RAID

Remote Acoustic Impact Doppler

A System for Mapping Structural Anomalies

A new concept in Non-destructive Testing

Prepared & Presented by: Dr John M. Webster
Johnmwebster@btinternet.com

www.asseca.co.uk

Operating Principles of RAID

The RAID system is a totally remote NDT system that can operate at stand-off distances of up to at least three meters.

RAID technology depends on the fact that any out-of-plane surface vibrations excited in an object will differ depending on the construction material and the underlying supporting structure. A highly simplified and limited analogy of the technology is the “tap test” where a coin is used to tap across a structure, the resulting sound giving an indication of the integrity of the structure or the presence of hollowness beneath the surface.

Laser Scanning Vibrometer and Exciter unit.

The exciter unit produces a shockwave that impacts the object undergoing testing, exciting it to produce out-of-plane vibrations at their natural resonate frequencies. These frequencies are directly dependent upon the material, design and subsurface conditions of the structure.

Synchronised to the exciter, the laser vibrometer scans the object, point by point, recording out-of-plane vibration. These frequencies and amplitudes that have been stimulated by a shockwave produced by the exciter. The response to the shockwave of an area of defect will be different from an undamaged area of similar material. After the scan, these frequencies and amplitudes are analysed using a specially designed computer algorithm to show subsurface defects present in the structure undergoing testing.

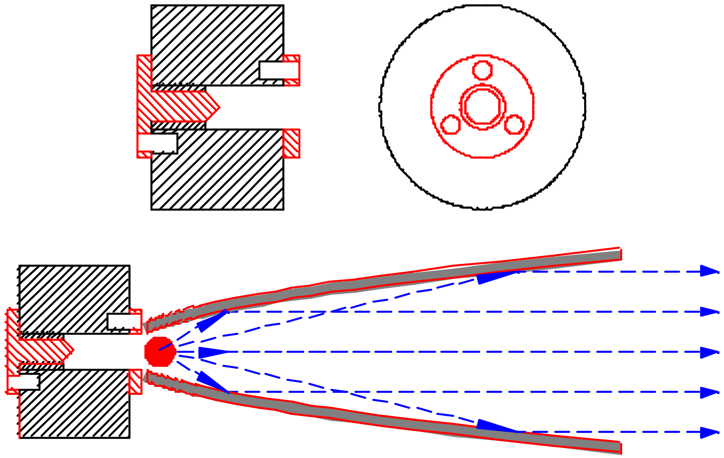
Laser scanning vibrometer & transducer

The Exciter Unit

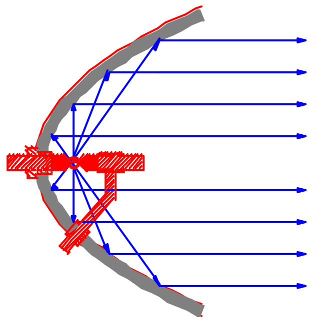
This has undergone an evolution of development. It uses a high voltage discharge to produce a shockwave. In its final design an innovative electrode is used so that a powerful shockwave is focused onto the object undergoing testing. The shockwave amplitude is in the region of 1 psi at a standoff distance of around 1 meter.

NOTE: CONSIDERATION AND PRELIMINARY EXPERIMATION HAS BEEN MADE TO RENDER THE DISHCHARGE SAFE IN POTENTIALLY EXPLOSIVE AREAS.

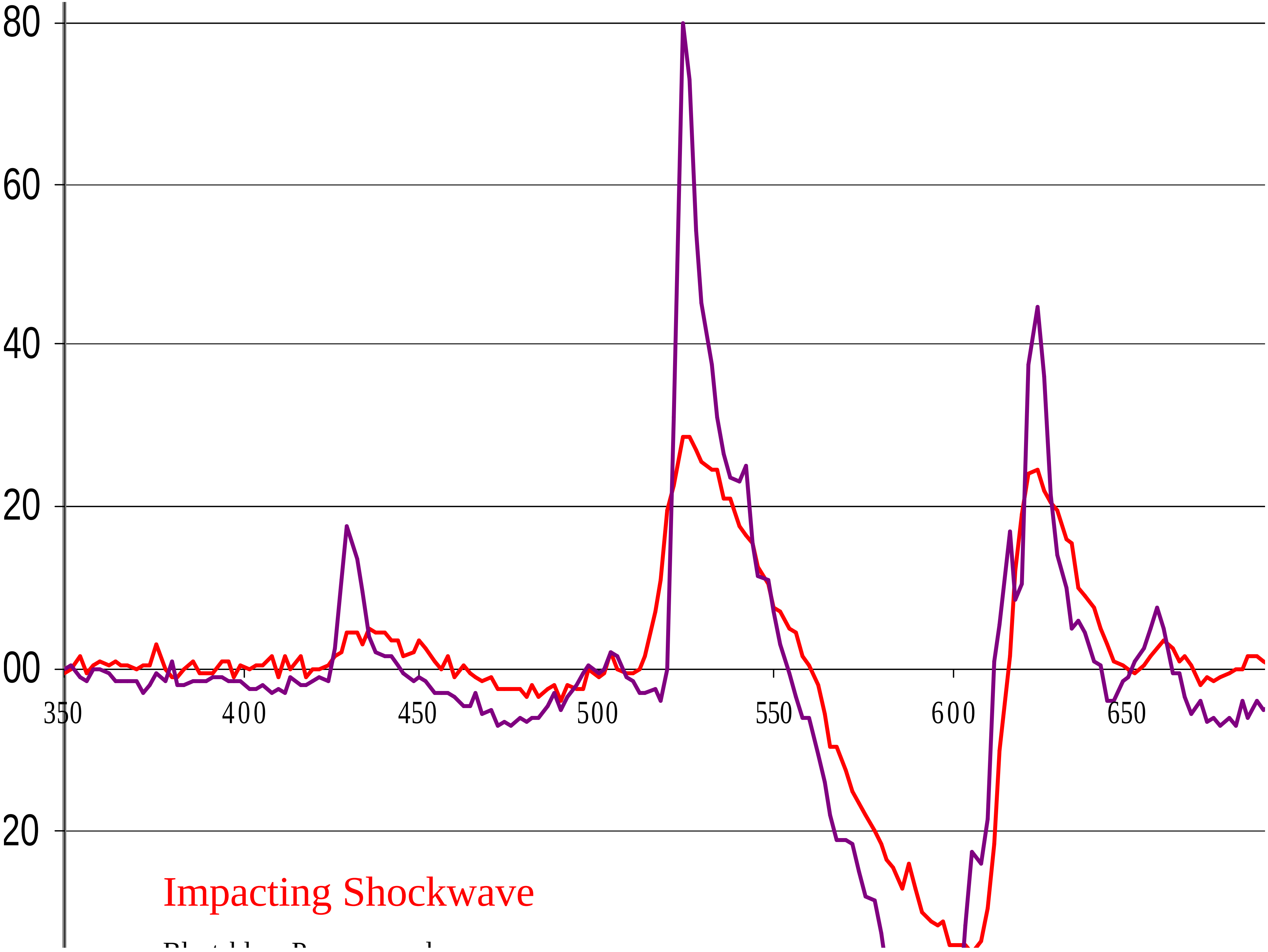
• *Evolution of the Acoustic Transducer*



A parabolic reflector was attached to large bore transducer; the red dot denotes the parabolic focus.



Parabolic dish design with open discharge.


80
60
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350
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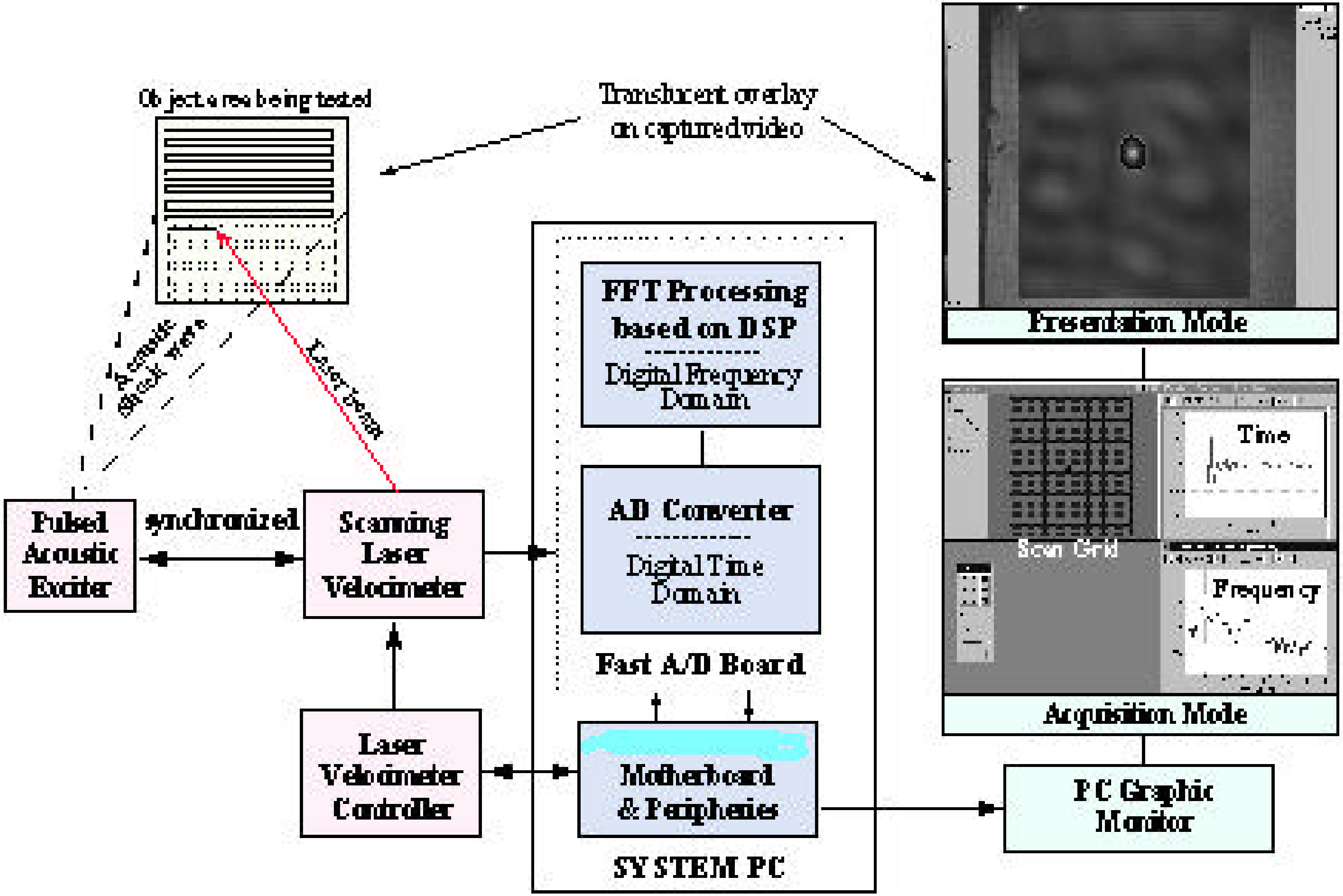
650
Impacting Shockwave

System Architecture

The shockwave impacting the test object is synchronised to the scanning laser. The laser vibrometer, which employs the Doppler effect, scans on a point-by-point basis to acquire data across the surface of the test object The resulting data is recorded in the form of a digitally time domain trace that is later processed to a Fast Fourier Transform (FFT); an FFT is a vibration spectrum of the data point(s) recorded.

