UTC Aerospace Systems

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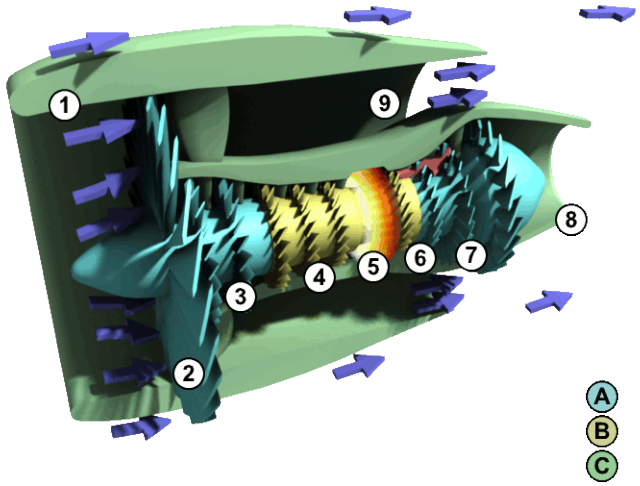
Aerostructures Overview

March 1, 2013



This is UTC Aerospace Systems

July 2012 – United Technologies formed UTC Aerospace Systems

UTC Aerospace Systems

40,000 employees

2 business segments

14 strategic business units

180 locations

Delighting customers

- Aircraft Systems
- Power, Controls & Sensing Systems

Global, 24/7 service
Game-changing technologies
Perfect delivery and quality
Right attitude

Customer Service

Simplified customer interface

Worldwide Customer Service

- 24/7, 365 days a year AOG / Technical Support
- Over 6,000 Customer Service employees
- Global MRO network, 64 sites

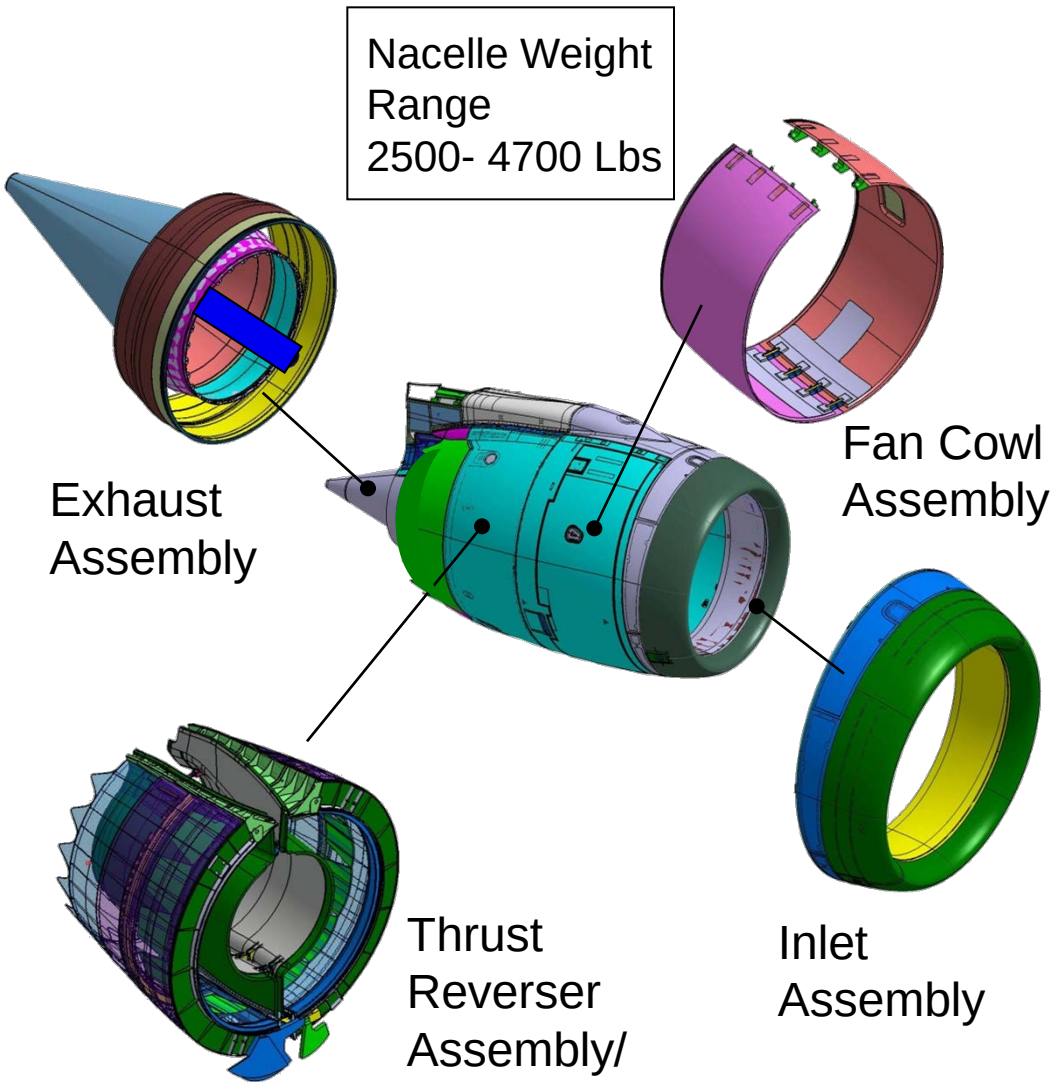
Business segment teams drive consistent:

