Project 31 Alternative Jet Fuel Test and Evaluation

University of Dayton Research Institute

Project Lead Investigator

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University Participants

University of Dayton Research Institute

- PIs: Steven Zabarnick, Division Head
- FAA Award Number: 13-C-AJFE-UD
- Overall Period of Performance: April 8, 2015 to August 10, 2021
- Tasks:
  - Period of Performance: April 8, 2015 to March 14, 2016 – Amendment No. 006
    1. Evaluate the performance of candidate alternative fuels via the ASTM D4054 approval process.
  - Period of Performance: August 13, 2015 to August 31, 2016 – Amendment No. 007
    2. Evaluate the performance of candidate alternative fuels via the ASTM D4054 approval process.
  - Period of Performance: August 5, 2016 to August 31, 2017 – Amendment No. 012
    3. Manage the evaluation and testing of candidate alternative fuels.
  - Period of Performance: July 31, 2017 to August 31, 2019 – Amendment No. 016
    4. Manage the evaluation and testing of candidate alternative fuels.
  - Period of Performance: August 30, 2018 to August 31, 2019 – Amendment No. 021
    5. Manage the evaluation and testing of candidate alternative fuels.
  - Period of Performance: Extended period of performance end from September 10, 2019 to September 9, 2020 – Amendment No. 023
  - Period of Performance: February 5, 2020 to February 4, 2021 – Amendment No. 25
    6. Manage the evaluation and testing of candidate alternative fuels.
  - Period of Performance: Extended period of performance end from September 9, 2019 to September 9, 2021 – Amendment No. 028.
  - Period of Performance: August 11, 2020 to August 10, 2021 – Amendment No. 32
    7. Manage the evaluation and testing of candidate alternative fuels.

Project Funding Level

Amendment No. 006	$309,885
Amendment No. 007	$ 99,739
Amendment No. 012	$693,928
Amendment No. 016	$999,512
Amendment No. 021	$199,966
Amendment No. 025	$1,926,434
Amendment No. 032	$1,049,700
Total	**$5,279,164**

In-kind cost sharing has been obtained from:

Organization	Amount	Year
LanzaTech	$ 55,801	2015
LanzaTech	$ 381,451	2016
UDRI	$ 43,672	2016
Neste	$ 327,000	2017
Boeing	$2,365,338	2017
Shell	$ 280,000	2019
IHI	$1,150,328	2019
Shell	$ 325,000	2020
Total	**$4,928,590**	

Investigation Team

- Steven Zabarnick, PI, New candidate fuel qualification and certification.
- Richard Striebich, Researcher, Fuel chemical analysis and composition.
- Linda Shafer, Researcher, Fuel chemical analysis and composition.
- John Graham, Researcher, Fuel seal swell and material compatibility.
- Zachary West, Researcher, Fuel property evaluation.
- Rhonda Cook, Technician, Fuel property testing.
- Sam Tanner, Technician, Fuel sampling and shipping.
- Carlie Anderson, Researcher, Fuel chemical analysis.
- Tak Yamada, Researcher, Fuel chemical analysis.

Project Overview

Alternative jet fuels offer the potential benefits of reduced global environmental impacts, increased national energy security, and stabilized fuel costs for the aviation industry. The FAA is committed to the advancement of “drop-in” alternative fuels. The successful adoption of alternative fuels requires approval for use by the aviation community, followed by large-scale production of a fuel that is cost-competitive and that meets the safety standards of conventional jet fuel. Alternative jet fuels must undergo rigorous testing to become qualified for use and be incorporated into ASTM International specifications.

Cost-effective, coordinated performance testing capability (in accordance with ASTM D4054) is needed to support the evaluation of promising alternative jet fuels. The objective of this project is to provide the necessary capability to support fuel testing and evaluation of novel alternative jet fuels.

