIR-IIP
- HFP-HEFA (Green Diesel)
- Shell IH2

Boeing responses to OEM step 3 review comments submitted, awaiting Neste confirmation of commercialization

**OEM Review**
- Rejected
- Re-Eval As Required
- ASTM Specification
- ASTM Balloting Process
- ASTM Review
- Accept
- Reject

**FAA Review**
- ASTM Specification
- ASTM Balloting Process
- Phase 1 ASTM Research Report
- Engine/Research and Development
- OEM Review & Approval

A1 FT SPK
A2 HEFA SPK
A3 SIP
A4 SPK/A
A5 ATJ
A6 CHJ
A7 HC-HEFA SPK
(D1655)

Lipids Co-processing
FT Co-processing

Mark Rumizen
February 22, 2021
# Reduce Fuel Approval Volumes

As a result of the investments made by FAA and others, time and fuel volume requirements for ASTM International approval have fallen over time

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<th>Fuel Type</th>
<th>ASTM Data Review</th>
<th>Final Phase II Report</th>
<th>ASTM Specification (D7566)</th>
<th>Estimated gallons of fuel produced for testing</th>
<th>Estimated time from first review to approval</th>
<th>Composition</th>
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<td>FT-SPK</td>
<td>09/2007</td>
<td>09/2008</td>
<td>09/2009</td>
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<td>04/2015</td>
<td>06/2016</td>
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<td>5 1/2 years</td>
<td>Wider range of molecules</td>
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<td>Lanzatech ATJ-SPK (ethanol)</td>
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<td>02/2019</td>
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<td>04/2020</td>
<td>50</td>
<td>~1 year</td>
<td>40% cyclopentane</td>
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*Approved at 10% volume  
**First Fast Track approval – approved at 10% volume blend limit

ARA – Applied Research Associates  
<sup>1</sup>USAF fuel purchases in 2007-08 for fleetwide qualification  
<sup>2</sup>USAF & Navy fuel purchases in 2009-11 for fleetwide qualification  
<sup>3</sup>USAF, Navy and CLEEN fuel purchases in 2012-2014  
<sup>4</sup>Only Tier 1-2 testing due to existing knowledge base and similarity to approved fuels
Beyond 50%

Evaluate testing programs to support higher blend limits of alternative jet fuels

- Recent conversations emphasize need for fuel evaluations to support higher blend limits
- Current ASTM D7566 specifications limit most pathways to 50% by volume blending with conventional jet fuel
- Seeking to isolate fuel properties which currently constrain fuel blend volumes
- Need to ensure fuels are drop-in compatible with existing and legacy systems
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Analysis: Supply Chain Research & Tools
Understand benefits, costs and potential supply

- Considering entire supply chain via analysis of:
  - Feedstock production
  - Techno-economics of pathways
  - Existing infrastructure
  - Community assets
  - Transportation routes and capacity
  - Economic Impacts

- Three regional studies:
  - Inland Pacific Northwest
  - Hawaii
  - Southeast/Tennessee

- Developing open source tools
  - FTOT; TEA models

- Support for ICAO CAEP

https://ascent.aero/project/alternative-jet-fuel-supply-chain-analysis/
https://github.com/VolpeUSDOT/FTOT-Public

Research Team:
- U.S. DOT Volpe Transportation Center, DOE Argonne National Lab & National Renewable Energy Lab (NREL)
**Freight & Fuels Transportation Optimization Tool (FTOT)**

**Motivation:** Transportation costs, infrastructure requirements & emissions depend on mode choice & routing

**Objective:** Understand transportation needs & impacts of SAF production

**Outcome:** FTOT
- Optimize mode choice & routing of feedstocks & products
  - Assess viable options
  - Identify SAF supply patterns
- Optimize routings & material flow over multimodal GIS network
- Collaboration with WSU; USAF; Southeast Partnership for Advanced Renewables from Carinata (SPARC) and others
- **FTOT 2020.4 released 01/08/2021**
- [https://github.com/VolpeUSDOT/FTOT-Public](https://github.com/VolpeUSDOT/FTOT-Public)
Frontiers in Energy Research SAF Topic

- **Online Journal**
- **SAF Research Topic**
  - Central point for SAF research
  - Make ASCENT 01 work visible
  - Open to other research
  - Variety of article types
- **Feedstocks; Conversion; C/Q; Economics; Environment; Supply chain; Cost/risk reduction; & Policy**
- **Editors**: WSU; FAA; DOE; USDA; Volpe; PNNL

https://www.frontiersin.org/research-topics/19527/sustainable-aviation-fuels
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Sustainable Aviation Fuels and CORSIA

CORSIA Eligible Fuels provide a secondary means to comply with CORSIA

1. Offsetting
2. Claiming Emissions Reductions from CEF

\[ ER_y = FCF \sum MS_{f,y} \left(1 - \frac{LS_f}{LC}\right) \]

- Life cycle emissions value for a CORSIA eligible fuel
- SAF and CORSIA are Key

ICAO’s Basket of Measures

Source: IATA/ATAG
ICAO Fuels Task Group (FTG) and Long Term Aspirational Goal Task Group (LTAG-TG) Fuels Sub Group

- FTG working across five subgroups with a focus on maintaining the fuels-related sections of Annex 16 Vol IV (CORSIA).

- LTAG-TG working to inform 41st ICAO Assembly in October 2022 on feasibility of a long-term global aspirational goal for international civil aviation CO₂ emissions reductions.

- LTAG-TG Fuels Sub Group focused on fuel production and life cycle GHG emissions projections out to 2070.