- Spares and repair performance
- Product support and issue resolution

Strategic investments
Advanced products
Technology leadership

Driving innovation

NACELLE COMPONENT OVERVIEW



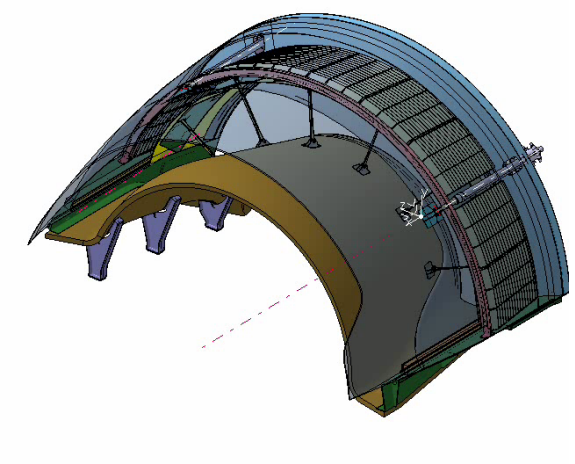
Nacelle Utilizes:

- Advanced Light Weight Complex Composite & Metallic Material Systems
- Advanced Design and Analysis Techniques
- Load Sharing to Reduce Engine Weight

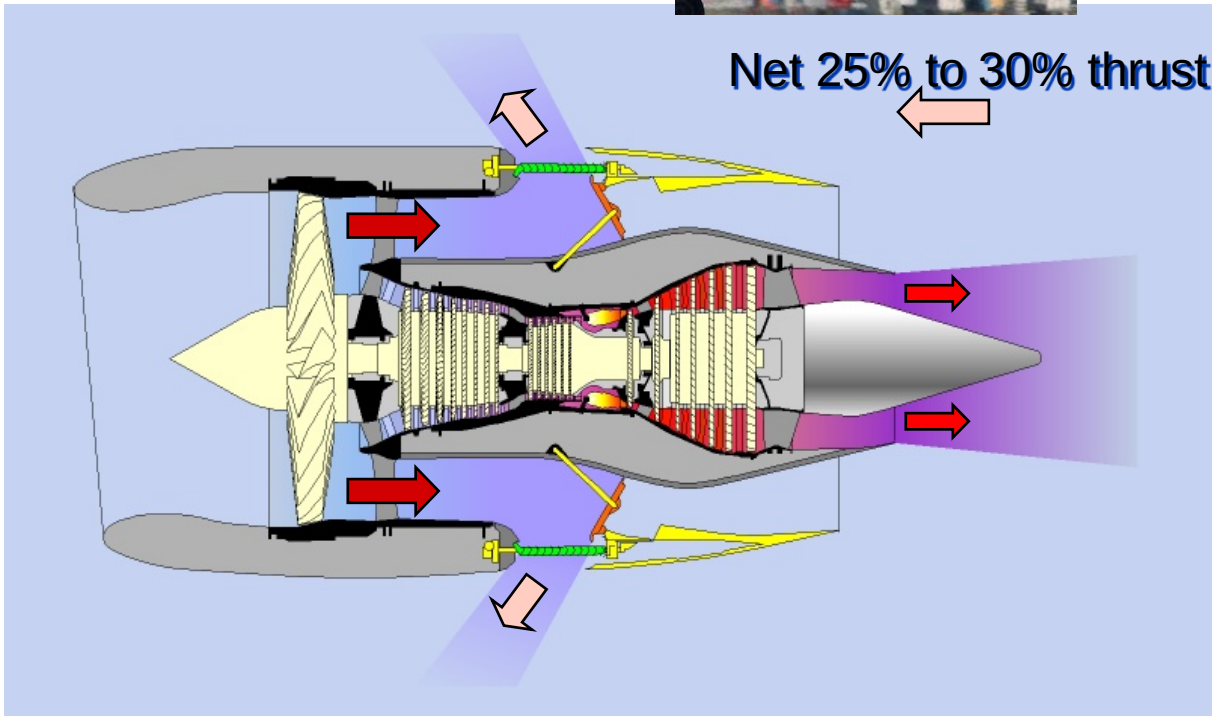
Nacelle Provides:

