WASHINGTON STATE UNIVERSITY

ASCENT 101:

SAF Repository

Joshua Heyne, Ph.D.
Director, Bioproducts, Sciences, and Engineering Laboratory
Co-director, WSU-PNNL Bioproducts Institute
Battelle Distinguished Professor
Associate Professor, Mechanical Engineering
Affiliate Faculty, Biological Systems Engineering
Scientist, PNNL (Joint Appointment)
Quad-chair, CAAFI R&D Committee

CAAFI Webinar
30 Jan. 2024

Turning today's waste into tomorrow's carbon resource

Pacific Northwest NATIONAL LABORATORY

WASHINGTON STATE UNIVERSITY

BIO-IN BIOPRODUCTS INSTITUTE

National Distinctions:

Fuller awarded Secretary's Honor Award

Wolcott only academic author of SAF GC Road Map

Joint Graduate Study Opportunities:

DGRP and first Alaska Airlines Fellow, Conor Faulhaber

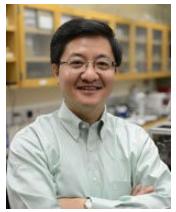
17 Distinguished Research Graduate Program Fellows since 2018, Tutored 11 Post-Docs and Students

Joint Appointments (13):

to **WSU**

to **PNNL**

to **WSU**



to **PNNL**

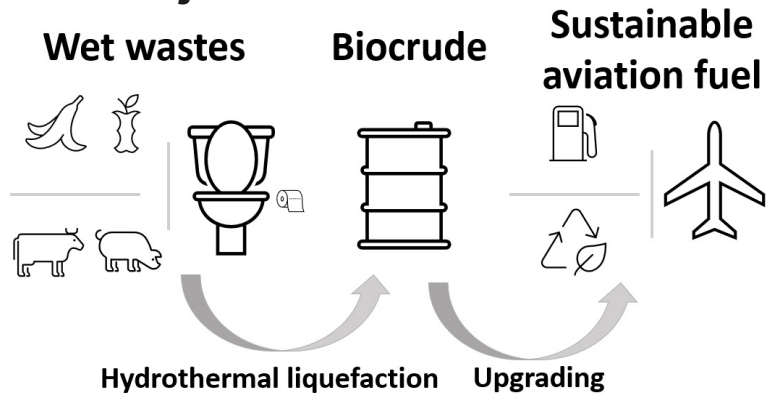
Joshua Heyne (WSU)

Corinne Fuller (PNNL)

Shared Space:

Centroid of Bio-In, space split 53/47 PNNL/WSU Bioproducts, Sciences, and Engineering Laboratory (BSEL), WSU Tri-Cities

Joint Projects:



>$33 million in new projects
>83 research publications

What is SAF as a material?

There are many properties and pathways

100%

FT-SPK sbc →

HEFA-SPK sbc →

HFS-SIP sbc →

FT-SKA sbc →

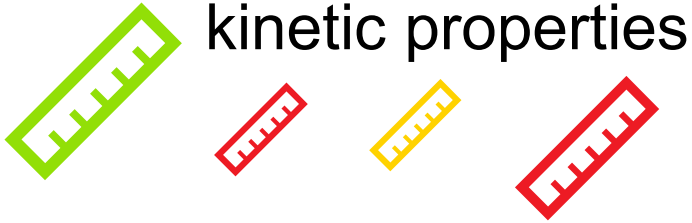
ATJ-SPK sbc → (depends on the producer)

CHJ sbc →

HC-HEFA-SPK sbc →

Blends of various SAF routes could be used to generate 100% drop-in SAF, e.g. SPK+SAK

Physical, compositional, and kinetic properties



Feedstocks and conversion processes can generate different properties.

- Identical to Jet A/A-1 (?) (fleetwide compatible, drop-in)
- Like Jet A/A-1 (limited fleet compatible, non-drop-in)
- Not-like Jet A/A-1 (not acceptable as a stand-alone jet fuel)

Kramer, S., Andac, G., Heyne, J., Ellsworth, J., Herzig, P., & Lewis, K. C. (2022). Perspectives on Fully Synthesized Sustainable Aviation Fuels: Direction and Opportunities. *Frontiers in Energy Research*, *9*. https://doi.org/10.3389/fenrg.2021.782823

joshua.heyne@wsu.edu

SAF testing the repository could impact

1. Tool and product development

- **ASCENT 25 and 65**: Low volume testing and prescreening
- Developing next generation fuel systems.
  - Capacitance gauging, pumps, nozzles, etc.

