Geodetic Services

V-STARS S6 and PRO-SPOT Demonstration
Measurement Report for
Daewoo Shipbuilding & Marine Engineering (DSME)
Geoje Shipyard, Korea

NOV 2003

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Objects Measured

Two objects were measured as part of the V-STARS and PRO-SPOT demonstration. The first object was a large section of curved plate. This is shown on the cover of this report. The objective in this measurement was to determine some of the key dimensions of the plate as well as points on the surface. A section of the surface was also measured using the PRO-SPOT target projector. The measurement was completed before and after heat forming of the plate.

The second object was a mock up using sections of pipe. The objective of the measurement was to determine the relationship between the pipes and their orientation to the floor. The mock up is also shown on the cover of this report.

Equipment Used

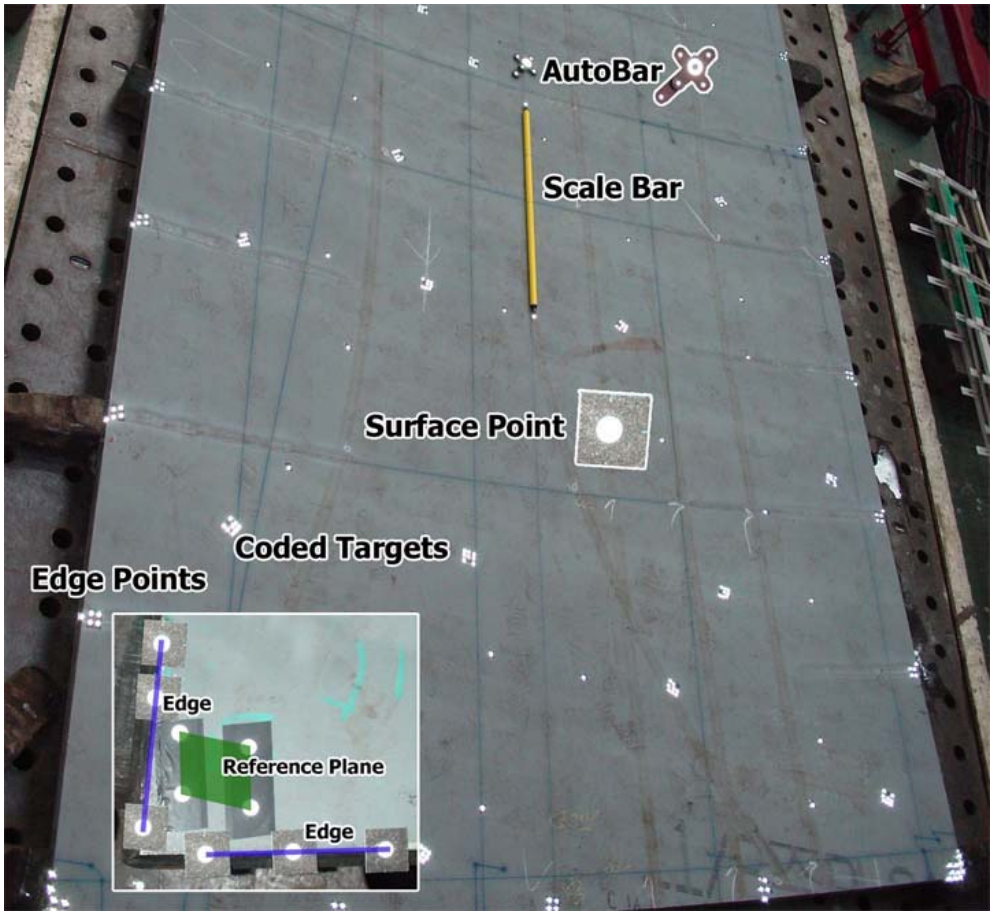
1. V-STARS S6 Camera System
2. Various targets
3. Scale Bar
4. PRO-SPOT Target Projector.

Curved Plate Measurement Objectives

1. Demonstrate camera use and object targeting
2. Determine edge of plate points and fit curves to edges
3. Determine surface points
4. Measure section of plate using PRO-SPOT
5. Re-measure the plate after heat forming
6. Compare curves and surface before and after heat forming

Curved Plate Targeting

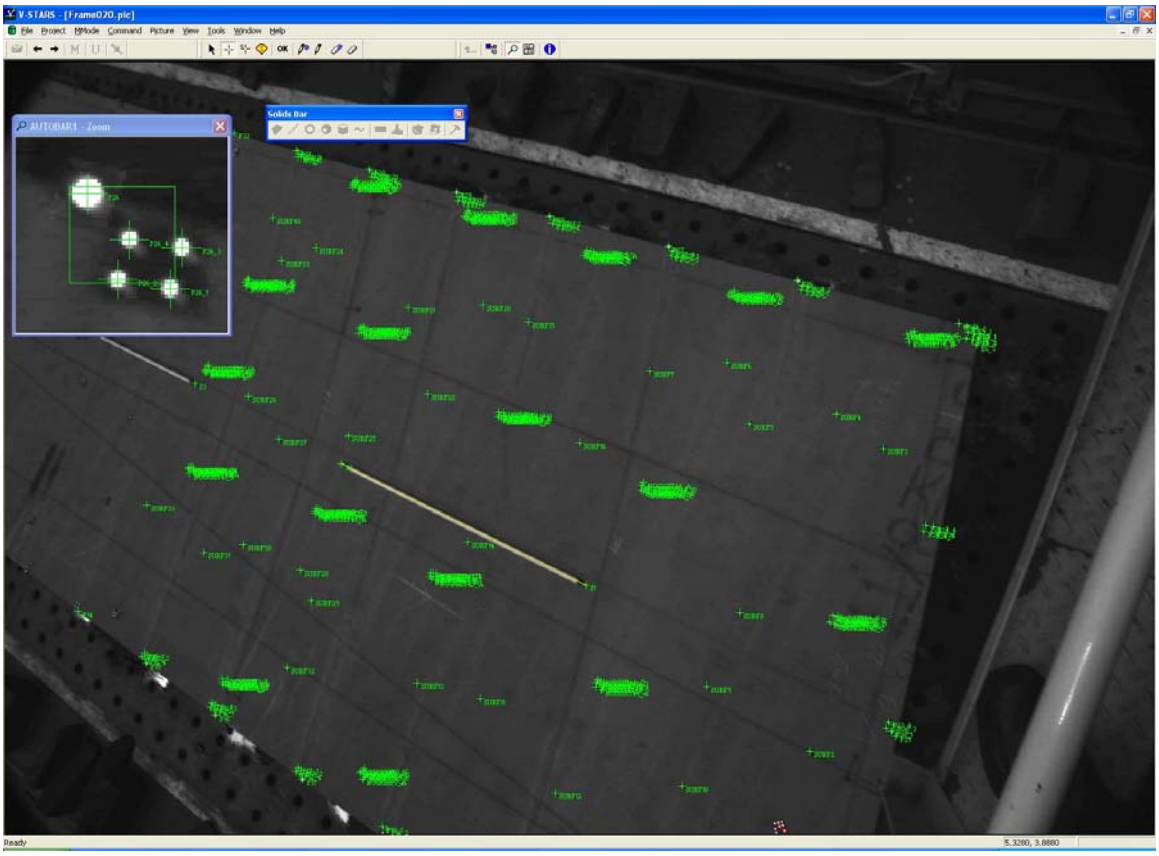
1. AutoBar for initial coordinate system
2. Coded targets to tie photography together
3. Targets to define the edge planes
4. Strip tape surface targets
5. PRO-SPOT projected targets
6. Two scale bars



