



TIME- AND COST-EFFECTIVE TESTING OF CFRP COMPONENTS BY UT MULTISENSOR TECHNIQUES

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- > Relation component - examination method,
Examination strategy
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Introduction

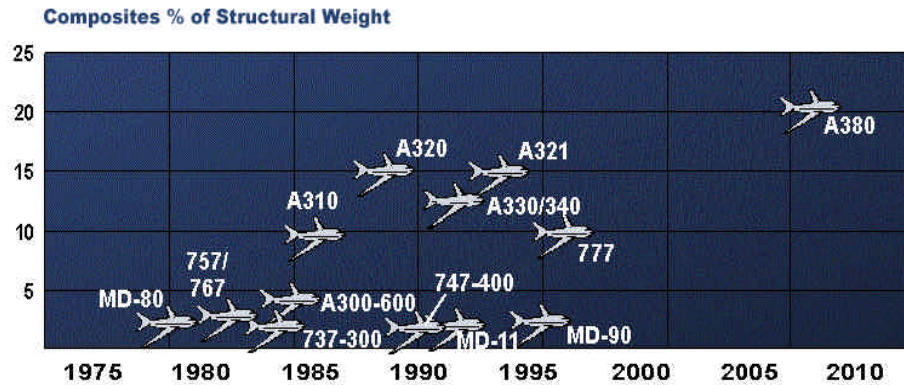


- > Growing share of CFRP components in advanced aircraft
- > Large variation of size and complexity of geometry
- > Further challenges for the design of NDE systems
 - High reliability of detection and sizing of eventual defects, predominantly delaminations
 - Time-efficient inspection, which supports the integration into the fabrication sequence
- > Advanced techniques in order to meet these requirements

Increasing share of CFRC in aircraft



Composite Applications in Commercial Aircraft



Source: <http://techreports.larc.nasa.gov/ltrs/PDF/2001/mtg/NASA-2001-22sampe-ceh.pdf>, page 8.

	757	767-400	777	A340-500/600	A380
Radome	•	•	•	•	•
Landing Gear Doors	•	•	•	•	•
Fairings	•	•	•	•	•
Rudder	•	•	•	•	•
Elevator	•	•	•	•	•
Ailerons, Spoilers, Flaps	•	•	•	•	•
Engine Nacelle Parts	•	•	•	•	•
Wing Fixed Leading Edge	•	•	•	•	•
Wing Trailing Edge	•	•	•	•	•
Vertical Tail			•	•	•
Horizontal Tail			•	•	•
Floor Beams			•		•
Keel Beam				•	•
Aft Pressure Bulkhead				•	•
Wing Box					•
Wing Ribs					•

Source: ASM Handbook Volume 21 Composites, Aircraft Applications p. 1057. For more information go to: www.asminternational.org.



Consideration of different approaches Squirter technique



- > Through-transmission mode predominant
- > Integration of pulse echo feasible
 - Problem areas: Signal to noise ratio and near-surface resolution
- > Small scanning index, typically 1/3 of required defect detection diameter, affects inspection time
- > Limited number of sensors - jet interference
- > High scanning velocity

Principle of Squirter Technique



Jet diameter max. 6 mm

Consideration of different approaches

Immersion technique



- > Sensitive refraction angle dependence requires
- > Precise adjustment of probe arrangement
- > Deviations from straight contour require individual probe adjustment
- > Small scanning index, typically 1/3 of required defect detection diameter, affects inspection time
- > Stand-off dimensioning, monitoring and control
- > High scanning velocity

Consideration of different approaches

Contact technique



- > Relatively simple probe holder system - contour itself guides the probe
- > Combination of backwall monitoring and pulse-echo
- > Combination of different techniques, incl. phased array, integration into probe modules
- > High near-surface resolution by optimized parameters
- > Scanning velocity not quite as high, but more than compensated by large system footprint of modules

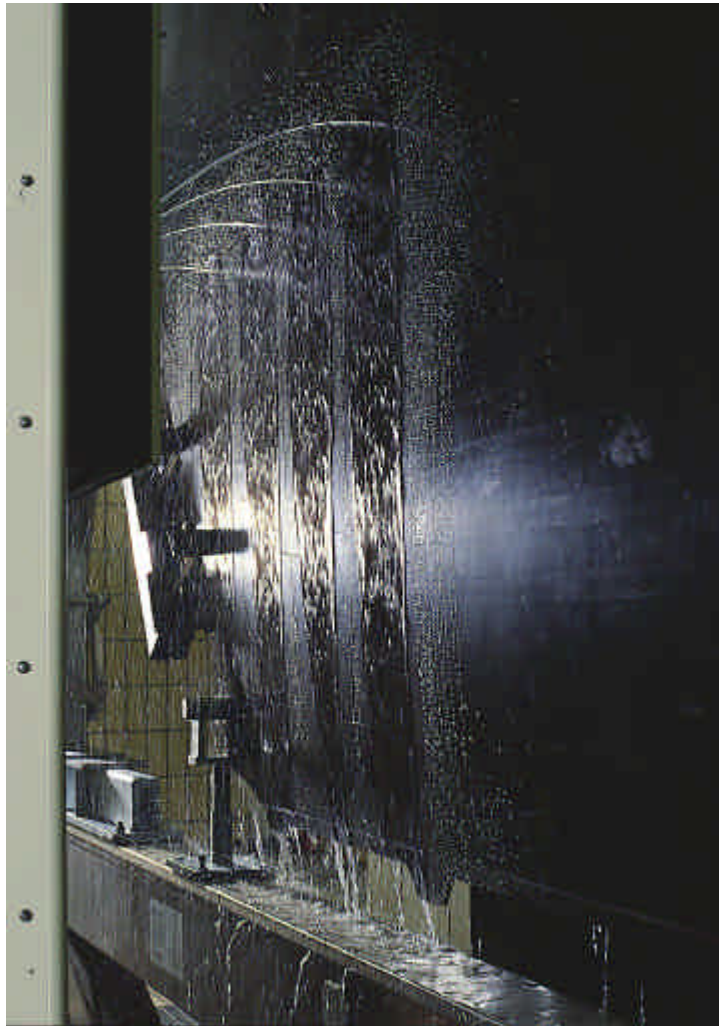
Examination Strategy (1)



