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Accuracy Assessment for A Stereo Pair of CARTOSATI Images by Used of GCP Points

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Abstract: *Due to increasing number of High Resolution Satellites, the production of ortho image and 3D maps from these images are becoming increasingly important. In order to do so acquiring Ground Control Points (GCP) is necessary. Higher quality aerial or satellite imagery will not replace the need for GCP. In fact, ground control point collection becomes increasingly more important as image quality improves. Fortunately, collecting ground control point is now a much faster, more accurate, and cost-effective process thanks to the use of GPS but the proper number of control points still is an issue. In this article, the P5 imagery from IRS series has been especially used because of 2.5-meter resolution and their affordable price. In order to orient satellite imagery with respect to the earth, ground control points (GCP) are designed and created in the region of interest. Having a stereo pair of images with near to full coverage; triangulation has been used for point distribution and block adjustment. The main calculations were performed by local triangulation software and we used a progressive control point number approach. Starting with a single control point, the amounts of vertical and horizontal accuracies are calculated and tabulated.*

Keywords: Ortho Image, 3D Maps, Stereo Images

INTRODUCTION

In recent decades, Remote sensing data becomes one of the basic information required for mapping and different applications in geomatics. The use of High resolution satellite images (HRSI) at 5 meters and better geometrical resolution has become a source of ongoing discussions since a number of years. In this article we mainly discuss about the HRSI satellite IRS-P5 (cartosat-1), it's capabilities and parameters (Fraser, 1999).

Cartosat-1 satellite was built by the Indian Space Research Organization (ISRO) mainly for mapping. The satellite was launched into circular (altitude is 618 km) near-polar sun-synchronous orbit on May 5, 2005. Cartosat-1 is equipped with two panchromatic cameras capable of simultaneous acquiring images of 2.5 meters spatial resolution (Edward et al., 2001). One camera is looking at +26 degrees forward while another looks at –5 degrees backward to acquire stereoscopic imagery with base to height ratio of 0.62. The time difference between acquiring of the stereo pair images is approximately 52 seconds. The imagery is supplied with Rational Polynomial Coefficients (RPC) and intended for image processing. The Other basic parameters of Cartosat-1 satellite are presented in the following table (Lutes, 2006).

Table 1: The other basic parameters of Cartosat-1 satellite

Key Parameters of the IRS-P5 Sensors	PAN Fore Camera	PAN After Camera
Swath-width	30 km	27 km
Radiometric Resolution, Quantisation	10 bit	10 bit
Spectral Coverage	500-850 nm	500-850 nm
Focal Length	1945 mm	1945 mm

Dataset Used

A stereo pair of P5 images from a region of Karaj is used as a test field area. These images are located near Tehran. A part of these images is shown in Figure 1. The images sizes are 12000×12000 pixels while their approximate geographic extents are:
Latitude from 35.575 to 35.808 degrees, longitude from 50.858 to 51.142 degrees.

Figure 1: a part of p5 satellite image

Also some other main characteristics of the acquired images are presented in Table 2.

Table 2: Technical specification of P5 Images

Image type	Pan, stereo
Datum	WGS 84
Map Projection	UTM
Zone Number	39
Acquisition date	28 JAN 2007
File Format	Geo TIFF

Experimental Results and Accuracy Assessments

In order to evaluate the horizontal and vertical accuracy assessment, nine well distributed GCP points were considered in a stereo pair of images as the control points. Table 2 presents the accuracy of GCP's acquired from geodetic dual frequency GPS in relative mode (Mikhail et al., 2001). (Assuming the NGO-Fardis as a fixed point)

Table 3: The accuracy of GCP's acquired from dual frequency GPS in relative mode

Point		Sigmas(mm)		
No	NGO-Fardis	0.0	0.0	0.0

1	PA4011b	3.3	3.3	9.0
2	PA4012a	18.4	23.7	33.8
3	PA4013a	9.5	8.1	19.8
4	PA4014b	2.8	2.7	8.1
5	PA4015b	12.5	13.2	27.6
6	PA4016a	15.2	9.2	28.8
7	PA5014b	5.5	5.5	17.3
8	PA5015b	6.5	4.3	13.5
9	PA5016b	6.4	6.5	12.7

