COLLINS AEROSPACE

COMMERCIAL AIRCRAFT TECHNOLOGY DEMONSTRATOR

CLEEN II CONSORTIUM PUBLIC PLENARY SESSION

MAY 8, 2019

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OUTLINE

- Company Overview
- Elevator Speech
- Case for Action
- Program Summary
- Opportunity Cost
- Nacelle Technologies
- Technology Risks
- Technology Risk Reduction
- Project Schedule
- Past Achievements
- Future Plans (2019)
- Future Plans (2020)
- Summary

COMPANY OVERVIEW

Collins Aerospace

United Technologies

Collins Aerospace
A United Technologies Company

Pratt & Whitney
A United Technologies Company

Carrier

Otis
A United Technologies Company

Leading provider of high technology systems for the commercial building and aerospace industries

Employs approximately 220,000 people in more than 4,000 locations

Located in approximately 70 countries around the world; 2018 net sales of $74B

ABOUT COLLINS AEROSPACE

Collins Aerospace, a unit of United Technologies Corp. (NYSE: UTX), is a leader in technologically advanced and intelligent solutions for the global aerospace and defense industry.

Created in 2018 by bringing together UTC Aerospace Systems and Rockwell Collins, Collins Aerospace has the capabilities, comprehensive portfolio and expertise to solve customers' toughest challenges and to meet the demands of a rapidly evolving global market.

Collins Aerospace

OUR SYSTEMS MAKE MODERN FLIGHT POSSIBLE

WE **POWER** IT
WE **START** IT
WE **VENTILATE** IT
WE **CONTROL** IT
WE **MONITOR** IT
WE **PROTECT** IT
WE **LAND** IT
WE **STOP** IT

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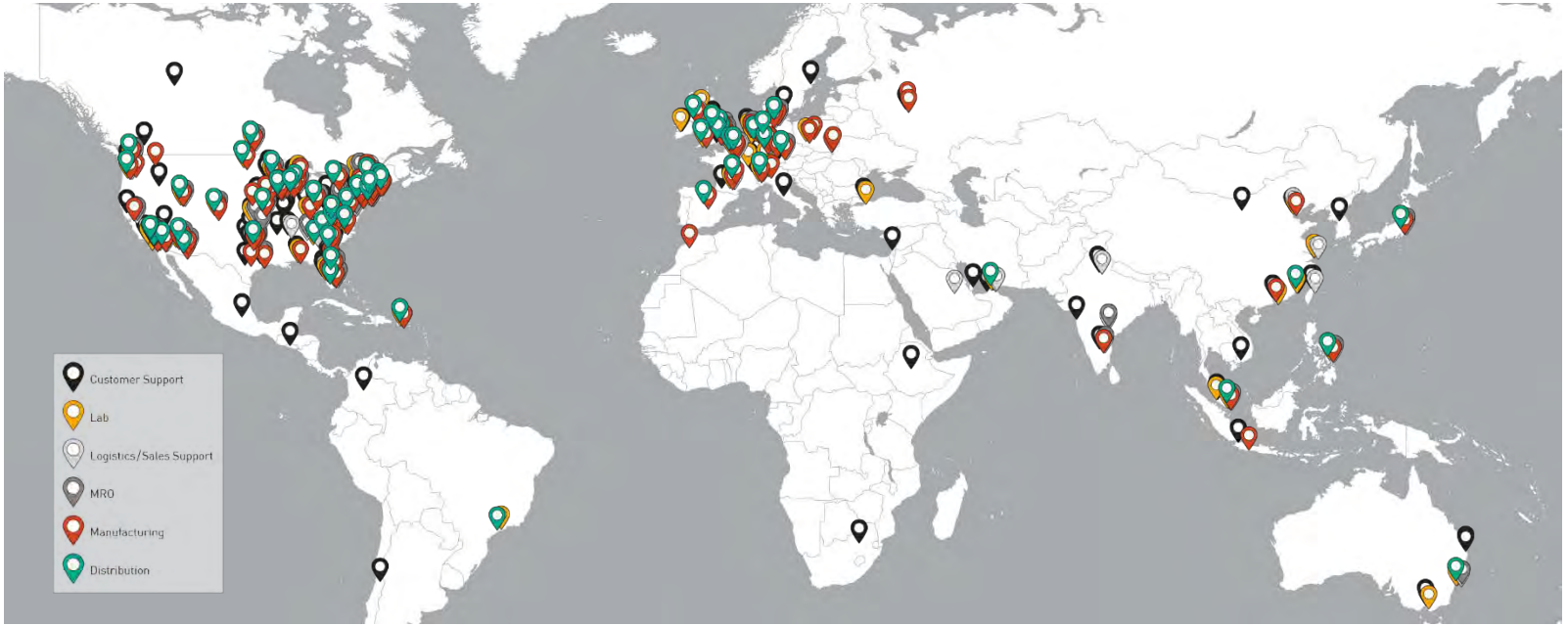
GLOBAL LOCATIONS, LOCAL SUPPORT



