Bird Strike Requirements for Transport Category Airplanes

Compliance by Analysis

Presented to:	Analytical Methods in Aircraft Certification Workshop
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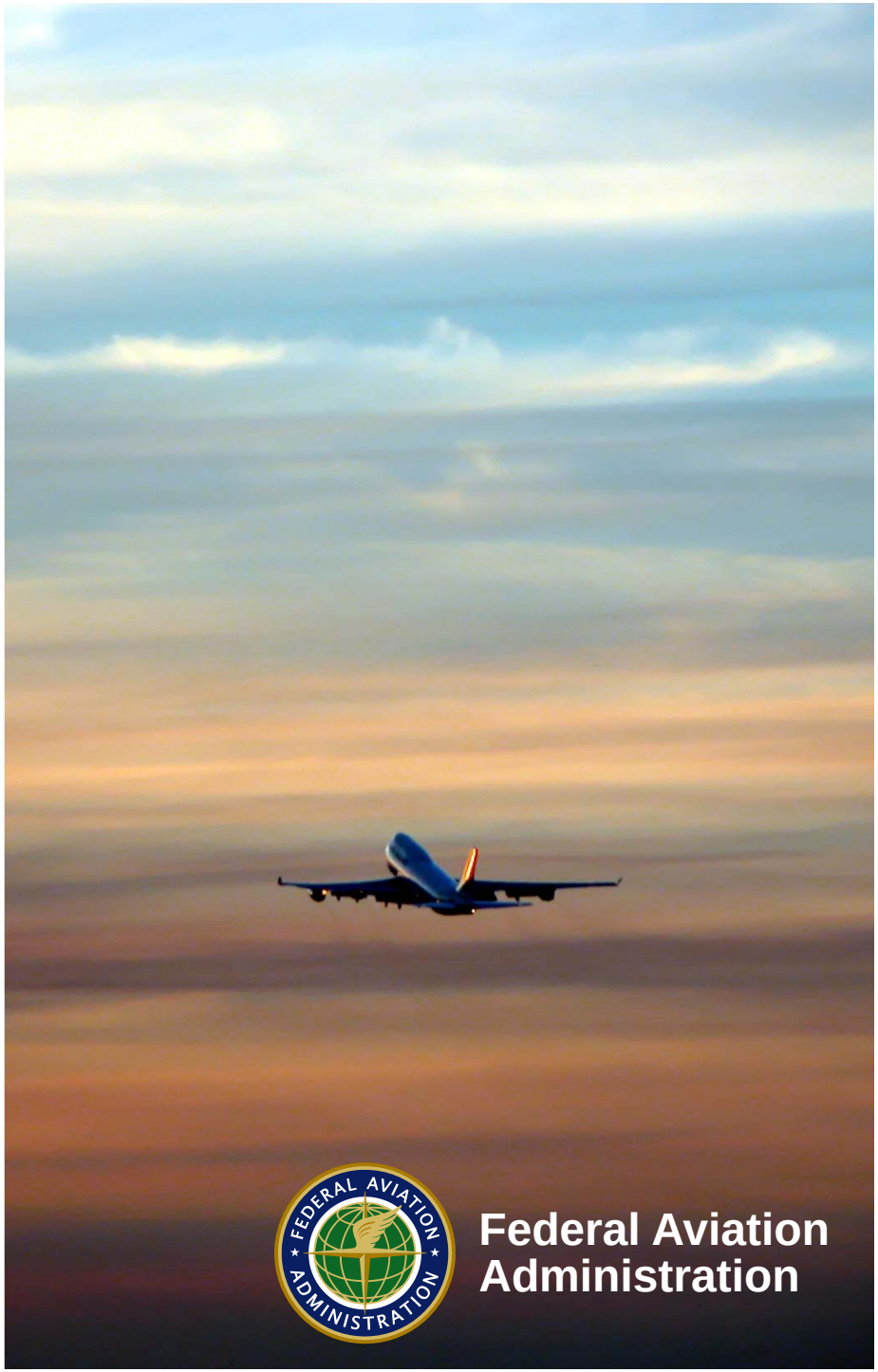
Date:	August 10, 2016



Part 25 Bird Strike Requirements

- **Section 25.571 (Amdt 25-132) Damage-tolerance and fatigue evaluation of structure**

  (e) Damage-tolerance (discrete source) evaluation. The airplane must be capable of successfully completing a flight during which likely structural damage occurs as a result of--

  (1) Impact with a **4-pound bird** when the velocity of the airplane relative to the bird along the airplane's flight path is equal to V_C at sea level or 0.85 V_C at 8,000 feet, whichever is more critical

- **Section 25.631 Bird strike damage**

  The **empennage structure** must be designed to assure capability of continued safe flight and landing of the airplane after impact with an **8-pound bird** when the velocity of the airplane (relative to the bird along the airplane's flight path) is equal to $\mathbf{V_C}$ at sea level, selected under Sec. 25.335(a).