2. Pathway development

- Novel SAF producers/non-ASTM D7566 pathways
- What are the shortfalls of various pathways for commercialization/ASTM qualification?

3. Specification broadening or fuel research

- Does the type of nitrogen in the fuel from HTL matter for thermal stability?

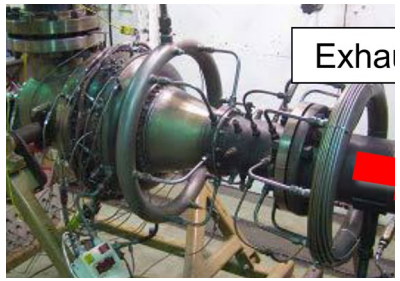
4. ASTM D4054 Qualification Testing

joshua.heyne@wsu.edu

Major Repository Components

Storage and distribution:

- **Level 1:**
  - Broad distribution with the ability to support full scale aircraft testing
  - 2-3 batches
- **Level 2:**
  - Rig testing across OEMs, research labs, and qualification
  - 5-10 batches
- **Level 3:**
  - Posterity for development of new technologies and investigation of anomalous observations
  - Approx. 100 batches



- **Blending**
  - Multiple materials could be blended for designing unique compositions for testing
- **Distillation**
  - 500 gallon batch distillation

joshua.heyne@wsu.edu

Key components of Repository Stockholders

Producers:

1. **Novel SAF Producers**
   non-ASTM D7566 compliant

2. **Commercial SAF Producers**
   ASTM D7566 compliant

Project execution:

1. **Management (IP, procurement, etc.)**

2. **Physical location for:**
   - Storage
   - Blending
   - Distribution

3. **Testing and characterization**

4. **Distribution of data and reference information**

User community:

1. **OEMs**

2. **Research institutions**
   - **Academic**
     - **ASCENT universities**

   - **National Labs**

3. **SAF producers**

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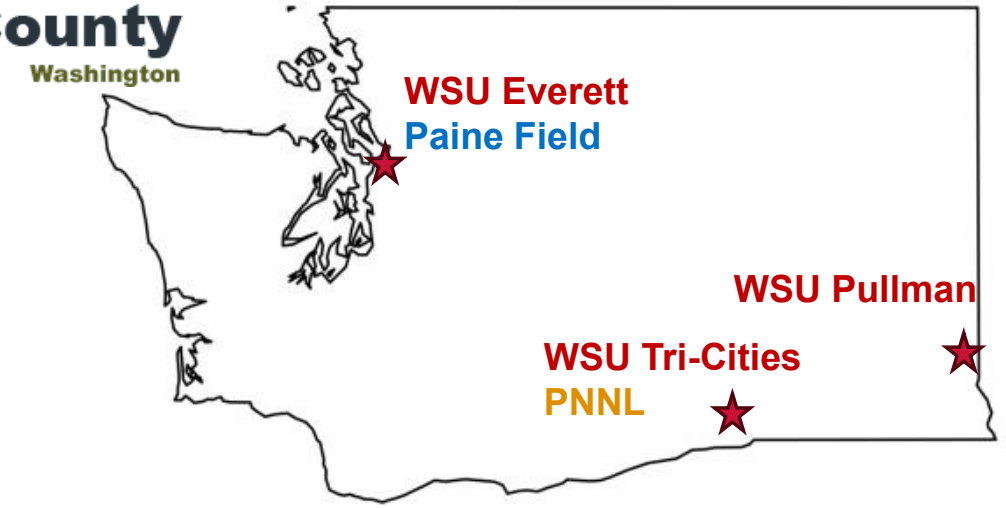
Background

Paine Field- Physical location



- Owned by **Snohomish Co.**, which is the county just north of Seattle.
- Commercial service by Alaska Airlines and Kenmore Air
- Active General Aviation ecosystem (>500 aircraft)
- Boeing 737 MAX, 767, KC-46, 787 and 777s built at and take their first flights from Paine Field
- Major hub for aircraft servicing and aviation companies
- Former military base
- 3 museums relating to flight:
  - Boeing Future of Flight
  - Flying Heritage and Armored Combat
  - Museum of Flight Restoration Center

joshua.heyne@wsu.edu

Current proposed siting

Temporary site location:

