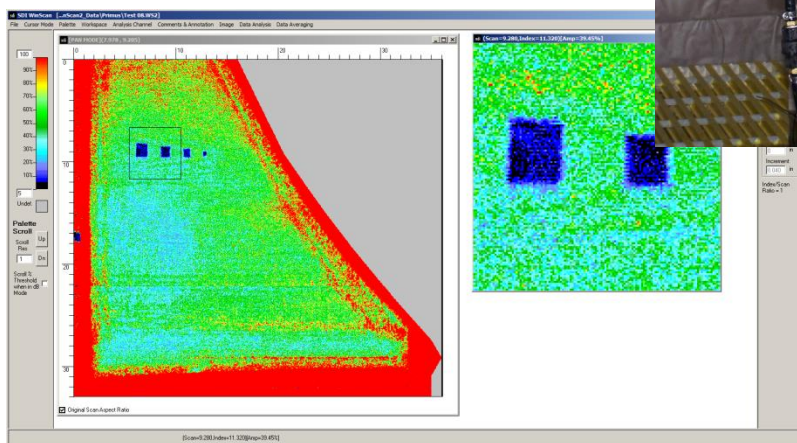
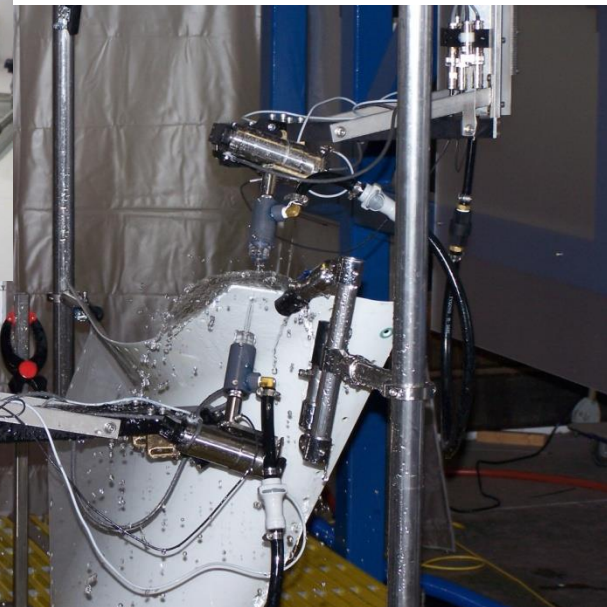




## **SDI-5380 Delta X Gantry Through Transmission 3D Scanning Ultrasonic System**



Note: This specification is for a typical SDI-5380 Inspection System and is for information only. The details may differ significantly from those proposed for specific customer requirements. The specification provided in the Statement of Compliance and formal quotation supersedes this document.



## 1 INTRODUCTION

The SDI-5380 is a high performance, 3D curve scanning, UT system designed for both through transmission and pulse echo testing of composites and bonded structures. The Delta X Drive Bridge allows complex curve following in all orientations. A wide range of parts positioning devices can be integrated into the programmable motion sequence. These include horizontal rotators, turntables and head and tail stocks.

The system is designed to inspect a complete range of part geometries, such as aircraft control surfaces, wings, doors etc in addition to highly contoured fuselage and cabin components. The motion control, data acquisition and instrumentation components can be installed in a system control room, or operated from a shop floor console. The system is based on modules widely used in SDI's product range, which can be viewed on our web site at [www.sdindt.com](http://www.sdindt.com). All components/modules used in the system are designed and manufactured in-house by SDI in their Camarillo, CA facility.

### **System Features**

- Scan speed up to 35 ips.
- Linear Amplifier UT for greater defect amplitude resolution.
- Log Amplifier UT for greater dynamic range.
- Optional simultaneous dual channel through-transmission (TTU) and pulse-echo (PE) providing four data files from one scan; one PE from each side and two TT at different gain levels.
- Four pulser selections - high power spike (1000v), high resolution spike(400v), tone burst and square wave.
- Optional coordinated parameter control – instrument parameters such as gain and gate position can be built into a scan plan as additional coordinated “axes” changing at rep rate speeds.
- 130 dB dynamic range.
- 40dB Distance Amplitude Correction.
- Multi-processing allowing scans to be analyzed while they are being acquired.
- Auto-normalization and auto-teach of scan profiles.
- Complex curve following in any orientation, with 3 point part location.
- Optional full waveform capture usually used with mini-scan described below.
- Return to defect – automatic return to ROI identified by the operator.
- Mini-scan – automatic re-scan around ROI for defect analysis.
- Absolute encoding eliminating the need for frequent homing even after activation of collision switch or E-stop.
- 3D to 2D image mapping for accurate flaw sizing.
- Optional automated pen marking controlled from image analysis station.

## 2 MECHANICAL CONFIGURATION

The mechanical configuration is outlined in the attached concept drawing. All gantry members are welded box section. The gantry is mounted directly to the floor with a recessed or above floor sump fitted with water containment and recirculation components. The main bridge assembly is fabricated from welded aluminum tube forming an extremely rigid and stable box girder platform. Two Y axis carriages are mounted on ball shafts, each of which incorporates a Delta-X axis supporting the main Z drive assembly.

The Z axis search tubes are designed to accept a range of interchangeable gimbal assemblies for various applications. The standard extended reach gimbal/gimbal unit is used for the majority of applications where access is not a problem. Where there are restrictions, such as at the leading edge, the compact gimbal/swivel unit is used.