- Smooth Aerodynamic Airflow & Reverse Thrust A/C Stopping Force
- Major Acoustic Systems to Reduce Engine Noise
- Protection of Key Engine and Aircraft Systems

NACELLE CASCADE THRUST REVERSER



Nacelle Thrust Reverser is responsible for safe stopping of the aircraft in normal landings, rejected takeoffs or aborted landings

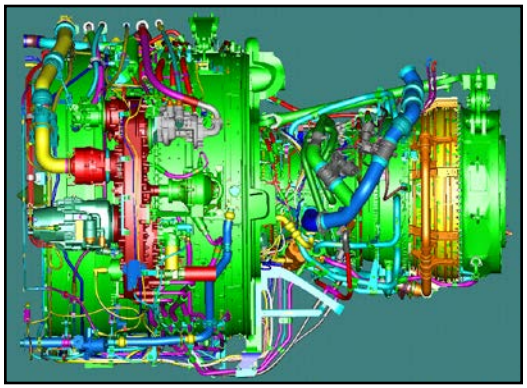


Nacelle Must be Fully Functional for Over 60,000 Flight Cycles and 20 Years of Operation

NACELLE INTEGRATION WITH ENGINE SYSTEMS

Access to Core & Fan Systems

EBU Installation



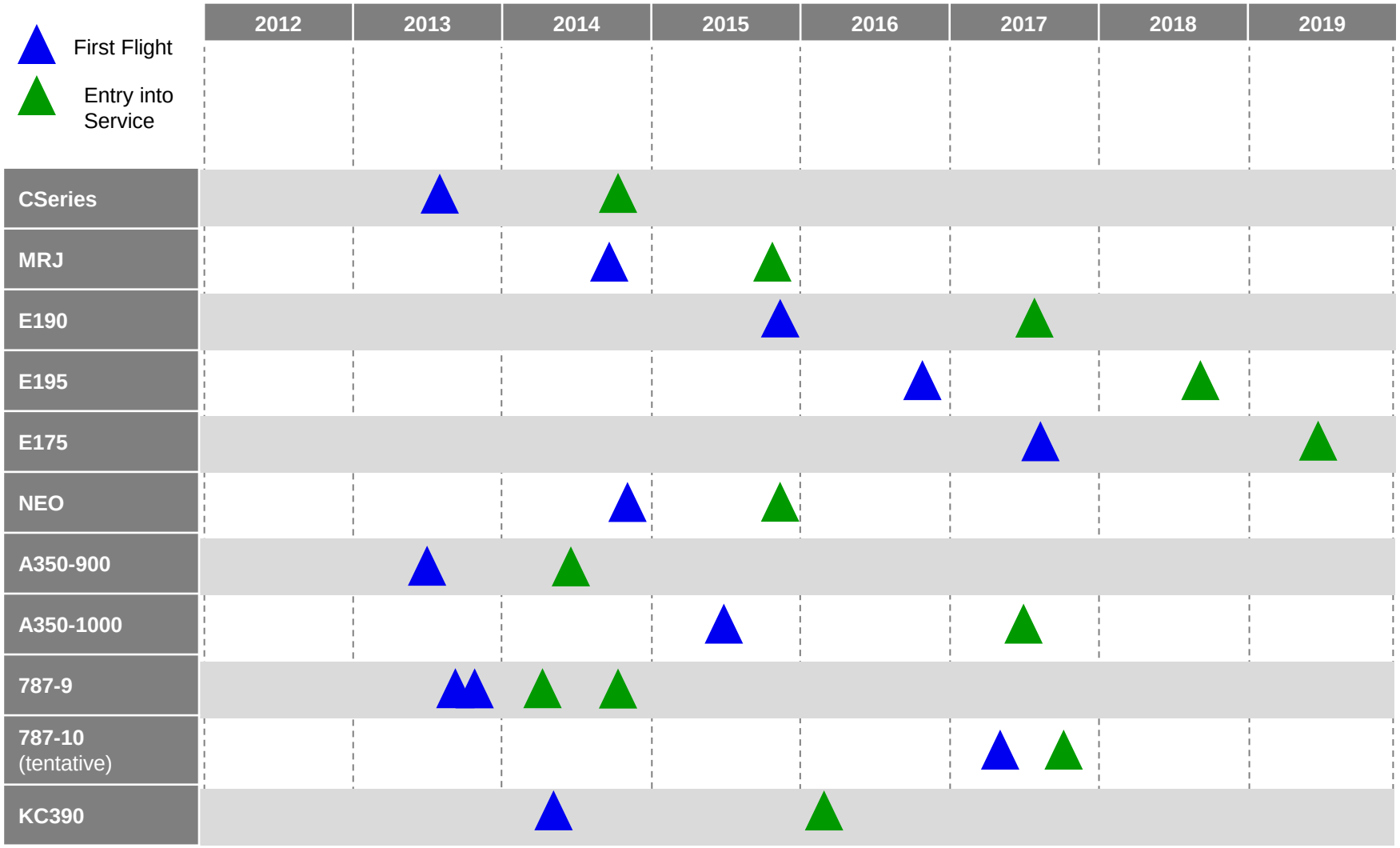
Typical EBU Installation

Typical Systems Provided:

- Hydraulic System
- Thermal Anti-Ice System
- Cabin Bleed
- ECS Valve Sense Lines
- Starter Systems
- Fuel System

