Breakout Session on Structural Testing Protocols

The following charts document the results of a session conducted at the July 2006 FAA Composite Damage Tolerance & Maintenance Workshop.

The basic charts were prepared in advance of the session to facilitate brainstorming and discussion, and the text and/or slides highlighted in red represent comments and feedback provided by workshop participants during the session.

Breakout Session on Structural Testing Protocols

Primary Objective: Identify acceptable means of compliance & associated technical issues for demonstration of fatigue, damage tolerance and static strength substantiation of composite airframe structures

Secondary Objectives:

1. Discuss existing methods of compliance – use of articles for multiple purposes
2. Discuss elements of building block and use of shared databases
3. Discuss incorporation of realistic service damage scenarios and categories
4. Discuss practical problems crucial to airframe substantiation
5. Identify needs for regulatory requirements & guidance
6. Identify needs for engineering guidelines, shared databases, standard tests and training
7. Provide directions for research and development

Detail of Topics Covered

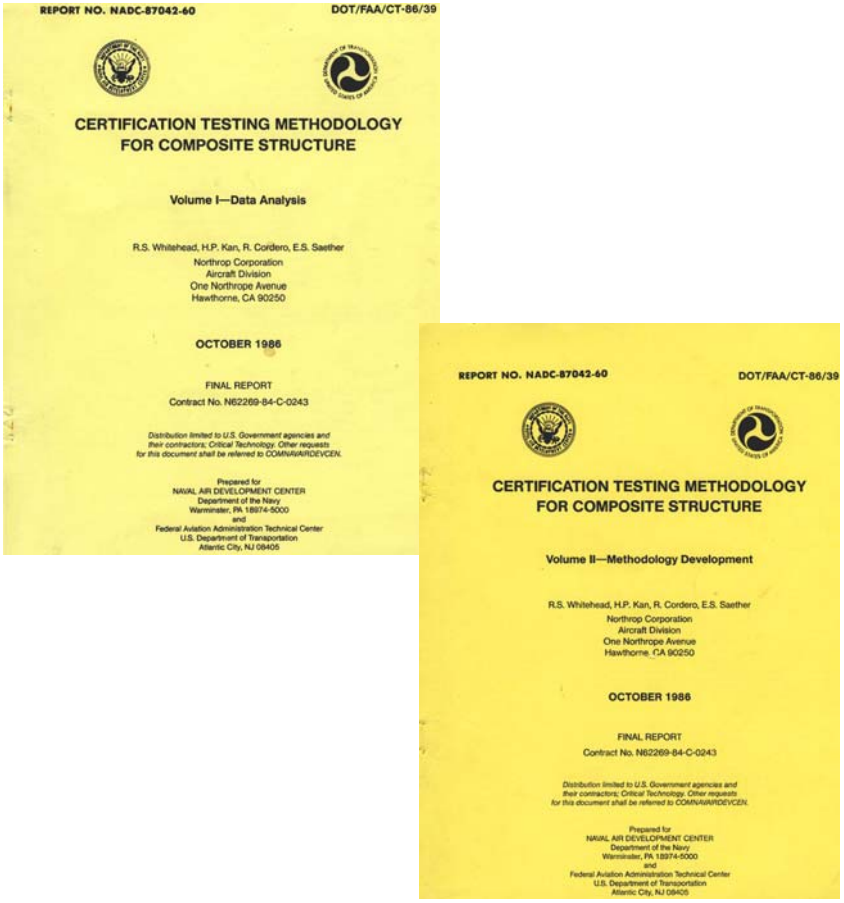
1. LEF
2. Fatigue Spectrum Development
3. Damage Tolerance and Repair
4. Environmental Factors

