ASIP 2007

Certification Issues for Hybrid Aircraft Structures



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2007 Aircraft Structural Integrity Program

Palm Springs CA

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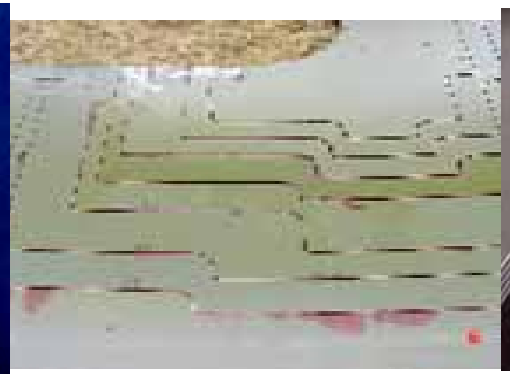
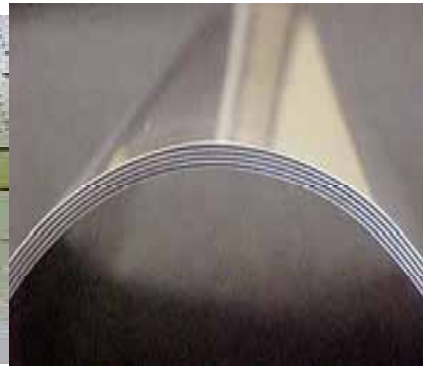
Overview

- USAF Structural Maintenance Trends
- Certification needs for Hybrid Structures
- Opportunity: “Design for Inspectability”