Curved Plate Measurement Statistics

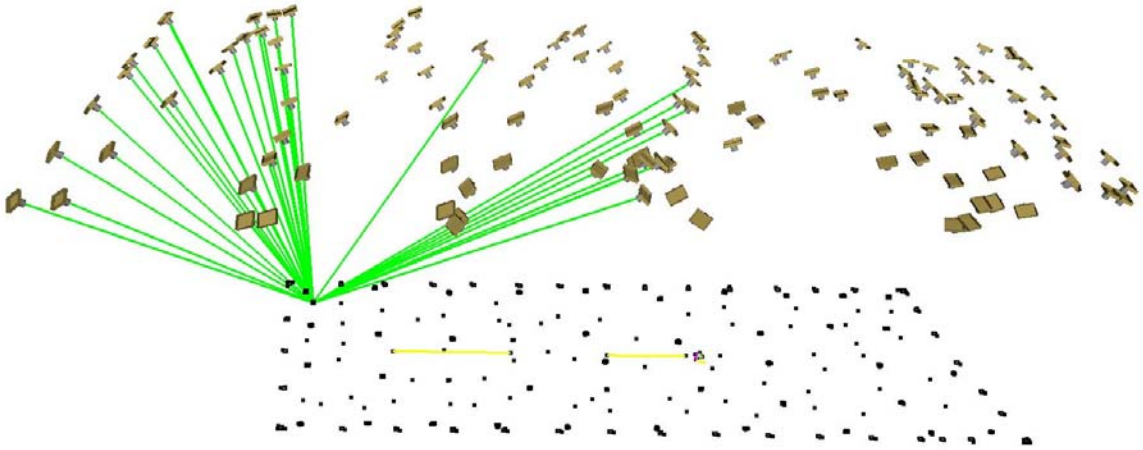
Network 1 – Before heat forming

No. of photos	127	
No. of points	320	
Accuracy RMS X,Y,Z	X	0.015
	Y	0.009
	Z	0.008



Typical V-STARS measurement image

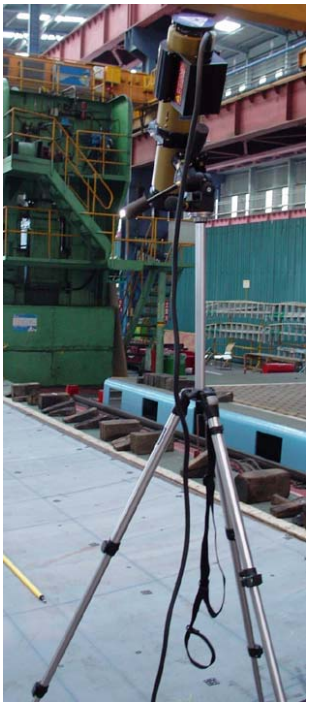
The diagram below illustrates the geometry used to create the point cloud.

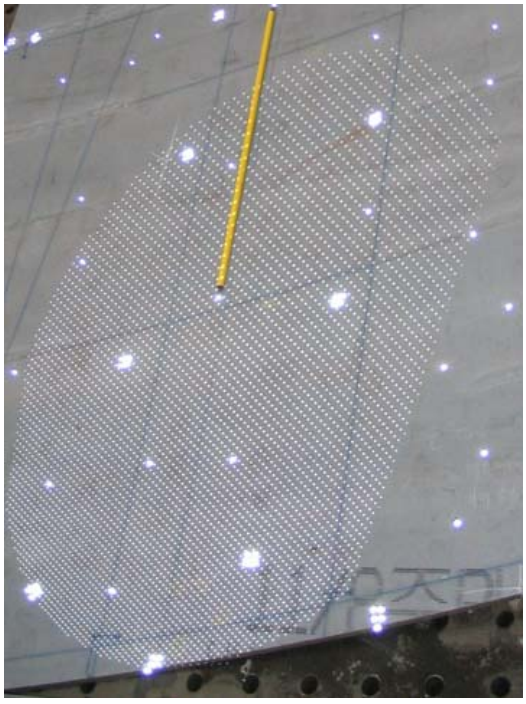


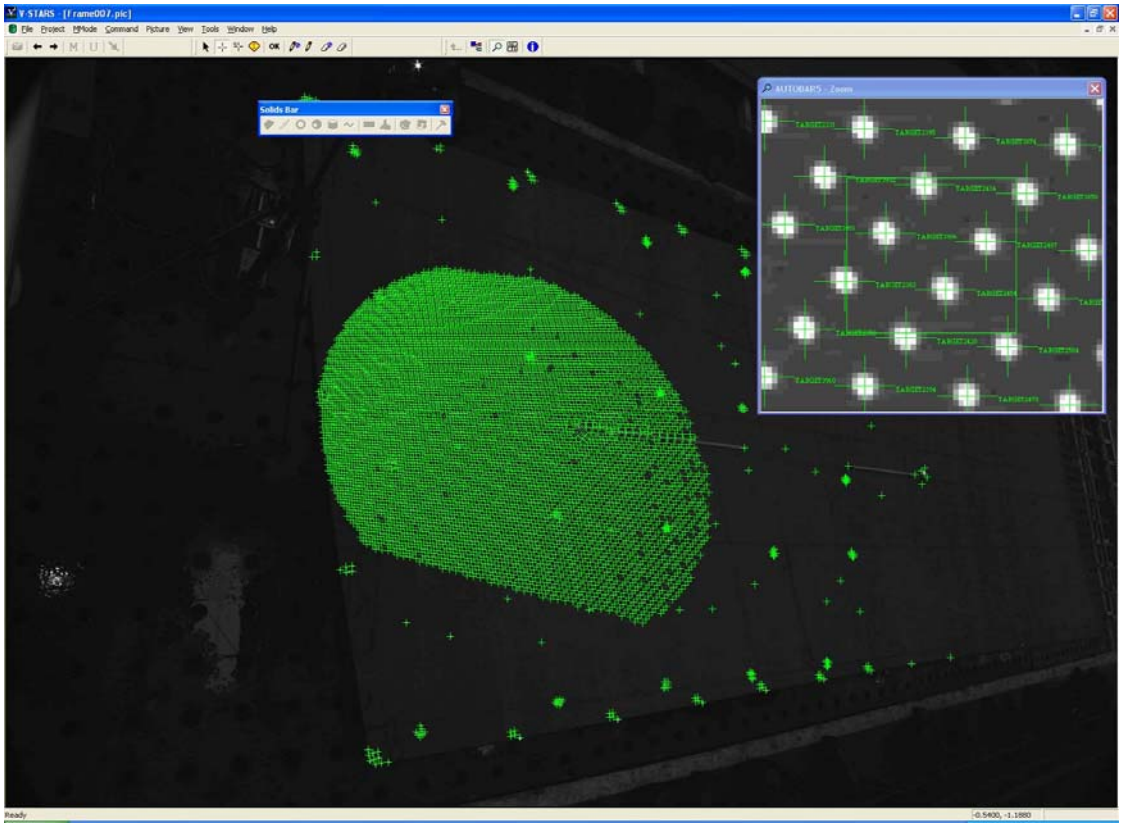
Side View

Network 2 – PRO-SPOT, before heat forming

No. of photos	20	
No. of points	5536	
Accuracy RMS X,Y,Z	X	0.067
	Y	0.060
	Z	0.035





