Geodetic Systems

V-STARS S8 Demonstration Measurement Report

February 2006

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Object Measured

One measurement was completed as part of the V-STARS demonstration. The measurement involved the determination of some key dimensions of a kort nozzle and base plate. The object is shown on the cover of this report.

Equipment Used

1. V-STARS S8 Camera System
2. Scale Bars
3. Retro-reflective targets
4. Hard body edge targets

Measurement Objectives

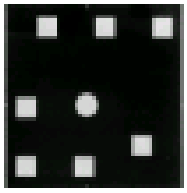
1. Demonstrate camera use and object targeting
2. Measure location of the base plane
3. Measure nozzle circles and end planes
4. Determine base plane width
5. Determine base plane mid-point line
6. Calculate distance between center line and base plane
7. Calculate nozzle length

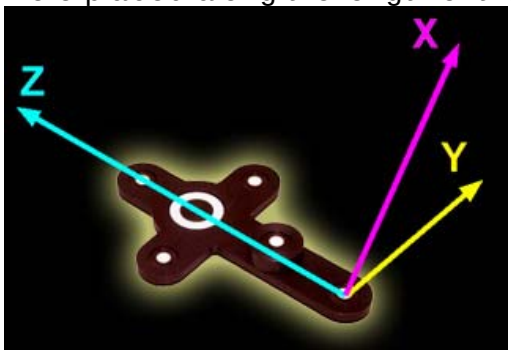
Measurement Targeting

1. AutoBar for initial coordinate system
2. Coded targets to tie photography together
3. Two scale bars
4. Single dot targets on the inside circle of the nozzle
5. Single dot targets on the end planes
6. Hard body targets on bottom plane
7. Hard body targets on inside circle

In order to meet the measurement objectives outlined earlier it was necessary to target the area. In general, targets are placed on points or surfaces that are of interest. For surfaces, strips of retro-reflective tape of variable pitch and dot size are commonly used. They are relatively cheap, disposable and easy to apply. To coordinate tooling datums such as bushed holes or button datums, tooling targets are used. These come in a variety of shank and dot sizes. They are also available in variable orientations. The remaining key planes and lines were measured using single dot targets with a cross hair or single dot targets.

To automate the measurement process it was necessary to add "coded" targets to the block and the area surrounding it. These targets are automatically detected and help the software determine the location and orientation of the camera at the time the photo was taken. They also help tie the entire object into a uniform coordinate system. The codes were placed along the length of the front of the jig.