In the first step, we evaluate the horizontal and vertical accuracy assessment of these images without the contribution of the GCP points. Therefore, the process of triangulation for automatic tie generation was performed. In figure 2 the 47 green colored points are the tie points that have been automatically generated in a well-distributed form. These tie points are generated through the cross-correlation method in a stereo pair of images. The blue colored points are the check points which are measured by GPS on the terrain.

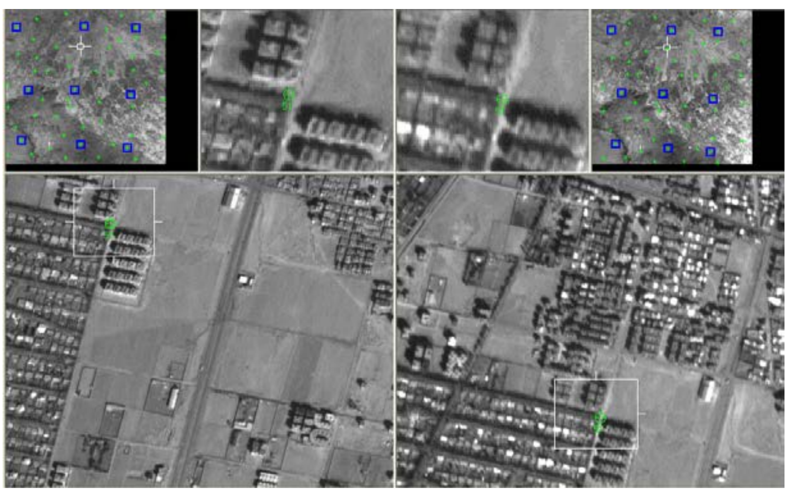


Figure 2: Triangulation and block adjustment without usage of GCP points

The RMSE on the check points are calculated and the obtained amounts are given in Table 4.

Table 4: Results without usage of GCP points

Type	No.	Residual_x(m)	Residual_y(m)	Residual_z(m)
check	1	132.97859293	94.65303507	28.41800218
Check	2	136.93886339	73.13814702	25.19804426
Check	3	136.71610588	95.58230066	20.41114061
Check	4	139.07553526	87.30414595	18.56989590
Check	5	137.84192098	77.37337324	26.32284429
Check	6	139.45541568	86.38939930	17.35160431
Check	7	138.00227256	76.03698043	25.84290020
Check	8	134.72766807	81.1367447	24.26735965
Check	9	141.11197771	73.19195529	13.99420958

Also the total RMSE calculated on these check points are:
Ground X:137.4472(m), Ground Y:83.1584(m), Ground Z:22.7316(m)

In the second step, we evaluate the horizontal and vertical accuracy assessment of these images on 8 check points with the contribution of a GCP point (figure 3). In the third step, we evaluate the horizontal and vertical accuracy assessment of these images on 7 check points with the contribution of 2 GCP points (figure 4). In the fourth step, we evaluate the horizontal and vertical accuracy assessment of these images on 6 check points with the contribution of 3 GCP points (figure 5). In the fifth step, we evaluate the horizontal and vertical accuracy assessment of these images on 5 check points with the contribution of 4 GCP points (figure 6). In the sixth step, we evaluate the horizontal and vertical accuracy assessment of these images on 4 check points with the contribution of 5 GCP points (figure 7). In the seventh step, we evaluate the horizontal and vertical accuracy assessment of these images on 3 check points with the contribution of 6 GCP points (figure 8). In the eighth step, we evaluate the horizontal and vertical accuracy assessment of these images on 2 check points with the contribution of 7 GCP points (figure 9). In the ninth step, we evaluate the horizontal and vertical accuracy assessment of these images on a check point with the contribution of 8 GCP points (figure 10).

