GE Aerospace

FAA CLEEN III Consortium Industry Day, Spring 2023





At GE Aerospace, we **invent the future** of flight, **lift people up** And bring them **home safely**

GE Aerospace CLEEN III - Industry Day, Spring 2023

Powering the world's airline fleets with nearly 41,000 engines



0:02

Every two seconds an aircraft with GE engine technology^{*} is taking off somewhere in the world

3/4 takeoffs

Three out of every four takeoffs are powered by GE*

650,000 people

~650,000 people flying at any given time on GE* powered aircraft

www

*Includes joint venture engines built by CFM and Engine Alliance CFM is a 50/50 joint company between GE and Safran Aircraft Engines Engine Alliance is a 50/50 Joint Venture between GE and PW



More than 100 years of innovation **GE Aerospace has achieved the following firsts:**

- U.S. jet engine & U.S. turboprop engine
- Mach 2 engine
- Composite fan blade in airline service
- World record for thrust GE90 & GE9X
- Additive jet engine parts certified by U.S. FAA



GE Aerospace 100% SAF testing



1st commercial aircraft flight with 100% SAF*

2018 - GE90

Ground and in-flight emissions testing using 100% SAF in one engine

2022 – Passport
Ground testing

• 2022 - HF120 Ground testing

2023 – CFM56 Ground testing



2016 - F414

1st military jet flight with 100% SAF in at least one engine

2019 - GE9X

Combustor component testing

2021 - LEAP-1B

1st experimental flight with passengers using 100% SAF in one engine 2022 – GEnx

On-wing ground testing to study emissions

2023 - GE90

1st Middle East demonstration flight using 100% SAF in one engine

*Tests included 100% SAF in one engine, as well as in both engines.

LEAP and CFM56 engines are a product of CFM International, a 50-50 joint company between GE Aerospace and Safran Aircraft Engines. HF120 engines are a product of GE Honda Aero Engines LLC, a 50/50 joint company between GE Aerospace and Honda Aero, Inc.

Emirates Operates First Flight in Middle East Using 100% SAF in One Engine

- <u>Emirates</u> recently operated the first demonstration flight in the Middle East using 100% SAF in one engine
- The <u>Boeing</u> 777 was powered by GE90 engines
- Flight tests like the one with Emirates help improve available data to support the standardization and approval of drop-in 100% SAF
- All <u>GE Aerospace</u> and <u>CFM International</u> engines can operate on approved SAF.
- Multiple GE Aerospace engines have been tested with 100% SAF to support industry efforts to qualify the alternative jet fuel
- Sustainable Aviation Fuel (SAF) can reduce lifecycle CO₂ emissions from how it's made and is key to helping the aviation industry reach its net zero ambitions



CFM RISE technology demonstration program



Targeting more than 20% lower CO2 emissions

- Advancing open fan architecture
- Propulsive efficiency step change
- Same speed & cabin experience
- Ground and flight tests mid-2020s

- Advanced materials
- Hybrid-electric capability
- Additive manufacturing
- 100% SAF, hydrogen capability
- EIS by mid-2030s



Revolutionary Innovation for Sustainable Engines

*CFM International is a 50-50 joint company between GE and Safran Aircraft Engines. RISE is a registered trademark of CFM.

Airbus and CFM International launch open fan flight demonstration

Through CFM's RISE program:

- Collaboration with <u>Airbus</u> to flight test CFM's open fan engine architecture with A380 testbed
- Evaluate open fan propulsive efficiency and performance
- Assess aircraft engine integration and aerodynamics
- Understand hybrid electric capabilities
- Assess internal and external noise sources



RISE is a registered trademark of CFM International, a 50-50 joint company between GE and Safran Aircraft Engines

CFM RISE Technologies



Anticipated Benefits

- Noise: 13 EPNdB cum margin relative to Stage 5
- Combined Fuel Burn: 20+% reduction relative to current CFM LEAP* engine
- Targeting NOx reduction for a future high overall pressure ratio engine cycle, equivalent to 70% margin to the CAEP/8 standard at 30 OPR

Objectives

- Open Fan: develop unducted single fan architecture
- Low emissions combustor: develop low NOx and nvPM combustor and enable compact, high OPR core to achieve 20% fuel burn
- Develop Advanced Thermal Management System and waste heat recovery system
- **Hybrid Electric Generator**: develop integrated electricpower generation system within the engine

High Level Schedule

	2021	2022	2023	2024	2025
Design					
Fabrication, Procurement, Assembly					
Technology Demonstration					



CLEEN III MESTANG III



Anticipated Benefits

- More Efficient +/- 270Vdc generator with high power density and increased fuel savings
- New cooling method for increased thermal performance
- Self contained oil system

Risk/Mitigation Plans:

• Risk : Oil Pump performance fails to meet requirements Mitigation : Lab test with dummy generator

Objectives

Mature a +/- 270Vdc electric generator development as part of an integrated more-electric primary power system

Work Statement

- Design and develop a 90 kW, +/- 270Vdc generator to address requirements of mid-size aircraft, business jets.
- Improved power generation system design with increased power density at lower cost.

High Level Schedule

	2021	2022	2023	2024
Design				
Fabrication, Procurement, Assembly				
Technology Demonstration				

(ge)

Sustainable Aviation Fuel



Anticipated Benefits



• Accelerate the standardization and therefore the introduction of 100% SAF

Objectives

- Support qualification of candidate SAF test/demo
- Advance standardization of 100% SAF

Work Statement

- Evaluate 100% & 50% (if needed) of CPK-0 SAF for combustor (FAR*) operability/emissions
- Help develop ASTM standard for 100% SAF

*Full Annular Combustor Rig

High Level Schedule

	2021	2022	2023	2024
Fuel Testing*				
Development of Fuel				
Specification for 100% SAF				

* Delayed due to fuel availability

CLEEN III Advanced Acoustics







Objectives

- Develop Novel Acoustic Liners.
- Develop Fan Source Strength Reduction Concepts

Anticipated Benefits

Novel Liners:

2 EPNdB cumulative noise reduction relative to conventional liner w/ neutral performance impact

Fan Source Strength Reduction: 1 EPNdB cumulative noise reduction w/ performance neutral impact

High Level Schedule

	2021	2022	2023	2024	2025	2026
Rig Scale Technology						
Demonstration*						
Full-Scale Design						
Full-Scale Fabrication,						
Procurement, Assembly						

* Delayed due to facility availability







Shank You!

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