The final analysed result is presented to the operator superimposed on a picture of the object undergoing testing. By simply clicking on any defect present on the monitor the operator can cause the scanning laser to point to the defect region on the test object.


Object area being tested
Translucent overlay
on captured video
Presentation Mode
Acoustic
Shock wave
Laser beam
FFT Processing
based on DSP
Digital Frequency
Domain
AD Converter
Digital Time
Domain
Fast A/D Board
Time
Scan Grid
Frequency
Acquisition Mode
Pulsed
Acoustic
Exciter
synchronized
Scanning
Laser
Velocimeter
Laser
Velocimeter
Controller
Motherboard
& Peripheries
SYSTEM PC
PC Graphic
Monitor

Processing Algorithm

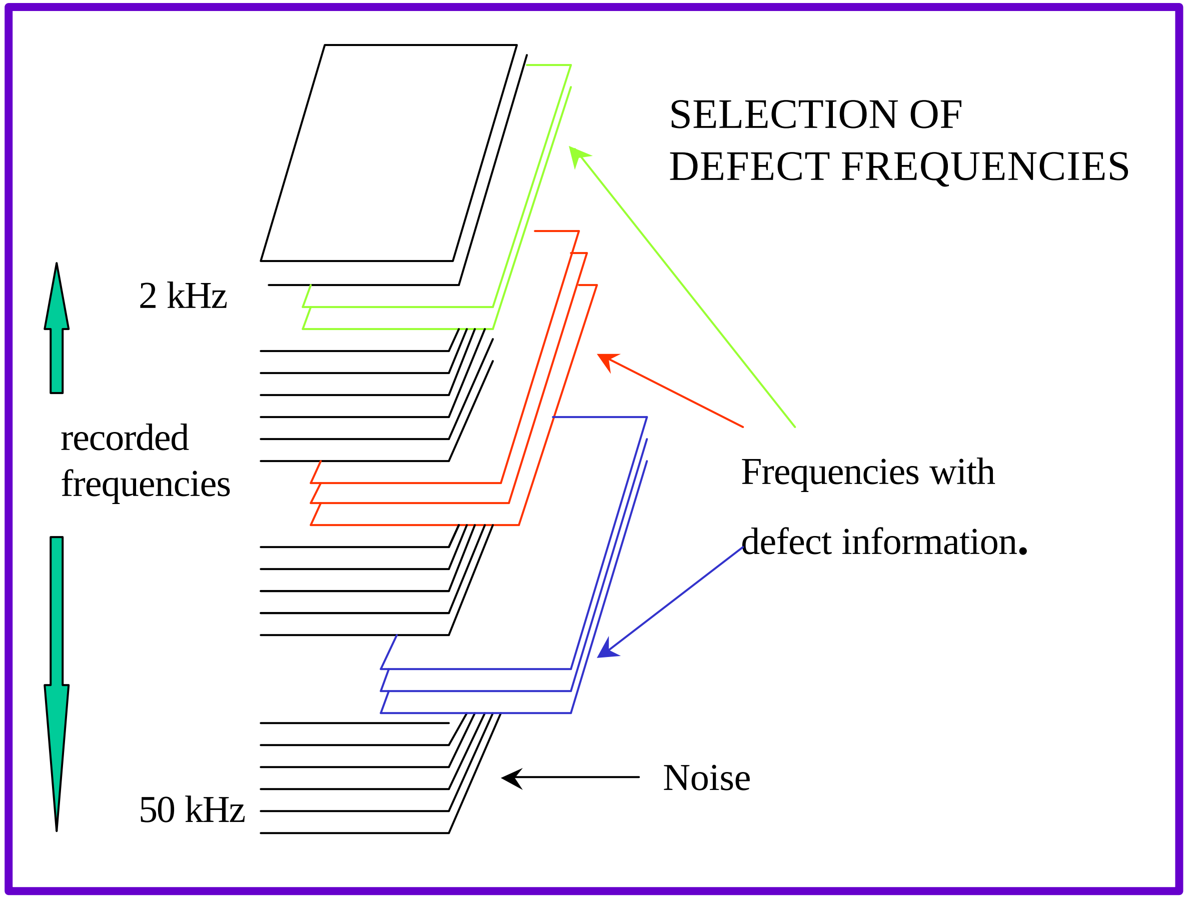
(Brief explanation)

The system has the potential record up to a a thousand frequencies, therefore potentially images of the object vibrating at these different frequencies of the object vibrating at each of these different frequencies. In practice these usually cover a range from 0 to 20kHz. In application a frequency range is selected best suited to the test object's material & structure.

Most of the frequencies recorded invariably do not pertain to any defects and constitute noise. The objective of the analysis program is to eliminate these and retain only those frequencies carrying information relating to defects and present these as a single combined image.

Any defect will have a range of frequencies depending on a number of parameters including its shape and size. Therefore the final image must incorporate all these to be representative of the defect shape.

