RapidScan II
Application Note

General Composite Scanning

Applications

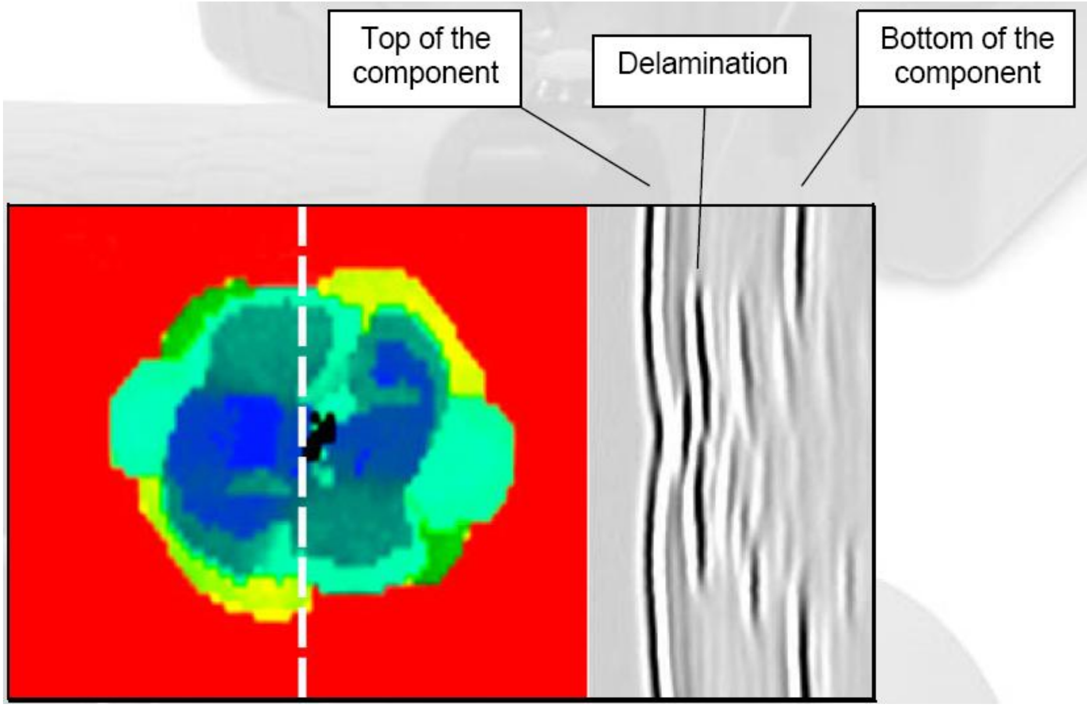
The RapidScan system has been utilised for a wide range of inspections for carbon fibre composites. This section summarises a selection of these applications:

1. Delaminations
2. Bonding
3. Porosity
4. Large Area Scanning

1. Delaminations

One of the major concerns with the increasing use of carbon fibre for structural components is the influence of delaminations upon performance. It is possible for delaminations to arise post-manufacture from impact upon the external face of the component leaving little visual evidence yet gross sub-surface damage.

