Report of Ship Block Test Measurements

Introduction:

The following is a summary of the videogrammetry work carried out at the XXX Shipyard facility in XXXXX on behalf of the XXXXXX. One object was measured as part of an evaluation study involving a number of different 3D measurement system manufacturers. The object in question is a large ship block (SR237) with approximate dimensions of (6.2 x 6.8 x 2.9m).



#All the dimensions shown are in mm.

#There is a 25mm offset between the edge of the block and the edge scribe lines.

Using the dimensional information supplied in the plans a "theoretical" file was created. This file contains the XYZ coordinates for each of the 36 points.

Primary Requirement:

• To determine the XYZ location of 36 points at nominated locations on block SR237. These locations are signalised by the intersection of scribe lines. The numbering diagrams are shown below.



Additional Information:

To take advantage of the fact that videogrammetry can measure additional data with very little additional effort the following information was also collected: -

- Six corner points on transverse beams. (Refer to diagram below)
- Plane information on key surfaces. (Refer to diagram below)
- Distances between lower transverse beams
- Plane fit between ends of transverse beams.
- Lengths of transverse beams.



Documentation:

The following documentation is included in this report.

- A report outlining methodology and results.
- The XYZ coordinates of the 36 determined points.
- The XYZ coordinates of the 6 corners on the transverse beams
- Results of the least squares fit between V-STARS data, Sokkia data and nominal information from supplied plans of the ship block.
- Analysis of plane information gathered.
- Dimensional information on the transverse beams.
- Background information on the V-STARS system

Itinerary:

The itinerary undertaken was as follows: -

Sunday 13 th	September
12:20pm	Introduction to measurement.
12:45pm	Overview of V-Stars System
1:00pm	Measurement of ship block (Targeting, photography and processing)
2:00pm	Point re-labeling, target removal and initial discussion
3:00pm	Measurement discussion
3:45pm	Close of discussion.

Measurement Procedure:

Targeting.

The key objective of this test measurement was to determine the coordinates of 36 scribe intersection points on the block. To complete this objective it was necessary to place offset targets on the points of interest. The targets used had an offset of 15.5mm.

In order to collect the additional information outlined earlier in the *Additional Information* section it was also necessary to target these points. Both offset targets and normal stick on dots were used to target these points.

To automate the process it was necessary to add "coded" targets to the block. 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 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 target1 at the bottom of the AutoBar. The positive Y axis goes through point 3 at the top of the bar. The positive Z axis is up out of the AutoBar. Photogrammetric measurements are initially dimensionless. An example of this is shown below. The picture of the first car could be a picture of a full-size car or of a match box model; there is no way to tell. However, if we know the size of something that is also in the picture, we can now say something about the size of the car.



To scale a photogrammetric measurement, there must be at least one known distance. Four scale distances were used in the block measurement.

Photography

Once the object targeting was completed the object was photographed. 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 survey photos were taken both close to the ground and from a stepladder. The photography was completed in approximately 15 minutes. The camera station locations are shown in the diagram below. Also shown are some sample intersection angles to points of interest.



Approximately 80 photographs were taken. With planning this number can be reduced to approximately 40-60 depending on the measurement requirements.

Processing

Once the photography was completed the images were 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. The AutoMeasure dialog box is shown on the The AutoMeasure command will right. 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.

Ме	asure Project						×		
S	Status: Press the begin or continue button to scan pictures								
Α	Activity:								
Г	Pictures								
	Measured: 81 of	81	Nur	nber Le	ft: O				
	Picture	Points	Codes	Bars	RMS		-		
	Frame001.pic	66	17	1	0.22um		_		
	Frame002.pic	55	13	1	0.26um				
	Frame003.pic	56	11	1	0.29um				
	Frame004.pic	51	10	1	0.25um				
	Frame005.pic	60	14	1	0.24um				
	Frame006.pic	55	12	1	0.21um				
	Frame007.pic	45	10	1	0.25um				
	Frame008.pic	56	14	1	0.23um		-		
Γ	Points								
	Total: 235	Matched	: 0	Co	des: 81	Bars:	1		
	Find new points Solve picture stations Attended Mode								
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Seen below is an image taken as part of the ship block measurement.