Explanation of the data "cube" & frequency selection process

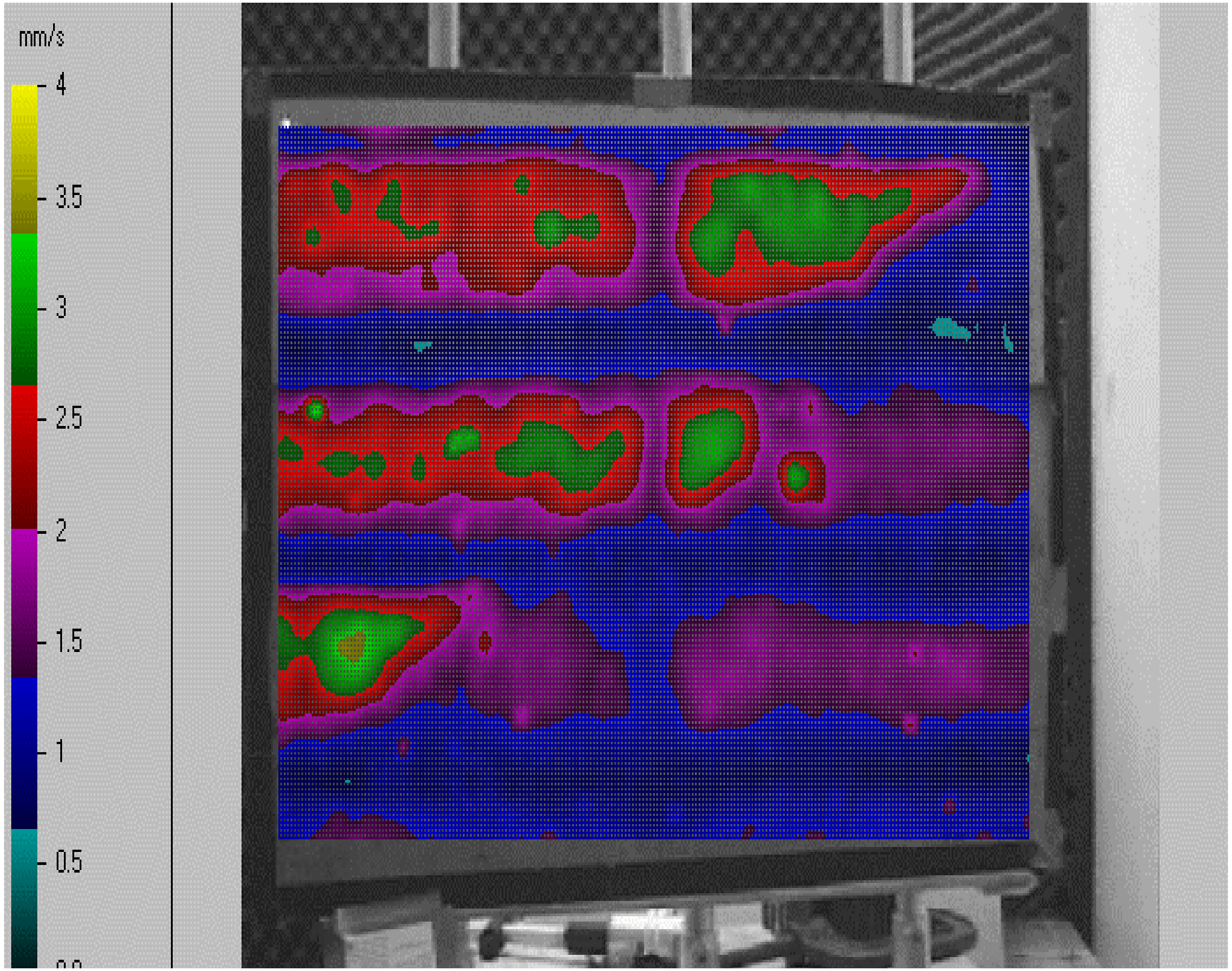


Detection of subsurface corrosion

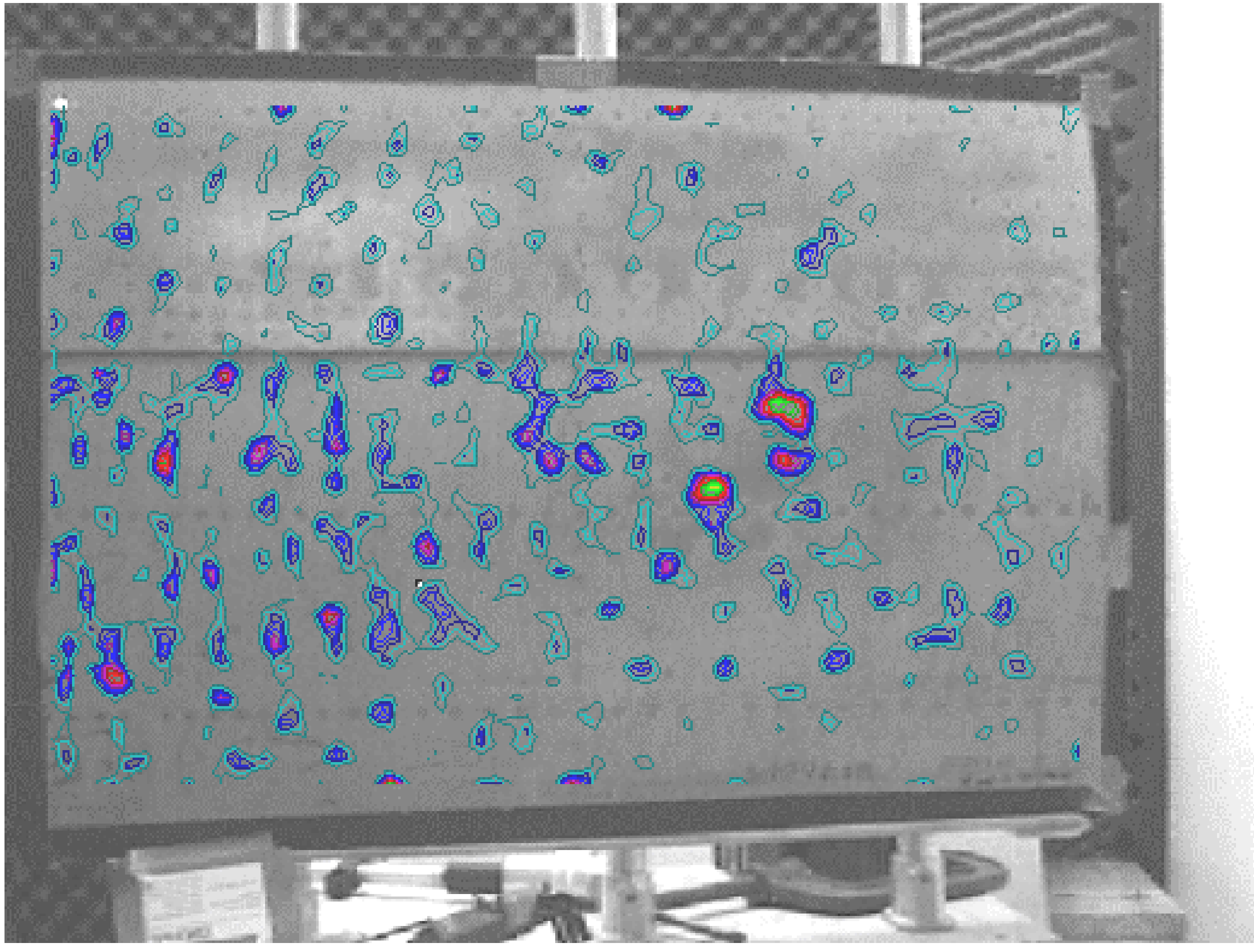
Subsurface corrosion occurs beneath the skin in various areas of aircraft particularly along overlapping joints (lap joints). The following example illustrates the detection corrosion in a VC10 tanker aircraft as used by the RAF for in-flight refuelling. It also illustrates how the RAID system performs an analysis of the data recorded during a scan.

In the first slide, all the recorded frequencies are present; in other words it is the unprocessed data as produced by the laser vibrometer prior to analysis. The subsequent three slides show a selection of the individual frequency groups that were chosen by the analysis program on the basis that they contained data relevant to a defective condition. The last slide shows these combined to give the overall picture of the corrosion present. These results were later confirmed by destructive examination of the lap joint.

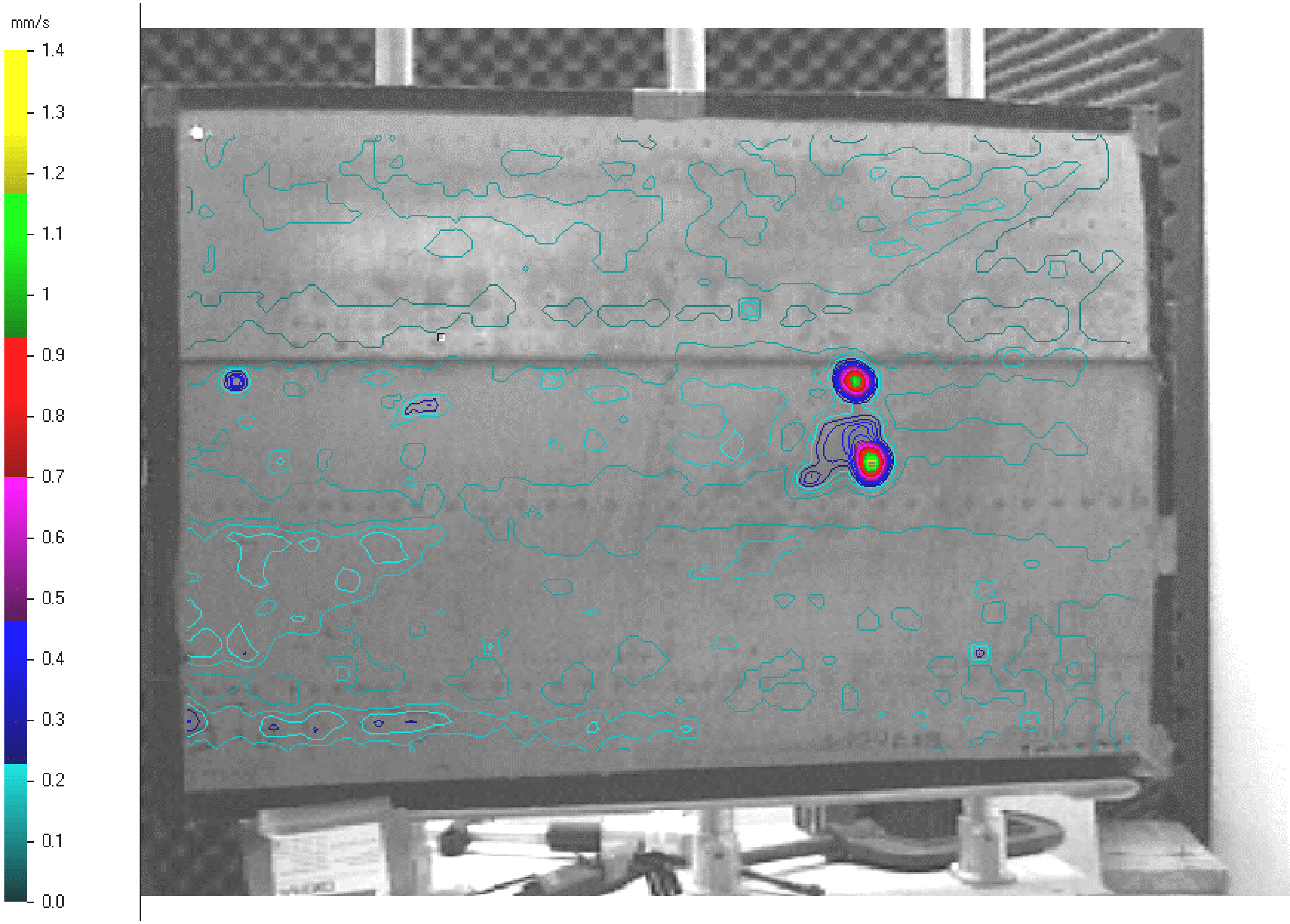
Entire bandwidth of data as recorded by the vibrometer
ted over frequency spectrum of 20 kHz with 100 FFT lines; all recorded frequencies are present in this image



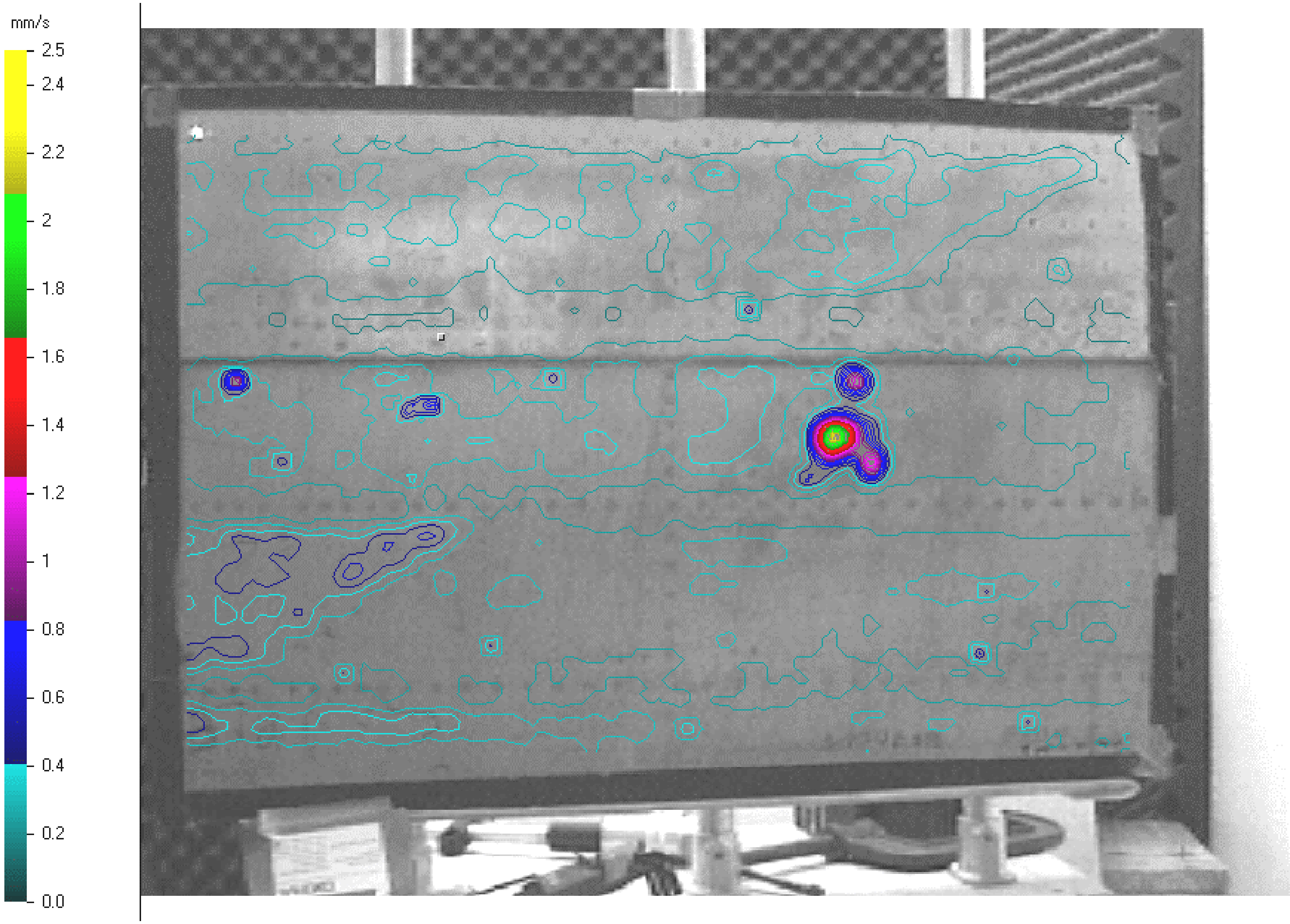
Corrosion Sample VC10 Aircraft Lap Joint at 1830 Hz



