

**FAA Bombardier Composite
Transport Workshop (Sept 15
17, 2015)**

Prepared: J. van Doeselaar/ S. Rabois/
J.L. Leon-Dufour

**Smart(er) testing –
Airbus perspectives**

**Pyramid considering past
experience, and use of
demonstrators**



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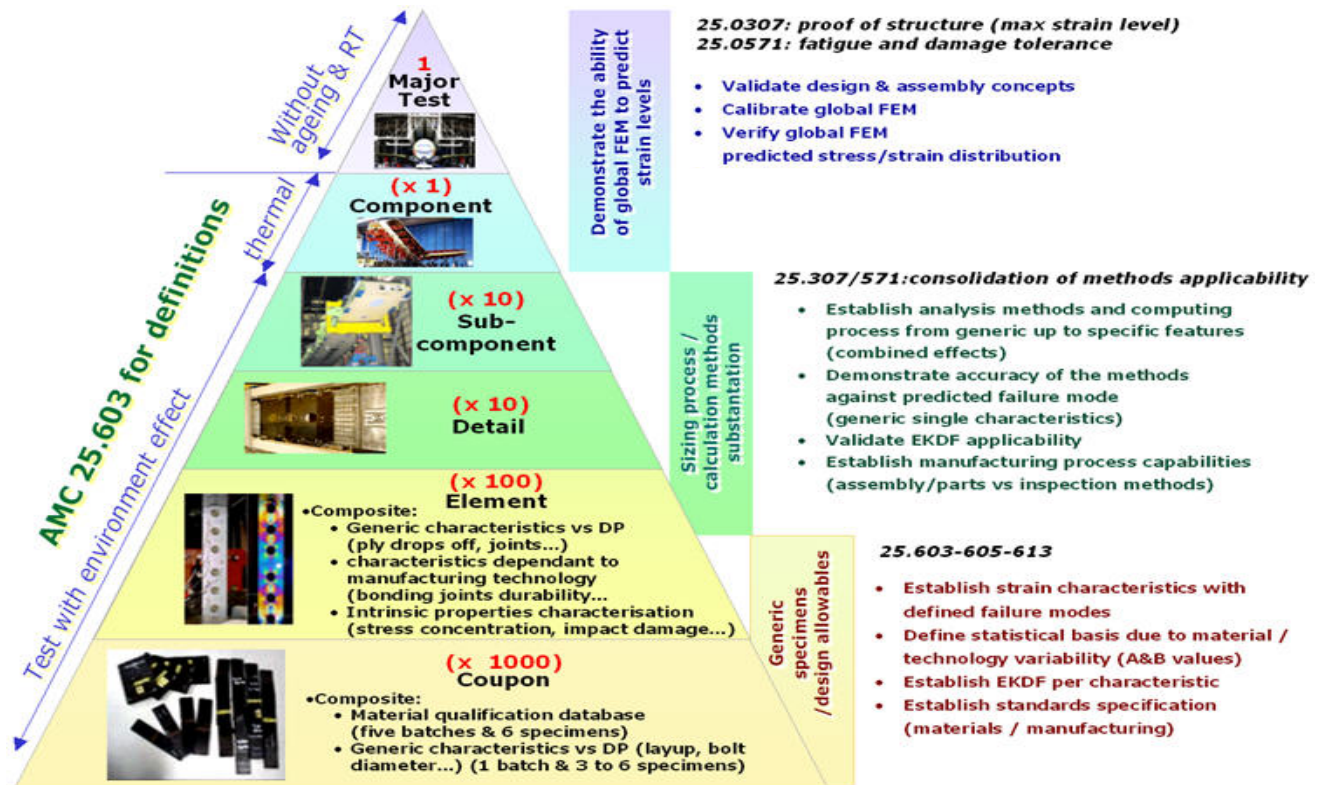
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Certification & testing approach

- Certification & testing methodology using building block approach
- Extensive test program developed to fill the pyramid



Pyramid considering past experience – regulatory context CS25.307 and AMC25.307



- CS25.307 ...Structural analysis may be used only if the structure conforms to that for which experience has shown this method to be reliable. In other cases, substantiating tests must be made.....
- AMC25.307...The application of methods such as Finite Element Method or engineering formulas to complex structures in modern aircraft is considered reliable only when validated by full scale tests (ground and/or flight tests). Experience relevant to the product in the utilisation of such methods should be considered....
- *Full Scale*. Dimensions of test article are the same as design; fully representative test specimen (not necessarily complete airframe).



Analysis can be used if methods at one point in time have been validated by a representative specimen at appropriate scale.

(Inline with intent AMC20-29)

Pyramid considering past experience – regulatory context AMC25.307



- AMC25.307 The following factors should be considered in deciding the need for and the extent of testing including the load levels to be achieved:
 - (a) The classification of the structure;
 - (b) The consequence of failure of the structure in terms of the overall integrity of the aeroplane;Relevant service experience may be included in this evaluation



Distinguishes between ‘New structure’ and other structures for which reliable analysis methods are applicable.



Focus on structure items linked to overall integrity of aircraft, i.e. PSE

Pyramid considering past experience – regulatory context AMC25.307



- *New Structure*. Structure for which behaviour is not adequately predicted by analysis supported by previous test evidence. Structure that utilises significantly different structural design concepts from previously tested designs.
- Typically new structure: Analysis, supported by new strength testing.
.....normally requires testing of sub-components, full scale components or full scale tests of assembled components (such as a nearly complete airframe).
- Elements that should be considered are :
 - (i) The accuracy/conservatism of the analytical methods, and
 - (ii) Comparison of the structure under investigation with previously tested structure.