The green text represents points that have been located in this particular image. Note that the image appears very dark and difficult to see. This is intentional as the best photogrammetric measurements are made on images that have dark backgrounds and bright targets. One of these targets is shown in the zoom window in the top left-hand corner.

Y V-STARS - [ship demo.prj]									_ 0	×
V File Project MMode Comman	d Pjoture <u>V</u> iew	<u>T</u> ools <u>V</u>	√indow <u>H</u> e	lp					_ [편]	×
¥ ship demo	Point Label	Х	Y	Z	SigmaX	SigmaY	Sigma Z	Offset	t Description	-
🕀 🚰 Cameras	AUTOBAR2	3524.682	6195.547	1428.861	0.030	0.049	0.023	0.000)	
Pictures	💠 AUTOBAR3	3589.883	6197.177	1477.552	0.030	0.049	0.023	0.000)	
- 30 Data	AUTOBAR4	3528.047	6196.112	1530.330	0.030	0.047	0.023	0.000)	
30 40 points	AUTOBAR5	3469.115	6207.352	1481.443	0.029	0.046	0.022	0.000)	
+	AUTOBAR6	3539.062	6196.136	1479.362	0.031	0.062	0.026	0.000)	
Applyoin planes	💠 CODE1	2609.603	6293.420	1247.436	0.038	0.057	0.026	0.000)	
Points	💠 CODE2	6100.599	356.049	-31.603	0.055	0.050	0.039	0.000)	
Planes	💠 CODE3	6062.734	3011.476	-33.794	0.064	0.038	0.033	0.000)	
H Measurements	💠 CODE4	6047.898	3595.059	2347.634	0.067	0.039	0.030	0.000)	
+ 3D Analysis - Transverse	💠 CODE5	2103.673	6642.001	-9.284	0.036	0.055	0.028	0.000)	
	💠 CODE6	5498.733	24.825	-22.585	0.038	0.048	0.032	0.000)	
	💠 CODE7	21.836	3270.797	1548.500	0.064	0.036	0.025	0.000)	
	CODE8	-40.381	6226.860	1884.840	0.043	0.054	0.030	0.000)	
	💠 CODE9	3728.802	21.869	6.347	0.037	0.052	0.028	0.000)	
😑 😼 Final Bundle	CODE10	6117.231	6116.006	1810.926	0.084	0.058	0.037	0.000)	
Points	💠 CODE11	6047.307	5249.134	2335.661	0.071	0.040	0.032	0.000)	
🕀 🕂 AutoBars	CODE12	2826.833	1049.729	1363.890	0.046	0.070	0.028	0.000)	
	💠 CODE13	30.721	693.396	2357.973	0.056	0.037	0.030	0.000)	
mail Measurements	💠 CODE14	6072.327	5756.822	-48.387	0.048	0.043	0.032	0.000)	
- 30 SR237BLULK - sokkia	CODE15	-48.876	6112.853	1861.597	0.076	0.051	0.034	0.000)	
	💠 CODE16	1488.718	13.401	16.069	0.035	0.048	0.027	0.000)	
	CODE17	3934.685	1043.411	1447.088	0.065	0.086	0.031	0.000)	
Triangulation 20	💠 CODE18	4793.210	1162.673	2001.171	0.036	0.068	0.030	0.000)	
+- / ScaleBars	💠 CODE19	1291.419	6186.719	2495.097	0.037	0.108	0.038	0.000)	
Recycle Bin	💠 CODE20	4304.167	6286.084	1479.330	0.034	0.057	0.025	0.000)	
	CODE21	-54.004	360.405	38.184	0.047	0.046	0.033	0.000)	
	CODE22	3.105	5431.769	173.950	0.070	0.040	0.034	0.000)	
	CODE23	6127.105	6794.600	744.657	0.040	0.047	0.031	0.000)	
	CODE24	4732.773	6185.035	2199.586	0.034	0.070	0.031	0.000)	
	CODE25	6036.162	2662.363	1259.006	0.056	0.036	0.025	0.000)	
	CODE26	1373.121	1160.180	1896.731	0.033	0.059	0.027	0.000)	
	CODE27	6100.417	6233.463	1796.199	0.050	0.049	0.031	0.000)	
	CODE28	-26.347	2960.016	18.692	0.063	0.035	0.031	0.000)	
	CODE29	223.797	6651.677	-4.171	0.040	0.070	0.035	0.000)	
	🗢 CODE30	6105.332	1111.604	1811.811	0.060	0.057	0.028	0.000)	
	CODE31	4846.966	6735.351	-43.906	0.036	0.056	0.031	0.000)	
	CODE 32	27.607	4972.430	2390.286	0.061	0.038	0.028	0.000)	-
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Ready										

Finally, the points can be listed. A typical point listing is shown below.