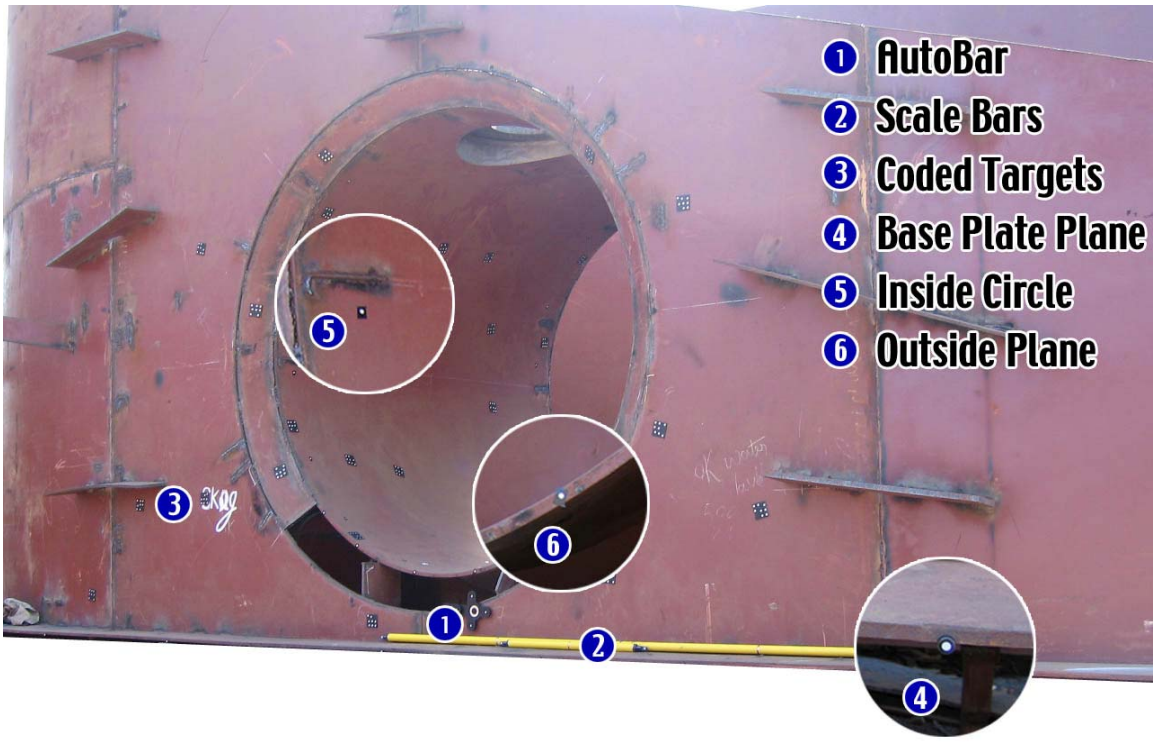


The initial coordinates system and scale is determined via the AutoBar. The AutoBar used by the V-STARS system is a fixture with five targets arranged in the form of a cross. The target's known coordinates are used by the AutoMatch procedure to determine the camera's orientation relative to the AutoBar. The AutoBar is securely attached on or near the measured object, preferably in a highly visible location. The AutoBar's default

coordinate system has its origin at Target 1 at the bottom of the AutoBar. The positive Z-axis goes through Target 3 at the top of the bar. The positive X-axis is up out of the AutoBar. The diagram on the left shows both the AutoBar and its coordinate system

To scale a photogrammetric measurement, there must be at least one known distance. Normally this distance comes from a calibrated coded graphite scale bar or invar scale bar (Refer to adjacent image). Typically multiple scales are used for redundancy. Two scale bars were used to complete this measurement.

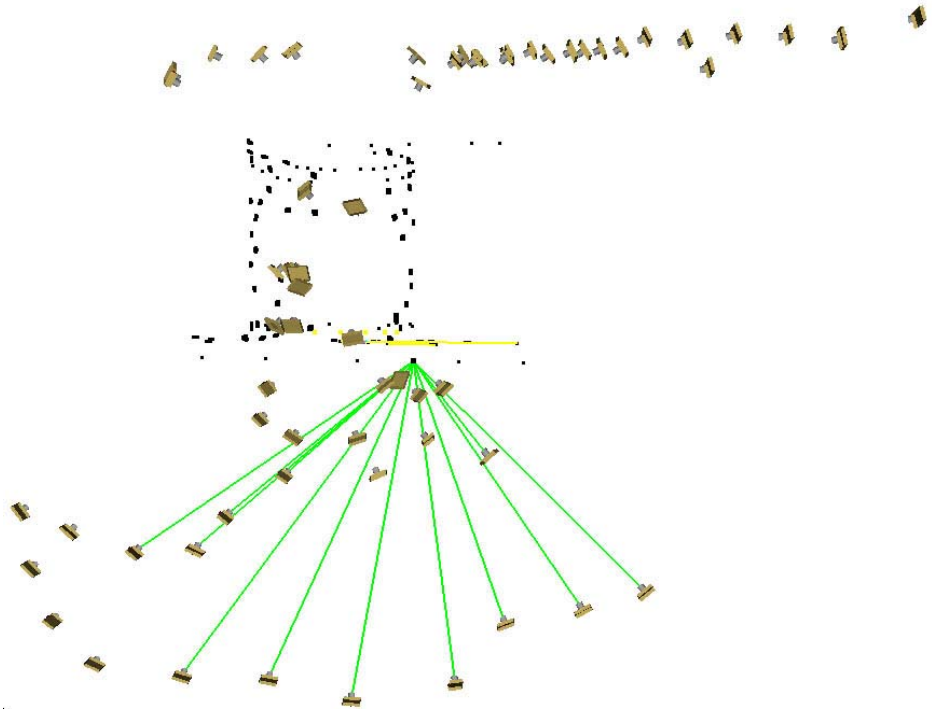
Some of the key targeting elements of the measurement are shown in the image below.