NEARLY 300 SITES WORLDWIDE

Where you need us, when you need us – everywhere, every day

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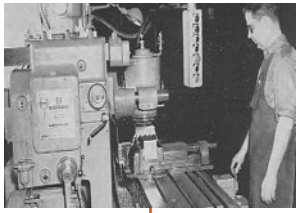
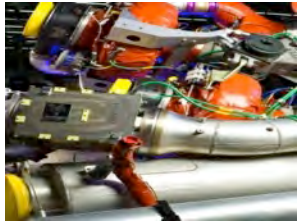
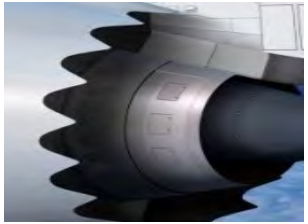
LEGACY OF INNOVATION

AVIONICS AND COMMUNICATIONS	ELECTRIC SYSTEMS	ENVIRONMENTAL CONTROL SYSTEMS	LANDING SYSTEMS	NACELLES	PROPELLER SYSTEMS
 Arthur Collins	 David Sundstrand	 Thomas Hamilton	 Benjamin Goodrich	 Fred Rohr	 Paulin Ratier
					
					

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STRATEGIC BUSINESS UNITS

Aerostructures

Avionics

Interiors

Mechanical Systems

Mission Systems

Power & Controls

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COLLINS AEROSPACE – AEROSTRUCTURES

Key Products and Systems

Nacelle systems

Pylons and fairings

Tailcones

Key Platforms

Collins Aerospace – Aerostructures

Industry leading independent supplier and integrator of nacelles and pylons, offering complete life cycle design/build/support for large commercial and regional jet customers around the world

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COLLINS AEROSPACE – AEROSTRUCTURES

Based in Chula Vista, California

We design, invent and deliver the
MOST ADVANCED
AND DIVERSE
range of aerospace systems
- and solutions -
on the market

Propulsion

- Nacelle systems
- EBU's
- Engine Mounts
- Pylons

Non-Propulsion

- Flight control surfaces
- Tailcones
- Doors
- Radomes
- Naval composites

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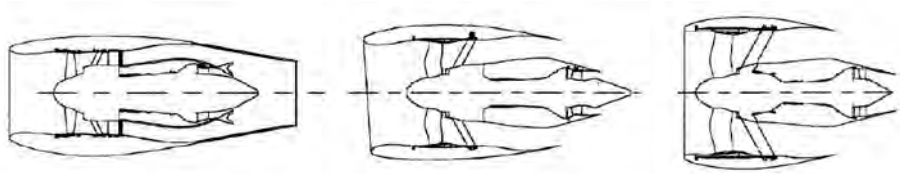
ELEVATOR SPEECH

Aerodynamically and acoustically optimized Inlet and Fan Duct architectures, enabling lower emissions, energy and noise initiatives, aimed at maximizing efficiency of the next generation high bypass ratio propulsion systems for reducing climate impact from aviation.