The axes of motion provided on the system are shown in the table below: Typical ranges are given. These will vary according to customer requirements.

<b>Axis</b>	<b>Description</b>	<b>Range in.</b>	<b>Speed</b>	<b>Resolution</b>	<b>Accuracy</b>
X	Primary axis along the frame. Bi Polar d.c. servo drives with resolver.	96-480	35 in/sec	.001 in.	.004 in/ft
Z1, Z2	Vertical column rack and pinion drives. Bi polar d.c. servo drives with resolver.	48-72	4 in/sec	.001 in.	.004 in/ft
Y1, Y2	Lead screw drive with Bi polar d.c. drives and resolvers	48-72	12in/sec	.001 in.	.004in/ft
Delta X	Mounted on both Z axis carriages.	24	12in/sec	.001 in.	.004in/ft
A1, A2	Gimbal in X, Y plane	+/- 90 deg	30 deg/sec	.01deg	0.01deg
B1, B2	Gimbal in Y, Z plane	+/- 90 deg	30 deg/sec	.01deg	0.01deg



**Linear Drives.** The X axis motion is provided by driving the bridge assembly along steel rectangular section girders fitted with leveled aluminum tracks and ball shafts. Heavy duty dual power belt drive provides accurate positioning with encoder feedback. The heavy frame structure is designed to maintain positional accuracy throughout the operating range. The linear ways for Z, Y and delta-X axes are precision stainless steel, heavy duty, ball shafts with high endurance large diameter toroidal bearings. These are also fitted with precision rack and pinion drives or lead screws. All drives are closed loop d.c. with encoders/resolvers.

**Gimbal Drives.** The gimbals incorporate dc drives with resolvers and zero backlash harmonic drive gearboxes. The units are housed in sealed stainless steel enclosures as used on the SDI immersion systems.

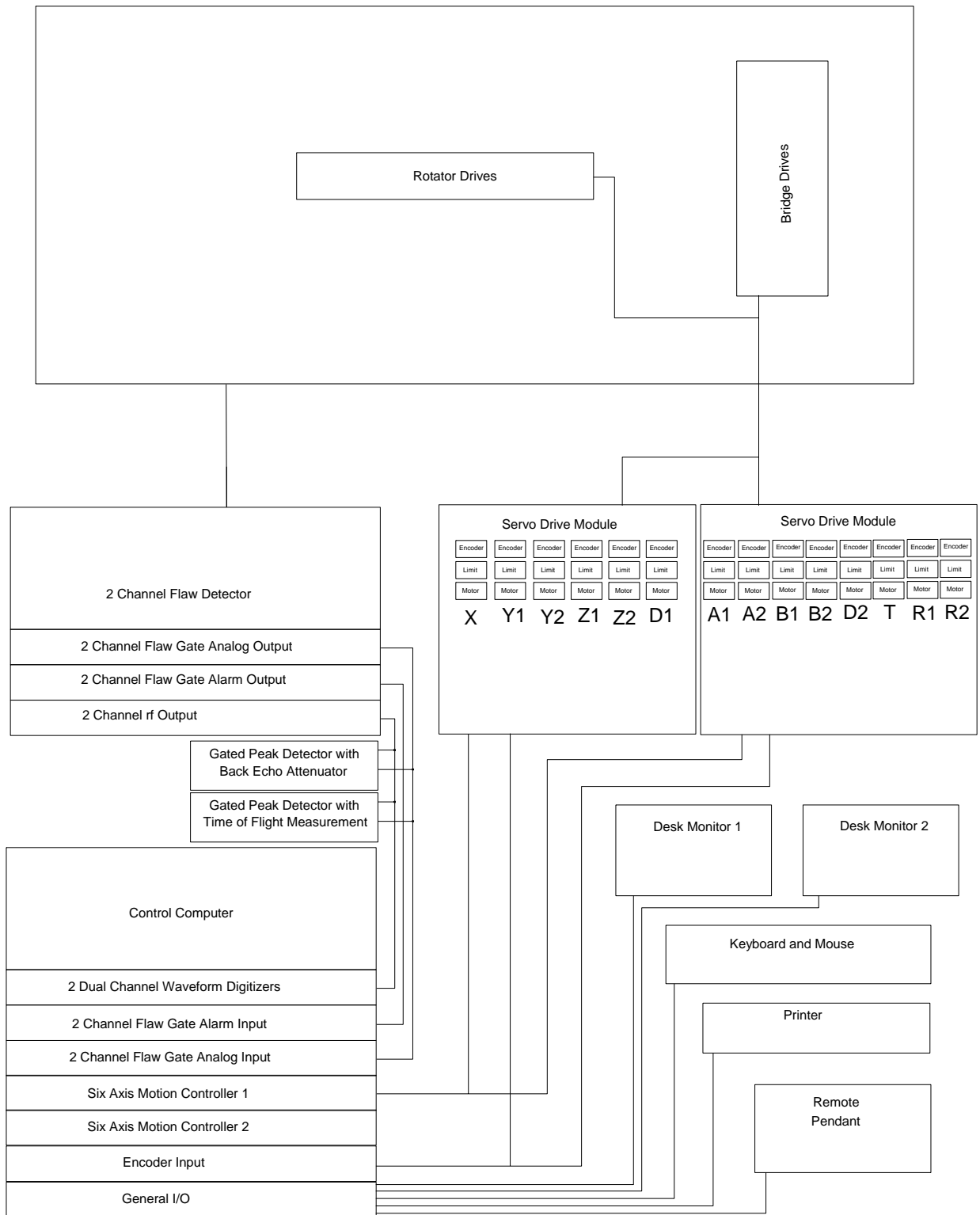
**Control Console.** The mobile control console can be positioned anywhere within reasonable distance from the system. Current SDI systems have similar remote consoles up to 80 ft. from the scanner. It is fitted with two 21 inch monitors linked in the Windows operating environment to allow windows to be dragged from one screen to the next, or expanded over two screens. The console requires a single 110V 60 Amp single phase supply. SDI will install the necessary transformers to achieve this from the customer's supply. The console houses all the computing, drive and instrumentation components required to operate the system. The enclosure includes a filtration and refrigeration unit.

