Adapting Analysis Tools to Engine Externals Analysis

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ADAPTING ANALYSIS TOOLS TO ENGINE EXTERNALS ANALYSIS

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ABSTRACT

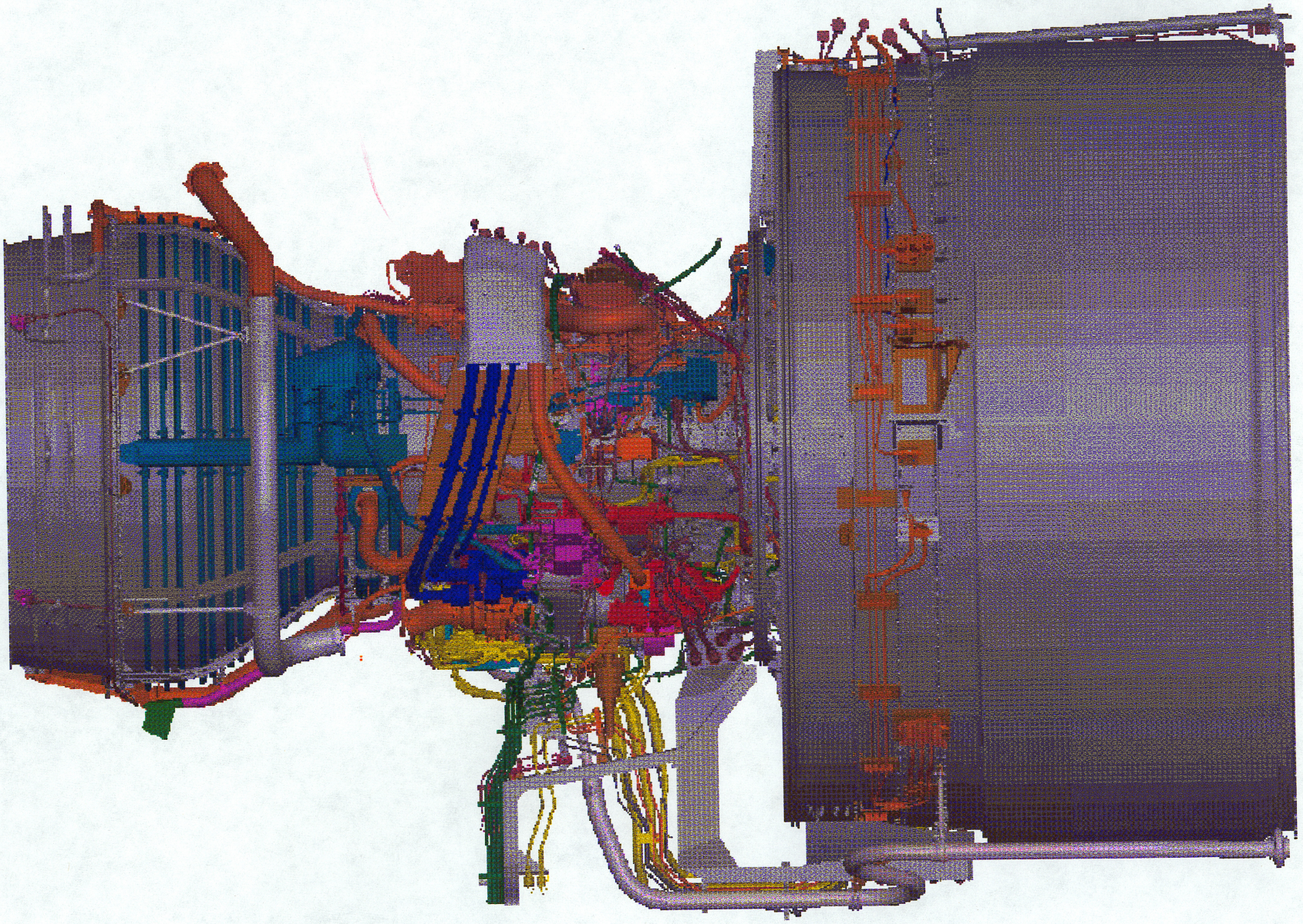
Market forces are driving industry to reduce product cycle time (the time required to conceive, design, build, test, validate and deliver a product). Application of existing tools in new areas can reduce the time required to design a new product and increase the confidence of acceptable test results later in the expensive testing and validation phase. Finite element methods, computational fluid dynamics codes and sharing of CAD datasets when applied to the design of engine externals can provide methods for product improvement and expedited delivery to the customer.

