Project 090 World Fuel Survey

University of Dayton Research Institute

Project Lead Investigator

Zachary West, PhD
Principal Research Engineer
Group Leader, Fuel Science
University of Dayton
300 College Park
Dayton, OH 45458
937-255-4062
zachary.west@udri.udayton.edu

University Participants

University of Dayton Research Institute (UDRI)

- P.I.: Zachary West, PhD
- FAA award number: 13-C-AJFE-UD
- Overall Period of Performance: January 1, 2023, to September 30, 2025
- Tasks:
  - Period of Performance: January 1, 2023, to December 31, 2023; Amendment No. 048
    1. Conduct a survey of commercial jet fuels and develop a modern technical dataset for relevant fuel samples
  - Period of Performance: September 22, 2023, to September 30, 2024; Amendment No. 049
    - No-Cost Extension
  - Period of Performance: March 19, 2024, to March 18, 2025; Amendment No. 051
  - Period of Performance: September 23, 2024, to September 30, 2025; Amendment No. 057
    - No-Cost Extension
  - Period of Performance: September 30, 2025, to September 30, 2026; Amendment No. 063
    - No-Cost Extension

Project Funding Level

Amendment	Funding
Amendment No. 048	$749,886.56
Amendment No. 051	$999,998.00
Total	**$1,749,884.56**

In-kind cost sharing has been obtained from the following organizations. Additional cost-sharing will be obtained from fuel refineries for the cost of fuel samples and testing services.

Organization	Amount	Year
Marathon Petroleum Corporation	$30,120	2023
ASG Analytik-Service AG	$9,357	2024
Total	**$39,477**	

Investigation Team

Dr. Zachary West (P.I.)
Carlie Anderson (staff scientist)

Dr. Amanda Arts (staff scientist)
Dr. Joseph Gord (staff scientist)
Shane Kosir (staff scientist)
Susan Mueller (staff scientist)
Linda Shafer (staff scientist)
Dr. Willie Steinecker (staff scientist)
CJ Nesbit (undergraduate student)
Taylor Nicely (undergraduate student)
Maria Baker (other professional)
Lisa Brown (other professional)
Jim Thompson (other professional)

Project Overview

Jet fuel is defined by a robust physicochemical and performance specification; however, the exact chemical composition is variable and depends on numerous market factors, such as petroleum crude sources, production/refinery techniques, and impacts from transportation/handling in the fungible fuel system. As the United States and other countries are accelerating the pace of fuel certification (via the ASTM D4054 standard practice [ASTM International, 2022]) and production of synthetic aviation turbine fuels (SATF) to include sustainable aviation fuels (SAF), having a robust and representative set of data for comparison is critically important to the safe adoption of SATF/SAF fuels. Almost two decades have passed since the last major survey of commercial jet fuels (CRC Report No. 647, 2006 [Hadaller & Johnson, 2006]); therefore, this project aims to collect a contemporary set of representative jet fuel samples and conduct both specification and non-specification testing on the subject samples. The results of this survey will be used to inform how to accelerate SAF adoption in the market.

Task 1 – Conduct a Survey of Commercial World Jet Fuels

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Objectives

The objectives of this task are to (1) secure relevant jet fuel samples directly from refineries around the world, (2) analyze the fuel samples to create a robust set of physicochemical and property technical data, and (3) make the test data available to the aviation fuels community, to enhance and expedite decisions regarding current and future SATF/SAF compositional requirements.

Research Approach

Our research approach has been two-fold where the first part involved collecting industry stakeholder interest/feedback and building partnerships with fuel refiners. The second portion of the project has involved the development and execution of the process shown in Figure 1. The execution of the process includes soliciting fuel samples from refiners, coordinating the shipping and handling of the samples to UDRI, subjecting fuel samples to testing at both UDRI and other vetted contracted laboratories, and reporting test data through partnerships with both the Coordinating Research Council (CRC) and Volpe National Transportation System Center (Volpe Center).