CASE FOR ACTION



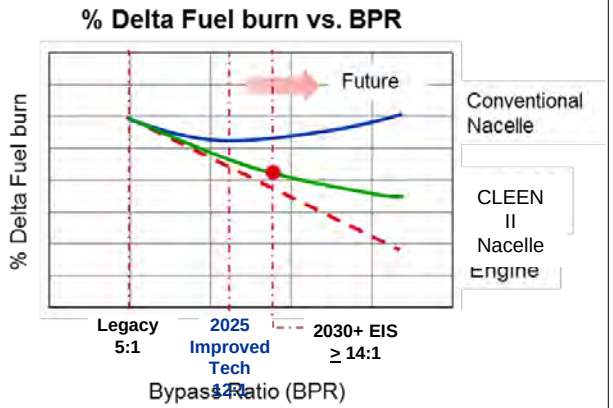
Legacy ~5:1 BPR or less

Improved technology ~12:1
Product Introduction 2025

Next Gen. technology ~15:1+
Entry into Service now 2030+

Collins Aerospace CLEEN II technology scope aligned with 2025 Middle of Market

UHBR: Fuel burn benefit



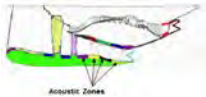
CLEEN II

Clean Fan Duct

Short Inlet

FAA CLEEN II acoustic demo

- ✓ Short Inlet & Clean Fan Duct
- ✓ Novel acoustics
- ✓ Advanced manufacturing
- ✓ Innovative materials



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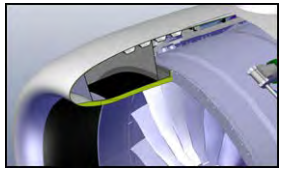
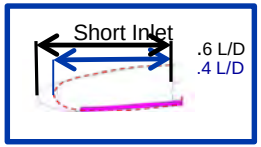
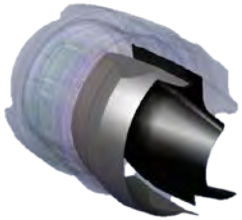
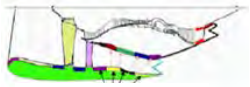
Project Technology

Short Inlet & Clean Fan Duct for HBR Engines









TR Zoned Liner

Anticipated Benefits:

- -1.05% fuel burn
- -2.0 EPNdB noise

Risks/Mitigation Plans:

- Acoustic performance/subscale tests, acoustic optimization models
- Load levels & paths, subscale tests, kinematic & stress model correlation
- Manufacturing tooling and assembly
- Test stand integration/work with P&W

Objectives:

- Achieve TRL6 for Clean Fan Duct acoustics
- Achieve TRL5 for Short Inlet
- Validate anticipated benefits

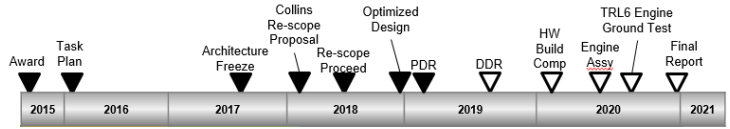
Work Statement:

- Develop ground test demonstrator
- Do subscale acoustic and kinematic tests to validate models
- Perform full-scale engine ground test
- Use test data & analyses to project aircraft-level benefits

Accomplishments:

- Zoned Liner acoustic design optimized and manufacturable
- Test facility availability confirmed
- Acoustic test plan matrix and instrumentation plan finalized
- Bond panel tooling & fixtures received
- All bond panel materials ordered

Schedule:



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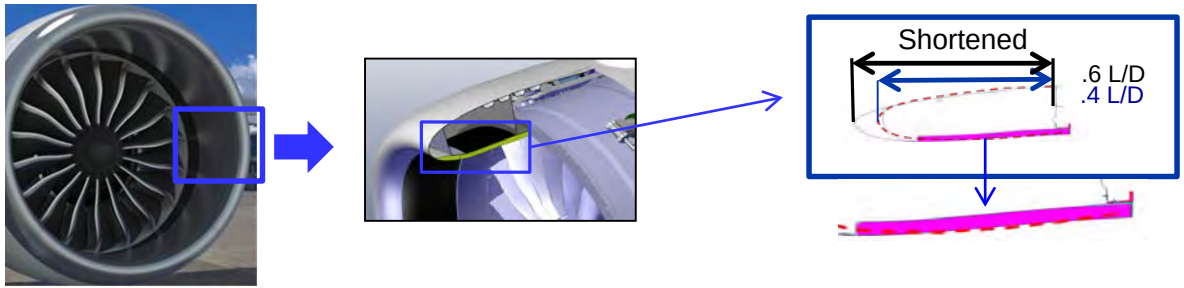
OPPORTUNITY COST

- Fuel burn and noise improvement technologies are important to UTAS future nacelle product competitiveness
- FAA funding:
  - Accelerates progressions of CLEEN II technologies to TRL6/MRL6
  - Supports allocation of IR&D funds to screen and mature more technologies
  - Promotes awareness of FAA CLEEN goals within company
- Possible negative impacts without FAA funding:
  - Delay introduction of these technologies to the commercial fleet
  - Defer introduction of other fuel burn/noise technologies
  - Unable to offer technologies to 2025 opportunities

SHORT INLET TECHNOLOGIES

Technology	Goal Impact	Benefits and Application
Short Inlet	Fuel burn	~0.5% reduction.
Advanced acoustics	Noise reduction	~0.0 EPNdB reduction. (Maintain Acoustics with shorter inlet)

CLEEN II Short Inlet



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TECHNOLOGY RISKS OF SHORT INLET ARCHITECTURE

Challenge:
Inlet innovative core development for shorter nacelle aero lines

Risks:

- Acoustic area limitations due to shorter nacelle aero lines
- Manufacturing methods of new and more effective acoustic treatment
- Test limitations – Validation of short inlet acoustics

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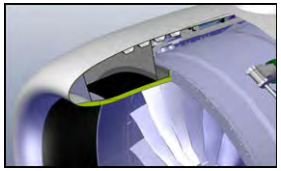
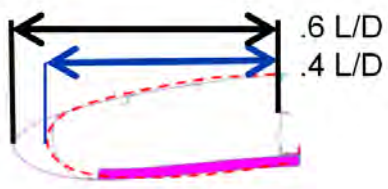
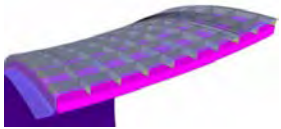
TECHNOLOGY RISK REDUCTION



- Developing **next generation acoustic core**
  - Analysis shows potential to **improve acoustic** performance by developing unique **non-conventional geometries**
  - **Large acoustic cavity** configuration **down-selected**
  - Focused on developing a **cost effect** large acoustic cavity **configuration**





Large Acoustic Cavity

Down selected

Current efforts focused on producibility

TECHNOLOGY RISKS OF SHORT INLET ARCHITECTURE

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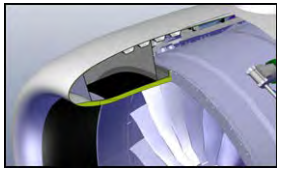
TECHNOLOGY RISK REDUCTION



- **Optimizing the acoustic** solution to **enable implementation**
  - Accessing **innovative industry source** to develop **next generation core** configuration
  - Focused on **developing** a **cost effective / producible solution**

Develop a producible solution to enable implementation

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TECHNOLOGY RISKS OF SHORT INLET ARCHITECTURE

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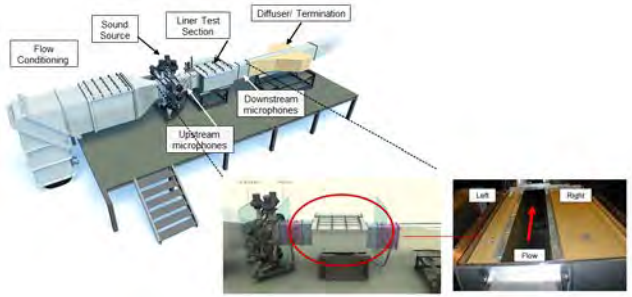
TECHNOLOGY RISK REDUCTION