Engine Externals Provide

- Engine
  - Fuel
  - Lubrication
  - Control
  - Cooling
- Airplane
  - Pneumatic power
  - Electrical power
  - Hydarualic power

- Flight Deck Indication
  - Primary thrust setting parameter
  - Secondary engine parameters
  - Warnings to flight crew
  - Indications of propulsion health

PW4084 (with externals, cowlings removed)



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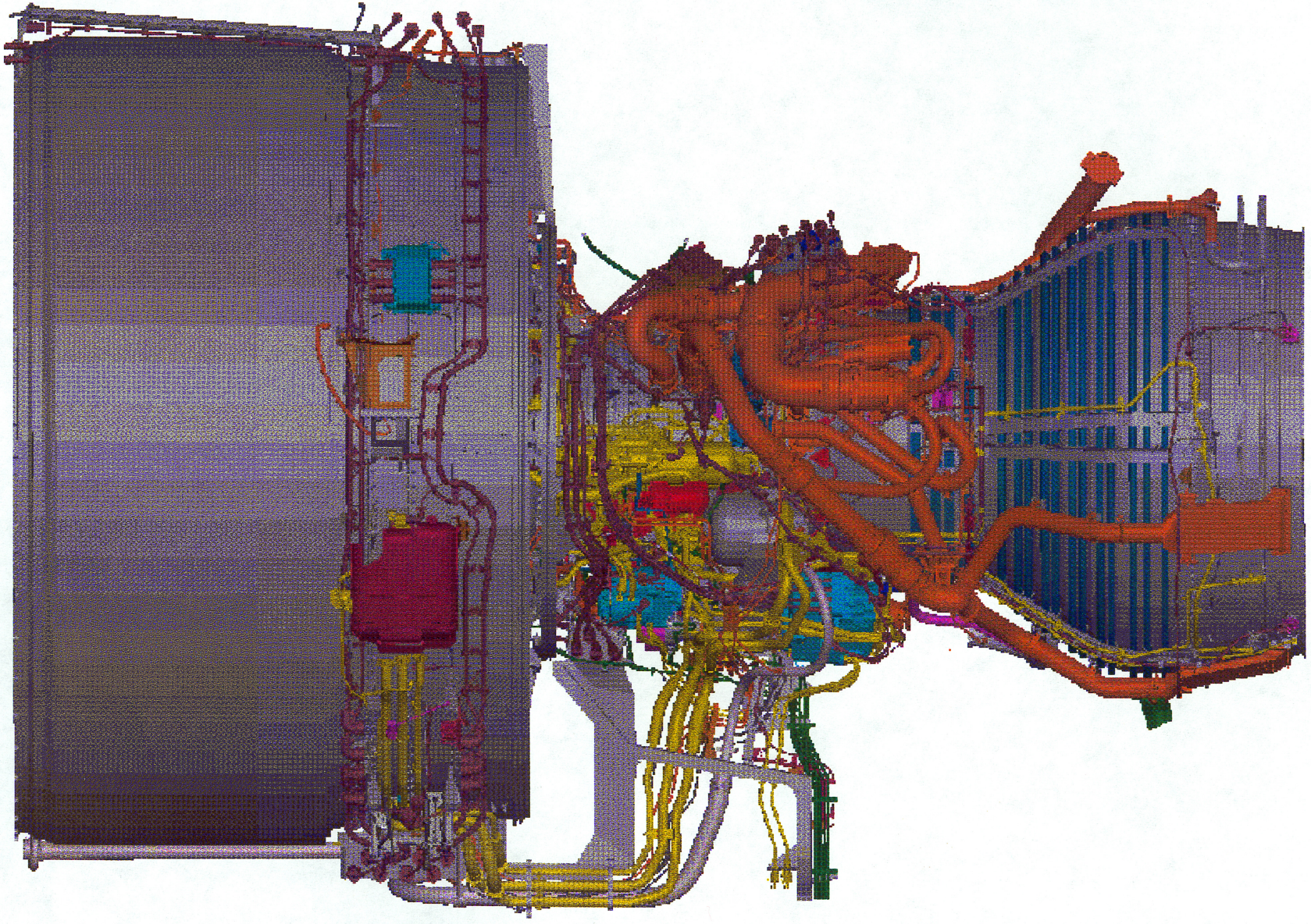
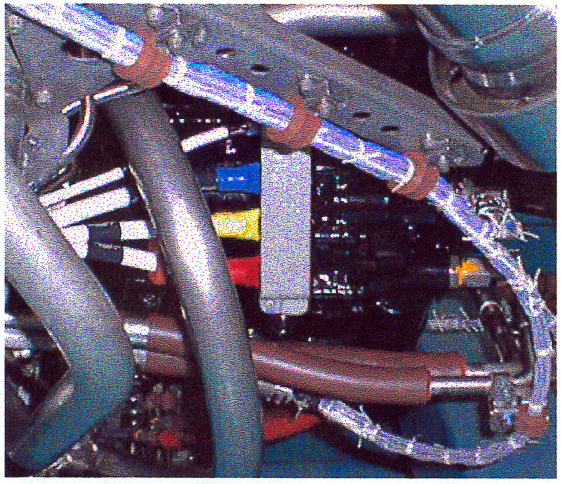