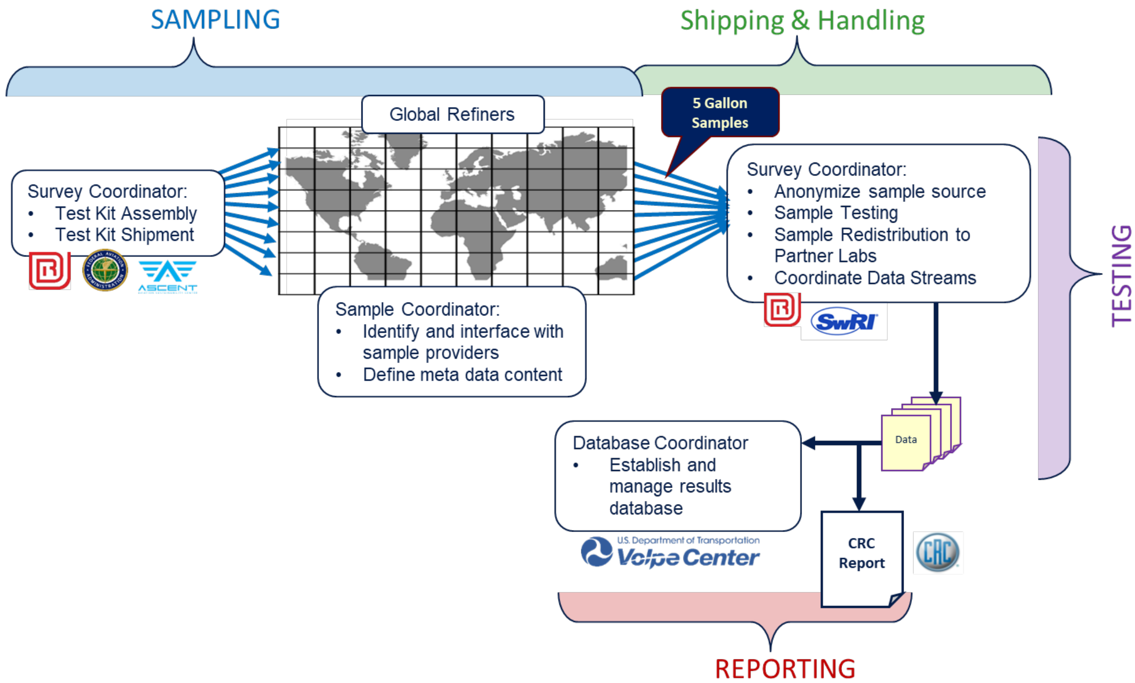

Figure 1. Schematic representation of the world jet fuel survey process.

Solicitation of Samples

Targeted email solicitations requesting samples of 5 gal were sent to our fuel producer partners. After obtaining positive responses, UDRI sent sampling kits and instructions to fuel producers to submit samples along with certificates of analysis. The ASCENT Project 090 team have received a total of 54 jet fuel samples as of December 10, 2025, which represents over 151 million US gallons of product (as self-reported by refiner batch volumes). The first 38 of these samples will be included in the first-year (Part 1) data reporting with the CRC and Volpe Center. Our team is actively soliciting additional samples to increase the total observed sample population and increase both the depth and breadth of the dataset. We have been working with Concawe in Europe over the past few months to procure an additional 15 samples by late first quarter in 2026.

Table 1 and Table 2 show fuel counts by continent for the Part 1 (2023-2024) and current Part 2 (2024-present) fuels, respectively. Although the number of fuels received during Year 2 decreased, the global distribution of samples is geographically more diverse, with contributions for Asia and South America.

Table 1. Part 1 Jet Fuel Samples (Collected from 2023-2024).

Continent of Origin	Fuel Count	Total Batch Volume (US MGal)
North America	28	71
Europe	9	27
Asia	1	8

Table 2. Part 2 Jet Fuel Samples (Collected from 2024-Present).

Continent of Origin	Fuel Count	Total Batch Volume (US MGal)
North America	4	4
Europe	3	8
Asia	7	29
South America	2	5

Testing
In addition to the refiner's reported specification data (i.e., Refiner's Certificate of Quality [RCQ]), fuels are being subjected to 27 chemical, physical, and performance tests (Table 3). Testing is being performed at both UDRI and Southwest Research Institute (SwRI).

Table 3. Fit-for-Purpose Test List.

