EASA Sandwich Structure Workshop:

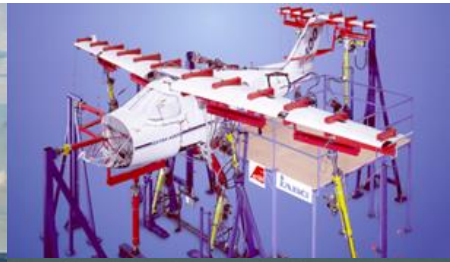
Sandwich structures in the AFF

Cologne October 18th 2016

Marcus J. Basien, AFF President




- Who and what is the AFF?
  - Companies
  - Products
  - Typical design
- Limits of the AFF universe
  - Production method
  - Materials
  - Airplane limits
- Sandwich structures and respective production technology
  - Curtesy Grob Aircraft AG, Example of Grob G- 120TP-A Trainer
- How are sandwich structures in this universe substantiated?
  - Structure criticality/classification
  - Analysis
  - Strain levels
  - Test
  - Service experience
- Repair



AFF





EASA
European Aviation Safety Agency




DLR

C. CRAMER & CO.
INDUSTRIAL FABRICS

adxc
aircraft design & certification ltd.

LBA

ETEMME

EASA
European Aviation Safety Agency

IFB Institut für Flugzeugbau
Universität Stuttgart

SFL

iABG

GROB AIRCRAFT
POWERED BY H3

AeroFEM GmbH
Simulation & Engineering

HEXION

EXTRA

ZEPPELIN NT
Die schönste Art zu fliegen

RS

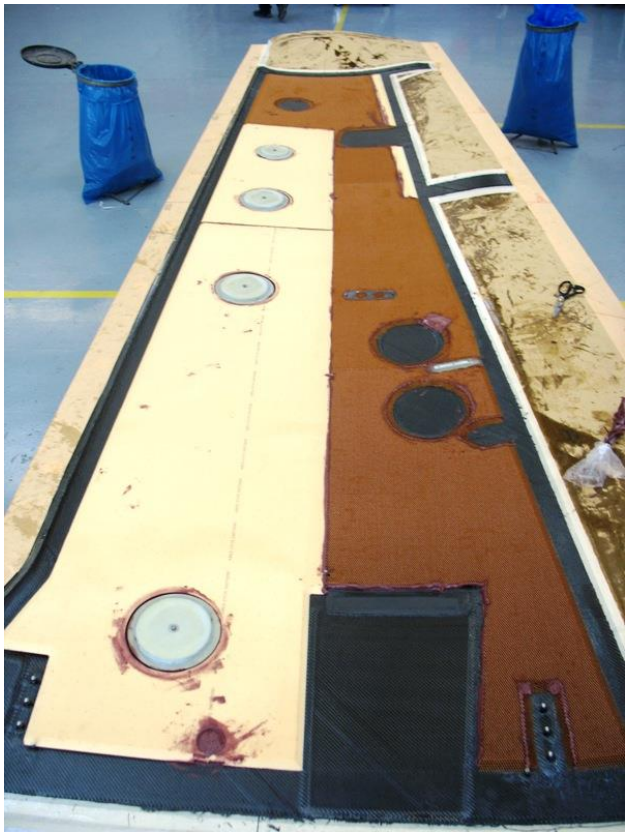
TohoTenax

DORNIER SEAWINGS

BAM
Bundesanstalt für Materialforschung und -prüfung

interglas

- Typical design wing shell



Curtesy: Grob Aircraft AG




- Typical design assembly

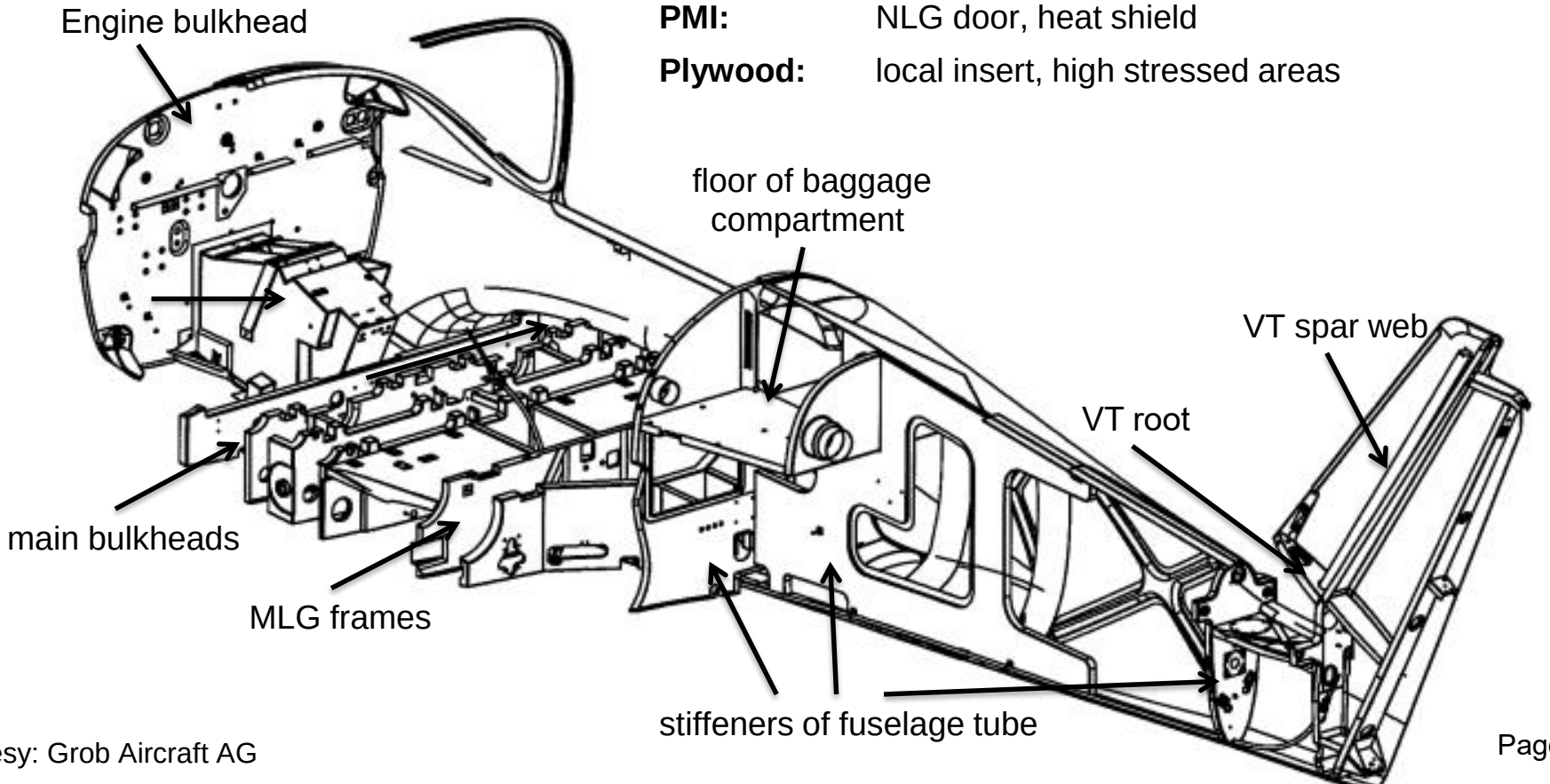


Curtesy: Extra Flugzeugproduktions- und Vertriebs GmbH




- Typical design

Honeycomb:	bulkheads, frames & stiffeners. Lifting surface shells