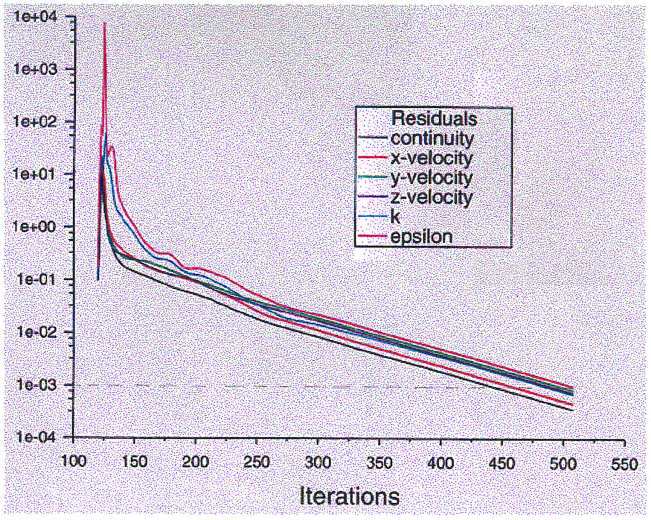
Types of engine externals analysis

- Straight forward problem solutions available for
  - Heat exchanger sizing
  - Oil cooling system performance
  - Fuel system performance
  - Pneumatic duct sizing
  - Pressure losses in ducting
  - Cooling system inlet recovery
- No straight forward problem solution available for
  - Prediction of undercowl ambient temperatures
  - Prediction of undercowl fire extinguishing agent concentration
  - Bulb seal performance

