OUTLINE

UTC/UTC Aerospace Systems company overview
Power plant system and historical trends
Next generation integrated propulsion system (IPS)
CLEEN II IPS thrust reverser demonstrator
Summary
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

2015 net sales of $56B
2,000,000
of our components in the air at any given time

1,500
Operators have

24/7 support to keep 70,000 aircraft flying

8 Business Units

42,000 People

150 Locations

26 Countries
UTC AEROSPACE SYSTEMS

Business Units

Actuation & Propeller Systems
Aerostructures
Electric Systems
Engine & Environmental Control Systems
Interiors
ISR & Space Systems
Landing Systems
Sensors & Integrated Systems
UTC AEROSPACE SYSTEMS

An Industry Leader: 50+ Years with 50+ Nacelle Programs

AEROSTRUCTURES NACELLE DESIGN HIGHLIGHTS

Early Engineering (20 Years)

- First Commercial Nacelle Components: Entered Service in 1958
- First Aircraft Major Structural Program: Retired from Service in 2006
- Design Assist to Boeing: Being Phased Out Since 1984
- First Dedicated Business Jet to Enter Service
- Opened Pylon Opportunities
- First Dedicated Business Jet to Enter Service

Major Expansion of Engineering (30 Years)

- First Aircraft Narrow Body Complete Nacelle
- First Boeing Narrow Body Complete Nacelle
- First Airbus Widebody Complete Nacelle
- First Boeing Widebody Complete Nacelle
- First Airbus Widebody Complete Nacelle
- First Geared Turbo Fan - Commercial Nacelles

- Sold Bizjet business to Nordam 1994
- Most Recent Pylon Program

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Aerostructures

Key Products and Systems

- Nacelle systems
- Pylons and fairings
- Tailcones

Key Platforms

- A320 Family / A320neo
- A350 XWB
- Boeing 737NG Family
- Boeing 787 Dreamliner
- Bombardier CSeries
- MRJ
- Embraer 170/190
- Embraer 175E2/190E2/195E2

UTC Aerospace Systems is a 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.
POWER PLANT SYSTEM (PPS) OVERVIEW

Elements of a legacy PPS

Nacelle provides:

Smooth aerodynamic airflow

Reverse thrust stopping force

Acoustic systems to reduce engine noise

Protection of key engine and aircraft systems
Reverse thrust efficiency trends

As bypass ratio, fan diameter and base drag increase for a given thrust, stopping force required from the thrust reverser can be reduced.
HISTORICAL TRENDS IN NACELLE WEIGHT

Nacelle weight increase with fan diameter, historical data from the 70s
HISTORICAL TRENDS IN ENGINE NOISE SOURCE

Aft fan noise becomes a dominant noise source for very high bypass ratio engine

* Source provided by Pratt & Whitney to NASA Acoustic Technical Working Group
Technology improvements have enabled a dramatic reduction of noise emissions to meet more stringent standards.

First Generation HBPR Turbofans (70s)

Second Generation HBPR Turbofans (80s)

Third Generation HBPR Turbofans (00s)
GREEN INNOVATIONS

Increasing Bypass Ratio

Mitsubishi MRJ
Airbus A350 XWB
Bombardier CSeries
Embraer E2
Airbus A320neo

360° spliceless acoustic inlet liner

1-4 dB forward fan

Reduced materials of concern use compared to legacy designs

![Graph showing Total Chromate Compounds over years from 2015 to 2019, with a 5x decrease in new designs compared to legacy designs.]
TECHNOLOGY DEMONSTRATORS

QTD2 inlet demonstrator
- 360° seamless acoustic inner barrel
- Main landing gear noise fairings
- Acoustic inlet lip
- Electric icing tunnel tests

GTF VAFN demonstrator
- Variable area fan nozzle
- Resin film infused fan cowl

FAA CLEEN II T/R demonstrator
- Short, clean fan duct
- Tailored acoustics
- Advanced manufacturing
- Innovative materials

Technology demonstrators and collaboration key to maturing technologies
THE NEXT GENERATION

Ultra high bypass ratio (UHBR) engines

It is more efficient to move a large amount of air slowly than it is to move a small amount of air quickly

Next generation engines achieve this by:

- Increasing fan diameters and bypass ratios (fan flow : core flow)
- Decreasing fan pressure ratios (out of fan : into fan)

Low fan pressure ratio places a premium on nacelle drag

UHBR drives increased nacelle size, weight and drag
ULTRA HIGH BYPASS RATIO

Future technology solutions

UHBR: Fuel burn benefit

% Delta Fuel burn vs. BPR

- Legacy 5:1
- Current 12:1
- Bypass Ratio (BPR)
- Future
- Conventional Nacelle
- ecoIPS Nacelle
- Engine

Weight and drag of increasingly larger conventional nacelle offsets performance benefit of lower fan pressure ratio

Inlet/fan cowl (Fanlet)

Novel thrust reverser architecture (FAA CLEEN II demonstrator)

- Variable area fan nozzle
- Hybrid laminar flow
- Tailored acoustics
- Advanced manufacturing
- Innovative materials

UTC Aerospace Systems
THRUST REVERSER TECHNOLOGIES

CLEEN II demonstrator – key to advance

<table>
<thead>
<tr>
<th>Technology</th>
<th>Benefit</th>
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<tr>
<td>Short, integrated fan duct thrust</td>
<td>~1.0% fuel burn reduction</td>
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<tr>
<td>reverser</td>
<td></td>
</tr>
<tr>
<td>Advanced acoustics</td>
<td>~2.5 EPNdB noise reduction*</td>
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* to offset short fan duct

Legacy Thrust Reverser Fan Duct
CLEEN II Thrust Reverser Fan Duct
GREEN INITIATIVES

Performance
- Fuel burn reduction
- Noise reduction

Materials of concern
- Design for the environment
- Alternate materials
- recyclability

Industrialization
- Reduced emissions
- Reduced greenhouse gases
- Reduced industrial process waste
CLEEN II SCHEDULE

Thrust reverser demonstration on P&W GTF Engine

Major Program Milestones

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
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<tbody>
<tr>
<td>2015</td>
<td>Award</td>
</tr>
<tr>
<td>2016</td>
<td>Task Plan</td>
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<tr>
<td>2017</td>
<td>PDR</td>
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<tr>
<td>2018</td>
<td>DDR</td>
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<tr>
<td>2019</td>
<td>TRL 6 -Engine Ground Test</td>
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<tr>
<td>2020</td>
<td>Final Test Report</td>
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THRUST REVERSER DEMO

Summary

Supports CLEEN II lower energy and noise initiatives

Maximizes efficiency of next generation PPS

Integrated thrust reverser to be matured to TRL6

Selected technologies applicable to the current fleet