COLLINS AEROSPACE

COMMERCIAL AIRCRAFT TECHNOLOGY DEMONSTRATOR

CLEEN II CONSORTIUM PUBLIC PLENARY SESSION

OCTOBER 28, 2020

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ECCN: NSR, CLS12708108

Collins Aerospace

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OUTLINE

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

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COMPANY OVERVIEW

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Raytheon Technologies

The future of aerospace and defense

Raytheon Technologies Proprietary

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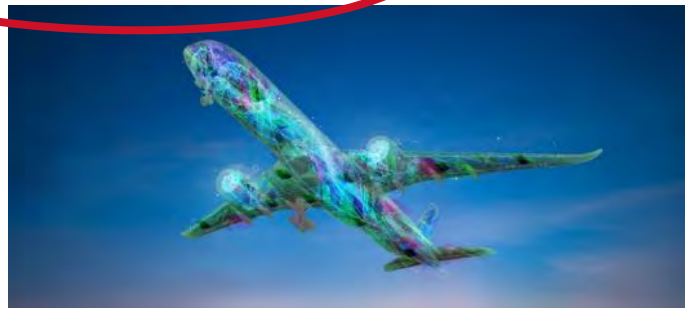
Raytheon Technologies

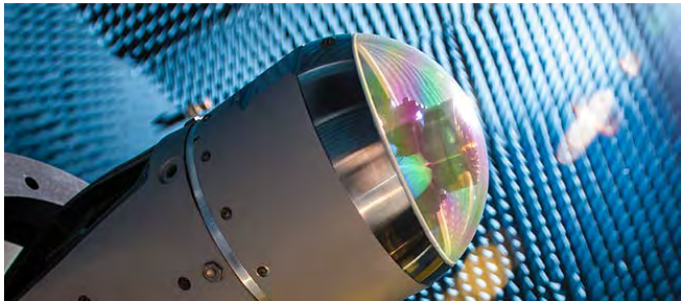
Collins Aerospace



Pratt & Whitney

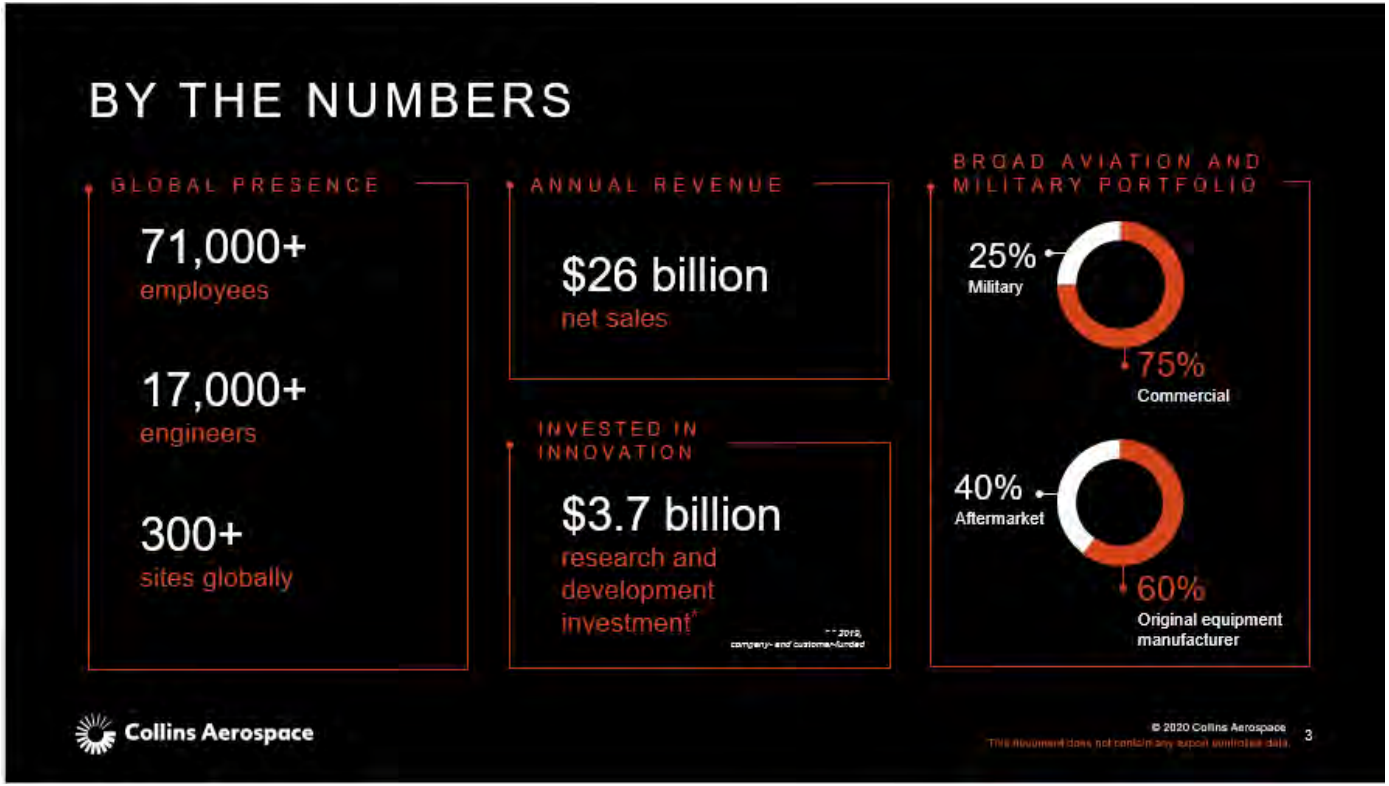
Raytheon Intelligence & Space

Raytheon Missiles & Defense



About Collins Aerospace

A leader in technologically advanced, intelligent solutions that help to redefine the aerospace and defense industry



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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STRATEGIC BUSINESS UNITS

Formed to meet customer needs and represent the best in innovation, technology and expertise

Aerostructures

Avionics

Interiors

Mechanical Systems