PVC:	engine bulkhead, spar web & root rib of vertical tail, wing walk area, wing spar stubs, winglets, control surface shells
PMI:	NLG door, heat shield
Plywood:	local insert, high stressed areas



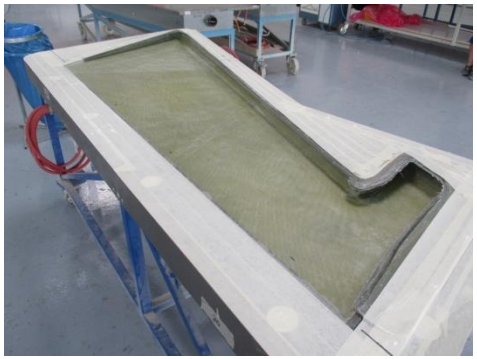
Curtesy: Grob Aircraft AG




- Limits of the AFF universe
  - Design and Production method
    - mostly wet fibre laminate
    - some resin infusion
    - very little pre-preg
  - Materials
    - mostly E-glass and T300 or similar
    - woven, UD and roving
    - epoxy resin with relatively little moisture take up
    - PVC / PMI / Nomex cores for sandwiches
    - Plywood, massive laminate for local insert
  - Airplane limits
    - OAT and Altitude range do not impose a too severe (sandwich) internal moisture/pressure problem
    - dto. for Airplane usage limits (cycles/hours per annum)




PRODUCTION TECHNOLOGY, FOAM CORE



laminate outer skin of sandwich

impregnate foam core with resin
(use 10 g/m^2 – 20 g/m^2 per side)

foam is perforated; hole spacing: 32 mm
edges of foam core are tapered

position foam core on outer skin

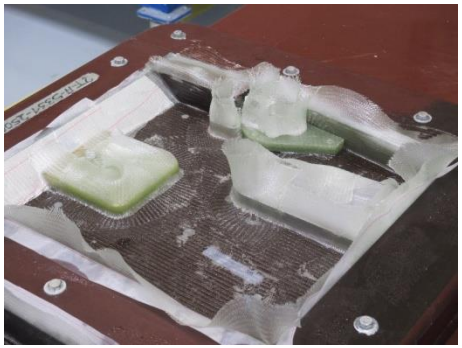
laminate inner skin of sandwich
& apply vacuum bag

prepare vacuum application
& cure sandwich structure

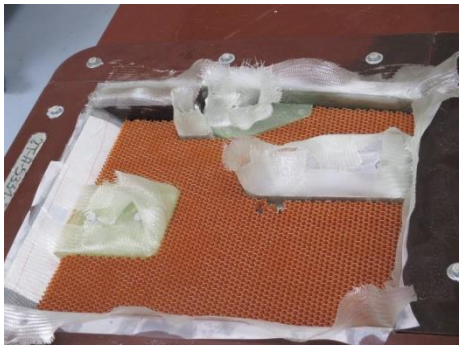
Curtesy: Grob Aircraft AG




PRODUCTION TECHNOLOGY, HONEYCOMB CORE

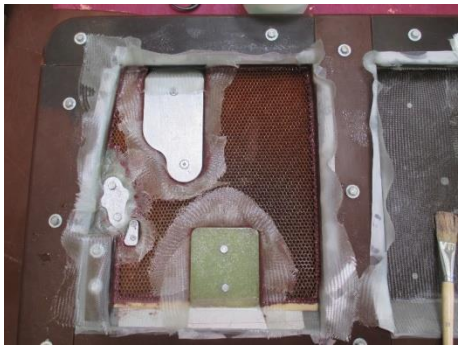


outer skin of sandwich
film of resin + thixotropic agent (80g/m²)