> Squirter technique:

- Maximum number of 4 pairs of water jets
- One pair of water jets for complex geometries with complex control system or twin robot
- Scanning velocity up to 1000 mm/sec, only helps for large straight geometries, small index as disadvantage
- Integration of pulse echo for defect depth location
- Only available technique for honeycomb structures

Squirter technique with maximum water jet arrangement



**4 Jets with
optimized offset
to avoid
interference**

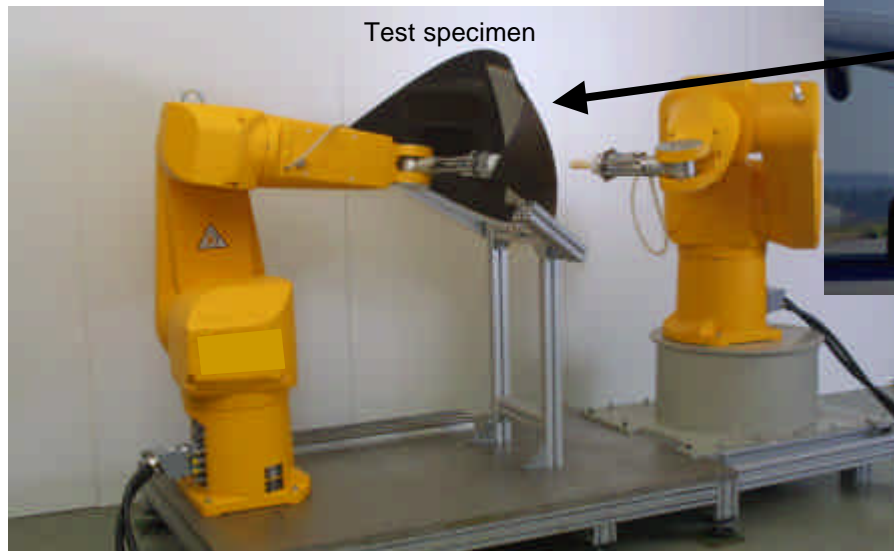
Example of components with complex geometries



Inspection of helicopter chassis with complex geometries

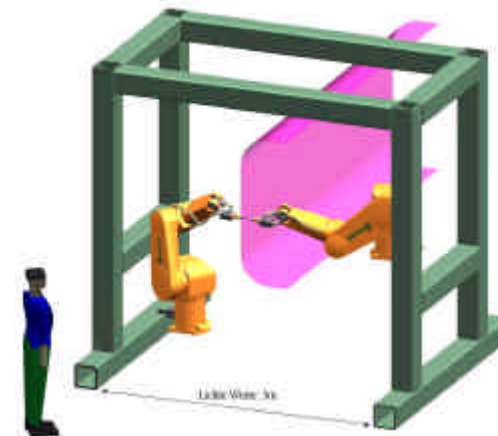


Inspection of components with complex geometries



Test specimen

Twin robots



Gantry solution

Examination Strategy (2)



> Immersion technique

- No couplant problem, if bubbles are removed
- No problems with scanning of components edges
- Number of probes depending on complexity of component due to
- Need for precise adjustment for each individual probe
- Need to maintain constant stand-off

Examination strategy (3)



> Contact technique:

- Largest range of application
- Replacing squirter technique for complex geometries with one- or two-probe arrangements employing robot
- Easy integration into multisensor probe modules for larger, less complex geometries

