# 2015 Industry/Authorities FAA Composite Transport DT & Maintenance Workshop – TCCA Perspectives

# Agenda Focus

- Composite Fatigue & DTA
- Bonded Repair
- Durability
- Furthering associated methodologies and standards

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- TCCA AARDD/S challenges, goals, and thoughts on Part 25 F&DT composite/hybrid structure

# TCCA Challenges

- Part 25 Primary Structure Composite & Hybrid designs regarded as potentially new and novel unless shown otherwise.
  - Fleet Data - *Limited*
  - Thick Composite Design & Analysis & Test Experience - *Somewhat limited*
  - Maturing of Methodologies Regs & Standards & Advisories - *ongoing/developing*
  - Generic WORKFORCE Experience & Expertise - ongoing/*developing*

# Goals

- Compliance Expertise
  - Certification Integrators
  - Designers, M&P, Stress-Persons
  - M&M (Build & Supportability)

# Goals

- <u>Supporting Regulations, Standards & Advisory Development</u>

  - Technologies and acceptable standards tend to evolve hand in hand; Standards evolution relies on technology expanded by engineering pursuits of SMEs.

## Goals

- Type Certification…maintaining ...as a minimum...the equivalent safety afforded by more conventional recent designs...evolved over 60+ years is central to TCCA's compliance expectations. Why?

# Goals

While standards and technology continue to mature…

- Gauging equivalent safety offered versus matured metal systems is a necessary safety "reference"; key to maintaining such:-
  - Maintaining overall design robustness (evolved over decades);
  - Maintaining Fail Safety <<multi load path>> <<large damage capability>>
  - Maintaining Fatigue & DTA robustness <<Flaw arrest and zero or near zero flaw growth>>
  - *Safe life alone may not be adequate for many TRANSPORT CAT designs…design dependent.*

# Goals

- Applying  Lessons learned in the TC effort

  - Make use of much good experience:- garnered in service over decades → it is essential to valuable lessons learned in effecting new designs and to support potential probabilistic based approaches and other methodologies

**Bonding - From Navair (1960)**

A problem in practical use of adhesive-bonded joints is the difficulty of insuring uniform quality. Small variations in procedure can lead to such defects as voids, unbonded areas, etc. These cannot be detected readily by (economical) nondestructive methods. Hence, scatter may be large and reliability low.

The present status of adhesive-bonded joints may be summarized as follows:

1. At best, joints in thin sheets may be quite good in fatigue—comparable in some instances to riveted or to spot-welded joints.
2. Joints may be relatively weak, and the conditions for avoiding this possibility are not yet well established. Moreover, the conditions may involve extremely careful control and inspection.

Hence, use of adhesive bonding in fatigue-sensitive areas must be viewed with caution.

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- Joint resistance to outdoor environment and  irradiation.
- Temperature and fracture energy G1c  (Epoxy to steel 60% reduction between 40C & -40C).
- Ensuring critical process variables are respected.