position honeycomb
foam core

fill the edges with
resin + microballoons



inner skin of sandwich,
film of resin + thixotropic agent

apply inner skin of sandwich

prepare vacuum application
and cure sandwich structure

Curtesy: Grob Aircraft AG

- Sandwich production technology, summary
  - General:
    - Preparation or sandwich in one or two steps, depending on complexity
    - Edge fillings, load introduction fillings and bonding layer formulated with laminating resin
  - Foam core:
    - Application of bonding layer on core
  - Honeycomb:
    - Application of bonding layer on laminate




- How are sandwich structures in the AFF universe substantiated?
  - **Structure criticality/classification (HFF 52 110)**
    - According DIN 65085
      - Class I: Primary structure with potential of loss of life or loss of aircraft
      - Class II: Primary structure with potential of loss of mission, controlled landing possible
      - Class III: Secondary structure
    - Classification drives requirements for quality control during production
      - Class I & II: component specific QA instruction, each component
      - Class III: general QA instruction, option for spot check on larger batches

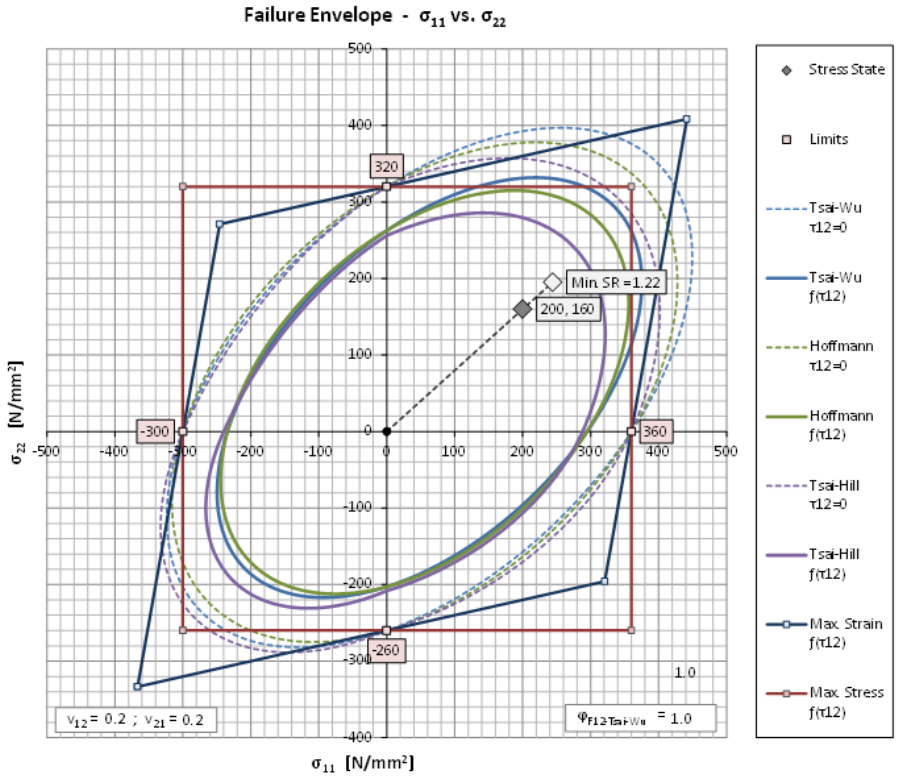



- How are sandwich structures in the AFF universe substantiated?
  - **Strain levels (at LL)**
    - Glas 0.7..0.10%
    - Carbon approx. 0.5%
    - Applicable to monolithic and sandwich facing

- How are sandwich structures in the AFF universe substantiated?

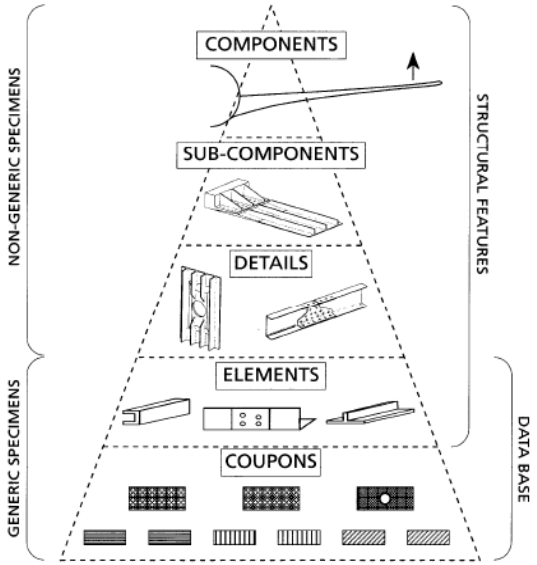
- **Analysis**
  - General:
    - Non symmetric laminates are rate
    - If stress state is not governed by a single load then usually quasi-isotropic laminate used
    - Classic laminate theory
    - FEM usually limited to symmetric failure mode evaluation (but with interaction criteria)
  - Sandwich
    - Sizing & isolated analysis with flat panel assumption
    - Face buckling, face wrinkling by strain limit
    - Face/Core bonding normally not evaluated in FEM (single bond allowable=ILS)