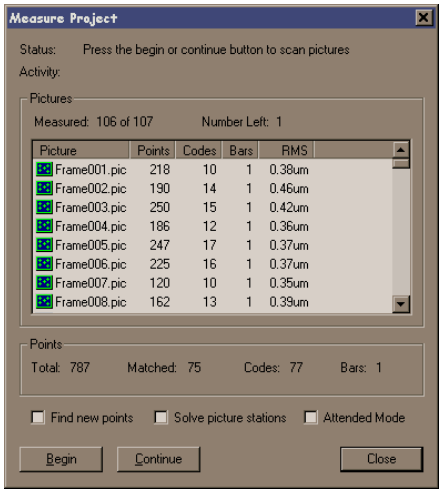
Photography

The photography is carried out once the object targeting is completed. Put simply, the aim of the photography is to record each of the targeted points in as many images as possible from as wide a range of angles as possible. To improve the accuracy of the measurement, generally photos are taken both close to the ground and from an elevated position. The number of photos taken depends on the complexity of the measurement and accuracy requirements.

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



Processing



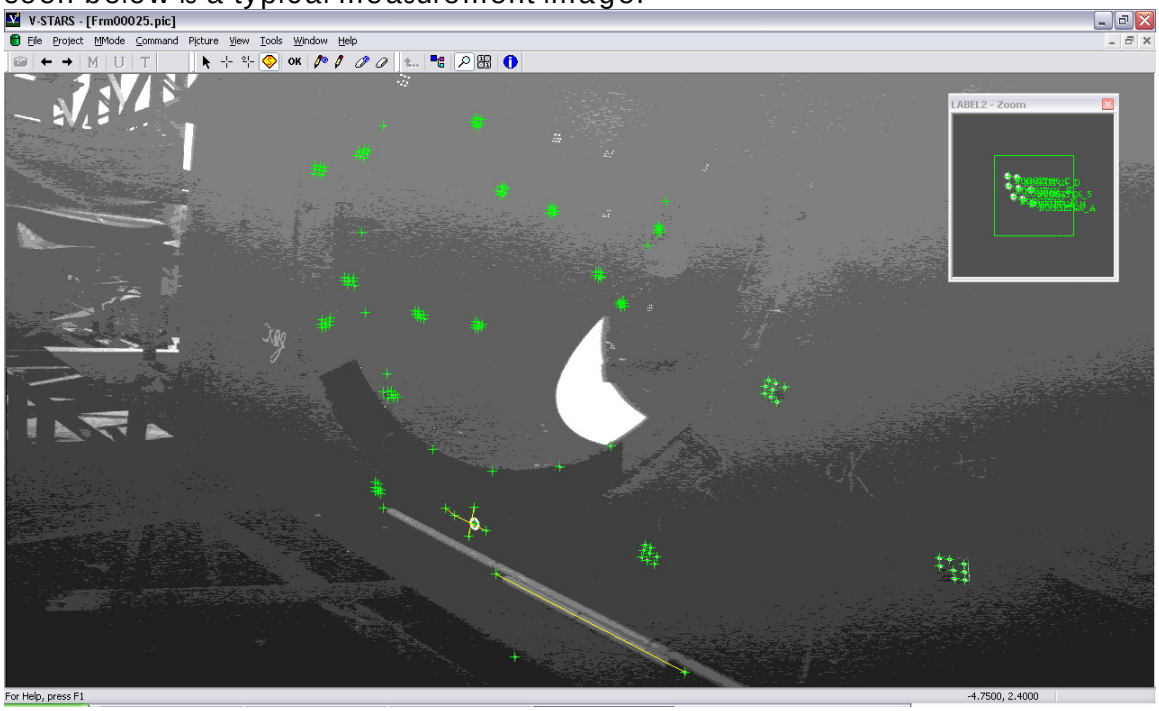
Once the photography has been completed the images are transferred to the system laptop. The images are stored on a PCMCIA hard drive and V-STARS accesses these images directly from the drive.

Almost all of the measurement process is automated. The images are processed and the coordinates extracted by the "AutoMeasure" command. A typical AutoMeasure dialog box is shown on the right. The AutoMeasure command will open each of the images, determine the camera location, find new target points and finally adjust all the measurements in the "Bundle Adjustment".