Mission Systems

Power & Controls

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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
- EBUs
- Engine mounts
- Pylons

Non-Propulsion

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

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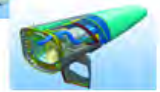
COLLINS AEROSPACE – AEROSTRUCTURES

Key Products and Systems

Nacelle systems

Pylons and fairings

Tailcones



Key Platforms

Airbus Family / A320neo

A350 XWB

Boeing 737NG Family

Boeing 787 Dreamliner

Dessault BizJet

Airbus A220

MRJ

Embraer 170/190

Embraer 175E2/190E2/195E2

Collins Aerospace – Aerostructures

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

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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.

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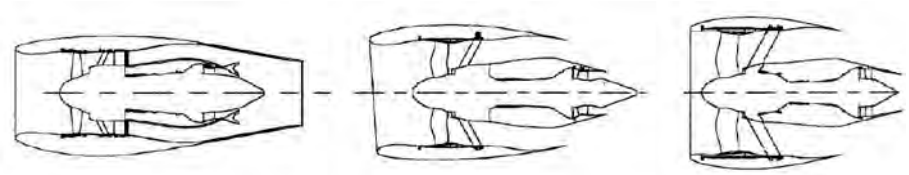
CASE FOR ACTION



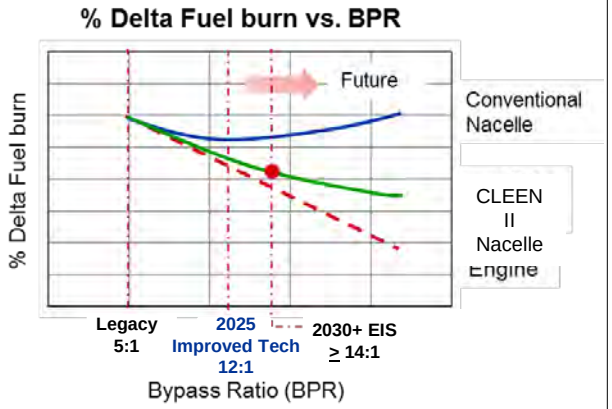
Legacy ~5:1 BPR or less

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



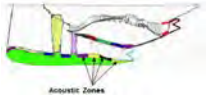
CLEEN II

Short Inlet

Clean Fan Duct

FAA CLEEN II acoustic demo

- ✓ Short Inlet & Clean Fan Duct
- ✓ Novel Acoustics
- ✓ Advanced Manufacturing
- ✓ Innovative Materials