The proposed program should provide the following capabilities:

- Identify alternative jet fuels, including blends with conventional jet fuel, with the potential to be economically viable and to support FAA’s NextGen environmental goals for testing.
- Perform engine, component, rig, or laboratory tests or any combination thereof to evaluate the performance of alternative jet fuels in accordance with ASTM International standard practice D4054.
- Identify and conduct unique testing, beyond that defined in ASTM International standard practice D4054, to support the evaluation of alternative jet fuels for inclusion in ASTM International jet fuel specifications.
- Obtain baseline and alternative jet fuel data to assess any effects of an alternative jet fuel on aircraft performance, maintenance requirements, and reliability.
- Coordinate efforts with activities sponsored by the Department of Defense and/or other government parties that may be supporting relevant work.
- Report relevant performance data for the alternative fuels tested, including quantified effects of the alternative fuel on aircraft and/or engine performance and on air quality emissions relative to conventional jet fuel. Reported data will be shared with the FAA National Jet Fuel Combustion Program, the broader community (e.g., ASTM International), and the ASCENT COE Program 33 “Alternative Fuels Test Database Library.”

Tasks 1 and 2 – Evaluate the Performance of Candidate Alternative Fuels via the ASTM D4054 Approval Process and Manage the Evaluation and Testing of Candidate Alternative Fuels

University of Dayton Research Institute

Objective

Cost-effective, coordinated performance testing capability (in accordance with ASTM D4054) is needed to support the evaluation of promising alternative jet fuels. The objective of this project is to provide the capability necessary to support either a) the evaluation of to-be-determined alternative fuel(s) selected in coordination with the FAA or b) a fuel test and evaluation project with a specific alternative fuel(s) in mind.

Research Approach

The intent of this program is to provide the capability needed to perform specification and fit-for-purpose evaluations of candidate alternative fuels, with the aim of providing a pathway forward through the ASTM D4054 approval process. The University of Dayton Research Institute (UDRI) team is capable of performing a large number of these evaluations, and we are prepared to work with other organizations, such as Southwest Research Institute (SwRI) and engine original equipment manufacturers (OEMs), with unique test capabilities, as needed. These assessments include additional engine, auxiliary power unit (APU), component, and rig evaluations. The UDRI testing capabilities include efforts at the laboratories of the Fuels Branch of the Air Force Research Laboratory (AFRL) and at our campus laboratory facilities.

The following lists provide examples of the evaluations that can be provided by UDRI:

Tier 1

1. Thermal stability (quartz crystal microbalance)
2. Freeze point (ASTM D5972)
3. Distillation (ASTM D86)
4. Hydrocarbon range (ASTM D6379 & D2425)
5. Heat of combustion (ASTM D4809)
6. Density, API gravity (ASTM D4052)
7. Flash point (ASTM D93)
8. Aromatics (ASTM D1319)

Tier 2

1. Color, saybolt (ASTM D156 or D6045)
2. Total acid number (ASTM D3242)
3. Aromatics (ASTM D1319 and D6379)
4. Sulfur (ASTM D2622)
5. Sulfur mercaptan (ASTM D3227)
6. Distillation temperature (ASTM D86)
7. Flash point (ASTM D56, D93, or D3828)
8. Density (ASTM D1298 or D4052)
9. Freezing point (ASTM D2386, D5972, D7153, or D7154)
10. Viscosity at -20°C (ASTM D445)
11. Net heat of combustion (ASTM D4809)
12. Hydrogen content (ASTM D3343 or D3701)
13. Smoke point (ASTM D1322)
14. Naphthalenes (ASTM D1840)
15. Calculated cetane index (ASTM D976 or D4737)
16. Copper strip corrosion (ASTM D130)
17. Existent gum (ASTM D381)
18. Particulate matter (ASTM D2276 or D5452)
19. Filtration time (MIL-DTL-83133F Appendix B)
20. Water reaction interface rating (ASTM D1094)
21. Electrical conductivity (ASTM D624)

22. Thermal oxidation stability (ASTM D3241)

Extended physical and chemical characterization

1. Lubricity evaluation: BOCLE test (ASTM D5001).
2. Evaluation of low-temperature properties: scanning Brookfield viscosity.
3. Detection, quantification, and/or identification of polar species: as necessary.
4. Detection, quantification, and/or identification of dissolved metals: as necessary.
5. Initial material compatibility evaluation: optical dilatometry and partition coefficient measurements to determine the fuel-effected swell and fuel solvency in three O-ring materials (nitrile, fluorosilicone, and fluorocarbon) and up to two additional fuel system materials.
6. Experimental thermal stability evaluation: quartz crystal microbalance to measure thermal deposit tendencies and oxidation profiles at elevated temperatures.
7. Evaluation of viscosity versus temperature: ASTM D445 to determine the fuel viscosity at 40°C and -40°C to assess the viscosity variation with temperature.