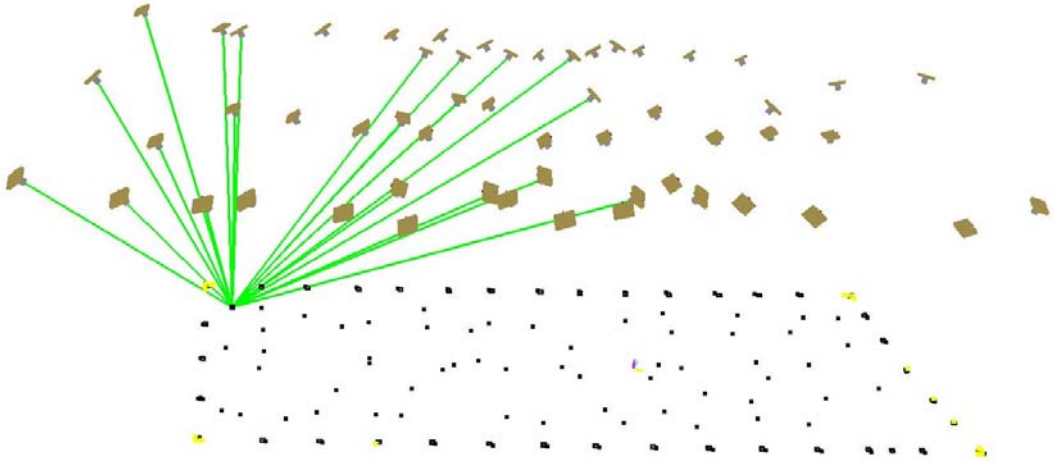


Typical V-STARS PRO-SPOT measurement image

Network 3 – After heat forming

No. of photos	55	
No. of points	315	
Accuracy RMS X,Y,Z	X	0.027
	Y	0.017
	Z	0.015

The diagram below illustrates the geometry used to create the point cloud.

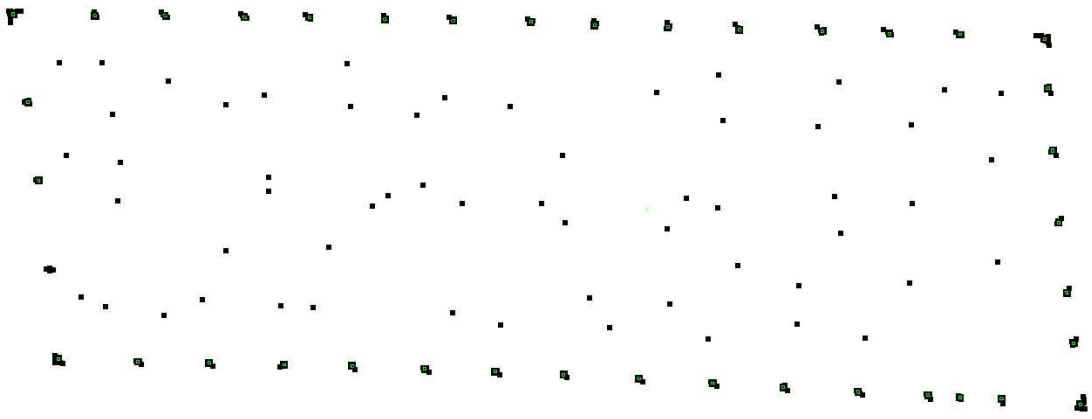


Side View

Curved Plate Point Clouds

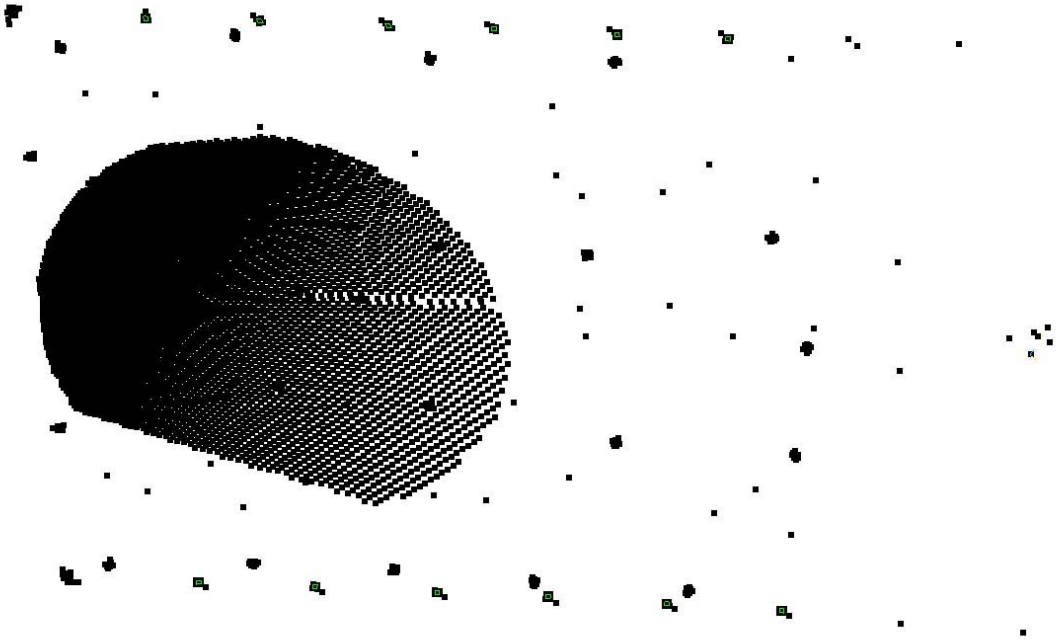
Network 1 – Before heat forming

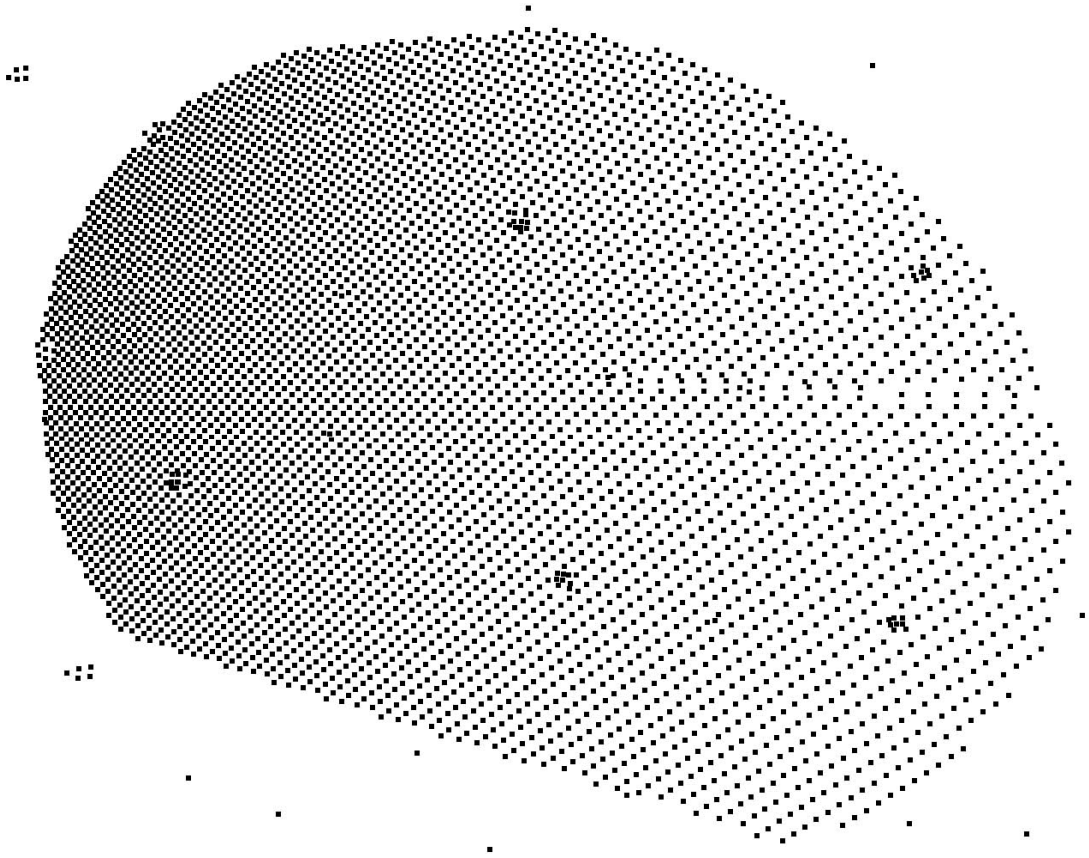
The final point cloud from the first network is shown below.