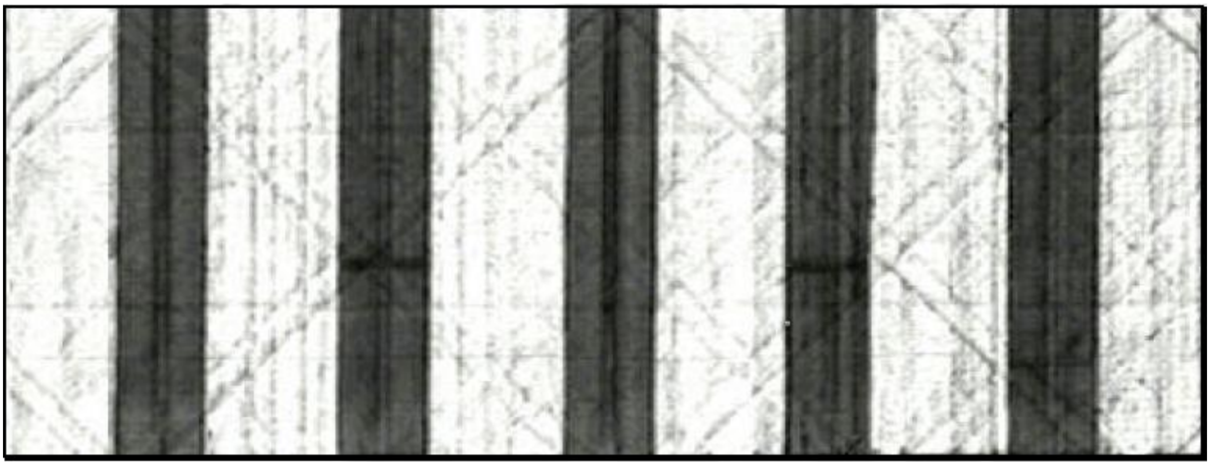
Combining the C-scan and B-scan capabilities of RapidScan II, the extent of the damage can be very quickly imaged before and after repair. This is of particular benefit to increase the efficiency of continual monitoring operations where very fast spot checks of an area are possible. The recorded data is saved to log the condition of a component and is therefore available as reference when the next inspection is conducted.



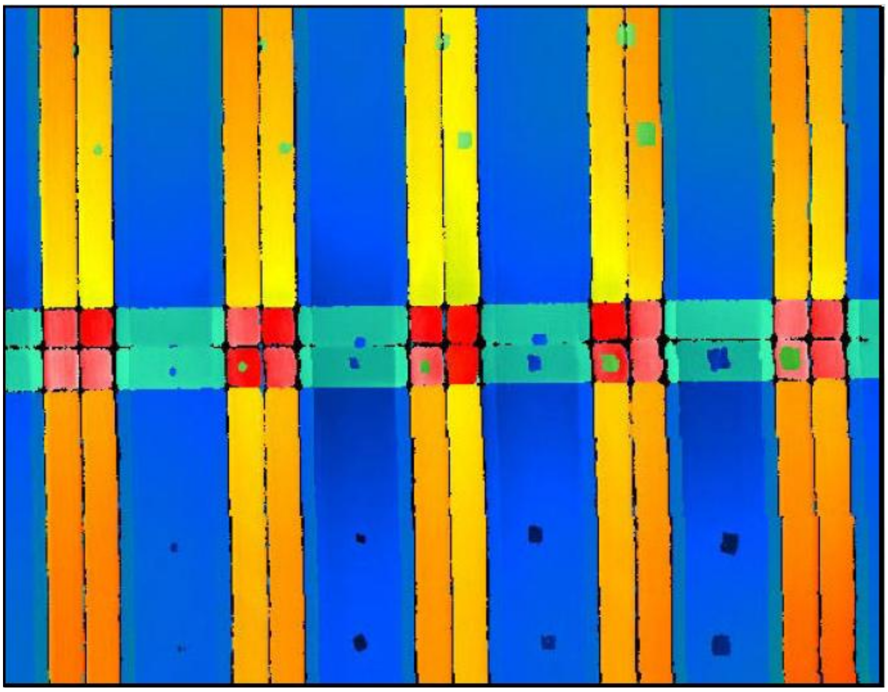
A C-scan showing delaminations after an impact and a B-scan taken through the 5mm monolithic carbon component along the dotted line

2. Bonding

Similar to delaminations, disbonds are detected by reflections received from composite to air interfaces. At a bond line, ultrasound is propagated through with some of the signal being reflected back to the transducer. When there is no bond, all the ultrasound is reflected and the amplitude of the signal from the interface is larger. The scan below shows an inspection performed to verify the bonding of five stringers onto a carbon fibre stabiliser skin. Any disbonds would be observed on the amplitude C-scan appearing as white "hot spots" within the dark grey bond lines. The fibre lay up is also visible where the edges of the prepreg tape can be observed.



Amplitude C-scan showing the bond lines of five stringers.

