GE Aerospace

GE Aerospace FAA CLEEN III Consortium Industry Day

Fall 2024

We are a world-leading provider of jet engines, components and integrated systems for civil and military aircraft.

We see an industry that matters to the world:

- History of innovation
- Purpose driven people
- Technologies to help enable net-zero flight

Photo courtesy of Boeing featuring Craig Bomben, Boeing's Enterprise Chief Pilot and VP of Flight Operations.

Our global footprint

North America
- Canada
- Mexico
- U.S.A.

Latin America
- Brazil

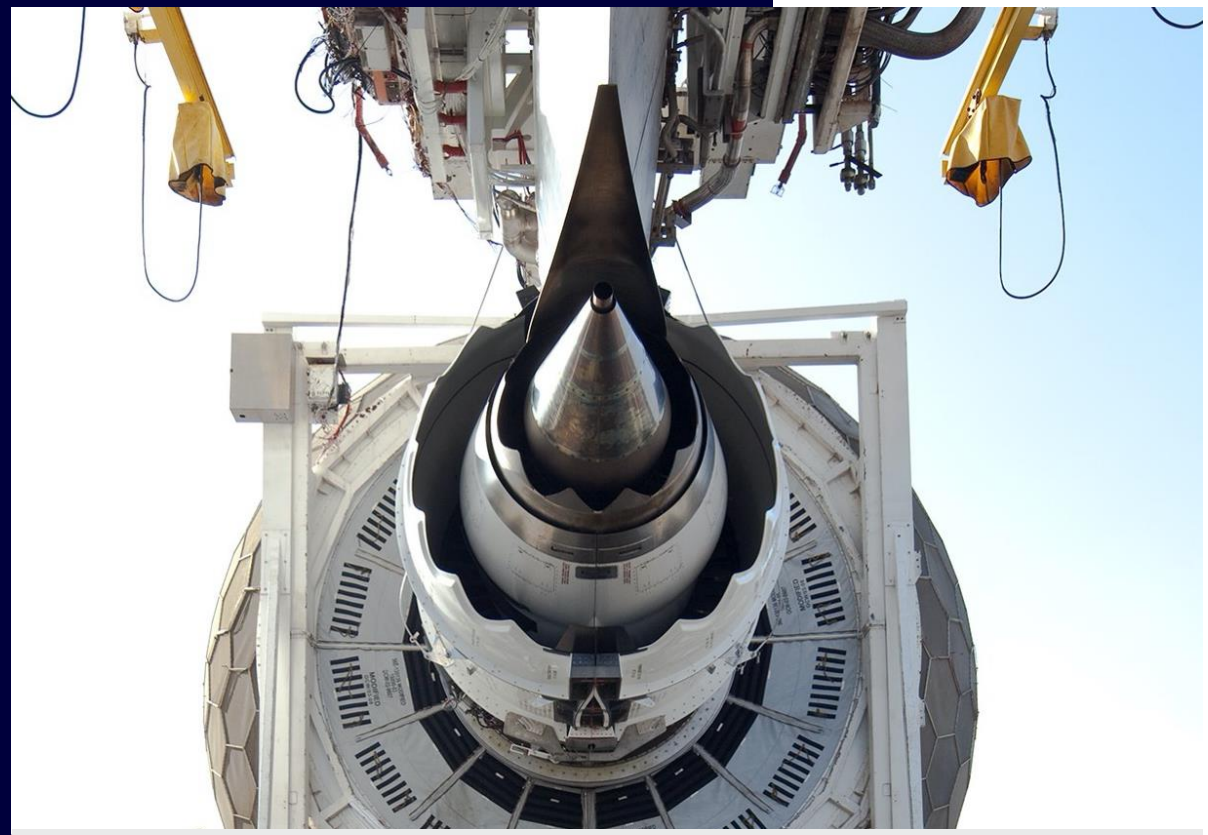
Asia Pacific
- Australia
- India
- Korea
- Malaysia
- Singapore

Greater China
- China
- Hong Kong
- Taiwan

Middle East
- Qatar
- United Arab Emirates

Europe
- Czech Republic
- France
- Germany
- Hungary
- Italy
- Poland
- Romania
- Sweden
- Turkey
- United Kingdom