Desired Output

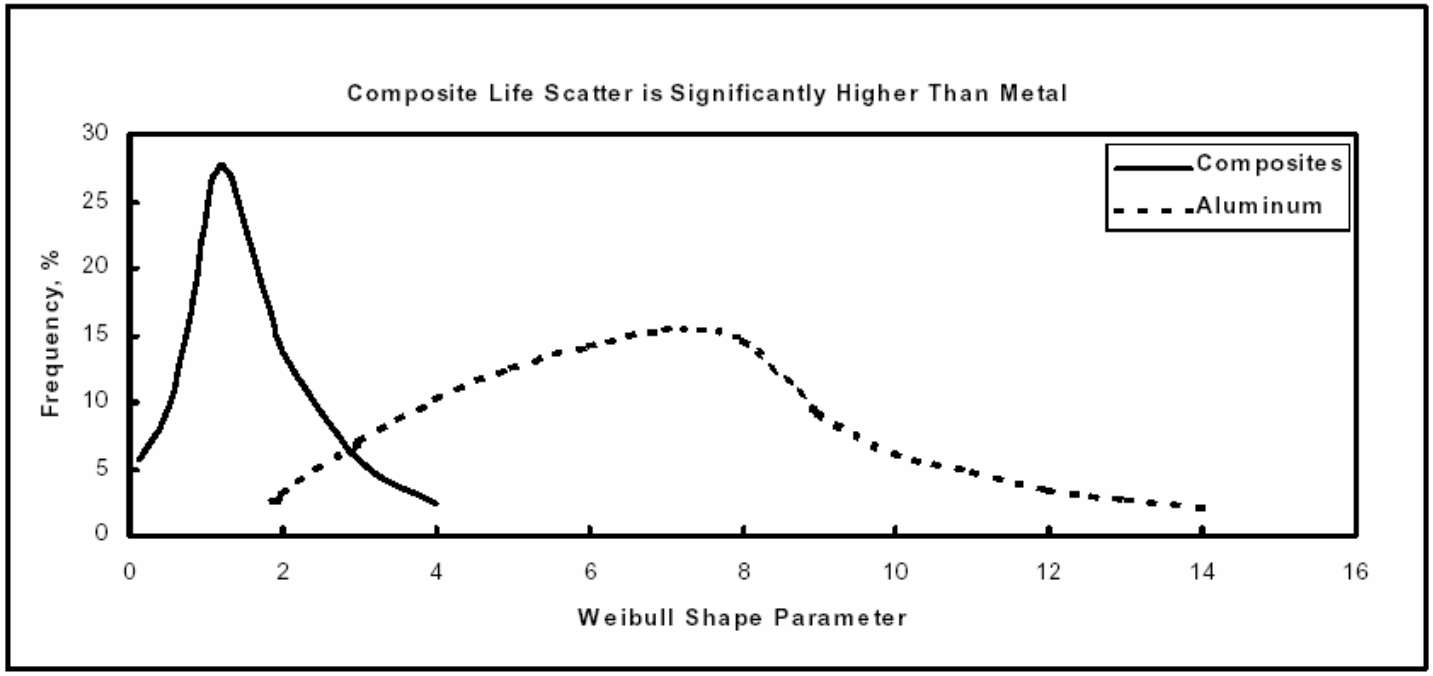
- Present practices & associated challenges
- Regulation needs (missing rules & guidance)
- Other safety concerns
- Technical “Gaps

Load Enhancement Factor Approach and Fatigue Life Assessment

- Background – most test programs reference the Navy/FAA reports by Whitehead, Kan, et. al. (1986) and follow that approach
- Most test programs have used the conclusions developed in this report regardless of design features, failure modes and/or materials
- EADS-CASA study (used for A340 aircraft) approach (2001) but redefined the shape factors