Primary Results:

The following is a summary of the measurement statistics from the measurements.

81		
235		
4		
0.06		
	Х	0.04
	Y	0.05
	Ζ	0.03
	81 235 4 0.06	81 235 4 0.06 X Y Z

A full listing of V-STARS coordinates can be found in Appendix 1

A full listing of Design coordinates can also be found in Appendix 1

Based on the coordinates determined by V-STARS and the Sokkia system the distances between points were computed. These distances were compared to the design distances. The differences between the three data sets were also computed. The blue lines shown below indicate computed distances.



		I	Distances(m	m)	Difference				
Start	End	Design	V-STARS	Sokkia	Design	Design	V-STARS -		
Point	Point				- V-STARS	- Sokkia	Sokkia		
20	23	75.0	70.4	72.4	4.6	2.6	-2.0		
11	12	75.0	72.2	72.7	2.8	2.3	-0.4		
16	21	75.0	72.5	74.4	2.5	0.6	-1.9		
2	7	75.0	73.5	73.5	1.5	1.5	0.1		
3	8	125.0	123.6	125.7	1.4	-0.7	-2.1		
22	27	125.0	124.4	123.6	0.6	1.4	0.8		
1	4	125.0	124.5	125.2	0.5	-0.2	-0.7		
31	32	125.0	125.3	124.1	-0.3	0.9	1.2		
20	19	575.0	571.0	570.4	4.0	4.6	0.6		
16	15	575.0	573.2	573.9	1.8	1.1	-0.7		
27	33	575.0	574.6	573.3	0.4	1.7	1.3		
32	37	575.0	575.1	575.2	-0.1	-0.2	-0.1		
13	7	1175.0	1172.5	1172.1	2.5	2.9	0.4		
35	4	1175.0	1172.8	1174.3	2.2	0.7	-1.5		
39	8	1175.0	1173.6	1175.1	1.4	-0.1	-1.5		
17	12	1175.0	1200.8	NA	-25.8	NA	NA		
11	10	1720.0	1719.5	1720.9	0.5	-0.9	-1.4		
2	б	1720.0	1720.0	1721.3	0.0	-1.3	-1.3		
22	26	1720.0	1720.8	1721.8	-0.8	-1.8	-0.9		
21	25	1720.0	1720.9	1719.6	-0.9	0.4	1.3		
30	31	1720.0	1721.2	1720.8	-1.2	-0.8	0.4		
23	29	1720.0	1721.2	1721.3	-1.2	-1.3	-0.1		
5	1	1720.0	1721.3	1721.4	-1.3	-1.4	-0.1		
9	3	1720.0	1722.1	1720.0	-2.1	0.0	2.1		
18	17	2000.0	1973.3	NA	26.7	NA	NA		
38	39	2000.0	1999.8	1999.8	0.2	0.2	0.1		
34	35	2000.0	2000.6	1999.7	-0.6	0.3	0.9		
14	13	2000.0	2001.0	2000.4	-1.0	-0.4	0.5		
30	29	2580.0	2580.6	2580.6	-0.6	-0.6	0.0		
25	26	2580.0	2581.7	2582.4	-1.7	-2.4	-0.7		
9	10	2580.0	2581.8	2581.5	-1.8	-1.5	0.2		
5	6	2580.0	2582.5	2581.7	-2.5	-1.7	0.8		
35	39	2900.0	2892.7	2892.8	7.3	7.2	-0.1		
27	32	2900.0	2894.2	2893.9	5.8	6.1	0.2		
33	37	2900.0	2894.2	2893.6	5.8	6.4	0.7		
4	8	2900.0	2894.7	2894.3	5.3	5.7	0.4		
34	38	2900.0	2895.0	2895.3	5.0	4.7	-0.3		
15	19	2900.0	2895.0	2894.9	5.0	5.1	0.2		
13	17	2900.0	2895.7	NA	4.3	NA	NA		
14	18	2900.0	2896.2	2895.9	3.8	4.1	0.3		
16	20	2900.0	2897.5	2897.8	2.5	2.2	-0.3		
7	12	2900.0	2898.1	2897.7	1.9	2.3	0.4		
22	31	2900.0	2898.3	2897.2	1.7	2.8	1.1		
1	3	2900.0	2898.5	2898.3	1.5	1.7	0.2		
21	23	2900.0	2898.7	2899.2	1.3	0.8	-0.4		