**Remote Operation.** – A range of control functions, including teaching the part shape, can be carried out through a remote wireless pendant,(Windows tablet). Display of the TTU signal amplitude allows normalization of the transducer while standing next to the part rather than at the control console.,

### **3 ELECTRICAL CONFIGURATION**

The electrical configuration describes the components and interconnections for the motion control, drive, instrumentation and data acquisition sub systems. The majority of the components are housed in the system console. All system components meet applicable US and International safety codes. Apart from the very low current ultrasonic signals, no voltages greater than 70 volts are present anywhere on the system outside the control console.

The electrical layout is shown below:





#### **4 INSTRUMENTATION**

The system can be supplied with any two channel systems instrument from a major instrument manufacturer. The units can be configured to be able to provide simultaneous pulse echo from each side together with two through transmission tests, resulting in the acquisition of four channels of data in a single scan. A range of auxiliary instrumentation can be provided to aid in the inspection of the more complex highly attenuative lay-ups. This will include log amplifiers, pre-amplifiers, tone burst pulsers and air transmission modules. With the SDI dual frequency transducers, scans can be performed at two frequencies simultaneously.

#### **5 MOTION CONTROL**

The motion control is provided by the SDI-1830 MasterScan advanced controller. Designed specifically for ultrasonic applications, it features ultrasonic functional axes and scripted scan plans. This means that complex motion control and acquisition activities unique to ultrasonic inspection techniques are available to the operator through simple commands using ultrasonic terminology. The operator can construct complex scans by chaining together individual motion commands, scan plans and instrument set-ups. Full details of MasterScan are given in the data sheet. Some of the key features are:-

- Functional axes using standard UT terminology
- Import/Export of scan plans to CAD programs
- Automated normalization
- Auto teach of scan plans
- Integrated instrument control coordinated with the motion along a scan trajectory.
- Scripted scan plans
- Chained scans
- Dual independent search tubes performing different scans simultaneously.
- Stop on defect
- Return to defect
- Display of scan progress and time to finish.
- Variable turntable rotation to maintain constant surface speed with changing diameter.
- Taught slave positions for TTU
- RadScan – pre-programmed radius scanning.
- 3D display of taught shape.