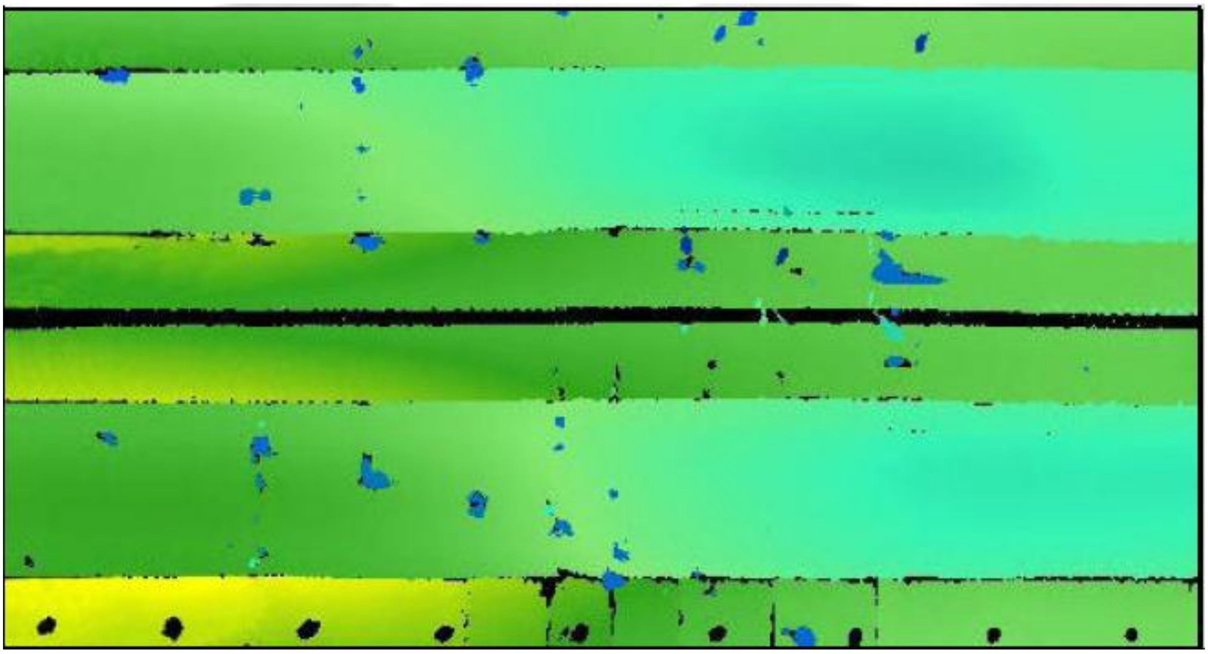


Time of flight C-scan of string and reinforcement assembly detecting inserts to simulate delaminations and disbonds