The distance results are shown in the table below.

	Distances(mm)					Difference	
Start	End	Design	V-STARS	Sokkia	Design	Design	V-STARS
Point	Point				- V-STARS	- Sokkia	- Sokkia
2	11	2900.0	2899.5	2898.9	0.5	1.1	0.7
26	30	2900.0	2904.3	2904.6	-4.3	-4.6	-0.2
25	29	2900.0	2905.4	2905.8	-5.4	-5.8	-0.4
6	10	2900.0	2905.5	2905.8	-5.5	-5.8	-0.3
5	9	2900.0	2905.8	2906.1	-5.8	-6.1	-0.4
33	34	3000.0	2999.5	3001.6	0.5	-1.6	-2.1
15	14	3000.0	2999.6	3000.2	0.4	-0.2	-0.7
37	38	3000.0	3001.3	3001.7	-1.3	-1.7	-0.4
19	18	3000.0	3001.7	3001.7	-1.7	-1.7	0.0
37	19	6220.0	6217.6	6218.7	2.4	1.3	-1.1
20	32	6220.0	6218.6	6219.1	1.4	0.9	-0.4
8	12	6220.0	6219.2	6219.8	0.8	0.2	-0.7
39	17	6220.0	6219.3	NA	0.7	NA	NA
38	18	6220.0	6219.6	6220.7	0.4	-0.7	-1.1
27	16	6220.0	6220.3	6221.8	-0.3	-1.8	-1.4
33	15	6220.0	6220.3	6213.3	-0.3	6.7	7.0
13	35	6220.0	6221.8	6222.1	-1.8	-2.1	-0.3
7	4	6220.0	6221.8	6222.6	-1.8	-2.6	-0.8
34	14	6220.0	6222.5	6222.7	-2.5	-2.7	-0.2
29	10	6750.0	6746.0	6746.5	4.0	3.5	-0.4
16	7	6750.0	6746.2	6746.6	3.8	3.4	-0.4
30	9	6750.0	6746.6	6748.6	3.4	1.4	-2.0
12	20	6750.0	6746.8	6746.5	3.2	3.5	0.4
25	б	6750.0	6747.0	6748.7	3.0	1.3	-1.7
26	5	6750.0	6747.1	6748.4	2.9	1.6	-1.3
4	27	6750.0	6747.5	6748.9	2.5	1.1	-1.4
32	8	6750.0	6749.8	6751.7	0.2	-1.7	-1.9
				Average	2.2	2.2	0.9
				Std Dev	1.8	1.9	1.0

Notes:

The distance between 17-12 and 18-17 shows a discrepancy of 25mm. This indicates that the target was placed incorrectly or that the point 17 is incorrectly marked.

There is a high level of agreement between the V-STARS data and the Sokkia data. The average of the differences was 0.9mm. The other statistical information indicates that the V-STARS and Sokkia data agree to about the same degree with the Design data.

It is also possible to fit the Design data and Sokkia data to the V-STARS data using a Least Squares transformation. The results of this transformation are shown below.

Fit of V-STARS data to Design Coordinates								
(mm)	х	Z	Total					
RMS	1.6	1.2	2.6	3.0				

The full results of the transformation can be found in Appendix 2 The results are represented graphically below.



Fit of V-STARS data to Sokkia Coordinates

(mm)	х	Y	Z	Total
RMS	1.0	0.9	0.4	1.4

The full results of the transformation can be found in Appendix 2 The results are represented graphically below.



Once again the data indicates that the V-STARS and Sokkia data fit very well considering that the data was collected at different times, using different targets and in different temperatures.

