Rolls-Royce CLEEN II Program Overview

Brad Belcher

8 May 2024

CLEEN Consortium Public Day Charts, Washington, DC

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US	NO TECHNICAL DATA	25 April 2024, BDBelcher

Public Release No. V024030
May 1, 2024

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Ready To Deliver.

Core Markets

Rolls-Royce is tightly focused into **three core businesses.**

Civil Aerospace

Power Systems

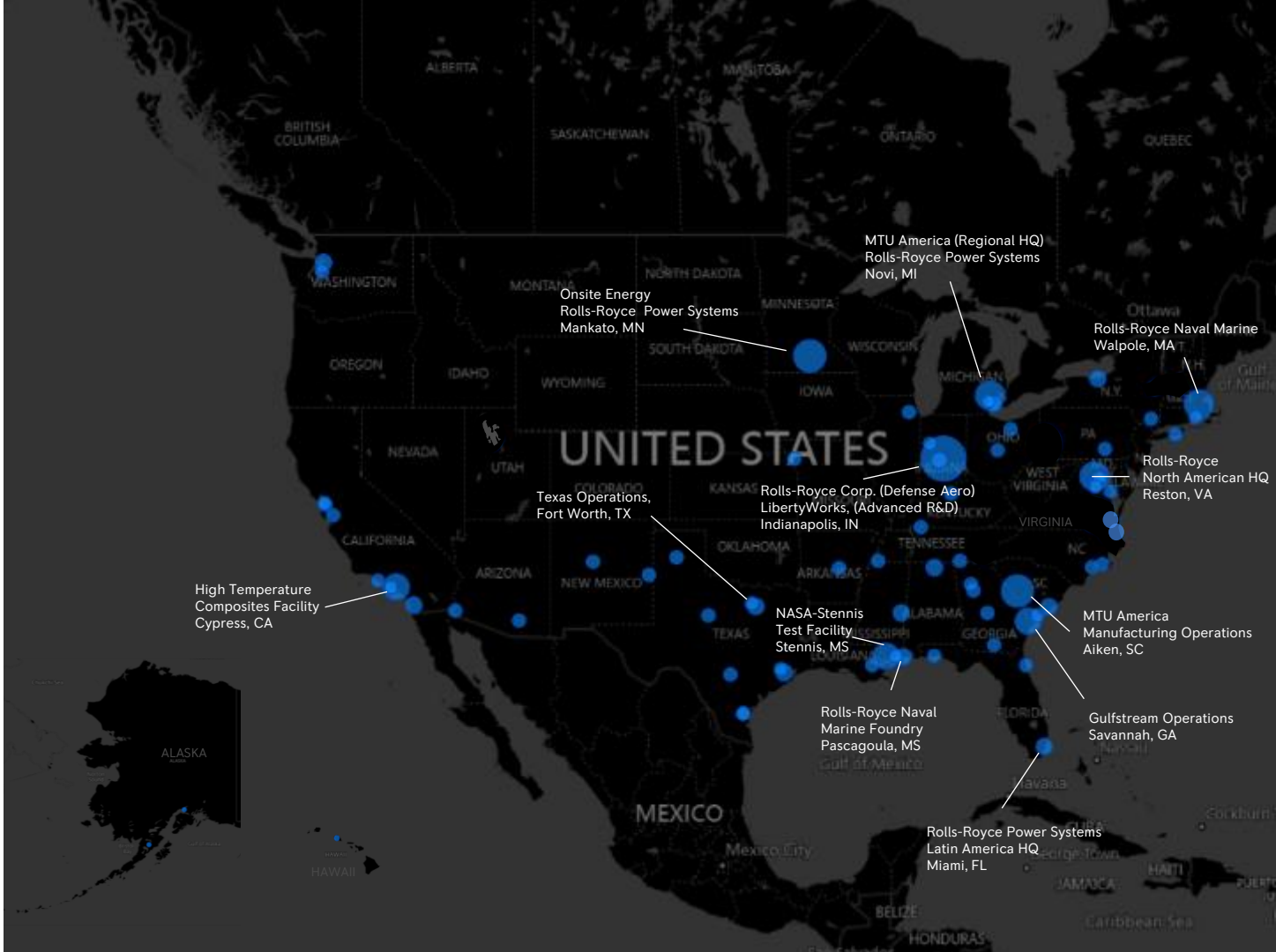
Defense

Our Footprint

Rolls-Royce directly employs more than **5,500 diverse high-skill U.S. teammates** and supports tens of thousands of jobs across our downstream network ($1.6B Annual U.S. Supplier Spend).

Since 2011, we have invested more than **$1.5B in our U.S. facilities**.

We also operate multiple University Technology Centers (UTCs) and support several apprentice and workforce development programs at our flagship sites.