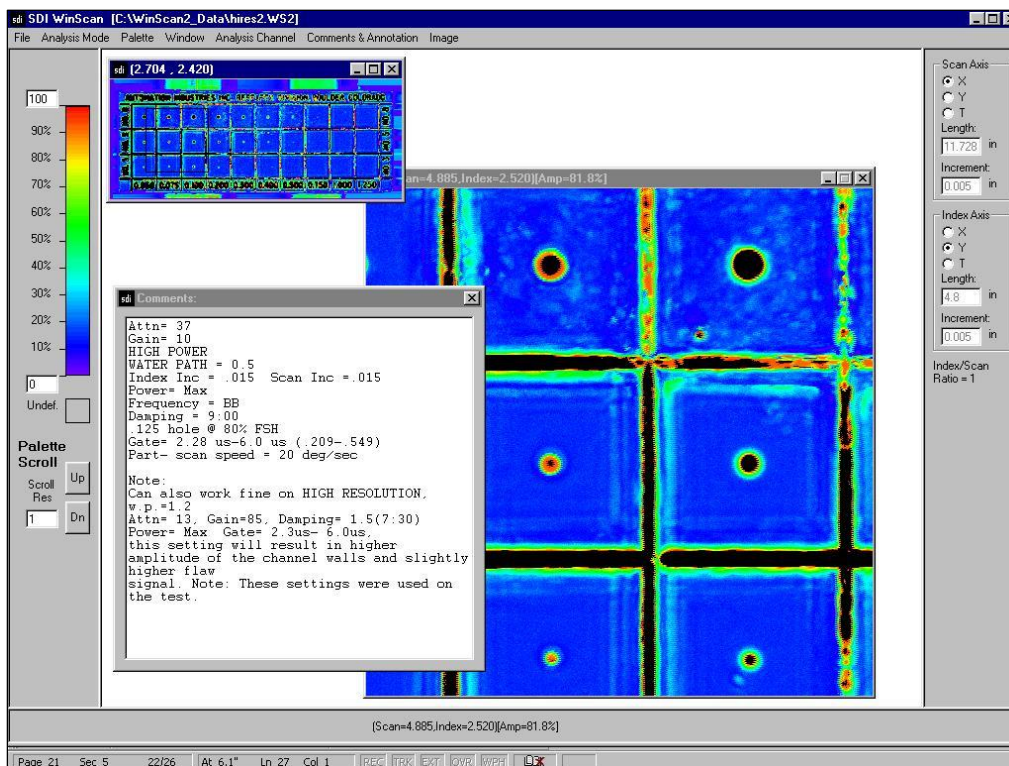


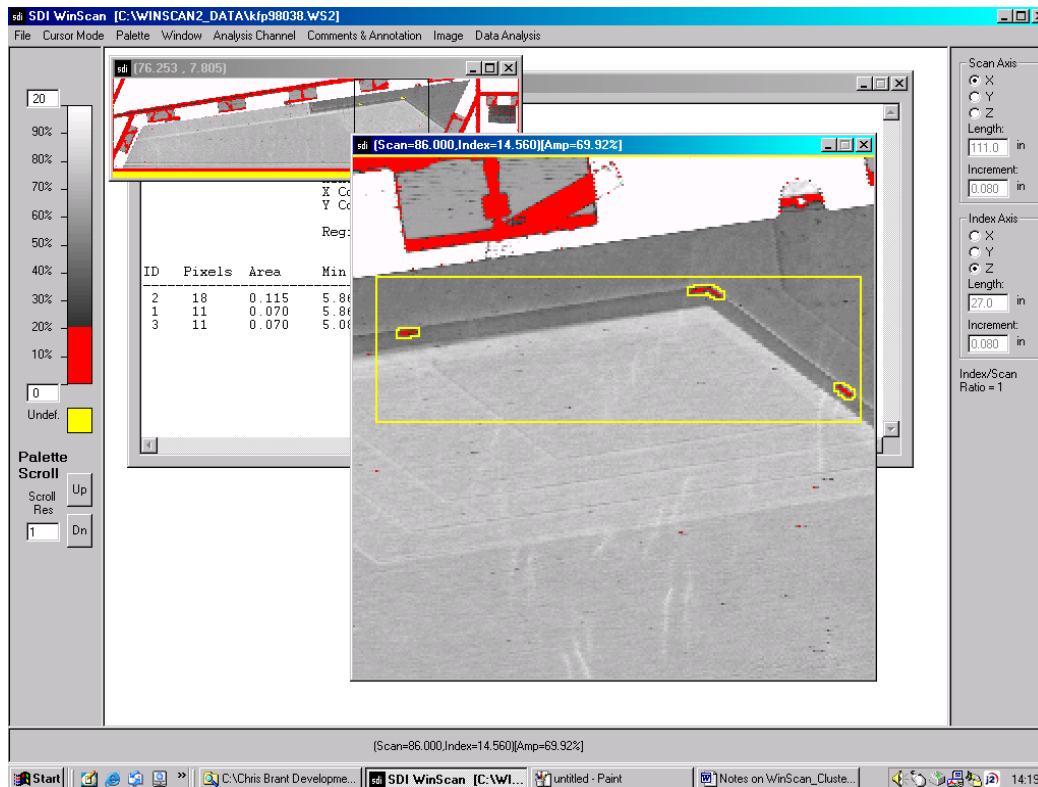
## 6 ACQUISITION/ANALYSIS

The system is supplied with the latest SDI-WinScan multi-tasking acquisition and analysis package designed for high throughput production applications. A technical description of the features and benefits of this high performance industrial package is attached. Some of the key features are :-

- High-speed pan and zoom through entire data file
- High speed, high quality 1:1 plotting of all or selected areas of the data file.
- Scan comments stored with the data file.
- Multi-channel operation.
- True multi-tasking to allow scanning, plotting and viewing of stored files to be performed simultaneously without a reduction in speed.
- Numerous analysis features such as histograms, in dB and linear scales, cluster analysis providing automatic defect identification, image smoothing and filtering with operator defined kernels.
- Full Waveform Capture with B-Scan

Another time saving feature of the fully integrated motion control and data acquisition package is the ability to perform mini-scans. Areas of interest can be tagged on the data file and the system will automatically drive back to them and re-scan the area using selected defect evaluation scan parameters such as full waveform capture.