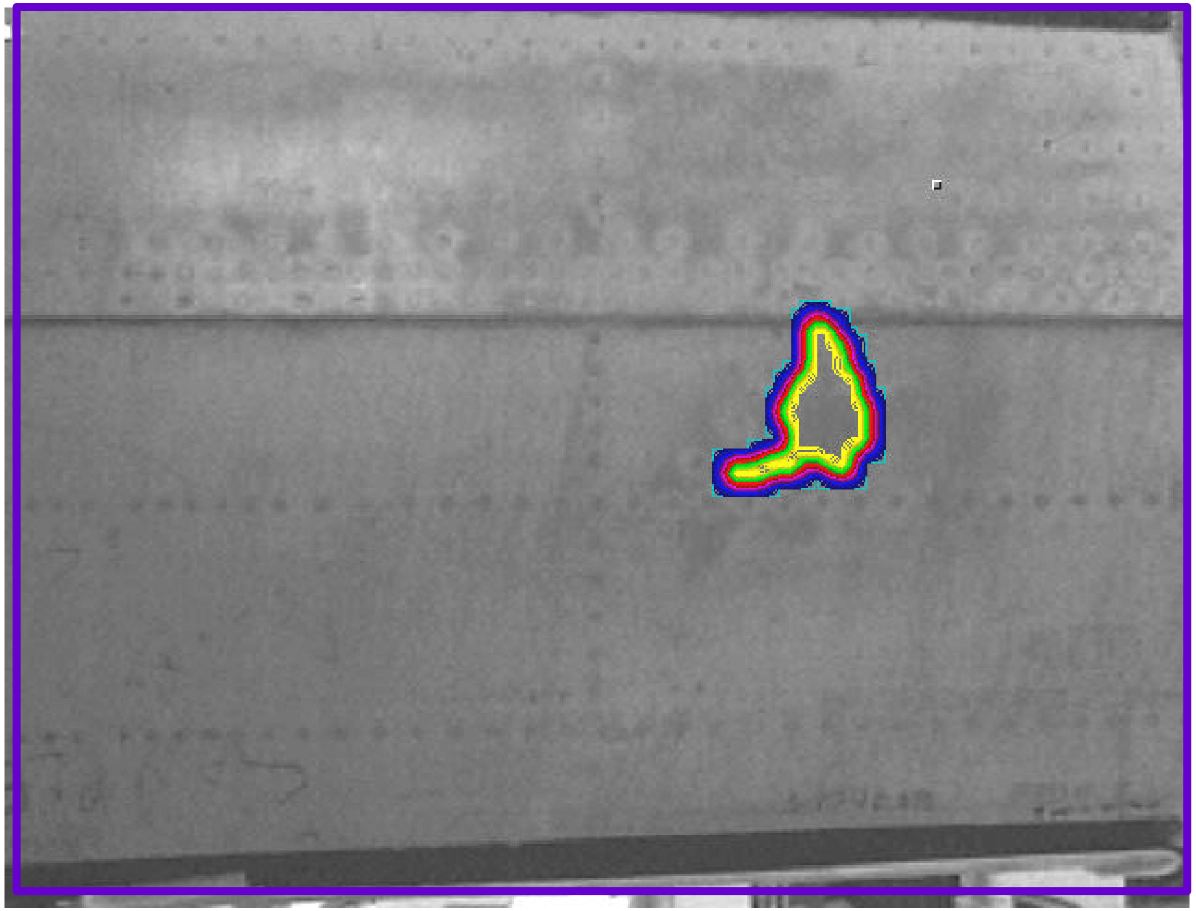
Lap Joint Corrosion (Hidden) at 14000 Hz



Lap Joint Corrosion (Hidden) at 8750 Hz



Corrosion: Fuselage Lap Joint. Frequencies selected by the analysis program only are represented

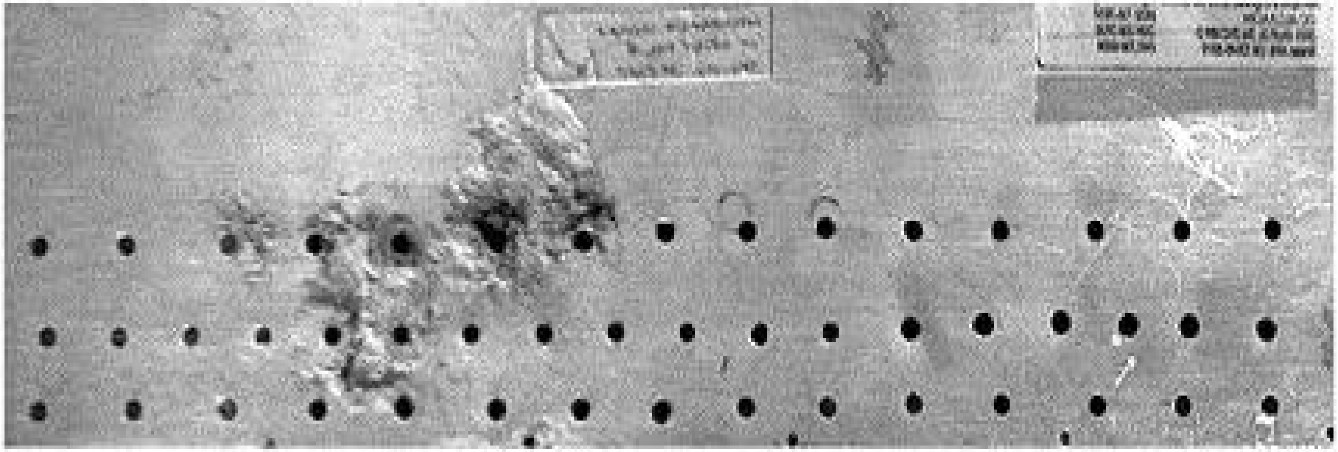


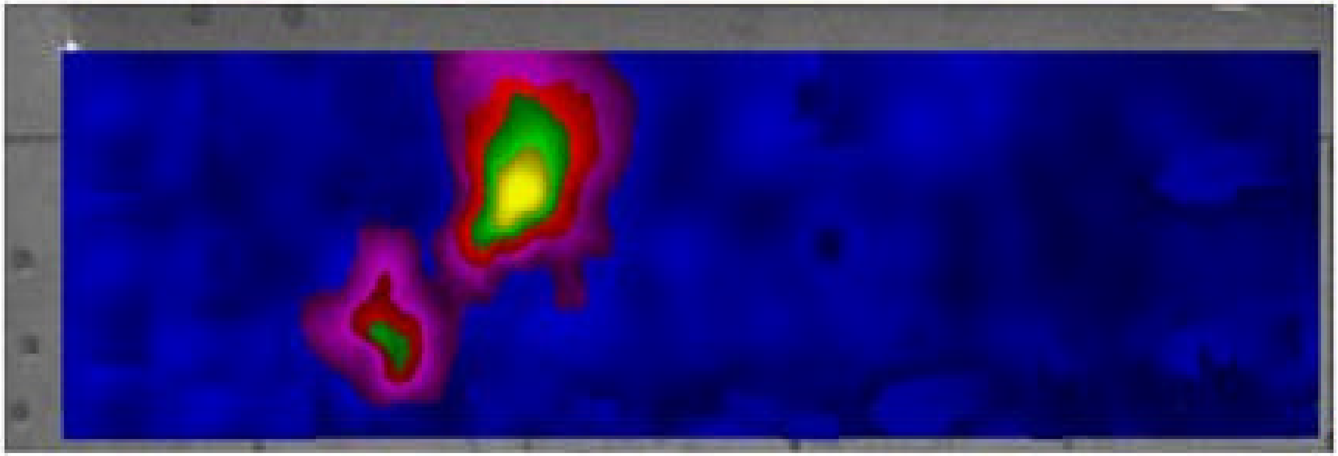
Subsurface corrosion occurring beneath the surface of a aluminium lap joints

The bottom section of the following illustration shows the lap-joint before it was opened for examination. The picture has been deliberately laterally reversed for simple comparison with the actual damage shown in the top photograph of the corrosion.

