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NATIONAL TRANSPORTATION SAFETY BOARD

Washington, D.C.

NASA Support Overview

(13 Pages)

NASA LANGLEY RESEARCH CENTER SUPPORT OF THE NTSB STRUCTURES GROUP FOR THE AMERICAN AIRLINES FLIGHT 587 ACCIDENT INVESTIGATION

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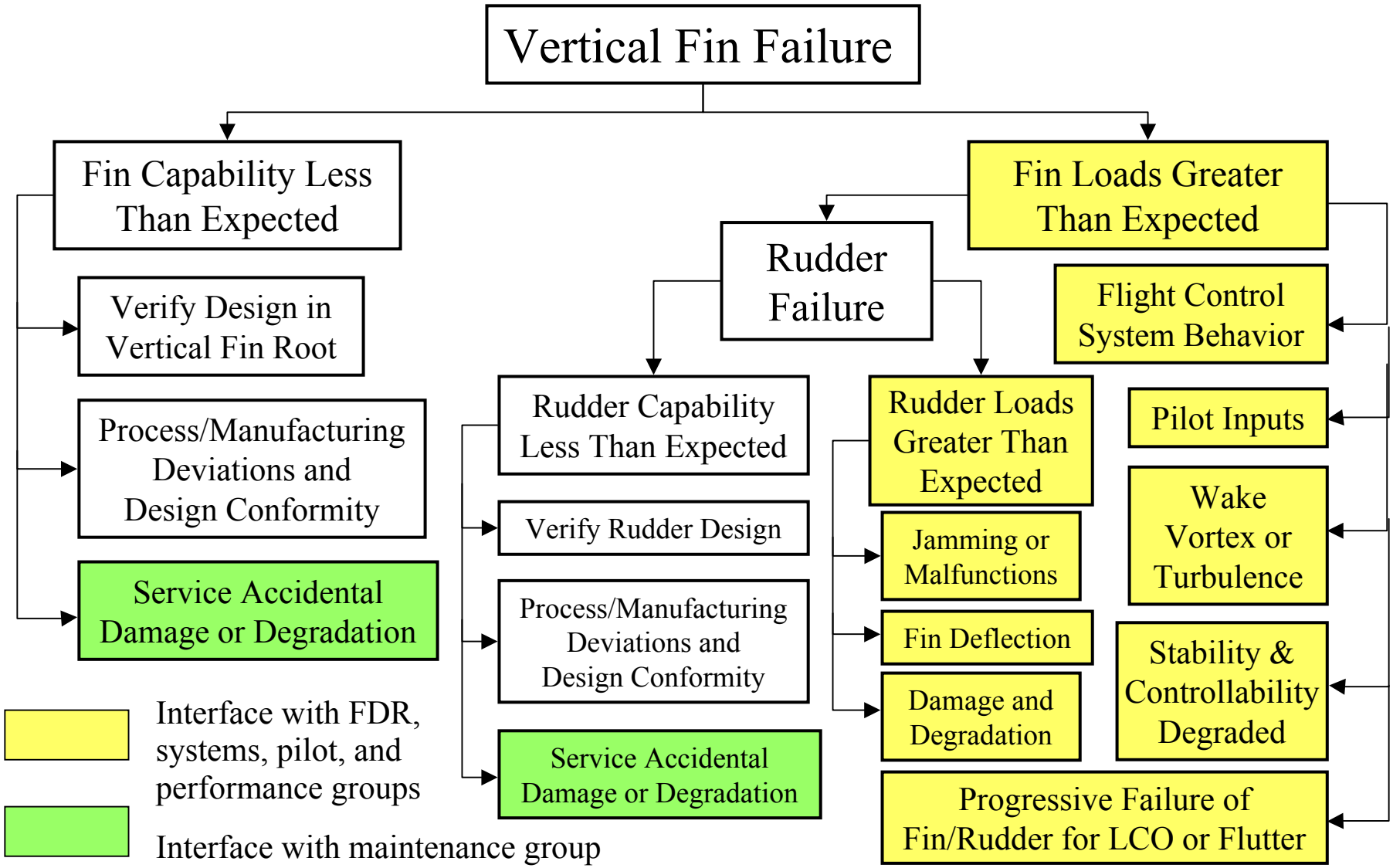
NASA LANGLEY RESEARCH CENTER SUPPORT OF THE NTSB STRUCTURES GROUP FOR THE AMERICAN AIRLINES FLIGHT 587 ACCIDENT INVESTIGATION

