"European Bonded Structure Meeting "

EASA – Cologne, June 2013

ENAC perspective

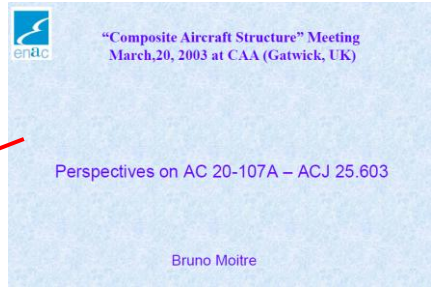
Bruno Moitre

- Issues evidenced from certification experience - Commonalities between fixed wing and rotorcraft

European Bonded Structure Meeting

Extract from ENAC Certification Experience

20-03-2003 at "Composite Aircraft Structure" Meeting, CAA Gatwick



- Lack of guidance material for primary adhesive bonded structures (definitions, examples, peculiarities, weakness, criticalities)
- Lack of specific guidance on fatigue spectra development, particularly with systems interacting with structures
- Acceptable LEF, C.of V. would be helpful
- Realistic threat assessment examples tailored to typical applications/products seen as valuable for standardisation (take MIL HBK17 and condense figures ?)
- Typical manufacturing discrepancies (type and size) examples vis a vis NDE selected of help

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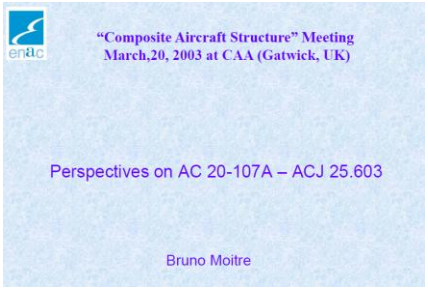
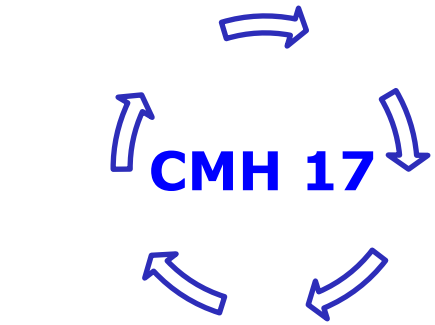
PERSPECTIVE

WHAT ?



- Courses, training opportunities (design, certification, manufacturing and Q.A.) for AA's and Applicants' specialists. Seminars valid for experts
- Promote Standardisation
- Cross fertilisation, certification experience



WHO & HOW ?

European Bonded Structure Meeting

From FAA AC 20-107 to AC 20 107 B & AMC 20-29

U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: Change 1 to COMPOSITE AIRCRAFT STRUCTURE | **Date:** August 24, 2010 | **Initiated by:** AIR-100 | **AC No:** 20-107B | **Change:** 1

1. PURPOSE. This Change corrects minor errors in the original AC. Under paragraph 8a(1)(c)(i), an "or" is changed to "and"; under Figure 3 in paragraph 8a(1)(c), the box for "Category 3 Damage" is reworded; the definition for "No-Growth Approach" is moved to place it into correct alphabetical order; and page numbers within Appendix 2 are revised to be correct.

2. CHANGE TEXT. Changed text is indicated by vertical bars in the margins.

PAGE CONTROL CHART

Remove Pages	Dated	Insert Pages	Dated
12	9/8/09	12	8/24/10
13	9/8/09	13	8/24/10
Appendix 2, A2-2	9/8/09	Appendix 2, A2-2	8/24/10
Appendix 2, A2-3	9/8/09	Appendix 2, A2-3	8/24/10

David W. Hempe
Manager, Aircraft Engineering Division
Aircraft Certification Service

20-03-2003

28-01-2009

8-9-2009

19-07-2010

CMH 17

ED Decision 2010/003/R
19/07/2010

European Aviation Safety Agency

DECISION N° 2010/003/R
OF THE EXECUTIVE DIRECTOR OF THE EUROPEAN AVIATION SAFETY AGENCY

OF 19 JULY 2010

amending Decision No. 2003/12/RM of the Executive Director of the European Aviation Safety Agency of 5 November 2003 on general acceptable means of compliance for airworthiness of products, parts and appliances (« AMC-20 »)