Courtesy Tinker AFB

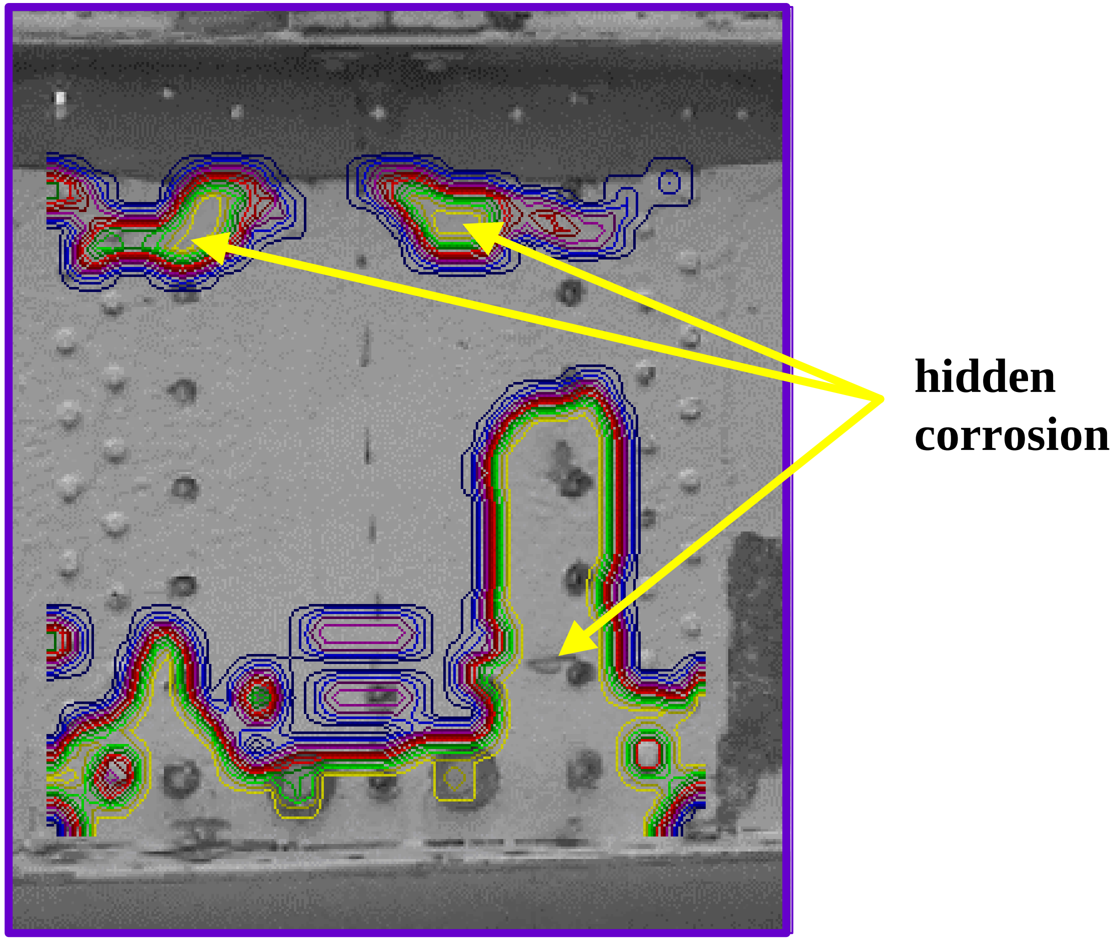
Corrosion in Lap Joint





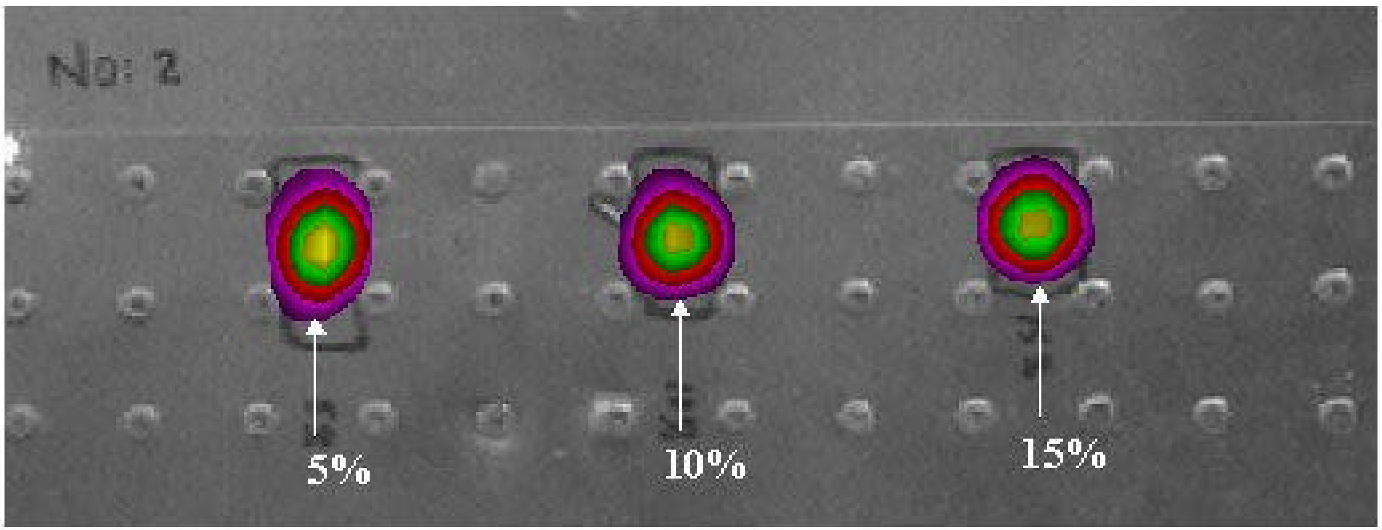
Corrosion: Floor Support Beam

Courtesy: Boeing Helicopters



Aluminium honeycomb filled I-beam (verified by Boeing)

Lap joint with simulated corrosion.

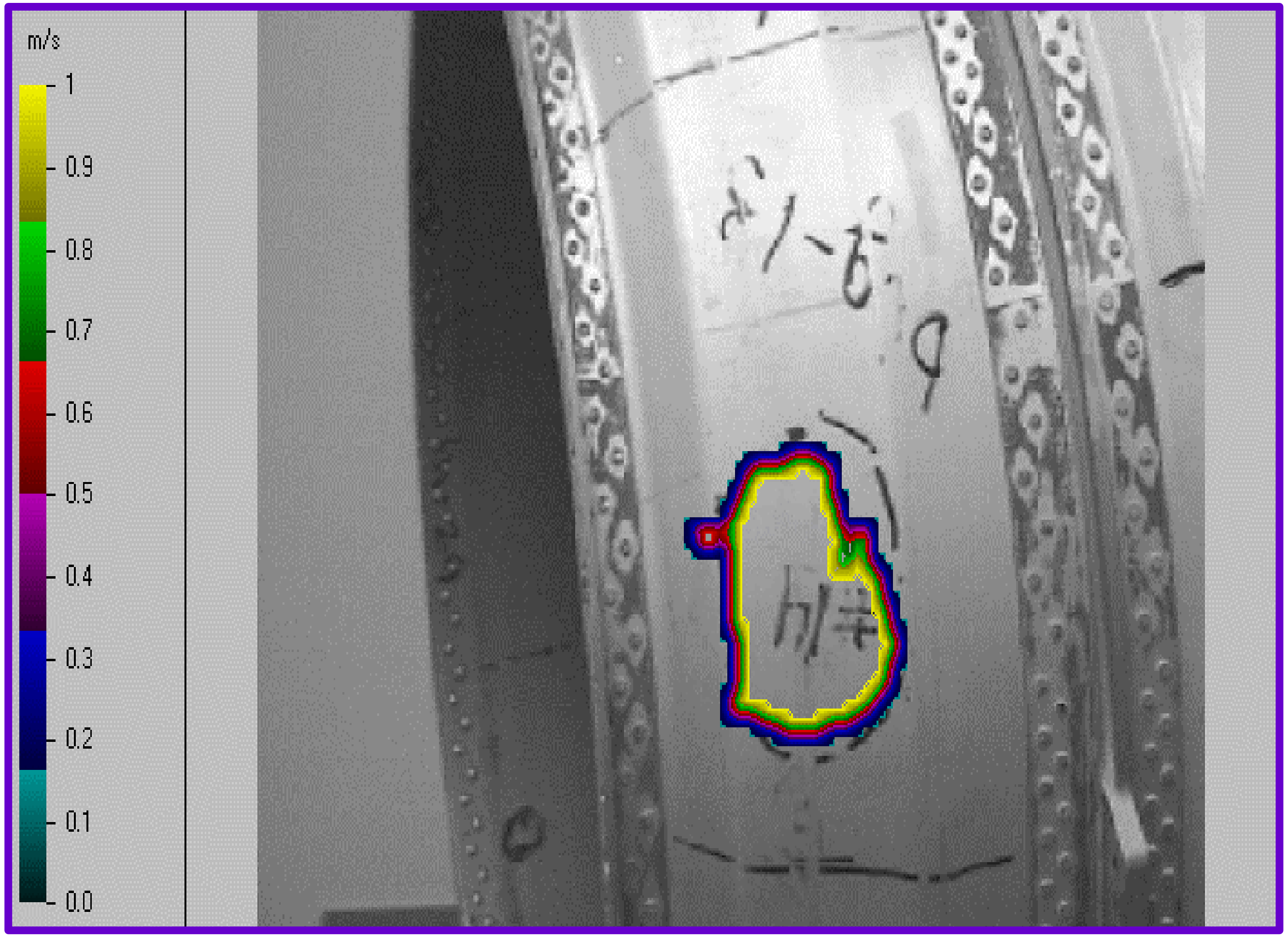


Pratt & Whitney Engine Bypass Duct

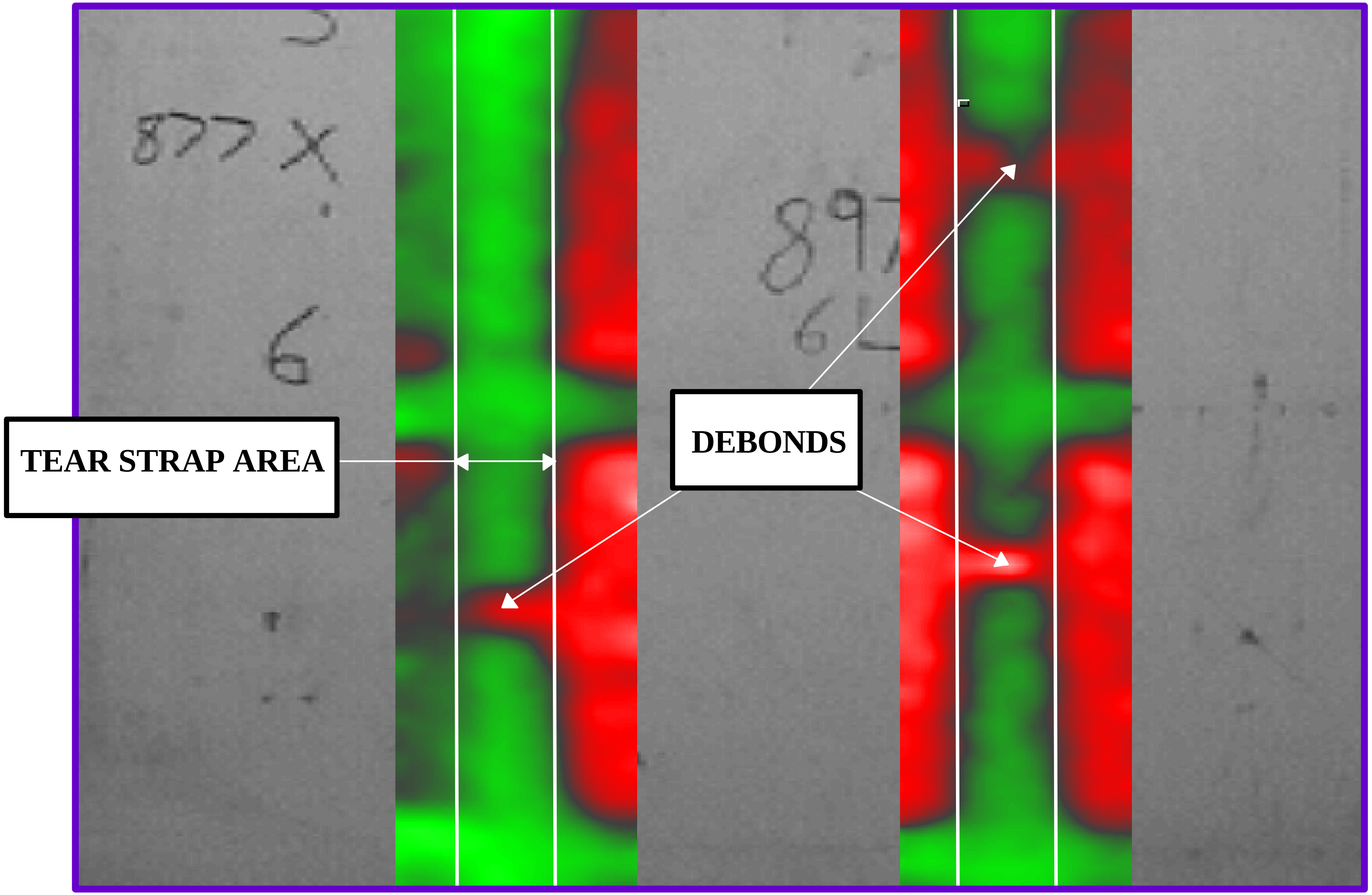
The sample was taken from a test rig. During its test life it had secured several damaged areas. The one shown in the following slide is a delamination between the metal honeycomb core and the skin