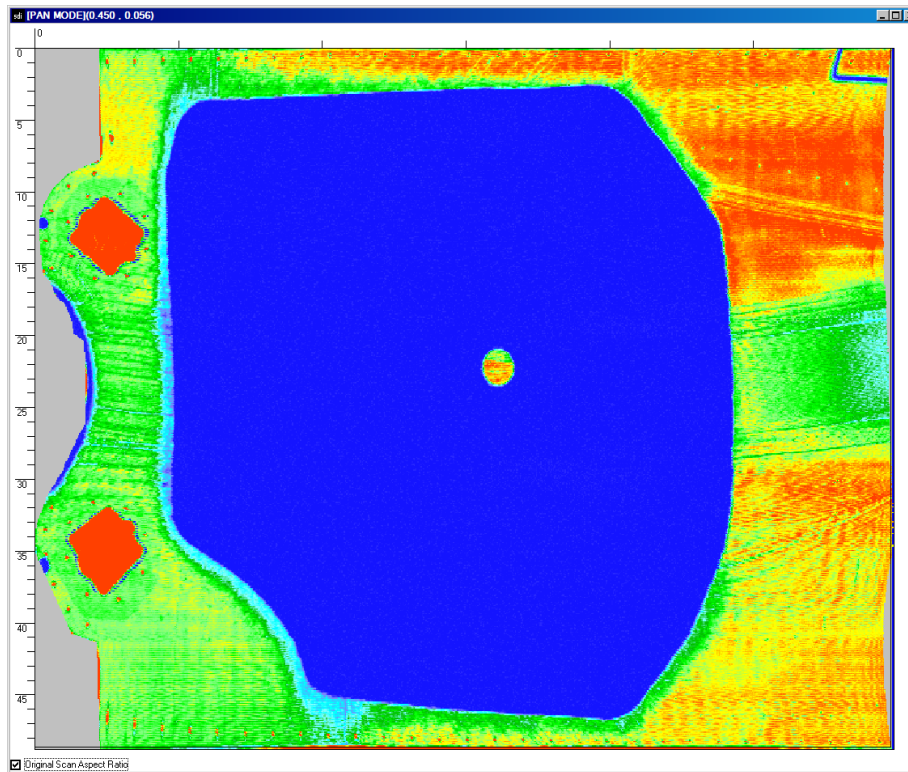




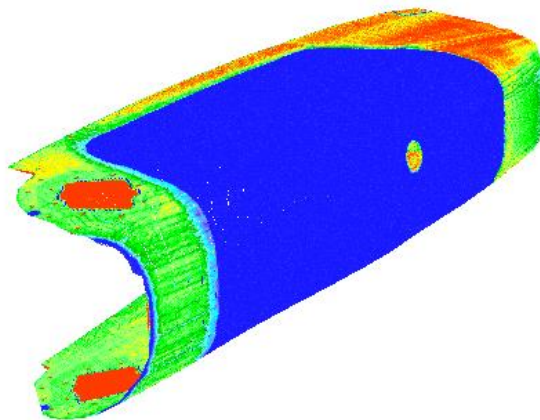
Using Cluster Analysis for Automatic Defect Location



This figure shows a graphite composite, honeycomb cored laminated structure being inspected in an SDI-5380 10 axis 3D scanning system. The inspection system can accept a number of specialized test head assemblies for different applications. For this inspection the extended reach graphite composite swivel/gimbal arms are used. In addition, as the inspection requirement is for both 5Mhz and 1 Mhz frequency, the proprietary SDI Dual element transducers are used to perform the inspection in a single scan.



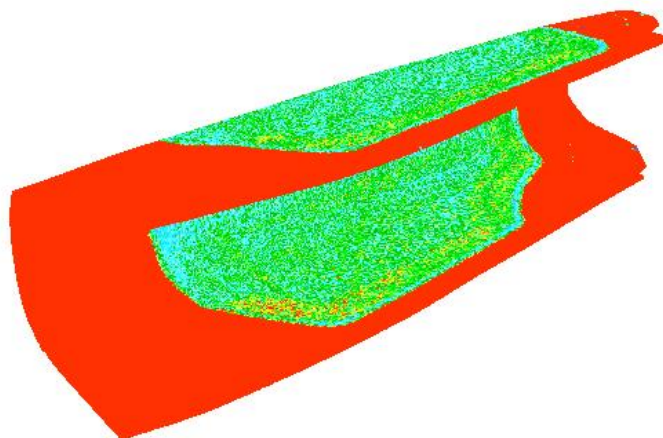
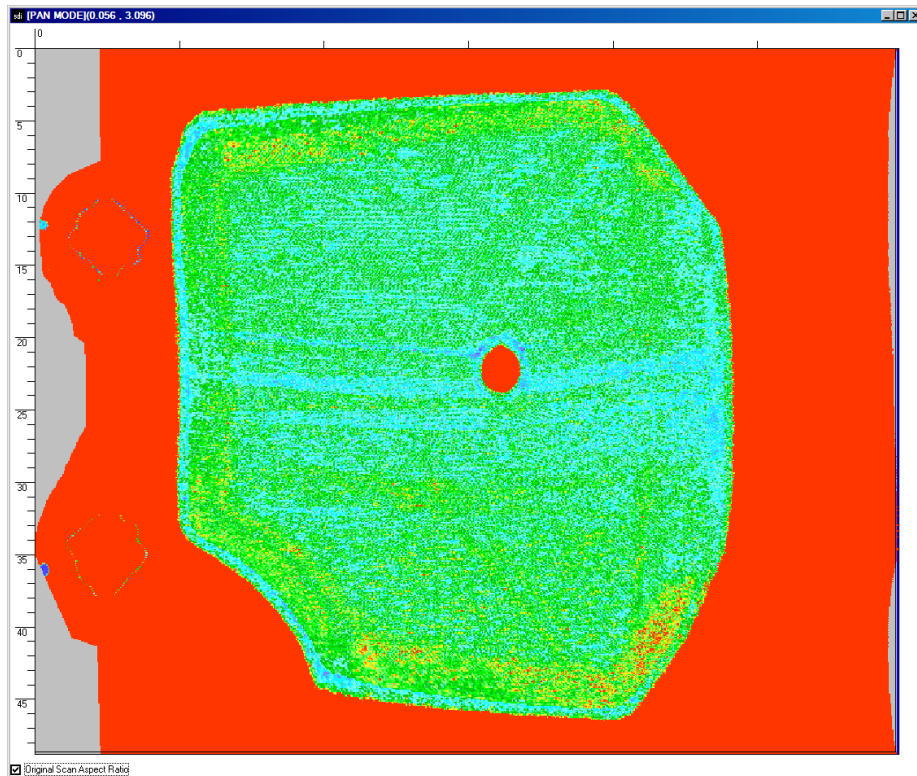
The C-scan above shows the 5 Mhz data revealing details in the solid laminate area. The uniformity of the data as the test heads scan around the entire “C” section channel demonstrates the accuracy and rigidity of the SDI system.