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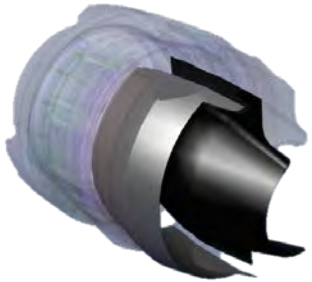
PROGRAM SUMMARY

BENEFITS



CLEEN II Short Inlet

No Increase

- 0.5%

CLEEN II Clean Fan Duct

-2.0 EPNdB

- 0.55%

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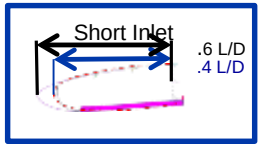
TECHNOLOGIES – SHORT INLET

Short Inlet



Anticipated Benefits:

- -0.5% fuel burn

Risks/Mitigations:

- Perforations requirements to produce attenuation may not be well understood
  - Develop perforation model
- Scale-up fabrication issues may not be well understood
  - Perform experimentation on large-scale equipment
- COVID-19 impact on schedule delay

Objectives:

- Develop and demonstrate a low-cost, structural bond panel with DDOF acoustic performance

Work Statement:

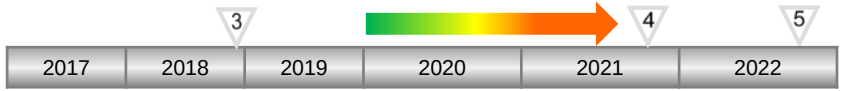
- Develop concepts & down-select technologies
- Test prototypes to confirm attenuation
- Confirm producibility & cost
- Test fabricated panels in relevant environment

Progress Update:

- Design concepts developed (Complete)
- Initial prototypes fabricated (Complete)
- Efforts stopped for 2020 will restart in 2021

TRL Schedule:

- COVID-19 Impact
- Collins Aerospace will continue efforts outside CLEEN II



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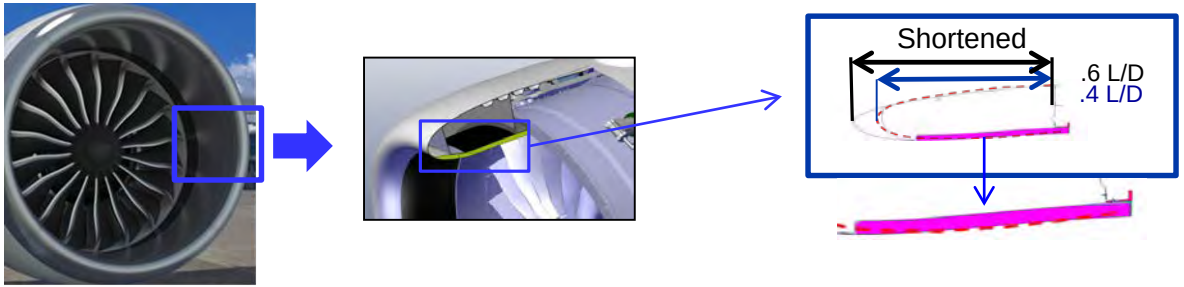
SHORT INLET TECHNOLOGIES

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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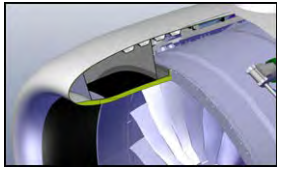
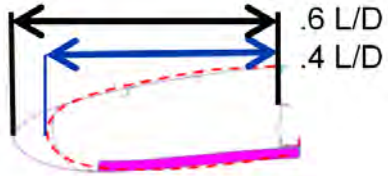
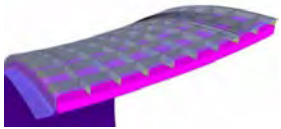
TECHNOLOGY RISK REDUCTION