This is GE Aerospace



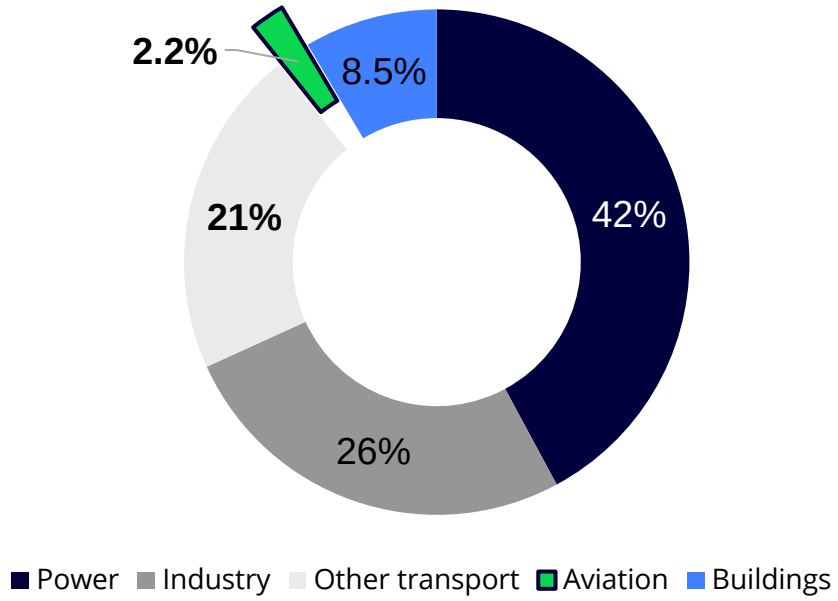
By the numbers

- ~52,000 employees
- ~12,000 engineering jobs
- 60+ manufacturing locations
- 15+ overhaul and component repair locations
- 8 engineering centers
- $2.3B in research and development*
- $16M in philanthropy

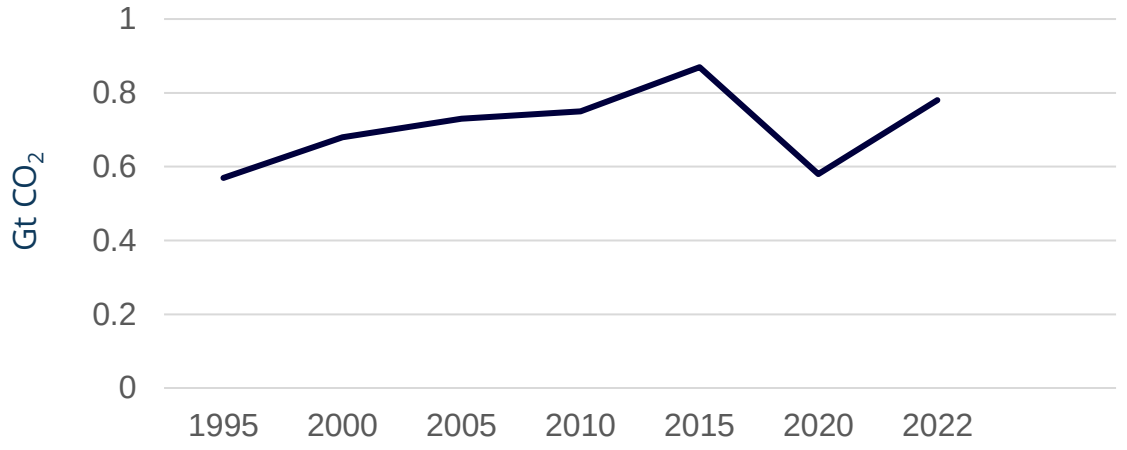
*Includes customer and partner funding

As aviation industry recovers from pandemic, challenge to meet net zero CO_2 emissions target by 2050

Global CO_2 emissions by sector 2022



Aviation CO_2 emissions projected to surpass 2019 peak around 2025



… Innovation to transform air travel at new inflection point

SOURCES: International Energy Agency (IEA) CO2 Emissions in 2022: https://www.iea.org/reports/co2-emissions-in-2022, https://www.iea.org/energy-system/transport and https://www.iea.org/energy-system/transport/aviation. This work is derived from IEA material and not endorsed by IEA.

