Accommodate Diverse Product Applications

- **Category**
  - Part 23
    - Normal
    - Commuter
    - Utility
  - Part 25

- **Operations**
  - Part 91
  - Part 135
  - Part 136

- **Operators**
  - Private Individuals
  - Corporate
  - Fractional

- **Maintenance**
  - Company Service Centers
  - Authorized Service Centers
  - FBO’s
  - Lots of others….
Test vs Analysis

• Historical reliance on certification by test.

• Composites challenge the ability and practicality to certify strength solely by full scale test.
  
  • Significant reliance now on analysis, supported by test.
    – Extensive (and expensive) building block testing
    – FEM/Analysis validations with knockdowns

• Analysis is not considered as good as a test, regardless how well the FEM may be validated.

• Limiting full scale testing as primary means for certification.
  – More reliance on analysis may be increasing risk.
  – Challenge to achieve proper test/analysis balance to maintain historical levels of high confidence.
• Extensive history of events and evolution and acceptance of rationale for applicability to metals…..still needed for composites

• Applying a metals based requirement to composites
  • Negates fatigue benefits & no growth behavior of composites
  • Need improved understanding of mechanics of damage

• Likely a non-issue for low utilization GA and corporate owner/operators, which is majority of fleets

• Clarity needed for composites; define “wear-out”.

• Allow for a means to extend composites LOV, comparable to metals?
Threat Assessment

• Limited commonality to (large) transport category airline operational environment
  - Conservative; penalizing

• Differences
  - Exposure areas
  - Types of exposure events
  - Threat sources
  - Scale of structure
  - Scale of (blunt) damage

• Account for differences in maintenance and reporting controls.
  - In general, a much less abusive environment; more controlled.
Damage Criteria

• Maintenance and part acceptance criterion
  − DOT/FAA /AR-96-111 Advanced Certification Methodology for Composite Structures
  6.3.3 Damage Tolerance Design Requirements
  7. No catastrophic structural failure below DUL for structure containing 2.0 inch diameter circular internal damage (detectable by NDI).

• Environmental testing
  − Saturate at ETW; moisture induces/sets damage
  − Test moisture induced damage at ET but without moisture control

• Category 3 hail damage
  − Thin skin construction more susceptible to hail damage.
  − Hail energy level for Category 3 classification?
• Part 25 large transport criteria not directly applicable to smaller Part 25 and Part 23.

• Limited commonality to airliner environment
  – Scale of threats
  – Scale of structure
  – Areas of exposure
  – Support operations

• Alternate basis for exposure environment and criteria:
  – Damage threat assessment
  – Probability based
Large Scale Damage

• What are the criteria for extent of large scale damage?
  − Need practical definition of criteria for composites to achieve large damage sizes.

• 2-Bay damage:
  − Metallic damage source and initiation, propagation and arrestment mechanics are well understood.
  − Conservative to apply a metallic based rationale directly to composites without accounting for damage mechanisms.
    • Rationale damage criteria needed

• Alternate basis:
  − Damage threat assessment to define largest Category 3 (or 4) damage.
  − Residual strength demonstration through full-scale testing.
Material Scatter & Factors

• Metallic
  – A/B basis allowables for static strength
  – Fatigue & damage tolerant allowables use average values
    • Typically no definition of scatter
    • Are environmental variables always consistently applied?

• Composite
  – Fatigue loads approaching static failure levels (e.g., 90%) often necessary to achieve a fatigue failure.
    • Fatigue failure loads are within the static scatter
    • Residual strength greater than static strength
  – Most or all spectrum loads may be below endurance limit
  – Composite truncation could be greater than metallic clipping
Material Scatter & Factors

• Load/life enhancement and environment factors
  – Rigorously defined; statistically significant….more than metals?
  – Conservative to apply load and environment factors simultaneously...may not occur at same flight regimes
  – Navy LEF data indicated less scatter in metals than composites
    • Data based on fighter spectrum
    • GA and corporate operates at lower stress levels and load factors
      » Typically there is greater scatter in material data at lower loads

Sequence Effects?
• Investigation into a new, different baseline is recommended:
  – Navy data is not viewed as an appropriate baseline
  – Testing to define new baseline
    • Test appropriate metallic materials using spectra representative of GA and small aircraft operational environments
    • Define new scatter parameters

• Test composite materials to spectrum equivalent to metallics and define scatter per standard LEF guidance

• Compare composite scatter to new baseline metals scatter
  ==> define GA/small aircraft specific LEF:
  – Adjusting for spectrum effects should reduce load/life factors
  – Reduced unnecessary conservatism
  – Possibly make composites more weight competitive
Crashworthiness

• Part 25 large transport criteria not applicable to smaller Part 25 and Part 23.

