Synthetic Aviation Turbine Fuel (SATF) Qualification

1. Aircraft Approved Operating Limitations Based on Industry Fuel Specifications
   - Jet A and Jet A-1 Fuel

2. ASTM D4054 SATF Evaluation Process
   - If New SATF Meets Conventional Jet Fuel Spec & Properties

3. ASTM D7566 Drop-In Jet Fuel Spec
   - Then New SBC Annex Added to Drop-In Fuel Spec

4. D1655 = D7566
   - Conventional Jet Fuel Spec
   - Drop-In Jet Fuel Spec

New SATF Meets Existing Operating Limitations, Therefore Approved to Use on Virtually All Existing Aircraft

ASTM Specification = Approval to Fly

Synthetic Blending Component (SBC)
D4054 Technical Evaluation

Tier 1
- Specification Properties
  - ASTM D7566 Specification Annex

Tier 2
- Fit-For-Purpose Properties
  - Phase 1 ASTM Research Report

Tier 3
- Component/Rig Testing
  - OEM Review & Tier 3 & 4 Requirements

Tier 4
- Engine/APU Testing
  - Phase 2 ASTM Research Report

- ASTM Balloting Process
  - FAA Review
  - ASTM Balloting Review & Ballot
    - Accept
    - Reject
    - Re-Eval As Required
  - ASTM Specification
  - OEM Review & Approval
D4054 Clearinghouse

University of Dayton Research Institute (UDRI)

Structured as a Cost Share Arrangement

FAA Funds Under ASCENT Center of Excellence

Coordinates, Manages, and Conducts D4054 Evaluation Process

But Does NOT “Approve” the SBC or SATF!

Candidate SATF In

Final Research Report Out

UDRI Contact
Dr. Steven Zabarnick
Steven.Zabarnick@udri.udayton.edu
(937) 266-7231

U.S. Department of Transportation
Office of In-Flight Safety
FAA Funds Under ASCENT Center of Excellence
SATF Pre-Screening

Property/Performance Predictions
- GCxGC,
- IR absorption, and/or
- NMR

Critical Properties
- DCN
- Density
- Distillation Curve
- Viscosity
- Surface Tension

ml’s of test fuel
Optimize/Refine Conversion Process/Composition

ASTM D4054 Evaluation Phase
100’s to 1000’s of gallons of test fuel
D4054 Fast Track (Annex A4)

Lite Testing Program For Synthetic Blending Components (SBCs) with Nominal Jet Fuel Properties and Composition, but...

Limited to a 10% Blend Percentage, and...

Eligible for D4054 Clearinghouse Support
Qualification Status – Till now

May 24, 2006
CAAFI Established

June 2009
FT-SPK Annex A1

June 2009
ASTM D7566 Issued

July 2011
HEFA-SPK Annex A2

December 2009
ASTM D4054 Issued

A1

A2

A3

A4

A5

A6

A7

Synthetic Aviation Turbine Fuel Annex

Commercial Aviation Alternative Fuel Initiative (see www.caafi.org)

Synthetic Aviation Turbine Fuel Evaluation Process

Drop-in Fuel Specification

June 2014
SIP Annex A3

April 2016
ATJ-SPK Annex A5
Isobutanol Feedstock Only

June 2018
Ethanol Feedstock Added

May 2020
HC-HEFA Annex A7

Isobutanol Feedstock Only

Ethanol Feedstock Added

Commercial Aviation Alternative Fuel Initiative (see www.caafi.org)
Qualification Status – Next

Initial Discussions

Pyrolysis based approaches

Hydrothermal Liquefaction based approaches

Tier 1

Tier 2

Tier 3

Tier 4

HEFA-SKA (Indian CSIR-IIP)

PtJ (OMV)

MtJ (many companies)

ATJ-SKA: Alcohol-to-Jet Synthetic Kerosene with Aromatics

ATJ-SPK: Alcohol-to-Jet Synthetic Paraffinic Kerosene

CPK-0: Cycloparaffinic Kerosene

FT-SKA: Fischer-Tropsch Synthetic Kerosene with Aromatics

FT-SPK: Fischer-Tropsch Synthetic Paraffinic Kerosene

HDO-SAK: Hydro-deoxygenation Synthetic Aromatic Kerosene

HEFA-SKA: Hydro-processed Esters and Fatty Acids Synthetic Kerosene with Aromatics

