LATEST DEVELOPMENTS ON INDUSTRIAL ULTRASONIC TESTING OF AIRCRAFT COMPONENTS

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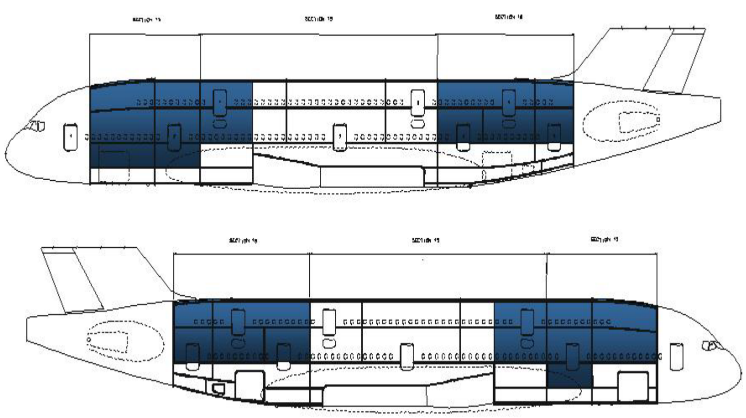
Abstract: This paper deals with automated non-destructive testing ultrasonic systems integrated into aircraft composite production plants mainly for military and commercial aircraft components. These systems are dedicated to non-destructive testing of aircraft components made of composite materials like GLARE, GFRP and CF.
The applied inspection technology is mainly thru transmission technique using water squirters. Additionally bubbler technology for precise pulse echo technique and multi channel acquisition is used.
Two main requirements are to be fulfilled

- Fast inspection using high inspection speed and / or multi channel inspection systems.
- High resolution and reliability using sensitive and state of the art UT equipment and precise mechanical scanner or linear robot systems, also for 3 dimensionally curved parts.

In this paper, specific applications of different system layouts are presented.
They include fully robotic 3D-scanning systems in single-and multi channel operation.

Introduction: NUTRONIK has worked in the NDT field for more than 30 years. Beside our Tube and Bar testing business aeronautic NDT is a major focus. In the following, customized systems for different applications are presented.

Results: The first example is a system dedicated to inspect GLARE (**GL**ass fiber **A**luminum **Re**inforced) panels. GLARE is a material to substitute solid aluminum panels in fuselage sections, which are mainly compression loaded. GLARE is more flaw propagation resistant and more lightweight. It consists of alternating layers of aluminum sheets and glass-fiber. After bonding, they need to be tested for delaminations of the bonded layers. These GLARE parts are installed in at the A380 forward and aft fuselage.



(Slide 1 GLARE sections in the fuselage of the Airbus A380)

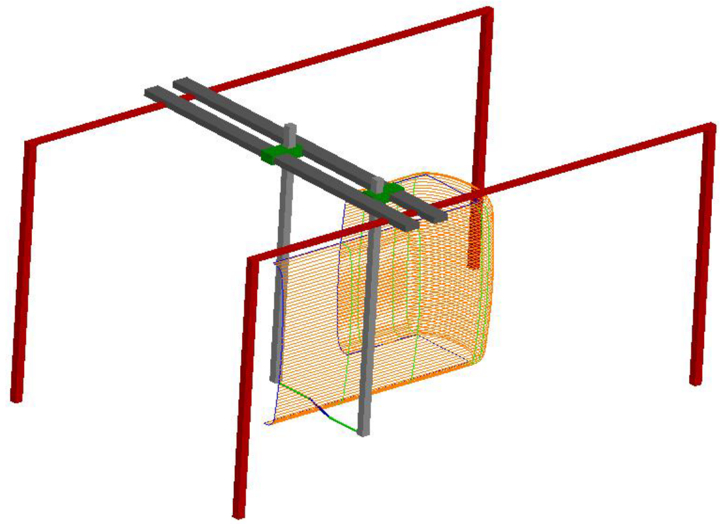
The basic ultrasonic requirements for testing of GLARE have been evaluated using parameters predefined by the University of Delft, Netherlands. The specified probe frequency is 10MHz. As a result of this high frequency, increased precision requirements to the mechanical accuracy and vertical incidence of the squirter probes positioning and correct inspection movement arose. Small angular deviations could cause high deviations in signal strength and reliability of

inspection results. As a result of these strict requirements, a multi axis scanner concept was developed with capability to vertically enter the part surface at any position of the part.
The panels are curved in Z-Y plane up to 20° and in the X-Y plane up to 17°. The scanner system for these GLARE components comprises 11 axes for movement and contour following.