At the conclusion the user is left with the XYZ coordinates for all the target points in the network. The AutoMeasure procedure is very powerful as it allows the user

to continue working while it processes the data. It also means that relatively unskilled workers can be used to process the data.

The AutoMeasure routine will assign random labels to the points it finds. These labels start with the key word “Target” followed by a number. If specific labeling is required the random labels can be easily changed to labels defined by the user. This is possible in both the picture view and the graphical 3D view. For this particular project it was necessary to re-label the points so that analysis could be simplified.
Seen below is a typical measurement image.



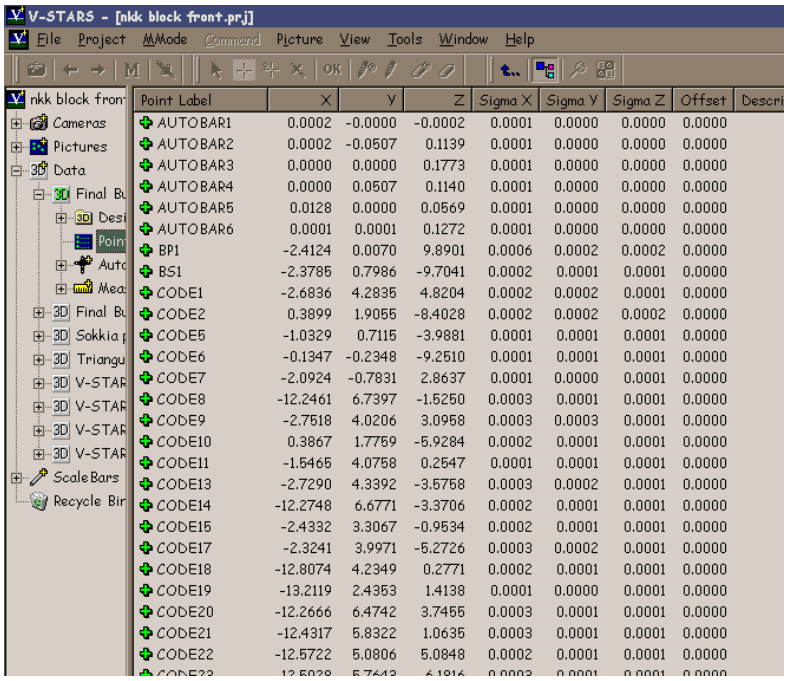
The green crosses represent points that have been located in this particular image. Note that the image appears a little dark and difficult to see. This is intentional as the best photogrammetric measurements are made on images that have dark backgrounds and bright targets. Some of these targets are shown in the zoom window in the corner. If the scale bar is visible then a yellow line will be drawn between the two end points.

Measurement Statistics

Network

No. of photos	63	
No. of points	458	
Accuracy RMS X,Y,Z	X	0.037
	Y	0.028
	Z	0.046
Scale Agreement	0.012mm	

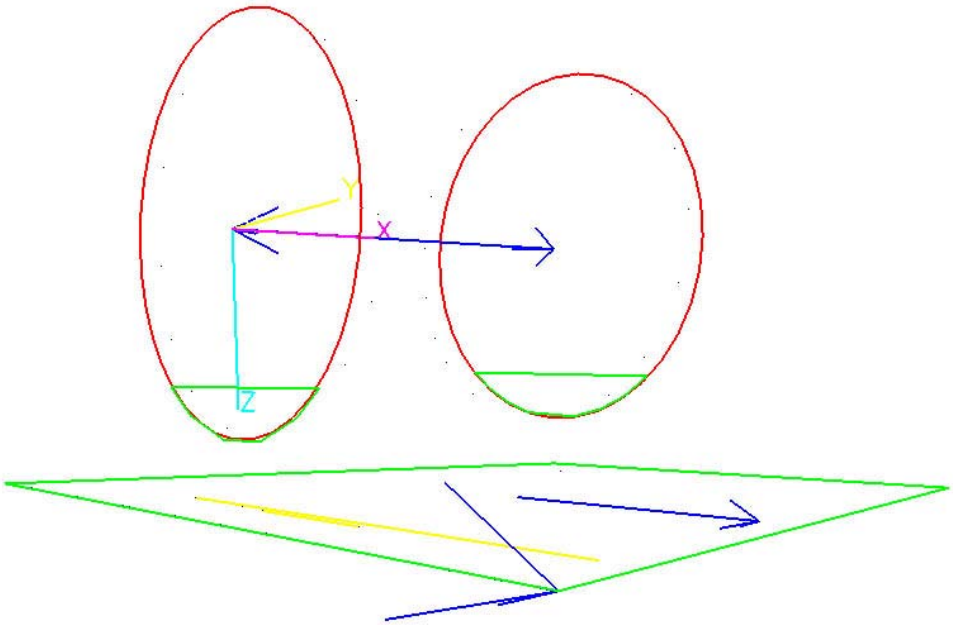
A typical point listing is shown below.