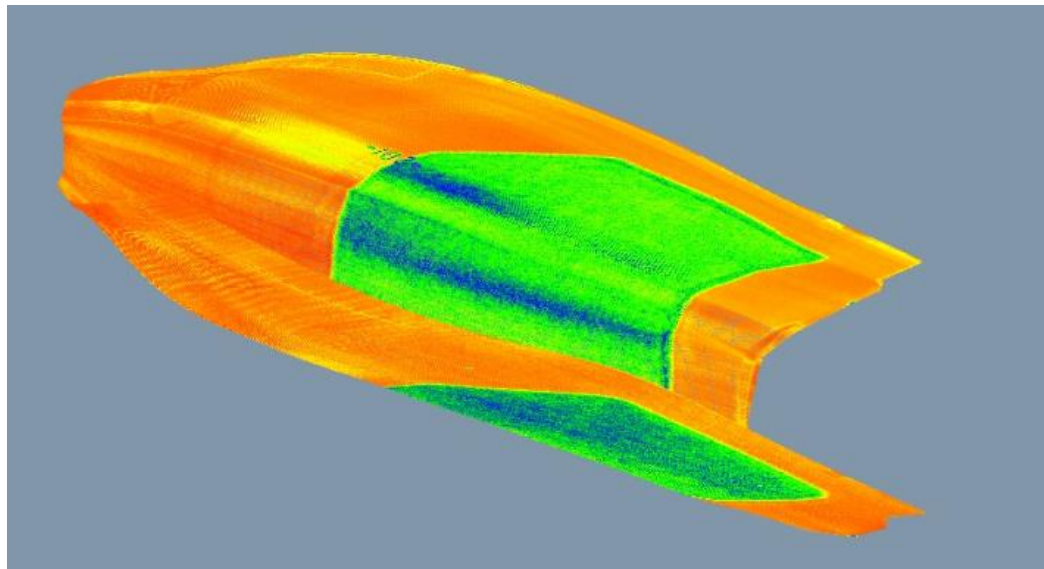
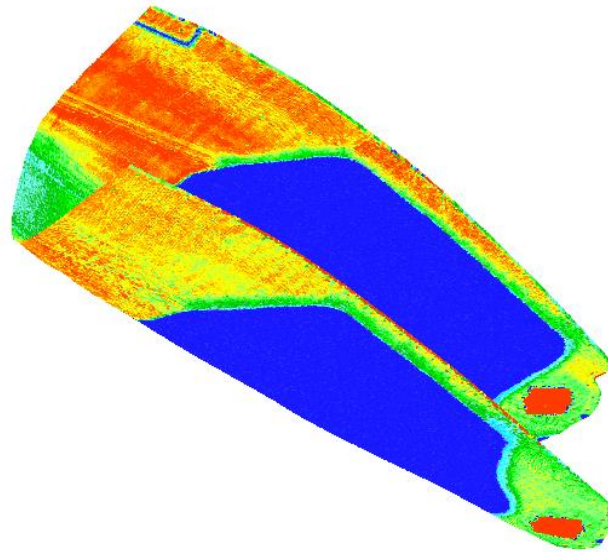