(Slide 2 Glare Inspection System)

- Due to the curvature in the X-Y plane additional axes for azimuth (B) and linear contour following (C) were required.
- The total scanning volume is 11.5 m (38") in X-direction, approx. 1 m (3 ft) in Y direction and 3.5 m (11.5") in Z direction.
- To reduce the inspection time 4 channels are installed.
- The system is able to scan at a maximum speed of 1 m/sec. (180 ft/min.).
- Inspection frequency 10 MHz, composite transducer material
- Logarithmic main amplifier with 80 dB dynamic acquisition range

Special features of this system:
3 D movement of 11 axes to keep the beam perpendicular to the part surface at any position
3 D scan set up by manual teach in or CAD data
10 MHz transducer using piezo composite material matched to GLARE inspection
The second scanning system was designed for full robotic scanning of complex shaped parts with 10 axes of movement and contour following.

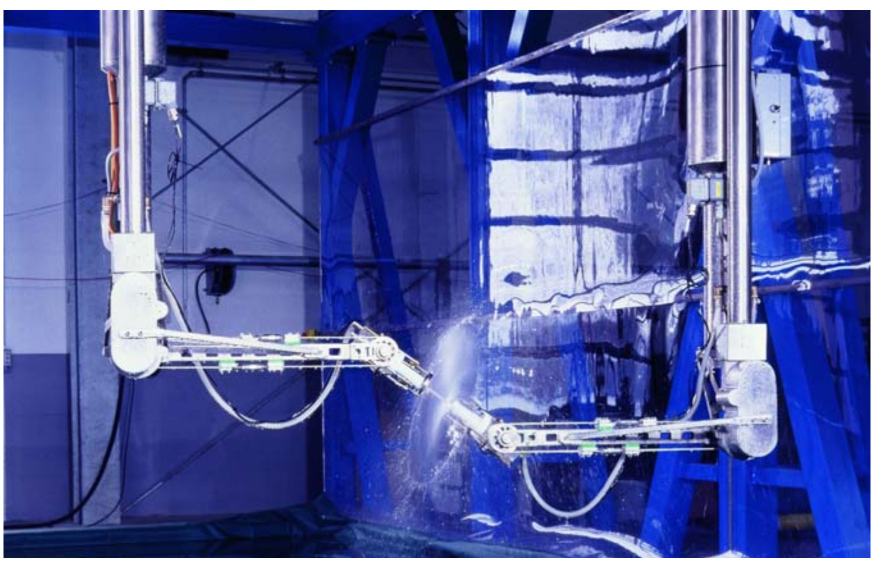


(Slide 3: basic layout of a 3D dual bridge System)

- The system is equipped with linear manipulators and comprises 2 separate X bridges. Each bridge is equipped with Y, Z, A, and B axes. Additional extenders are provided to enlarge the accessibility of C shaped parts
- The total scanning volume is 5,5 m (18") in X-direction, approx 3 m (10 ft) in Y direction and 3.5 m (11.5") in Z direction.
- 1 UT channel using two UT boards is installed.
- Combining the channels to increase the dynamic inspection range to 110 dB for parts with a high deviation in damping and low frequency transducers.

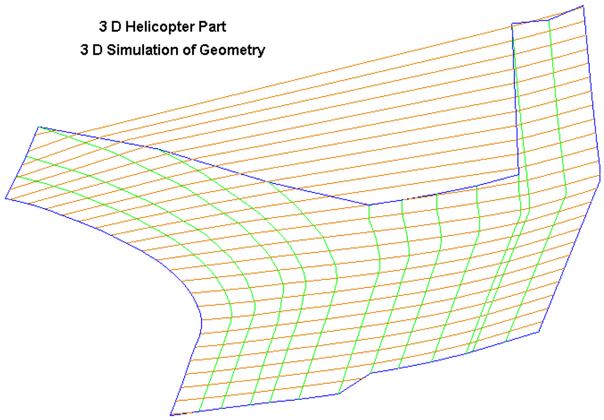
The system is able to inspect with maximum 1 m/sec. (180 ft/min.).

(Slide 4: Picture of the 3D dual bridge System)



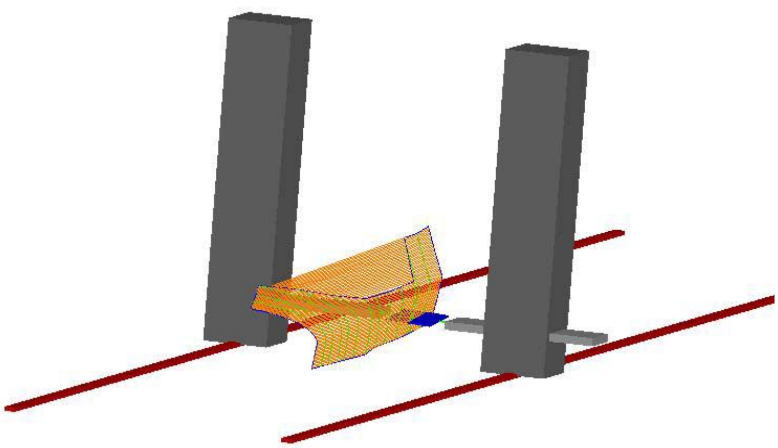
(Slide 5: Special capability: Test of cranked parts with extender arms)