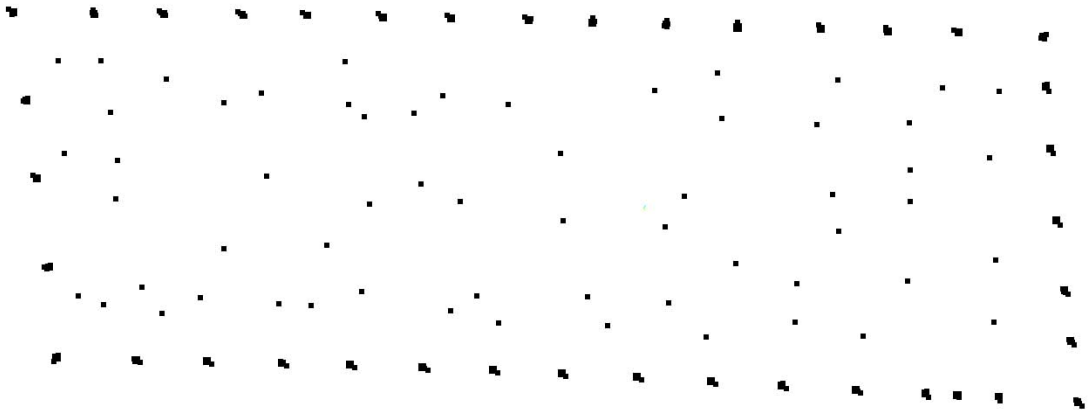
Network 2 – PRO-SPOT, before heat forming

The final point cloud from the second network is shown below.





Network 3 – After heat forming
The final point cloud from the third network is shown below.

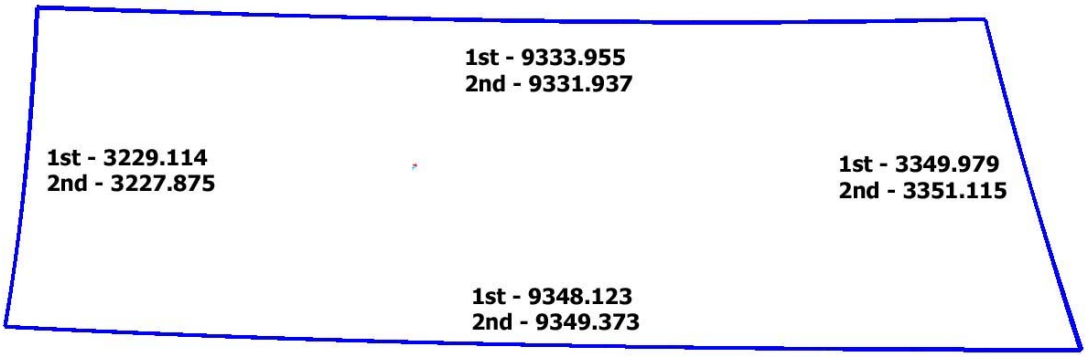


Curved Plate Alignment

As part of the measurement the four corner points of the plate were determined. These points would be used to complete the alignment. At the time this report was prepared no nominal corner point data was available.

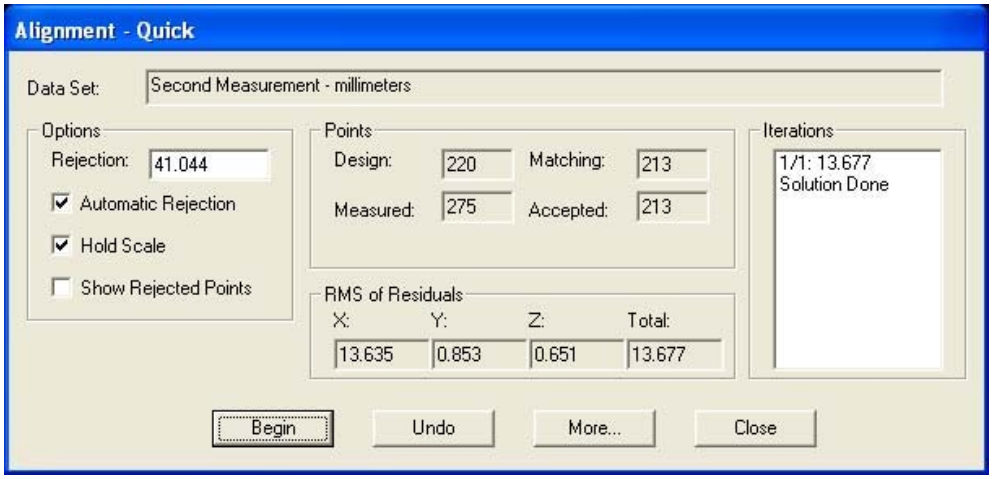
Curved Plate Analysis

The data collected in the first and second networks was used to compute the plate edge points. These points were then used to compute the best fit curves and curve distances(mm). The results are shown below.