Implementation of multisensor contact technique



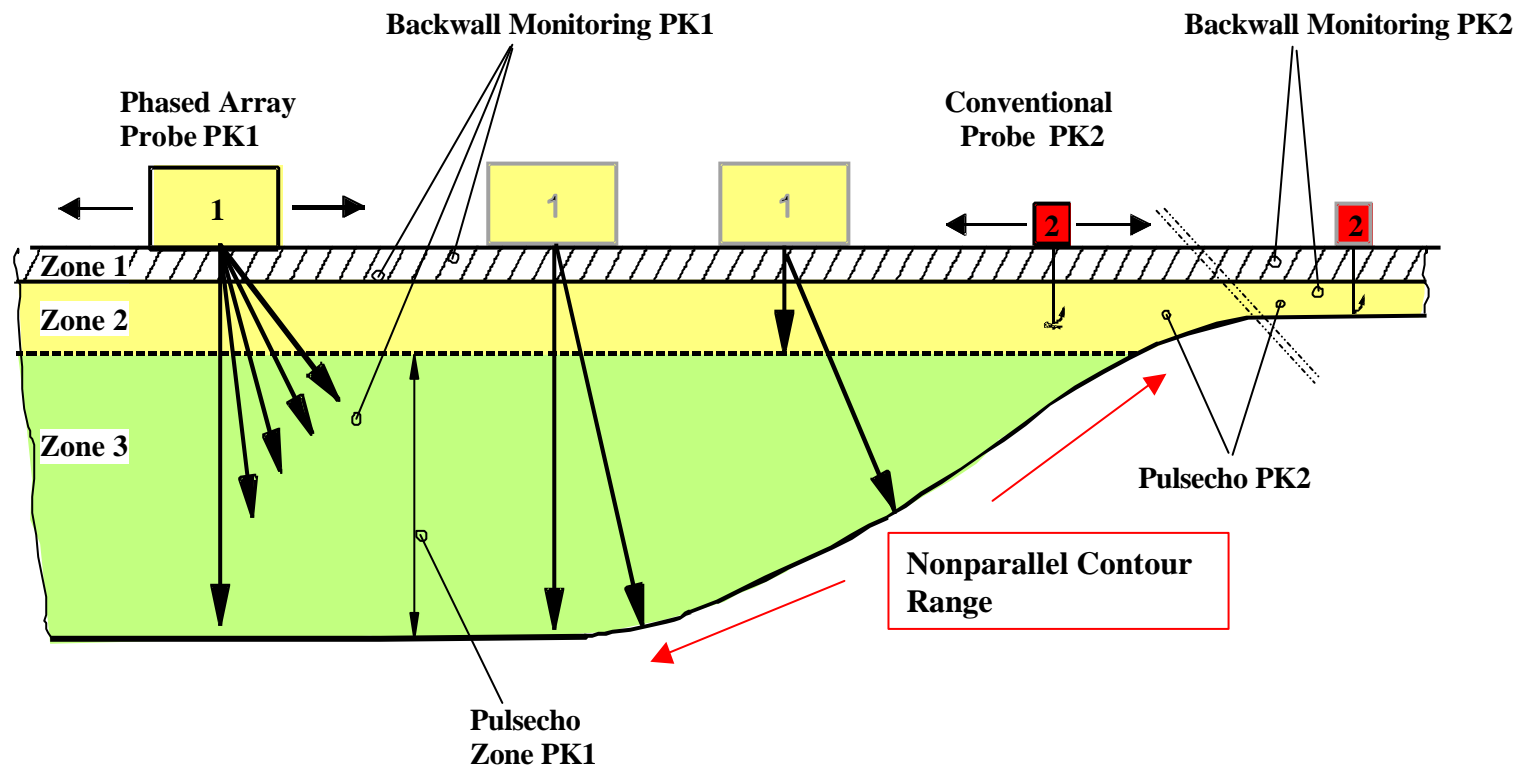
- > New inspection approach required
- > German research project MaTech, sponsored by Federal Ministry for Education and Research
- > Partners:
 - Airbus Deutschland, Bremen
 - Ingenieurbüro Dr. Hillger, Braunschweig
 - intelligenteNDT Systems & Services, Erlangen
 - TUHH Technologie, Hamburg-Harburg

Task



- > Integration into fabrication sequence leaves short time interval relative to large components dimensions
- > Combination of pulse echo (for defect location) and through transmission techniques is desirable
 - For the latter technique nonparallel contours pose a problem
 - High sound attenuation - low frequencies
 - High resolution - high frequencies
 - High positioning accuracy
 - 6 x 6 mm² detectable defect requires 3 mm scanning index
- > Scanning range up to: 28 m height and 8 m width