Point Label	X	Y	Z	Sigma X	Sigma Y	Sigma Z	Offset	Descri
AUTOBAR1	0.0002	-0.0000	-0.0002	0.0001	0.0000	0.0000	0.0000	
AUTOBAR2	0.0002	-0.0507	0.1139	0.0001	0.0000	0.0000	0.0000	
AUTOBAR3	0.0000	0.0000	0.1773	0.0001	0.0000	0.0000	0.0000	
AUTOBAR4	0.0000	0.0507	0.1140	0.0001	0.0000	0.0000	0.0000	
AUTOBAR5	0.0128	0.0000	0.0569	0.0001	0.0000	0.0000	0.0000	
AUTOBAR6	0.0001	0.0001	0.1272	0.0001	0.0000	0.0000	0.0000	
BP1	-2.4124	0.0070	9.8901	0.0006	0.0002	0.0002	0.0000	
BS1	-2.3785	0.7986	-9.7041	0.0002	0.0001	0.0001	0.0000	
CODE1	-2.6836	4.2835	4.8204	0.0002	0.0002	0.0001	0.0000	
CODE2	0.3899	1.9055	-8.4028	0.0002	0.0002	0.0002	0.0000	
CODE5	-1.0329	0.7115	-3.9881	0.0001	0.0001	0.0001	0.0000	
CODE6	-0.1347	-0.2348	-9.2510	0.0001	0.0001	0.0001	0.0000	
CODE7	-2.0924	-0.7831	2.8637	0.0001	0.0000	0.0001	0.0000	
CODE8	-12.2461	6.7397	-1.5250	0.0003	0.0001	0.0001	0.0000	
CODE9	-2.7518	4.0206	3.0958	0.0003	0.0003	0.0001	0.0000	
CODE10	0.3867	1.7759	-5.9284	0.0002	0.0001	0.0001	0.0000	
CODE11	-1.5465	4.0758	0.2547	0.0001	0.0001	0.0001	0.0000	
CODE13	-2.7290	4.3392	-3.5758	0.0003	0.0002	0.0001	0.0000	
CODE14	-12.2748	6.6771	-3.3706	0.0002	0.0001	0.0001	0.0000	
CODE15	-2.4332	3.3067	-0.9534	0.0002	0.0001	0.0001	0.0000	
CODE17	-2.3241	3.9971	-5.2726	0.0003	0.0002	0.0001	0.0000	
CODE18	-12.8074	4.2349	0.2771	0.0002	0.0001	0.0001	0.0000	
CODE19	-13.2119	2.4353	1.4138	0.0001	0.0000	0.0001	0.0000	
CODE20	-12.2666	6.4742	3.7455	0.0003	0.0001	0.0001	0.0000	
CODE21	-12.4317	5.8322	1.0635	0.0003	0.0001	0.0001	0.0000	
CODE22	-12.5722	5.0806	5.0848	0.0002	0.0001	0.0001	0.0000	

Measurement Alignment

No alignment was necessary to complete the analysis. However in order to simplify the interpretation of the results a simple alignment was carried out. The origin of the axis was placed at one of the end center points of the nozzle. The bottom plane was used as the clocking point. The alignment is shown in the image below.