  Emphasis of analysis is to reduce the amount of testing (upper end of pyramid)

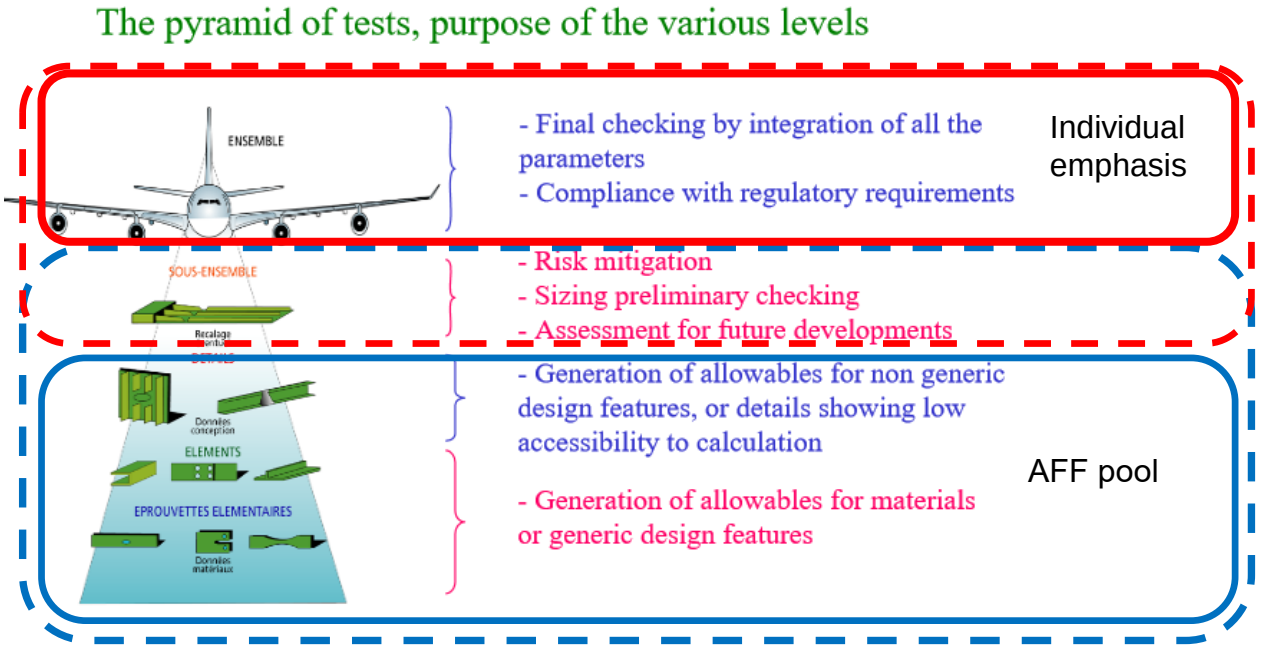





- How are sandwich structures in the AFF universe substantiated?
  - **Testing**



Ref.: AMC 20-29, Composite Aircraft Structure

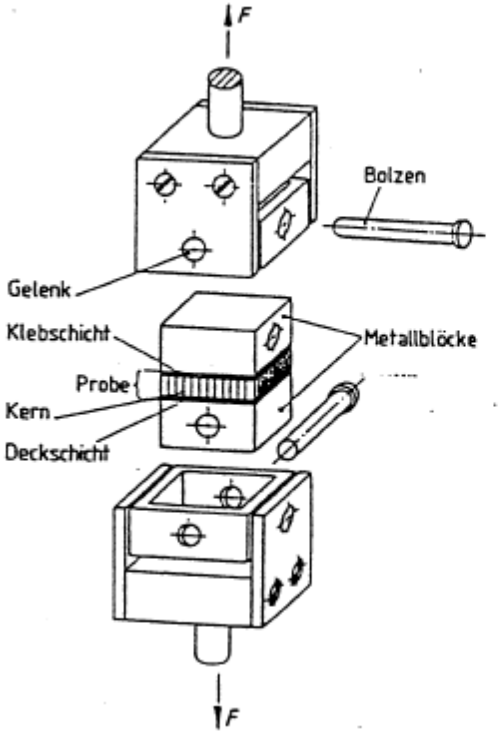


Ref.: Rouchon, J., CERTIFICATION OF AIRCRAFT COMPOSITE STRUCTURES, EUROSAE 2006 (training course material)