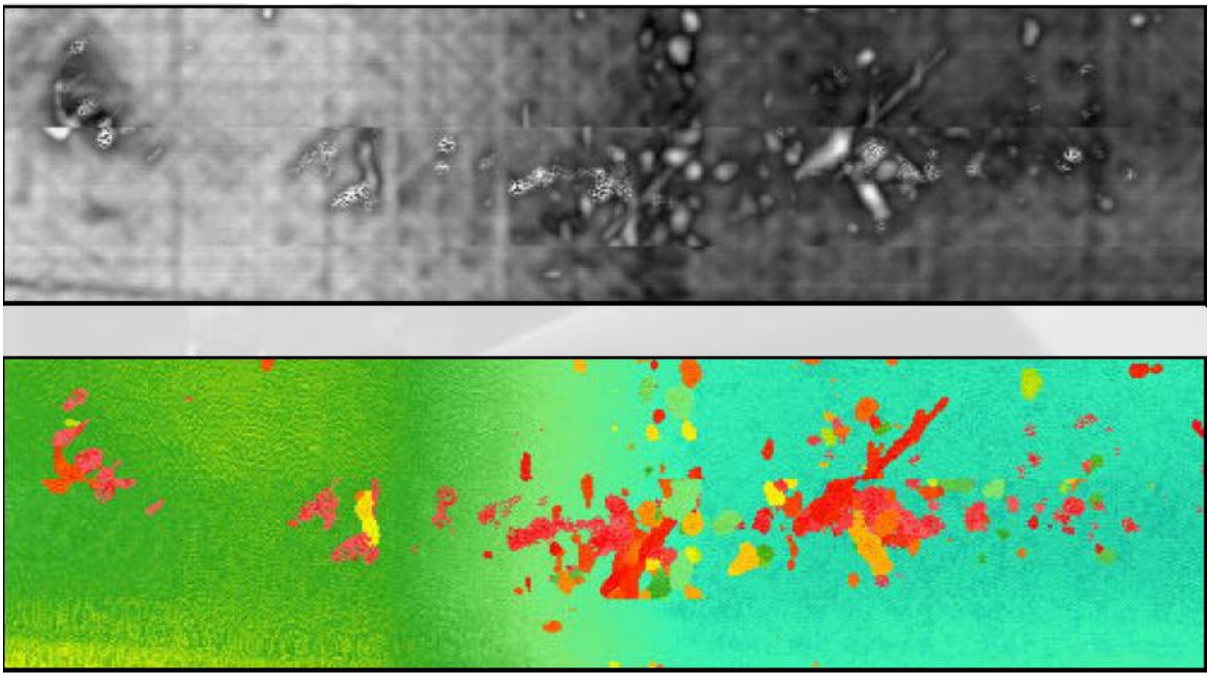
3. Porosity

Within composite manufacturing, there is a continual need to maintain tight controls over the local porosity level within a component. With the advancement of design complexity and size, there is an ever-increasing likelihood that a part may have been insufficiently consolidated during cure. Traditionally, porosity problems have been discovered and monitored by destructive batch testing. The need to monitor the porosity levels non-destructively has led to the development of several ultrasonic measurement techniques.

Currently there are several possible methods for assessing the porosity but no definitive standard to quantify. Several of the proposed methods have been investigated using RapidScan II with encouraging success. With large pores, signals are received from direct reflections. Smaller porosity is detected by an overall decrease in the amplitude of the back face signal from that area.



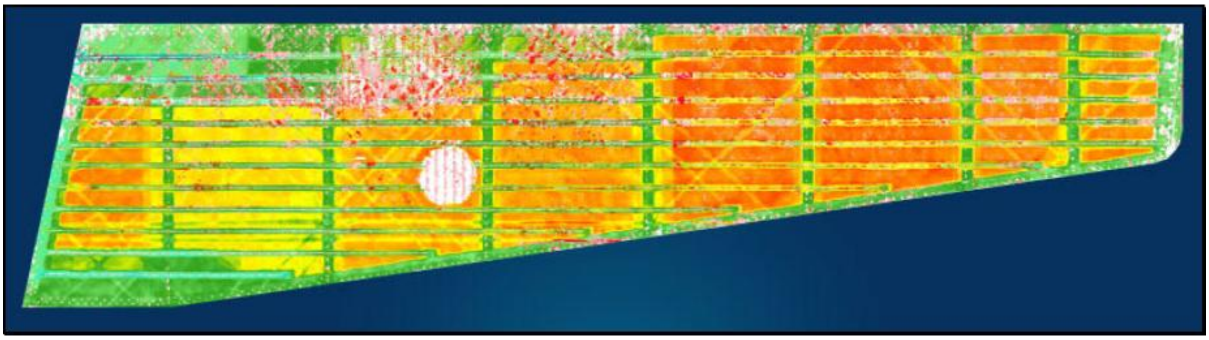
Time of flight C-scan showing direct reflections of large pores



Amplitude and time of flight C-scans showing reflections off large pores, thickness change and micro porosity detected as a loss of amplitude

4. Large Area Mapping

The following scans of a composite horizontal stabiliser were made as part of an inspection program to compare detectability of defects with several technologies and techniques. Ultrasonic pulse-echo testing using the RapidScan system was a favourable technique within the study, detecting the extensive porosity in the composite as well as several disbonds between the stringers and skin.



