



EUROPEAN AVIATION SAFETY AGENCY
AGENCE EUROPÉENNE DE LA SÉCURITÉ AÉRIENNE
EUROPÄISCHE AGENTUR FÜR FLUGSICHERHEIT

Composite Safety Issues

European Bonded Structure

Industry/Regulator

Working Group Meeting

Koeln

13-14th. June 2013

S.Waite



Your safety is our mission.



Welcome

EASA Koeln

Room 4/49 'goldfish bowl'

(safety/building facilities briefing)

Building access/co-ordination:

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Meeting Purpose: Safe Use of Bonded Structure

Following broadly delivered EASA invitation to European Industry (EASA e-mail 19/2/13) regarding interest in this subject, the dominant themes/objectives are:



- **building on existing GAG + Δ P progress** (CMH-17 WG, NASA meeting)
 - potential for transfer of knowledge between configurations/ applications
 - define most useful form of output, e.g. policy, guidelines etc
- **identifying future priorities** (sandwich and other bonded structures) e.g.
 - applicability of NDI to existing fleets/applications
 - **GAG cycle without significant Δ P**
 - better understanding of disbond initiation and degradation science (better/standardised forensics)
 - **define any other industry concerns/priorities for the future**





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Organisations represented (50+ attendees):

Suppliers:

CYTEC/Euro-Composites/**DuPont** (Kevlar/Nomex)/HEXCEL/Schuetz Gmbh & CO
KGAA

Manufacturers:

Agusta Westland/**Airbus**/**Alenia**/Boeing/Eurocopter/Extra/**Fokker**/GKN/
HawkerBeechCraft /Rolls Royce

DOAs:

Aircraft Design and Certification Ltd/**Leichtwerk**/Lufthansa Technik/UTAS UTC

R&D/Universities:

Element/**Florida Univ.**/German Technische Univ.Dresden/ Inst. Clement
Ader/ **Inst. for Mekanisk Teknologi Denmark**/ **Univ. Utah**/**IWM Fraunhofer**/
SERGEM /Composite Expertise and Sultions

Consultants:

Adhesion Associates (M.Davis) /J2R Consulting (J.Rouchon)

Regulators & other Gvt. organisations:

FAA/**NASA**/**CMH-17**/**ACS-A**/**DSTO**(Australia)/**ENAC**/**EASA**/**TCCA**

* red text – presenting at this meeting



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Bonded Structure Meeting – Scope:

Structural Bonding (Critical Parts, PSEs, Primary, Large Secondary):

- **disbond** wrt structural bonding, including co-cured, co-bonded structure and bonded repairs
 - sandwich (including **core failure** modes)/monolithic
 - metallic/composite/hybrid structures
 - all applications, static & dynamic, e.g. large/small fixed wing, rotorcraft, propellers, engines etc
 - existing fleet technology/new fleet technology etc
- &**
- **delamination** (future focus issue?)

Note: recent Airbus/CMH-17 priorities: CS25 sandwich structure, GAG + ΔP , existing fleet structure and repairs



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Agenda (Summary) : see spread sheet for details

June 13th: Introduction/ **Sandwich Structure** theme

- update on sandwich structures - GAG + ΔP progress
- lead into 'other' bonded structure issues (GAG, failure modes, NDI)
- Workshop 1 'Sandwich Structure'

June 14th: introduce **Other Bonded Structure** issues theme

- Sandwich Structures presentations continued
- Other bonded structure presentations
- Workshop 2 'Other Bonded Structures'



Meeting Ground Rules:

- **Open discussion** is essential for a productive meeting
(building upon the Airbus example, R.Thevenin, R.Hilgers)
- Details discussed, not already in the public domain, will not be shared outside the meeting without the contributor agreement



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Surveys: Workshop Preparation Survey and Meeting Survey

Preparation Survey (distributed before the meeting):

Thank You
to those who
returned it

- intended to **initiate thought** - increase the value gained from the meeting

Meeting Survey (distributed just before the meeting):

- **record thoughts / comments** regarding:
 - **Workshops 1 & 2**
 - **Presentations**
- completion by all attendees requested, recognising the different functions represented across the industry
- return to the organisers after the meeting (14th July 2013)
- organisers to use collated data to propose conclusions and objectives to the group, e.g. need for policy, guidance, R&D etc



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Background: Existing Rule/Guidance: AMC 20-29/AC20-107B, via ref. to **CS23.573(a)(5):**

many limitations/caveats

'For any bonded joint, the failure of which would result in catastrophic loss of the aeroplane, the limit load capacity must be substantiated by one of the following methods:

(i) The maximum disbonds of each bonded joint consistent with the capability to withstand the loads in paragraph (a)(3) (i.e. critical limit flight loads considered ultimate) of this section must be determined by analysis, tests, or both. Disbonds of each bonded joint greater than this must be prevented by design features; or