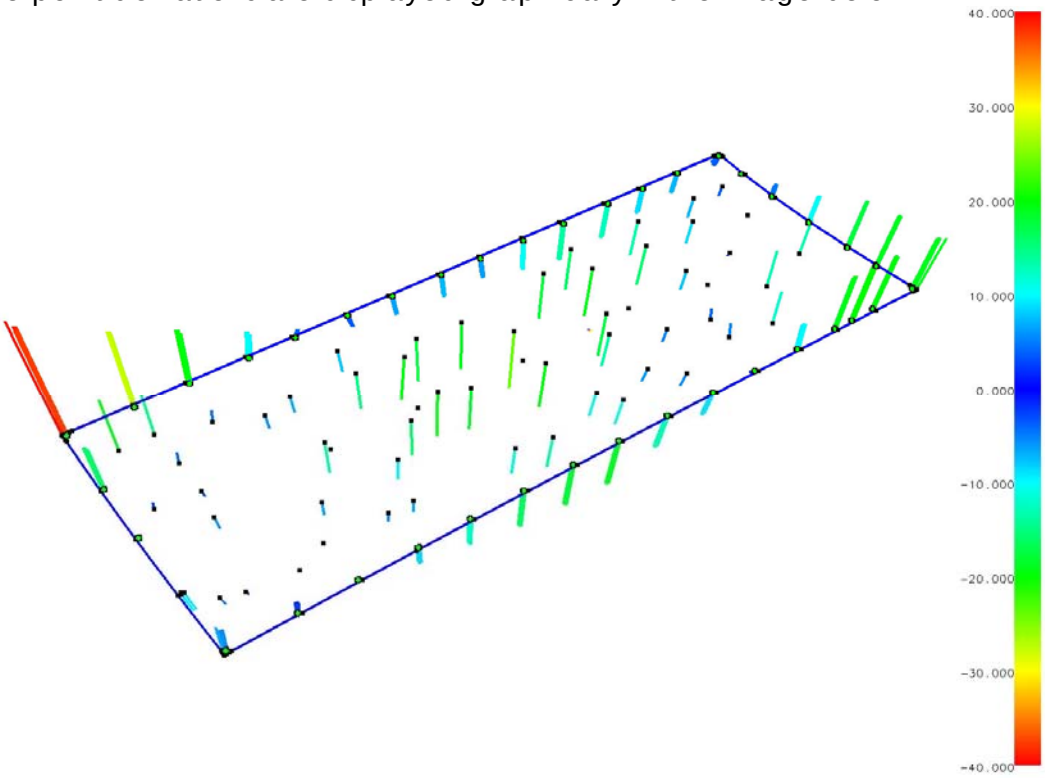


	1st X	1st Y	1st Z	2nd X	2nd Y	2nd Z	Distance
CORNER1	143.57	-3871.35	-3994.78	149.35	-3872.30	-3991.69	**6.6**
CORNER2	89.46	-5864.34	-1465.01	128.98	-5862.04	-1466.08	**39.6**
CORNER3	41.93	4292.79	548.78	60.85	4292.52	548.22	**18.9**
CORNER4	78.15	2229.44	3182.15	74.80	2227.74	3182.59	**3.8**

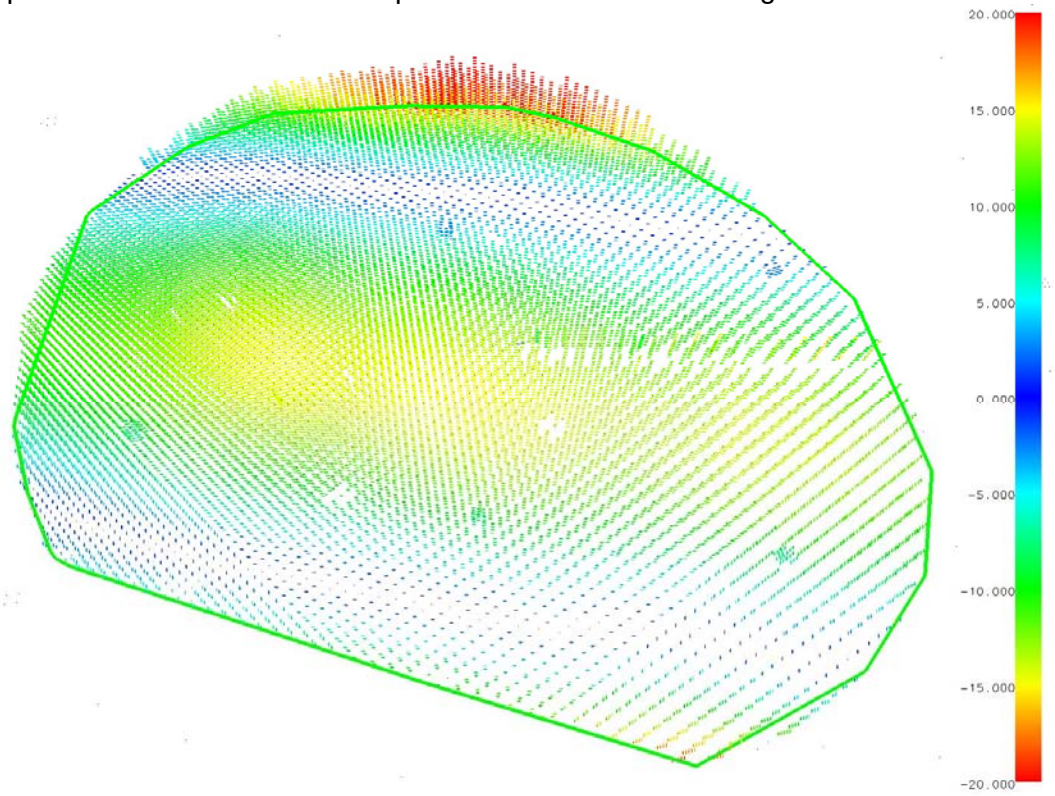
The point clouds between the first and second measurement were compared to indicate how the plate had changed before and after the heat forming. The alignment results are shown below.



The point deviations are displayed graphically in the image below.



Finally, to demonstrate how a point to surface (CAD) comparison might look a plane was created using the PRO-SPOT data. This data was then measured to the plane to create a color map. This is shown in the image below.



Curved Plate Time Summary

Network 1

Initial Investigation	5 minutes
Targeting	10 minutes
Photography	5 minutes
Processing	5 minutes
Data Analysis	5 minutes
Total	**30 minutes**

Network 2

Targeting	1 minutes
Photography	3 minutes
Processing	5 minutes
Data Analysis	2 minutes
Total	**10 minutes**