- Utilize **NASA LaRC CDTR (Curved Duct Test Rig)** followed by **NASA ANCF (Advanced Noise Control Fan)**, operated by the University of Notre Dame Turbomachinery Lab, test facilities to validate acoustics.
- CLEEN II Inlet **CDTR optimization** will be performed on **producible core configuration**
- CLEEN II **Acoustic prediction tools** will be **validated** based on CDTR test

CDTR Test Facility



TRL 4

ANCF Test Facility

TRL 5

Advanced Tailored Acoustic design feasibility verified by test and analysis

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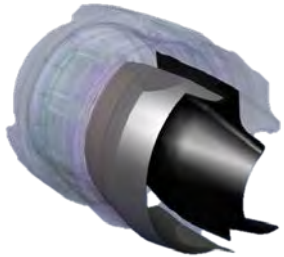
CLEAN FAN DUCT TECHNOLOGIES

Technology	Goal Impact	Benefits and Application
Clean fan duct Thrust Reverser	Fuel burn	~0.5% reduction Demo designed for 25,000-40,000 lb thrust-class engines with expected entry into service by 2025
Advanced tailored acoustics	Noise reduction	~2.0 EPNdB reduction. (Zoned Acoustics & Area Maximization)

Zoned/Thin Acoustics & Area Maximization



Low Drag Surface

Fewer Airflow Obstructions

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TECHNOLOGY RISKS OF CLEAN FAN DUCT T/R

Challenge:
Thrust Reverser design for a maximized acoustic clean fan duct

Risks:

- Acoustic maximization for clean duct aero lines
- Understanding load paths and vibration levels
- Fabrication methods and locations for ground test TR

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TECHNOLOGY RISKS OF CLEAN FAN DUCT T/R

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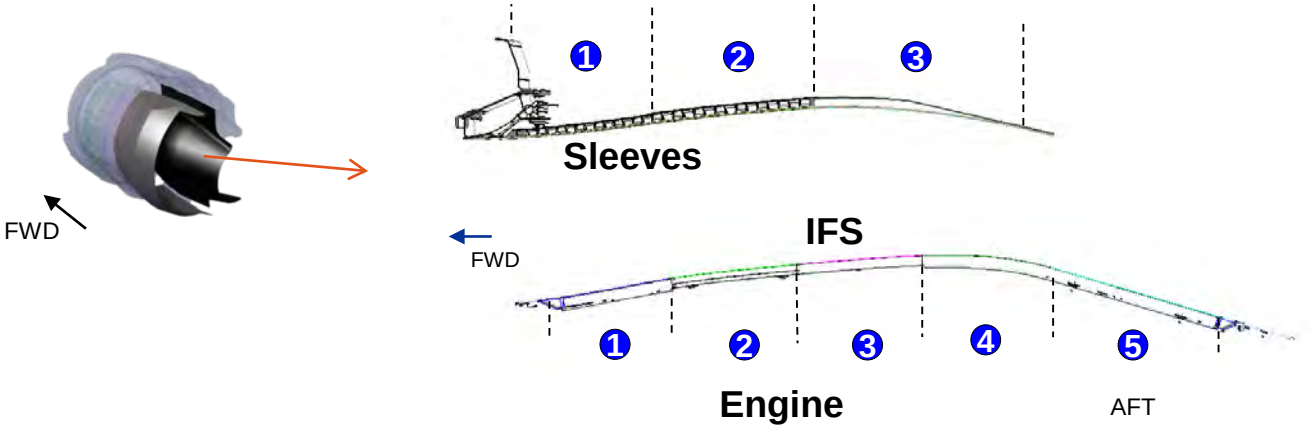
TECHNOLOGY RISK REDUCTION

- CLEEN II clean duct demonstrator design configuration finalized
  - Area maximized and zoned liner optimization complete: 3 zones in Sleeves & 4 acoustic zones + Aft in IFS
  - Low drag liner design integrated into zoned liner