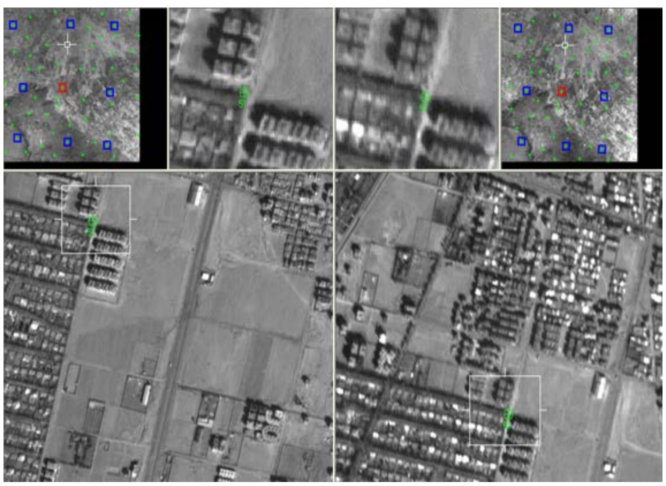


Figure 3: with the contribution of a GCP point

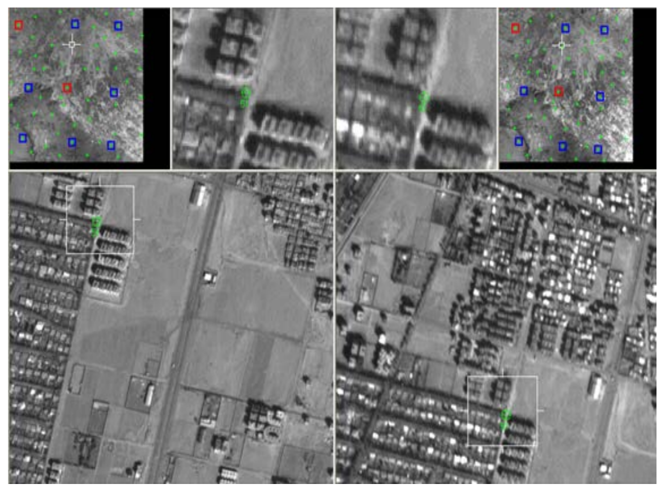


Figure 4: with the contribution of two GCP points

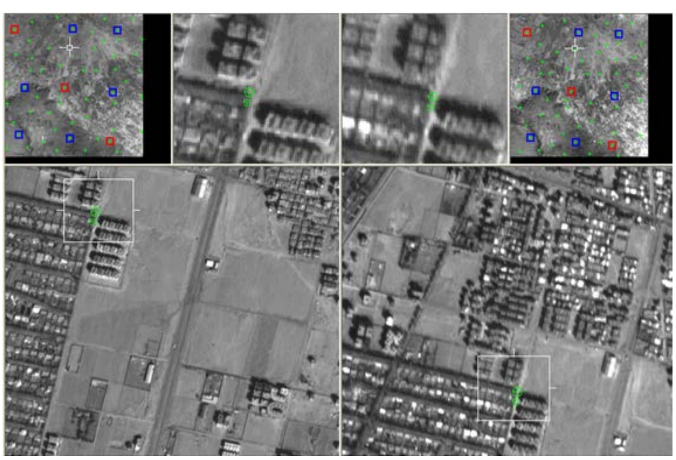


Figure 5: with the contribution of three GCP points

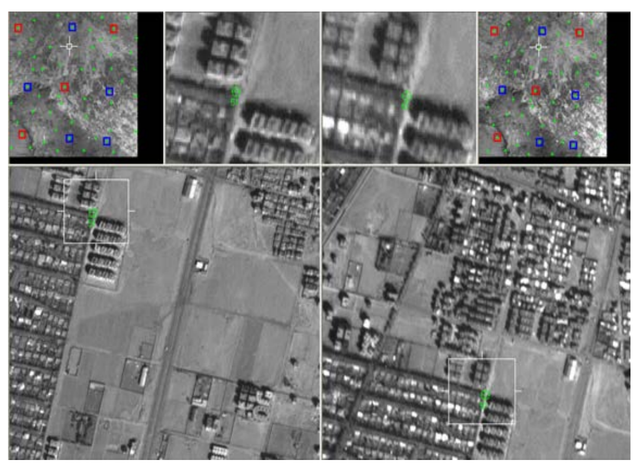


Figure 6: with the contribution of four GCP points

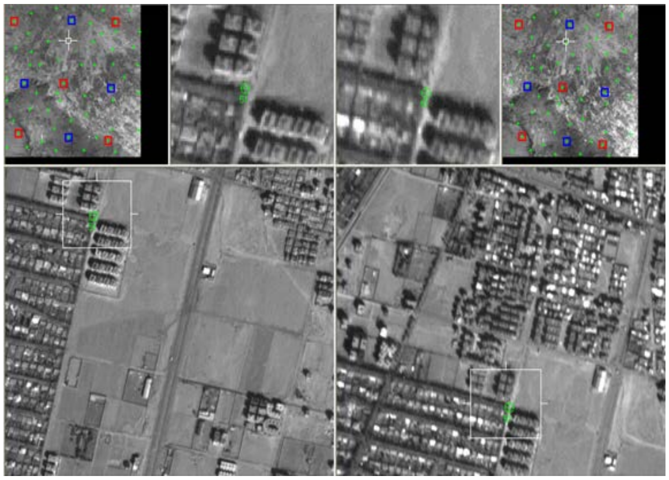


Figure 7: with the contribution of five GCP points

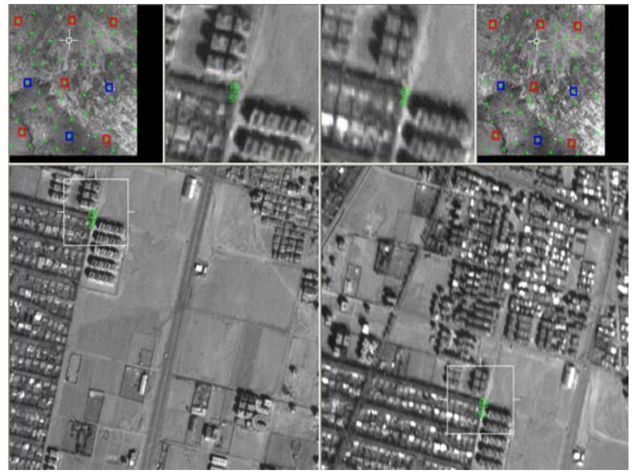


Figure 8: with the contribution of six GCP points

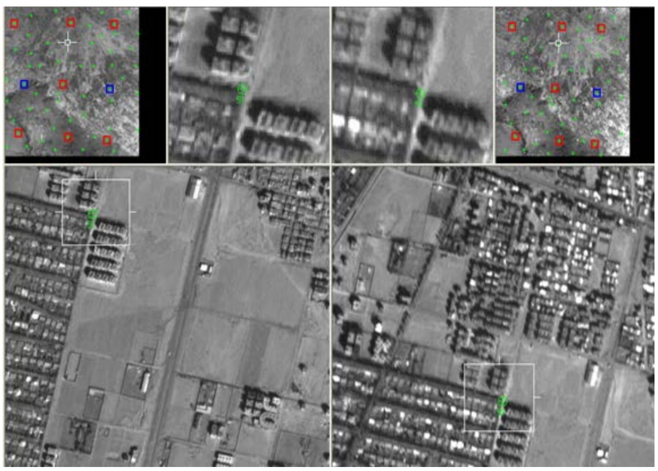


Figure 9: with the contribution of seven GCP points

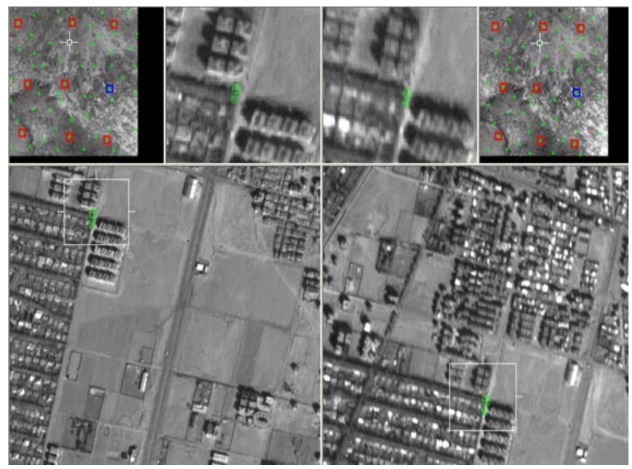


Figure 10: with the contribution of eight GCP points

Red colored point(s) is the GCP point(s) and the blue colored point(s) is the check point(s)

Also in each step, the RMSE on check points are calculated and the obtained amounts are given in following tables.