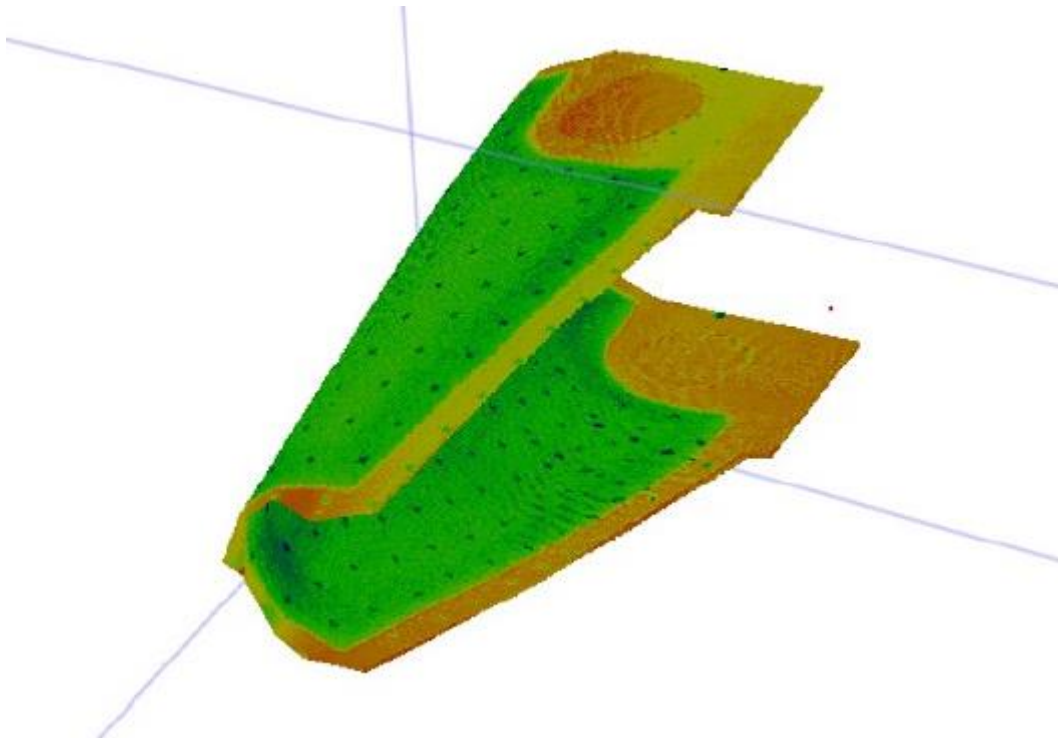
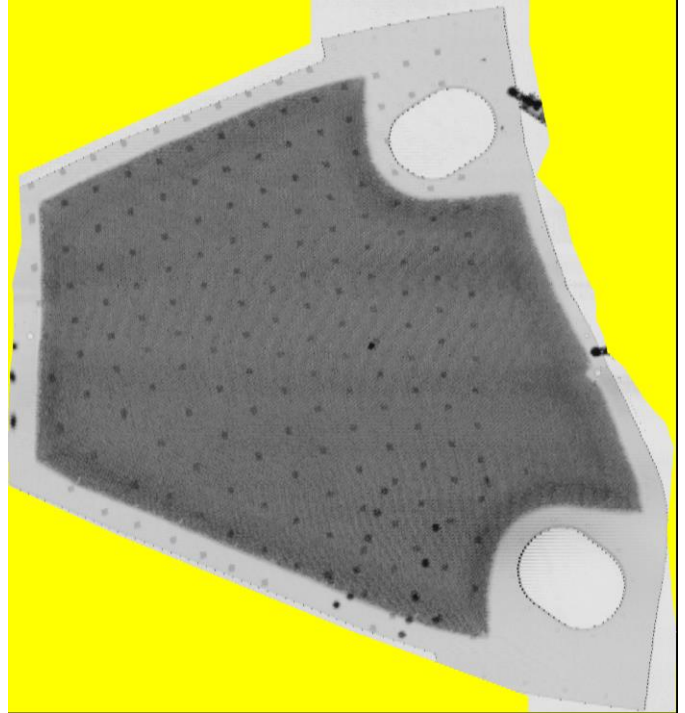
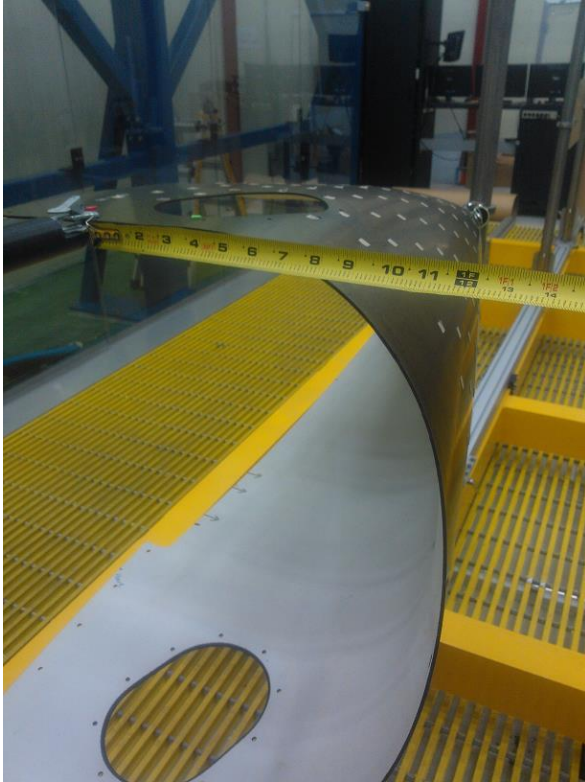
The 3D image above can be rotated on the screen during the analysis of the data to aid in defect sizing. Accurate sizing and analysis is also achieved using the 2D projection feature which displays the 2D data normal to the cursor position on the 3D data display.

The following C-scan shows the 1Mhz scan acquired at the same time. This clearly shows the details of the honeycomb core.





The next group of images is a smaller component being inspected in an SDI-5380 gantry system. Examples of 3D imaging and 2D mapping are provided.





**7      INSTALLATION**

The system will be fully assembled and made operational at the SDI facility in Camarillo for customer buy off. The Acceptance Test Procedure (ATP) will be carried out using the test samples supplied by the customer. SDI will address any items requiring rectification prior to authorization for shipment by the customer representative. Upon receiving approval, SDI will dismantle, crate and ship the system. SDI will carry out site preparation prior to the arrival of the system. The system will then be assembled and made operational on site. The ATP will then be repeated. The system timeline is attached.

**8      TRAINING**

SDI provide a comprehensive training program including 5 days training of personnel in the operation and routine maintenance of this equipment. This training will take place either at the SDI facility or at the customer site after installation.

**9      CUSTOMER SUPPORT**

9.1      Customer Support Department

SDI can offer 24-hour response to all product support requirements to ensure minimal equipment downtime.

9.2      Field Service Organization

SDI has a domestic and overseas field service organization to provide post installation service and maintenance on installed systems

9.3      Spare Parts

A recommended spare parts list will be provided with the system. Replacement of these recommended spares will be covered in the maintenance training given with the system.

9.4      Technical Support

Technical support and engineering staff at the SDI facility a available for telephone support as required. All customers are offered free consultation via phone or fax.