Not to be used to address poor process, poor process is unacceptable, ref. 2x.605

(ii) Proof testing must be conducted on each production article that will apply the critical limit design load to each critical bonded joint; or

Not practical for large aircraft, does not address degradation, loading process damage

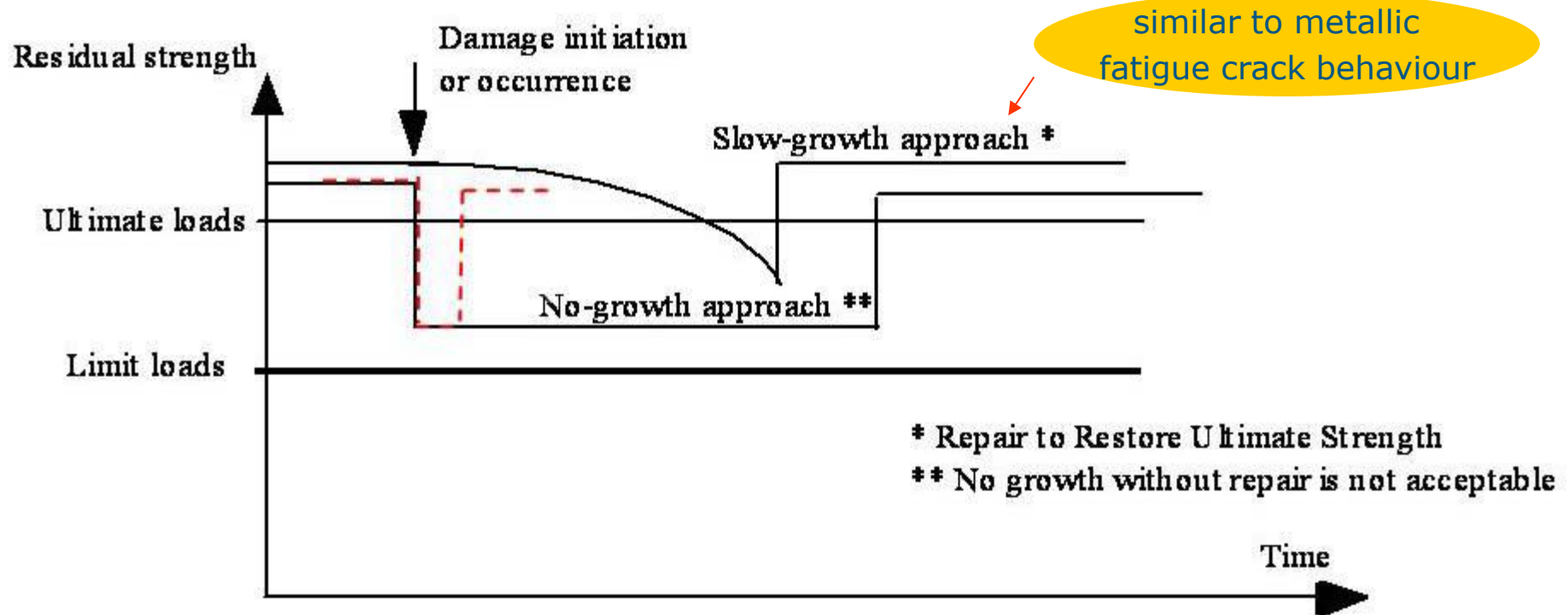
(iii) Repeatable and reliable non-destructive inspection techniques must be established that ensure the strength of each joint.'

'Weak Bonds' and 'Tight Disbonds'

- cannot be reliably detected by Visual Inspection*
- have not been shown to be reliably detected by NDI at a production scale*



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- Shows Acceptable Interval at reduced RS before being repaired (No-growth case).
- Shows Unacceptable Interval at reduced RS before being repaired (No-growth case).

or failed bond/repair!

Fig 4 - residual strength illustrating that significant **accidental damage** with "no-growth" should not be left in the structure without repair for a long time.

