Ultrasonic C-scan inspection of Airbus A380 Glare® fuselage panels.

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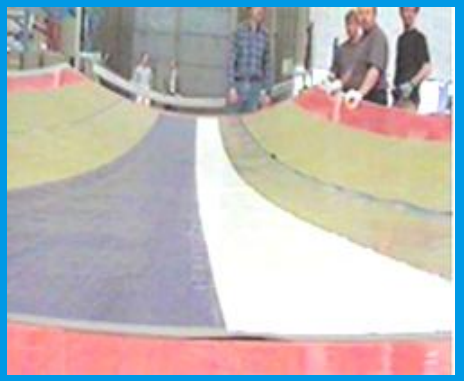
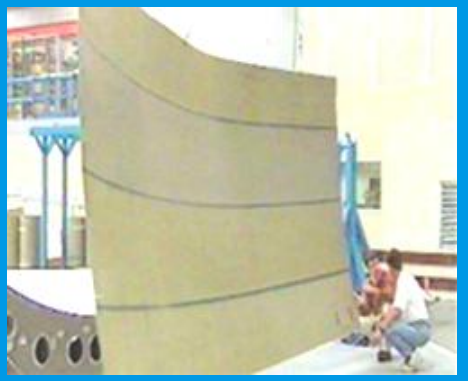
NDT level 3 UT/ET
Fokker Aerostructures BV

What's it all about ?

1. Introduction
2. Glare®
3. C-scan inspection
4. Glare® Ultrasonics
5. Qualification matters
6. And now … for something completely different ….





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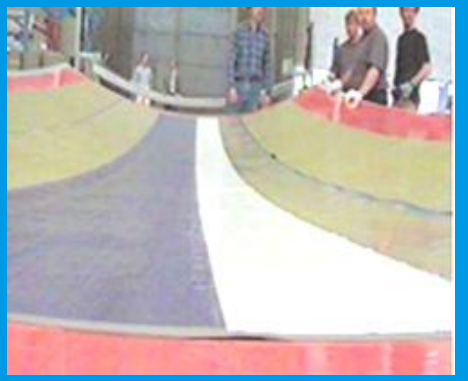


Introduction - Fokker Aerostructures BV

- **Locations Papendrecht and Hoogeveen**

- **Business**

  Aircraft substructure manufacture for OEM (a.o.Boeing, Airbus, Gulfstream, Dassault, NH90) and special products (a.o missile launch platforms)

- **Structure materials**

  Metals, bonded metals, Fibre Metal Laminates (Glare®) and composites (CFRP and GFRP; thermoset and thermoplast).

Introduction - The Fokker NDT community

- **Methods : UT-PT-RT-ET-MT**
- **NDT personnel Hoogeveen and Papendrecht**

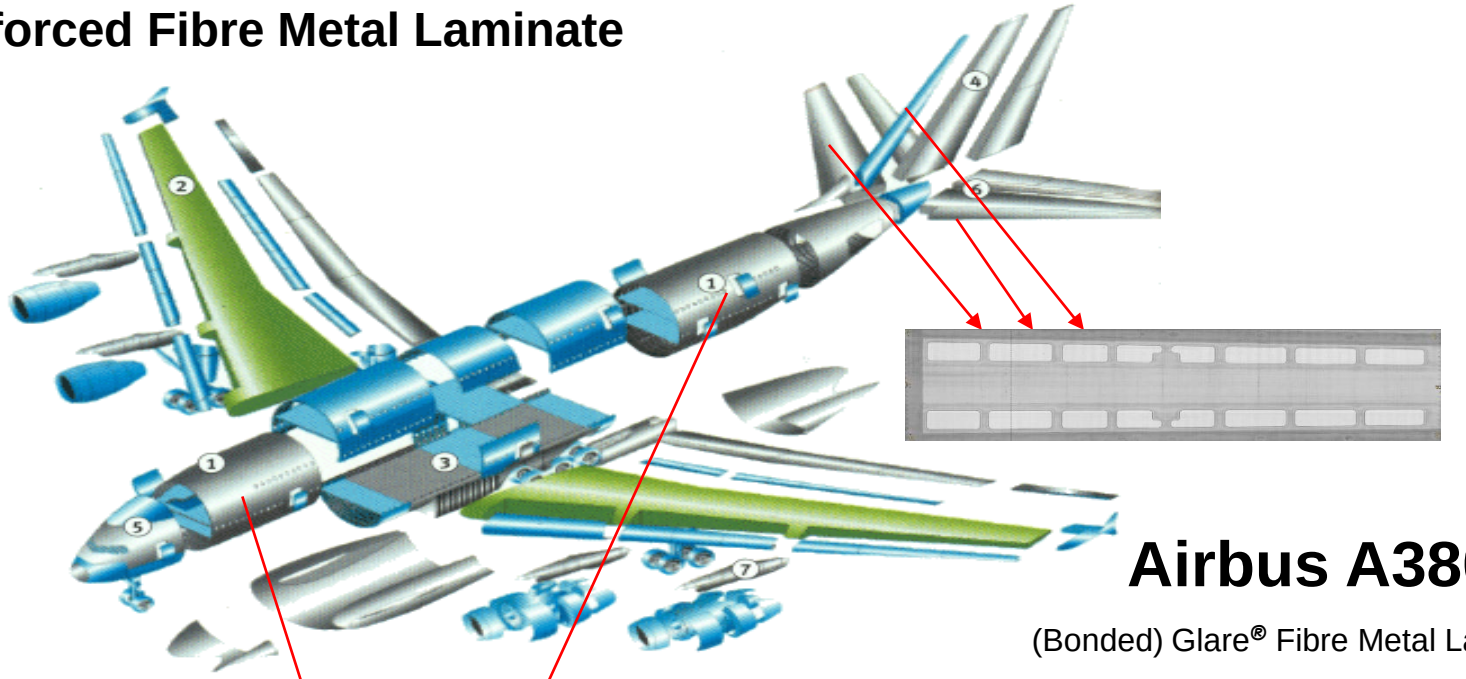
Amount	ET	MT	PT	RT	UT
Level 1	16	1	1	-	3
Level 2	2	4	7	2	13
Level 3	1	2	2	1	2

Introduction - In/outsourced NDT

- **Increased use of outside NDT capacity**
- **FAe NDT (EASA CS 25) not under NANDT authority**
- **Written Practice comparable to NANDT regulations (AIC-B 11/05).**
- **FAe Requirements in/outsourced Level 2/3**
  - EN4179/NAS410 certified
  - Passed specific and practical examination in corporate and customer specifications

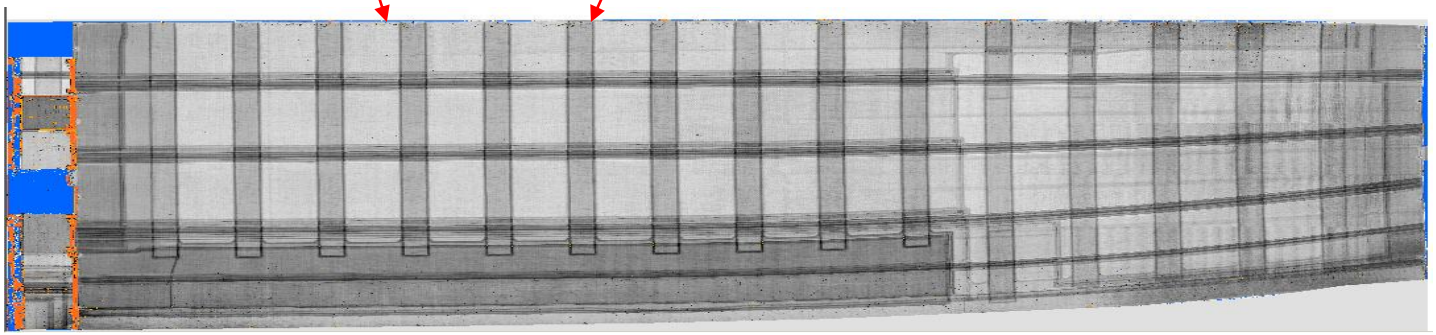
Introduction - Product range C-scan inspection at Papendrecht

