BCA Airplane Programs

Structural Compliance for Uncontained Engine Failure

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Date: **March 14, 2016**





Structural Compliance for Rotorburst

Agenda

- Purpose
- Process
- Minimization of Structural Risk
- Summary

Structural Compliance for Rotorburst

Purpose

- **Explain how Boeing shows compliance to 25.571(e) with regard to uncontained engine failure (rotorburst)**
- **Explain how structural designs inherently mitigate the rotorburst threat**

Structural Compliance for Rotorburst

Process

- **Structures group in BCA determines maximum allowable damage scenarios that meet loads requirements of AC 25.571-1D**
  - **A limited number of scenarios are developed to cover the very large number of possible damage scenarios from the 1/3 disk model in AC 20-128A**
  - **An event that causes structural damage exceeding the defined allowable damage is considered potentially catastrophic, depending on phase of flight**

- **Propulsion group then uses this information along with the system risks to determine if the Airplane meets the allowable risk**
  - **Airplane is shown to meet 1:20 and each stage meets 1:10 per AC 20-128A**
  - **Structural risk incorporates the phase of flight approach per AC 20-128A**
    - **1.0 while airplane is in the air,**
    - **0.0 when the airplane is on the ground**

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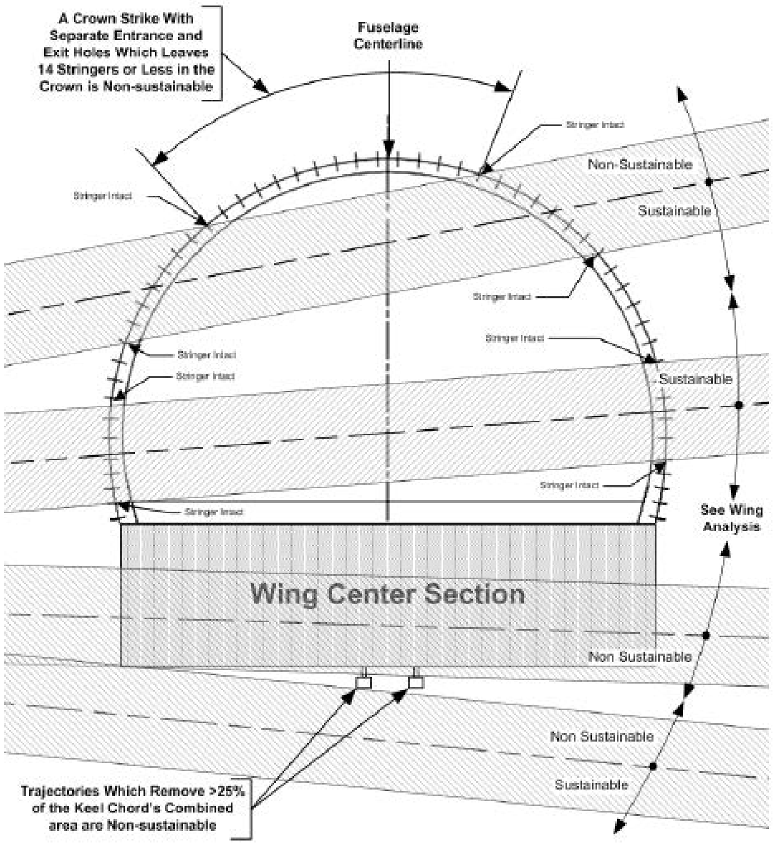
Structural Compliance for Rotorburst

Example Fuselage Allowable Damage Scenarios:



Example Upper Lobe Strike

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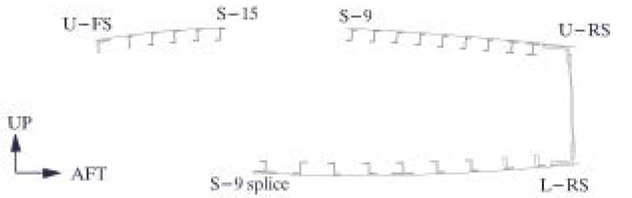
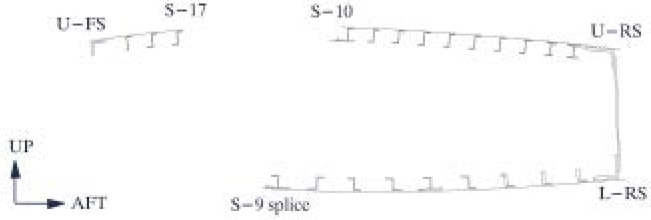
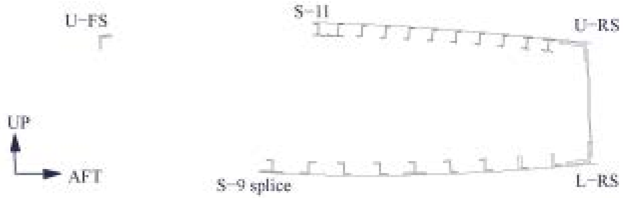
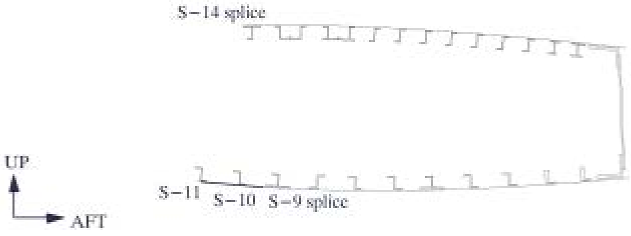
Example Wing Allowable Damage Scenarios:









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Process (continued)

- **If initial evaluation shows that the risk levels are not met, then Systems and Structures groups are asked to reduce conservatism in the analysis**
  - **expanding some of the allowable damage scenarios, or creating new scenarios, at optimal locations identified by Propulsion**

- **Once the airplane is shown to meet the risk levels, the final allowable damage scenarios are evaluated to ensure they meet flutter requirements.**

- **The final structural allowable damage scenarios are included in Structures Certification Documents to demonstrate compliance to 25.571(e)**

- **The final airplane level risk and per stage risk analyses are documented in Propulsion Certification Documents to demonstrate compliance to 25.903(d).**

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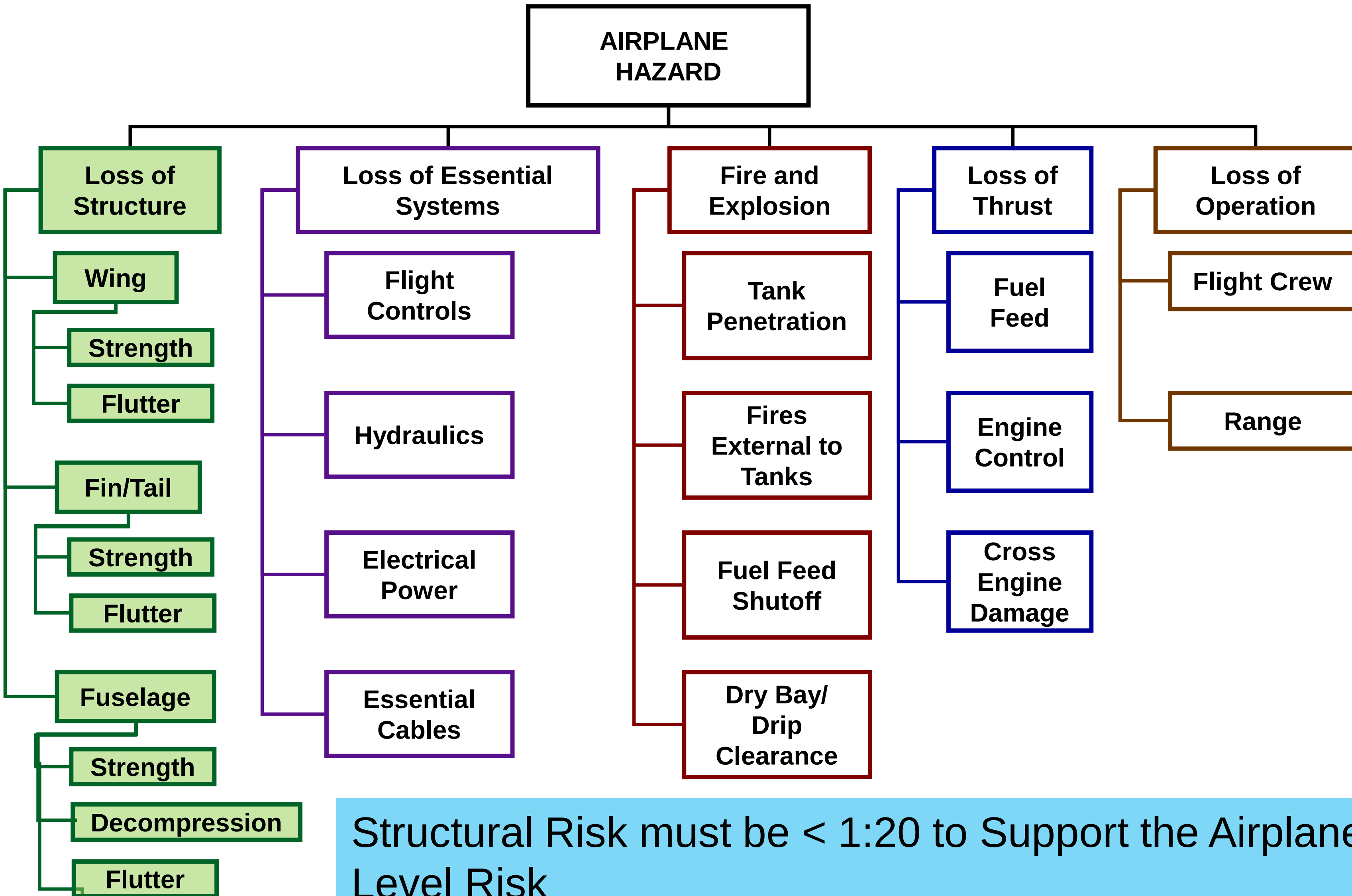