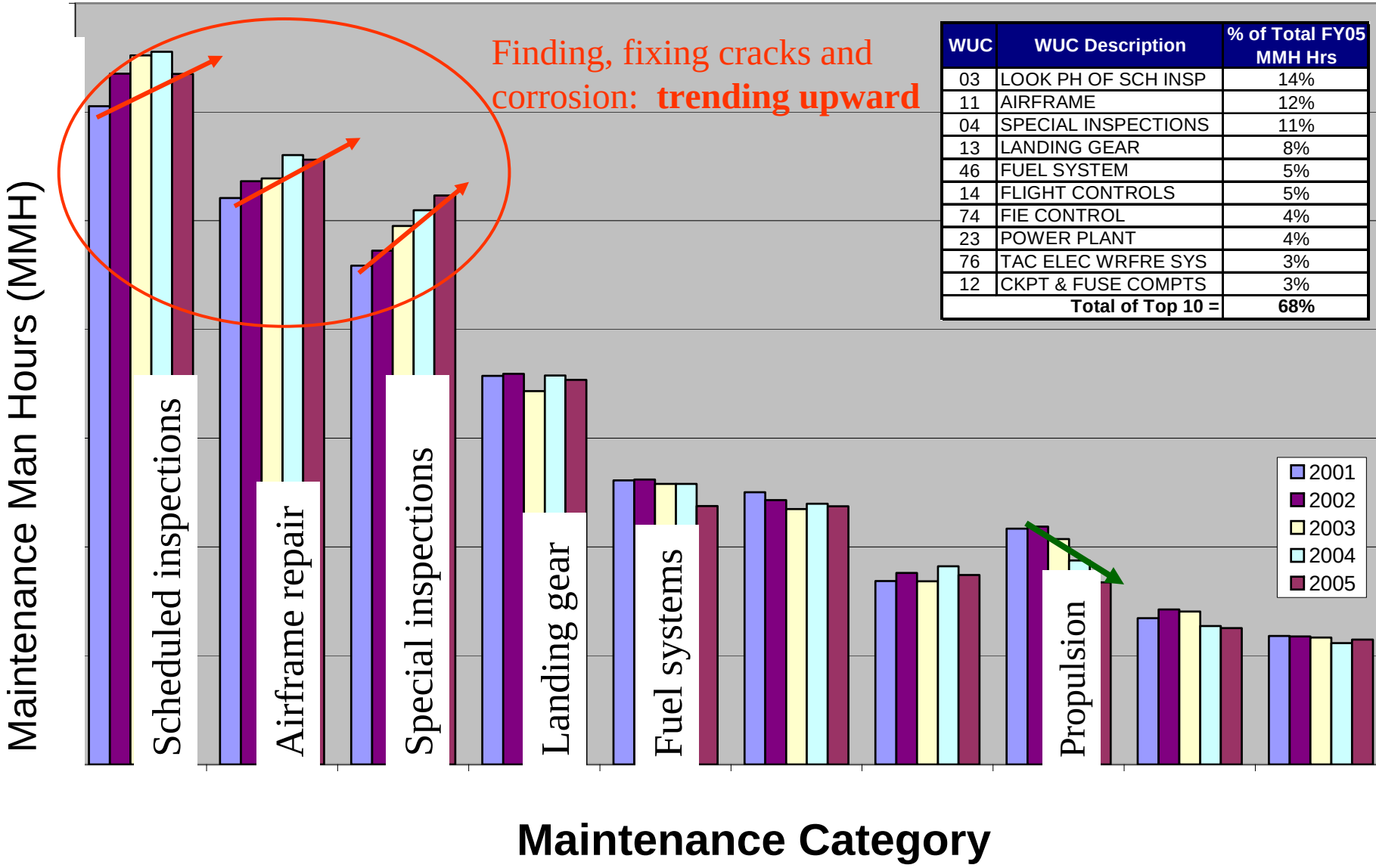




Previous ASIP Speakers:

- Peter Christiansen, C-130 Center Wing Box
  - Deployed 130s flying 4x the home station rate
  - Some aging 130s require 2 years of Mx to return to flight
  - Need to reduce inspections by using “throwaway” components?
  - Replace center wing boxes more frequently?
- Lt Col Scott Fawaz, Effects of new K models
  - Newman-Raju based K solutions unconservative
  - USAF may need to inspect sooner and more frequently
- Dr. Markus Heinimann, Alcoa Adv Hybrid Wings
  - “Care-free” hybrid structures available as low-risk option
  - Greatly reduced inspection and repair
  - 25% higher stress allowables + 4x longer fatigue lives

- ***Apparent over-reliance on inspection costs $$$, availability***
- ***Continued replacement with legacy alloys not effective***
- ***Dramatic improvements possible; big gains require bold thinking***