Glass Reinforced Fibre Metal Laminate



Airbus A380

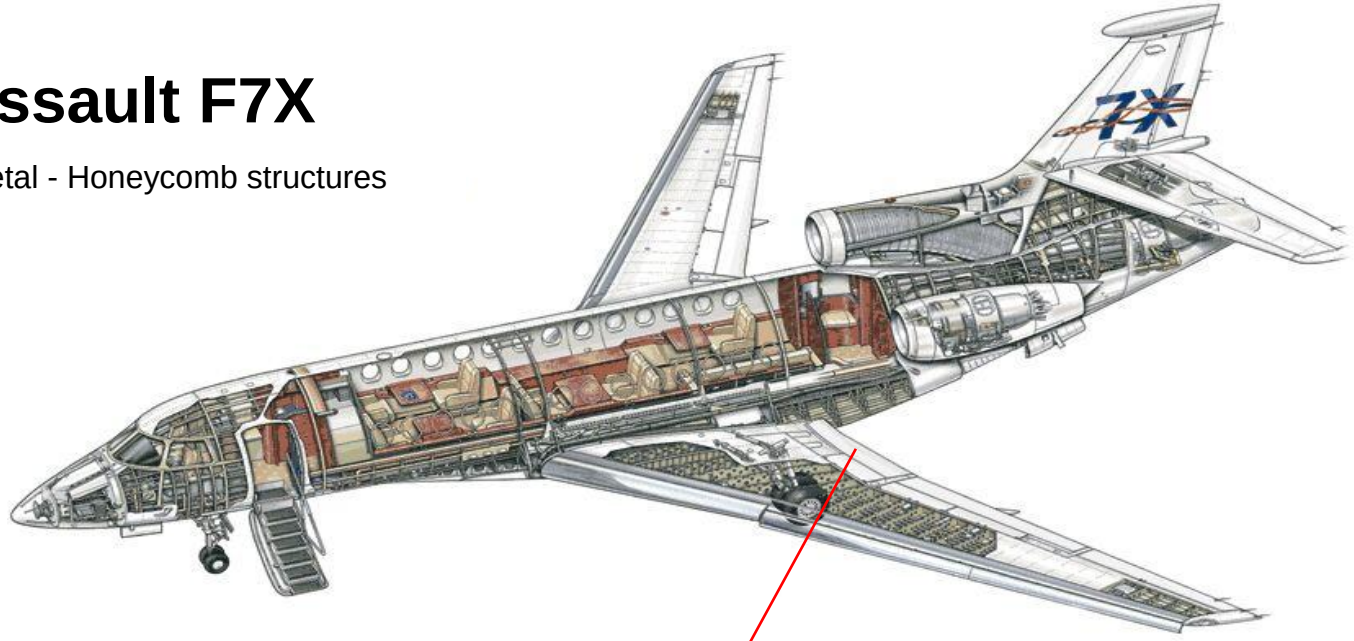
(Bonded) Glare® Fibre Metal Laminates

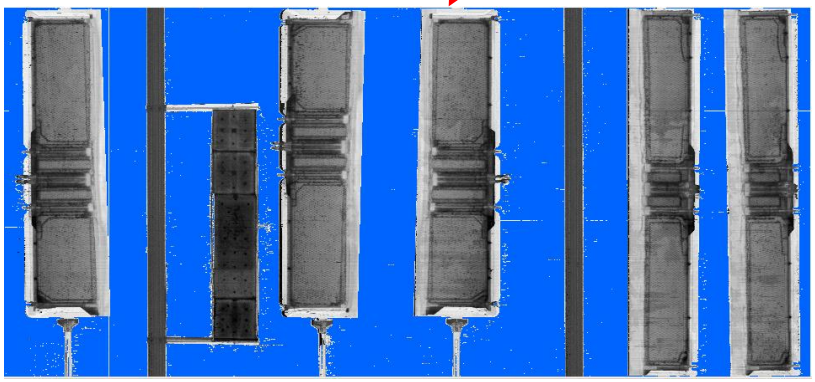


Introduction - Product range C-scan inspection at Papendrecht

Dassault F7X

Bonded Metal - Honeycomb structures

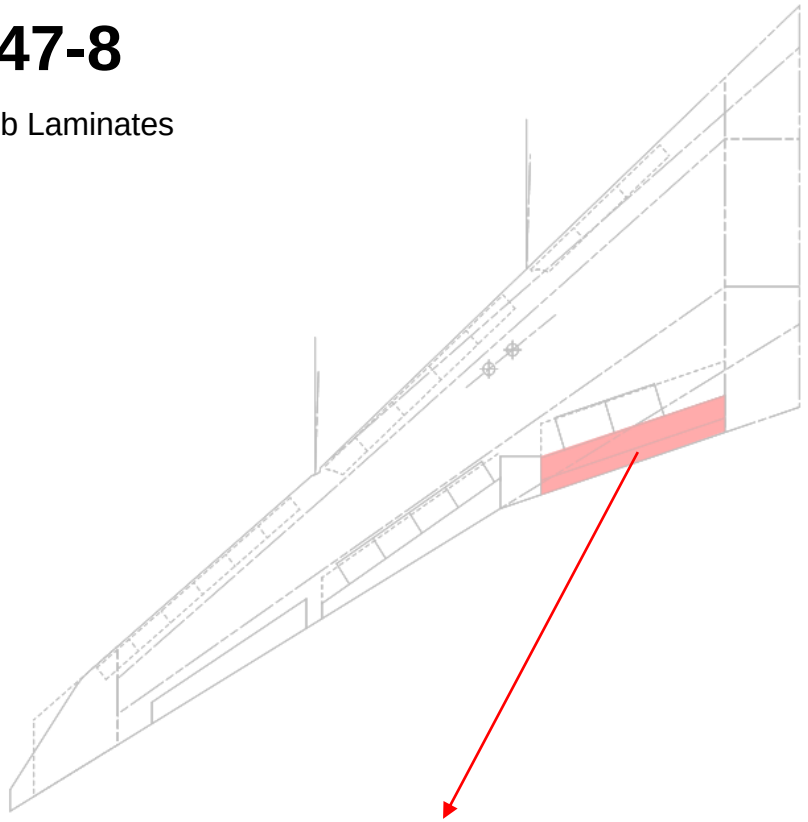


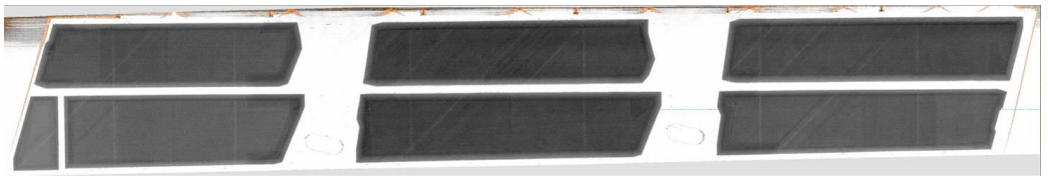


Introduction - Product range C-scan inspection at Papendrecht

Boeing 747-8

CFRP Solid/Honeycomb Laminates





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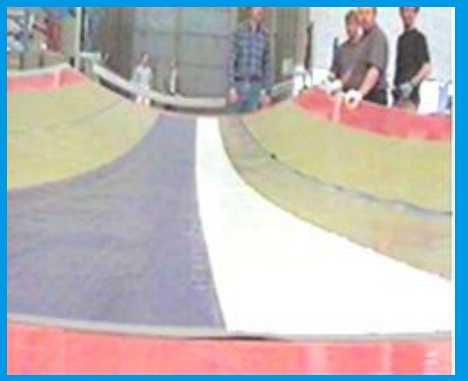
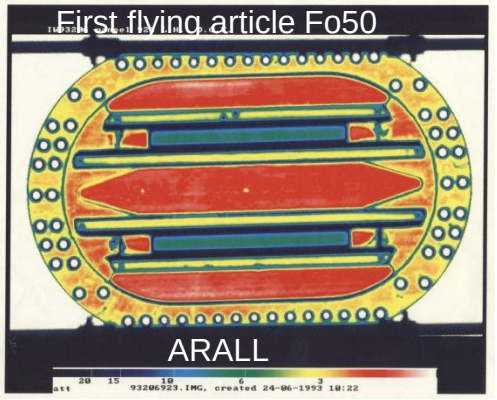