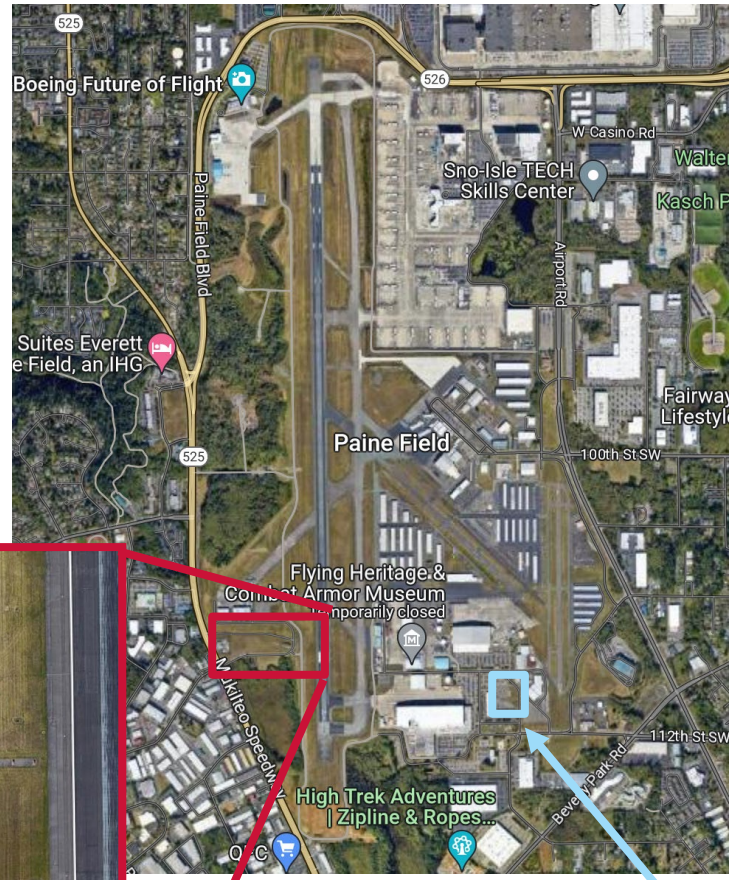
- Planned operations in June 2024

Permanent site location:

Approximately 8 acres are currently scoped for usage.

- Additional sites are potentially available.

Paine Field



Temporary site

joshua.heyne@wsu.edu

SAF Repository

Receive SAF samples from around the world

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SAF Repository

Fuels are:

1. Procured and Received
2. Indexed
3. Characterized & Databased
4. Stored
5. Distributed

Two 20,000-gallon storage units.

Hydrocarbon type characterization GCxGC-VUV/FID

Some property tests

joshua.heyne@wsu.edu

SAF Repository

Send SAF samples around the world

Testing and characterization
CY24- all Fast Track tests

Thanks to the **Murdock Charitable Trust** and **an airline**, we have the support to complete all Fast Track capabilities in CY24.

In use or ordered:

- Micro-distillation/optimization (BR Instruments)
- GCxGC-VUV/FID
- Density and viscosity (-55 °C)
- HHV and proton NMR (D4809)
- JFTOT with ellipsometer
- Dielectric constant (with chiller)
- Swell testing
- Flash Point
- Freeze Point
- Total sulfur
- Distillation (D86 and D2887)
- Vapor pressure
- Differential Scanning Calorimeter (-90 to 500 °C)
- Surface Tension (-20+ °C)
- FAME (GC-MS)
- Aromatics, olefins, and saturates (ASTM D1319)
- Particulates
- Dissolved water
- Acidity
- Conductivity
- BOCLE/lubricity
- Existing gums
- Copper corrosion