Time of flight C-scans of horizontal stabiliser

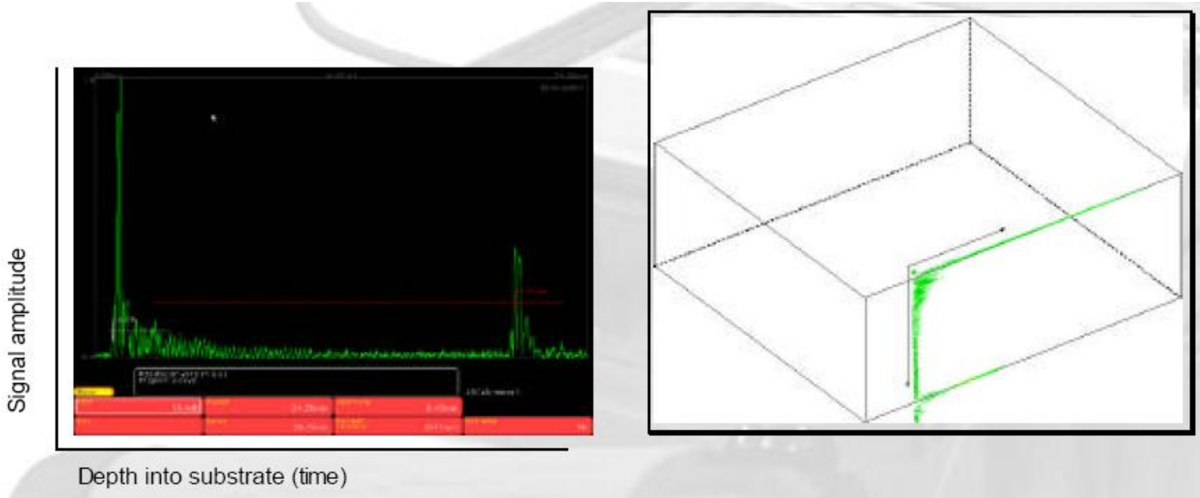
RapidScan II Description

Sonatest's RapidScanII system addresses the need for a fast, portable ultrasonic scanning instrument. Designed to aerospace requirements, the system incorporates modern advancements in ultrasonic imaging utilising array transducers. The transducer is housed within a novel wheel probe which is rolled across the surface of the test object recording a C-scan. Full A-scan data is captured enabling complete structural imaging of a component. C-scans are recorded in a fraction of the time associated with other portable systems and conventional immersion scanning.

The system comprises a single unit containing a powerful processor and the proprietary ultrasonic hardware housed within a rugged case. The software is Windows based and operates on a standard laptop, supplied with the instrument. A scanning sensor containing an ultrasonic array transducer is provided complete with transportation case. The sensor can be tailored to each application's individual requirements meeting the need for system versatility whilst providing an optimal solution.

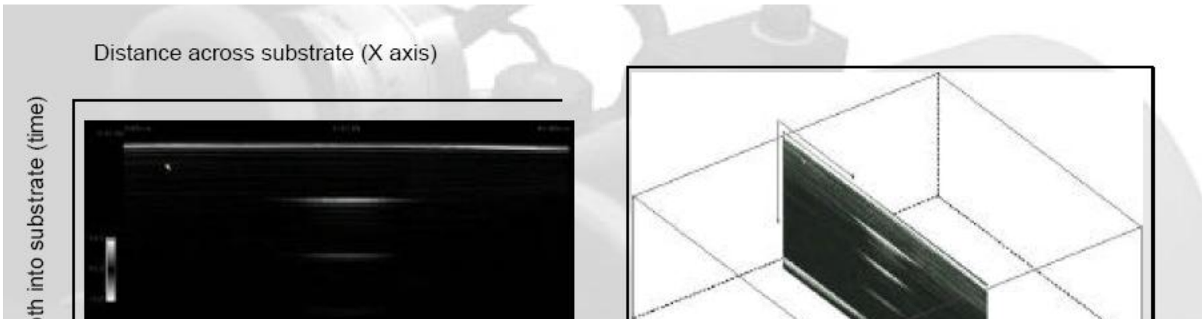
Ultrasonics and Conventions

Ultrasound is simply sound waves at high, inaudible frequencies (typically 500kHz to 20MHz). A pulse of sound is generated by applying a voltage spike to a piezo-electric crystal which is then directed into the test structure. Casing is built around the crystal to direct the sound beam, forming a transducer. The crystal receives echoes back from features within the structure which are recorded as a voltage. For a single position of the transducer, the voltage is recorded against time starting from the moment the pulse was sent. The pulse is resent many times a second constantly updating the signal. This plot is referred to as an A-scan.