Table 5: Results with contribution a GCP point

type	No.	Residual_x(m)	Residual_y(m)	Residual_z(m)
gcp	1	0.00464235	0.00584815	-0.19568283
Check	2	3.51358041	-21.40766477	-3.16350278
Check	3	3.85560725	0.89290522	-8.26113400
Check	4	6.63525698	-7.49039292	-10.35887507
Check	5	4.49236646	-17.17915768	-2.07901746
Check	6	6.94341768	-8.37237224	-11.54060854
Check	7	4.57551709	-18.48161403	-2.52447674
Check	8	1.79747825	13.50922371	-4.35761848
Check	9	8.54889518	-21.54573070	-14.76587562

Also the total RMSE calculated on these check points are:
Ground X:5.4415(m), Ground Y:15.2836(m), Ground Z:8.4147(m)

Table 6: Results with contribution two GCP points

type	No.	Residual_x(m)	Residual_y(m)	Residual_z(m)
gcp	1	0.14071991	-0.81336465	-0.31419715
gcp	2	2.41867599	-14.72221467	-2.18257660
Check	3	3.59165651	2.48229885	-8.02180822
Check	4	6.63525698	-7.61200135	-10.38166037
Check	5	4.33564827	-16.21879118	-1.92921122
Check	6	7.08047927	-9.18711325	-11.65948787
Check	7	4.80760823	-19.89893876	-2.73177099
Check	8	2.13315545	-15.53426588	-4.65928485
Check	9	8.61819526	-21.96310098	-14.83737147

Also the total RMSE calculated on these check points are:
Ground X:5.7079(m), Ground Y:14.7900(m), Ground Z:8.9531(m)

Table 7: Results with contribution three GCP points

type	No.	Residual_x(m)	Residual_y(m)	Residual_z(m)
gcp	1	0.05222133	-0.58136414	-0.15600430
gcp	2	2.51617885	-14.98763021	-2.36806764
gcp	3	5.36840890	-13.67430482	-9.25527784
Check	4	2.66113132	4.91592004	-6.35436589
Check	5	5.90015734	-5.69467234	-9.09004719
Check	6	4.72421281	-17.25908458	-2.63888568
Check	7	7.08826442	-9.20489932	-11.66796294
Check	8	2.43013380	-13.53996850	1.56254365
Check	9	-1.16532445	-6.98190207	1.04767002

Also the total RMSE calculated on these check points are:
Ground X:4.5041(m), Ground Y:10.5773(m), Ground Z:6.7039(m)