CFRP Inspection with contact technique



UT Instrument SAPHIR Plus

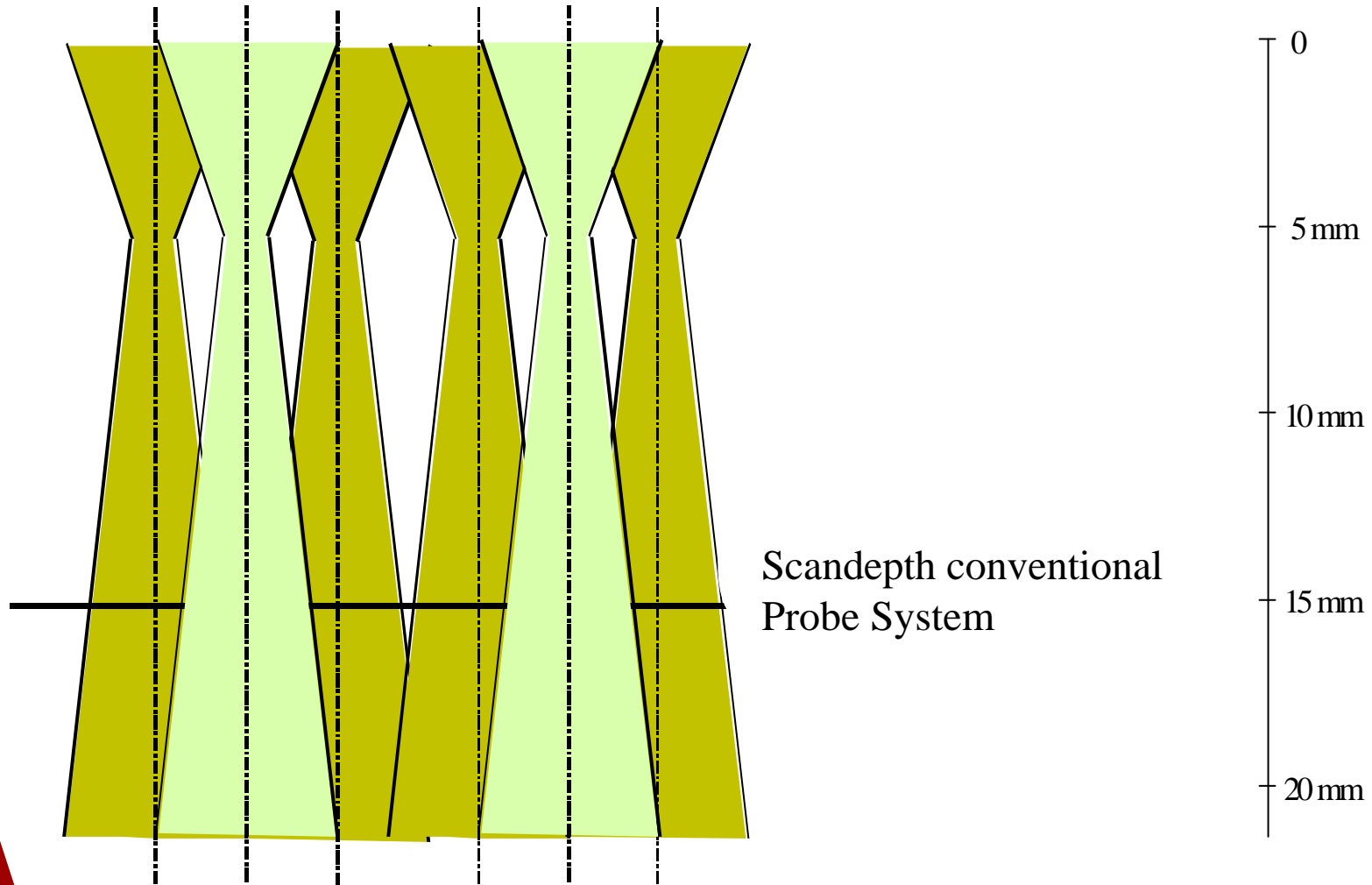


- Combination and interaction of phased array and conventional probes
- Various data reduction modes: RF, pixeling, ALOK, gates
- Precise beam pattern control (vertical, horizontal or combined skew, focusing)
- Equipment parameters for a wide range of applications
- Selectable lin. or log. amplifier
- Automated self-check and self-calibration within a quarter of an hour
- Extensive database of individual probes and probe system data
- Different operator access levels to the system
- Integration of EC-channels with preprocessing