In addition to the above physical and chemical fuel evaluation capabilities, UDRI has extensive experience in the evaluation of microbial growth in petroleum-derived and alternative fuels. These evaluations include standard lab culturing and colony counting methods and advanced techniques such as quantitative polymerase chain reaction (QPCR) and metagenomic sequencing. These methods enable quantitative measurements of microbial growth rates in candidate alternative fuels for comparison with petroleum fuels.

UDRI also has extensive experience in the evaluation of elastomer degradation upon exposure to candidate alternative fuels. Various methods are used to evaluate seal swell and O-ring fixture leakage, including optical dilatometry, sealing pressure measurements, fuel partitioning into the elastomer, and the use of a pressurized temperature-controlled O-ring test device.

Moreover, UDRI can perform fuel–material compatibility testing using the D4054 procedures for fuel soak testing, postexposure nonmetallic and metallic material testing, and surface and microstructural evaluation. The 68 “short-list” materials and the 255 materials on the complete list can be tested.

Milestones

The schedule for this project is dependent upon the receipt of alternative fuel candidates for testing. As candidate fuels are received, a testing schedule will be established via coordination with the FAA and collaborators. Our existing relationships with these organizations will help expedite this process.

Major Accomplishments

Shell IH^2 testing

Discussions with Shell on their IH^2 fuel and process (hydropyrolysis and hydrotreating of woody biomass, municipal solid waste (MSW), and agriculture residue) began in 2017 and proceeded through 2018. In January 2019, samples of their CPK-0 (zero aromatics) fuel were received by the Clearinghouse for testing. Testing proceeded at UDRI and SwRI through the spring of 2019, with a draft research report produced in the summer. In October 2019, initial warm lean blowout (LBO) testing of the CPK-0 fuel blends was performed in the referee combustor. We await the production of larger quantities of IH^2 fuel for additional cold LBO and ignition studies in the referee rig. In addition, a Phase 1 research report was presented to the OEM committee in the June 2020, with the anticipation of OEM APU and engine combustor sector testing in 2021. The unusually high cycloparaffin content (>95%) of this fuel will dictate the need for additional Tier 3 testing, with the extent of testing potentially being limited by the fuel’s excellent performance in the referee rig. We anticipate that OEM feedback from the Phase 1 research report will be available to the fuel producer in early November 2020.

IHI Bb-Oil SPK testing

Discussions with IHI of Japan on their Bb-oil fuel and process (algae cultivation with hydrocarbon and oil extraction) began in 2018, with initial fuel samples received in January 2019. Testing proceeded during the winter and spring of 2019, with a resulting Fast Track research report being submitted for OEM review in June 2019. This fuel consists of approximately 40% cycloparaffins and thus has a higher density than that specified in the Fast Track guidelines. The OEM review was completed in August 2019, and we completed additional testing on another production sample to address OEM questions during the year. The ASTM ballot was approved in March 2020 for the creation of D7566-20 Annex 7 with the fuel now referred to as HC-HEFA SPK (hydroprocessed hydrocarbons, esters, and fatty acids).

Fischer–Tropsch coprocessing
Fulcrum Bioenergy is interested in adding Fischer–Tropsch (FT) coprocessing to the D1655 fuel specification to permit small quantities (<10%) of FT waxes to be used as feed to petroleum refinery hydrocracking reactors. This change would allow the use of FT waxes produced from the gasification of MSWs in petroleum refinery operations, enabling jet fuel to be produced without operation modifications. To support this effort, this project received vacuum gas oil (VGO)-produced jet fuel and fuel produced from a co-feed of VGO and FT wax product. We assessed the D1655 Table 1 properties, JFTOT thermal stability, trace metals, GCxGC hydrocarbon type, GCxGC polars, lubricity additive responses, and conductivity additive responses. A research report was produced and FT coprocessing was balloted in an ASTM October 2019 ballot. The FT coprocessing ballot was approved in March 2020 with subsequent publication of D1655-20 which includes this process in paragraphs A1.2.2.2 of Annex A1.2 "Acceptable Fuels from Non-Conventional Sources."