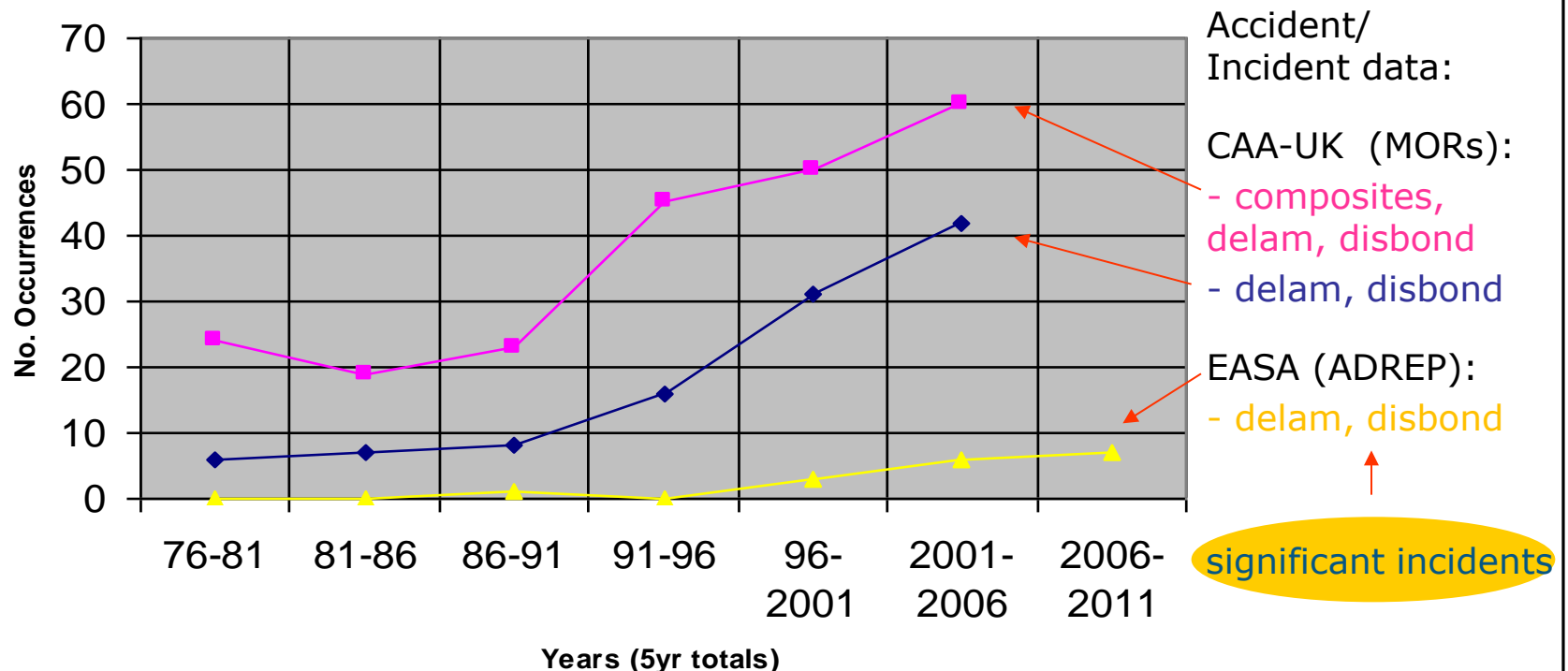


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Note: data needs further investigation: unacceptable 'disbond' – cause or witness?

Mandatory Occurrence Reports (MORs) & ADREP Incidents/Accidents

search terms: composites, delaminations, and disbond



*MOR (UK CAA CAP382) : prevent accidents/incidents...not to attribute blame/liability

Many examples: e.g. AD2010-26-53 ...emergency AD – significant failure during acceptance flight test – 7 foot skin disbond from the upper forward wing spar



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Several conditions are required to exist together for disbond or delamination to be a safety issue:

- a disbond/weak bond/delamination exists
&
- < UL capability
(large damage/disbond, critical location)
&
- damage/defect remains undetected
&
- load event > Residual Strength capability (>LL)
- all of these conditions do occur occasionally, but typically not together....
- not enough data to meaningfully quantify
- most events not significant safety issue
(most applications have not been significant)

e.g. in-service disbond reported
(repair/production issues) approx:

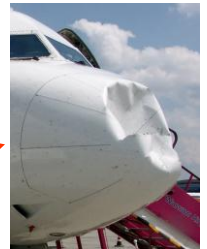
1 incident 10^6 hrs

1 serious incident 10^8 / 10^9 hrs

No fatal accidents

(CAA-UK MOR & fleet data only)

repair or
remanufacture?



However, some have
(incidents beyond CAA – UK data)

**1 serious incident/accident
> 10^8 hrs**

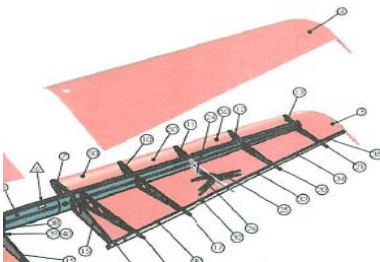


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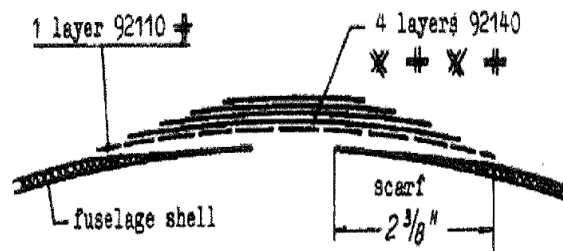
more standardisation
required?