Previous reasons for not pursuing analysis

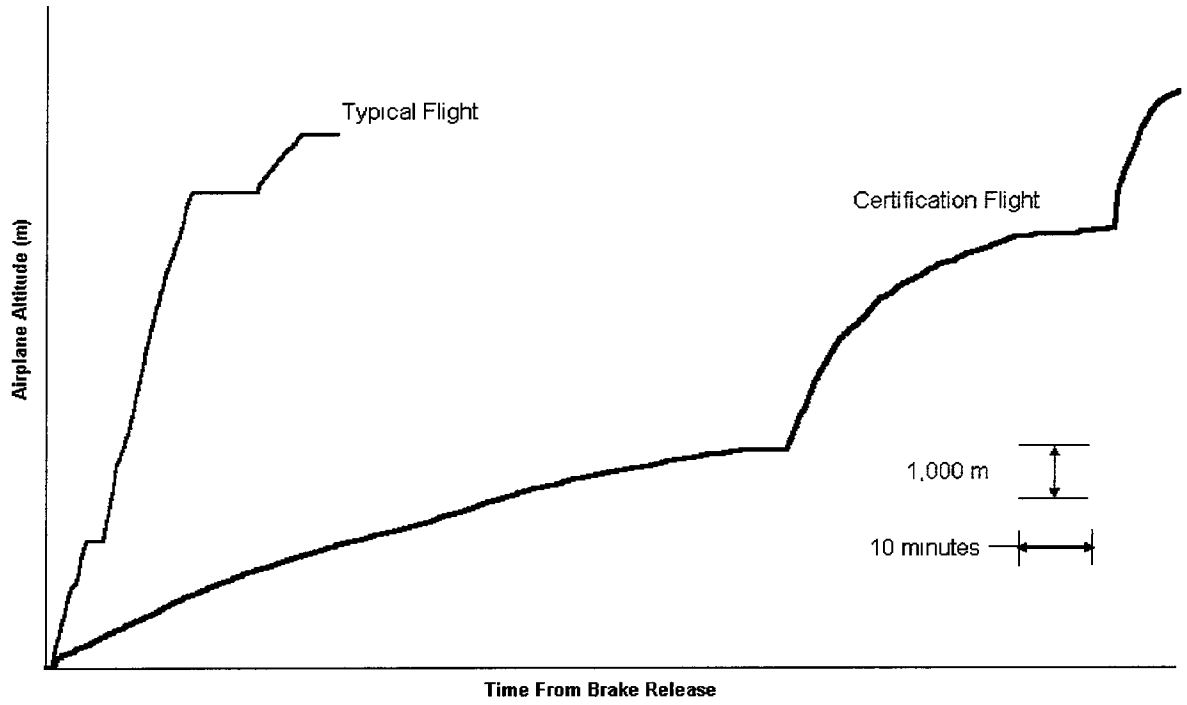
- Complex geometry unavailable to analysis software
- Lack of user friendly software
- Cost of computing (including speed)





Undercowl ambient temperatures - Requirement

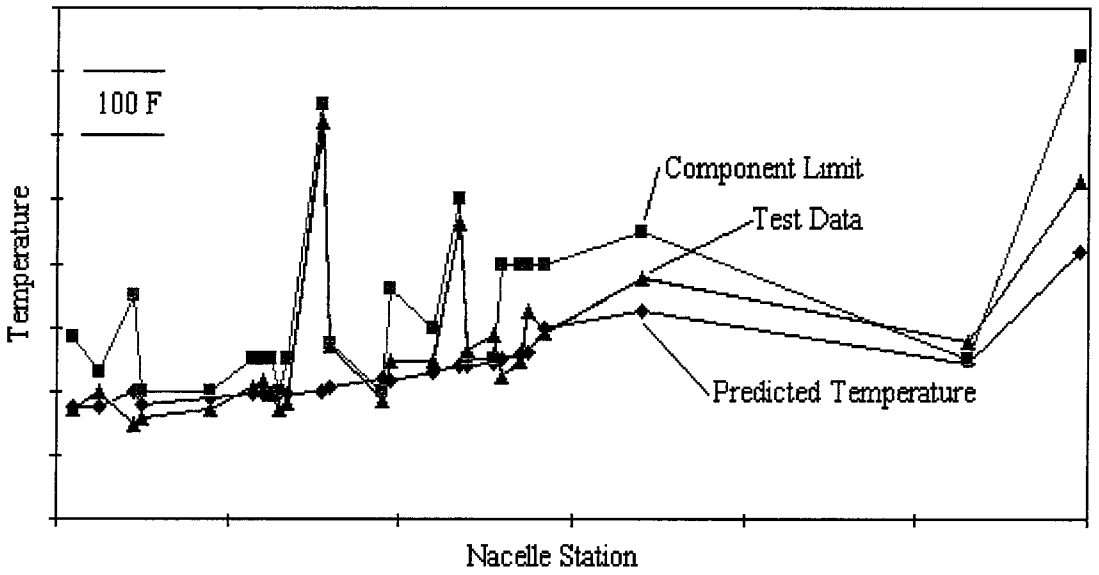
- FAA requires demonstration of cooling system performance, successful test results show that all component temperatures remain within their temperature limits during worst case airplane operating conditions.