- Fault tree analysis
- Global vertical fin and rudder analyses
- Local vertical fin lug analyses
- Flutter analyses
- Computational Fluid Dynamics (CFD) pressure distribution analyses
- Structural tests
- Other structures and materials support

Top Levels of the AA587 Fault Tree Analysis



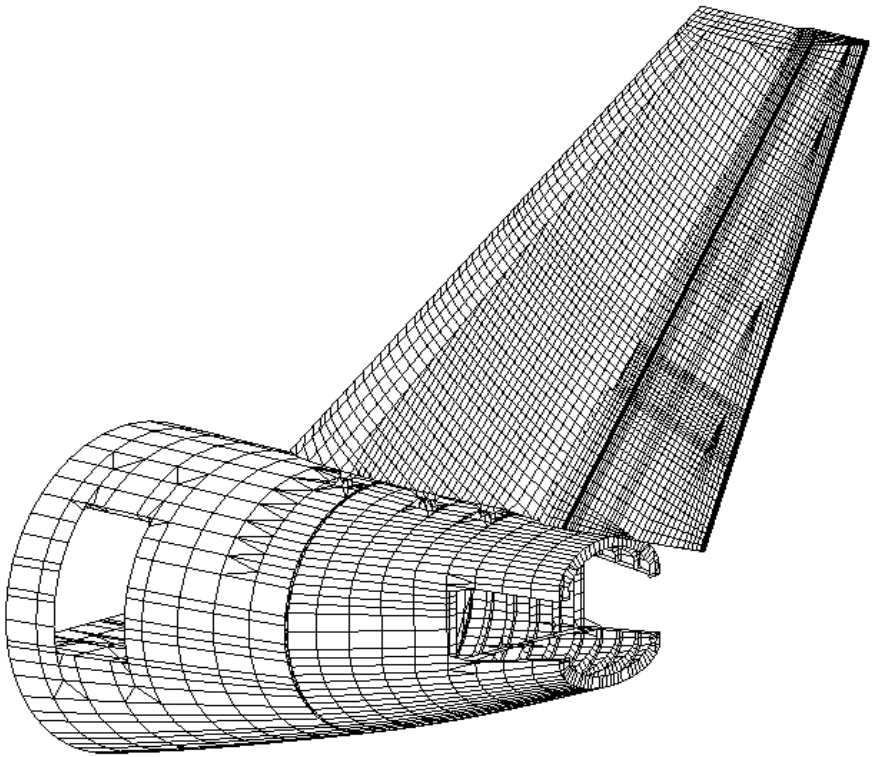
Global Vertical Fin and Rudder Structural Analyses

- **NASA Langley review of Airbus certification analysis results**
  - Review Airbus drawings and finite element models
  - Review Airbus finite element modeling assumptions
  - Review Airbus strength justification documents
  - Review Airbus finite element analysis and full-scale test correlation documents

- **Analyze critical response and failure characteristics, failure sequences and failure scenarios for accident loading conditions**
  - Determine effects of external loads on internal loads and response of pristine structure
    - Review aerodynamic load definitions
    - Compare linear and nonlinear analysis results
      - Identify any model refinement needed for local detail regions
      - Determine effects of buckling
      - Assess hinge-line deformation
  - Introduce local failure effects in specific locations and monitor redistribution of internal loads
  - Transfer loads from global models to local models
  - Conduct modal analysis to provide modes and frequency input for flutter analysis

- **Model test specimens and correlate analysis results with test results**
  - Identify critical locations and loading conditions for subcomponent and other tests
  - Correlate analysis results with test results