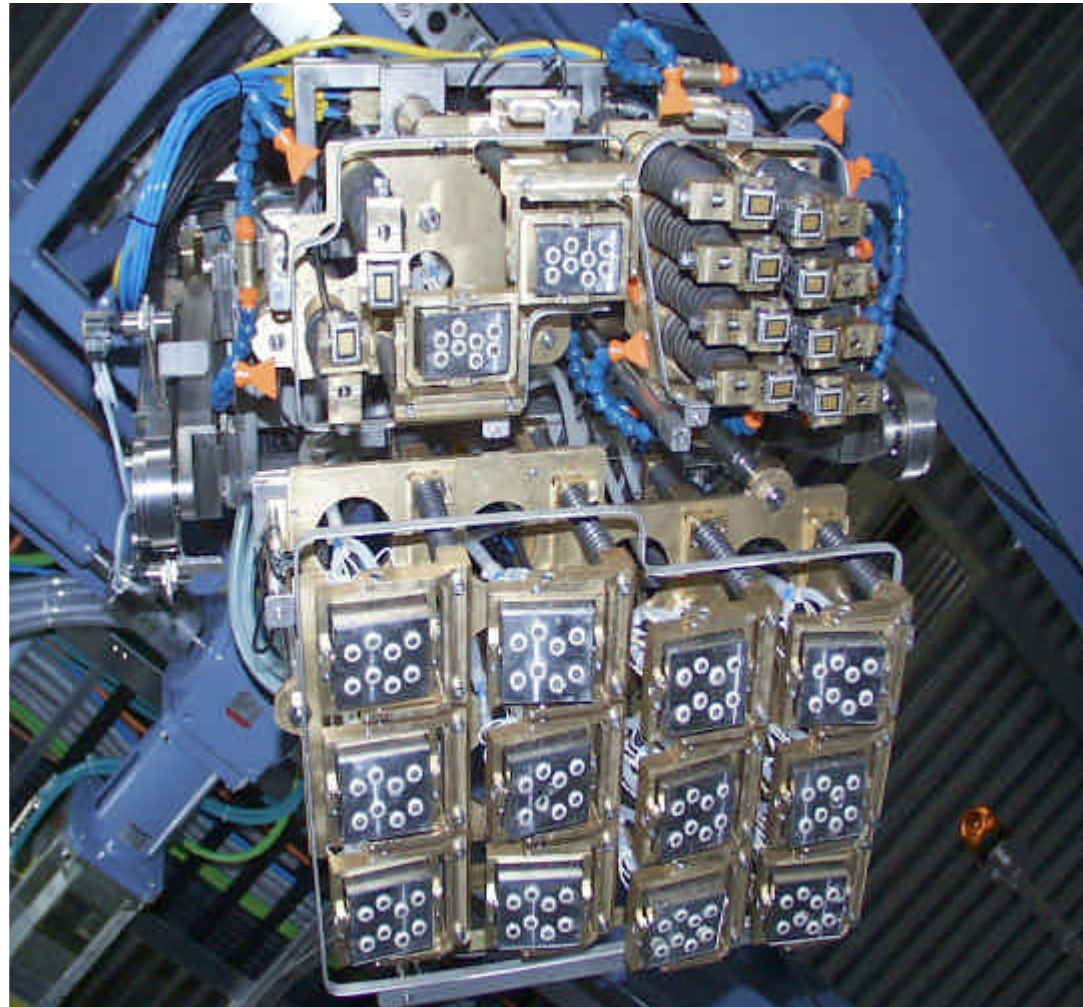
Phased Array Probe, specific Design



Beam Overlap within and between Phased Array Probe

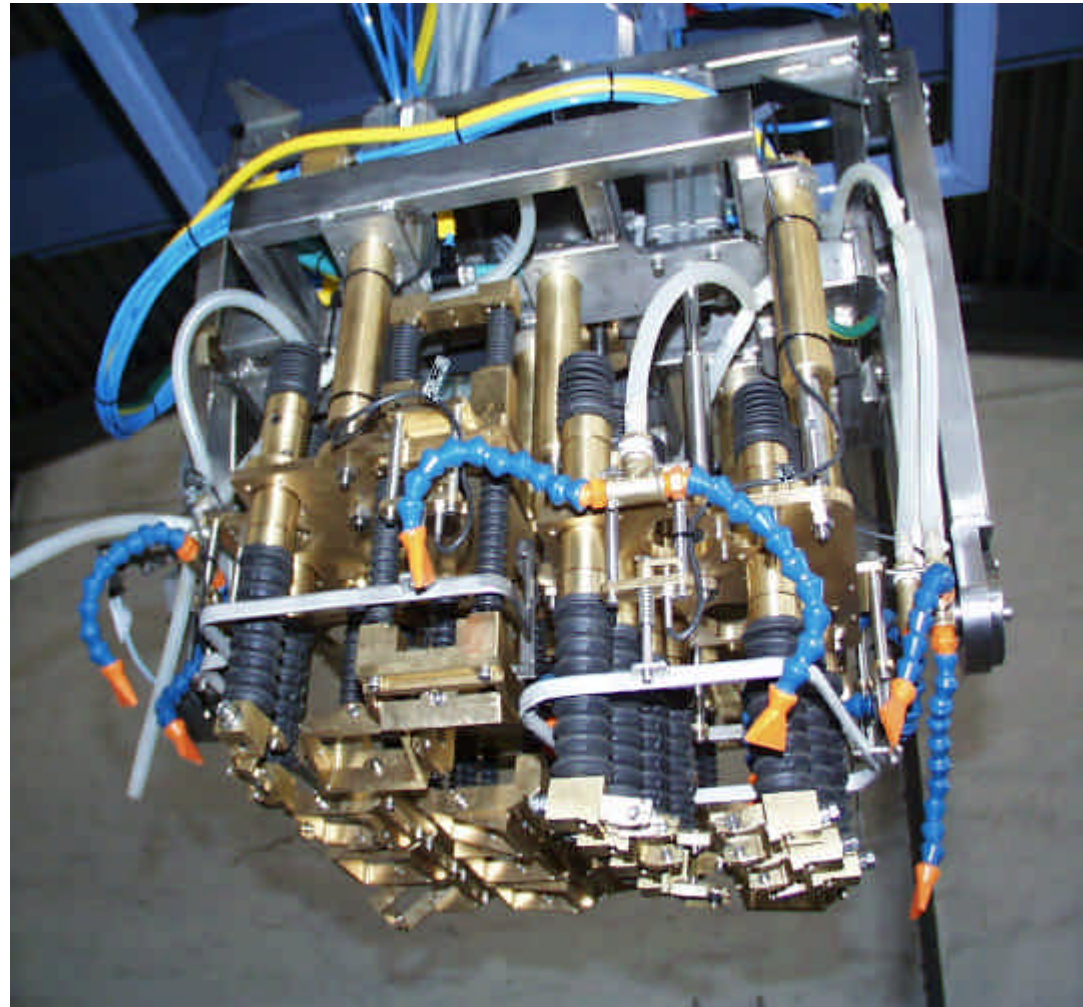


Multichannel Multiprobe System



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Multichannel Multiprobe System



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Test Stand



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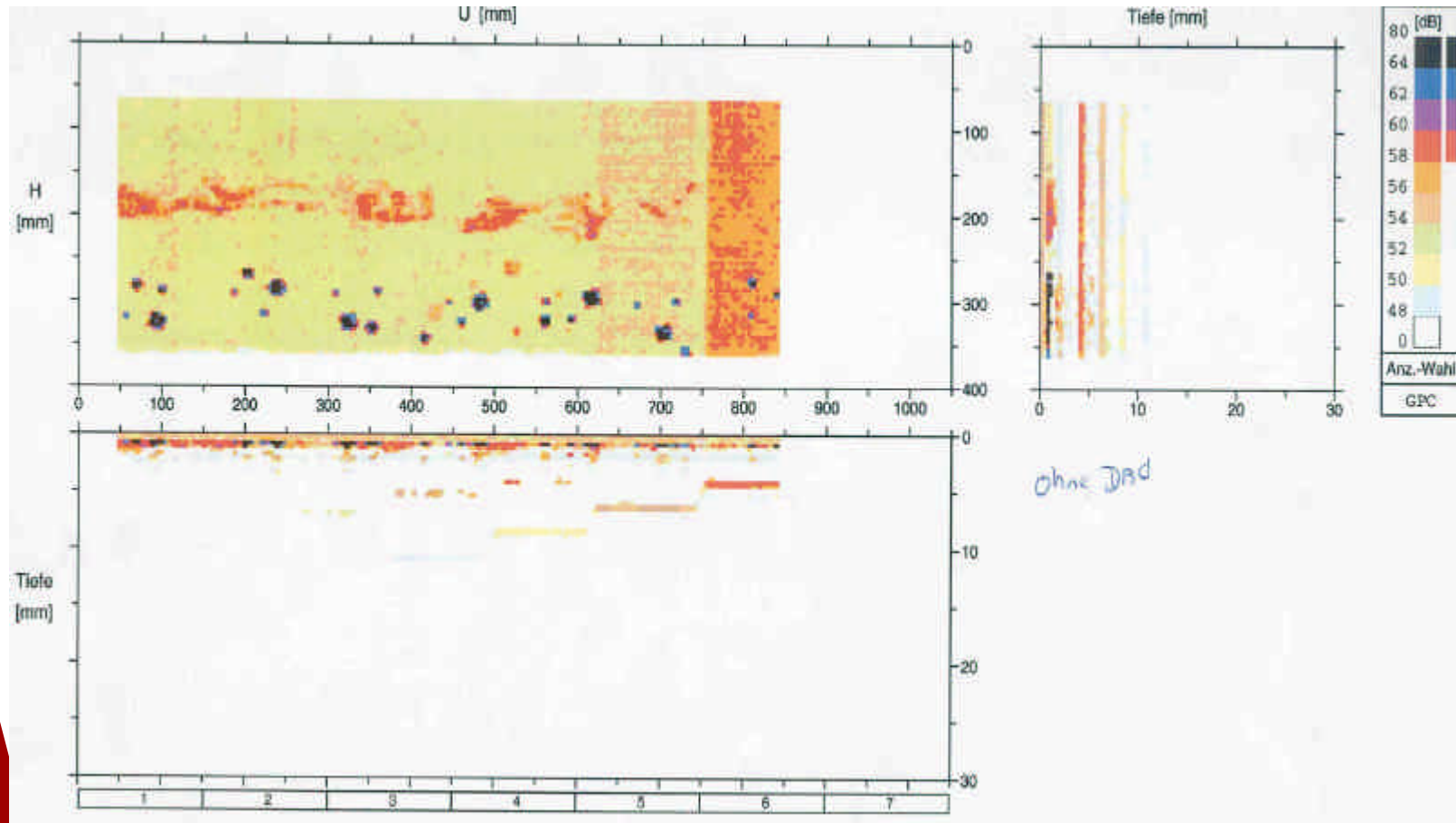
Test Stand