Advanced tailored acoustic design finalized

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TECHNOLOGY RISKS OF CLEAN FAN DUCT T/R

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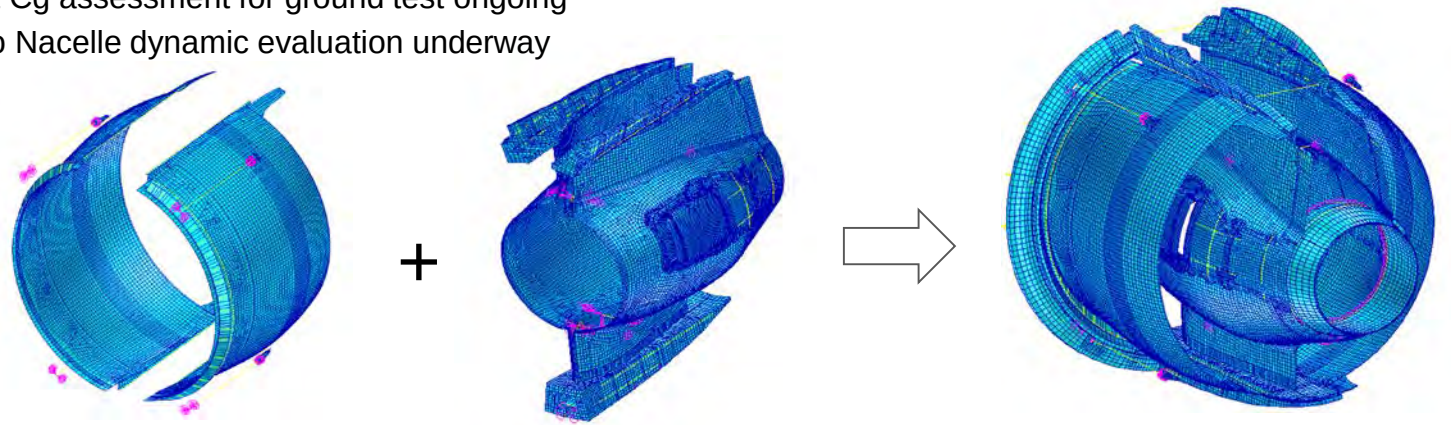
TECHNOLOGY RISK REDUCTION

- Preliminary ground test structural analysis complete
  - Design loads reviewed and approved
  - Analysis complete for major interfaces and bond panels. All margins positive.
  - Preliminary analyses approved by Chief Engineers
- Preliminary design complete
  - Weight & Cg assessment for ground test ongoing
  - Engine to Nacelle dynamic evaluation underway



Preliminary design structural evaluation complete. Acoustic & low drag objectives achievable

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TECHNOLOGY RISKS OF CLEAN FAN DUCT T/R

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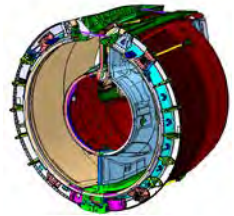
TECHNOLOGY RISK REDUCTION

- Tooling for bond panel fabrication on site in Riverside, CA facility
  - Supports 2019 & 2020 build schedule
- Bond panel and Thrust Reverser fabrication process finalized
  - XLS & IFS Bond panel fabrication in Riverside, California
  - Thrust Reverser assembly in Foley, Alabama