Major Awards & Programs

In a major vote of confidence, the U.S. Air Force awarded Rolls-Royce the contract to re-engine the B-52 bomber with the R-R F130 Engine.

The B-52 award was soon followed by the U.S. Army's award of the Future Long Range Assault Aircraft (FLRAA) program to Bell. Rolls-Royce will power the FLRAA Aircraft with our AE 1107®F engine.

The F130/B-52 and FLRAA will join several other major DoD programs in the Rolls-Royce portfolio.

We're just getting started.

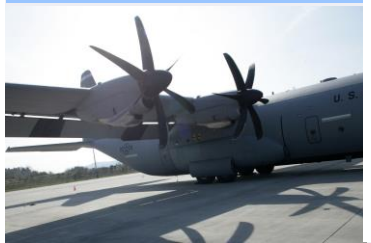
AE 1107F For FLRAA

Capable. Reliable. Low-Risk.

F130 For B-52

Proven. Efficient. Modern.

C-130J & C-130H Engines



Primary U.S. Navy Propeller Contract

V-22 Engines

F-35B LiftSystem

Civil Aerospace

Our Civil Aerospace group is a major manufacturer of high-performance aircraft engines.

Our Civil Aerospace group is a major manufacturer of aircraft engines, **leading the wide body commercial and business jet propulsion markets**.

All in-production Civil Aero engines are certified 100% Sustainable Aviation Fuel Compatible.

395+ Million

Flight Hours on Rolls-Royce Engines

Power Systems

Rolls-Royce Power Systems manufactures robust large-scale diesel engines for marine, land defense, off-highway and power generation applications.

86 Years of US-Built Engines

Primary

Engine Supplier For The U.S. Coast Guard

Image: USCG

Defense

We are the **engine market leader** in **transport and patrol aircraft**, and power a broad range of engines for **combat aircraft** and **helicopters.**

Rolls-Royce is the only fielded **tiltrotor** and **STOVL** aircraft propulsion provider for the U.S. military.

Rolls-Royce is also the **primary propeller supplier for the U.S. Navy** and a pioneer aero-derivative marine engines for the DoD.

16,000+

Military Engines In Service

Image: NGB

Novel Power & Energy Security

We are committed to delivering leading technologies to our civilian and defense customers supporting energy security and decarbonization.

Rolls-Royce will:

- ✓ Reach 75%+ of R&D spending invested in NetZero and Energy Security technology by 2025
- ✓ Reach NetZero carbon from our operations by 2030
- ✓ Reach NetZero carbon across our value chain by 2050


1000
ROLLS
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Rolls-Royce CLEEN III Program Overview

Steve Krautheim

8 May 2024

CLEEN Consortium Public Day Charts, Virtual Meeting

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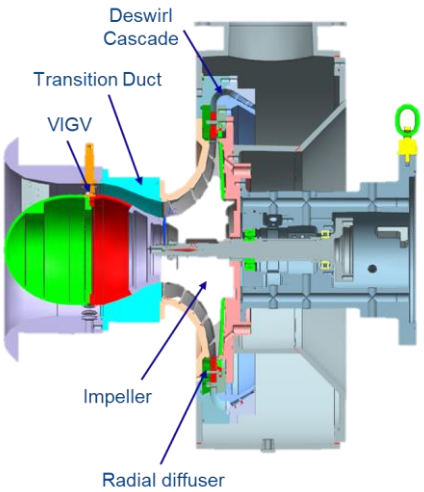
Public Release No. V024030
May 1, 2024