Property	Test Method
Detailed Hydrocarbon Type	UDRI FCM-101; FED-STD-791, Method 7508
Aromatics, saturates, and olefins	ASTM D1319
Hydrogen content	ASTM D3701
Polars	UDRI FCM-102
Inorganic compounds: N, total, and basic	ASTM D4629
Trace Metals	UDRI FC-M-107
Distillation	ASTM D86
Simulated distillation	ASTM D2887
Thermal stability, breakpoint	ASTM D3241
Thermal stability, QCM	ASTM D7739
Lubricity	ASTM D5001
Viscosity vs. temperature	ASTM D7042
Specific heat vs. temperature	ASTM E2716
Density vs. temperature	ASTM D4052
Surface tension vs. temperature	ASTM D1331
Isentropic bulk modulus vs. temperature and pressure	FED-STD-791, Method 7507
Thermal conductivity vs. temperature	ASTM D7896
Water solubility vs. temperature	Modified ASTM D6304
Air solubility (oxygen/nitrogen)	UDRI FCM-103
True vapor pressure vs. temperature	ASTM D6378
Refractive index (nD20)	UDRI In-House
Derived cetane number	ASTM D6890
Indicated cetane number	ASTM D8183
Dielectric constant vs. density	IP 638
Autoignition temperature	ASTM E659
Hot surface ignition temperature	ISO 20823

Reporting
UDRI has anonymized all the test data before reporting, to protect fuel producers' commercial interests. The ASCENT Project 090 team is working with the Volpe Center to establish an online database to archive test data. 225 lines of Python® code was written to unpivot the data for the database. Our team also intends to report the test data in a CRC report (CRC AV-33-22 [Kosir et al., 2025]). The report has undergone three rounds of revision, with an anticipated publication date around December 2025/January 2026. Some of the rebuttal edits include:

- Addition of a section for the certificate of analysis (CoA) data
- Documentation of specific instrumentation and methods used
- Inclusion of method precision when available
- Addition of antioxidant concentration to the dataset where available from the CoA

Figure 2 shows acidity values from the Part 1 data report as an example of CoA data reporting. The top histogram (blue) depicts Jet A fuels, and the bottom histogram (red) shows Jet A-1 fuels. The histograms generally mirror each other, with a significant number of fuels falling in the 0-0.005 mg KOH/g bin. Two Jet A-1 fuels had acidity greater than the Defence Standard maximum limit of 0.015 mg KOH/g but within the ASTM D1655 (ASTM International, 2023) limit of 0.10 mg KOH/g. Similar histograms are shown in CRC AV-33-22 for 20 properties taken from the CoA data.

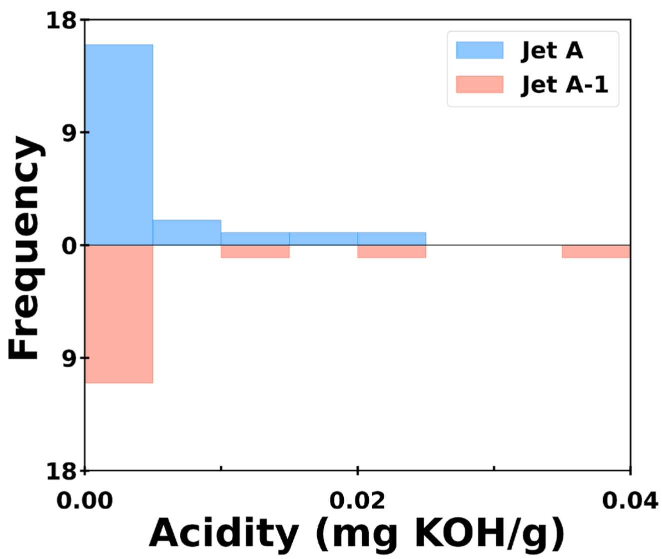

Figure 2. Comparison of Jet A fuel and Jet A-1 fuel acidity data taken from the certificates of analysis (CoA) contained in CRC AV-33-22 (in press).

Figure 3 shows a parity plot (left) and model coefficients (right) for an initial boiling point (IBP) model trained using partial least squares (PLS) regression with two-dimensional gas chromatography (GCxGC) hydrocarbon type data as its input. This is an example of a composition-to-property (C2P) model. In total, 19 C2P models were trained and included in CRC AV-33-22. The models serve a few roles: (1) they provide an indication of how well the measured properties correlate with existing fuel composition measurement techniques, (2) when the model performance is good, the model coefficients provide insight into fuel chemistry, and (3) when the model performance is poor, the models indicate that experimental method development and/or more advanced modeling techniques are required. In the case of the initial boiling point model the normalized root mean squared error (NRMSE) is low at 1.9%. Since the model demonstrates good correlation, the model coefficients can more confidently be assigned chemical meaning. That is to say, the model coefficients indicate that the lowest carbon numbers, in each class, contribute to lower IBP values, which makes intuitive sense. This same technique is applied to other properties, e.g., dielectric constant, that might not have as obvious chemical correlations.