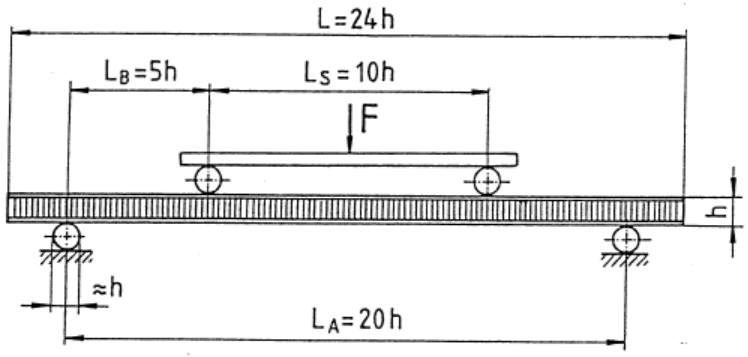



- Generic sandwich test specimen

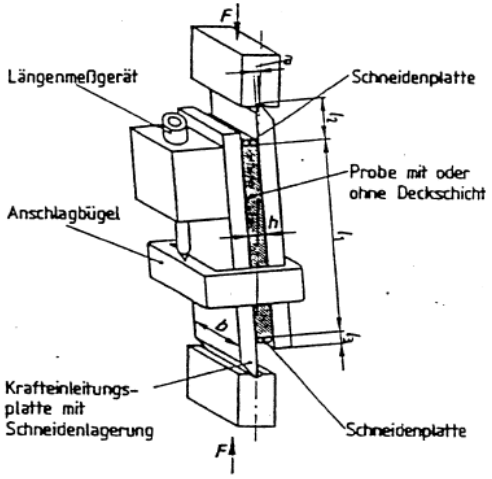
Flatwise Tensile Test:
Flatwise Compressive Test:



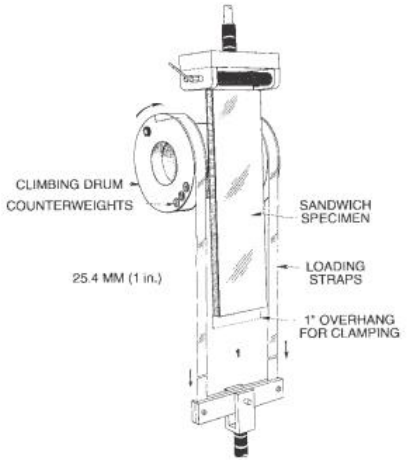
4-Point Bending Test:



Shear Test:



Climbing Drum Peel Test:






- Component testing (details vary from project to project)

Static strength § 305, §307
-crucial load conditions up to UL = LL x 1,5 x 1,15
-Test under elevated temperature (54°C/72°) or application of temperature load enhancement
-Inclusion of defects and BVID up to UL
-Acceptance of overload to simplify test set up

Fatigue / damage tolerance tests §573
-modified KoSMOS spectrum to allow for aerobatic maneuvers
-All tests on pre-damaged structure, BVID
-Limited tests with debonds and VID

Residual strength test
-Up to LL incl. VID and larger cracks
-up to UL (= LL x 1,5 x 1,15) VID in repaired condition