Network 3

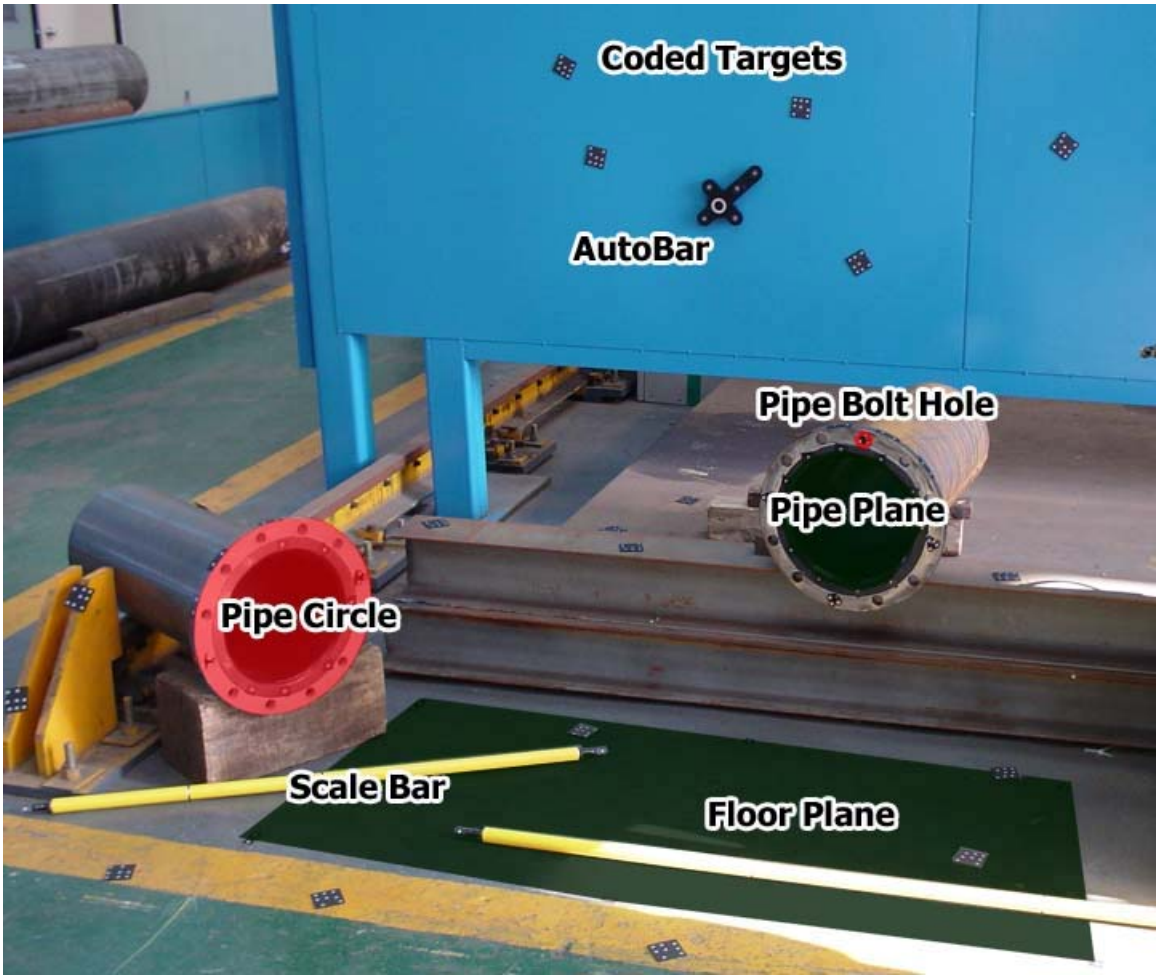
Photography	5 minutes
Processing	2 minutes
Data Analysis	3 minutes
Total	**10 minutes**

Pipe Measurement Objectives

1. Demonstrate camera use and object targeting
2. Calculate pipe relationship to each other and floor reference plane

Pipe Measurement Targeting

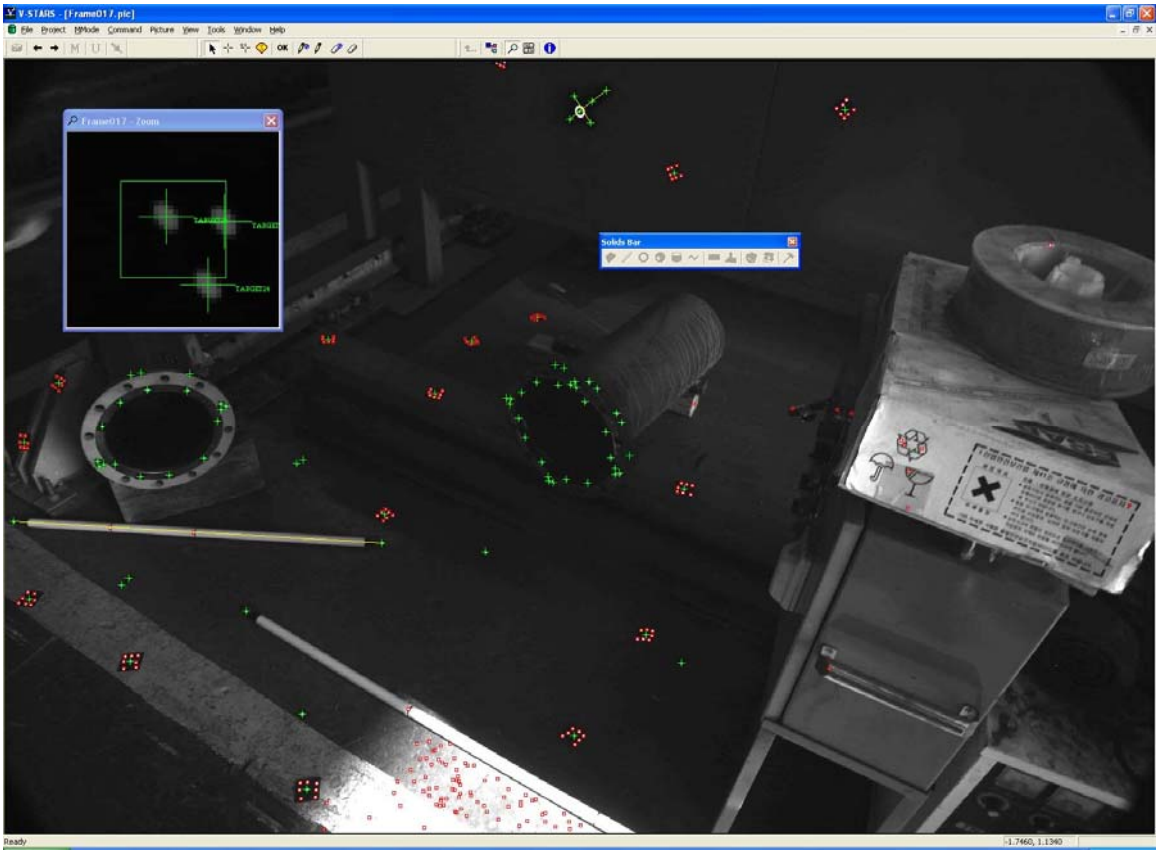
1. AutoBar for initial coordinate system
2. Coded targets to tie photography together
3. Targets on key planes
4. Targets on pipe flange circles
5. Edge targets on bolt hole circles
6. Two scale bars