- Developing **next-generation acoustic core**
  - **Improve acoustic** performance through unique **non-conventional geometries**
  - **Large acoustic cell** configuration **in development**
  - **Producible/Cost-effective** large acoustic cavity **configuration**





Large Acoustic Cell Concepts In Work
IP Sensitive

Producible design concepts for acoustic testing “On Hold” until 2021

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TECHNOLOGY RISKS OF SHORT INLET ARCHITECTURE

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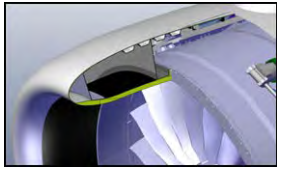

- **Optimizing the acoustic** solution to **enable implementation**
  - **Innovative industry source and Collins next-generation core** collaboration underway
  - **Cost-effective / producible solution** concepts identified
  - **Next-generation design prototypes** on hold until 2021

Collins Aerospace Intellectual Property Sensitive

Collaboration initiated in 2020. Design concepts identified & initial prototypes created. On hold until 2021.

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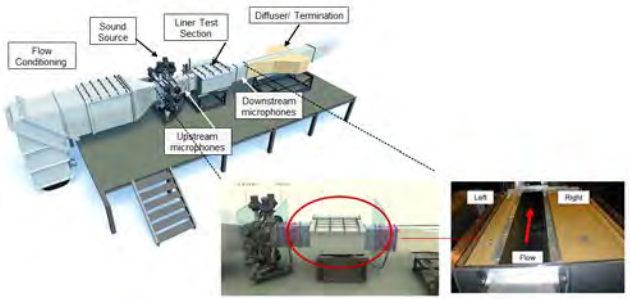
TECHNOLOGY RISK REDUCTION

- 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 **Acoustic prediction tools** will be **validated** based on CDTR test
- **CDTR core design optimization** initiated but now on hold
- **Short Inlet efforts** will resume in 2021

CDTR Test Facility



TRL 4

ANCF Test Facility

TRL 5

Advanced tailored acoustic design feasibility will be verified by test and analysis to resume in 2021

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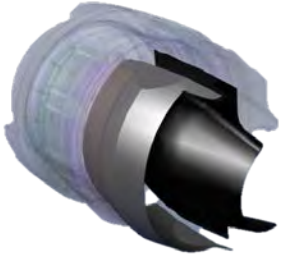
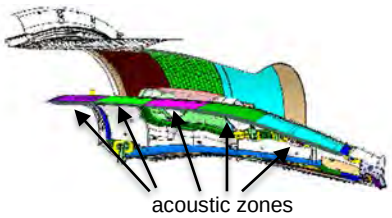
Acoustic Ground Test Clean Fan Duct for HBR Engines





Anticipated Benefits:

- -2.0 EPNdB noise

Risks/Mitigation Plans:

- Acoustic performance/subscale tests, acoustic optimization models
- Manufacturing tooling and assembly
- Test stand integration/work with P&W
- COVID-19 impact on ground test postponement

Objectives:

- Achieve TRL6 for Clean Fan Duct acoustics
- Validate anticipated benefits

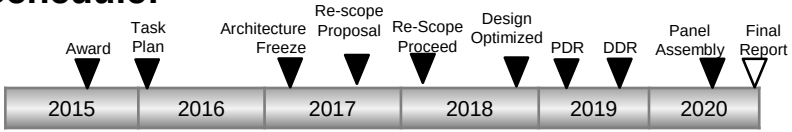
Work Statement:

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

Progress Update:

- Ground test TR passed DDR in Sep ’19
- IFS RH bond panel fabrication complete
- TRL6 achieved for two technologies
- All other builds on hold including ground test
- Contract extended 3 months to Dec 2020
- Final Report in work

Schedule:



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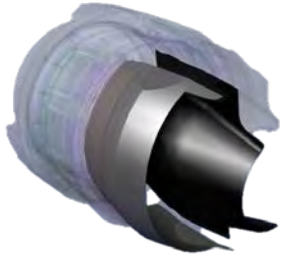
CLEAN FAN DUCT TECHNOLOGIES