Glare®- From scratch to maturity

- **1976-1996 Development of Fibre Metal Laminates**
  Technical University Delft and Fokker Aircraft BV in joint effort with, Akzo Nobel, Alcoa and others**.**

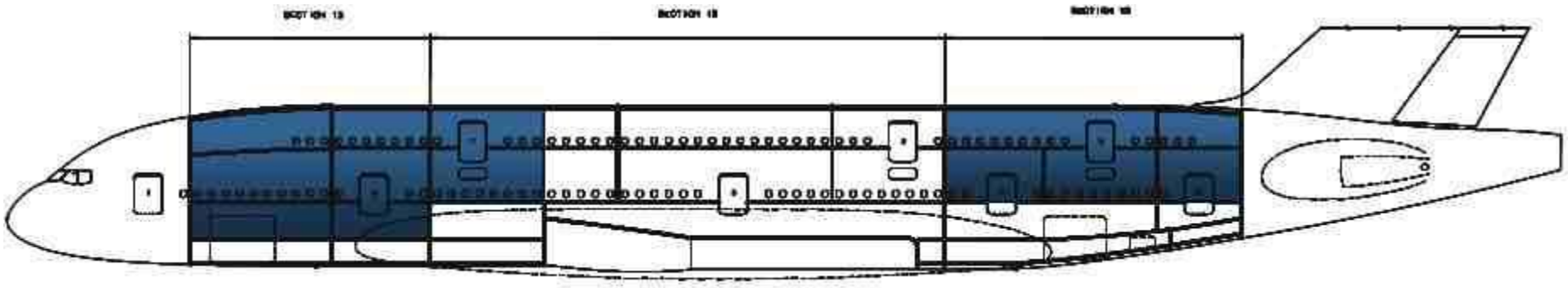


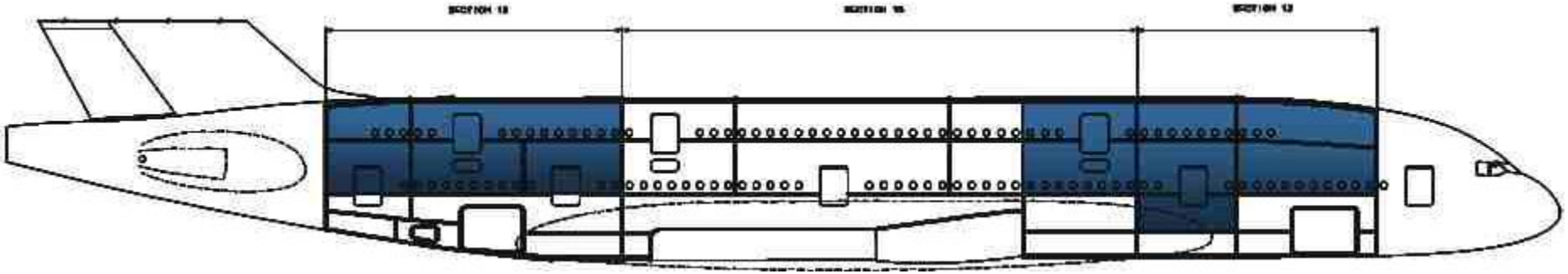
- **1996 - 1998 Continued development**
  SLC, Alcoa, TU Delft and others

- **1998 - 2002 Industrialisation**
  Fokker Aerostructures in joined effort with a.o. TU Delft, FMLC, NLR, Airbus-Germany (launching customer) and authorities.

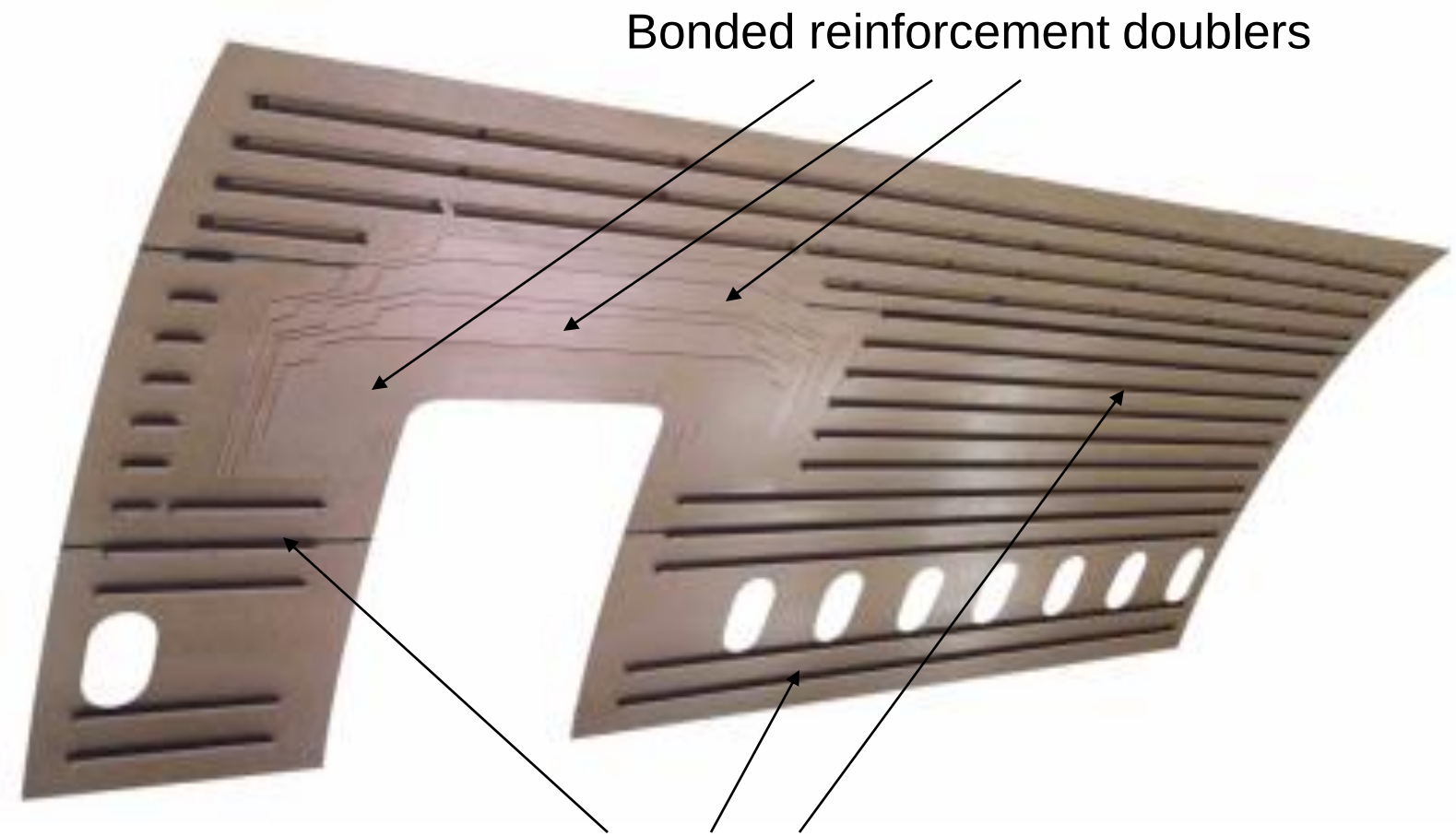
- **2002 - … Series production Airbus A380**
  Fokker Aerostructures (license holder) at Papendrecht and Airbus-Germany at Nordenham.