Nacelle Integrates Engine and Components Into the Airframe

AEROSTRUCTURES KEY MILESTONES

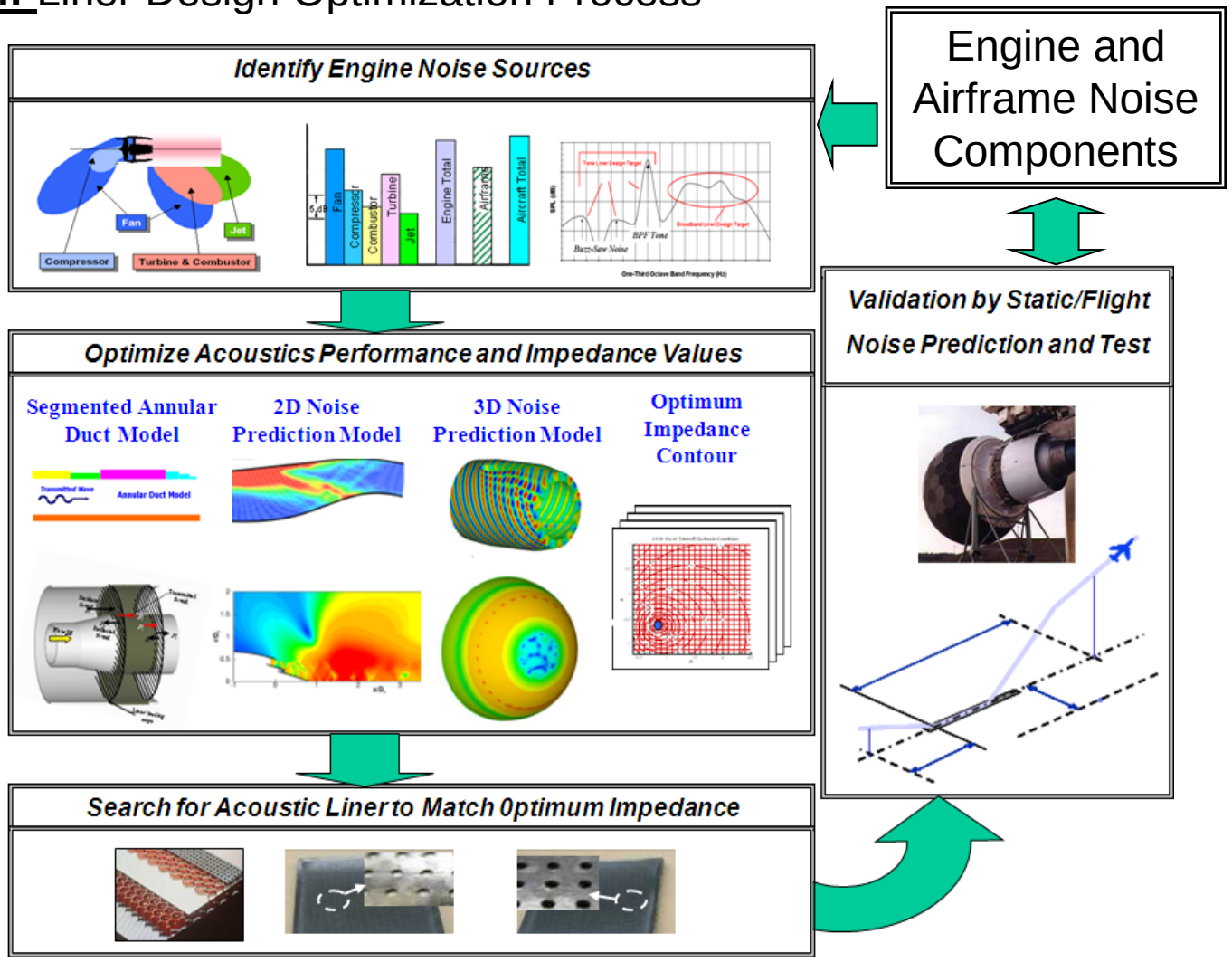


First flights every year through 2017

Acoustics

Goal: To design acoustic treatment that meets noise regulatory metrics.

Approach: Liner Design Optimization Process

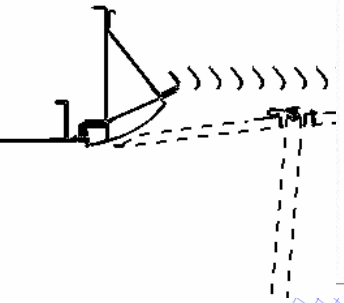


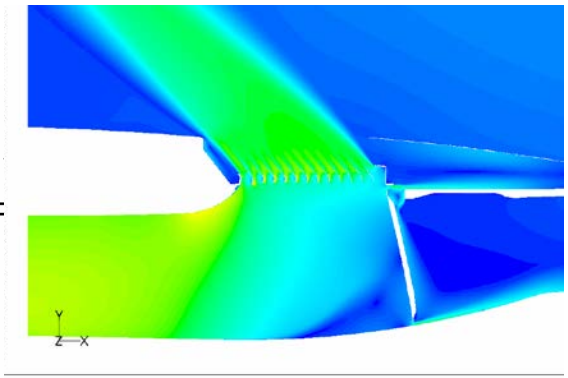
Aerodynamics

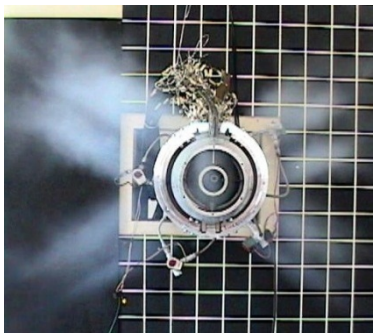
Goal: To assess performance of the nacelle and to design an aerodynamically efficient thrust reverser

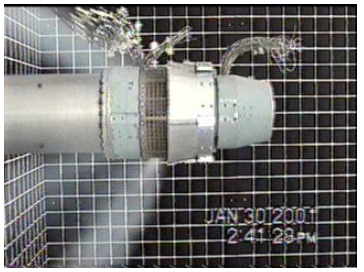
Approach:

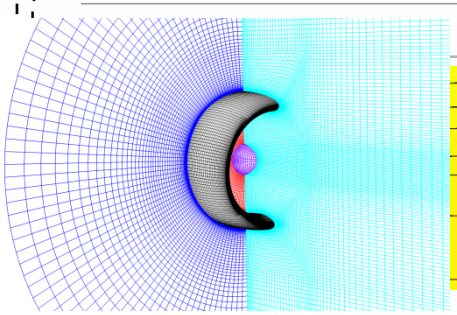
- Calculation based on empirical aerodynamic data for initial stages of design and to assess potential losses
- CFD (computational fluid dynamics) to assess and narrow down new designs
- Flow test and component wind tunnel tests to validate designs