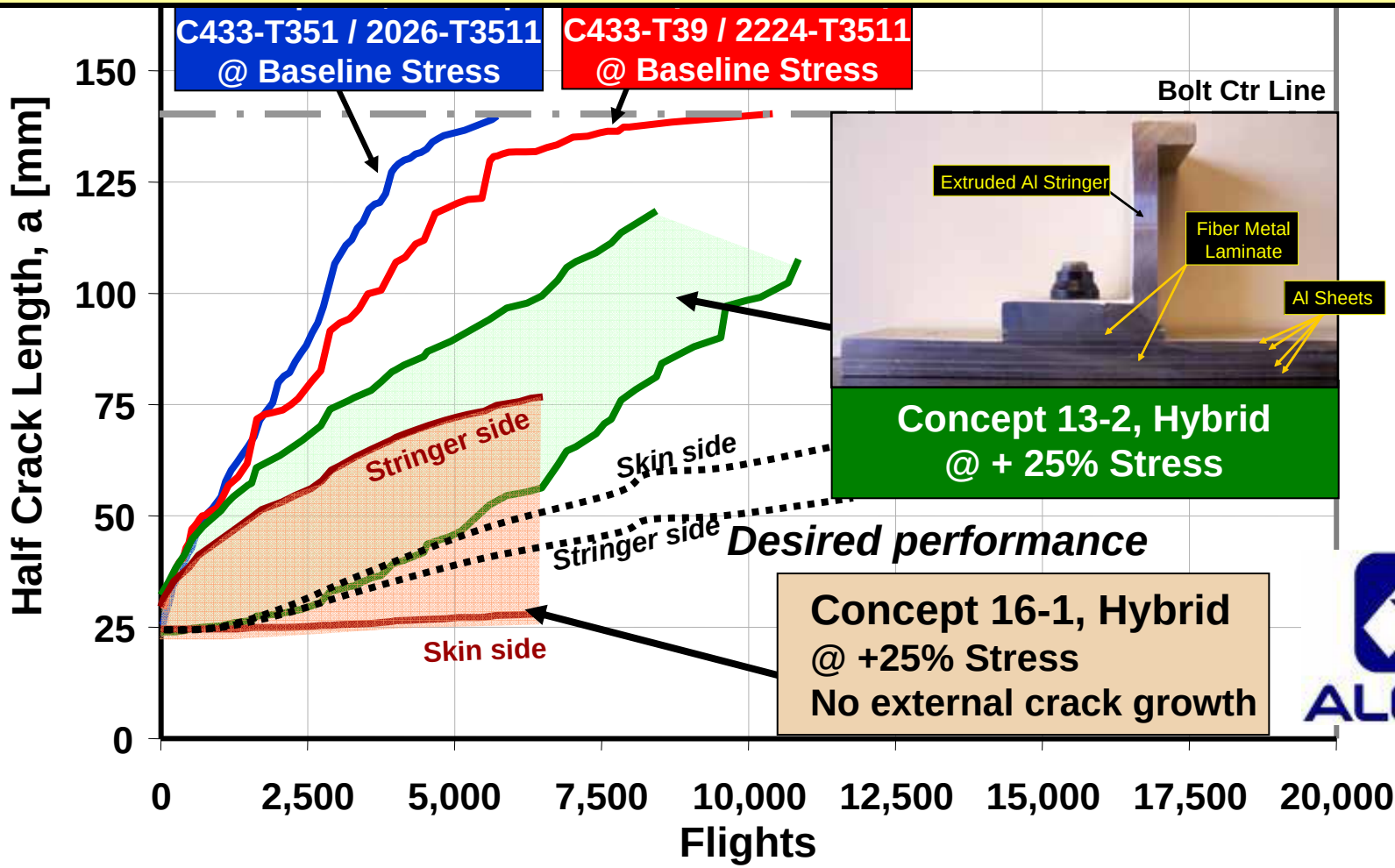
Top 10 Maintenance Drivers (MMH), Total AF



WUC	WUC Description	% of Total FY05 MMH Hrs
03	LOOK PH OF SCH INSP	14%
11	AIRFRAME	12%
04	SPECIAL INSPECTIONS	11%
13	LANDING GEAR	8%
46	FUEL SYSTEM	5%
14	FLIGHT CONTROLS	5%
74	FIE CONTROL	4%
23	POWER PLANT	4%
76	TAC ELEC WRFRE SYS	3%
12	CKPT & FUSE COMPTS	3%
	Total of Top 10 =	**68%**