Riverside, CA

Foley, AL



Fabrication plans in place to support 2020 ground test

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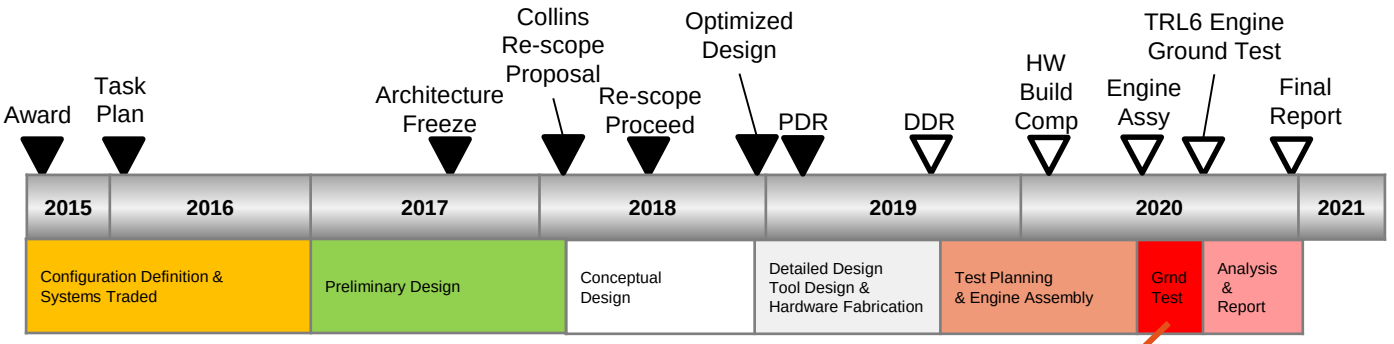
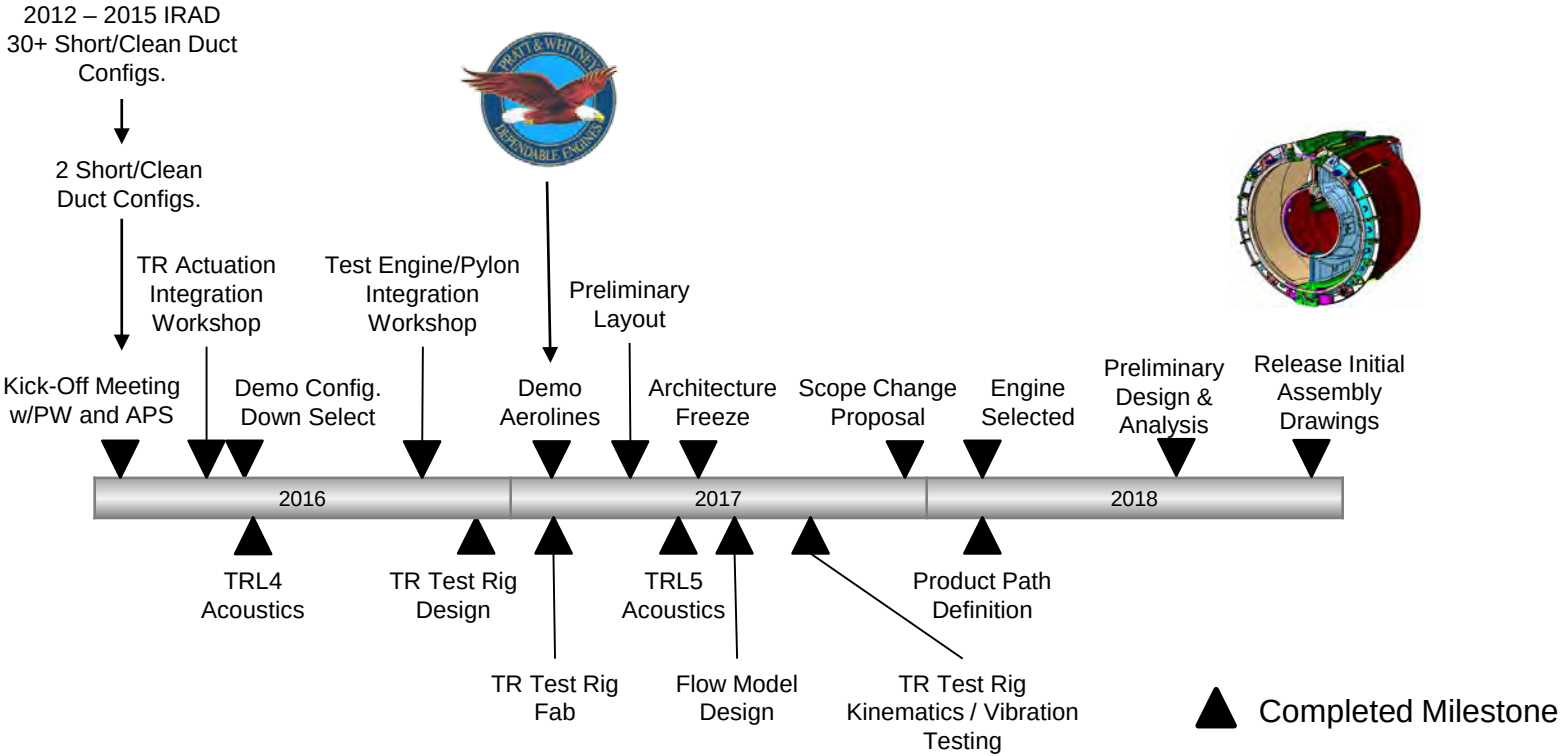
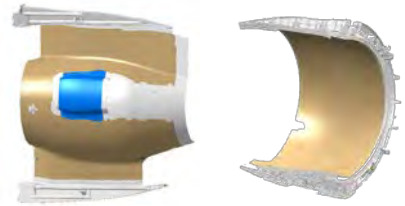
PROJECT SCHEDULE