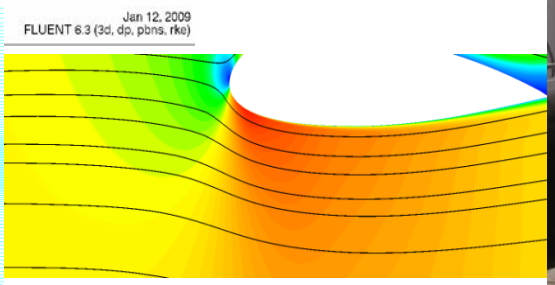


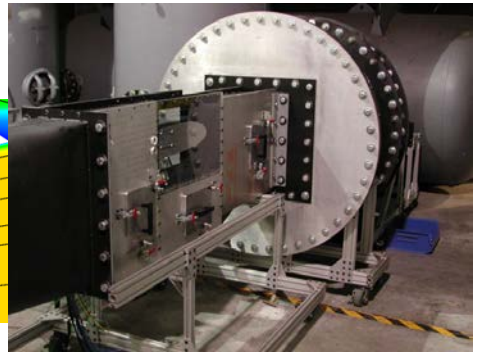




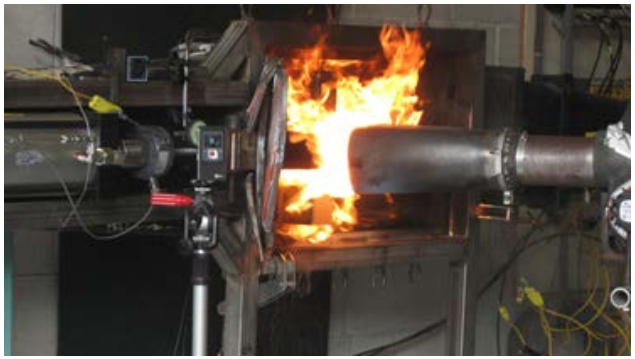


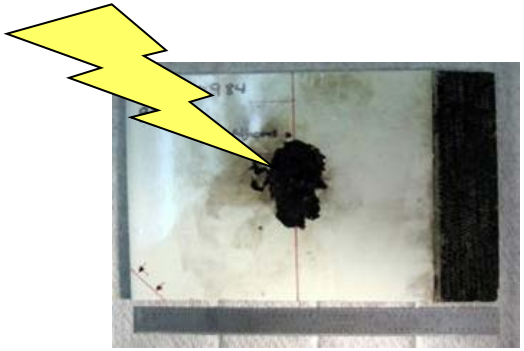






Fire and Lightning-Strike Test Models





Project Goal:

- Multi-physics simulations of fire and lightning strike tests
- Thermal, electric, structural, chemical, acoustic damage modes

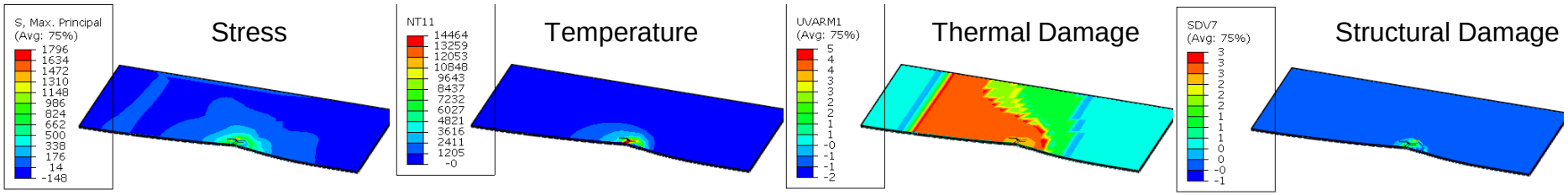
Benefits

- Reduce articles and testing required for certification (~50%)
- Incorporate fire and lightning requirements early in design cycle
- Quick screening tool for evaluating new materials systems

Approach

- Sub-scale testing to characterize thermal and structural loads due to fire and lightning events, and resulting damage to metals and composites
- CFD/FEA coupled models of sub-scale tests to develop/verify physics
- Model validation with full-scale tests