Courtesy: Pratt & Whitney

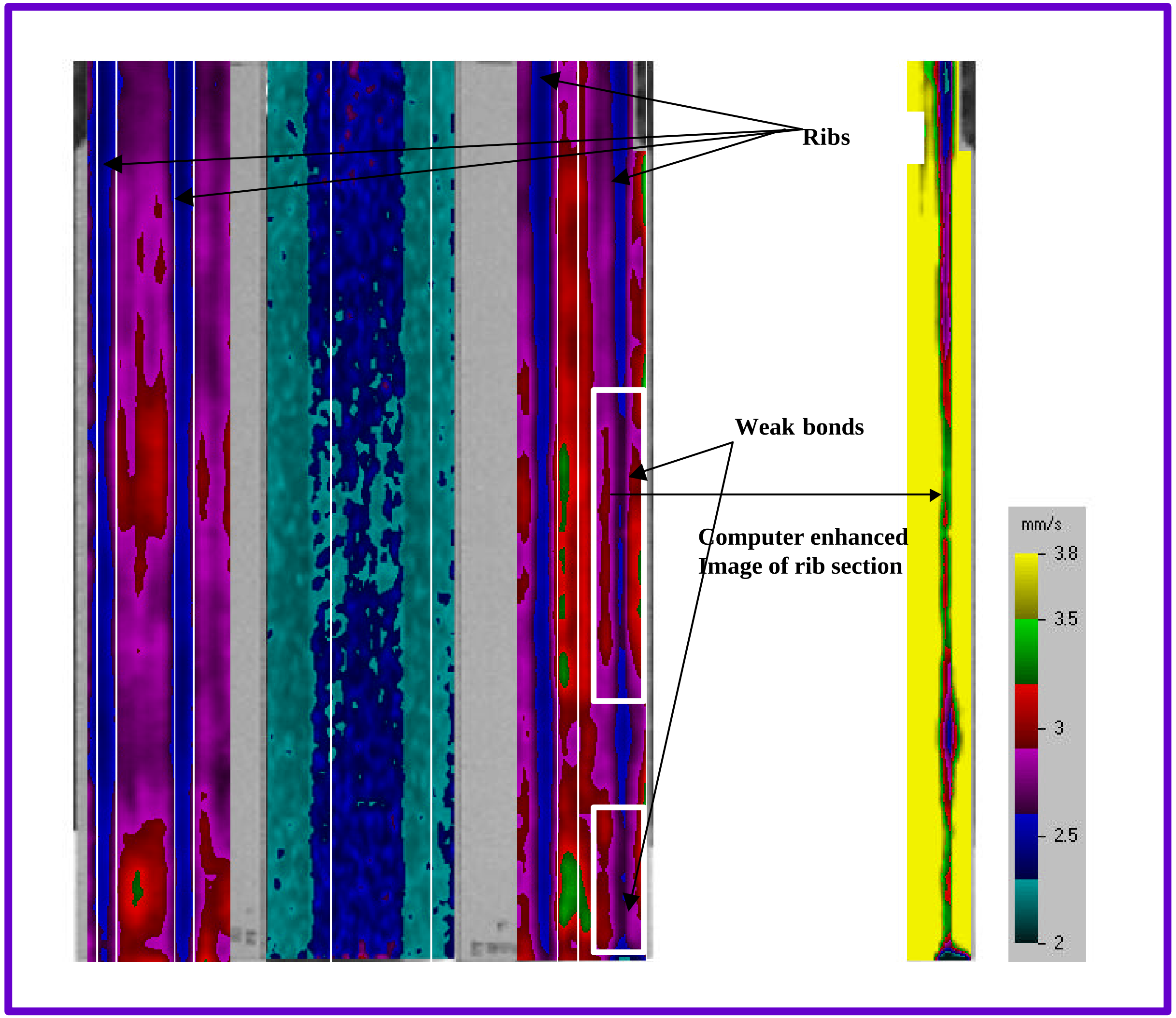
Disbond: Rim of Pratt & Whitney Engine Bypass Duct



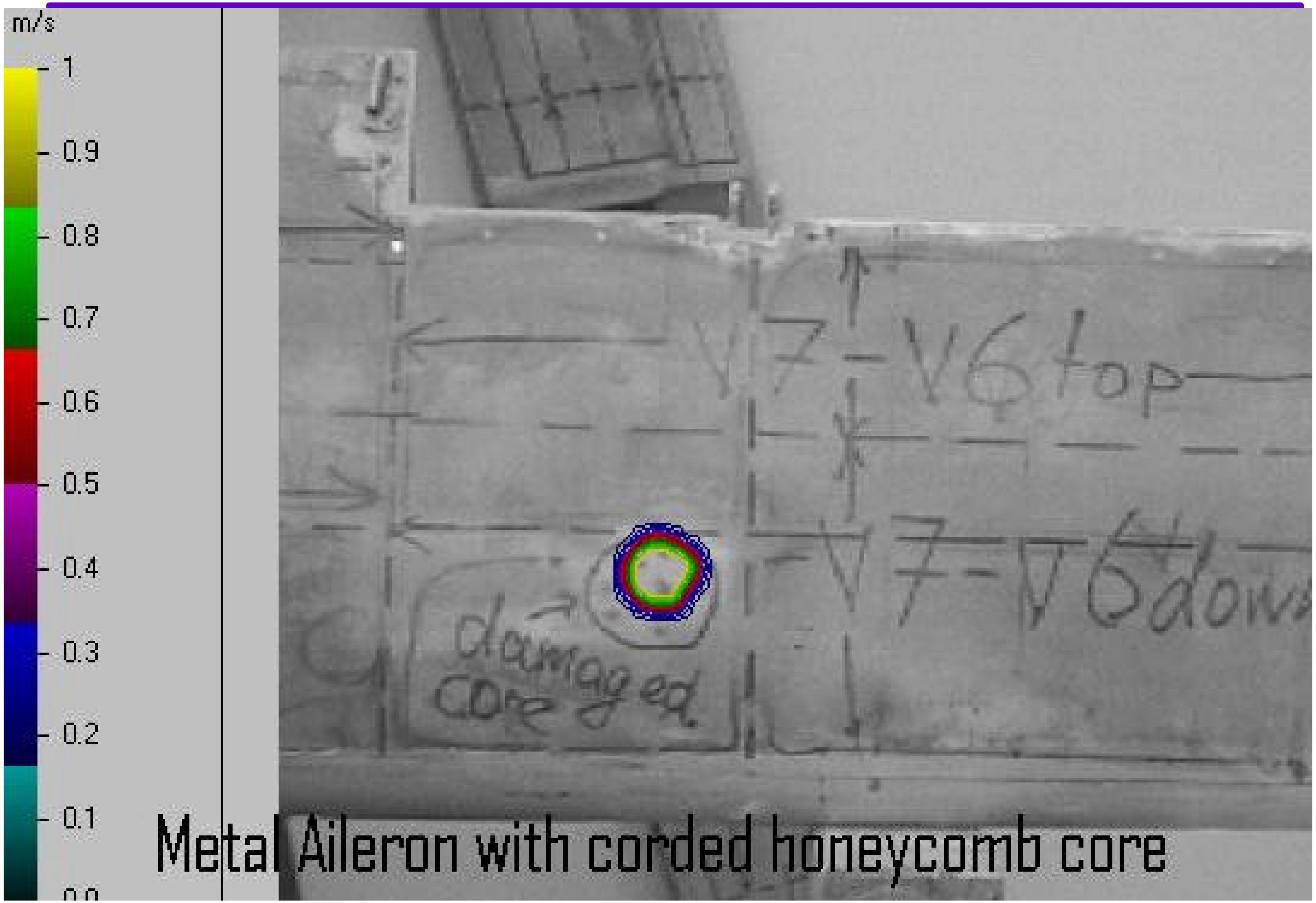
Disbond: Fuselage Tear Straps



Metal helicopter Blade: Weak bond in trailing edge joint



Skin/honeycomb debond in aileron. Possible cause: corrosion

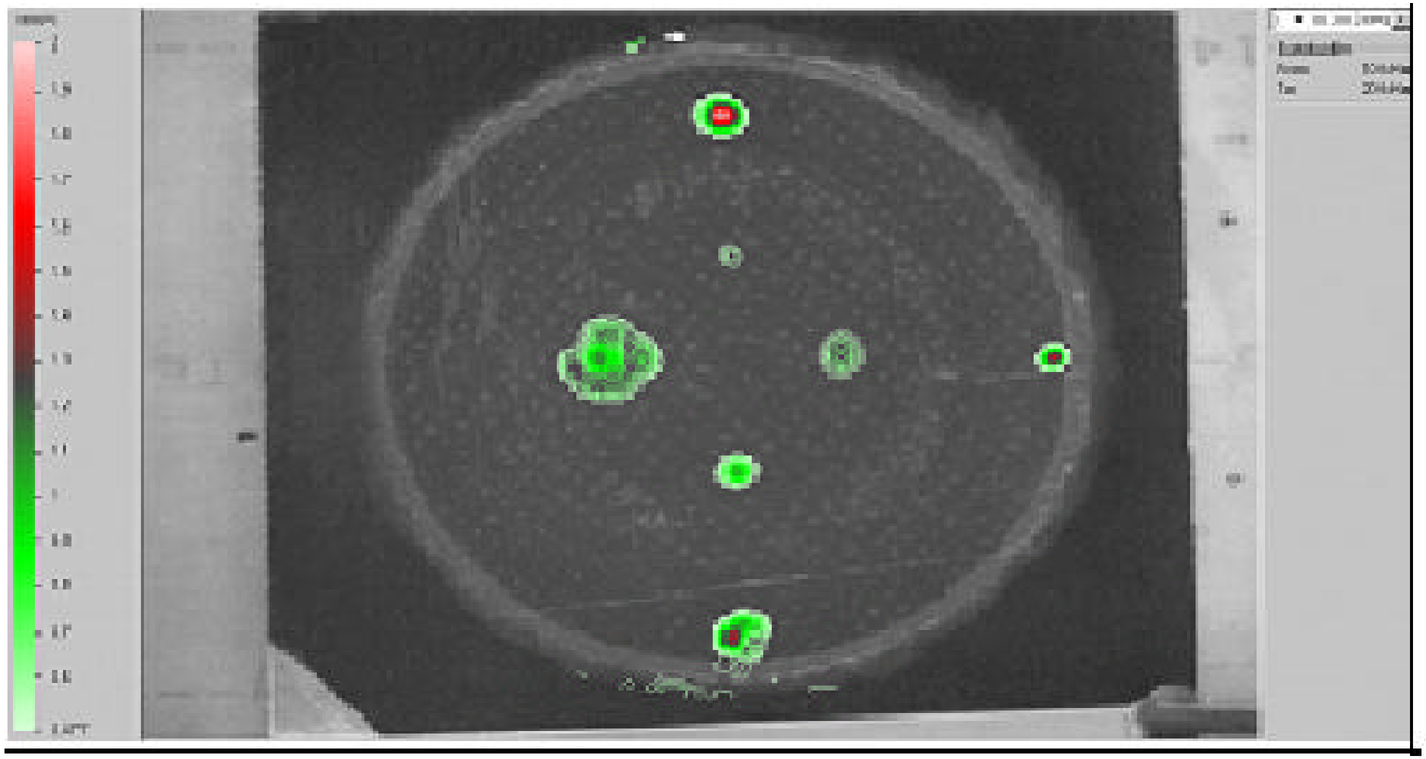


Carbon composite parametric repair sample

This lay-up test sample is designed to simulated a repair to a composite component.
The test sample supposedly contained eight defects of different kinds & sizes located at differing depths within the repair. Our record shows seven of the defects, which in fact was all there were.