CS 22/23 Bonded Structure – comments:

- extensive use of bonded structure in critical structure applications, e.g. spar/wing cover, bonded glider tail structure repair etc
- maintain a generally acceptable level of safety with more limited process control etc, for reasons not conclusively understood, but opinions include:
 - limited point design results in low stresses elsewhere - < weak bond strength levels...
 - some stiff structures e.g. bonded aerobatic spar/wing cover, limit strain contribution to divergent complex damage sequence deformation/stresses...



Bonded Wing/Spar
- no fasteners



Separated Glider Empennage
Splice Repair



Wing Rib Disbond
- porosity



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more standardisation
required?

CS25 Bonded Structure – comments:

Existing Fleet – extensive use of sandwich structures in Primary and large Secondary Structures – needs attention – NDI?

- evidence of poor repair execution – particularly sandwich structures
- configuration (old)/material degradation issues: Concorde Rudders*/Elevons, AIR TRANSAT Rudder (well described by Airbus)

New Fleet – less sandwich structure, improved configurations, improved use of design rules (>LL capability – one skin failed), more co-cured and co-bonded monolithic structure, e.g. fuselage skin/stringers

* only significant events in CAA-UK database - metallic sandwich structure, first set failure – suspected adhesive **degradation**, second set failure - machine oil **contamination**





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more standardisation
required?

CS27/29 Bonded Structure – comments:

- extensive use of monolithic and sandwich structure in critical structure applications (more than CS25)
- generally acceptable level of safety maintained
- some 'grandfathered' technologies continue to be used
- some significant disbonding, delamination, and core failure related incidents (sandwich and monolithic, in development and in-service), some events evident in ADs etc
- patchwork approaches to resolving development/certification/ in-service events across the industry

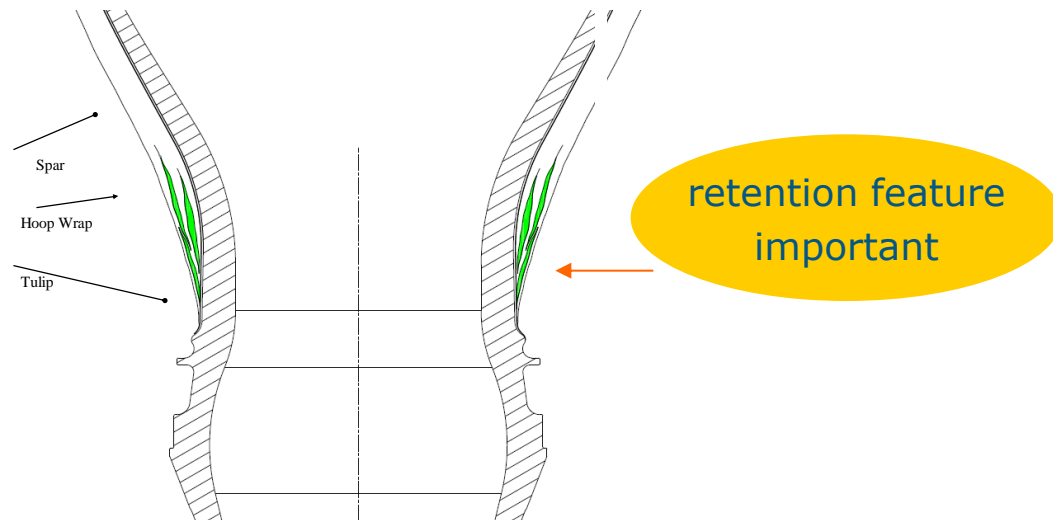
note: some development
test failure is useful – aids learning



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CS-P (propellers) Bonded Structure – comments:

- VARTM cover bonded to metallic tulip root
- disbonded blade retained by 'back-up' feature during in-service event (AD issued)
- importance of 'back-up' retention feature proved





Composite Repair Standardisation

Pre-Meeting Conclusion:

Safety requires:

- good practice - design, production, and continued airworthiness
- reliable prediction of Failure Loads, Modes, and Locations
- **industry has experienced several serious, and generally lucky, warning incidents, some challenging the requirements above**
- **industry cannot afford catastrophic bonded structure failure**
(concern: undetectable and BVID level disbond, core failure modes, or delamination)
- **need to improve current practice, refine design rules, and to standardise**

Reminder: CS 2x.601 General

The aeroplane may not have design features or details that experience has shown to be hazardous or unreliable...



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THANK YOU!

QUESTIONS?