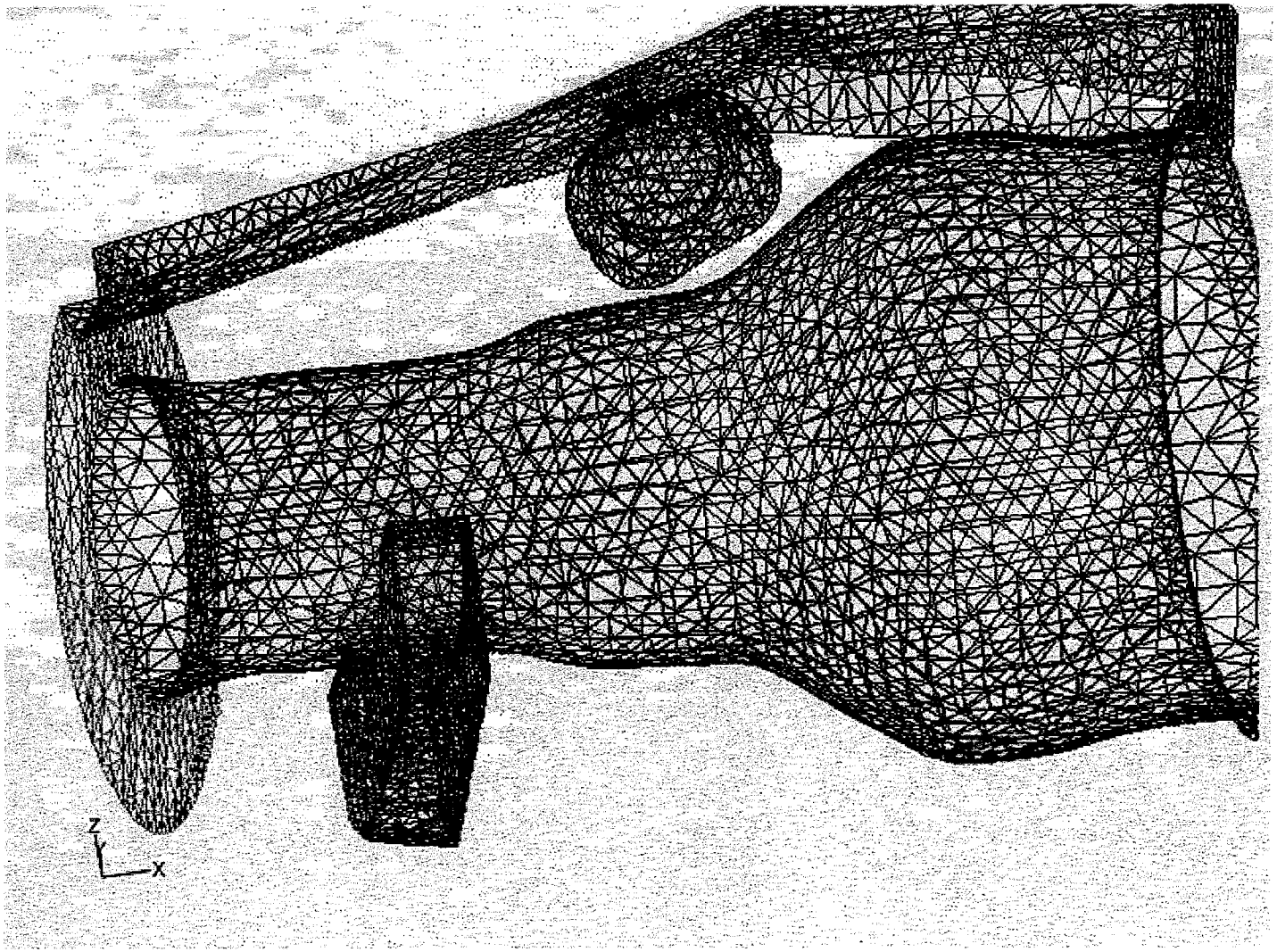
Undercowl ambient temperatures - Current Approach