New developments for this system:
3D true- to- location trigger
Extended dynamic range of 110 dB during the scan, i.e. a signal fluctuation of up to 110 dB can be acquired without readjustment of the system.
3 D inspection and complex geometrical set up by manual teach in or by CAD data



(Slide 6: 3 D Geometry Setup)

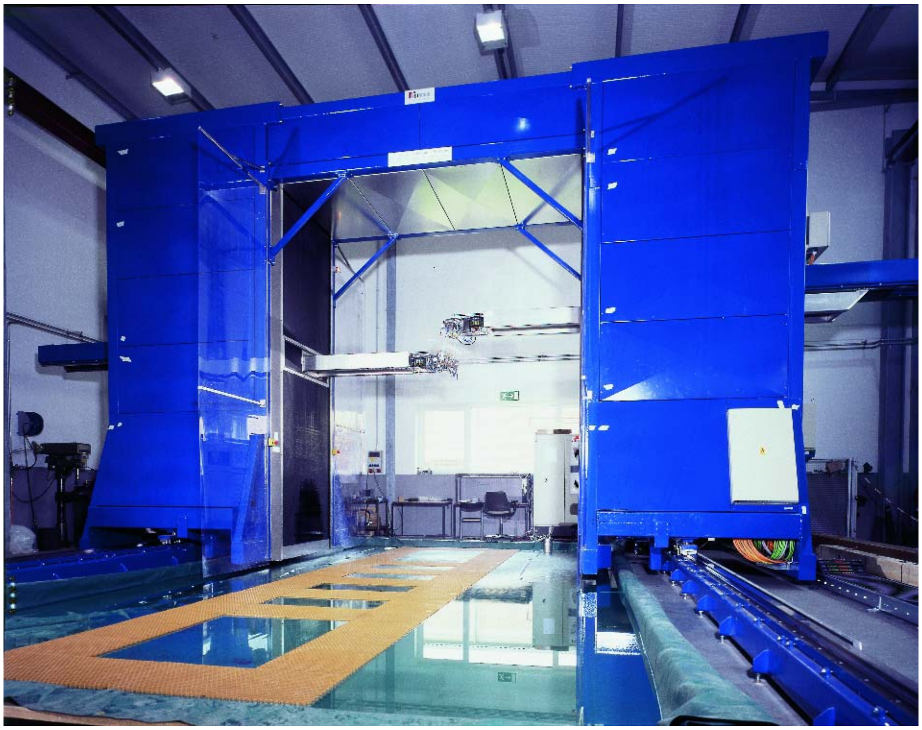
An additional concept of a fully robotic scanner is described in the following example: It consists of 12 axes for movement and contour following.



(Slide 7: Robotic System)

- For curvature in the X-Y plane of up to ± 50 ° additional axes for azimuth (B) and linear contour following (C) were required.
- The total scanning volume is 8.5 m (28") in X-direction, approx 2.2 m (7 ft) in Y direction and 3.5 m (11.5").
- 2 UT channels are installed. The channels can be used for reducing the inspection time, inspecting with 2 different frequencies or by combining the channels to increase the dynamic inspection range to 110 dB for parts with a high deviation in damping.
- For highly damping parts with honeycomb sandwich up to 120 mm a tone burst transmitter is provided.
- The system is able to inspect with maximum 0.6 m/sec. (120 ft/min.).

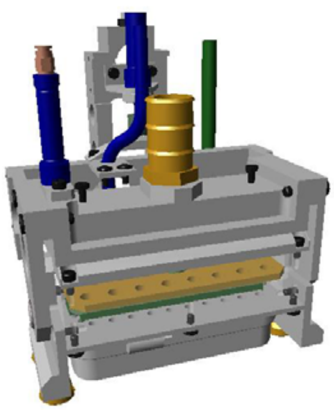
Inspection frequencies from 0.5 to 10 MHz



(Slide 8: Robotic System)

New developments for this system:

- Using two cannels in different combinations
- Adaptation of Airborne Ultrasound to our standard UT system (to be presented at a later date)
- Preparation for multi channel inspection using PAT (Phased Array Technology) electronics in combination with bubbler technology.



(Slide 9: Bubbler Probe Multi channel Array)

Conclusions: The systems presented provide state-of-the-art technology for inspecting aircraft components for different applications, mainly for complex geometrical requirements and high reliability. All technological disciplines like advanced mechanics and motion controls as well as UT- equipment and data acquisition and evaluation system have been upgraded for advanced capability. In a next step, Phased Array Technology will be integrated for multi channel application and parallel B-scan. This new technology integration will further enhance detection capability and throughput.

References: Proceedings of Aerospace Testing Hamburg, 30.3. – 1.4.2004: Multi Axis Automated Ultrasonic Inspection Systems for new AIRBUS A380 composite Glare Panels by Jeroen Rutten