Publications

Written reports

ASTM Ballot. (2019). Modification of ASTM D1655: Co-processing of Fischer-Tropsch feedstocks with petroleum hydrocarbons for jet production using hydrotreating and hydrocracking.

D4054 Fast Track Research Report. (2019). Evaluation of synthesized paraffinic kerosene from algal oil extracted from *botryococcus braunii* (ihi bb-spk).

ASTM D1655-20, Standard Specification for Aviation Turbine Fuels.

Outreach Efforts

Presentations on Project 31 activities were given at the March/April 2020 and September 2020 ASCENT virtual meetings. Meetings were held with the OEM team, FAA, fuel producers, and others at numerous virtual (generally two per month) FAA/OEM meetings.

Awards

None

Student Involvement

None

Plans for Next Period

We are awaiting the receipt of larger quantities of the Shell IH^2 fuel for further evaluation, including cold LBO testing, ignition testing, APU cold start and ignition evaluation, and engine OEM sector evaluation. We expect the Shell IH^2 Phase 1 research report OEM feedback to be returned to the fuel producer in November 2020. We will likely be performing additional testing of the Shell IH^2 fuel as a result of this feedback. We will continue discussions with new fuel producers and expect new candidates to enter the process in the coming months, such as fuels from Global Bioenergies, OMV, Revo, CSIR-IIP.

Tasks 3 and 4 – Manage the Evaluation and Testing of Candidate Alternative Fuels

University of Dayton Research Institute

Objective

The objective of this work is to manage the evaluation and testing of candidate alternative jet fuels in accordance with ASTM International standard practice D4054 (see Figure 1).

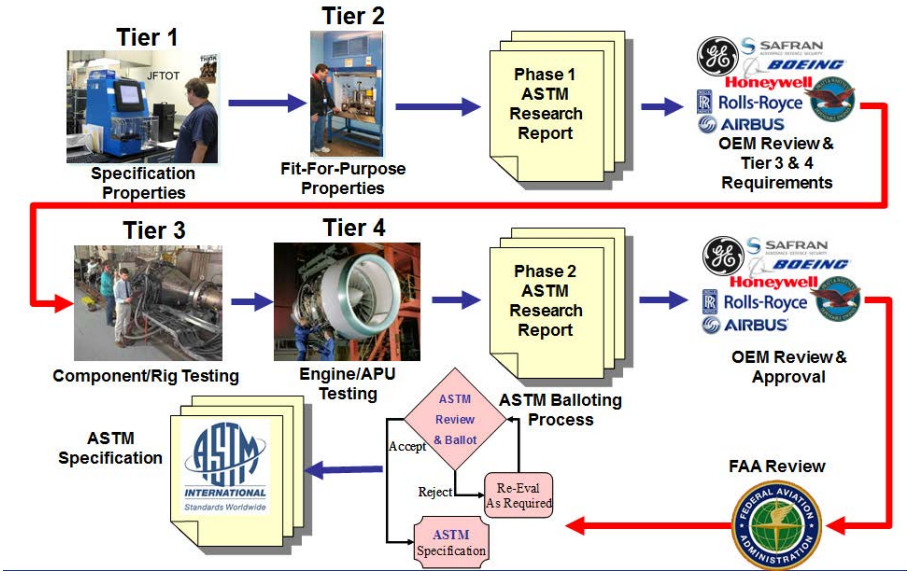


Figure 1. ASTM D4054 qualification process.

Research Approach

UDRI will subcontract with other research organizations, test laboratories, and/or OEMs to conduct the following tasks in support of the evaluation and ASTM specification development for alternative jet fuels. The purpose of this project is to manage and coordinate the D4054 evaluation process illustrated in Figure 2 in order to facilitate the transition of alternative fuels to commercial use.