- Simplistic analysis followed by test (and retest)
  - Analysis assumptions
    - One dimension analysis
    - Uniform mixing of flows
  - Hardware revisions by test (and retest)
    - Schedule disruptions
    - Increased cost

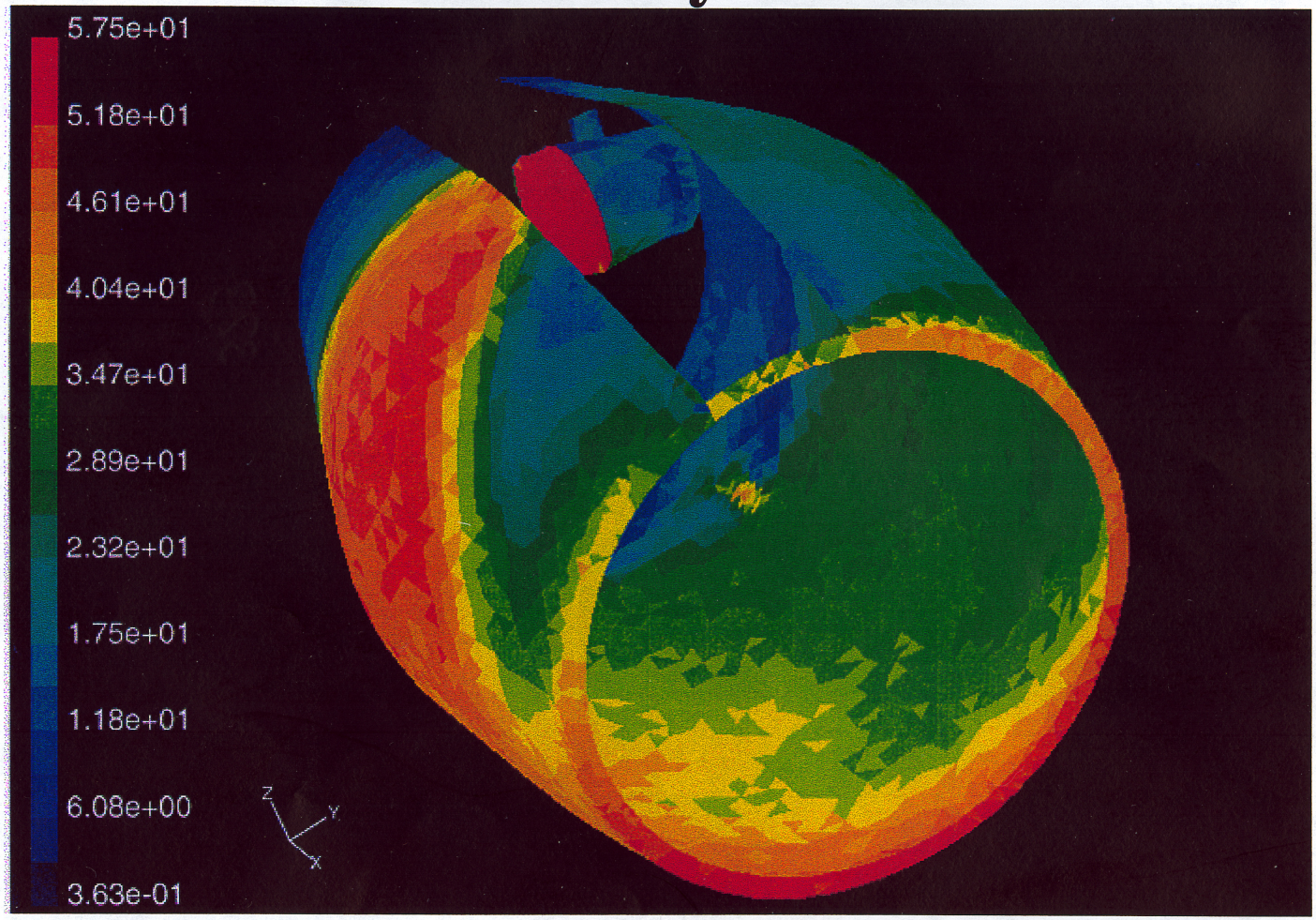
- It costs time and money, but it can be made to work