**Durability / Aging Effects - From Navair 1960**

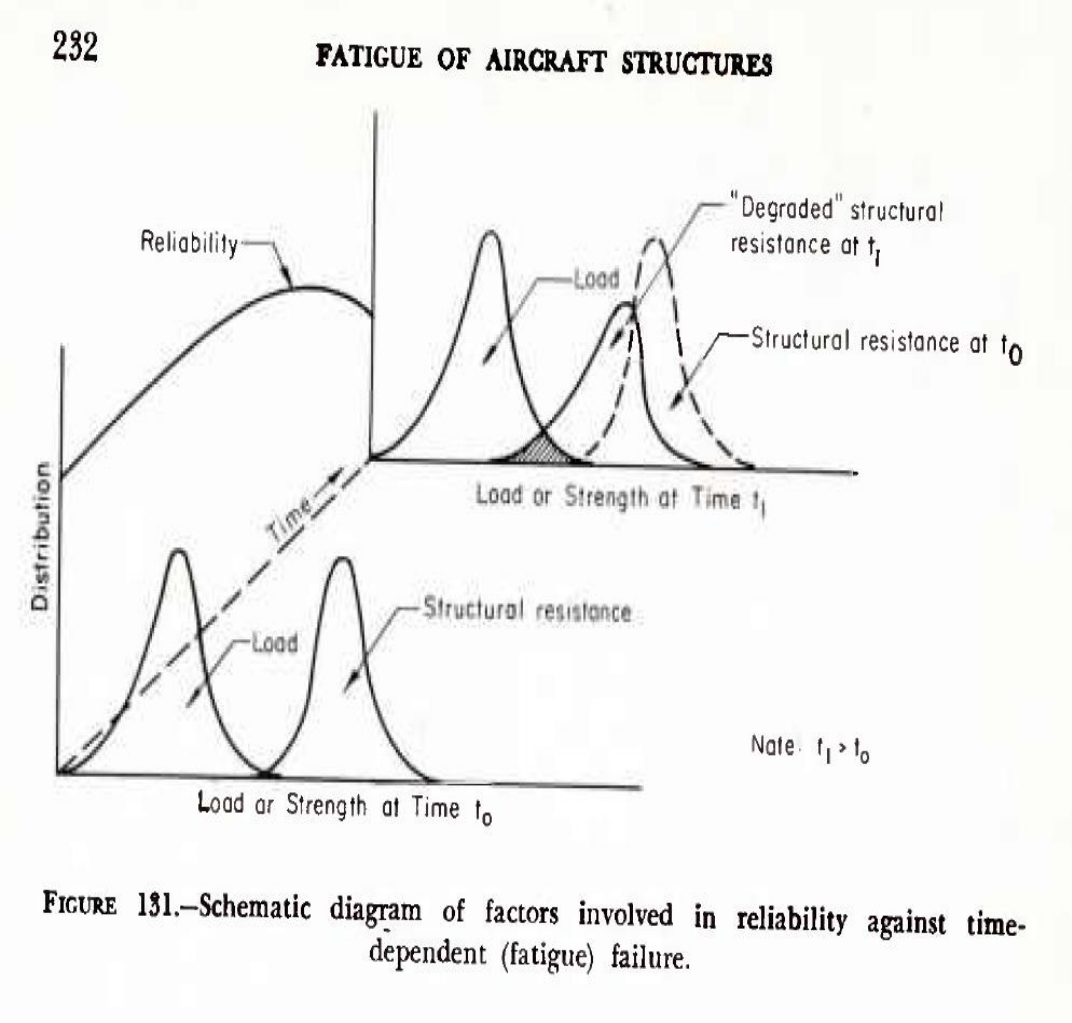


FIGURE 131.–Schematic diagram of factors involved in reliability against time-dependent (fatigue) failure.

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- From: Kinloch, A.J. (1995)Adhesion & Adhesives Science & Technology, Chapman & Hall

"Another problem that may arise upon bonding fibre-laminates is that absorbed moisture in the composite may be evolved during the adhesive bonding cycle..."

# Concluding

- **Mitigating risk associated with new or novel technologies and their "weaknesses" compared to legacy system milestones.**
- Mandating conservative approaches where necessary…conservative approaches are well founded unless empirical and fleet data allow otherwise...otherwise...less structural optimization or less critical design implications & applications.
- Ensuring Regulations & Standards are effective and efficient (in the interim…mitigation afforded by ensuring methodologies are appropriate - as established via certification endeavours to provide equivalent levels of safety.

# Concluding

- As novel materials lose there perceived “novelty”...a higher propensity to expand design application...to more complex levels. A new set of challenges.
- Designs with significant tri-axial stress states...an issue due to Matrix SigmaZ strength limitations & peeling, other intra-laminar strength limitations.
- Built-up areas prone to impact & instability driven design.
- Vigilance of the enablement of designs via empirical or probabilistic data which is “shallow” or non robust.
- Ensuring fail-safe design is maintained (multi load path or near multi load path).

# Concluding

- Ensuring the test gap/ analysis gap is minimized (test limitations/ design limitations) & understood.

  *Are our M & P interrogations for standard fastener joints for example...representative of long term degradation? TBD?*

# Concluding

- Complex designs may require the sophistication in analysis only recently achieved by many large OEMs. … FEA/PPs capable of interrogating inter-laminar stresses.

- Due to gaps in composite built-up structure analytical capability alone, complex designs necessitate extensive testing to “calibrate” or “tune” some analysis methods. This is not uncommon even for isotropic materials...but empirical public domain data is much harder to come by. The onus is on the Approved Design Organizations to empower analysts with good quality methods based on sound empirical data.

## Concluding

- Maintain Levels of Safety achieved with legacy primary structure material systems.
- Recognize material shortcomings and ensure DESIGN Compliance and AWLs & ICAs offer adequate interrogation and risk mitigation.

Quite the wish list!

End – Thank-you!