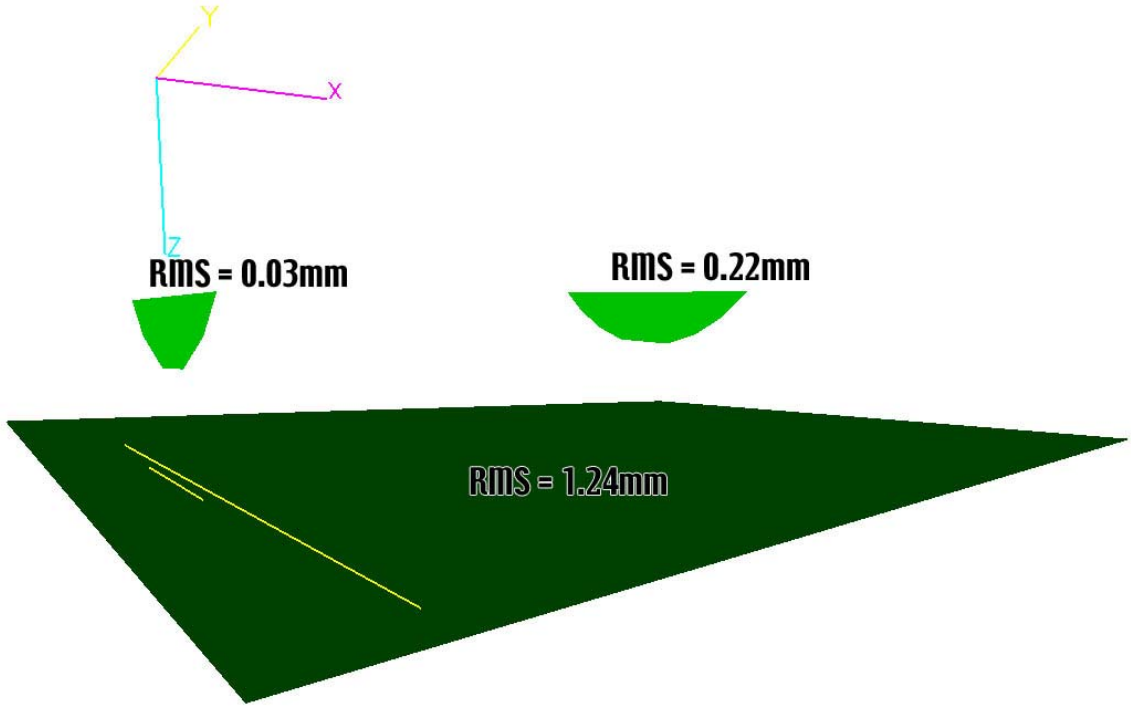


Measurement Analysis

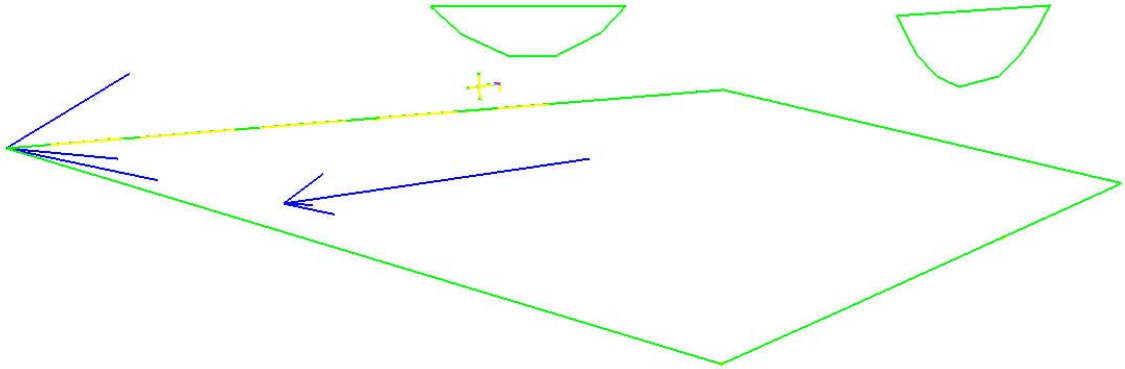
The results of the analysis are shown below.

Planes

The points located on the base of the piece were used to create the best-fit plane. The points on the ends of the nozzle were also used to create the two end planes. The results of the plane fits are shown below.