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
- Design verification and validation
- CLEEN II fabrication, contract closure, and reassess in the future

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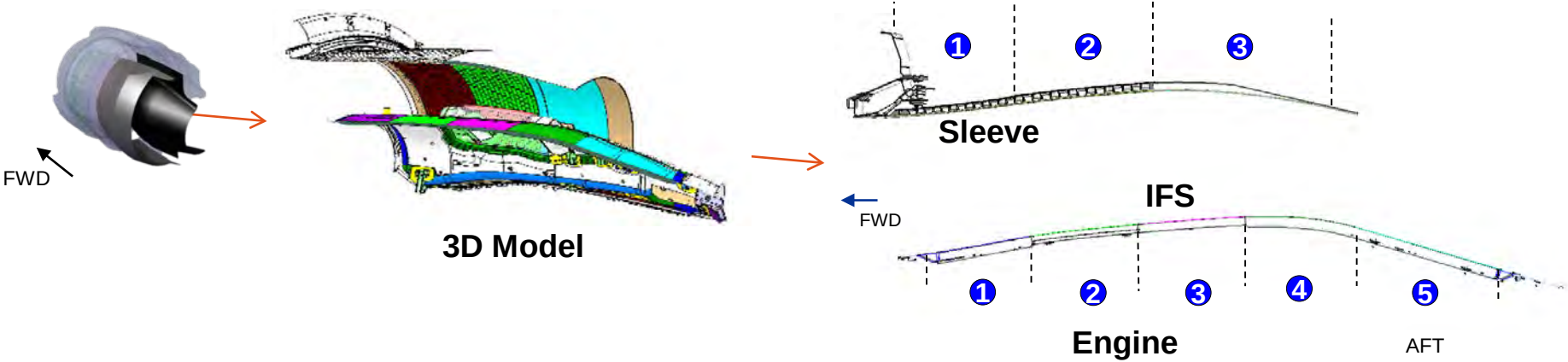
TECHNOLOGY RISK REDUCTION

- CLEEN II clean duct demonstrator on hold
  - 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
  - Right Hand Inner Fixed Structure (RH IFS) fabrication complete. All other builds on hold.



Advanced tailored acoustic design fully released. RH IFS build complete. All other builds on hold.

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TECHNOLOGY RISKS OF CLEAN FAN DUCT T/R

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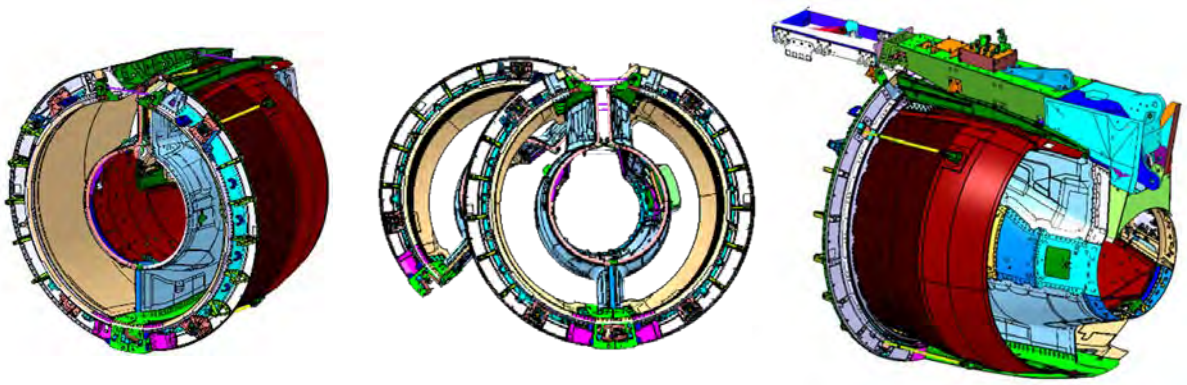
TECHNOLOGY RISK REDUCTION

Bond Panel design complete

- All drawings released
- IFS and XLS skin perforations complete
- IFS RH bond panel fabrication complete