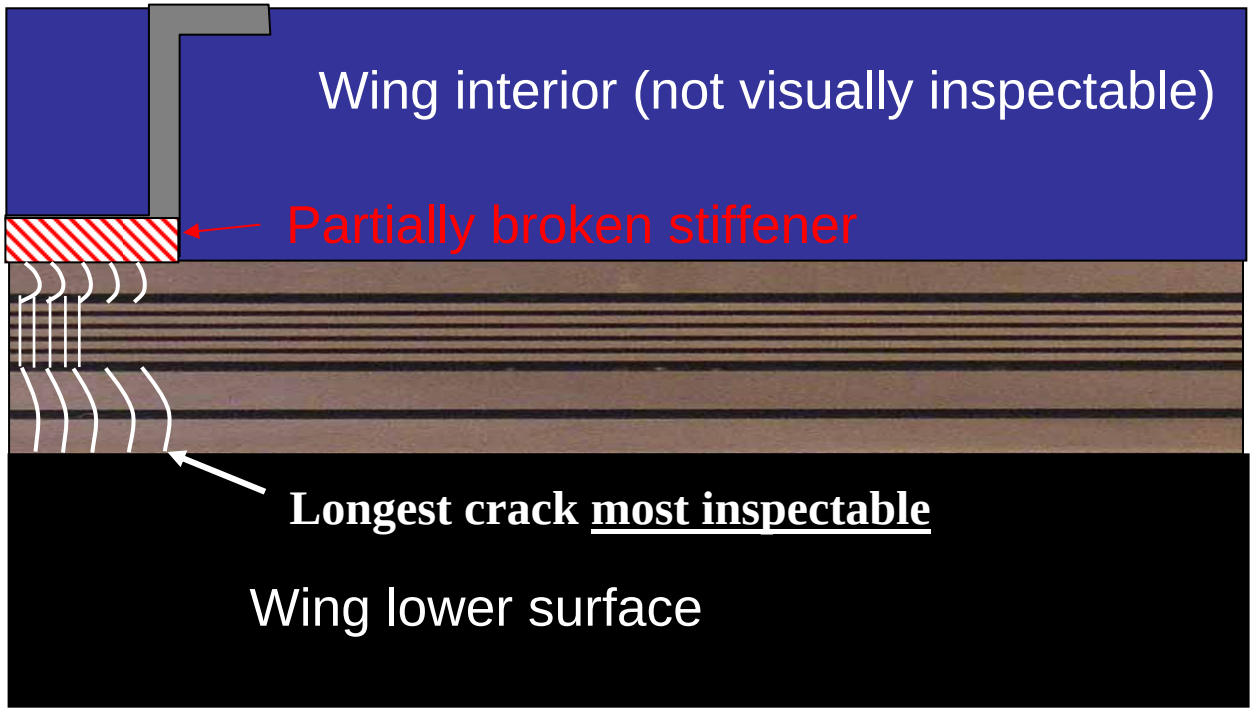
How to certify long life structure?

- *Five principles of ASIP show the way to certify hybrid structures*
- *Best to follow mixed composite/metal approach like A380, B787*
- *Further inspectability improvements possible*



Notional Modified CentrAl™ for Max Inspectability

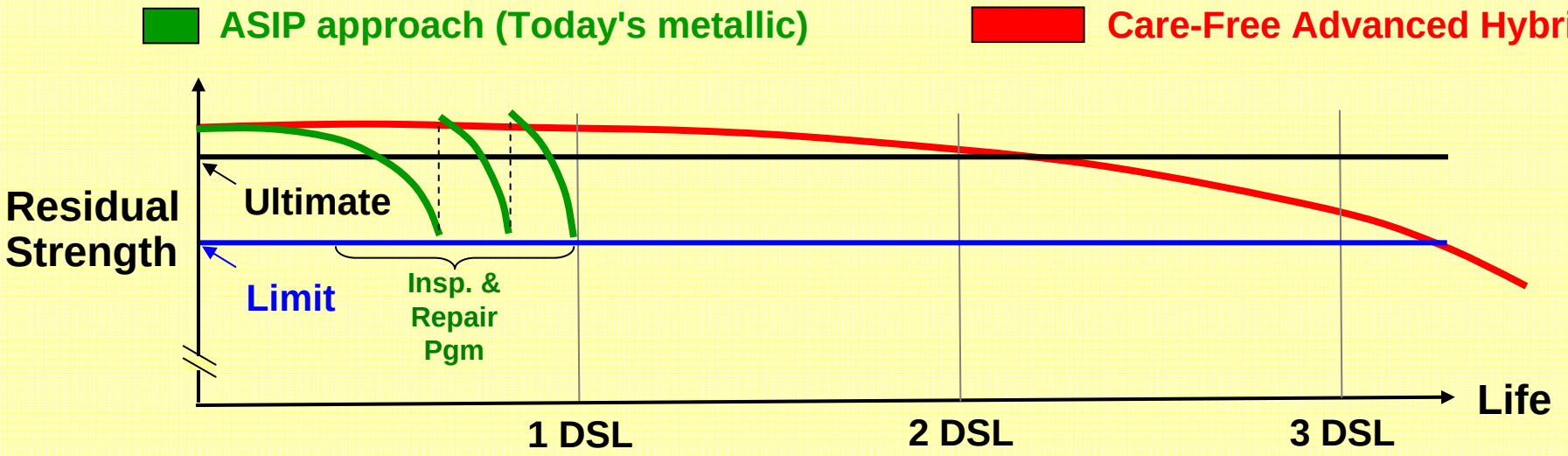
- Lower wing skin with offset Glare layer
- Modified CentrAl™ ensures skin side flaws are no smaller than stringer side
- Glare cracks grow slowest, give restraint