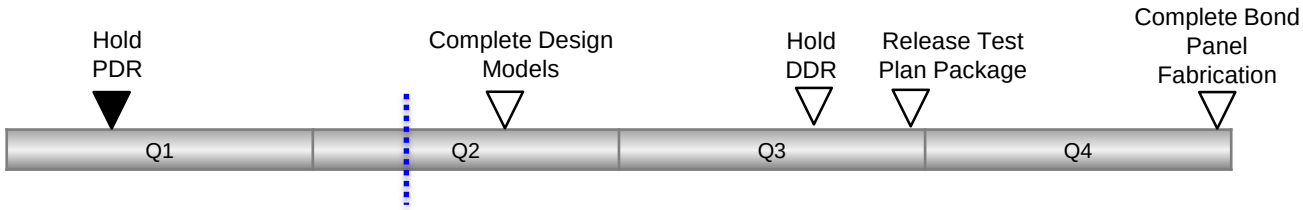


PAST ACHIEVEMENTS



2019 PLANS





▲ Completed Milestone △ Planned Milestone

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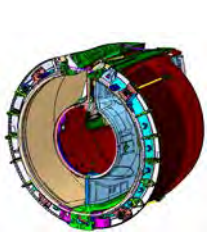
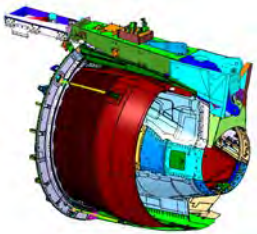
FUTURE PLANS (2020)





CLEEN II GT TR Assembly Complete

Engine Assembly Complete

TRL 6 Engine Ground Test

Final Report

Q1 | Q2 | Q3 | Q4

TRL 4 CDTR (Short Inlet)

TRL 5 ANCF (Short Inlet)

▲ Completed Milestone △ Planned Milestone

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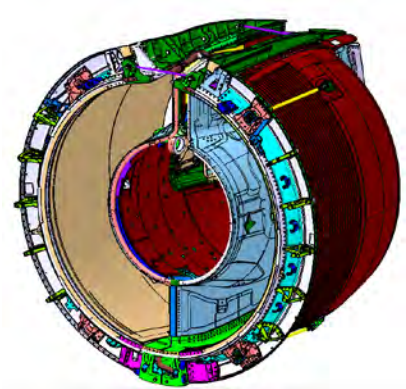
SUMMARY

- Efforts target maximizing efficiency of 2025 high bypass ratio propulsion systems
- Technologies align with next generation single aisle, new midsize, and middle of the market aircraft
- Architectures support CLEEN II lower energy and noise initiatives
- Selected technologies applicable for performance insertion on current production programs
- Ground Test demonstrator preliminary design & analyses complete and PDR successfully passed. Fabrication process mapping complete. Final design releases are in progress with DDR scheduled for August 2019.

THANKS!

Any Questions?



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