"Composites"

THE EXECUTIVE DIRECTOR OF THE EUROPEAN AVIATION SAFETY AGENCY,

Having regard to the Regulation (EC) No 216/2008 of the European Parliament and of the Council of 20 February 2008 on common rules in the field of civil aviation and establishing a European Aviation Safety Agency, and repealing Council Directive 91/670/EEC, Regulation (EC) No 1592/2002 and Directive 2004/36/EC[1] (hereinafter "The Basic Regulation"), and in particular Article 38(3)(a) and (e) thereof,

Having regard to the Commission Regulation (EC) No 1702/2003 of 24 September 2003 laying down implementing rules for the airworthiness and environmental certification of aircraft and related products, parts and appliances, as well as for the certification of design and production organisations[2], in particular 21A.16A of the Annex to Commission Regulation (EC) No 1702/2003 (Part-21) thereof,

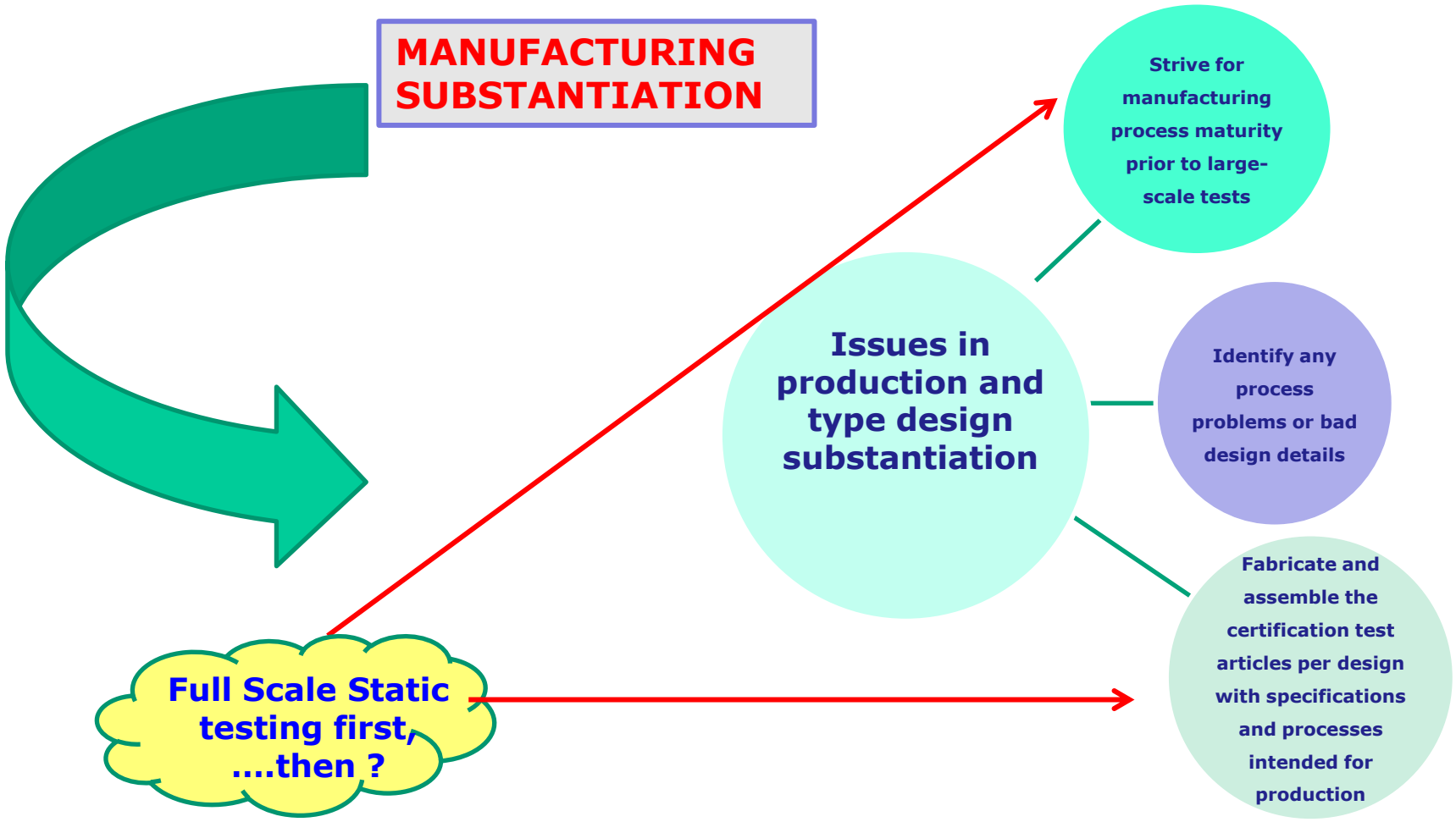
Whereas:

(1) The Executive Director of the European Aviation Safety Agency issued general acceptable means of compliance for airworthiness of products, parts and appliances («AMC-20») in the Annex to Executive Director Decision 2003/12/RM of 5 November 2003 (Initial Issue)[3].

[1] OJ L 79, 19.03.2008, p. 1. Regulation as last amended by Regulation (EC) No 1108/2009 of the European Parliament and of the Council of 21 October 2009 (OJ L 309, 24.11.2009, p. 51).
[2] OJ L 243, 27.9.2003, p. 6. Regulation as last amended by Regulation (EC) No 1194/2009 of 30 November 2009 (OJ L 321, 8.12.2009, p. 5).
[3] Executive Director Decision 2003/12/RM of 05 November 2003 as last amended by Executive Director Decision 2009/019/R of 23 December 2009 (AMC-20 Amendment 5).

R.F012-02 © European Aviation Safety Agency, 2010. All rights reserved. Proprietary document. Page 1 of 2

FAA AC 20 107 A , 25/4/84


MANUFACTURING SUBSTANTIATION
Strive for manufacturing process maturity prior to large-scale tests
Issues in production and type design substantiation
Identify any process problems or bad design details
Fabricate and assemble the certification test articles per design with specifications and processes intended for production
Full Scale Static testing first, ….then ?

- Issues evidenced from certification experience -

Commonalities between fixed wing and rotorcraft

Issues evidenced from certification experience

ISSUE	COMPONENT	FIXED WING	ROTORCRAFT	IN COMMON
Critical condition selection under competing failure modes/loads	Fin		Y	Partially
Premature failure (Static HW)	Fin		Y	Potentially
Manufacturing discrepancies & Impact Risk assessment	All	Y	Y	Partially
Fatigue Spectra Development	All	Y	Y	YES (but significantly different)
Fatigue Spectra Truncation & 1g level flight load	H STAB	Y		NO
Side loads at landing (Thrust Rev. Deploy/t)	Empennage (T Tail)	Y		NO
Leading edges static strength (including residual)	Empennage Wings	Y		NO

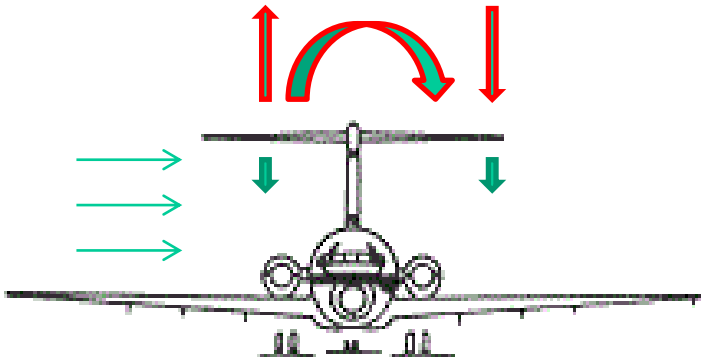
Issues evidenced from certification experience

ISSUE	COMPONENT	FIXED WING	ROTORCRAFT	COMMON
Strains induced by differential thermal expansion - GAG Thermal Cycling [Static & Fatigue]	Composite Pressure Bulkheads & Fin/Fuselage attachments	Y		Potentially
In service occurrences (tail strike)	Rear fuselage		Y	Potentially
Quality Control & Proof Testing	All	Y	Y	With differentiations
Moisture ingression Honeycomb Side Facing	All	Y	Y	Y
Process Control & Production deviations	All	Y (GA & VLA)		May be
Secondary Structures	Canopies- Doors	Y	Y	YES
Aluminium skin-stringers bonding process & QC	Fuselage upper and crown panel	Y		YES (H.P.'s)