The A-SCAN shows the features inside the substrate below a single point

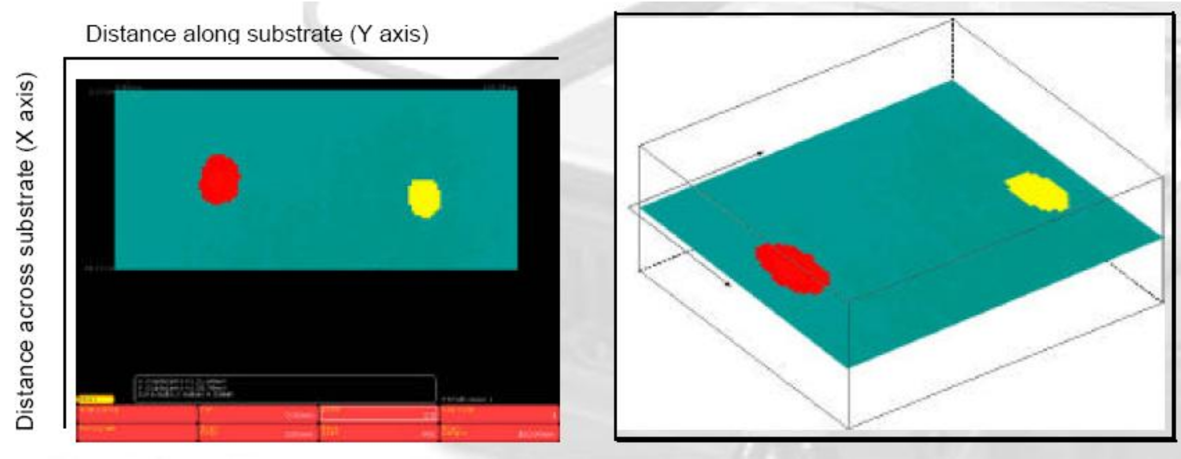
Moving the transducer in a line perpendicular to the direction of the sound beam allows a series of A-scans to be recorded. These can be plotted on a graph of distance the probe has moved against time starting from the moment the pulse was sent. The signal amplitude is then plotted from a colour scale, e.g. black is 0V and white is maximum voltage recorded, all values in between are varying shades of grey. This plot is referred to as a B-scan.



The B-SCAN shows the features as a "slice" through the substrate

By recording a series of B-scans moving perpendicular to the B-scan slice, we record enough data to build a 3D reconstruction of the structure being tested.

However without the use of advanced graphic software to view it, a simplified system has become standard. This involves identifying features within the signal and plotting a 2D map. Either the amplitude of the identified feature or the time from the top surface to the feature is plotted as a colour scale. The feature might be that which gives the largest echo, or the amplitude signal that is observed from a specific depth in the structure. The resultant 2D map generated is referred to as a C-scan. For the same set of 3D data it is possible to generate many C-scans depending on the information that is required.



The C-SCAN shows a map of the selected features inside the substrate

With RapidScanII, array transducers are used. An array transducer is a single piezo-electric crystal that is laser cut into many smaller sections. The linear array transducers used in the wheel probes consist of a rectangular crystal that is cut across it's width into a series of evenly sized elements. A group of elements are pulsed at the same time forming a sound beam and generating an A-scan. The next group of elements along the array are then pulsed and so on forming a B scan along the length of the array. RapidScan is typically able to record over two hundred B-scans per second although the exact number depends on parameters such as the thickness of the structure, the material, the size of the transducer etc. As the wheel probe is rolled forwards a B-scan is recorded at set intervals along the structure (say every 1mm). Typical achievable scan speeds and area coverage rates are shown in the table below.

Array Width (mm)	50		100	
Scan Resolution (mm)	0.8 x 0.8	0.8 x 1.6	1.6 x 0.8	1.6 x 1.6
Scan Speed (mm/s)	150	300	150	300
Area Coverage Rate (m^2/s)	0.45	0.9	0.9	1.8