• Applying larger airframe standards to smaller class of aircraft may be prohibitively restrictive and penalizing weight.
  • Factor of scale.....weight, size, etc.
  • Maintaining space......smaller volumes
  • Occupant loads.....minimal floor space for energy absorption

VS
Fatigue Evaluation

23.571 Metallic pressurized cabin structures.

For normal, utility, and acrobatic category airplanes, the strength, detail design, and fabrication of the metallic structure of the pressurized cabin must be evaluated under one of the following:

(a) A fatigue strength investigation in which the structure is shown by tests, or by analysis supported by test evidence, to be able to withstand the repeated loads of variable magnitude expected in service.

(b) A full-scale strength investigation in which it is shown by analysis, tests, or both, that the fatigue behavior of the structure is not probable after fatigue or obvious partial failure of a principal structural element, and that the remaining structure is able to withstand the ultimate load factor of 1.5 times the critical limit load factor as defined in §23.574.

(c) The damage tolerance evaluation of §23.574(b).

23.572 Metallic wing, empennage, and associated structures.

(a) For normal, utility, and acrobatic category airplanes, the strength, detail design, and fabrication of those parts of the airplane's structure whose failure would be catastrophic must be evaluated under one of the following:

(i) A fatigue strength investigation in which the structure is shown by tests, or analysis supported by test evidence, to be able to withstand the repeated loads of variable magnitude expected in service.

(ii) A full-scale strength investigation in which it is shown by analysis, tests, or both, that the fatigue behavior of the structure is not probable after fatigue or obvious partial failure of a principal structural element, and that the remaining structure is able to withstand the ultimate load factor of 1.5 times the critical limit load factor as defined in §23.574.

(iii) The damage tolerance evaluation of §23.574.

23.573 Damage tolerance and fatigue evaluation of structure.

(a) Component airframe structure. Comprise airframe structure must be evaluated under this paragraph instead of paragraphs §23.571 and §23.572. The applicant must evaluate the composite airframe structure, the failure of which would result in catastrophic loss of the airplane, in each wing (including engine cowlings, nacelles, engines, and other supporting structures) and fuselage, and related inspection programs required for applicable operation and maintenance personnel.

(b) For any bonded joint, the failure of which would result in catastrophic loss of the airplane, the limit load condition must be established by one of the following methods:

(1) The normal operating differential pressure combined with the expected external aerodynamic pressures applied to the structure, in accordance with conditions specified in this part, and

(2) The expected external aerodynamic pressure in a flight condition combined with a cabin differential pressure equal to 1.5 times the normal operating differential pressure without any other loads.

§23.574 Metallic structure durability and fatigue evaluation of commuter category airplanes.

For commuter category airplanes:

(a) Metallic structure durability. An evaluation of the strength, detail design, and fabrication must show that catastrophic failure due to fatigue or obvious partial failure of a principal structural element, or damage to any component part of the airplane, would result in a catastrophic failure.

(b) Fatigue (safe-life) evaluation. Components of the airplane structure, the failure of which would result in catastrophic loss of the airplane, are subject to the fatigue tested evaluation prescribed in this section if specified in paragraphs (c) and (d) of this section, for each part of the airplane's structure that could contribute to a catastrophic failure.

23.575 Inspections and other procedures.

Each inspection or other procedure, based on an evaluation required by §23.571, §23.572, §23.573 or §23.574, must be established to prevent catastrophic failures and must be included in the Limitations Section of the Instructions for Continued Airworthiness required by §23.1529.
Part 23 Rewrite: Summary

- Part 23 regulations changed **entirely**
  - Prescriptive language removed from rule
  - Only safety aspects retained

- Prescriptive language defined in approved ASTM standards
  - ASTM F44 light aircraft standards based on EASA VLA and glider MOCs….with extensive industry input
  - OEM can create standard(s) for FAA approval

- Much discussion on…
  - Flutter, material allowables, fatigue/DT, design and construction

- Common ground
  - Tiering allows different requirements based on airplane
    - Size, seats, performance…
  - Existing tiering: VLA, normal category, commuter

- Schedule:
  - March 2015 EASA A-NPA 2015-06
  - Fall 2015: FAA NPRM followed by EASA NPA

Primary goal: Lower cost of certification without reducing safety.
Part 23 Rewrite: Composites and the Durability Standard

• Desired: Provide option to eliminate cyclic test requirement.

• Options being discussed:
  – Show that overall airframe stresses are low
    • EASA CS-VLA regulations already allow this
      – Definition of “low stress”? Reference AMC for CS-VLA. Also, fleet data.
    • EASA certifications: no safe life. FAA validations: define a safe life.
  – Enhanced strength test
    • Intent: Ultimate strength testing can demonstrate low airframe stresses
    • No cyclic test if static strength testing at or beyond limit load x 2.0
      – Should enhanced factor be 2.0? For composite, use LEF instead?

Need to start taking into consideration how the rewrite will affect composite standardization efforts, and vice-versa.
Summary

• One size does not fit all.

• Ensure Part 23 and small Part 25 aircraft are not unnecessarily and unfairly burdened by criteria based on large transport category aircraft.

• Equitable requirements while properly accounting for operational environments.

• Awareness of Part 23 rewrite and it’s affect.