Rolls-Royce CLEEN III Program

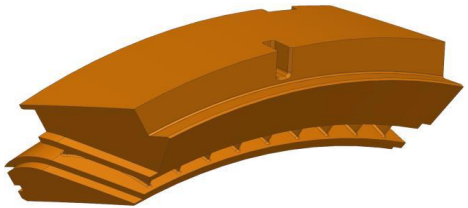
CSTAR Gen2.5 Rig

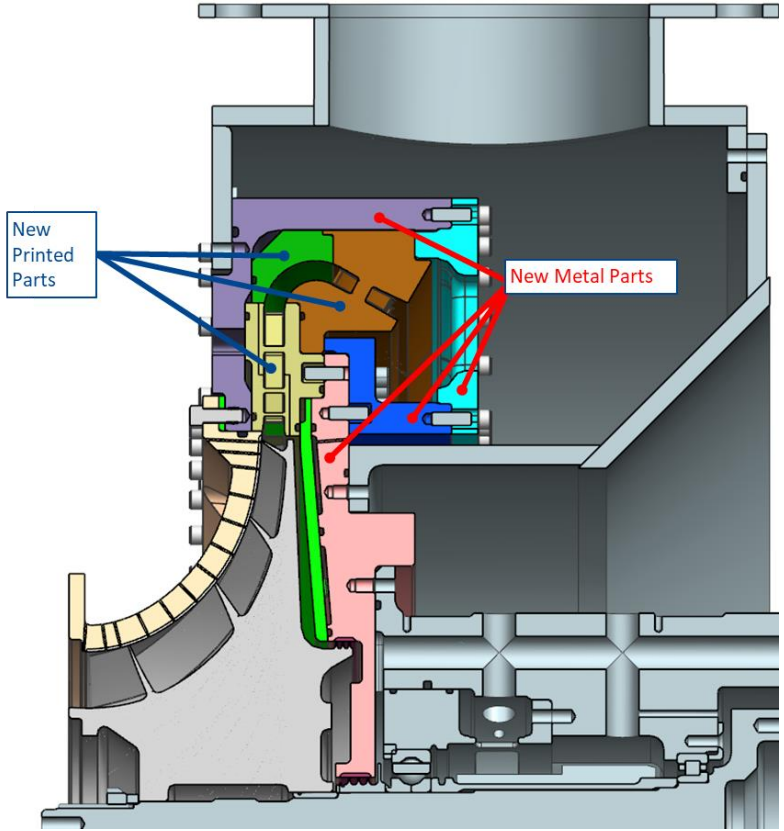


- Rolls-Royce is developing advanced centrifugal compressor stage technologies to improve the performance of a high overall pressure ratio axial-centrifugal compression system.
- The goal of the work is to improve both component efficiency and surge margin while reducing the physical size of the machine.
  - Combined centrifugal stage efficiency target: 0.3% (~0.3% Fuel Burn)
  - Combined centrifugal surge margin target: +2%
  - Engine performance model will be used to calculate engine and fleet level impact
- The effort includes design, fabrication, and assessment of candidate technologies, including testing in the Centrifugal Stage for Aerodynamic Research (CSTAR) rig at Purdue University.
- Through this approach, concepts are progressed from TRL3 to TRL5.

CSTAR GEN2.5 CF Compressor Rig

- Rig allows for inexpensive printing of downstream diffuser and deswirler geometries
- Sectors are printed from high temperature capable polymer
- Enables optimization of the diffuser and deswirler as a system
- Diffuser technologies to be studied include injection holes and end wall contouring
- Deswirl technologies to be studied include vane configuration and 3D geometry



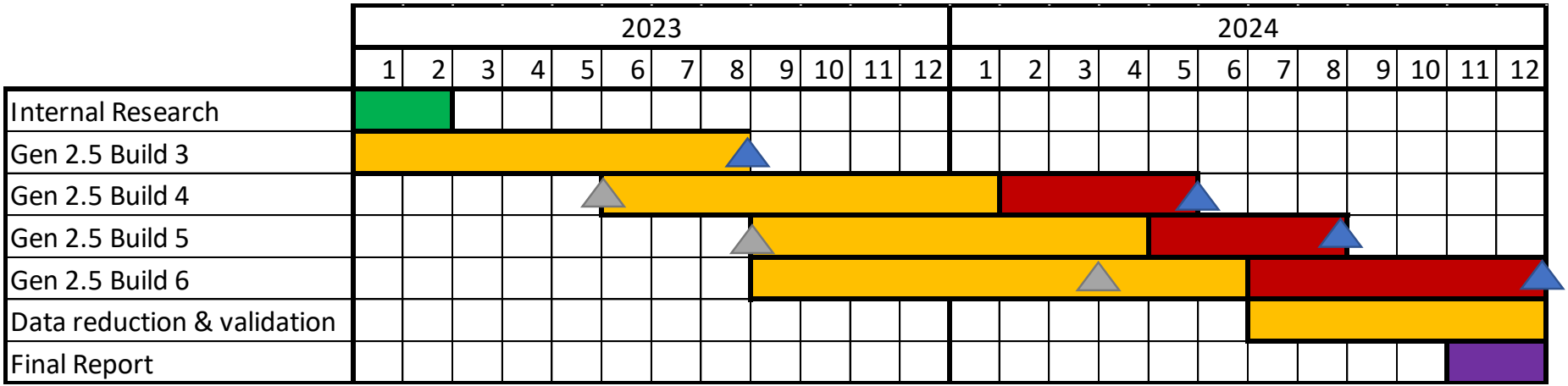


CSTAR Gen2.5 Rig

CLEEN III CSTAR Test Sequence

Build 6 at risk before end of year

Rolls-Royce Baseline
CLEEN III Funding
Late / Risk
TRL 3
TRL 5



Aerodynamic technologies which are successful will be considered TRL5 at program conclusion.

Lessons Learned

- Original 3-month test cycle was optimistic
  - 6-month test cycle achievable
  - Still faster than before
- Need time for post-test analysis and to incorporate findings into analysis and/or test
- Experimental testing always leads to learning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