Issues evidenced from certification experience - T Tail Configurations

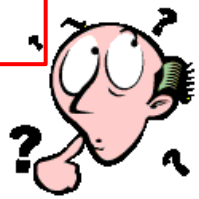
HSTAB Loading Condition & Top Rolling Moment oscillations on ground

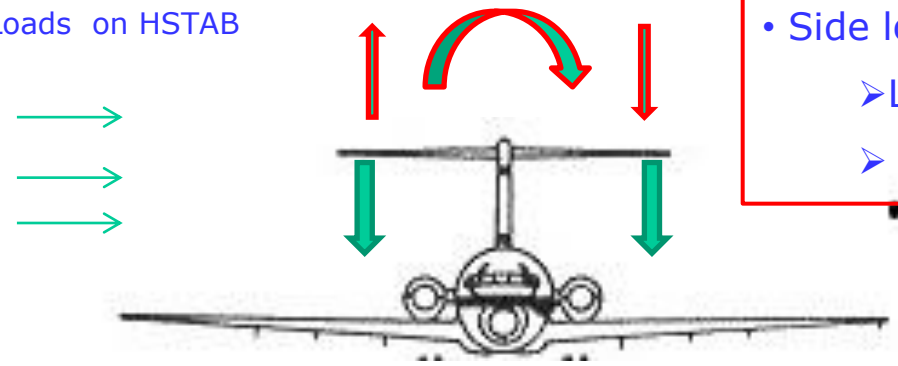
- Side loads on the FIN
  - Lateral Gusts
  - **Thrust reverser application**
  - Rudder Displacement



= Top Rolling Moment & Forces

= Symm. Loads on HSTAB





HSTAB Loading Condition & Top Rolling Moment in flight

- Side loads on the FIN
  - Lateral Gusts
  - Asymm. Manouvres

RH or LH upper HSTAB Panels :normally tension loaded in flight (1 g level flight) **but compression loaded** on ground (oscillatory loads resulting from thrust reversers application)

Issues evidenced from certification experience - T Tail Configurations

•During Landing run segment, thrust reversers' application produce air flow turbulence around the empennage

• For empennage T-Tail configurations, turbulence induce oscillatory rolling movements on the HSTAB, transferred through the whole empennage and rear fuselage, lasting the entire thrust reversal phase

• Load oscillations have negligible effect on static strength point of view **however can have effect** on Durability & DT :

- ❑ **for composite** empennage components/back up structure if measured peak loads combined with LEF > 30% of limit TRM
- ❑ **for metallic parts** (particularly on metal fittings at HSTAB-FIN interface) since in flight compressive dominated stress fields do locally change to tension dominated-crack opening stress fields)
- ❑ may affect **rear fuselage** as well

Issues evidenced from certification experience - T Tail Configurations

- Flight testing data measurements recommended with (conservatively) minimum braking power applied
- Flight test data & fatigue analysis with modified fatigue spectra showed significant decrease of expected inspections intervals in the empennage zone (metals)
- Oscillatory measured loads were shown within acceptable 30% of LL truncation level for composite structure ….however …

Depending on specific designs may show no negligible effect on composite as well

Issues evidenced from certification experience – Rotorcraft Composite Tail Unit

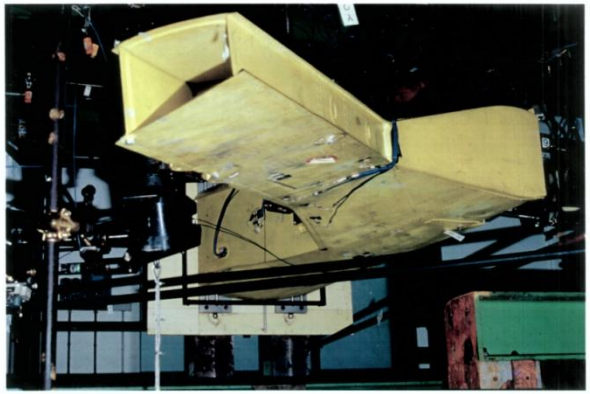
Rotorcraft Composite Tail Unit experience