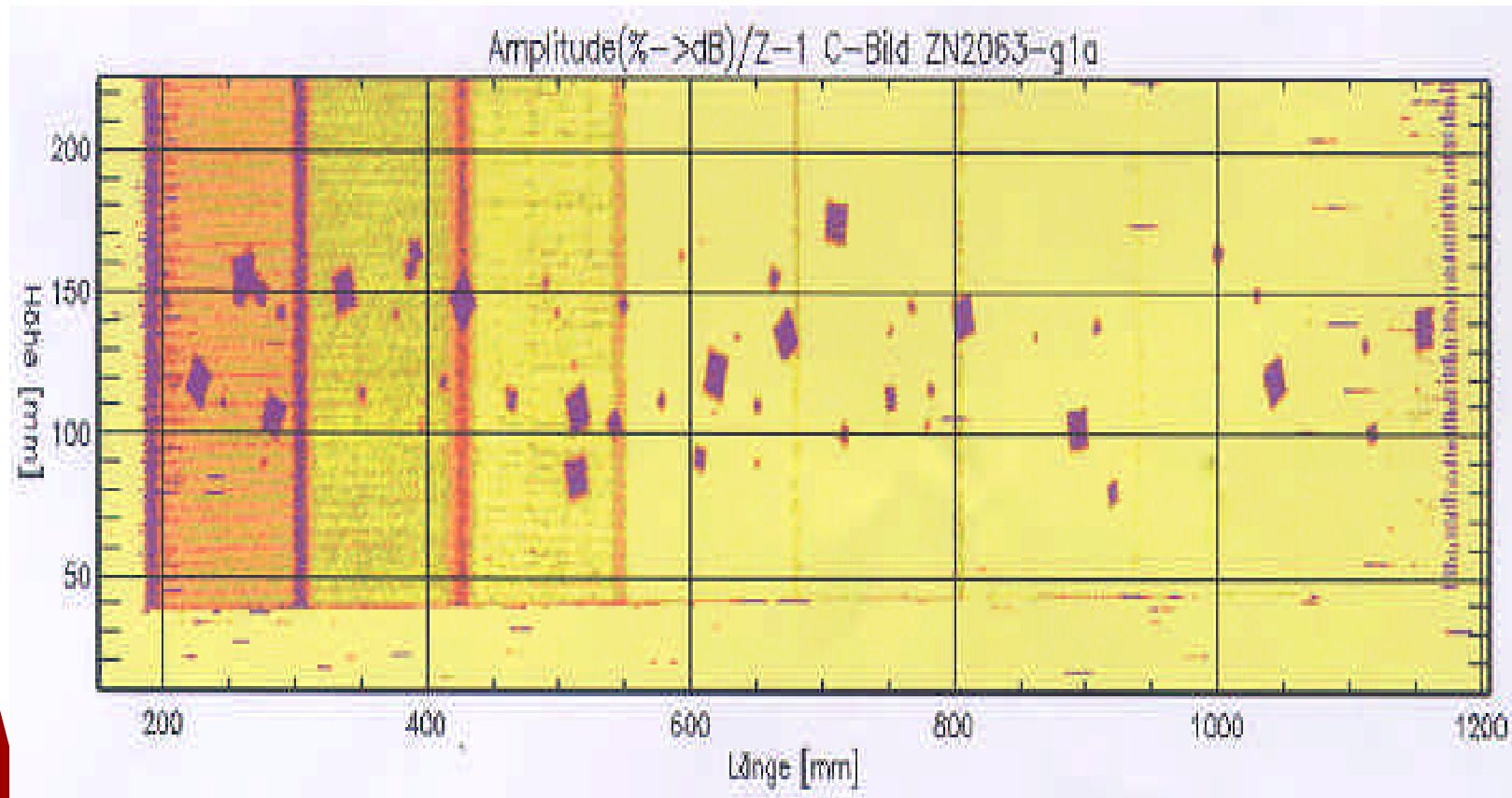
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> Aerospace Testing Expo 2003 in Hamburg - 26.-28.2.2003