Subtask 1: General support

- Develop and make available a D4054 process guide that describes logistical procedures for the handling of test fuels, documentation requirements, test report issuance and delivery, and contact information. This guide is intended to provide clear instructions to candidate fuel producers for entering the ASTM D4054 process.

Subtask 2: Phase 1 support

- Coordinate the handling of Phase 1 candidate test fuel samples for Tier 1 and 2 testing.
- Review process descriptions provided by the fuel producer to determine acceptability for incorporation into the Phase 1 research report.
- Review test data from Tier 1 and 2 testing to determine acceptability for incorporation into the Phase 1 research report.
- Issue and deliver a Phase 1 research report to OEMs.
- In conjunction with the fuel producer, review and respond to comments regarding the Phase 1 research report, as submitted by the OEMs.
- Conduct additional Tier 1 or 2 testing in response to OEM comments as required.
- Review and consolidate OEM requirements for D4054 Tier 3 and 4 testing, as submitted by the OEMs.
- Deliver consolidated D4054 Tier 3 and 4 testing requirements to the fuel producer.

Subtask 3: Phase 2 support

- Coordinate the funding and scheduling of D4054 Tier 3 and 4 testing with OEMs and other test facilities.
- Coordinate the handling of Phase 2 candidate test fuel samples for Tier 3 and 4 testing.
- Review test data from Tier 3 and 4 testing to determine acceptability for incorporation into the Phase 2 research report.
- Issue and deliver the Phase 2 research report to OEMs.
- In conjunction with the fuel producer, review and respond to comments submitted by OEMs regarding the Phase 2 research report.

- Conduct additional Tier 3 or 4 testing in response to OEM comments as required.
- Issue and deliver Phase 2 research report addendums reporting the additional Tier 3 or 4 test results as required.

Subtask 4: OEM review meetings

- Schedule periodic OEM meetings to review the testing status and the research report evaluations.
- Identify suitable meeting venues and support equipment.
- Develop agendas and coordinate with attendees for participation in these meetings.
- Record meeting minutes, including agreements, commitments, and other action items
- Issue and distribute meeting minutes to all attendees

Subtask 5: Single-laboratory GCxGC method documentation

- Document UDRI GCxGC methodology for hydrocarbon type analysis
- Develop reference materials for the creation of GCxGC hydrocarbon type templates
- Measure single-laboratory precision of the GCxGC methods

Subtask 6: Multi-laboratory GCxGC method documentation

- Validate the precision of GCxGC methods over multiple laboratories
- Identify alternative GCxGC methods, including column selection and order, and modulation techniques
- Perform a correlation study to determine the agreement among laboratories, methods, and hardware choices