Additional Results:

The following is a result summary for the additional measurement information collected.

Plane Data

A total of six planes were fit to the collected data. These are shown in the diagram at the start of this report. The six planes were named face1, face2, face3, face4, bottom face and top face respectively. The results of the plane fits are shown below.

Face	Final RMS(mm)
Bottom Face	1.8
Face 1	1.1
Face 2	1.3
Face 3	0.8
Face 4	1.8
Top Face	2.5

Using these planes it is possible to compute the perpendicularity and parallelism of the planes. These results are shown below.

Face	Angle°
Face 1 to Face 2	89.96
Face 2 to Face 3	89.99
Face 3 to Face 4	89.96
Face 1 to Face 4	89.99
Face 1 to Face 3	0.13
Face 2 to Face 4	0.07
Bottom to Top	0.02
Bottom to Face 1	89.97
Bottom to Face 2	89.99
Bottom to Face 3	89.85
Bottom to Face 4	89.97
Face 4 to Top	89.95
Face 3 to Top	89.85
Face 2 to Top	89.99
Face 1 to Top	89.98

Transverse Data

Various information was also collected on the transverse beams.

A diagram of the beams is shown below.



Distances were measured at a point near the top of the beam and at a point near the bottom of the beam. The diagram below shows these distances for both sides of the block.





The length of the beams was also computed. These are tabulated below: -

Beam	Length(mm)
1	6800.5
2	6800.6
3	6801.6
4	6802.2
5	6801.5
б	6801.4

Concluding Remarks

This ship block demonstration has clearly shown that videogrammetry is a very powerful measurement tool in the ship building industry. The results of the measurement are very accurate and more importantly were produced quickly. The time taken to complete the measurement can be significantly improved via the used of the correct targets and through adequate planning.

GSI and Leica would like to thank the XXX for welcoming us into their facility and the XXXX for the opportunity to present our system to them. We will be happy to discuss the results of this report or any other aspect of the technology presented.

Appendix 1 - Coordinate Data

V-STARS Coordinates (mm)

	(Coordinate	1	Accuracy Estimate			
Point	х	Y	Z	SX	SY	SZ	
1	4.1	2.9	-9.0	0.04	0.05	0.03	
2	6027.6	4.0	-67.0	0.04	0.05	0.03	
3	32.2	13.7	2889.3	0.04	0.06	0.04	
4	-120.4	3.0	-5.9	0.04	0.04	0.03	
5	1725.3	2.3	-27.3	0.03	0.05	0.03	
6	4307.7	2.9	-51.6	0.03	0.05	0.03	
7	6101.1	3.6	-67.4	0.04	0.05	0.04	
8	-91.5	13.3	2888.6	0.05	0.05	0.04	
9	1754.2	13.9	2878.2	0.03	0.05	0.03	
10	4335.8	15.2	2853.8	0.04	0.06	0.03	
11	6055.2	14.0	2832.4	0.04	0.06	0.04	
12	6127.4	15.1	2830.6	0.06	0.07	0.04	
13	6101.7	1176.0	-71.2	0.05	0.04	0.03	
14	6100.6	3177.0	-79.1	0.06	0.04	0.03	
15	6097.4	6176.5	-89.7	0.05	0.04	0.04	
16	6097.9	6749.7	-92.4	0.05	0.05	0.04	
17	6126.6	1215.9	2824.1	0.06	0.04	0.03	
18	6126.6	3189.1	2817.0	0.06	0.04	0.03	
19	6125.2	6190.8	2805.2	0.05	0.05	0.03	
20	6125.0	6761.9	2804.9	0.05	0.05	0.04	
21	6025.4	6750.1	-92.7	0.04	0.05	0.04	
22	2.2	6750.1	-34.0	0.04	0.05	0.03	
23	6054.6	6760.7	2805.9	0.05	0.05	0.04	
25	4304.5	6749.8	-80.1	0.03	0.05	0.03	
26	1722.9	6749.3	-54.6	0.03	0.05	0.03	
27	-122.1	6750.5	-30.8	0.04	0.05	0.04	
29	4333.5	6761.2	2825.1	0.03	0.05	0.03	
30	1753.0	6760.4	2849.5	0.03	0.05	0.03	
31	31.8	6760.5	2864.1	0.04	0.05	0.04	
32	-93.4	6763.1	2863.2	0.04	0.05	0.04	
33	-122.6	6175.9	-29.2	0.05	0.05	0.03	
34	-121.6	3176.4	-18.0	0.06	0.04	0.03	
35	-119.8	1175.8	-9.5	0.05	0.04	0.03	
37	-92.1	6188.0	2864.9	0.04	0.05	0.04	
38	-92.7	3186.7	2876.9	0.06	0.04	0.03	
39	-92.4	1186.9	2883.0	0.05	0.04	0.03	
C1	4391.3	6777.0	499.3	0.04	0.05	0.03	
C2	4238.7	6776.5	503.2	0.04	0.05	0.03	
C3	2668.1	6775.1	517.1	0.04	0.05	0.03	
C4	2519.4	6774.2	520.1	0.04	0.05	0.02	
C5	952.7	6772.3	533.4	0.03	0.05	0.03	
C6	804.9	6771.9	536.2	0.04	0.05	0.03	
Average				0.04	0.05	0.03	