RESULTS

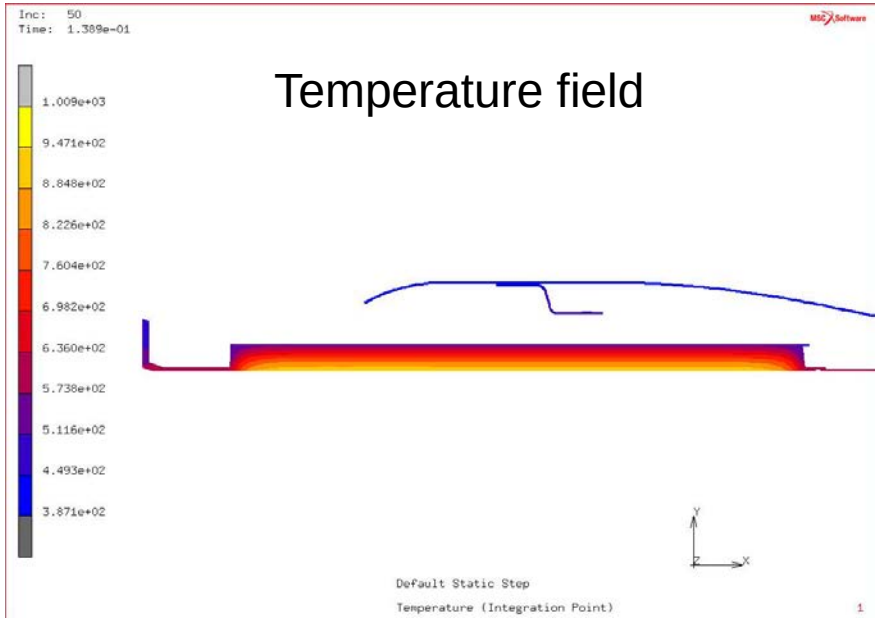


Structures

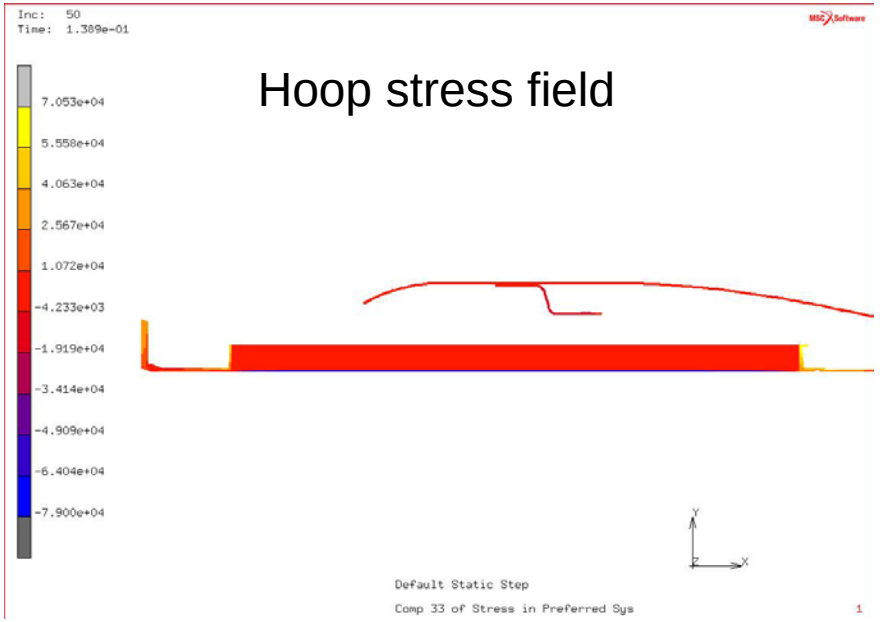
Goal: To assess nozzle structures under thermal and pressure loading

Approach:

- Calculations require inter-disciplinary cooperation (Thermal and Structural Engineers)
- Thermal analysis and structural analysis performed simultaneously for faster turnaround
- Thermal transients with radiation and creep analysis are computationally intensive
- Temperature transients produce complex stress fields requiring time history analysis
- Stresses peak at different times though out the structure due to thermal lags
- Axi-Symmetric models are used to quickly develop a feasible design



Temperature field



Hoop stress field

SUMMARY

R&D Vision - Adding business value through Creativity in Products, Processes & Procedures

Industry expects the right balance between perfection and “just good enough”

Certify the nacelle by analysis, verified by test

Technical experience is necessary but not sufficient for success in Engineering, “soft” skills are required

Nacelles and Thrust Reversers are technically sophisticated structures and systems

SUMMARY

Nacelles and Thrust Reversers are technically sophisticated structures and systems, typically comprising 5%-7% of aircraft value