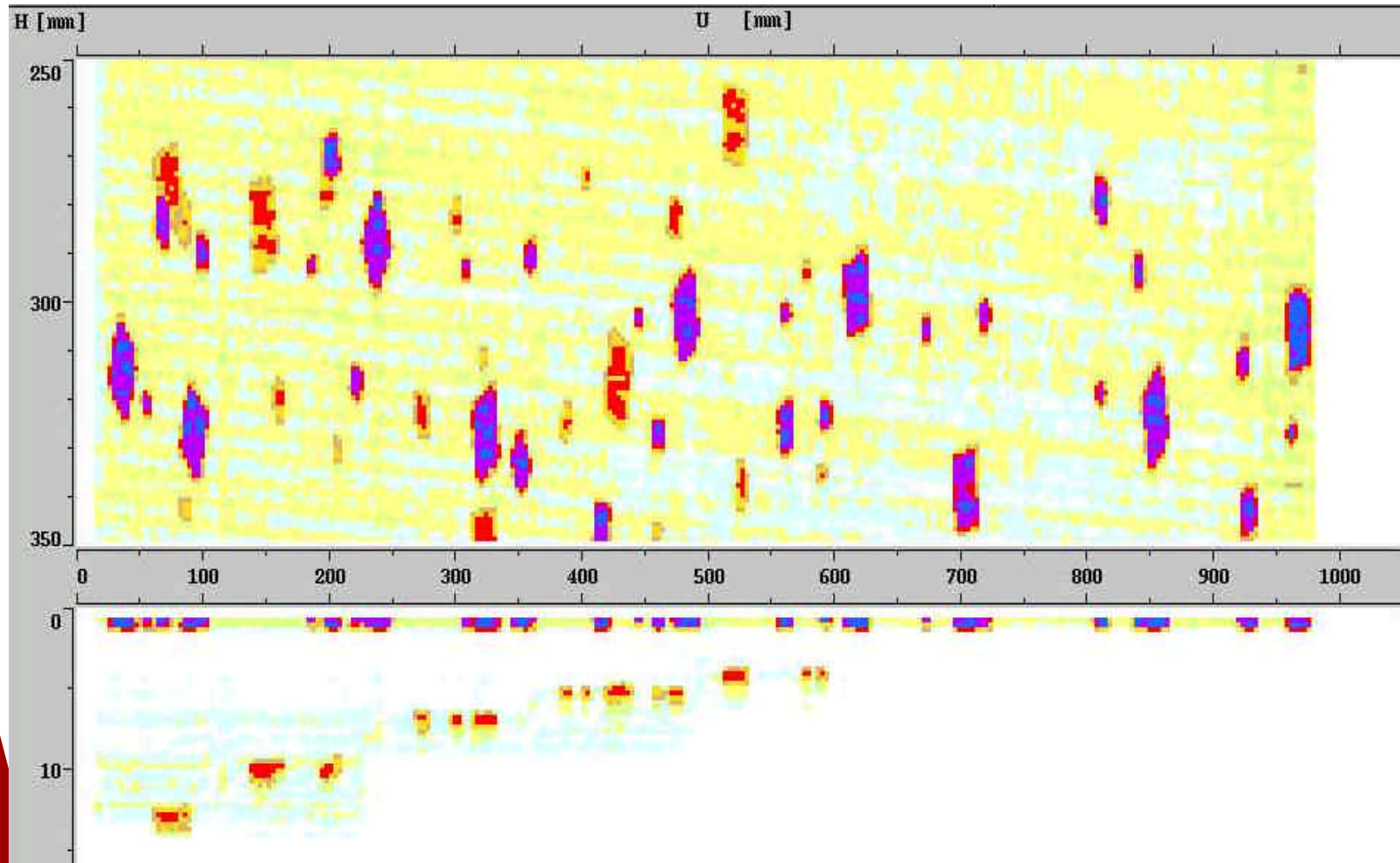
Testpiece with Porosities and Delaminations



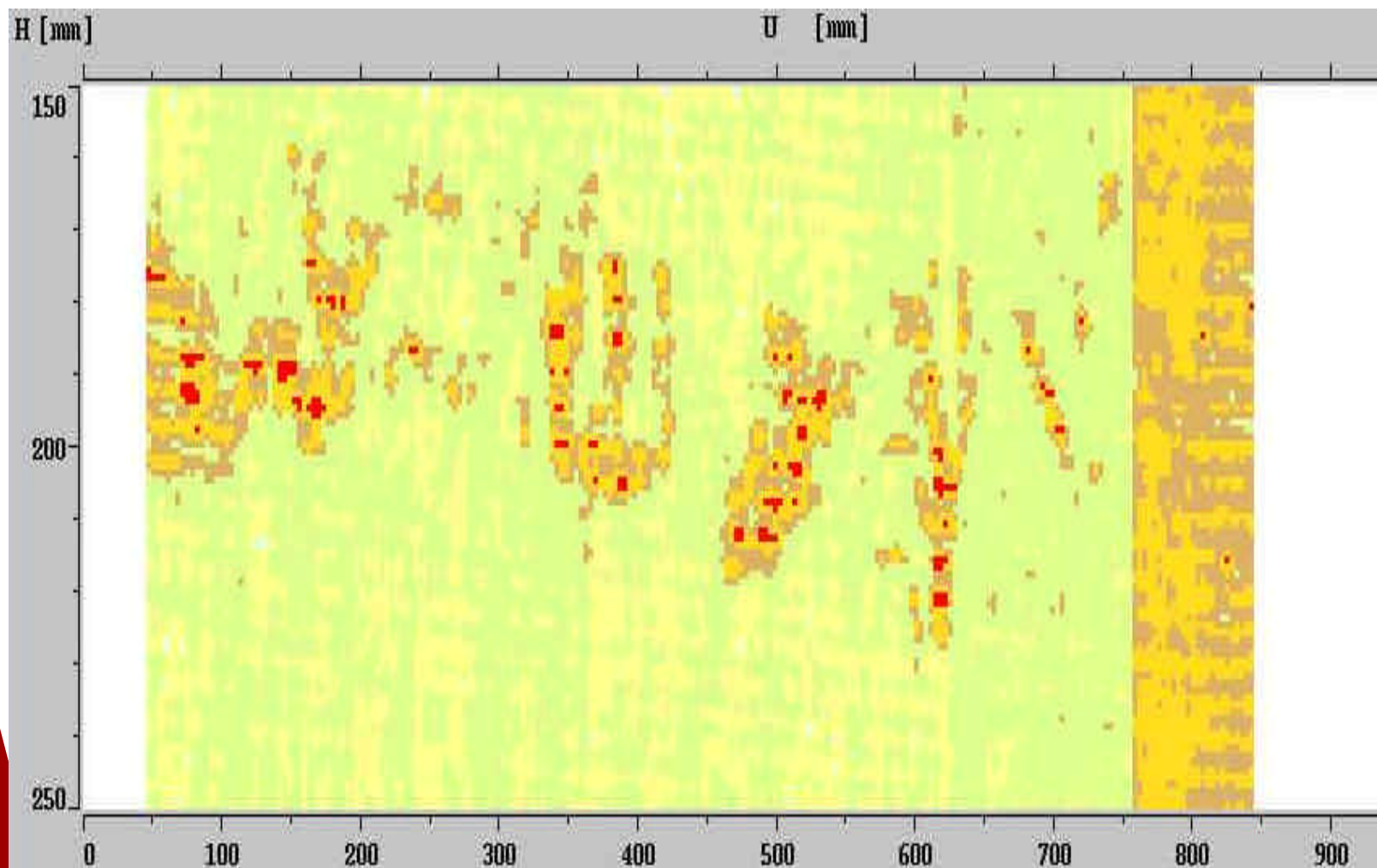
Squirter Technique, Results from Test Piece