Undercowl ambient temperatures - Simplified Geometry



Undercowl ambient temperatures - Preliminary Results



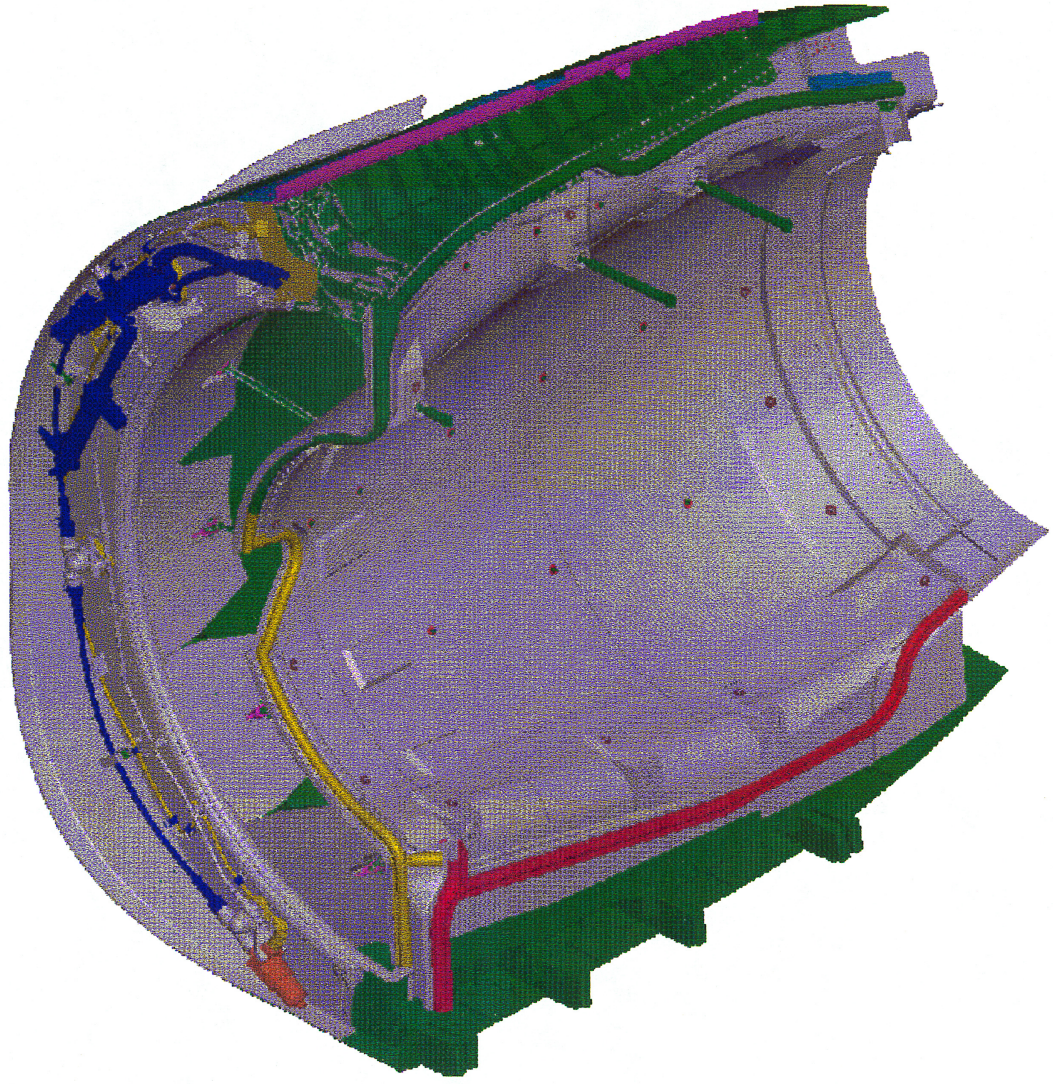
Undercowl ambient temperatures - Preliminary Results