Table 8: Results with contribution four GCP points

type	No.	Residual_x(m)	Residual_y(m)	Residual_z(m)
gcp	1	2.54408142	10.80845976	-1.10473597
gcp	2	-0.19292966	-0.82313607	-0.11123829
gcp	3	0.10085059	0.44380078	-0.15734633
gcp	4	-0.55662166	-2.32790636	-0.10541398
Check	5	-2.44445003	-4.33489362	-1.32847979
Check	6	-0.21507306	-10.73725470	-5.55459212
Check	7	0.28089930	-0.83308510	-3.68583660
Check	8	3.55146716	-10.08250927	-9.37893839
Check	9	-2.66124292	-1.71453885	3.80914416

Also the total RMSE calculated on these check points are:
Ground X:2.2714(m), Ground Y:6.9191(m), Ground Z:5.4531(m)

Table 9: Results with contribution five GCP points

type	No.	Residual_x(m)	Residual_y(m)	Residual_z(m)
gcp	1	2.08043212	12.81668914	0.77117498
gcp	2	0.20088009	-0.83801615	-0.58220534
gcp	3	-0.43385931	0.27118116	0.36513709

gcp	4	-0.17305951	0.50447177	0.24268870
gcp	5	0.28670391	-2.22775434	-0.97558282
Check	6	-2.09594057	-3.13128043	-0.36362014
Check	7	-0.80072838	-3.22196853	2.96677865
Check	8	-2.64083229	1.73300567	6.11543015
Check	9	-2.93731491	-2.09648815	0.24537065

Also the total RMSE calculated on these check points are:
Ground X:2.2713(m), Ground Y:2.6261(m), Ground Z:3.4057(m)

Table 10: Results with contribution six GCP points

type	No.	Residual_x(m)	Residual_y(m)	Residual_z(m)
gcp	1	2.14013732	12.85912845	0.76350209
gcp	2	0.38665953	-0.70498118	-0.60014600
gcp	3	-0.03002205	0.55923442	0.32758661
gcp	4	-0.16734636	0.50866957	0.24333071
gcp	5	0.51751404	-2.06305598	-0.99618708
gcp	6	-2.41967382	-1.72629566	0.19911976
Check	7	-2.23495053	-3.23081598	-0.35096590
Check	8	-2.39001491	-1.96233298	0.16726840
Check	9	-2.35236858	1.9385789	6.08393587

Also the total RMSE calculated on these check points are:
Ground X:2.3267(m), Ground Y:2.4527(m), Ground Z:3.5197(m)

Table 11: Results with contribution seven GCP points

type	No.	Residual_x(m)	Residual_y(m)	Residual_z(m)
gcp	1	2.22149752	12.79076299	0.54837713
gcp	2	0.26143830	-0.59683920	-0.25348534
gcp	3	0.09225463	0.46179976	0.01910172
gcp	4	0.29280764	0.11575878	-1.02574660
gcp	5	-1.72735156	1.42431030	4.43896371
gcp	6	1.03896577	-2.48271839	-2.32037316
gcp	7	-2.25024977	-1.86617940	-0.24550926
Check	8	-2.27185650	-3.20006711	-0.24984346
Check	9	-2.50813613	-1.06512447	4.63624654

Also the total RMSE calculated on these check points are:
Ground X:2.3929(m), Ground Y:2.3848(m), Ground Z:3.2831(m)

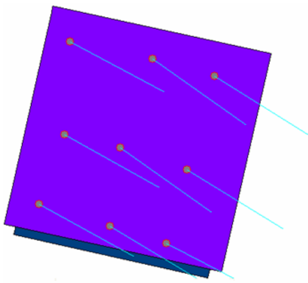
Table 12: Results with contribution eight GCP points

type	No.	Residual_x(m)	Residual_y(m)	Residual_z(m)
gcp	1	2.34441773	12.96391936	0.55827293
gcp	2	0.36463343	-0.45116312	-0.24362459
gcp	3	-0.01335284	0.31273610	0.01043295
gcp	4	-1.99839037	-2.81545817	-0.22875124
gcp	5	-0.49990628	0.40663747	-1.01074669
gcp	6	-1.76023819	1.37903502	4.43977541
gcp	7	0.91613553	-2.65615071	-2.33087423
gcp	8	-2.34149242	-1.99542814	-0.25491770

Check	9	-2.05085144	-2.83184615	-3.04922938

Also the total RMSE calculated on these check points are:
Ground X:2.0508(m), Ground Y:2.8318(m), Ground Z:3.0492(m)

Also the residual vectors on check points are shown in following figures in each step respectively.