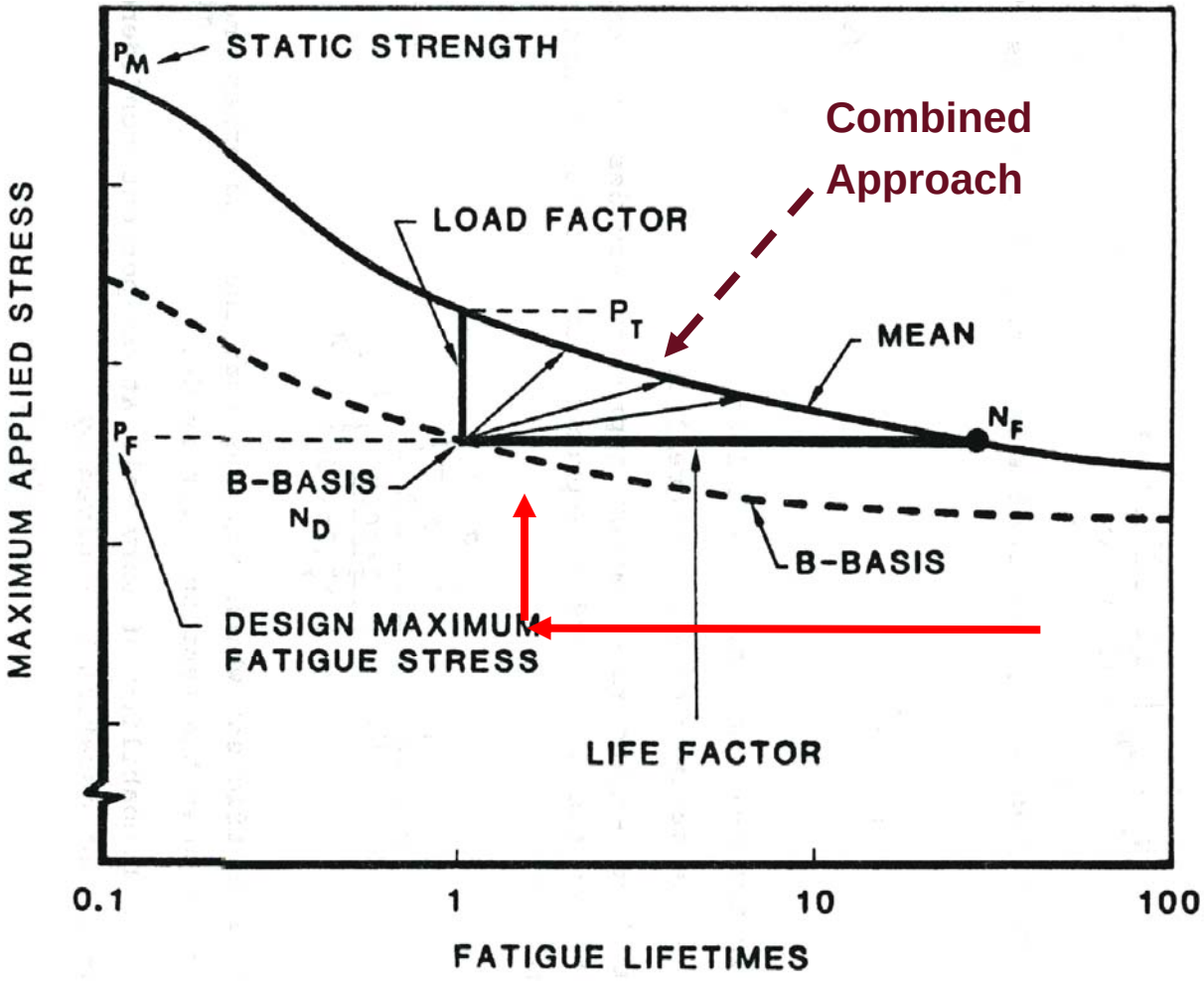
LEF - Overview of Methodology



Comparison of graphite-epoxy and aluminum fatigue life scatter distributions

data was pooled on the basis that the life scatter is not significantly influenced by load level, loading mode, laminated layup, fatigue life and failure mode

Load / Life Tradeoff



Discussion on Load Enhancement Factors

- Discussion of previous approaches – necessary should be supporting data required if this data is be used – NAVY data appears conservative – general thoughts were that a guideline procedure would be useful
- Data should be generated based upon design details and flaws/damage and representative of expected failure modes
- LEF should not be required if operating strains are below threshold
- Update of 20-107A is needed to address this topic
- Current FAA research plan is a good idea and will produce needed background for guideline and 20-107A update

Discussions on Truncation Levels

- Load level truncation criteria and necessary supporting information
  - Criteria based on strain levels (damaged or undamaged, coupons or elements)
  - Address postbuckled structure
  - Supporting data - transverse tension and shear tests
  - Explore approach presented by Christos Kassapaglou
  - Should be based upon no-growth philosophy using coupon level tests
- Hybrid composite/metallic concerns
  - Need two test spectra which address both metallic and composite
  - Use a hybrid approach for testing
    Ex: High load cycles towards the end of the test
- Guidance documentation would be useful

Discussions on Damage Tolerance and Repair

- Full-scale tests should simulate established damage threats
- Discussion of the types
  - Category 1: Allowable damage that may go undetected
  - Category 2: Damage detected by field inspection
  - Category 3: Obvious damage detected within a few flights
  - Category 4: Discrete source damage known to pilot
  - Category 5: Severe damage created by anomalous ground or flight events (not covered by design substantiation)
- Repeated load testing incorporates Category 1 type damage
- Category 2 and 3 should be addressed after repeated load test and residual strength verification
- Category 4 and 5 usually will not be addressed in the full-scale test – some category 4 concerns will be addressed using sub-components (ex. rotorburst, bird strike, etc.)
- Discussion: Incorporation of damage into test articles and protocols for testing – should not reflect what is being done in metals but address realistic damage threats
- Repair substantiation could be included during full-scale testing (usually after repeated load testing)

Discussion of Environmental Effects

- Previous approaches - static strength and residual strength only
- Incorporation of building block data for environmental factors – general consensus that larger elements are preferred
- Environmental factor based on mean-to-mean data
- Moisture content based upon expected service history average and type of structure – will not reach equilibrium
  - Ex: 110 deg F, 85% RH for two months

General Discussions

- A big part of the full-scale structural test is to validate the analytical model
  - within 10% ??
  - focus on major load paths
- Single article versus two articles
  - economic and risk factors play an effect
  - single article is possible