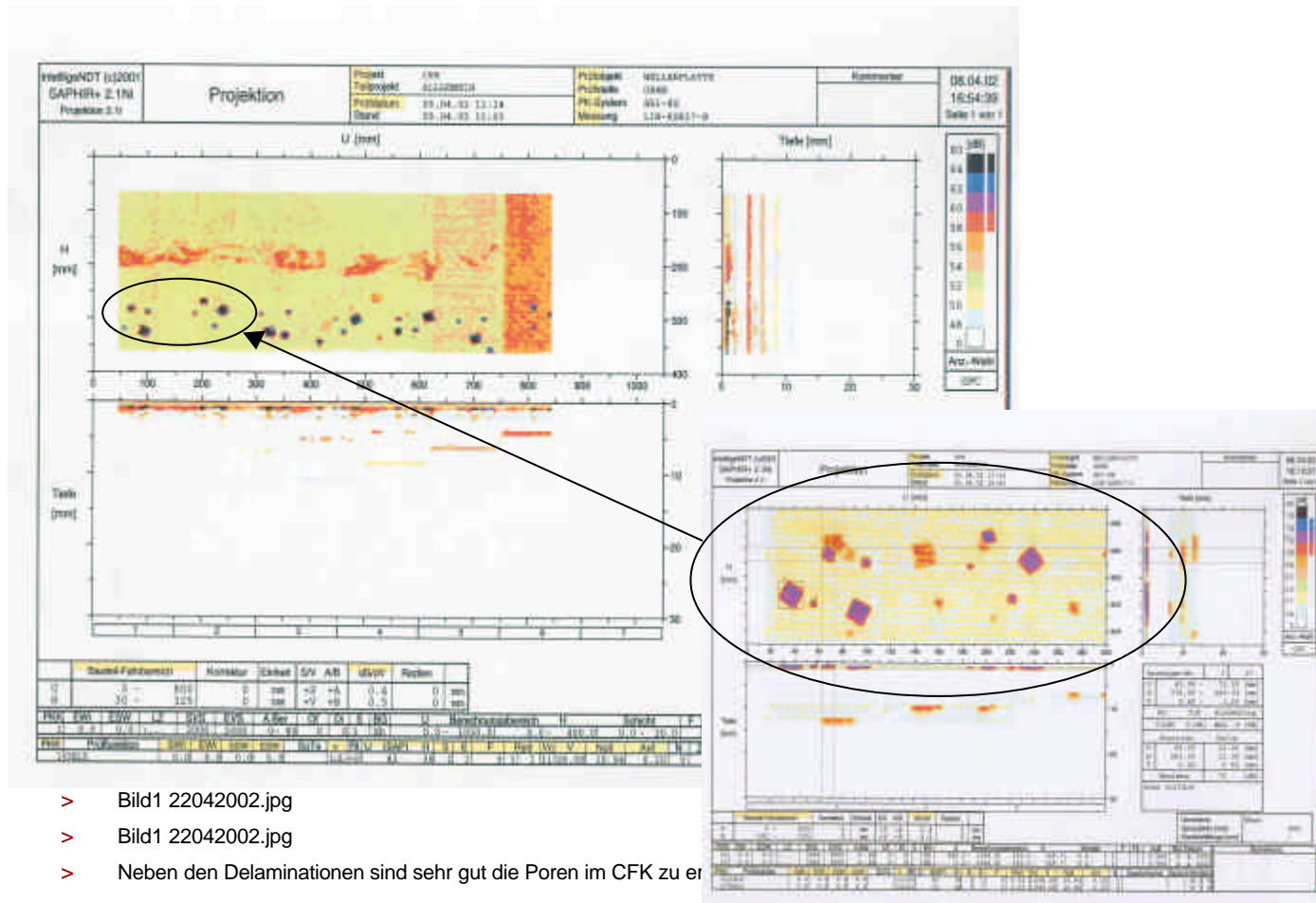
Multichannel Results from Test Piece: Delaminations in different Depths



Surface-near Porosities in Contact Technique



Test Piece Results with Zoom Display



- > Bild1 22042002.jpg
- > Bild1 22042002.jpg
- > Neben den Delaminationen sind sehr gut die Poren im CFK zu er

Experience, Conclusion



- > First multichannel multisensor system in operation since 2001 for fin box examination
- > High productivity (factor 10 compared to other systems), high availability, clear results
- > Highest degree of automation
- > More such systems in start-up or on order
- > Prototype system with contact technique twin probe system and robot with excellent performance