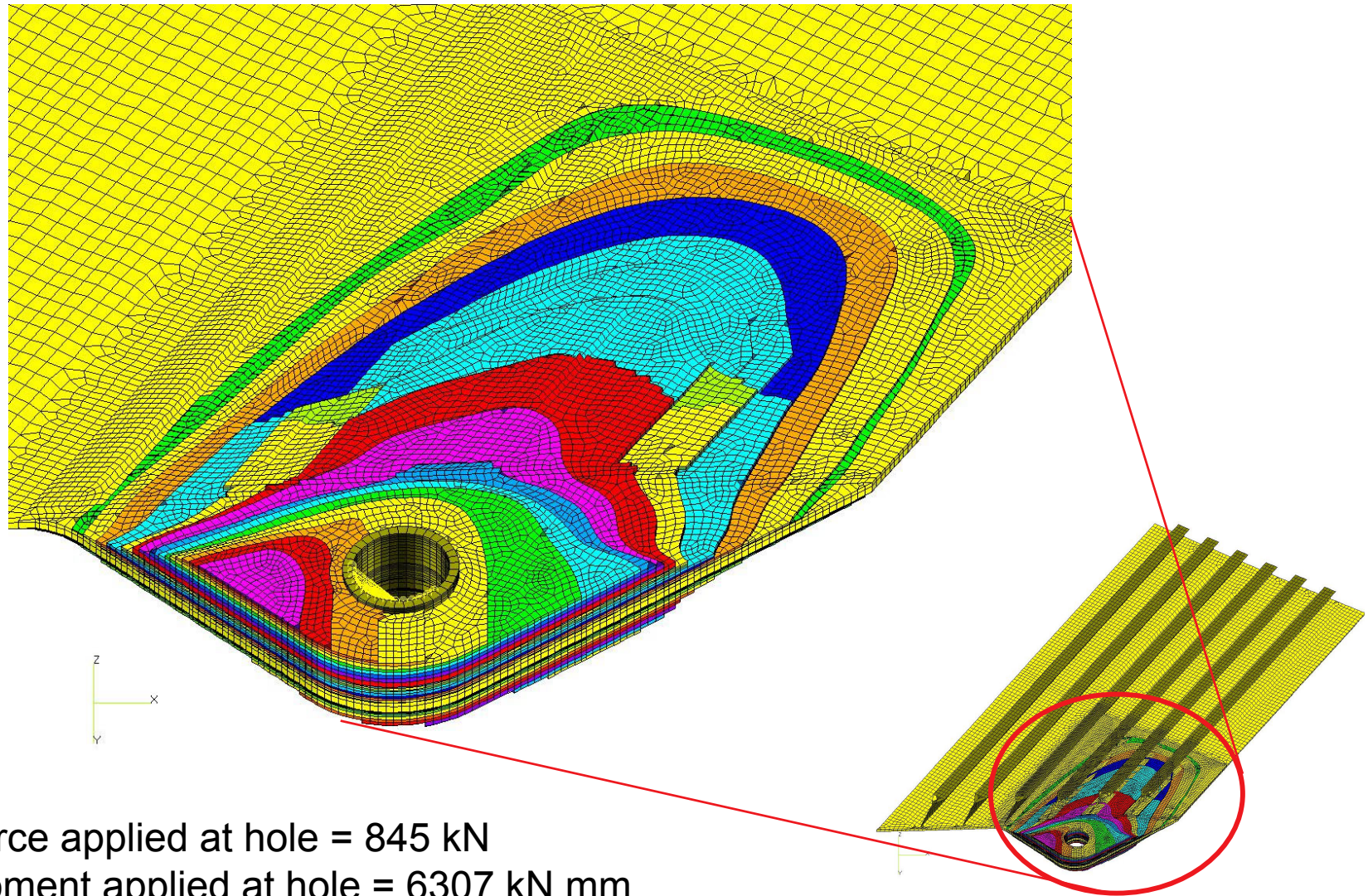
Airbus Finite Element Model



Local Vertical Fin Lug Analyses

- Evaluate right rear lug
  - Analyze Airbus 3-D lug models with linear and nonlinear analyses
  - Develop specialized lug modes to study candidate failure scenarios
    - Develop coarse 3-D lug models
    - Develop layered-shell lug models and validate with 3-D analysis
- Analyze observed failures of AA587 tail lug components
  - Loading conditions, failure modes and locations including NDE results
  - Progressive failure analyses for damage growth
- Evaluate lug certification analysis
- Model and analyze test specimens and tests
- Repeat evaluation process for three additional lugs
  - Forward lug
  - Pristine center lug
  - Repaired center lug

Airbus 3D Model of Right Rear Lug



Force applied at hole = 845 kN
Moment applied at hole = 6307 kN mm
Force applied at yoke = 93.2 kN