Glare® - A380 Fuselage Sections



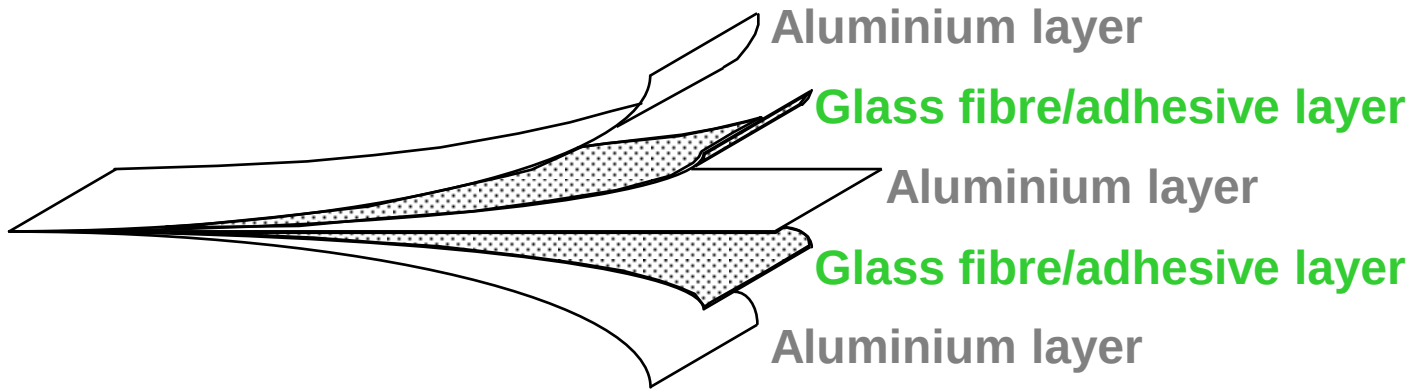


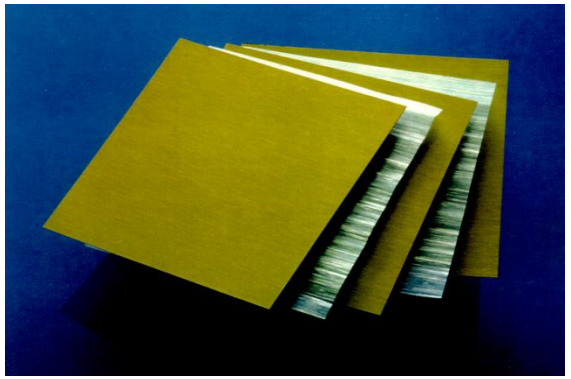
Glare® - Typical A380 fuselage panel



Glare® - The material

Hybrid material built-up from alternating layers of aluminium and glass fibre layers





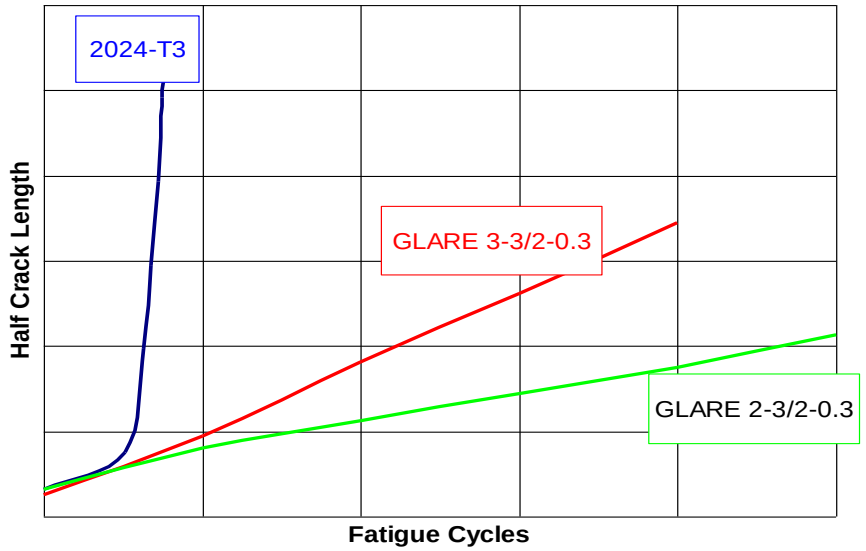
Al sheet thickness : 0.3 – 0.4 mm

Glass layer thickness : 0.25 – 0.38 mm

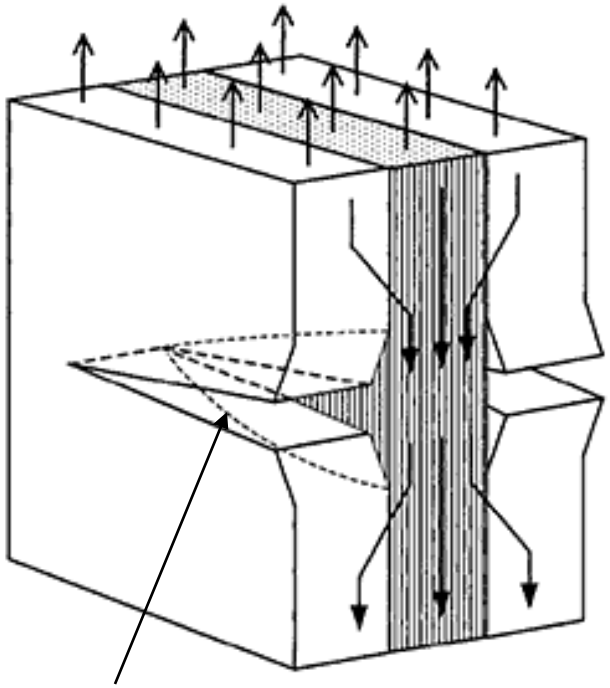
Glare® - Damage tolerance - fatigue

No fatigue crack failure

- If fatigue cracks occur, propagation in length and depth will be **very slow**
- Even cracked Glare® can in most cases carry ultimate load.



Glare® - Fatigue resistance mechanism



Crack initiation

Fatigue (initiation) cracks occur in aluminium layers only,
starting in outer aluminium layers.

Fibres stay intact and bridge the fatigue crack

Crack initiations hardly grow or not at all

Glare® - Advantages over conventional aluminium

- **Lighter structure carrying the same load.**
- **Less inspections and repairs.**
  - No specific inspection for fatigue cracks.
- **Better corrosion resistance**
- **Better fire resistance**

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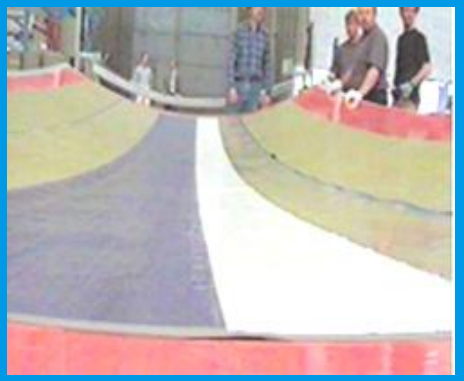
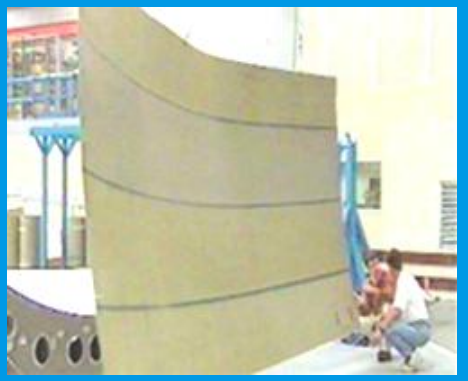