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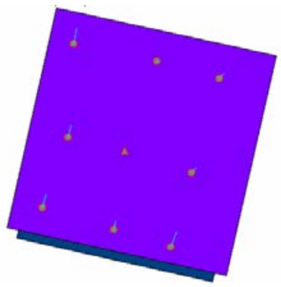

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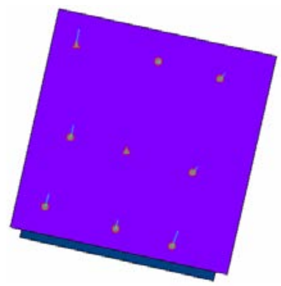

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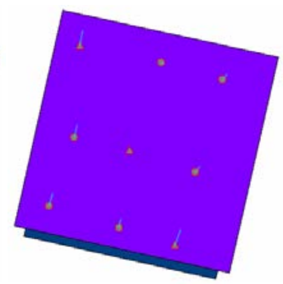

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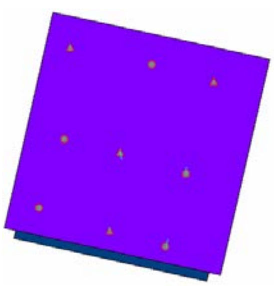

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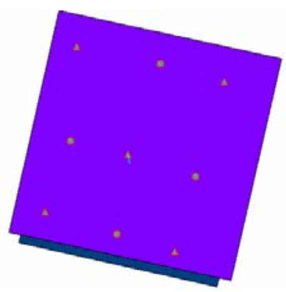

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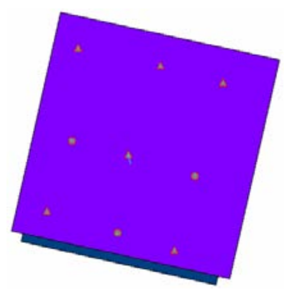

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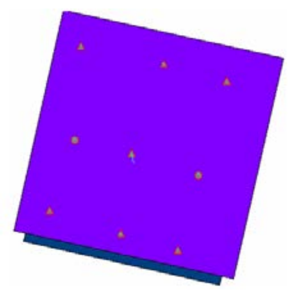

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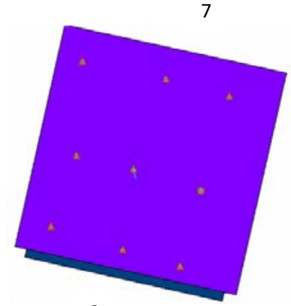

9

Conclusion

With a progressive method, we evaluate the horizontal and vertical accuracy assessment of a stereo pair of p5 images in nine steps. In the first step no GCP point is used and we perform the process of triangulation for automatic tie generation and block adjustment, then in next steps GCP points are contributed in triangulation and block adjustment one by one and the amounts of RMSE on check points are calculated and tabulated.
In each step, arrange of the GCP points in order to evaluate the accuracy assessment will be effective on the check points, so the location of GCP points as presented in this investigation will have great influences on results.
The investigation shows that in order to generate a map in 1:25000 scale ratio, especially in countries border and in area where the flying operations isn't possible, using a stereo pair of p5 images with five well-distributed GCP points (as shown in figure 7) is producing enough criteria for accuracy. Therefore, you can see using more

GCP points will not increase accuracy and just increase the processing time and lost money. Also with the usage of a stereo pair of p5 images, we can generate four sheets in the scale of 1:25000 at the outside.

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