⇒ **Further testing required only when no previous test evidence is applicable due to significant different concepts**

⇒ **Further testing at “appropriate integrated level” is intent of AMC**

SMART testing – example 1

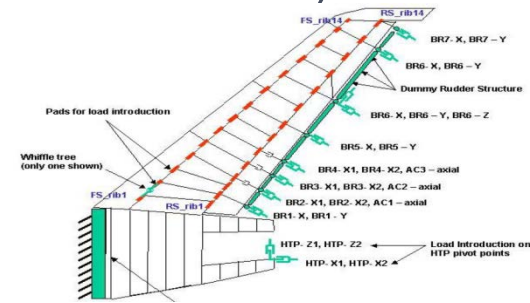
Vertical tailplane component test

The objective of this test is to:

- Validate the analysis methods (incl. GFEM, internal loads distribution)
- Contribute to proof of structure demonstration (limit and ultimate load)
- Contribute to damage tolerance demonstration

- Review of past test experience:

- Maximum strain levels + fatigue spectrum are within previous test experience.
- BVID criteria comparable to previous programs.
- Manufacturing damages are comparable
- No detrimental growth covered by previous test experience.



Fatigue phase of test covered by previous test experience.

Use of demonstrators

Demonstrators developed when design concept doesn't encompass previous experience

- Example A350 composite demonstrators:
- For Fuselage:
 - Fuselage barrel Demonstrator
- For Wing:
 - Outer Wing box Demonstrator
- For Empennage:
 - Vertical Fin root joint Demonstrator

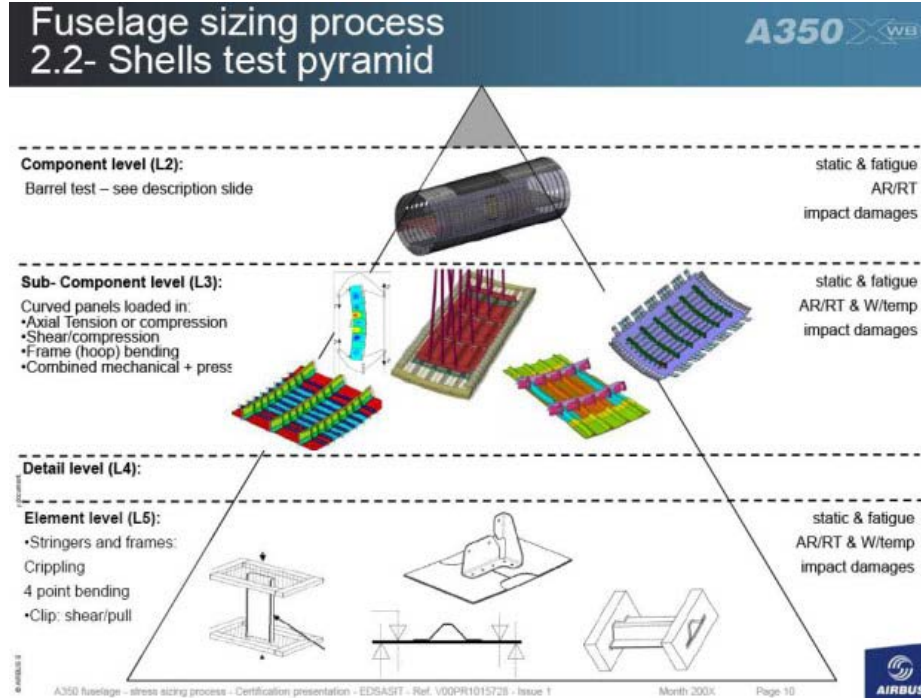


Use of demonstrators – example 2

Pyramid developed for CFRP fuselage

- Demonstrators on fuselage (Barrels tests) are able to confirm at integrated level the lower pyramid tests (panels & details)
 - accurate levels of validation for methods (modelling & failure criteria interactions)
 - accurate boundary conditions (i.e. confirm no scale effect)
- Demonstrators consolidate Design principles and Manufacturing processes

➔ **Barrel test used as top pyramid test for typical CFRP fuselage static and F&DT analysis validation**



Use of demonstrators

Analysis and demonstrator testing approach.

- Intensive use of Modelling (GFEM, DFEM, Linear and Non linear) to consolidate analysis process, address demonstrator test prediction models, and bridge differences with TC design.
- Demonstrate the ability of DFEM to predict strain levels so as to contribute to proof of structure as per CS or FAR 25.307 (a):
 - Validate design and assembly concepts
 - Validate GFEM & DFEM models and predicted stress/strain distribution
 - Predicts non-linear static behaviours up to failure



Conclusion: Pyramid considering past experience and use of demonstrators

- MoC is generally analysis validated by testing
- Strong link in regulation between testing and validation of analysis methods
- Take into account significant test portfolio of past 40 years programs and evolution of analysis capabilities
- Large scale demonstrator test specimen able to function as “top of pyramid” test at integrated level
 - Validate the analysis methods at integrated level (FEM, internal load distribution)
 - Encompass failure mechanisms
 - Static, fatigue and damage tolerance demonstration
- Smarter testing aspect:
 - ⇒ Focus more on re- using existing testing
 - ⇒ Demonstrators as basis for new program development
 - ⇒ Combined with significant effort on predictive analysis

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