For additional information on the CAEP Task Groups
FTG: https://www.icao.int/environmental-protection/Pages/CAEP-FTG.aspx
LTAG: https://www.icao.int/environmental-protection/Pages/LTAG.aspx
Life Cycle GHG Emissions and Sustainability

- FAA and ASCENT P1 / Volpe / ANL Team providing key data and leadership that is determining how Sustainable Aviation Fuels and Lower Carbon Aviation Fuels are credited within CORSIA

- Much work ongoing to develop core life cycle emissions values for SAF made from waste CO emissions, jatropha, and co-processing of biomaterials with petroleum in today’s refineries

- Team also developing a life cycle analysis methodology for use with LCAF to determine fuel eligibility under sustainability criteria 1 and amount of crediting

- Sustainability Certification Schemes have been approved by the ICAO Council and posted on the CORISA Eligible Fuel website

- Sustainability criteria are currently being developed for LCAF based on the list of SAF criteria

- FAA helped to convene a series of meetings with CAEP Members and Observers on LCAF to help overcome current impasse

For additional information on CORSIA Eligible Fuels [https://www.icao.int/environmental-protection/CORSIA/Pages/CORSIA-Eligible-Fuels.aspx](https://www.icao.int/environmental-protection/CORSIA/Pages/CORSIA-Eligible-Fuels.aspx)
Future Fuel Production

- FTG & LTAG-TG have considerable ongoing work to project future SAF production – being led by FAA and ASCENT P1 / Volpe / ANL Team
- Team have assembled a global near-term SAF production database and are extending it to 2035-2050
- Team looking carefully at SAF production from waste CO/CO₂ gases and atmospheric CO₂
- ASCENT P52 team are working to quantify infrastructure challenges associated with hydrogen use by commercial aviation
- Team considering fuel volumes, life cycle GHG emissions, investment requirements, etc.
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The Biomass Research and Development Board
Leads the Bioeconomy Initiative

- Co-Chaired by DOE and USDA; at least one Board Member from each of 8 agencies
- Coordinate federal R&D activities relating to biofuels & bio-based products & their commercialization with collaboration between agencies
- Commercialization includes production at competitive prices via collaborations to enhance efficiencies along the entire bioenergy supply chain
- Assesses & provide strategic guidance regarding energy & environmental impacts
- Directs Board Operations Committee and interagency working groups (IWG)
  - SAF IWG established in July 2020 – co-chaired by FAA
Biomass R&D Board

• The Sustainable Aviation Fuels Interagency Working Group (AAF IWG)
  – Ensuring aviation biofuel research and development efforts reflect critical needs
  – Advancing a revised and coordinated federal research and development roadmap on sustainable aviation fuels
  – Developing and scaling best practices to foster the success of sustainable aviation fuels in commercial, business, and military aviation sectors.

• Discussion of a SAF “Grand Challenge” within the Board.

For additional information on SAF IWG: https://biomassboard.gov/sustainable-aviation-fuels-interagency-working-group
Federal Alternative Jet Fuels R&D Strategy - 2016

Purpose
Enable the development, production, and use of environmentally sustainable, cost-competitive and socially responsible alternative jet fuel with stable supply to significantly meet the needs of U.S. jet aviation (released by White House OSTP June 2016)

R&D Goals & Objectives
• Feedstock Development, Production, and Logistics
• Fuel Conversion and Scale-Up
• Fuel Testing and Evaluation
• Integrated Challenges

8 participating Departments & Agencies: USDA, DOC, DOD, NASA, FAA, DOE, EPA, NSF, DOS

New initiatives?

• Emphasis on transportation decarbonization
• Interest in SAF from leadership at DOT, DOE, USDA and others
• SAF a critical technology for aviation
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Where we stand on U.S. SAF commercialization

Initiation under way, still early, but growing

- Five years of sustained & increasing commercial use
- 4.6M gallons in 2020 – 190% increase over 2019
- Commercial & General Aviation engaged
- Two facilities in operation
- Two facilities under construction, others in development
- Cost delta still a challenge, and renewable diesel favored
- New parties interested in SAF

*Reflects voluntarily reported data on use by U.S. airlines, U.S. government, manufacturers, other fuel users, and foreign carriers uplifting at U.S. airports.
^2017-2020 calculation incorporates data reported by EPA for RFS2 RINs for renewable jet fuel.
Airline & Producer Offtake agreements
Demonstration of broad airline industry commitment

Collectively, announced airline offtake agreements total $6.4B and >350M gpy

Credit: CAAFI
### Worldwide SAF production Projection

Announced intentions with specific commitments to SAF

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<th>Year-end Production Levels (M gpy)</th>
<th>2019</th>
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Credit: CAAFI. Not comprehensive; CAAFI estimates (based on technology used) where production slates are not specified
Commercial Aviation Alternative Fuels Initiative (CAAFI)

A public/private partnership of FAA, A4A, AIA & ACI-NA

- **Continued outreach & coordination**
- **2021 Goals & Priorities**
  - Communicate the Value Proposition of SAF
  - Enhance the Fuel Qualification Approach
  - Align Efforts to Enable Commercial Deployment of U.S. SAF Supply
  - Implement Frameworks & Share Best Practices
- **Virtual workshop planned for June 2021**
- **In person General Meeting for June 2022**
Next Steps

• Establish the development of Sustainable Aviation Fuels (SAF) as a key DOT and U.S. climate priority
  – Continue funding of testing efforts including higher blend levels
  – Continue Analysis efforts to address scaling and deployment of fuels
  – Continue outreach via CAAFI to support industry activity
  – Exercise leadership on the Biomass Board to promote interagency support for SAF
  – Develop a multi-agency roadmap for increasing use and availability of SAF
  – Monitor legislative efforts underway for SAF support policies
QUESTIONS