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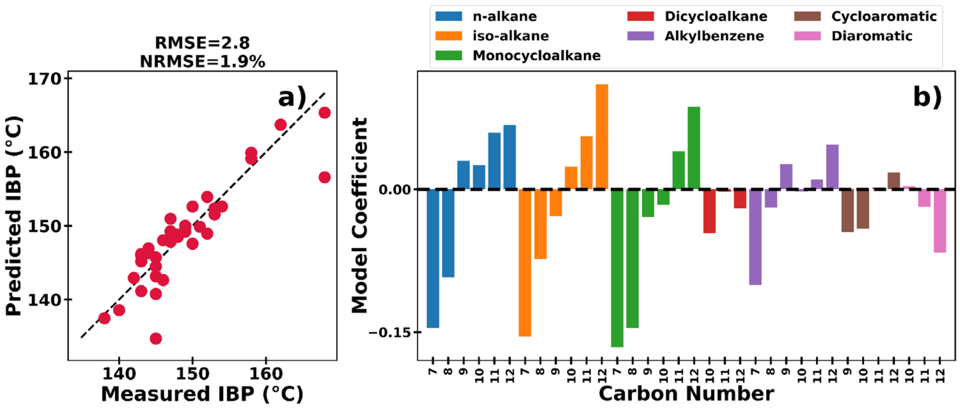

Figure 3. (a) Partial least squares (PLS) initial boiling point predictions made using two-dimensional gas chromatography (GCxGC) hydrocarbon type data as training features. (b) Model coefficients for the initial boiling point model. IBP: initial boiling point.

ASTM D4054 Plots

Eleven figures have been developed to update the existing figures in ASTM D4054 Annex A1: "Basis of Engine and Airplane Manufacturers' Experience." These figures have been created using data from CRC Report 647, CRC AV-33-22, and other sources when available. Figure 4 shows the typical viscosity characteristics of jet fuel from CRC Report 647 and CRC AV-33-22 (91 fuels in total). Boxes represent the interquartile range (IQR), and whiskers represent the non-outlier range. The horizontal bars in the boxes represent median values. As expected, the viscosity median and IQR increases exponentially as temperature decreases. A task force was created by Dr. Zach West at the December 2025 ASTM D02.0J meeting to investigate updating the Annex A1 figures in ASTM D4054. The preliminary timeline is to host a task force meeting in the first quarter of 2026 to solicit feedback, with the potential to ballot updated figures by the June 2026 ASTM meeting.

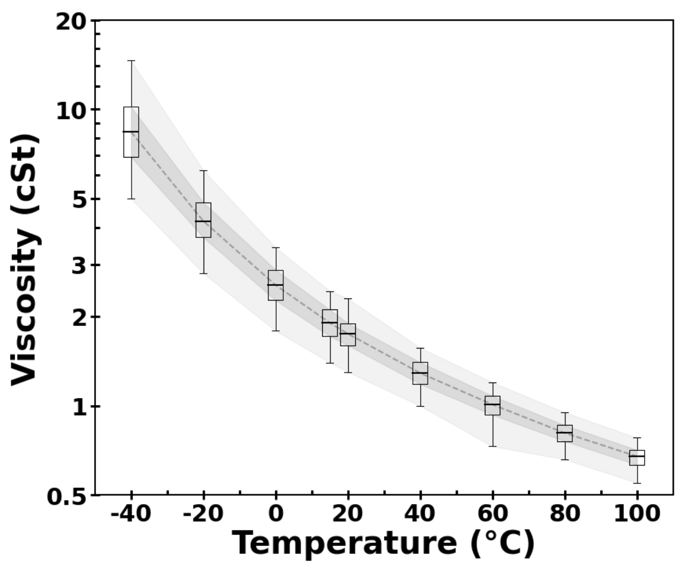

Figure 4. Typical viscosity characteristics of jet fuel. Data was pulled from CRC Report 647 (ASTM D455, measured at -40, -20, and 20°C) and CRC AV-33-22 (ASTM D7042 [ASTM 2025], measured at all depicted temperatures).