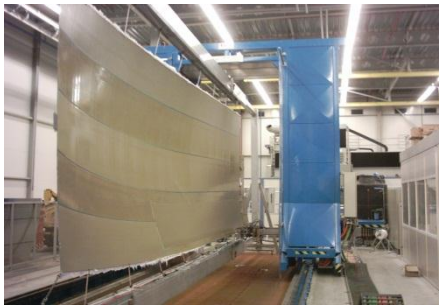


C-scan inspection – Glare® production process

Pretreatment

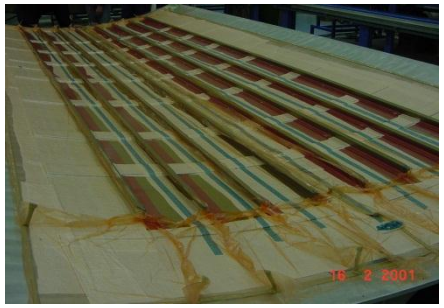
Lay-up

Autoclave curing



C-scan inspection

Milling



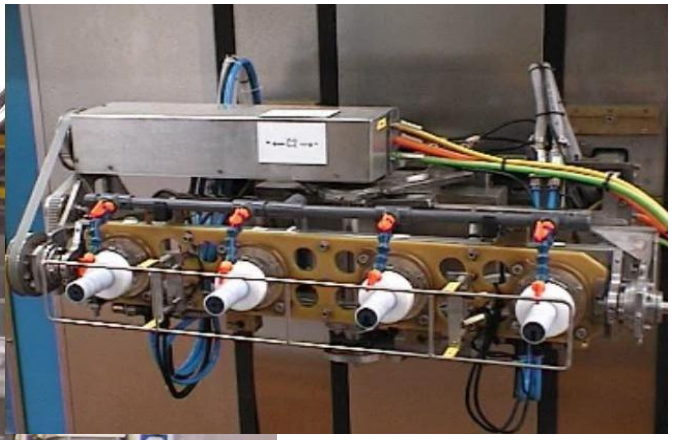
Second bonding cycle

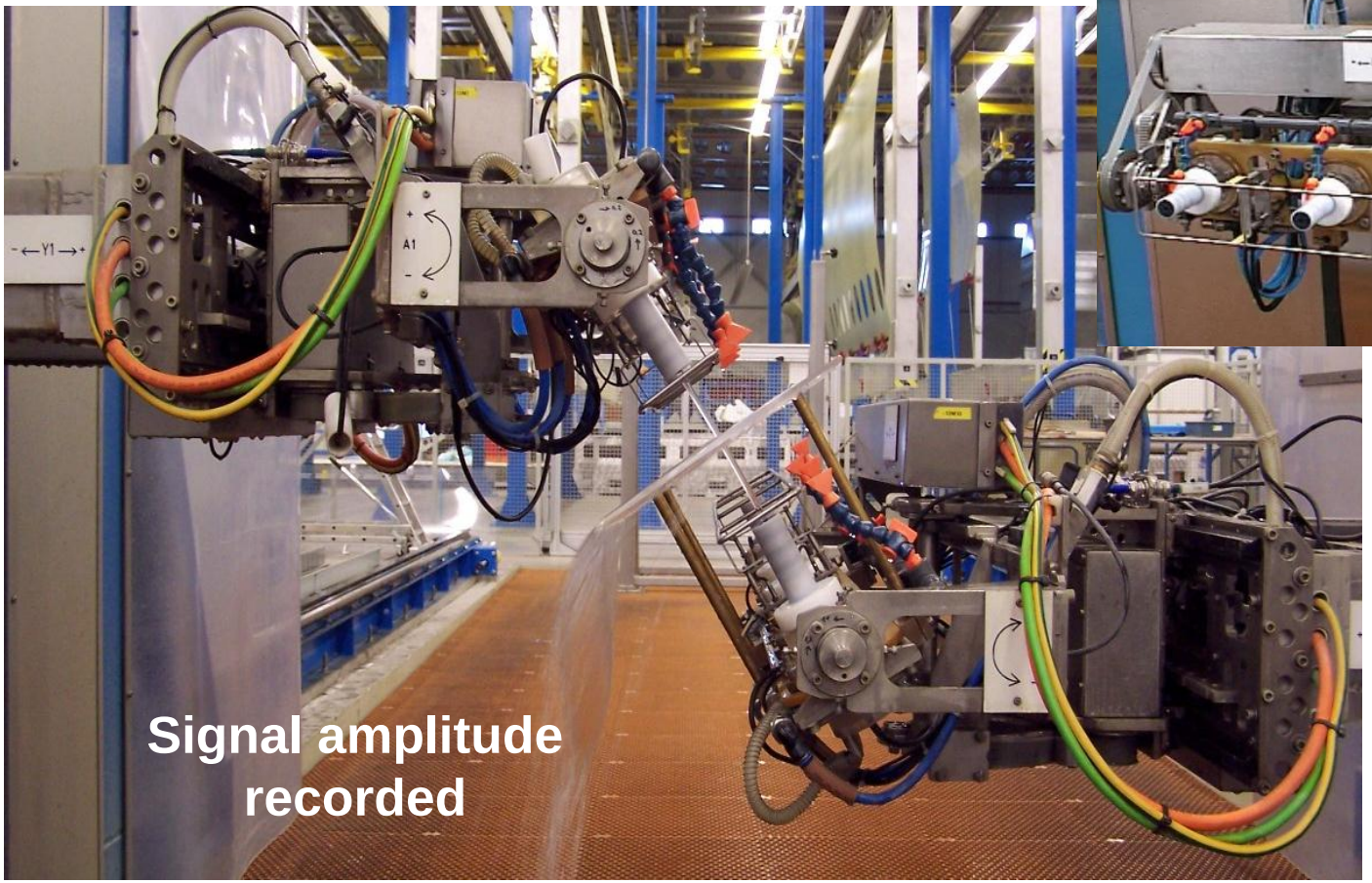
Painting

Transport

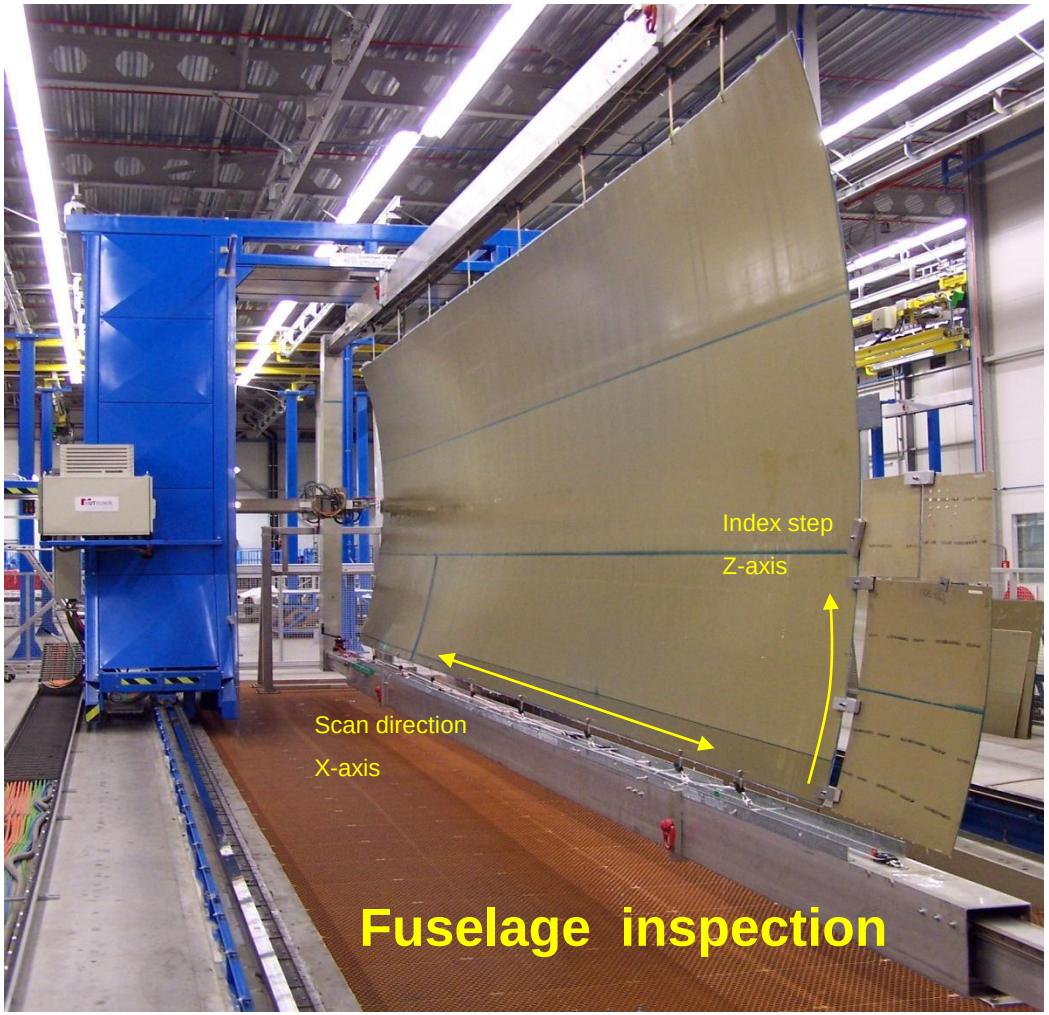
C-scan inspection - Through Transmission