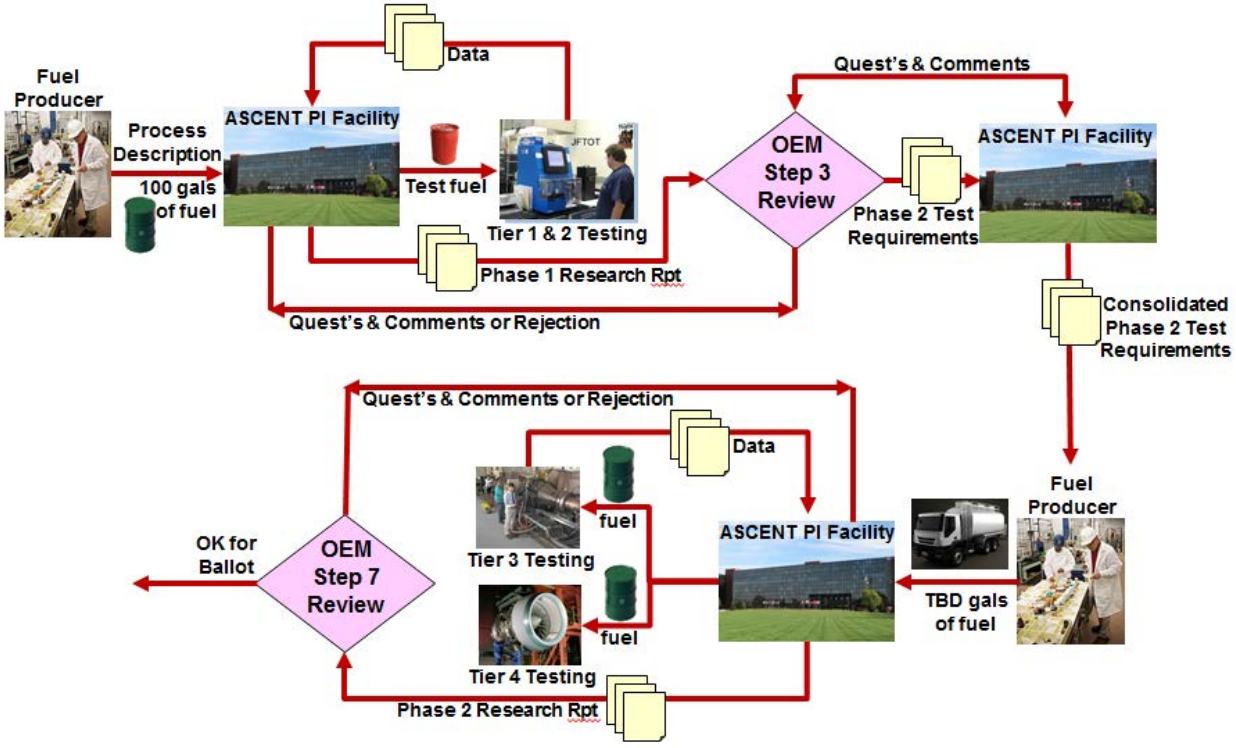
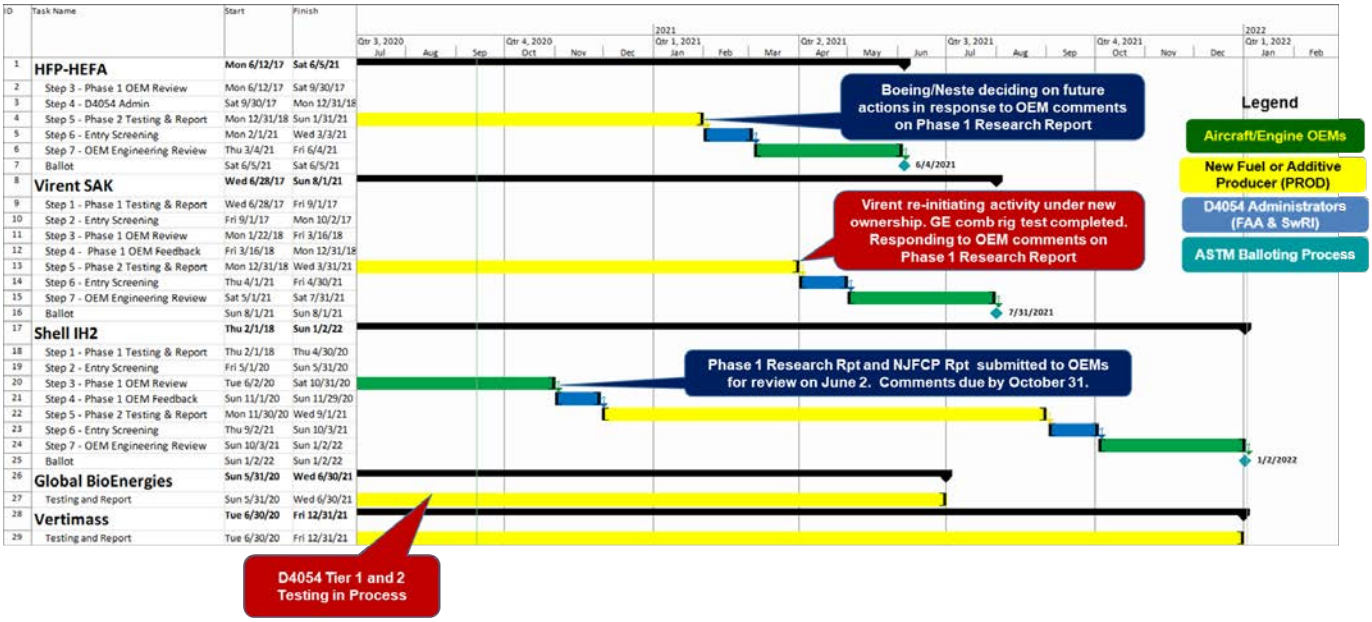


Figure 2. D4054 evaluation process.