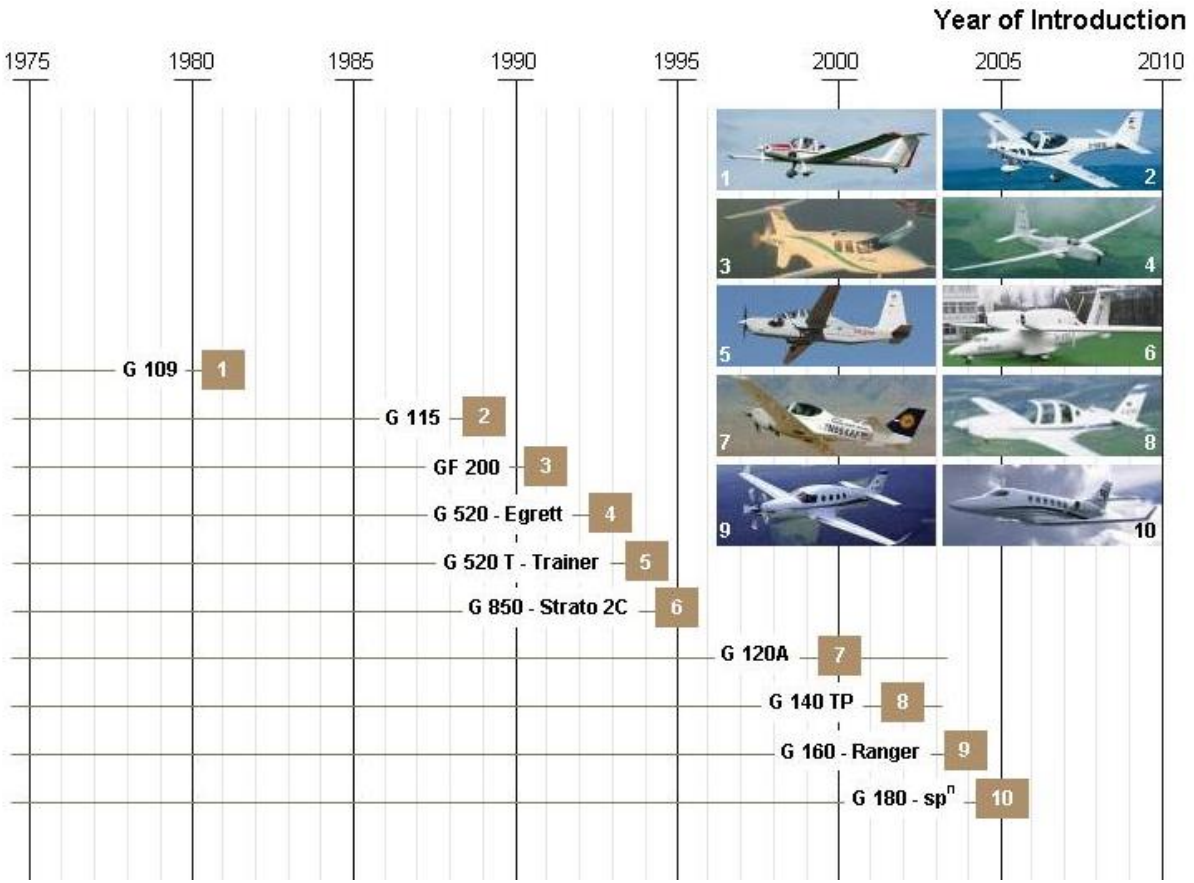
Curtesy: Grob Aircraft AG




- How are sandwich structures in the AFF universe substantiated?
  - Service experience
    - Within AFF production similarity
      - of processes
      - of design details
      - of environmental spectrum
      - exposure to media
    - Large overlap in design and material to glider technology
    - For maintenance and repair M/145 comparable
      - Comparable design details
      - Comparable material and processes

SERVICE EXPERIENCE

• same design principles & production methods for more than 40 years (wet lay-up & cure under ambient pressure)
• 1971: production of Cirrus sailplanes (JAR 22; under license granted by Schempp-Hirth)
• 1974: introduction of first Grob type G 102 Astir CS (JAR 22); further sailplane projects followed
• “motorized Grob legacy” see below (G 109: JAR 22; others: JAR/FAR 23)



• 2013: introduction of G 120TP-A training aircraft (CS/FAR 23); aerobatic +6g/-4g; 450 hp; max. alt.: 25000 ft; service experience: about 2500 flight hrs