Transducer and squirter set-up

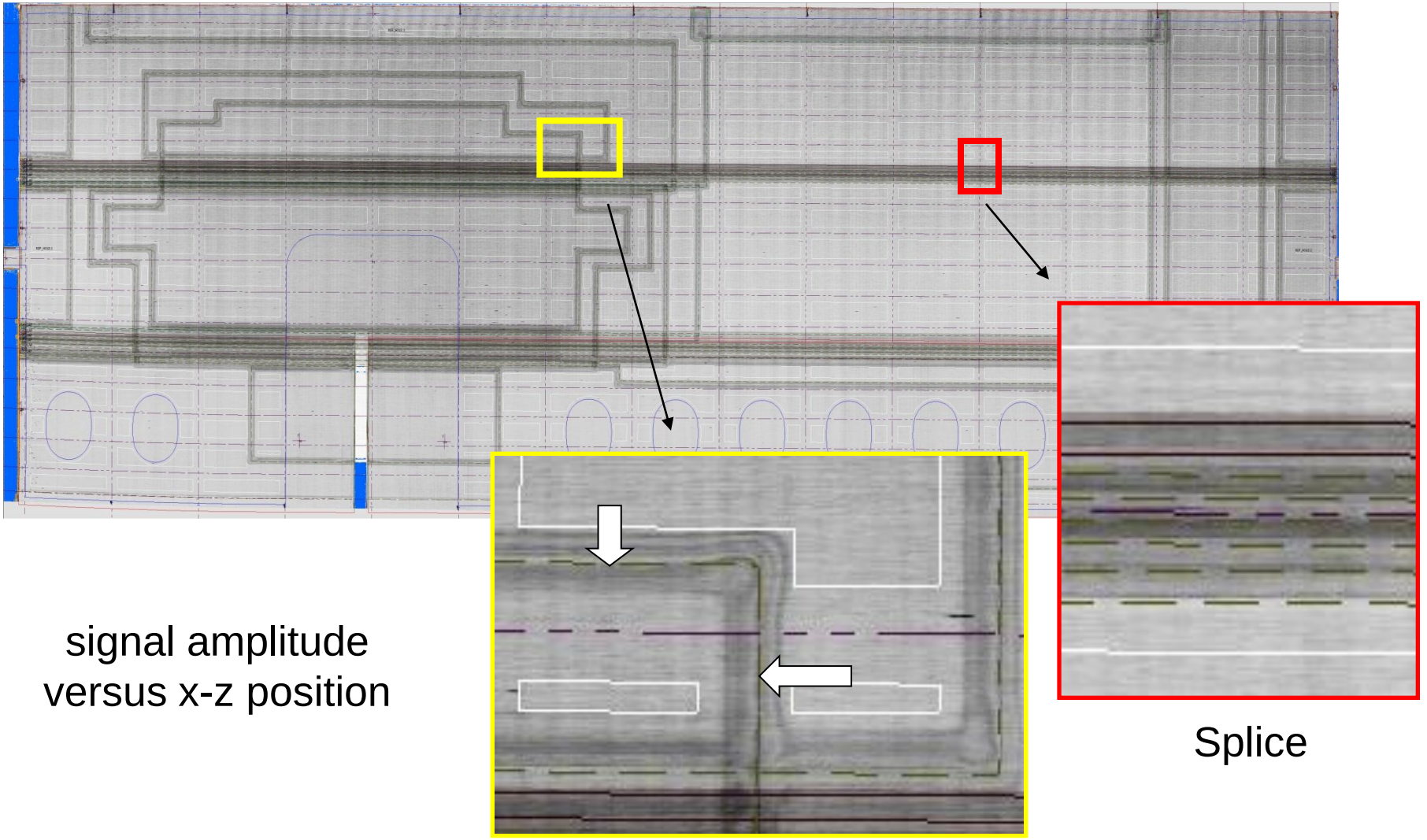




C-scan inspection - Data acquisition



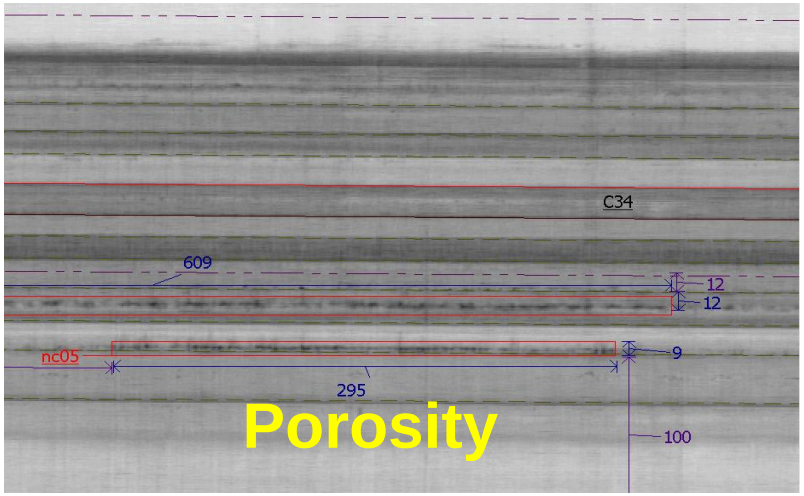
C-scan inspection - C-scan image

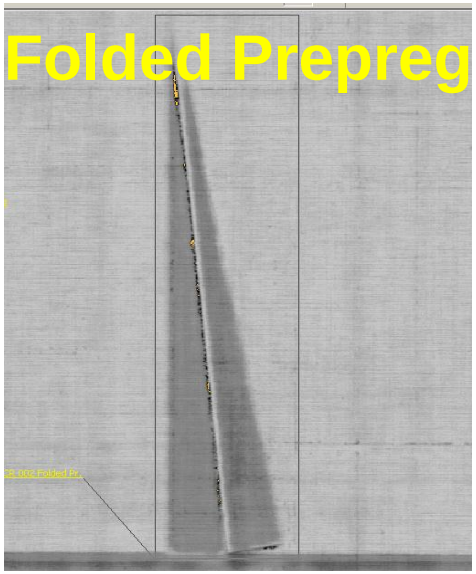


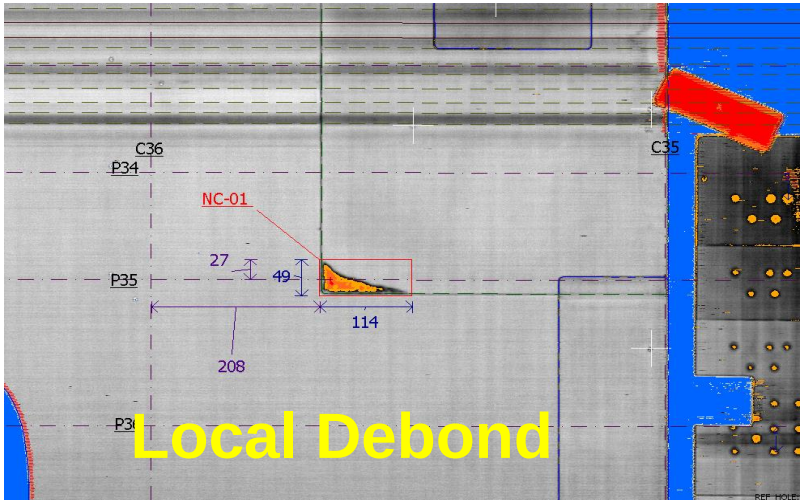
signal amplitude
versus x-z position

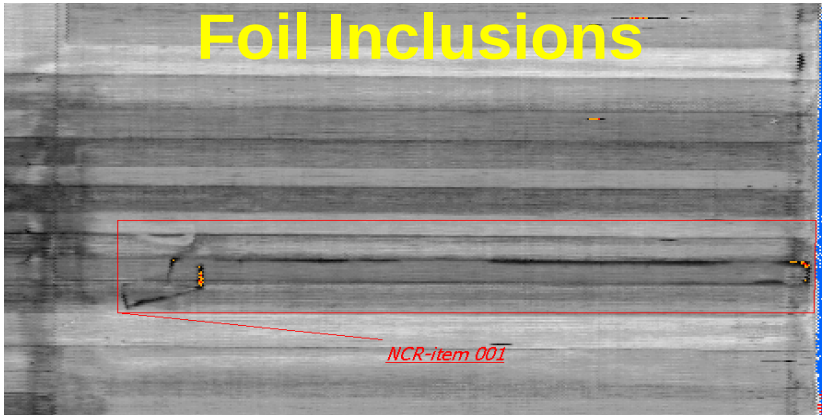
Splice

C-scan inspection - Defect indications



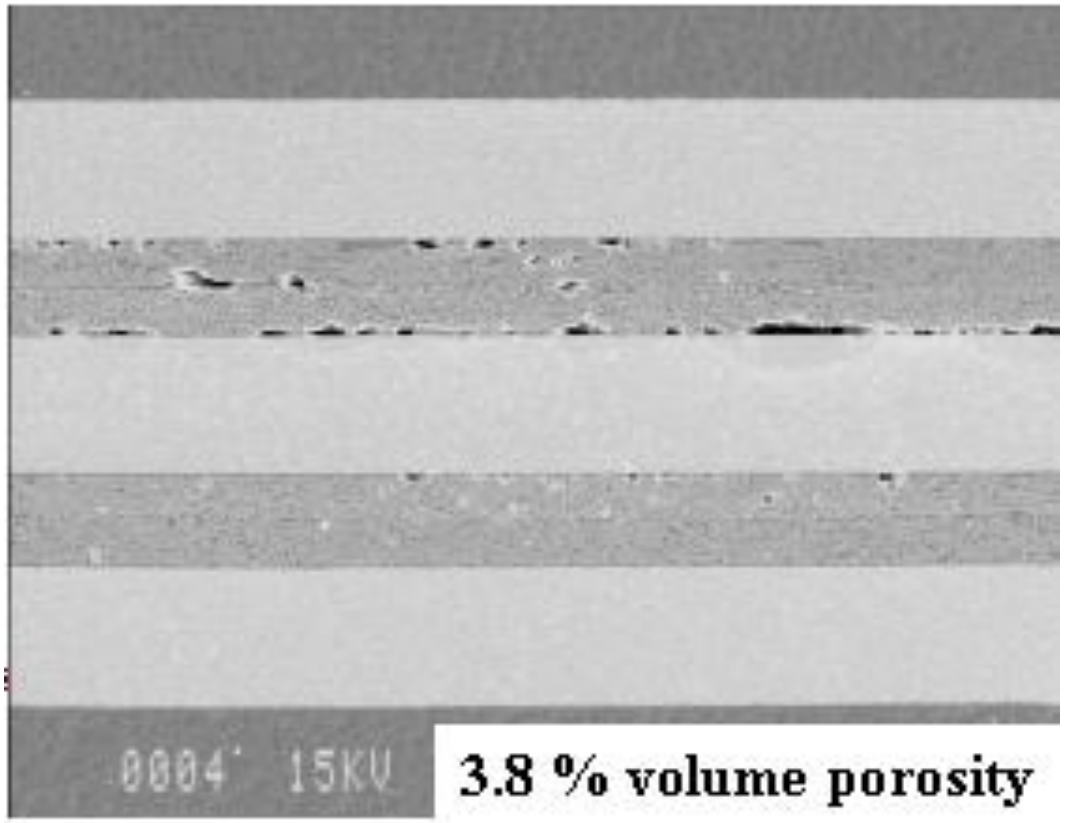






C-scan inspection – Porosity in Glare

Microscopy section



0.5 mm

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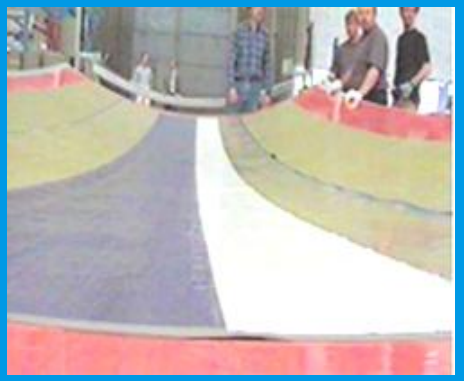
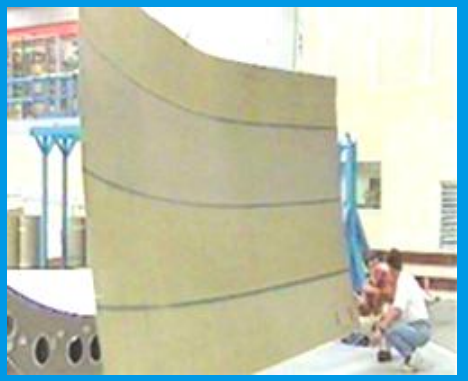
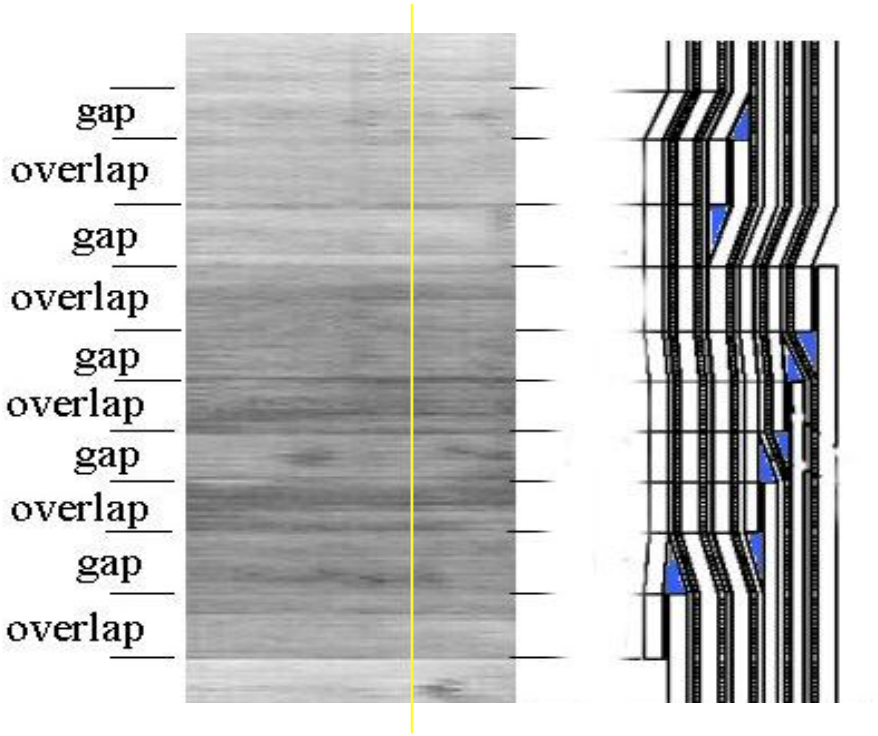




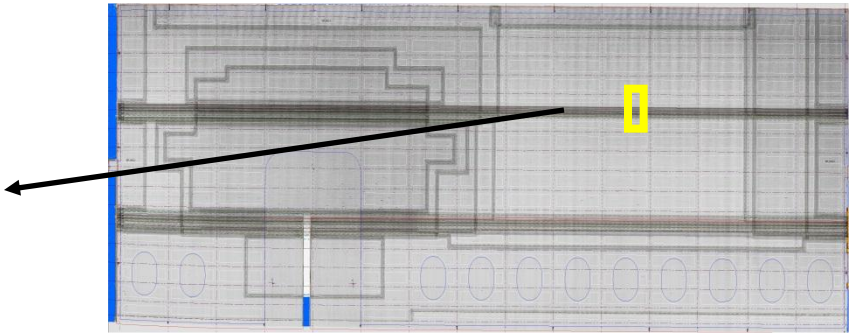