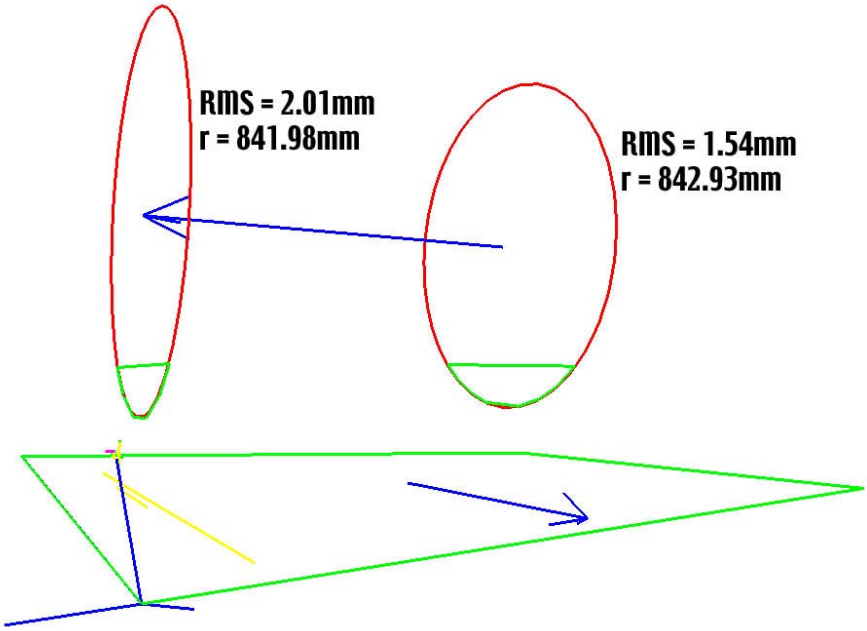
The points on the edge of the base plane were used to generate the plate mid-point line. This is shown below.



Based on these calculations, the plate width was determined to be **2505.76mm**

Circles

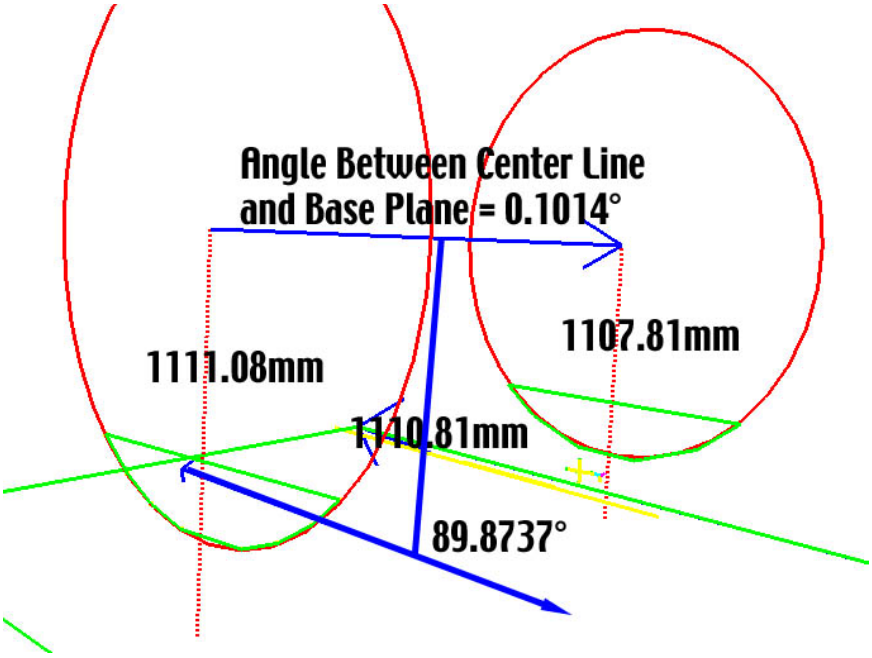
Circles were generated through the two end plane circles of the nozzle. The results of this are shown below.



Based on the center points the cylinder distance was determined to be **1851.14mm**.

Analysis

The data collected was used to create the necessary measurements. The results are shown below.



Measurement Time Summary

Measurement	
Initial Investigation	1 minutes
Targeting	10 minutes
Photography	6 minutes
Processing	13 minute
Total	**30 minutes**

Concluding Remarks

The measurement undertaken has shown that the V-STARS S8 system can be a very powerful measurement tool. The results of the measurement undertaken were very accurate and produced quickly.