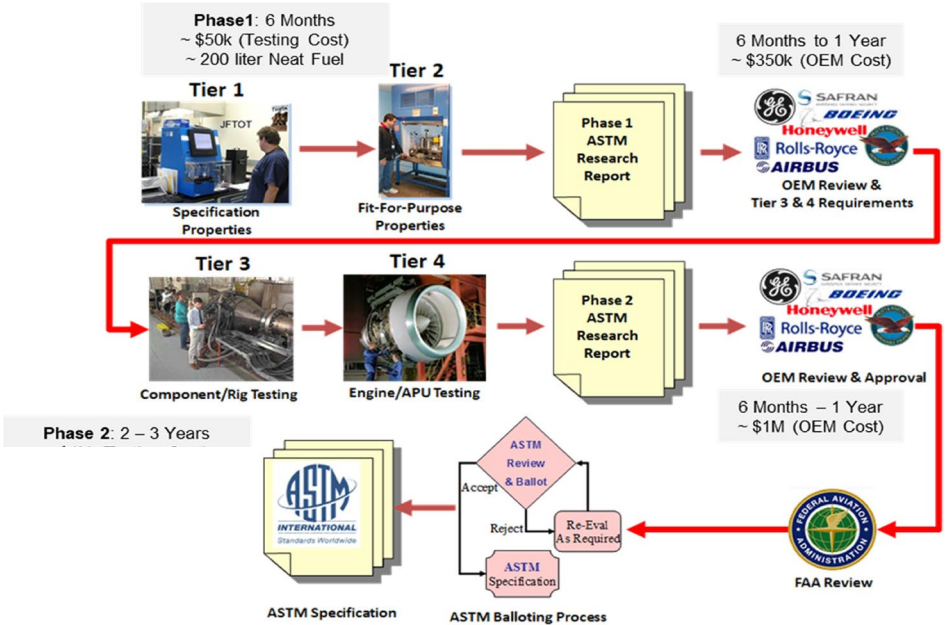
joshua.heyne@wsu.edu

Novel SAF qualification process

Pre D4054 entrance

1. **Prescreen** composition/properties and refine candidate process (milliliters of material)
2. **Engage a select number of ASTM committee members** (and CAAFI) with:
   - Initial data
   - Commercialization plan
   - Pathway description
3. Establish an **ASTM Task Force** on the candidate pathway
4. **Prescreen** batch(es) for ASTM consideration (liters)

Post D4054 entrance



5. Submit approx. 200-300 liters of candidate material and a more detailed commercialization plan to **FAA D4054 Clearinghouse**
   - Multiple batches may be required; batches can sum to 200-300 liters
6. Work with **FAA, OEMs,** and **Clearinghouse** to complete research reports and potentially produce more fuel

Heyne, Rauch, Le Clerq, Colket, Sustainable aviation fuel prescreening tools and procedures, Fuel 2021, https://doi.org/10.1016/j.fuel.2020.120004

joshua.heyne@wsu.edu

SAF Prescreening

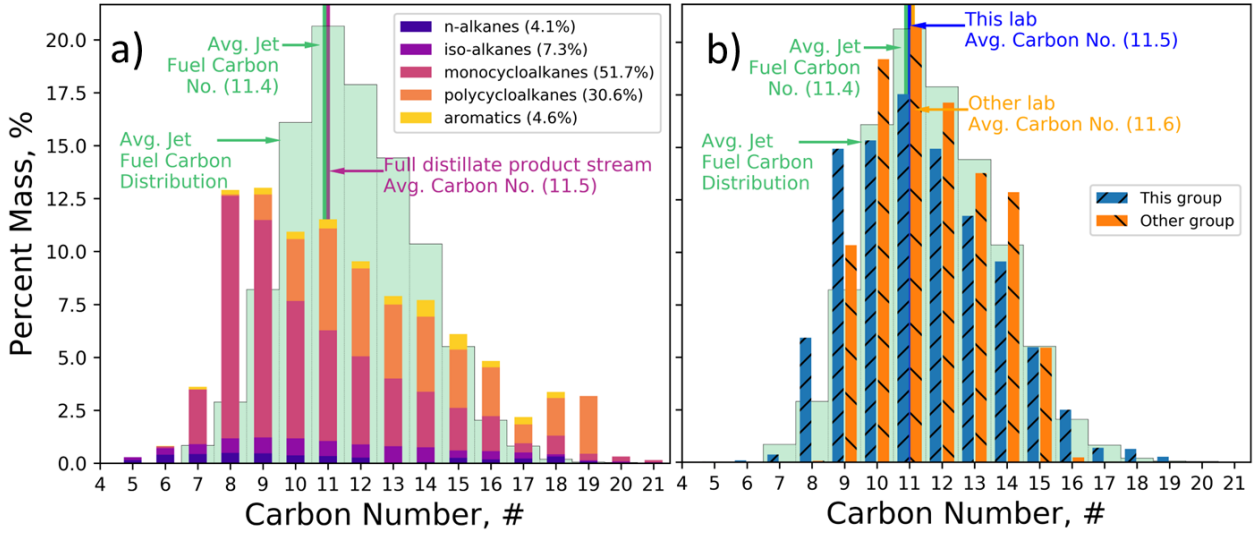
- **ASCENT 65a (PM: Ana G.)**
  ana.b.gabrielian@faa.gov
- **Experience:**
  - >220 unique SAF samples
  - 3 dozen institutions across North America and Europe
  - A dozen different pathways
- **Cost:**
  - >$2k/sample
- **Timelines:**
  - MTA and NDAs allow at least 6 weeks
  - 1 to 2 weeks after the sample is received