Glare® Ultrasonics - Through Transmission

C-scan image part of splice

Cross-section of splice structure



C-scan image of panel



- **Constant laminate thickness.**
- **Large differences in amplitude.**
- **Adhesive and prepreg layers**
  - different thicknesses
  - varying thickness

Glare® Ultrasonics - Pulse Echo

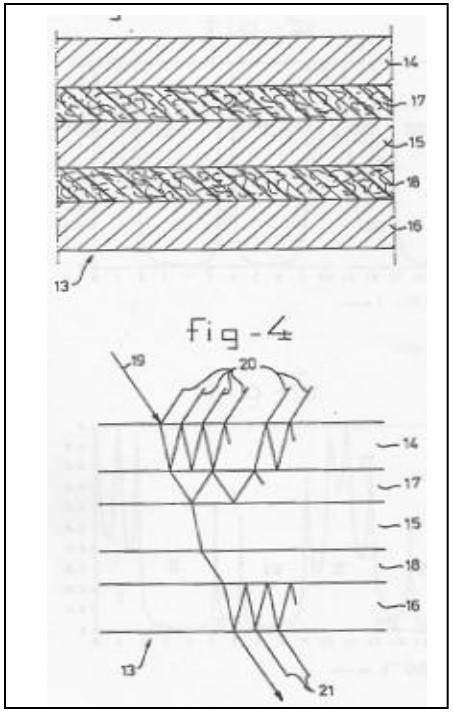
No application in production Glare® yet

Pulse echo signals with sufficient signal-to-noise ratio are possible, but

- Fail/success is very hardware dependent.
- Inconsistent back wall echo and defect echo amplitudes for a specific structure. Back wall echo's may even dissappear at all without having defects.
- No control yet over this phenomenom.