Max				0.06	0.07	0.04
Design Coordinates (mm) (Derived from plans)						

	Coordinate					
Point	х	Y	Z			
1	0	0	0			
2	6020	0	0			
3	0	0	2900			
4	-125	0	0			
5	1720	0	0			
б	4300	0	0			
7	6095	0	0			
8	-125	0	2900			
9	1720	0	2900			
10	4300	0	2900			
11	6020	0	2900			
12	6095	0	2900			
13	6095	1175	0			
14	6095	3175	0			
15	6095	6175	0			
16	6095	6750	0			
17	6095	1175	2900			
18	6095	3175	2900			
19	6095	6175	2900			
20	6095	6750	2900			
21	6095	6750	0			
22	0	6750	0			
23	6095	6750	2900			
25	4300	6750	0			
26	1720	6750	0			
27	-125	6750	0			
29	4300	6750	2900			
30	1720	6750	2900			
31	0	6750	2900			
32	-125	6750	2900			
33	-125	6175	0			
34	-125	3175	0			
35	-125	1175	0			
37	-125	6175	2900			
38	-125	3175	2900			
39	-125	1175	2900			

Appendix 2 – Transformation Results

Point	x	Y	Z	Total
1	-2.0	1.5	-0.3	2.5
2	2.6	1.3	-0.1	2.9
3	-1.9	0.9	-1.4	2.5
4	-1.5	1.6	1.7	2.8
5	-0.5	0.5	-2.0	2.1
6	2.4	0.6	-1.3	2.8
7	1.2	0.9	0.2	1.5
8	-0.5	0.6	-3.2	3.3
9	0.4	0.7	4.2	4.3
10	2.5	1.5	4.6	5.5
11	2.3	-0.1	-0.2	2.3
12	-0.5	1.0	-1.3	1.7
13	2.0	-1.5	1.0	2.7
14	1.4	-0.2	0.9	1.7
15	-1.0	-0.3	2.1	2.3
16	-0.4	-2.0	1.6	2.6
17	-1.0	27.0	-3.1	27.2
18	-0.5	0.6	-2.5	2.6
19	-1.1	2.7	-2.5	3.9
20	-1.3	-1.2	-0.5	1.8
21	2.1	-1.6	0.6	2.7
22	-2.2	-0.3	1.2	2.5
23	3.3	-2.3	-0.2	4.1
25	0.9	-1.5	-3.4	3.8
26	-1.1	-1.4	-2.8	3.3
27	-1.6	0.1	3.3	3.7
29	1.9	-1.5	2.4	3.4
30	0.9	-1.7	2.0	2.8
31	-0.5	-1.3	0.0	1.4
32	-0.8	1.3	-2.1	2.6
33	-2.2	0.4	2.6	3.5
34	-2.0	0.5	2.1	2.9
35	-0.6	-0.4	2.7	2.8
37	0.4	1.2	-2.7	3.0
38	-1.0	-0.5	-2.5	2.7
39	-1.1	-0.6	-4.2	4.4

V-STARS Coordinates v Design Data (mm) coordinate residuals

Data once again indicates that point 17 is in an incorrect position