HEFA-SPK: Hydro-processed Esters and Fatty Acids Synthetic Paraffinic Kerosene

HHC-HEFA: Hydroprocessed Hydrocarbons, Esters and Fatty Acids

MtJ: Methanol-to-Jet

PtJ: Plastics-to-Jet

SIP: Synthetic Iso-paraffins

D1655
Co-processing of alternate crude with petro-crude

Lipids crude
Fischer-Tropsch crude

ASTM Task Force to increase current blend limit from 5% to 30%

ASTM Task Force for pyrolysis oil from used tires

ASTM Task Force for hydproprocessed biomass

D1655 Co-processing of alternate crude with petro-crude

Lipids crude
Fischer-Tropsch crude

ASTM Task Force to increase current blend limit from 5% to 30%

ASTM Task Force for pyrolysis oil from used tires

ASTM Task Force for hydproprocessed biomass
D4054 Road to Qual

UK & EU Clearinghouses are coming online soon to provide parallel support.

Pathway Overview to D4054 Clearinghouse:
- Property Data
- Process Description
- Commercialization Plans

1000's gals of Fuel to Clearinghouse if Necessary

1 Liter of Fuel

OEM Introductory Meeting(s)

D4054 Testing/Research Report at Clearinghouse

50-100 gals of Fuel to Clearinghouse

Pathway Overview
- Ready to Engage Clearinghouse?
- Fast Track?

Form ASTM Task Group

ASTM Balloting & Deliberations

ASTM Annex Issuance

OEM Research Report Review

50-100 gals of Fuel to Clearinghouse

George Wilson
Steve Zabarnick
Mark Rumizen

Gurhan Andac

Steve Zabarnick

Gurhan Andac

Gurhan Andac

George Wilson (SwRI)
Mark Rumizen

Josh Heyne

Georg Eckel
(DLR)

Pre-Screening
Washington State University

CAAIFI®
## 100% SATF Standardization Status

Drop-in: not just compatible with particular engine and/or aircraft, but fleet-wide and infrastructure-wide compatible

<table>
<thead>
<tr>
<th>100% SAF</th>
<th>Drop-in</th>
<th>non-Drop-in</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Composition:</strong></td>
<td>Fully formulated Jet A/A-1</td>
<td>Subset of Jet A/A-1</td>
</tr>
<tr>
<td><strong>Applicability:</strong></td>
<td>Fleet Wide drop-in</td>
<td>Designated aircraft/engines only</td>
</tr>
<tr>
<td><strong>Example pathways:</strong></td>
<td>CHJ (D7566 Annex A6), FT-SKA (D7566 Annex A4), future: ATJ-SKA, HEFA-SKA, blending of blend components</td>
<td>FT-SPK (D7566 Annex A1) HEFA-SPK (D7566 Annex A2) ATJ-SPK (D7566 Annex A5) certain types</td>
</tr>
<tr>
<td><strong>Specification:</strong></td>
<td>ASTM D7566</td>
<td>New standard needed</td>
</tr>
<tr>
<td><strong>Regulatory Cert/Substantiation:</strong></td>
<td>No change</td>
<td>Required for each intended aircraft/engine model</td>
</tr>
<tr>
<td><strong>Infrastructure:</strong></td>
<td>No impact</td>
<td>Separate supply chain/handling/storage required</td>
</tr>
</tbody>
</table>

---

ASTM Task Force est. Apr ’21
Chair: G. Andac (GE), Vice-Chair: M. Rumizen (FAA)
Approval of use of conforming 100% SAF as Jet A/A-1

ASTM Task Force est. Apr ’22
Chair D. Parmenter (Airbus), Vice-Chair: A. Hobday (Rolls-Royce)
**NOT** approval of use as Jet A/A-1 or as a new fuel; to be used for testing and certification
Thank You

Mark Rumizen
Email: mark.rumizen@gmail.com
Phone: 781-521-7143

Gurhan Andac
Email: gurhan.andac@ge.com
Phone: 513-552-2346

Questions?