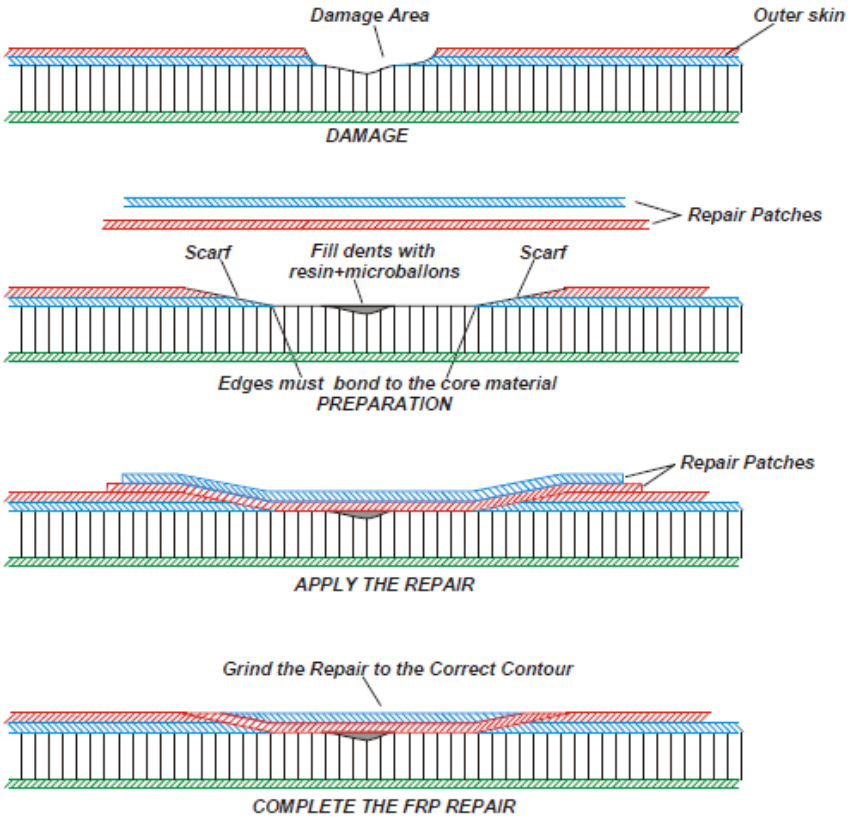
Curtesy: Grob Aircraft AG



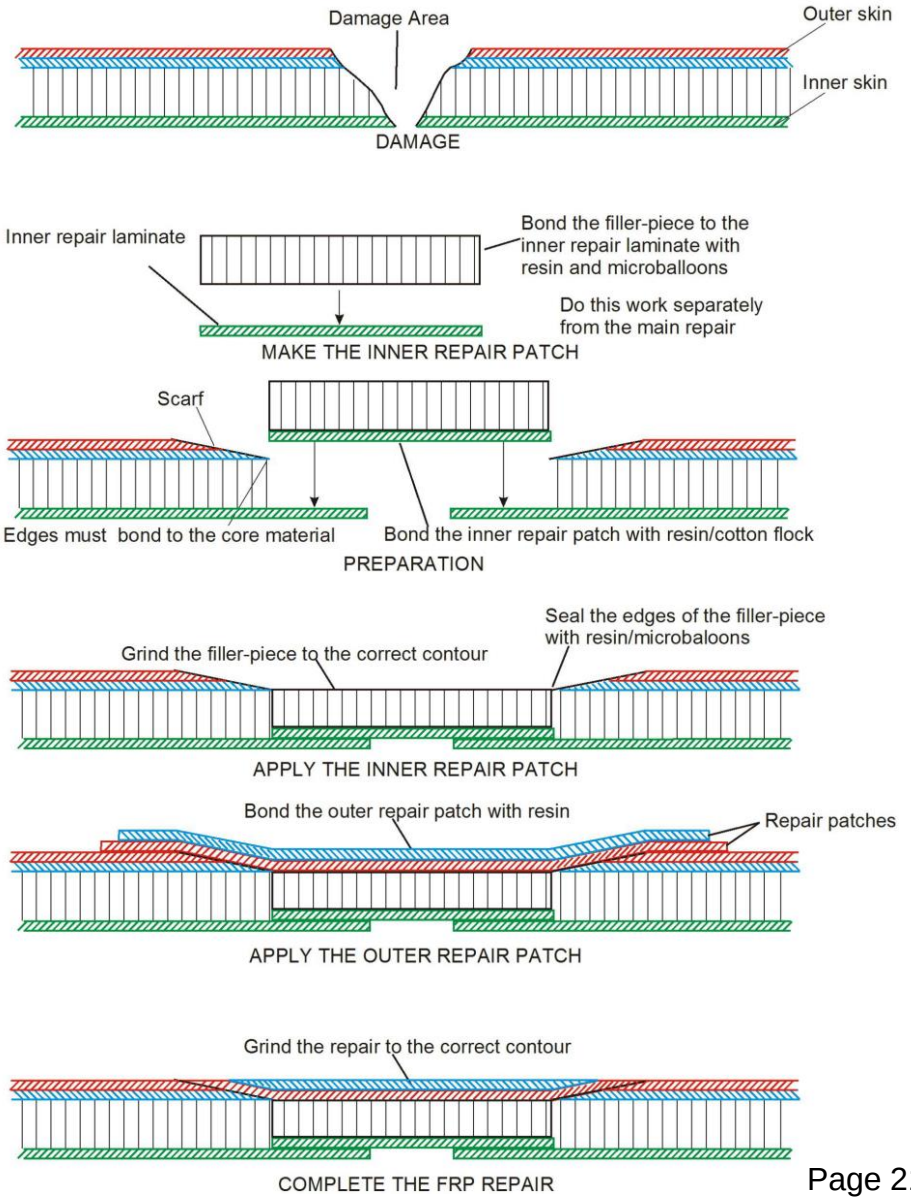

- Repair
  - Damage Classification according AMC 20-29 (HFF 44 240)
    - Cat. 1: BVID and below – covered by damage tolerance during airplane life
    - Cat. 2: VID – covered by damage tolerance between defined intervals
    - Cat. 3: recognizable by untrained personnel – repair in timely manner
    - Cat. 4: obvious damage (hail/birdstike/lighning) – immediate repair however transfer flight might be possible
    - Cat. 5: severe damage not covered in certification
  - Repair instruction
    - General instruction in AMM or repair manual – potentially limited in size – mostly limited to Cat 2…3
    - Specific instruction through approved DO for all other
  - Repair method “wet”, identical materials and essentially same process as in production

REPAIR OF SANDWICH

OUTER SKIN AND CORE



ALL THROUGH DAMAGE



Curtesy: Grob Aircraft AG

REPAIR TO OUTER SKIN OF HONEYCOMB-CORE-SANDWICH

find the limits of the delaminated area
–
coin-tap test

cut away the damaged laminate with a diamond saw

carefully remove the damaged outer skin

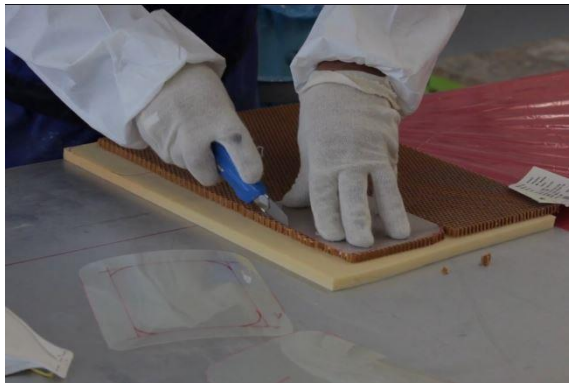
separate the degraded honeycomb-core from the inner skin

prepare the edges and the inner skin for the repair patch

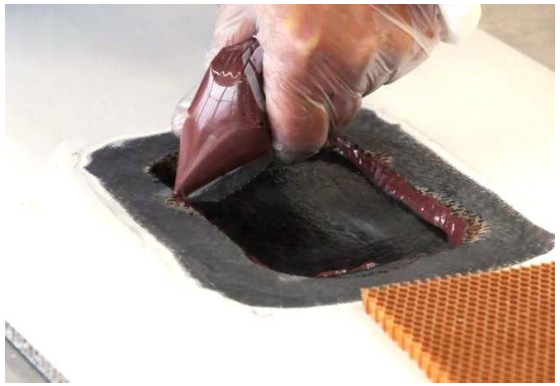
grind a scarf (taper) at the edges of the outer