- Longest cracks always visually inspectable
- Slow crack growth plus visual inspectability = **care-free structure**
- *Concept only; other variations may prove more effective*

Certification via Damage Tolerance Approach

Conventional Aluminum and Hybrid FML Structures



- **Advanced hybrids offer promise of Care-Free structures:**
  - ✓ Extremely Slow Crack Growth behavior – *long inspection intervals*
  - ✓ Corrosion resistance: not simply trading one failure mode for another
  - ✓ Impact, lightning strike resistance means accidental damage rare, visually detectable
- **New possibilities for minimizing life cycle costs:**
  - ✓ Significantly reduced inspection costs for corrosion and fatigue
  - ✓ Tailorability of laminates can mean externally visible crack is worst case
  - ✓ Metal-like repair practices reduces training, equipment bills
  - ✓ Depot (heavy D) cycles can be extended greatly

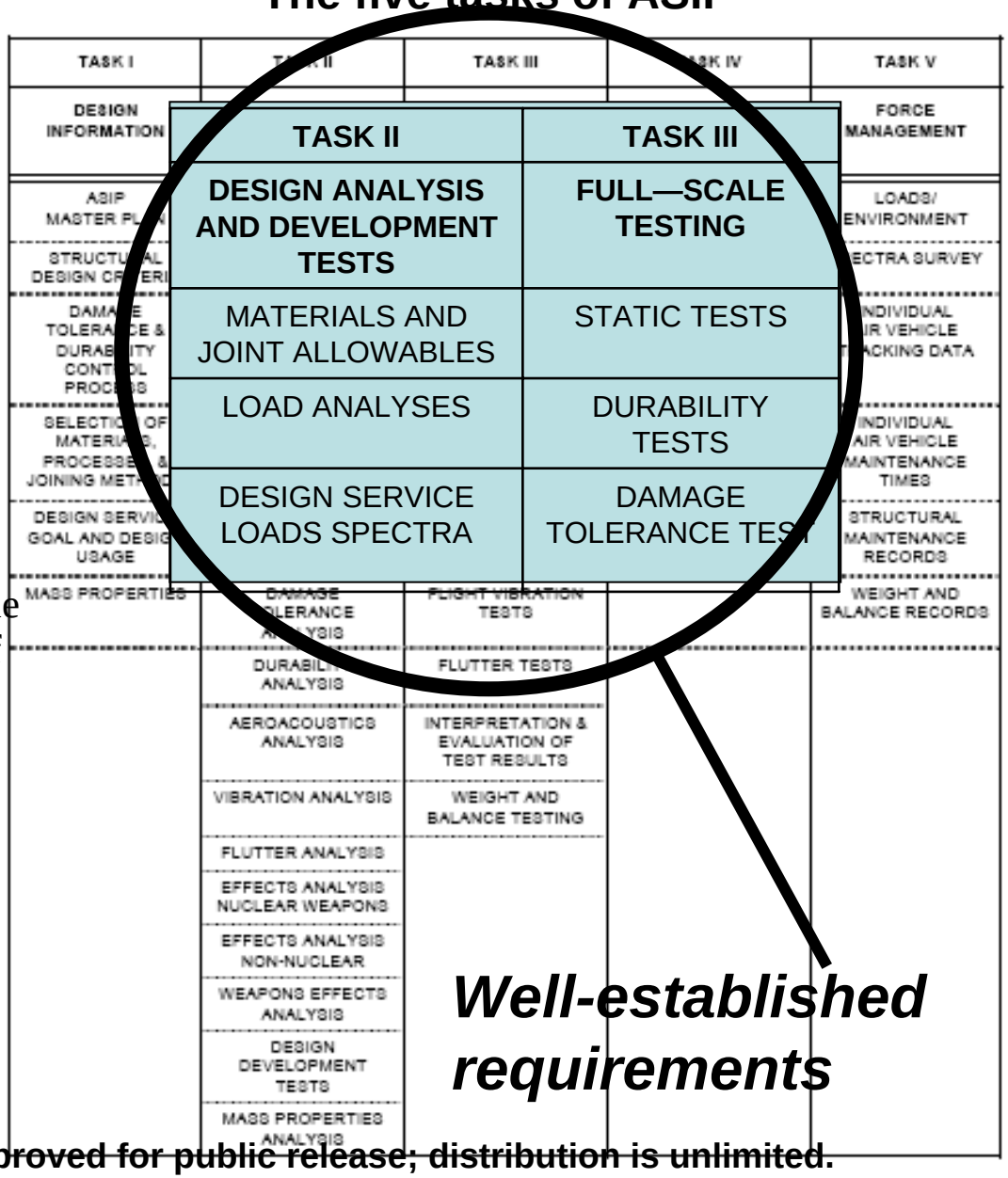
Certification Needs for Hybrid Structures