Pipe Measurement Statistics

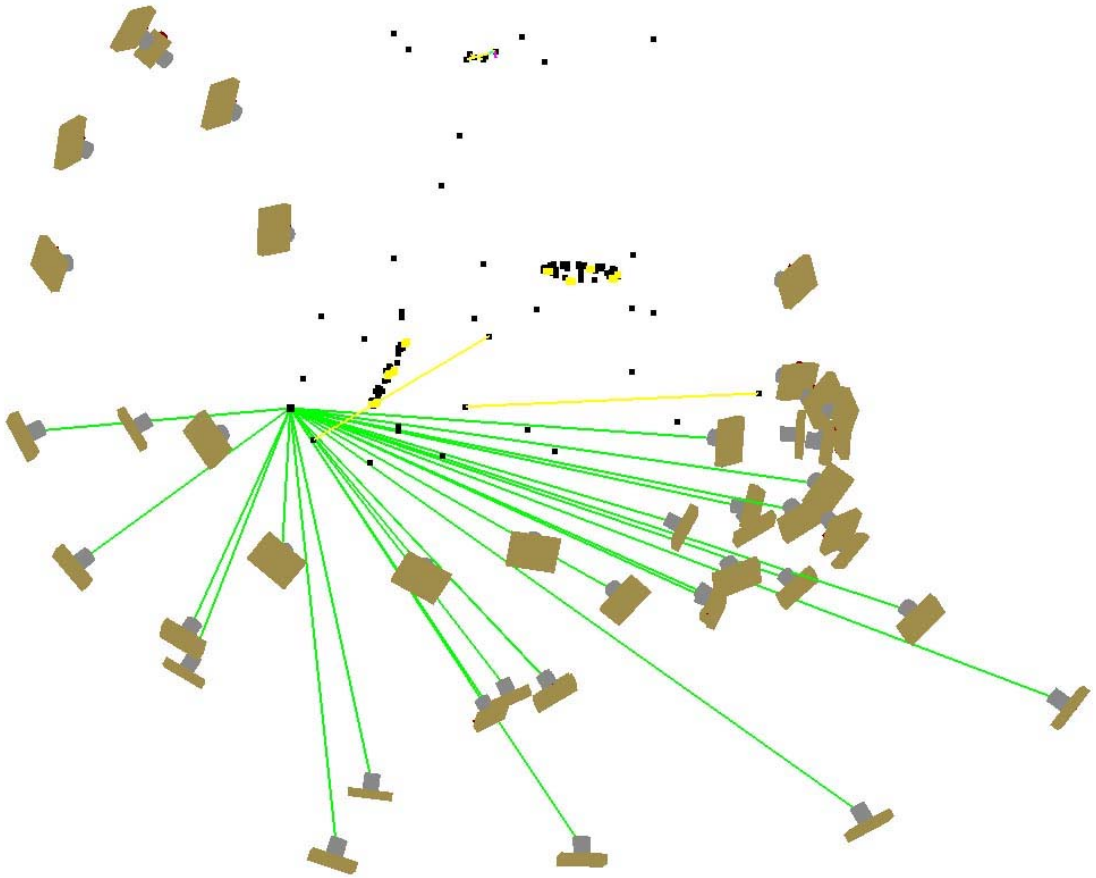
Network

No. of photos	45	
No. of points	106	
Accuracy RMS X,Y,Z	X	0.014
	Y	0.011
	Z	0.013

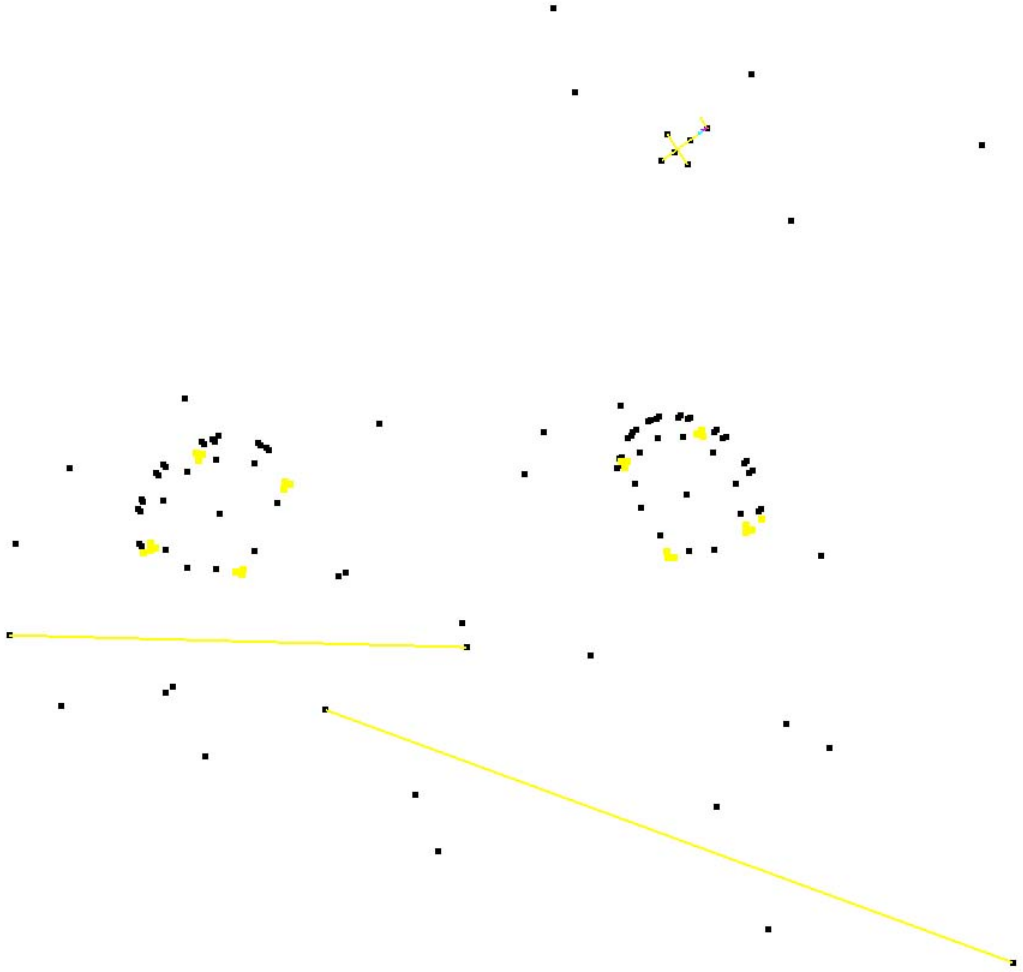


Typical V-STARS measurement image

The diagram below illustrates the geometry used to create the point cloud. One point has been highlighted to show the measurement observations (rays) used to determine its XYZ coordinate.



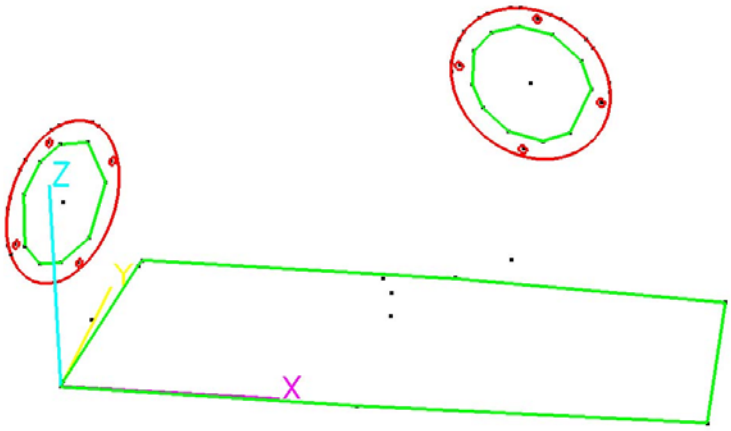
The final V-STARS point cloud is shown in the image below:



Side View

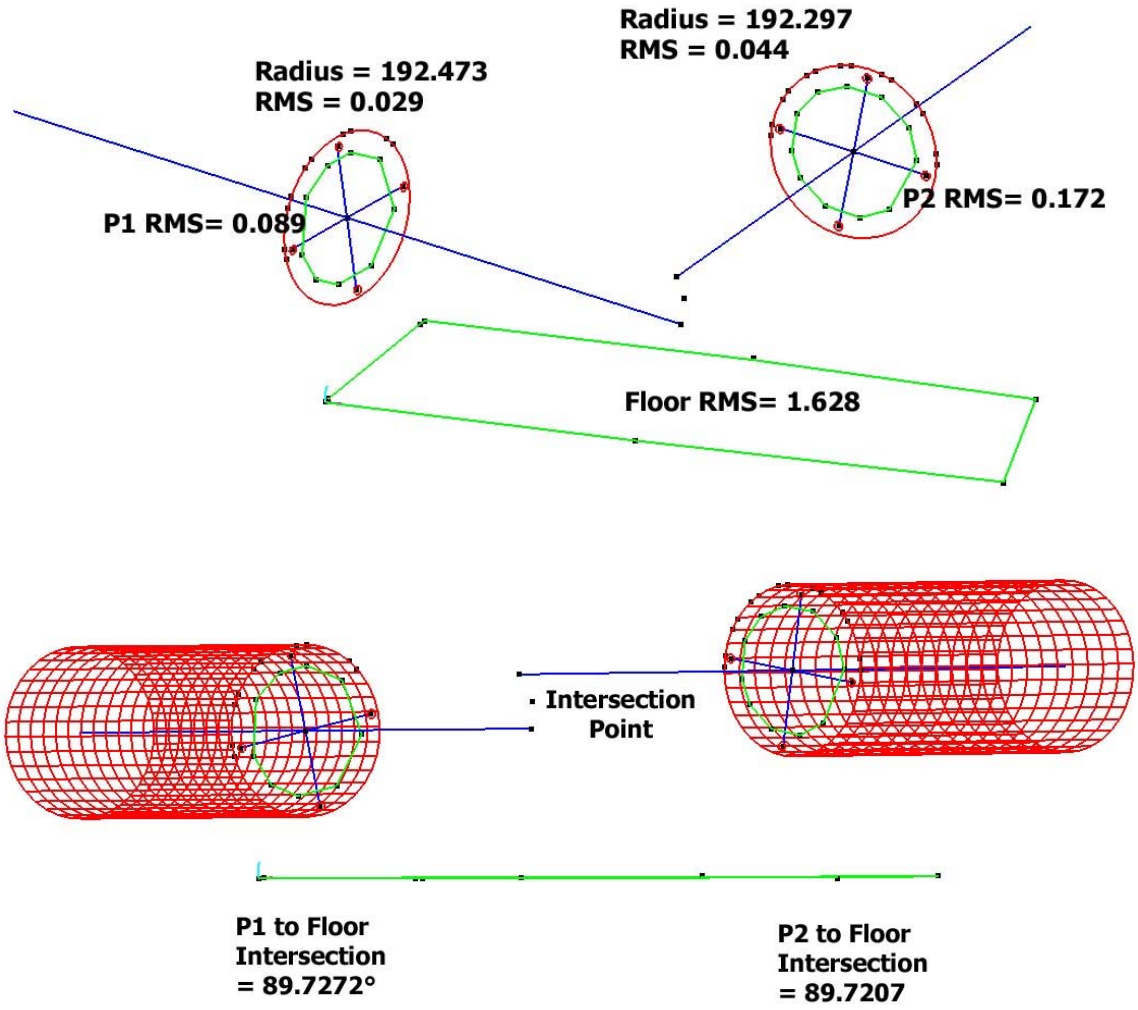
Pipe Measurement Alignment

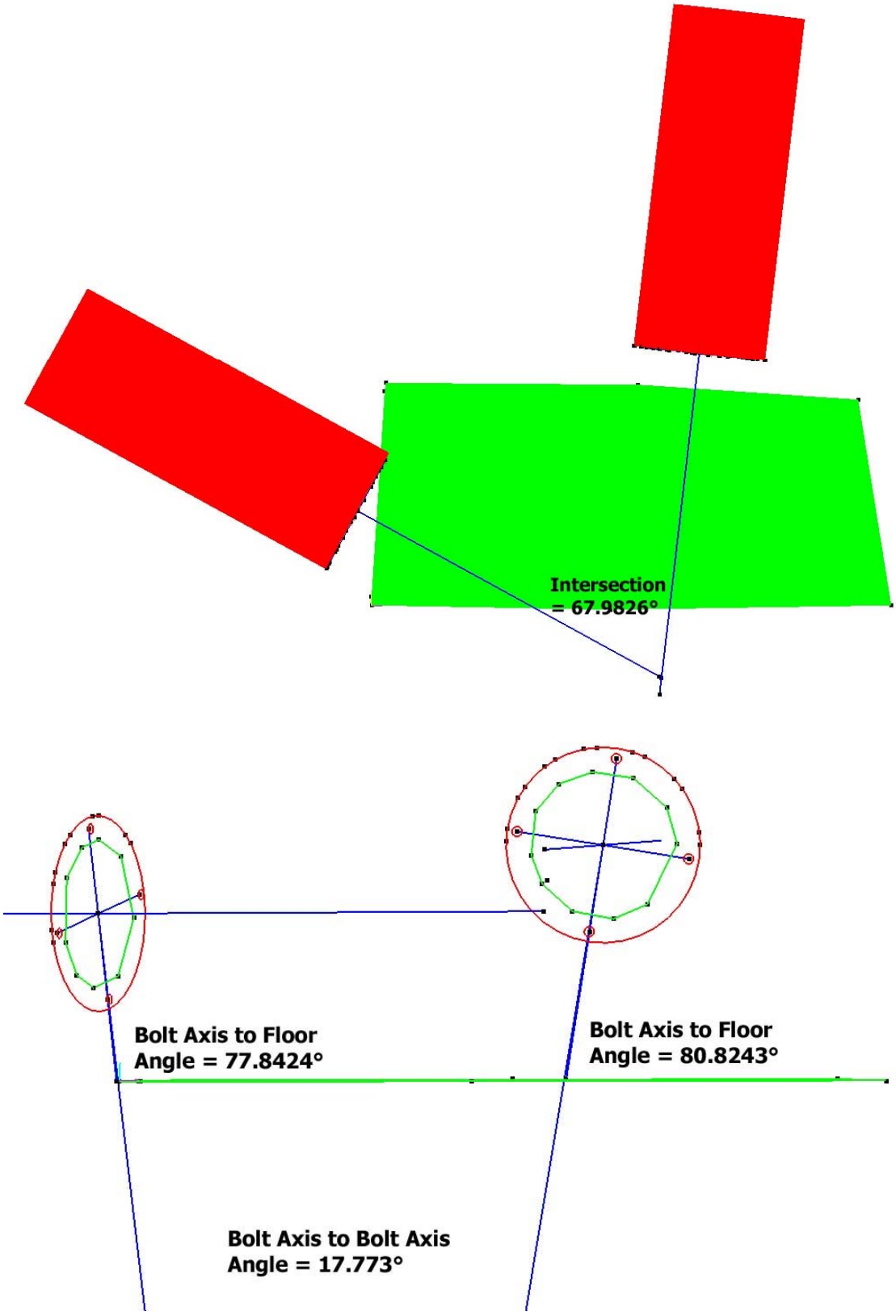
The data was aligned so that the floor plane formed the XY Plane. This was done to simplify the analysis.



Pipe Measurement Analysis

The data was used to create best fit planes, circles, lines, and intersection points. Models showing some of the analysis aspects are shown below.




Intersection
= 67.9826°
Bolt Axis to Floor
Angle = 77.8424°
Bolt Axis to Floor
Angle = 80.8243°
Bolt Axis to Bolt Axis
Angle = 17.773°

Pipe Measurement Time Summary

Initial Investigation	2 minutes
Targeting	10 minutes
Photography	3 minutes
Processing	5 minutes
Data Analysis	10 minutes
Total	**30 minutes**

Concluding Remarks

The measurement undertaken has shown that V-STARS and PRO-SPOT can be a very powerful measurement tool. The results of the measurement undertaken were very accurate and more importantly were produced quickly.

GSI would like to thank DSME for welcoming us into their facility. We will be happy to discuss the results of this report or any other aspect of the technology presented.