Technology Readiness

- Low Drag & Acoustic Zoned Liner
  - Incorporated into production program
- TRL 6 achieved Q1 2020



Design fully released; Low Drag & Acoustic Zoned Liner technology used in production

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TECHNOLOGY RISKS OF CLEAN FAN DUCT T/R

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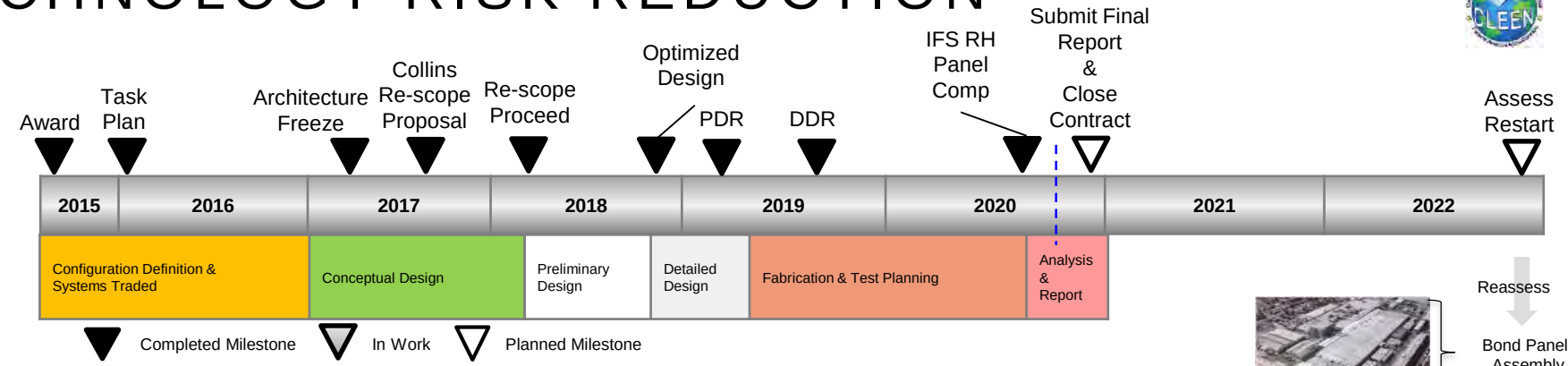

Riverside, CA

Foley, AL

West Palm Beach, FL

Reassess

Bond Panel Assembly

Refresh

Thrust Reverser Assembly

Renew

Ground Test

- ➢ COVID-19 Impact
  - Delays need for Technology 2-3 years
  - Collins extends CLEEN II contract 3 months
- ➢ Contract Closure Key Activities:
  - Hardware
    - ✓ IFS RH Bond Panel Manual Perforation and Repair
    - ✓ IFS RH Bond Panel POA & Impedance Test
    - ✓ Secured storage of
      - ✓ IFS LH, XLS LH & RH bond panel components
      - ✓ IFS RH bond panel
  - Report
    - o Document results in a final report Dec 2020