Technologies to help meet industry net-zero ambition

Now

Renewed commercial engine portfolio, plus services technologies, reduce existing fleet CO_2 emissions

Near

100% Sustainable Aviation Fuel (SAF) standards and greater SAF adoption to reduce lifecycle CO2 emissions

Next

Breakthrough technology demonstrators … CFM RISE*, hybrid electric, hydrogen combustion

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

Revolutionary change to continue efficiency legacy

Low Bypass

CFM56

– 25%

CFM LEAP

-15% to 20%

Open Fan

– 20%

1970s | **1982*** | **2016*** | **~2035***

GE Aerospace

CFM is a 50/50 Joint Venture between GE and Safran Aircraft Engines. RISE is a registered trademark of CFM.

*compared to previous generation engines

Ten different engine models tested with unblended SAF

2016 – F414
1st military jet flight with 100% SAF in at least one engine

2018 – GE90
1st commercial aircraft flight with 100% SAF*

2019 – GE9X
Combustor component testing

2021 – LEAP-1A
Ground and in-flight emissions testing using 100% SAF in one engine

2021 – LEAP-1B
1st experimental flight with invited passengers using 100% SAF in one engine

2022 – Passport
Ground testing

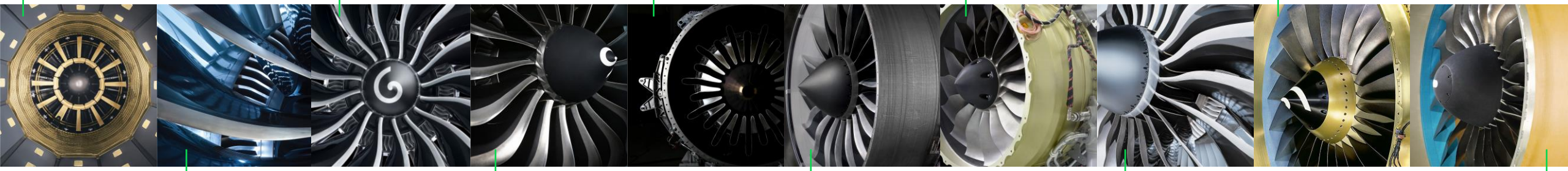
2022 – GEnx
On-wing ground testing to study emissions

2022 – HF120
Ground testing

2023 – GE90
1st Middle East demonstration flight using 100% SAF in one engine

2023 – CFM56
Ground testing

2023 – GP7200
Ground testing and flight demonstration



*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.

CFM RISE program: developing a more sustainable future of flight for customers

Technology pillars

Open Fan

Enables maximum fuel efficiency gain ... targeting >20% better fuel efficiency vs. today's engines

Compact core

Compressor, combustor, and high-pressure turbine technologies to improve thermal efficiency

Hybrid electric

Integrating propulsion and power systems for flight, including battery and fuel cell sources

Alternative fuels

100% sustainable aviation fuel (SAF) compatibility, advancing hydrogen combustion

Technology developments across pillars

Today — **2030s**

>250 baseline and part-level tests completed

First tests of Open Fan blade ingestion, high-pressure turbine blades and nozzles, >200 hours of wind tunnel and acoustic testing[a)]

Ongoing baseline, part-level, and module-level tests

Moving from part-level to module and rig tests

Engine and system-level ground tests

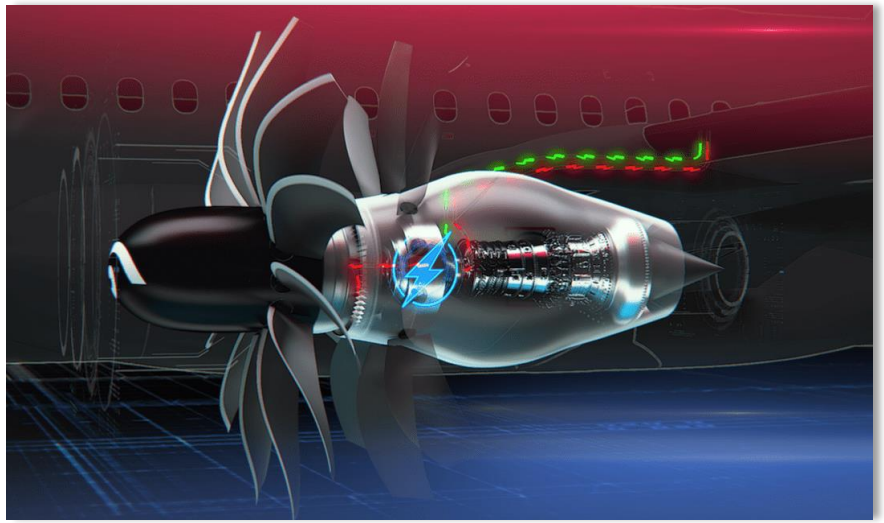
Includes Open Fan, hybrid electric, and compact core technologies