• Early identification by FSS testing at RTD of a design criticality (drastic geometric change - Kink) solved by pre cert/n design improvement then followed by :

• Impact damage hazard assessment : in production and in service

• Manufacturing Discrepancies – commensurate to audit by T.C. Team specialists

• Sub-component testing (test articles with manufacturing discrepancies and BVID impact damages) agreed upon to establish appropriate truncation levels to be applied during full scale spectrum fatigue tests



Issues evidenced from certification experience – Rotorcraft Composite Tail Unit

Rotorcraft Composite Tail Unit experience

- Selection of critical condition for static strength substantiation :
  - TR thrust loads as function of Temperature (higher thrust at lower T)
  - Yaw maneuver in hovering and forward flight (V_{NE})
  - Rolling pull out maneuver
  - Hybrid load condition selected
  - No competing failure modes (RTD vs HTW) evidenced (hybrid load condition was selected for testing)

Concluding Remarks on ENAC perspective

- Composite Production(Manufacturing & Q.C.) of rotorcraft susceptible to Human Performance Lim./ns (applicable to fixed wing as well)
- Maintenance should already cover H.P. Lim/ns [ref. Part 145] however the burden should also be seen at the type design stage level (i.e. Maint. & Repair Manual)
- Need for early design considerations on accessibility, maintainability, probability of flaws/damage hazards/detection, frequency of inspections commensurate to Human Performances
- Fatigue spectra and usage' assumptions: this aspect is to some extent in contrast with the characteristic operation flexibility of helicopters.
- Certification effort to be paid as aimed at evaluating and comparing severity of different spectrum
- Conservative versus realistic omission levels in particular when crack propagation or flaw tolerance testing are conducted

Concluding Remarks on ENAC perspective (cont.)

- TC team specialist involvement in pre-production for definition of Test articles seems essential for new design/process/material in absence of previous validation/experience by either the POA (particularly with new production sites) or production subcontractors
- Concern on GA small/new Applicants with limited composite experience
- A dedicated **QAPP** (elsewhere named **Product Integrity Program Plan**) during Type Certification phase is suggested aimed at managing and controlling the qualification activities to be launched for the dual scope of assessing the envisaged production capability (including sub contractors) as well as providing evidences in support of TC with the required degree of certitude and traceability.
- Also contribute to limit the burden to AA's personnel involved in TC,DOA,POA approval (interfaces)

Concluding Remarks on ENAC perspective (cont.)

- A **QAPP** could be conceived to constitute the basic design data tool (albeit susceptible of revisions and changes in parallel with the needs coming from production/ qualification experience and data gathered during the process) to (listed not in any order of importance) :
  - ✓ guide production/engineering/Q.A. people on their allocated work and scope, identify their acting functions and responsibilities in the development and production phases
  - ✓ form the basis for conformity declaration of test articles
  - ✓ coordinate in an efficient, controlled manner the many and differentiating tasks
  - ✓ help AA's team (POA,DOA,TC) to better address their involvement with no undue burden but in an efficient and coordinated fashion at the right point in time increasing efficiency and reducing gaps

Concluding Remarks on ENAC perspective (cont.)

- ✓ identify and record the evolutionary steps of the Type Design configuration before TC is granted of each single critical item and process parameter to best support engineering judgement on the maturity achieved by POA, DOA, TC compliance demonstration
- ✓ ensure representativeness (conversely the degree of non conformance) of the many specimens and test articles proposed in support of TC for their intended scope and limitations
- ✓ guarantee readiness for the implementation of engineering special drawing/deviations such as instrumented test specimens, production witnesses pieces, tear down production articles
- ✓ guarantee the Product's Integrity

Concluding Remarks on ENAC perspective (cont.)

- Entry into service of large full composite fuselages has prompted attention on adequacy of current SARPS envisaged by ICAO Annex 8 to maintain global recognition of the Certificate of Airworthiness.
- It is recommendable to invest on ground handling personnel awareness having regard of the high number of occurrences nowadays recorded for the time being on conventional metal fuselages
- Presentation on fatigue spectra development to follow

Thanks for the attention !