Significant benefits will be documented with continuation plans into the future

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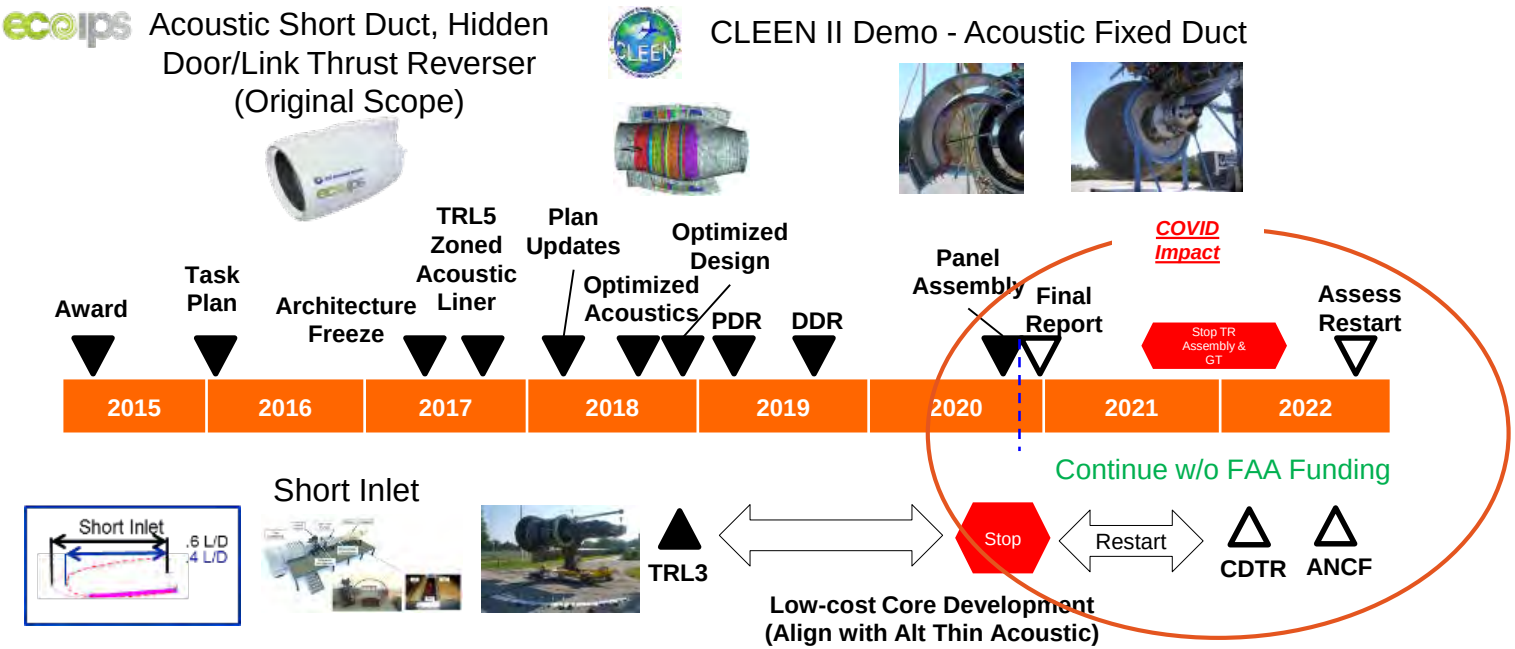
PROJECT SCHEDULE