Milestone(s)

The schedule for this project is dependent upon the receipt of alternative fuel candidates for testing. As candidate fuels are received, a testing schedule will be established via coordination with the FAA and collaborators. Our existing relationships with these organizations will help expedite this process. Figure 3 shows a Gantt chart schedule for the testing and approval of candidate fuels that are currently under evaluation or that will soon enter the evaluation process.

D4054 Clearinghouse
Forecasted Fuel Evaluation Schedule



ID	Task Name	Start	Finish
1	**HFP-HEFA**	**Mon 6/12/17**	**Sat 6/5/21**
2	Step 3 - Phase 1 OEM Review	Mon 6/12/17	Sat 9/30/17
3	Step 4 - D4054 Admin	Sat 9/30/17	Mon 12/31/18
4	Step 5 - Phase 2 Testing & Report	Mon 12/31/18	Sun 1/31/21
5	Step 6 - Entry Screening	Mon 2/1/21	Wed 3/3/21
6	Step 7 - OEM Engineering Review	Thu 3/4/21	Fri 6/4/21
7	Ballot	Sat 6/5/21	Sat 6/5/21
8	**Virent SAK**	**Wed 6/28/17**	**Sun 8/1/21**
9	Step 1 - Phase 1 Testing & Report	Wed 6/28/17	Fri 9/1/17
10	Step 2 - Entry Screening	Fri 9/1/17	Mon 10/2/17
11	Step 3 - Phase 1 OEM Review	Mon 1/22/18	Fri 3/16/18
12	Step 4 - Phase 1 OEM Feedback	Fri 3/16/18	Mon 12/31/18
13	Step 5 - Phase 2 Testing & Report	Mon 12/31/18	Wed 3/31/21
14	Step 6 - Entry Screening	Thu 4/1/21	Fri 4/30/21
15	Step 7 - OEM Engineering Review	Sat 5/1/21	Sat 7/31/21
16	Ballot	Sun 8/1/21	Sun 8/1/21
17	**Shell IH2**	**Thu 2/1/18**	**Sun 1/2/22**
18	Step 1 - Phase 1 Testing & Report	Thu 2/1/18	Thu 4/30/20
19	Step 2 - Entry Screening	Fri 5/1/20	Sun 5/31/20
20	Step 3 - Phase 1 OEM Review	Tue 6/2/20	Sat 10/31/20
21	Step 4 - Phase 1 OEM Feedback	Sun 11/1/20	Sun 11/29/20
22	Step 5 - Phase 2 Testing & Report	Mon 11/30/20	Wed 9/1/21
23	Step 6 - Entry Screening	Thu 9/2/21	Sun 10/3/21
24	Step 7 - OEM Engineering Review	Sun 10/3/21	Sun 1/2/22
25	Ballot	Sun 1/2/22	Sun 1/2/22
26	**Global BioEnergies**	**Sun 5/31/20**	**Wed 6/30/21**
27	Testing and Report	Sun 5/31/20	Wed 6/30/21
28	**Vertimass**	**Tue 6/30/20**	**Fri 12/31/21**
29	Testing and Report	Tue 6/30/20	Fri 12/31/21

September 14, 2020

Figure 3. Schedule for fuel evaluations.

Major Accomplishments

Fast Track annex development

A D7566 Generic Annex concept was originally presented to the OEM committee, in which a set of highly stringent property requirements would be used to create a D7566 annex without the feedstock or process being defined. This annex would enable the rapid approval of a wide variety of fuels that closely resemble already approved fuels with regard to composition and physical properties. However, the OEM committee was concerned about the lack of an OEM review for each fuel approved through this process. Thus, the Generic Annex pathway was abandoned in the spring/summer of 2018. In response to OEM concerns, a Fast Track Annex to D4054 was proposed in the winter of 2018/19, which included a list of stringent properties and chemical composition requirements. This Fast Track Annex would require an identification of the feedstock and processing, along with a required OEM review of the research report results. The goal would be an allowed 10% blend limit with a much more rapid approval pathway. Fast Track approval would result in the creation of a D7566 annex for each approved fuel. Ultimately, the Fast Track Annex was balloted in the spring of 2019 and approved in April 2019. To date, one candidate fuel has been approved via the Fast Track process, the IHI HC-HEFA D7566 Annex 7 fuel.