Structural Risk must be < 1:20 to Support the Airplane Level Risk

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Minimization of Threat to Structure

- Wing and fuselage structure are made with highly redundant features
- This highly redundant configuration is a result of stringer, frame, and rib sizing and spacing on the wing and fuselage, which are driven by other regulatory requirements such as static flight and ground loads, fatigue, damage tolerance, and flutter criteria.
- The resulting architecture then has inherent damage capability for discrete damage threats with sizes on the order of 1/3 disk fragments. Only worst case trajectories can cause enough damage to be catastrophic.
- Tear Straps or Shear Ties (Ref. AC20-128A Paragraphs 7.b(6) and 8.e) are also utilized in the basic design to help meet damage tolerance requirements, but these features do not contribute significantly to mitigating the risk from large damage swaths from 1/3 disk fragments.

Design features to meet structural regulatory requirements inherently address Minimization of the rotorburst threat

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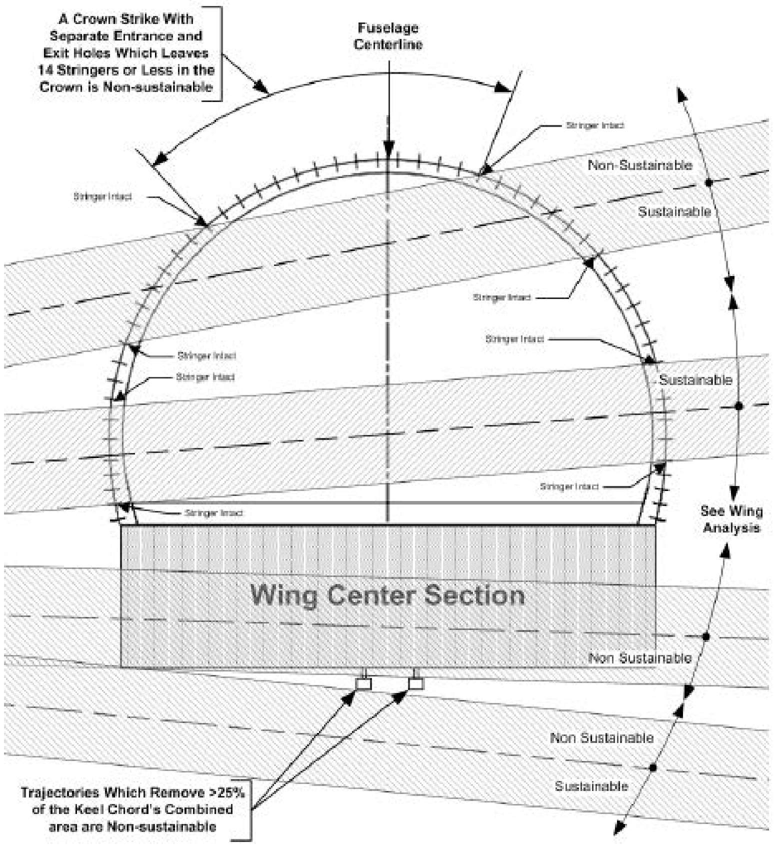
Example Fuselage Minimization Practices:



Example Upper Lobe Strike

Large Number of Stringers Provide Inherent Robustness for 1/3 Disk Fragment Strikes

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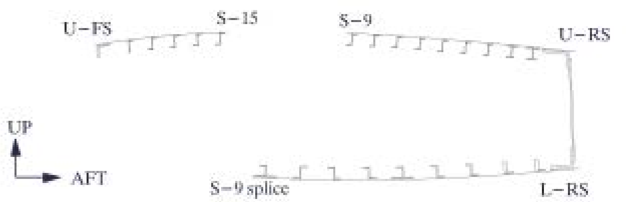
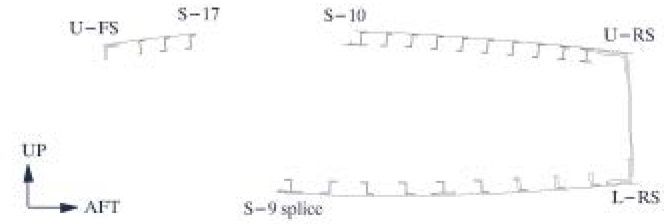
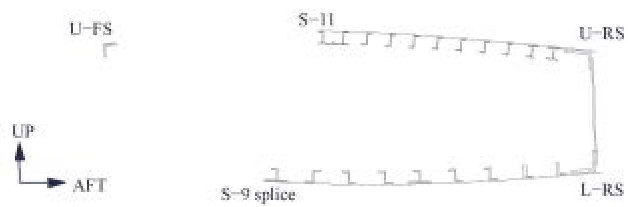
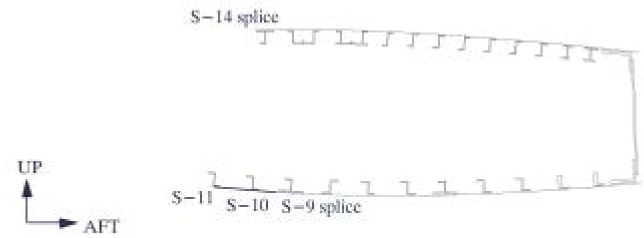
Example Wing Minimization Practices:









Large Number of Stringers Provide Inherent Robustness for 1/3 Disk Fragment Strikes

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Structural Compliance for Rotorburst

Minimization of Threat to Structure

- **Further minimization of the structural threat from the worst case trajectories would require significant architectural changes that are not considered practical, considering that there has not been a safety concern identified with the current design practice**

- **The risk levels in AC 20-128A (both airplane level, and per stage) will continue to serve as checks on the design, so that changes to the threat (engine size and configuration) or the structural configuration will not appreciably alter the safety.**

Rotorburst threat is adequately minimized with existing design practices and regulatory requirements, and will continue to be so in the future.

Structural Compliance for Rotorburst

Summary

- **Boeing has followed a consistent FAA approved approach for compliance for all models since rotorburst became a structural requirement.**
  - **Airframe is designed to structural requirements**
  - **Structural risk of resulting design is included with other airplane risks when showing compliance with 25.903(d) using methods prescribed by AC 20-128A**
  - **The airplane risk and per stage risk will always be within the levels prescribed by AC 20-128A**
  - **Identification of structurally allowable damage scenarios, that are utilized in the airplane level risk analysis, demonstrates compliance to 25.571(e)**

- **Minimization practices are in place**
  - **The airframe design inherently minimizes the rotorburst threat by meeting regulatory structural requirements.**
  - **The current approach will continue to provide safety, and adequately minimize the risk, even as design configurations evolve.**