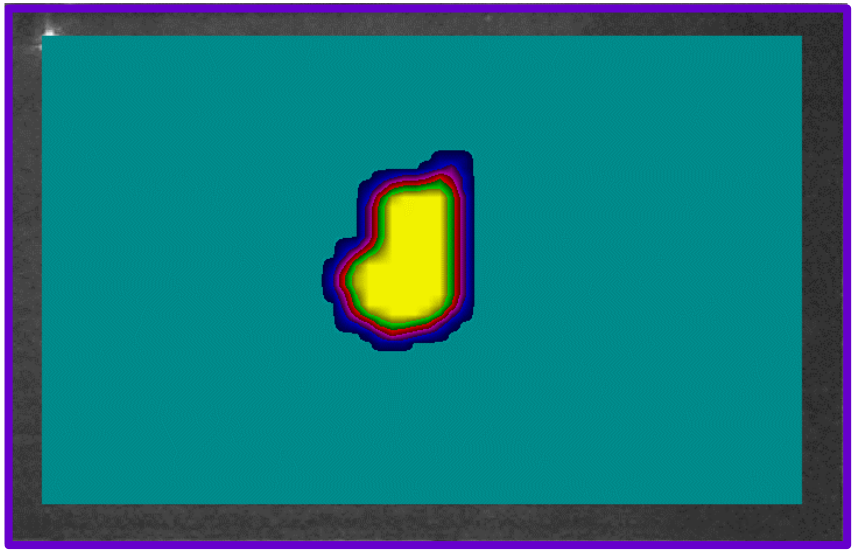
Courtesy: Boeing aircraft

Composite Parametric Repair Sample by Boeing Aircraft

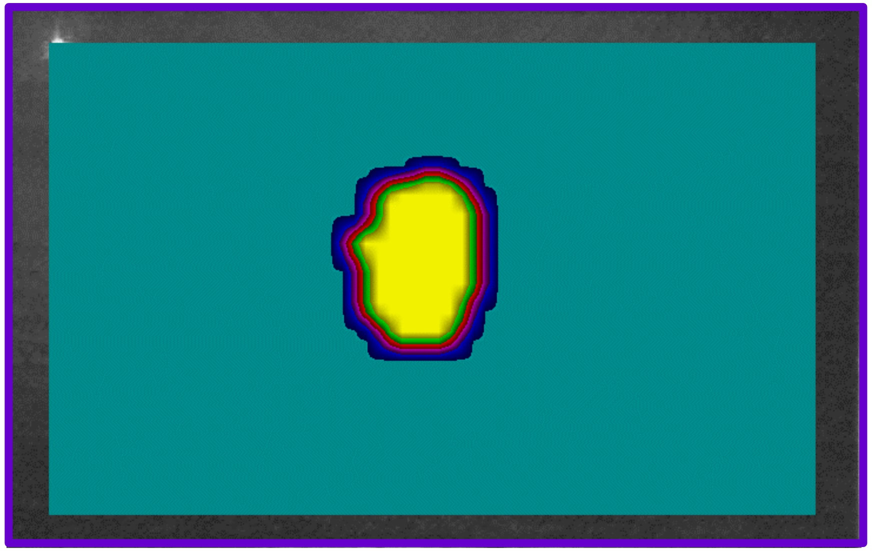


Impact Damage: 0.5 inch thick composite
Leading edge section of Airbus

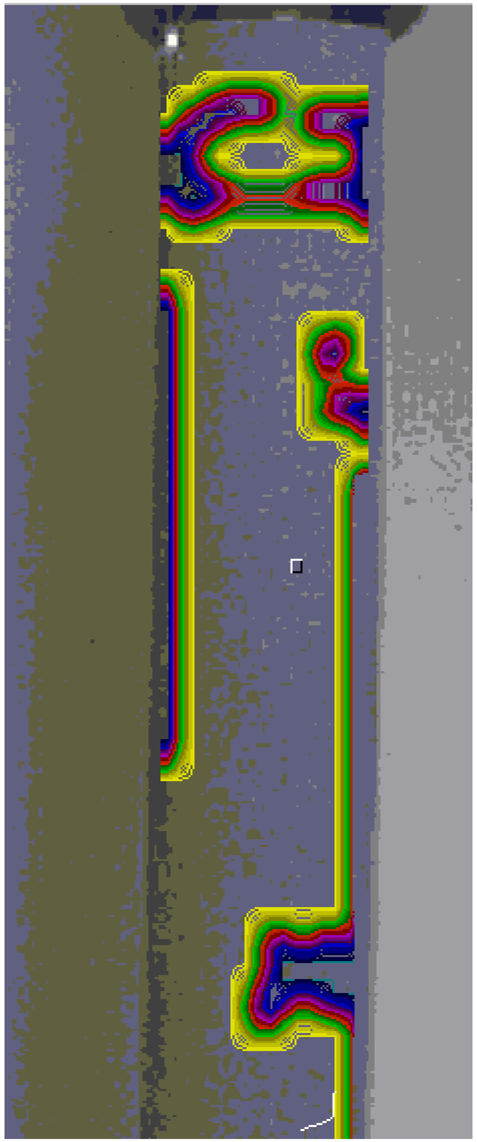
Courtesy: BAe (UK)



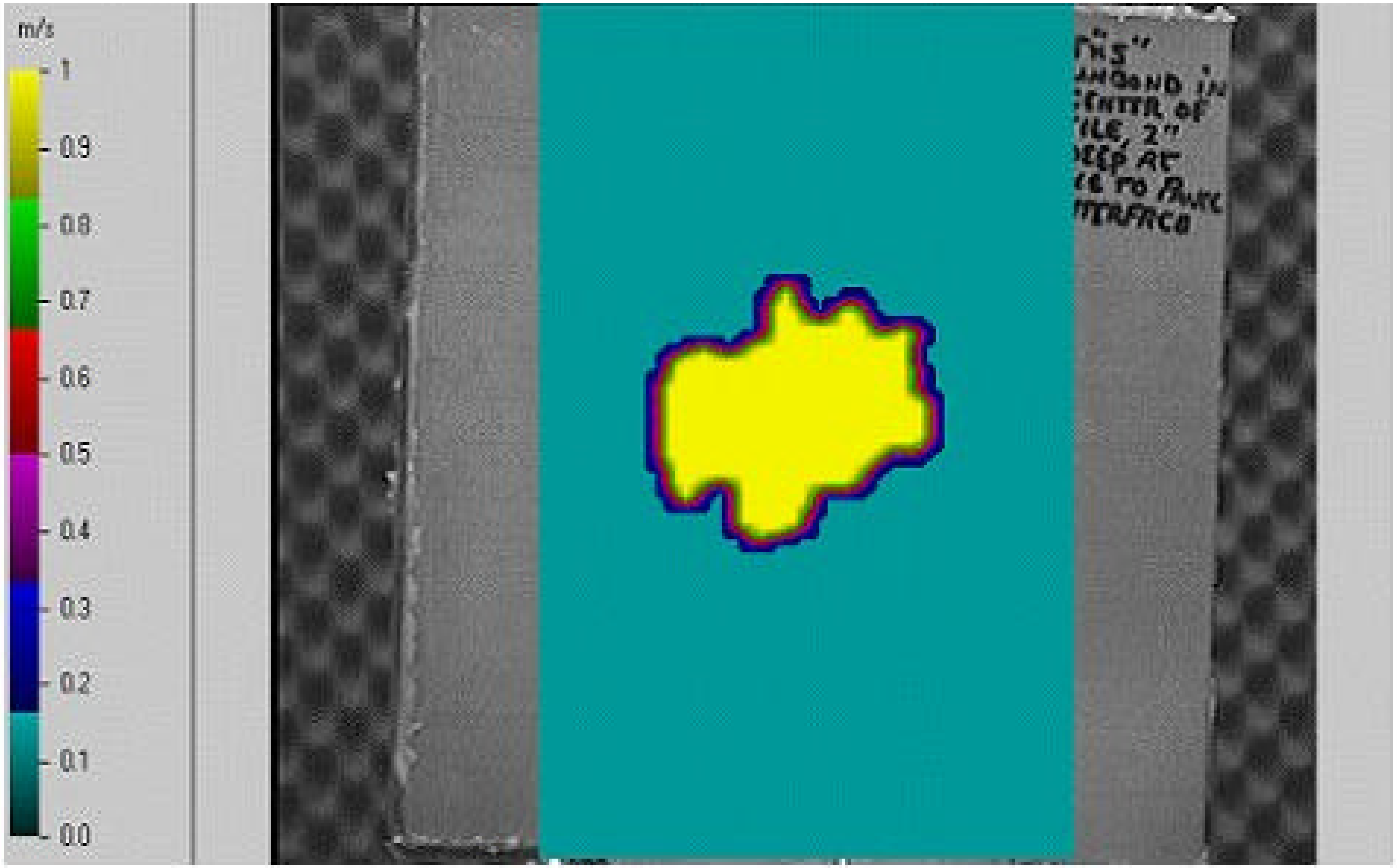
Scan from impacted side



Scan from non-impacted side



Cork insulation surrounding a tube. Delaminations of the cork from the tube have been pre-programmed into the assembly. These are delineated by the RAID NDT technology



Heat shield tile from: B2: 50 mm thick soft ceramic material with central pre-programmed debond from base