Undercowl ambient temperatures - Proposed Approach

- CFD analysis to determine airflow patterns and temperatures
- Status:
  - First stage of geometry definition complete
  - Major air sources identified and included in model
  - Preliminary adiabatic solution complete
- Future efforts
  - Refine geometry
  - Include engine case heat

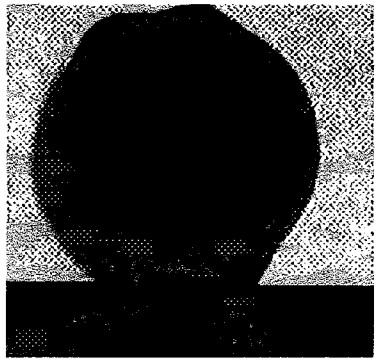
Bulb seal performance - Requirement

- FAA requires demonstration that no “hazardous quantity” of fluid pass between areas of the nacelle designated as fire zones.



Bulb seal performance - Current Approach

- Boeing uses fireproof, elastomeric bulb seals to provide barriers between fire zones



- Main design concerns
  - Required geometry
  - Ease of manufacture
  - Design standards for seal compression

Bulb seal performance - Test Results

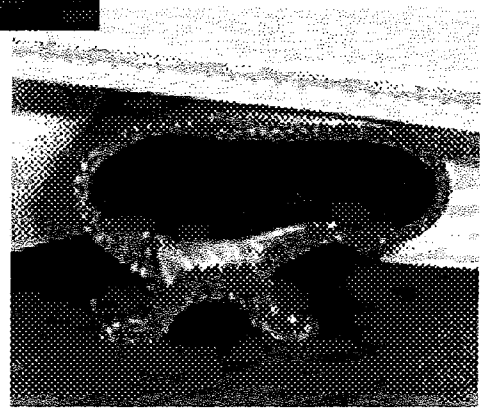
- Colored fluids are dumped into fire zones to demonstrate separation

- Mixed colors in the same fire zone indicate a seal leak and failure

Bulb seal performance - Failure Modes

- Incomplete or inadequate seal compression

- Sliding contact (scrubbing) rather than normal compression



- Seal creased during assembly

Bulb seal performance - Proposed Approach

- Finite element modeling of seal to predict response to failure modes, complex geometry and new manufacturing methods

Conclusion

- Valuable insight to the problems of engine externals can be gained by application of analytical tools in new areas
  - Applications should be driven by current design problems that arise in test or inservice.
  - Analytical tools should be easily adapted to new classes of problems.
  - Process can be implemented now to minimize impact to customer.

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13. ABSTRACT ***(Maximum 200 words)***

This workshop has six categories. (1) In the opening sessions we are attempting to provide an overview of the engine technology, applications, and perceived needs from the programmatic point of view. (2) In the second session more details of seals and secondary flows are presented. (3) In the third session some of the tools and techniques are examined. (4) In the fourth session engine externals, the region between the case and the nacelle are examined in more detail. (5) Some sealing needs as applied to High Speed Research (HSR) are presented in a limited exclusive rights session. (6) A short course on engine design development margins by Charles Bentz rounds out the workshop. Through these sessions the efforts at NASA LeRC, contractors and universities are applied to seals/secondary flow problems in a continued effort to expand the U.S. aerospace technology and marketshare. A second volume containing related HSR discussions is available to selected U.S. citizens.

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