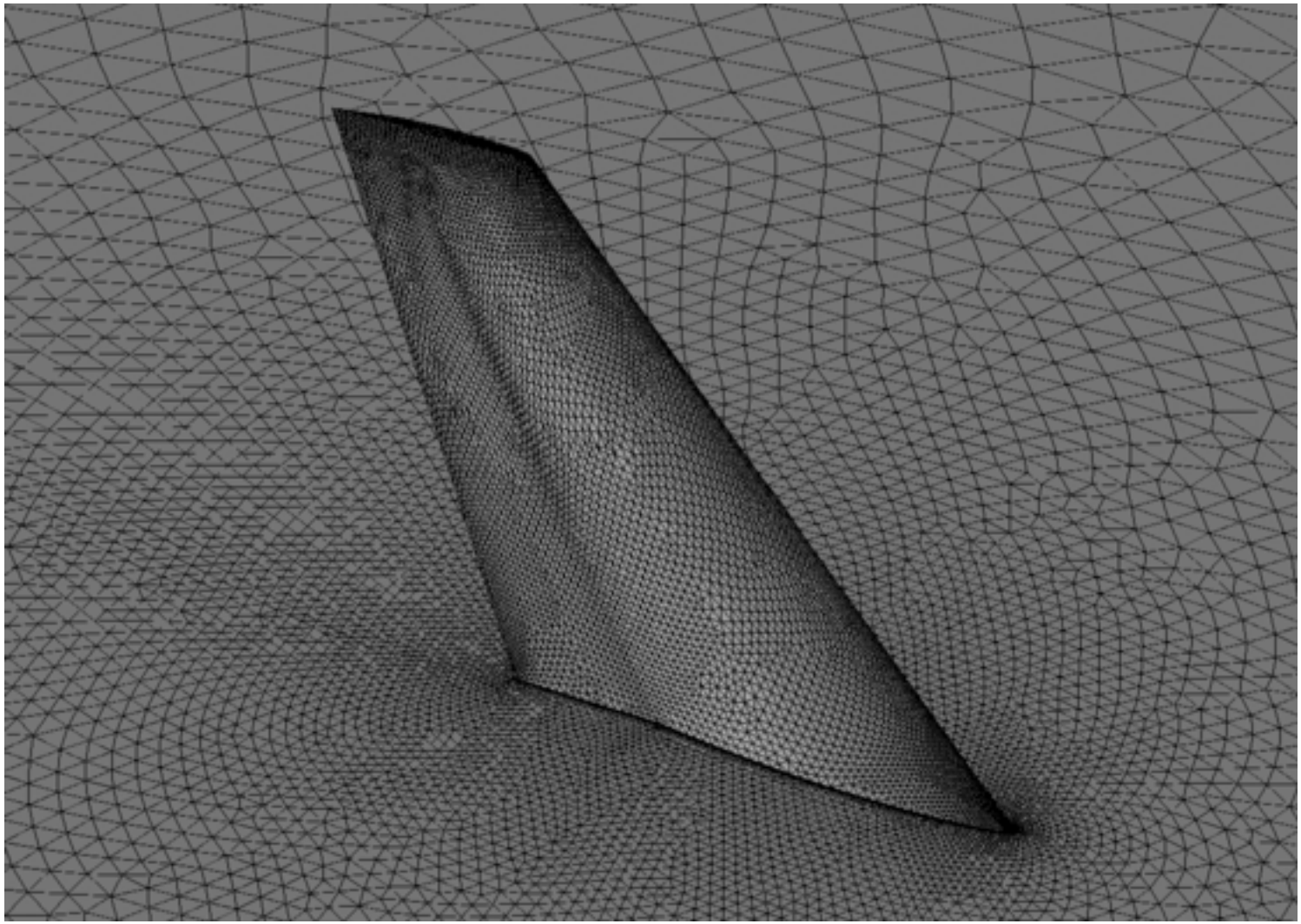
Flutter Analyses

- Identify potential vertical-fin/rudder flutter and limit-cycle-oscillation characteristics
- Assess and conduct flutter analyses at Airbus and at NASA
- Identify and assess potential stall flutter characteristics

CFD Pressure Distribution Analyses

- **Compute external pressure distributions for accident loading conditions with NASA USM3D CFD code**
- **Compare CFD results with Airbus pressure distribution results**
- **Map CFD pressure distributions to finite element model so global structural analysis results are representative of accident loading conditions**

Unstructured Surface Mesh for $\delta_R = -10°$



Structural Tests

- Conduct tests to confirm that failure is possible for accident loading conditions
- Use test results to validate failure modes observed in AA587 vertical fin and rudder
- Verify local and global analyses used to support the accident investigation
- Tests are planned to consist of:
  - Coupon and element tests on specimens from AA587 vertical fin and rudder to quantify strength and stiffness properties
  - Subcomponent lug tests for critical accident loading conditions using right-rear lug and others as needed to:
    - Determine if a lug is location of failure initiation
    - Determine effect of severe overload on fatigue resistance and residual strength
  - Full-scale vertical fin and rudder test if determined to be necessary

OTHER STRUCTURES AND MATERIALS SUPPORT

- In-depth photographic records and map of failure sites
- In-depth NDE surveys of vertical fin and rudder
- Fractogaphic analysis of failed metallic parts
- Fractogaphic analysis of failed composite parts
- Mechanical property tests of composite parts
- Chemical analysis of composite parts
- Remove specimens from AA587 vertical fin and rudder for chemical analyses, tests, and NDE evaluations