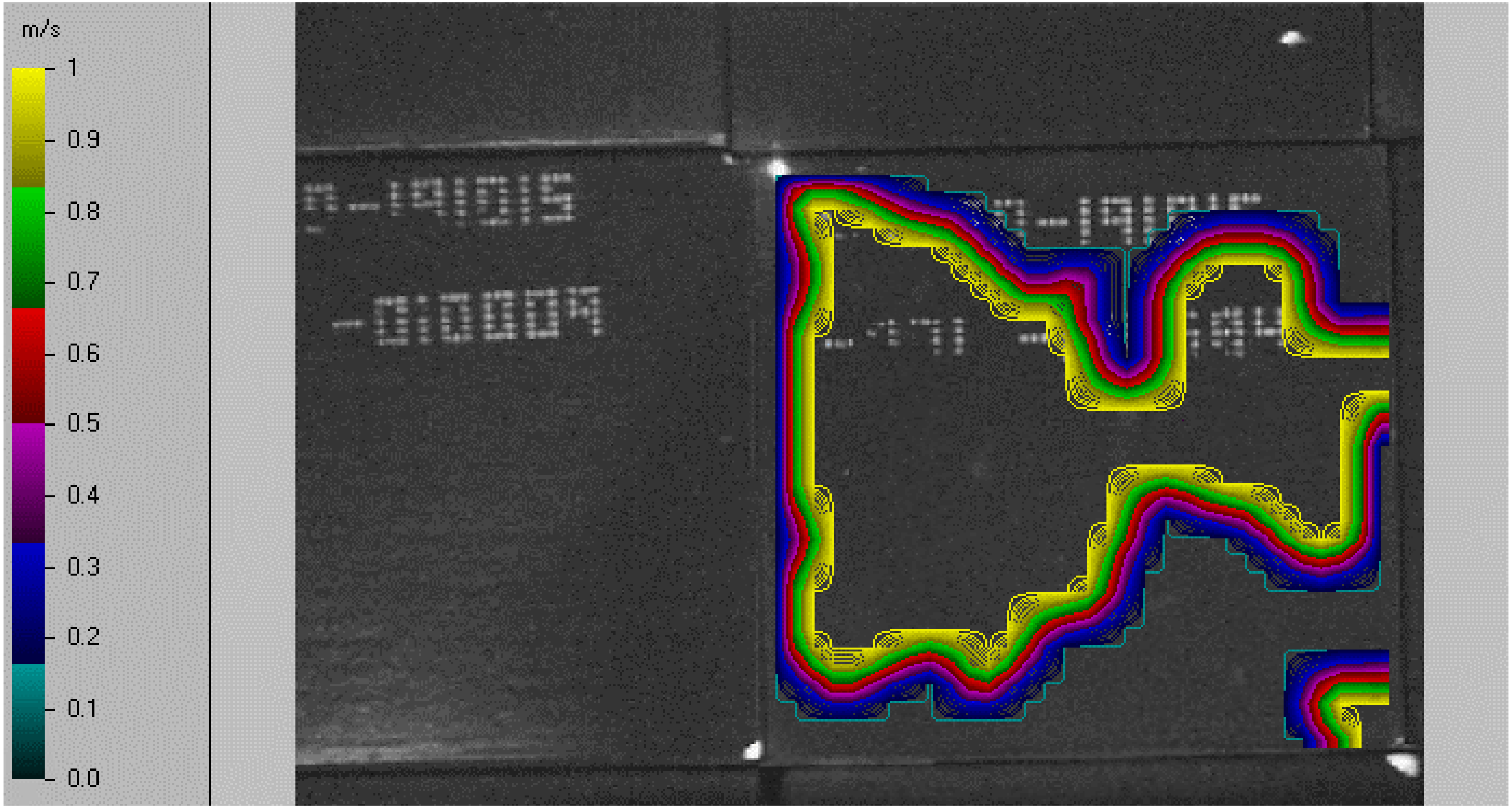
Ceramic Heat Shied Tile from Space Shuttle

The samples tested had various types of pre-programmed defects.

The tile shown in the following illustration had 2 major defects and 1 minor defect. On the right was a debond and, on the left an in-plane crack sometimes called a “pocket”. A third minor defect, possibly caused in transportation, is visible at the bottom right corner

Courtesy of NASA

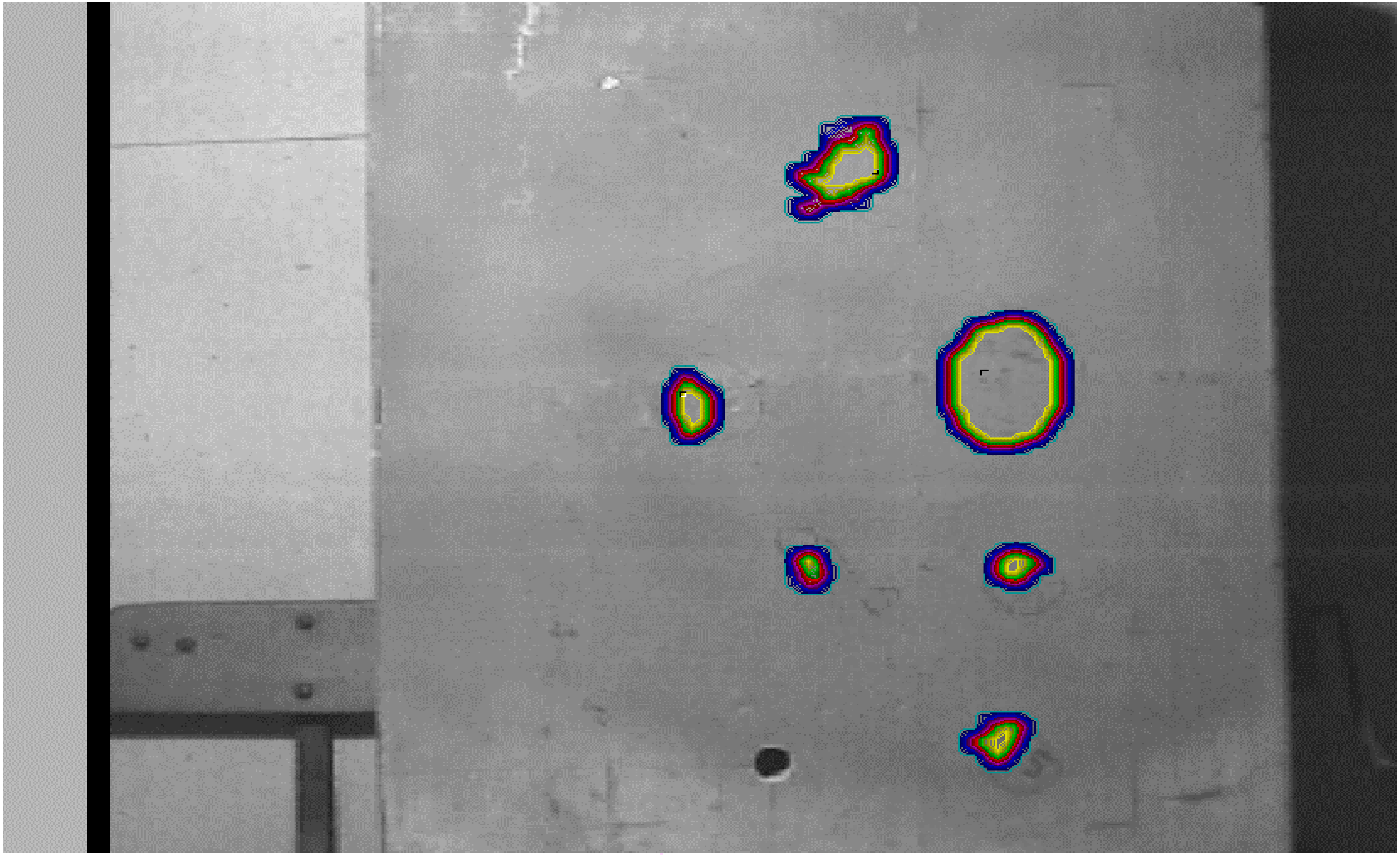
Shuttle Tile with "pocket" & debond



Naval Radar Mast

Fibre glass type of construction. The sample tested was ~50 cm thick. Delaminations had been simulated at various depths

Naval Radar Mast



Inspection of radar domes on AWAC aircraft

The dome is manufactured from a radio-transparent fibreglass material. Consequently, it is relatively soft and susceptible to damage from such incidents as a bird strike or hail impact.

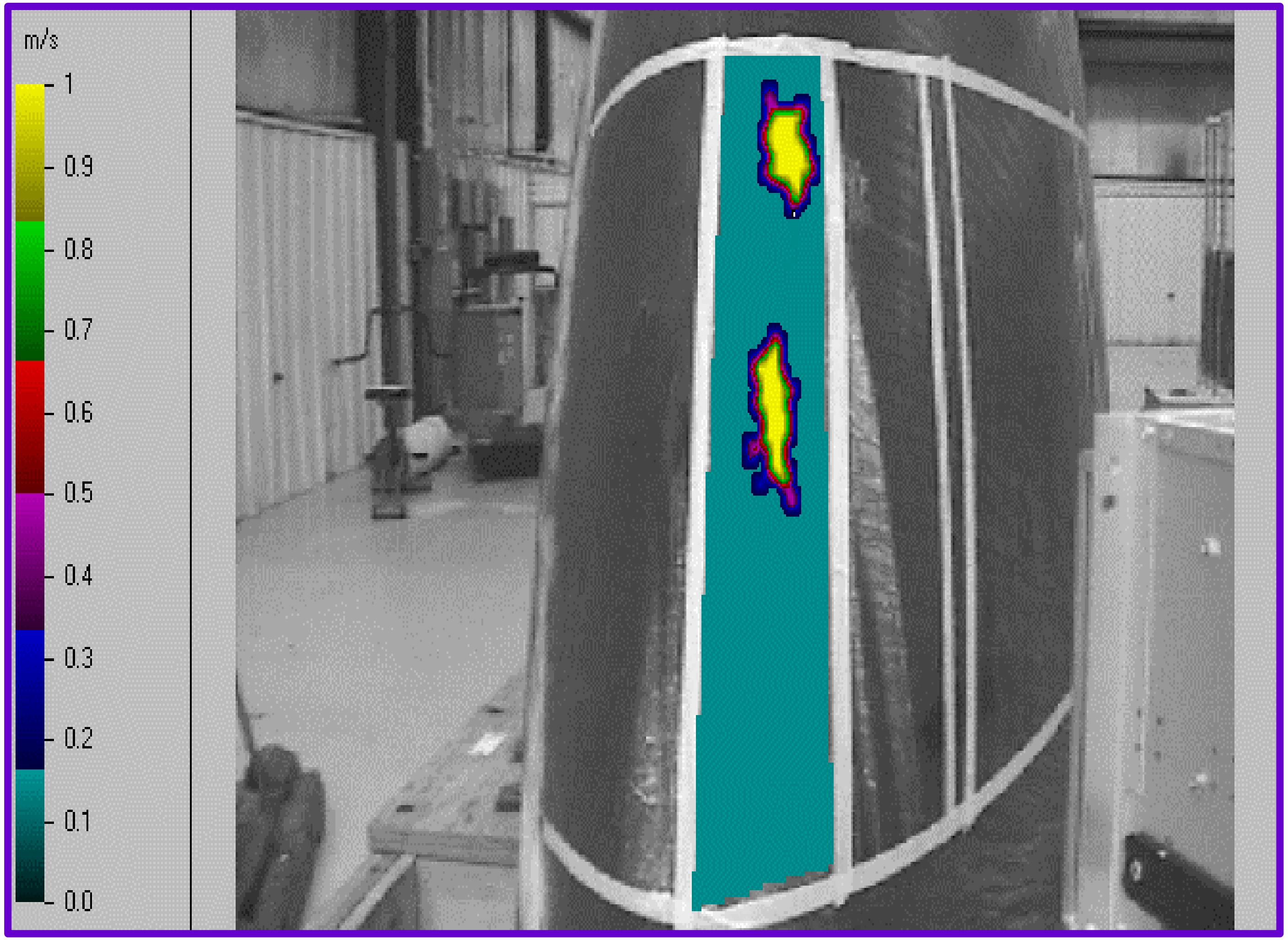
In the example shown, the dome half-section had been removed to the laboratory. However, the dome could easily be inspected in-situ using RAID technology

Courtesy: Tinker AFB

AWAC Navy

Radome inspection.

Impact Damage: AWAC Rotodome Radome



The RAID NDT system is covered by the following Patents:

Method & apparatus for Non-Destructive Testing of Structures
US. Patent No. 5,679,899. 1997.

Acoustic Wave Generating Apparatus.
US Patent No. 5,616,865 1997

Method & Apparatus for Non-Destructive Inspection of Composite Materials and Semi-Monocoque Structures
US Patent No. 5,505,090 1996

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· *Patents are registered in the name of the inventor: Dr John M. Webster and assigned to Holographics Inc.*

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