Flight tests

Announced plans to test Open Fan integration with Airbus

a) Completed by CFM

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 electric-power generation system within the engine

High Level Schedule

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

Sustainable Aviation Fuel

Anticipated Benefits

- Advance understanding of fuel composition on combustor performance
- Advance the approval of SAF qualifications
- Accelerate the standardization and the introduction of 100% SAF

Objectives

- Support SAF qualifications – test/demo
- Advance standardization of 100% drop-in SAF

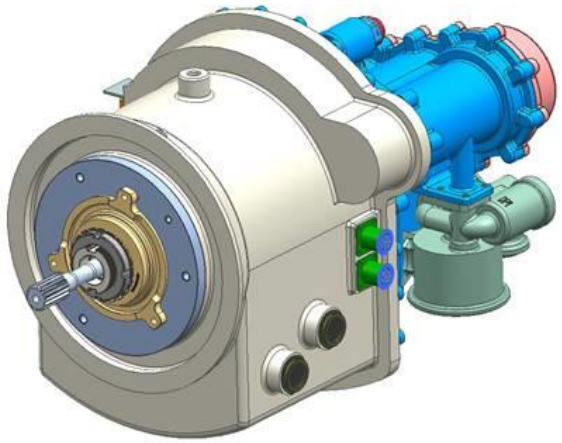
Work Statement

- Evaluate 2 fuels of mutual interest to GE/FAA
- Help develop 100% drop-in SAF ASTM standard

High Level Schedule

Activity	2021	2022	2023	2024	2025
Fuel Testing					
Fuel Specification Development					

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

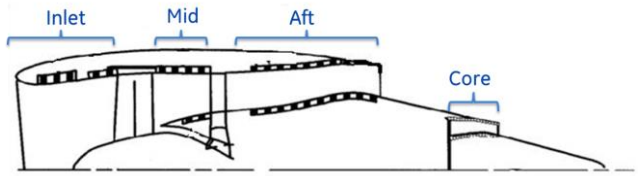
Work Statement

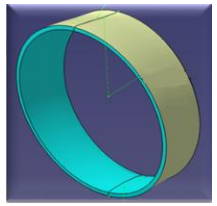
- Design and develop a 90 kW, +/- 270Vdc generator to address requirements of mid-size aircraft, business jets.
- Improved power generation system design with increased power density at lower cost.

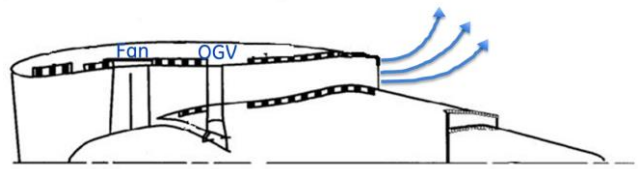
High Level Schedule

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

CLEEN III Advanced Acoustics







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

Objectives

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

High Level Schedule

Advanced Acoustics	CY 2021				CY 2022				CY 2023				CY 2024				CY 2025				CY 2026			
Full Scale Hardware Design Phase	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Advanced Acoustic Liner Design																								
Acoustics Design Consensus Review																								
Mechanial Design Consensus Review																								
Acoustics Design Review																								
Mechanical Design Review																								
Advanced Liner Report Generation																								
Fan Source Strength Reduction Concept Design																								
Aero and Acoustic Design Consensus Review																								
Aero and Acoustic Deign Review																								
Fan Source Strength Reduction Report Generation																								


GE Aerospace
Thank You!