- Five principles of ASIP show the approved path
- Mixed composite/metal approach should apply
  - *Validate effects of defects (Ultimate load with largest undetectable defects)*
  - *Validate "durability impact" (Strength, life after 6 ft-lb hemisphere impact)*
- Validation of reduced costs for scheduled maintenance
  - *Eliminate fatigue as a life-limiting mechanism?*
  - *Substantially reduced corrosion?*
  - *Extended inspection requirements?*
  - *Simplified requirements for "Barely Visible Impact Damage?"*
- Durability testing still required for full-scale structure
- Validate extended life of hybrids with sub-scale panels to reduce costs?

USAF Aircraft Structural Integrity Program (ASIP)

- A proven, successful process of disciplined, managed, time-phased tasks for achieving aircraft structural integrity while also minimizing cost of ownership and associated cost/schedule risks.
- Initiates at the start of full-scale development and continues through aircraft retirement. The five tasks of ASIP are shown in the chart at the right.
- Before committing a new material to full-scale development, it must be evaluated in terms of the following five factors:
  - Producibility
  - Stabilized materials and processes
  - Characterized mechanical properties
  - Prediction of structural performance
  - Supportability

The five tasks of ASIP



Summary

- **High inspection burdens costing USAF availability, money**
  - Frequent re-inspection to achieve structural integrity expensive
- **Hybrid solutions: excellent value proposition for long-life structures**
  - Weight competitive with carbon fiber composites (CFRP), better impact performance
  - Supportability, LCC promise to be much better than Al or CFRP
- **Need to emphasize "design for inspection" of hybrid structures**
  - Keep balance between inspection, fatigue, corrosion and repair
  - Tailored FML laminates make this possible, allow largest flaws to be externally visible
- **Composite-like approach needed to certify hybrid structures**
  - Greatly improved fatigue life implies transforms expected failure modes
  - Conventional aluminum portions of structure still require durability testing
  - Akin to certification of mixed composite/metal structures
  - Need to validate "effects of defects" on structural integrity and durability
- **Reality of carefree airframes achievable**
  - Long economic life and lowest life cycle cost must be realized
  - Full-scale development of real wing structure the logical next step