Part 25 Bird Strike Requirements

- **From sea level to 8000 feet, address:**
  - Full range of certified design weights, CG limits
  - All phases of climb, cruise, descent and approach
- **Rule requires evaluation at design cruise speed, V_C, at sea level or 0.85 V_C at 8,000 feet**
  - Not 250 knots (Section 91.117)
  - Not V_{MO} (for amdt 25-72 and later)
- **Probabilistic arguments not acceptable to avoid assessment of bird strike**

Part 25 Bird Strike Requirements

- **If bird impact causes release of debris, assess effects of potential damage on continued safe flight and landing**
  - Probabilistic arguments not acceptable to avoid assessment of damage
  - Best practice: keep parts attached to the airplane
  - Apply engineering judgment, service experience
- **Advisory Circular (AC) 25.571-1 provides guidance on load conditions**

Certification by Analysis

- **The FAA approves the data, not the analytical technique**
- **The FAA holds no list of acceptable analyses, approved computer codes, or standard formulas**
  - Use of a well established analysis technique is not enough to guarantee the validity of the result
  - The applicant must show the data are valid
  - The FAA or our designees must find the data accurate and applicable, and that the analysis does not violate the assumptions of the problem

(Refer to FAA Order 8110.4C Type Certification, Paragraph 2-6)

Analysis Validation

- **Agreed upon validation acceptance criteria**
  - Correlation - time history (loads, deflection, failures, etc.)
  - Validating data
    - Test results (strain/accelerometer gages, high speed video, photometric, etc.)
      - Sampling rate
      - Data filtering
  - Test instrumentation should be appropriate to ensure data collected is appropriate for validation
  - Validate analysis for full design space

- **Analysis modeling factors / sensitivity studies**
  - Structural damping
  - Part to part friction
  - Material properties / material failure criteria
  - Joint idealization / joint failure criteria
  - Stiffness
  - Strain rate sensitivity
  - Bird model

Analysis Validation

- **Other modeling considerations**
  - Element types/element formulation
  - Filtering
  - Boundary conditions
  - Part Interfaces
  - Integration time steps
  - Scaling effects
- **Design space**
- **Good engineering judgment**
  - Supported by past relevant experience

Analysis Validation

- **Relevant guidance**
  - Advisory Circular 20-146, “Methodology for Dynamic Seat Certification by Analysis for Use in Parts 23, 25, 27, and 29 Airplanes and Rotorcraft,” dated May 19, 2003.
    - Section 6, “Definitions” (computer modeling, mass scaling, stability of explicit codes)
    - Section 7, “Computer Model Validation”
    - Section 8, “Application of Computer Modeling in Support of Dynamic Testing”
    - Section 11, “Documentation Requirements for Compliance”

Analysis Validation

- **Additional guidance**
  - Project specific issue paper
    - Large antenna and radome installations
    - Finite element model validation
  - Designee training
    - Finite element analysis

Analysis Documentation for Compliance

- **Analysis report should include at a minimum**
  - Description of the approach used to demonstrate compliance to the applicable regulations
  - Description of the analysis methodologies (including all computer analysis models/methods)
  - Description and data of all analysis validation
  - Description of the any computer modelling tools used
  - All assumption and supporting justification
  - Documentation of sensitivity studies/assessments used to characterize model inputs (e.g., damping, part to part friction, strain rate effects, etc.)
  - Description of the materials used, material properties, and reference sources of data and supporting documentation to support applicability of material properties (e.g., source of material failure criteria)

Analysis Documentation for Compliance

- **Analysis report should include at a minimum (continued)**
  - Detailed description of the analysis model
    - Assumptions
    - Constraints and boundary conditions
    - Loads and load cases
    - Element types/formulation
    - All analysis control parameters
    - All model input parameters and supporting data reference or justification (including but not limited to: structural damping, part to part friction, material energy absorption characteristics, material failure criteria, strain rate criteria, joint simulation/idealization, joint failure criteria, etc.)
    - Model processing parameters and justification
    - Model acceptance criteria

Analysis Documentation for Compliance

- **Analysis report should include at a minimum (continued)**
  - Analytical results
    - Model output
    - Data filtering (type of filter and supporting justification)
    - Identification of failed joints/fasteners and elements
    - Identification of differences between analytical predictions and validation test data, and justification/resolution of the differences
    - Discussion (as applicable) of the relevant validated design space
      - Range of speeds
      - Various impact locations
      - Angle of attack
      - Etc.

Challenges

- Expanded use of complex (including explicit codes) finite element models for certification compliance
- Flow down of requirements from compliance finders to analysts
- Need to build experience base of compliance finders
- Need more communication between FAA and applicant
- FAA and applicant expectations
- Standardization

FAA Activity

- **Internal and external webinars to review certification requirements and compliance**
- **FAA (designee and internal) training**
  - Bird strike certification for external modifications (new, available)
  - Finite element analysis for certification compliance (in work)

Questions?