Tests	Vol, mL
Hydrocarbon type analysis (GCxGC), distillation curve, LHV, viscosity, density flash point, freeze point, surface tension, nitrile rubber swelling, smoke point/TSI	30*
JFTOT and DCN	+800

*finished material, does not include yield losses if distilled at the lab.

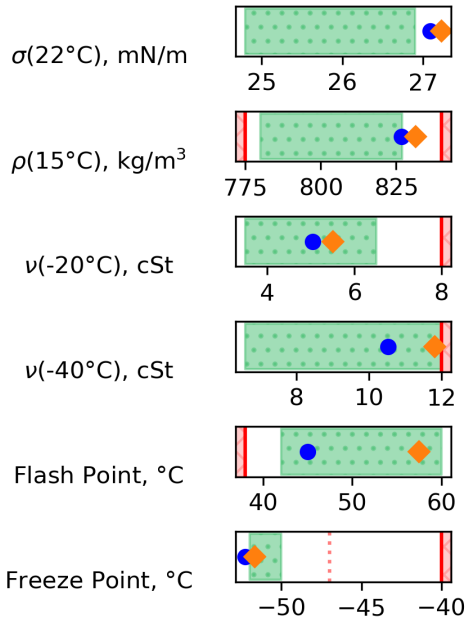
joshua.heyne@wsu.edu

Distillation cut points are important for properties and yields

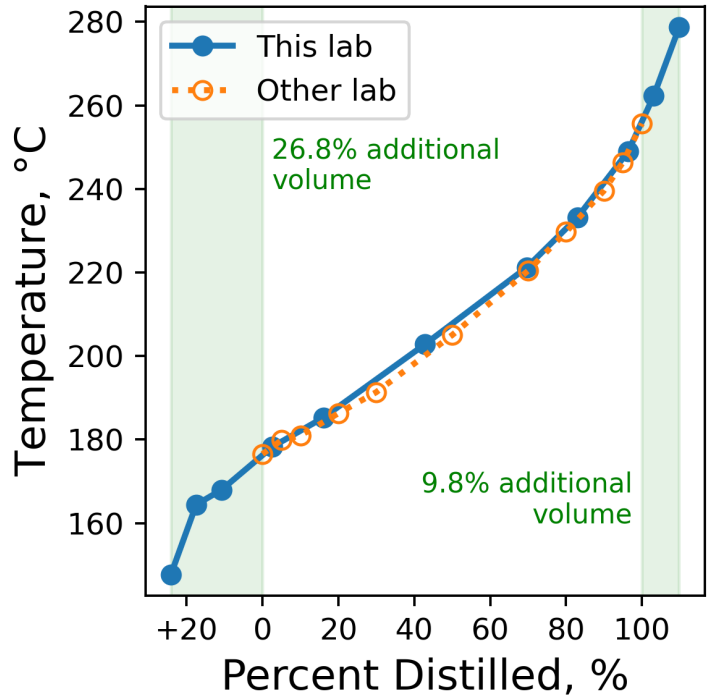


SAF product straight from producer.

Carbon number distribution from two different distillation cuts.



The viscosity is nearly off-spec for the orange cut.



36% more SAF is yielded with better properties

Currently exploring the potential of getting a larger scale distillation column for ASTM qualification and fuel research.

joshua.heyne@wsu.edu

Repository timeline and next steps

- **Initial operations upon receipt of funding from FAA**
- **Temporary site:**
  - June 2024
- **Permanent facility:**
  - >2 years out
- **We are looking for more partners.**
- **Interested in contributing or receiving materials?**
  - Email: randall.boehm@wsu.edu and joshua.heyne@wsu.edu
  - Put ‘SAF Repository’ in the subject line.

Thank you & Questions

joshua.heyne@wsu.edu