Milestones

The original project proposal indicated that sample testing would be completed by July 1, 2023, and a final report and analysis would be complete by September 30, 2023. However, this timeline failed to account for fuel producer schedules to provide samples and the time required for outside/sub-contracted testing services. That said, the Part 1 data report (to be published circa December 2025) will be delivered to the aviation fuels community at a faster pace than other, less detailed survey data (e.g., CRC Project AV-18-18/19 contains data from 2018-2019 and was published in April 2025), especially considering the level of effort to stand up the new processes. It is recommended to continue data collection and reporting with the current, active processes while it is operating at high efficiency. It is anticipated that Part 2 data will be reported by December 2026.

Major Accomplishments

- Received 54 jet fuel samples to date, which represent over 151 million US gallons of product (as self-reported by the refinery batch volumes).
- Presented the ASCENT Project 090 preliminary data at two major, international jet fuel conferences.
- Drafted the Part 1 report, which is expected to be published by December 2025/January 2026.

Publications

West, Z. (2024, April 29-May 2). *World jet fuel survey* [Conference presentation]. 2024 CRC Aviation Committee Meeting, Alexandria, Virginia.

Kosir, S., & West, Z. (2024, September 8-12). *World jet fuel survey (preliminary results)* [Poster presentation]. 18th International Conference on Stability, Handling and Use of Liquid Fuels (IASH 2024), Louisville, Kentucky.

Kosir, S., Arts, A. M., Nicely, T., Nesbit, C. J., Mueller, S., Landsaw, A., Baker, M., Brown, L., Thompson, J., Anderson, C., Shafer, L., Steinecker, W. H., Zabarnick, S., & West, Z. J. (2025). *World Jet Fuel Survey Part 1: 2023-2024* (CRC AV-33-22). Coordinating Research Council (CRC), Atlanta, Georgia. In press.

Outreach Efforts

The ASCENT Project 090 activities were presented at the spring and fall ASCENT semi-annual meetings in 2024 and 2025. Additionally, the project has been briefed at the following conferences and meetings:

- CRC Aviation Committee Meeting, Alexandria, Virginia, April 29 – May 2, 2024
- ASTM International D02.0J Sub-committee meeting, Anaheim, California, December 11, 2024
- OEM Technical Review Panel meeting, online #74, September 3, 2024
- 18th International Conference on Stability, Handling and Use of Liquid Fuels (IASH), Louisville, Kentucky, September 8-12, 2024
- UK MoD Aviation Fuels Committee Meeting, Manchester, United Kingdom, March 18-19, 2025
- ASTM International D02.0J Sub-committee meeting, Brussels, Belgium, April 9, 2025
- CRC Aviation Committee Meeting, Dayton, Ohio, April 28 – May 1, 2025
- International Air Transport Association (IATA), Aviation Energy Forum, Mexico City, Mexico, November 19, 2025
- ASTM International D02.0J Sub-committee meeting, Houston, Texas, December 10, 2025

Awards

None.

Student Involvement

Two undergraduate chemical engineering students that have been involved with the preparation of samples for solid phase extraction, GCxGC with tandem flame ionization detection and mass spectrometry detection analysis for polar organic compounds (UDRI FC-M-102) and investigating simulated distillation data analysis techniques.

Plans for Next Period

- Continue to solicit samples from fuel producers.
- Collect test data in earnest (i.e., fit-for-purpose property data).
- Prepare to report Part 2 data.

References

ASTM International. (2022). *ASTM D4054-22: Standard practice for evaluation of new aviation turbine fuels and fuel additives*. https://doi.org/10.1520/D4054-22

ASTM International. (2023). *ASTM D86-23ae1: Standard test method for distillation of petroleum products and liquid fuels at atmospheric pressure*. https://doi.org/10.1520/D0086-23AE01

ASTM International. (2023). *ASTM D1655-22a: Standard Specification for Aviation Turbine Fuels*. https://doi.org/10.1520/D1655-22A

ASTM International. (2025). ASTM D7042-21a: Standard Test Method for Dynamic Viscosity and Density of Liquids by Stabinger Viscometer (and the Calculation of Kinematic Viscosity). https://doi.org/10.1520/D7042-21A

Hadaller, O. J., Johnson, J. M. (2006). *World Fuel Sampling Program* (CRC Report 647). Coordinating Research Council, Inc., Alpharetta, Georgia. https://crcao.org/wp-content/uploads/2025/07/CRC-647.pdf