NO CHANGE IN ACOUSTIC TECHNOLOGY SCOPE INTO THE FUTURE



Collins Aerospace will continue to develop technology to close TRL/MRL gap

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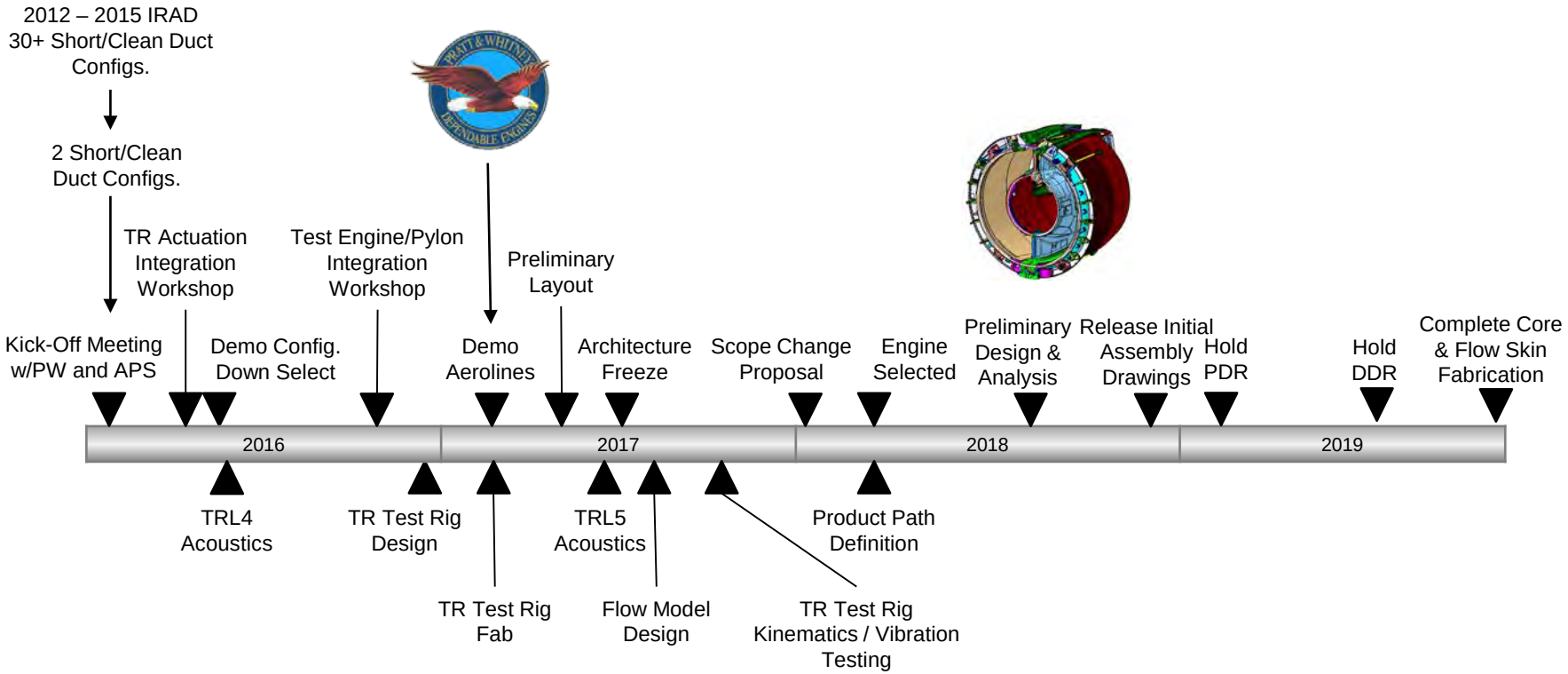
PAST ACHIEVEMENTS



Completed Milestone

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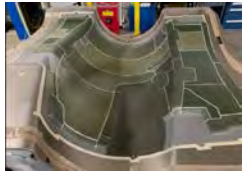
POST-COVID-19 PLAN (2020)



FAA CLEEN II Consortium

FAA CLEEN II Consortium

Description	1 ‘20	2 ‘20	3 ‘20	4’ 20	5’ 20	6 ‘20	7’ 20	8 ‘20	9 ‘20	10 ‘20	11 ‘20	12 ‘20
Key Milestones		▲ XLS Skin Perf	▲ LDL/AZL Production Implementation		▲ IFS LH Skin Re-Perf	▲ IFS RH Cores	▲ IFS RH Bond Panel Cure	▲ NDI		▲ Impedance Test	△ Acoustic Analysis	△ Final Report to FAA

▲ Completed Milestone △ Planned Milestone

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SUMMARY

- Efforts target maximizing efficiency of 2025 high bypass ratio propulsion systems
- Architectures supports CLEEN II lower energy and noise initiatives
- Technologies align with
  - Next-generation single aisle, new midsize, and middle of the market aircraft
- Low Drag and Acoustic Zoned Liner
  - Technologies inserted on current production program achieving TRL 6
- IFS RH bond panel fabricated and impedance test complete as of October 2020
- Due to COVID-19 impact
  - CLEEN II program at Collins Aerospace will end in December 2020
  - Proposed ground test will be reassessed in 2022

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THANKS!

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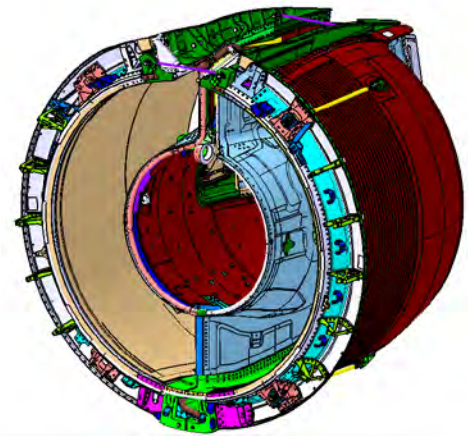

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