## Summary Of Features

ITEM	FEATURE	DESCRIPTION
<b>Part Teaching</b>		
1	Auto-normalization	Automatic maximization of the pulse echo signal from the part surface at a position selected by the operator
2	Auto-Teach	An automatic sequence of repeated auto-normalization and point recording at specified spacing over the part. Scan can be set to start automatically after the auto-teach is complete.
3	Auto-correct slave for misalignment	Automatic maximization of the through transmitted signal at the taught points. Allows compensation for part geometry or squirter droop etc. which would mean the exact geometric alignment of the squirter would not give optimum results.
4	3 Point Correction	Scan plans can be stored with 3 reference points. If subsequent scans of similar parts need to be performed at different locations in the scan volume, it is only necessary to teach the three reference points and the stored scan plan will be re-oriented to the new location.
5	Taught Slave	Taught slave, as opposed to calculated geometrical slave, is used where the squirter are not geometrically opposing each other or where the water path separation varies throughout the scan.
6	Point Reversal	For occasions where it is beneficial to teach profile in one direction and scan in another, it is possible to reverse the order of taught points, and reverse order of profiles
7	3D display of current taught points and surface	A 3D display of the part surface and gimbal positions is generated as the part is taught.
8	XYZ file Import/export.	The part shape can be exported as an XYZ file of the surface coordinate points. In addition, CAD files converted to XYZ can be imported to aid in part teaching.





ITEM	FEATURE	DESCRIPTION
<b>Motion Control</b>		
9	Functional Axes	Calculated functional moves, tangential A, tangential B, rotation about pivot point, water path, can be moved as a single axis through jog pad or screen jog.
10	Zonal Speed.	The scan can be split up into 10 zones each with a different scan speed.
11	Absolute Encoders,	Maintain position of up to 16 axes at all times. Allows rapid resume after E stop with no homing requirement.
12	3D contour following	Either single or double delta X allows full contour following.
13	Scripting	A sequence of previously stored scan plans can be executed automatically
14	Nesting	A taught scan plan can be executed a number of times with offsets for an array of parts mounted in the same fixture.
15	Instrument Integration	Instrument parameters such as gate position, gate width, gain etc can be integrated into a scan plan as a virtual coordinated axes. i.e. gain or gate position can vary along a scan line.
<b>Data Acquisition</b>		
16	A, B and C scans.	A, B and C scans can be captured and stored. (B scan only when full wave form capture option is installed).
17	Full Waveform Capture	A 200MHz waveform digitizer is used to acquire the entire waveform over a specified area. Although it is possible to acquire over the entire part, this feature is usually used with the miniscan feature described below.
18	Sampling Options	Standard data sampling for amplitude and thickness is performed at 12 bit resolution. Sampling can be selected as pulse on position (POP) or over-sampling. Over-sampling provides enhanced data fidelity by sampling multiple times for each data point and then allowing the highest, lowest or median to be stored for that point.



ITEM	FEATURE	DESCRIPTION
19	Scan Re-Start	Scans can be restarted after power outage, E stop, collision etc and continued from any point on the scan plan specified by the operator. The data collected so far is overwritten if the operator chooses to restart in an area previously scanned. This feature can also be used if the operator wishes to perform a scan of a smaller area of a previously stored scan plan.
20	Data Swathing with Multiple Transducers	For components with little or no curvature a second pair of squirters can be added to the search tubes. The additional squirters are offset in the X and Z directions a whole number of sample points. The motion control and acquisition will then perform a sequence of swaths which are reconstructed into a single data file.
21	Double Indexing with Averaging	Several users have the requirement to perform double indexing. This is where the scan increment is, say .040, but the index is .080. The SDI software has the ability to insert an averaged scan line between the actual scan lines, thus all data pixels remain as .040 x .040.
<b>Data Analysis</b>		
22	Log or Linear	Data can be analyzed as log or linear data. A full range of standard palette manipulation features is included.
23	Data Annotation	A wide range of data annotation options are included. The annotation is stored along with the data file without overwriting data.
24	Return to defect	The squirters can be sent back to any location marked on the data file. The curvature of any component is followed
25	Mini-scan.	An automatic mini-scan can be performed with selectable size centered on an indication identified in the data file. The scan parameter can be different to the original scan and also include such options as full waveform capture.
26	3D data display	The data for a curved part can be displayed as a colored overlay on the shape of the part.
27	Scaled Plots	Accurate scaled plots: 1;1, 1:2, 1:4 1: 8,2:1, 4:1, 8:1 on any windows printer including HP inkjet plotters



ITEM	FEATURE	DESCRIPTION
28	Data Exporting	Data can be exported as 256 level TIFF files or .CSV files for export to a spread sheet.
29	Histograms	Histograms with extensive data measurements can be produced.
30	Cluster Analysis	Automatic analysis of the data can be performed by specifying defect amplitude, area and proximity to other indications.
31	Collision switches	Collision switches are installed to eliminate part damage. Recovery from limit switch activation employs the re-start feature.
32	Pendant Teach and E stop.	A rugged pendant is provided with key functions required for part teaching.
33	Extended Reach Squirter Assemblies	ERSA gimbal arms are available for small radius of curvature, down to 2.5in. radius.
<b>Automatic Operation</b>		
34	Auto Air/Water on/off	Automatic control of the air and water can be built into the scan plans.
35	Automatic paint marker.	Auto Paint marker allows ROIs identified in the data file to be marked on the part surface
36	Light Curtain	Laser light curtain for automatic shutoff in case the light curtain is tripped.
<b>Instrumentation</b>		
37	High Power Spike pulser 1000v	These auxiliary functions can be added to any third party system flaw detector.
38	High resolution spike pulser 300v	
39	High power (800v p-p) sine wave tone burst pulser with adjustable burst length	



ITEM	FEATURE	DESCRIPTION
40	Square wave pulser	
41	Log Amp	
42	Simultaneous TT and PE	
43	“On the fly” instrument Control,	