Glare® ultrasonics – Explaining Mechanism

- Thin layers (t/λ << 1).
- Multiple reflections from each interface interfere with signal.
- Constructive or destructive interference, depending on layer thicknesses and ultrasonic signal.
- Eigenfrequency transmitted best by each layer (t=½λ)
- The measured signal amplitude strongly depends on the interference result.



Minor change in layer thickness ➡ **Large change in signal amplitude**

Glare® Ultrasonics <> CFRP Ultrasonics

CFRP part inspection

- Detection with UT through transmisson C-scan.
- Verification/characterisation with manual pulse echo (A-scan).
- Standard as reference for defect characterisation

Glare® part inspection

- Detection and characterisation with UT through transmission C-scan.
- No pulse echo technique for verification.
- Local reference for defect characterisation.

Glare® Ultrasonics – Pulse echo in the future ?

- **Benefits of pulse echo include**
  - Defect depth information.
  - Better distinction between defect types.
- **Various institutes have explored this area.**
  - a.o. TNO-TPD at Delft, TUDelft-LR.
- **A solution for production …. WHO ?**

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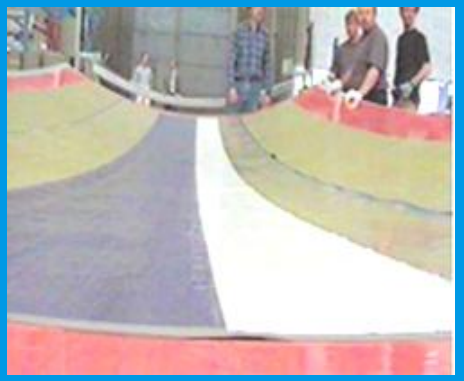
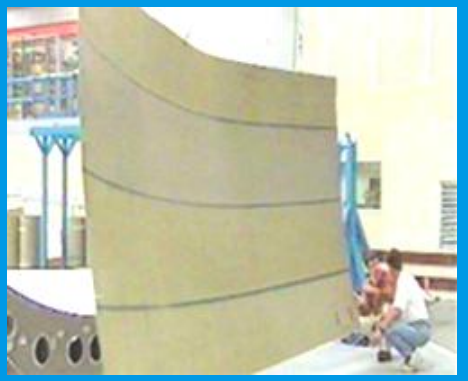
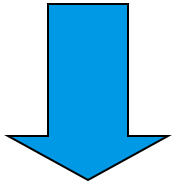


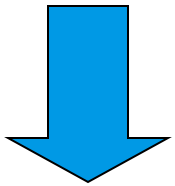


Qualification matters !

No qualified process



No part delivery



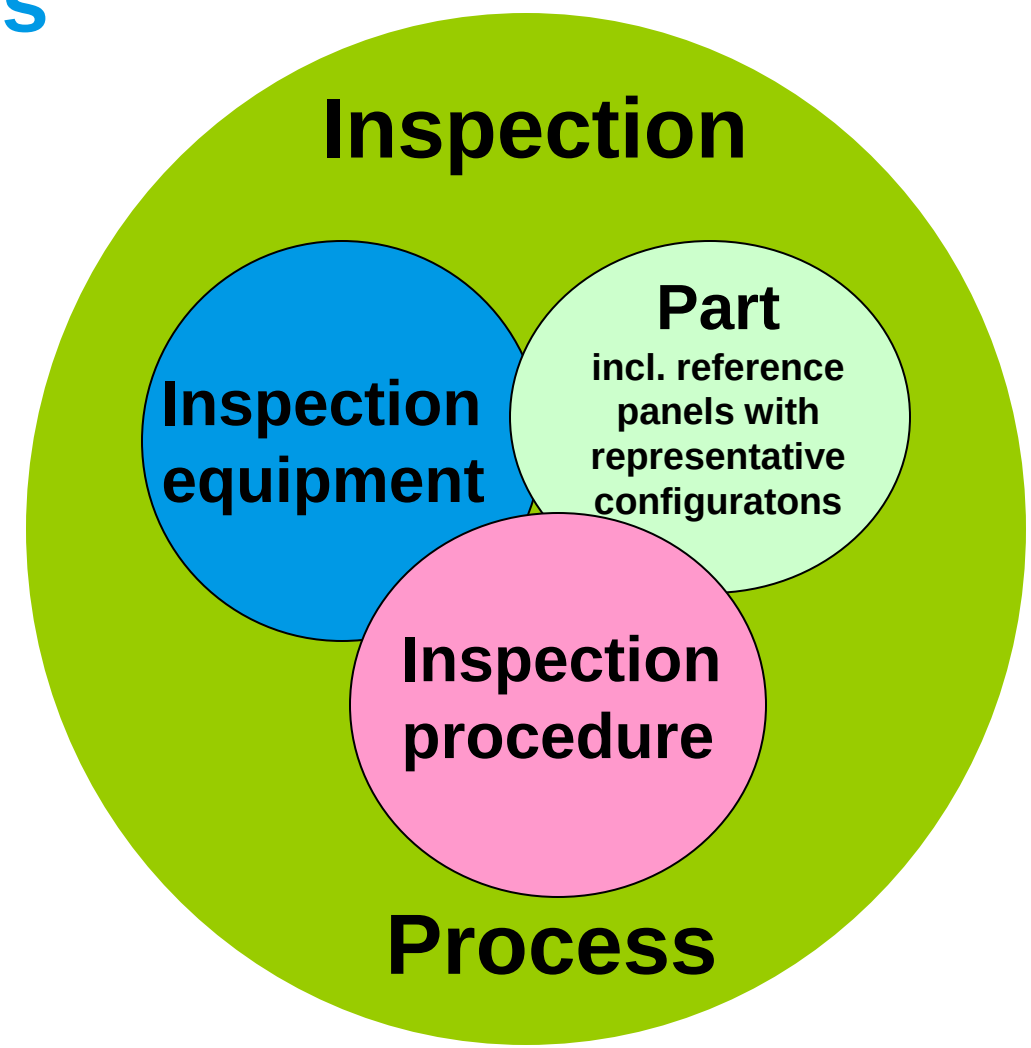
Bad business

“The devil is in the detail”

Kees de Koning, first CEO of Fokker Aerostructures

Qualification matters

Qualification refers to all three Inspection process items together



Qualification matters

Two important starting points for a qualification

- **Qualification** ≠ **Investigation !!**
  - Predictable outcome — Outcome not sure
  - Predictable timeframe — Timeframe highly unsure

- **Qualify = Prove what you already know.**

Qualification matters - principles

- **Well defined Inspection procedure**
  - compliant with Specifications
  - compliant with Inspection requirements (defects to be found, etc.)

- **Well defined Qualification Test Plan**

Qualification Matters - Inspection Procedure

Unambiguous - Reproducable - Traceable

Write down what you do

and

do what you wrote down.

Qualification Matters - Qualification Test Plan

- **Be specific about every detail:**
  Test panels, inspection parameter windows, test execution, result evaluation, analysis method, acceptance criteria shall be specific.

- **Adequate tests to prove requirements**
  Statistical prove 90% Probability of Detection 95% confidence level.

- **Agreement by all parties prior to execution**.

Questions

Comments