GCxGC method documentation

Two GCxGC method reports were completed and made available to the fuel community (UDRI Method FC-M-101 Flow Modulation GCxGC for Hydrocarbon Type Analysis of Conventional and Alternative Aviation Fuels; UDRI Method FC-M-102 Identification and Quantitation of Polar Species in Conventional and Alternative Aviation Fuels Using SPE-GCxGC). The first report documents the UDRI/AFRL hydrocarbon type analysis method based on flow modulation GCxGC and “normal phase” column order (nonpolar followed by polar columns). The second report documents the UDRI/AFRL polar analysis, which uses a solid-phase extraction pre-separation technique to separate and concentrate trace polar species. After pre-separation, the fuel polars are analyzed by GCxGC separation. These reports are being made available to any parties that express interest. These documents are now included in the ASTM D4054 Fast Track Annex A4 (ASTM D4054 Annex A4. Fast Track OEM Qualification and Approval Process for New Aviation Turbine Fuels). These methods provide the fuel community with new tools to enable accurate fuel composition analysis and improved techniques for evaluating and qualifying new candidate alternative fuels.

GCxGC precision – intra- and interlab comparisons
To investigate the precision of GCxGC hydrocarbon type analyses, we assessed a single fuel over a number of years using a single instrument (intralab comparison). We also compared two different GCxGC systems, i.e., flow modulation with a nonpolar initial column and a polar secondary column versus thermal modulation with a polar initial column and a nonpolar secondary column. We also compared measurements between two labs (UDRI/AFRL versus NASA Glenn) for a number of fuels using the same instrument type and column configuration.

OEM committee coordination
The ongoing effort of ASTM OEM committee coordination continued during this period. This effort involves coordinating the engine and airframer OEM meetings, which have occurred in concert with the biannual ASTM D02 sessions and at the annual UK MoD AFC meeting in London. SwRI continues to receive funding to aid in coordinating the OEM meetings and in communicating with the OEMs for discussions and research report reviews of new candidate alternative jet fuels. In addition, a Gantt schedule is updated monthly; this schedule shows a queue of candidate fuels and the completed and expected schedule as these fuels move through the ASTM D4054 process of testing, review, balloting, and approval. A recent version of this schedule is shown in Figure 3. In support of the ongoing OEM committee coordination, subcontracts were extended to our ASCENT grant end date of February 4, 2021 with Boeing, GE Aviation, Honeywell, Rolls Royce, Pratt & Whitney, and SwRI. As the current end date was recently extended to August 10, 2021, we are in the process of extending these subcontracts to reflect the new end date.

Publications

Written reports

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.

Evaluation of Integrated Hydropyrolysis and Hydroconversion (IH^2®) Cycloparaffinic Kerosene (CPK-0), D4054 Phase 1 Research Report, May 2020.

Evaluation of Synthesized Paraffinic Kerosene from Algal Oil Extracted from *Botryococcus braunii* (IHI Bb-SPK), Fast Track Research Report, 2019.

Outreach Efforts

Presentations on Project 31 activities were given at the March/April 2020 and September 2020 ASCENT virtual meetings. Meetings were held with the OEM team, FAA, fuel producers, and others at numerous virtual (generally two per month) FAA/OEM meetings. We continue to have biweekly teleconferences with Shell on their IH^2 fuel candidate. We have had meetings with a number of candidate fuel producers, including Global Bioenergies, OMV, CSIR-IIP, and Revo.

Awards

None

Student Involvement

Plans for Next Period

We plan to continue coordination of the OEM committee reviews. We held an OEM committee meeting at the December 2019 ASTM D02 meeting in Denver and will hold virtual OEM committee meetings until the coronavirus situation is resolved to allow business travel.