Curtesy: Grob Aircraft AG

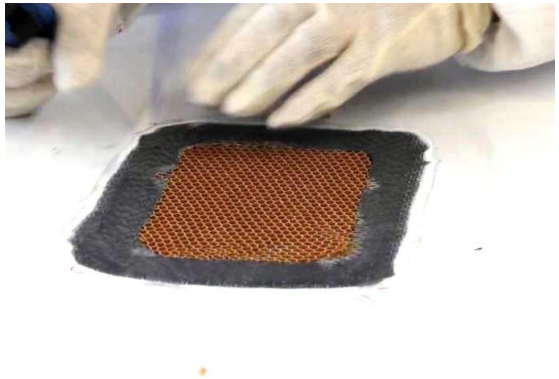
check for the correct angle of the taper



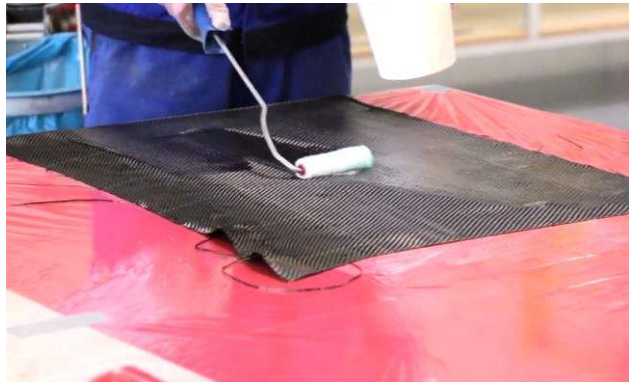
prepare suitable piece of honeycomb-core material



coat the inner skin with resin and apply resin with microballoons to the edges



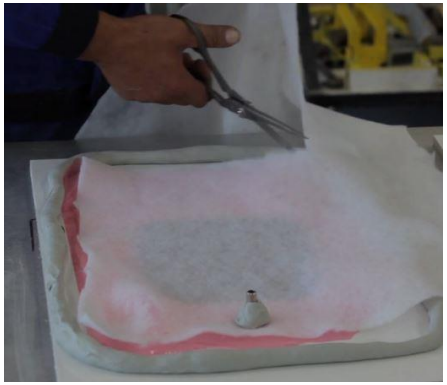
bond the piece of honeycomb-core to the inner skin of the structure



prepare the carbon layers of the outer laminate

apply the outer skin of the sandwich structure

Curtesy: Grob Aircraft AG



prepare perforated film and fleece for the vacuum application

apply vacuum (ambient pressure) and cure the repair for at least 8 hrs at 60 degC

grind the outer skin to the correct contour and post-cure the repair for another 15 hrs at 80 degC (heat-up rate: 20 degC/hr)

finally finish and paint the repair area

Curtesy: Grob Aircraft AG




Thank you for your attention

- “ Bonus material”

AFF / HFF Overview and Targets

- AFF = Arbeitskreis Faserverbundflugzeuge (Industrial working group fibre composite airplanes)
  - Founded 1986
  - 20 active member companies
  - PO and DO companies
  - Test institutions and Universities
  - Service providers and Suppliers
- HFF = Handbuch Faserverbundflugzeuge (Handbook fibre composite airplanes)
- Historical
  - Initially only DO companies with TC projects in CS-23
  - Later opening to Suppliers and service providers and CS-VLA/LSA
  - Cooperation with ANF (CS-22 world)
  - Earlier formal acceptance of HFF by LBA (Status of AC)
  - No legal basis for formal acceptance by EASA
  - usage within TC through acceptance by OA/CVE
- Current focus on consolidation of procedures

AFF Members (active)

- DOA & ADOA
  - GROB Aircraft AG
  - Extra Flugzeugproduktions- und Vertriebs GmbH
  - ZLT Zeppelin Luftschifftechnik GmbH & Co. KG
  - Aircraft Design & Certification Ltd
  - Dornier Seawings GmbH
  - Game Composite Ltd.
  - Stemme AG
  - Stemme UAS GmbH
- Test and research institutes
  - IABG (Industrieanlagen-Betriebsgesellschaft mbH)
  - DLR Stuttgart (Deutsches Zentrum für Luft- und Raumfahrttechnik)
  - BAM (Bundesanstalt für Materialforschung und –prüfung)
  - IFB (Institut für Flugzeugbau Universität Stuttgart)
  - FH-WS (Fachhochschule Würzburg-Schweinfurt, Kunststofftechnik)




AFF Members (active)

- Suppliers and Service provider
  - Toho Tenax Europe GmbH
  - Hexion GmbH
  - P-D INTERGLAS TECHNOLOGIES GmbH
  - Ingenieurbüro Prof. Dr. Reiling
  - AeroFEM GmbH
  - Ingenieurbüro Jörg Heubischl
  - Steinbeis Flugzeug- und Leichtbau GmbH
  - C. Cramer, Weberei, GmbH & Co. KG (CCC)
- Authorities (observing)
  - LBA (Luftfahrt-Bundesamt)
  - EASA (European aviation safety agency)

HFF Content

10000 Design of fibre composite
20000 Materials
30000 Structure analysis
40000 Manufacturing technology and repair
50000 Quality assurance
60000 Certification rules and testing requirements
70000 Testing (results)

≈ 140 finished contributions (6th edition)
≈ 50 in progress
≈ 20 prioritized
≈ 6 discussed in individual meeting
≈ 2 finished in individual meeting

Entwicklung HFF

Handbuchseiten

Handbuchbeiträge

„Crisis“

Number of meetings

Initial Certifications G115/SC01/Seastar

Akkumuliert Seiten

Akkumuliert Beiträge

Sitzungen