A.Z. Khalaf
Building and Construction Department Engineering, University of Technology, Baghdad, Iraq.
khalaf1955@yahoo.com

I.A.K. Alwan
Building and Construction Department Engineering, University of Technology, Baghdad, Iraq.

T.A. Kadhum
Building and Construction Department Engineering, University of Technology, Baghdad, Iraq.

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Accuracy Assessment of World View-2 Satellite Imagery for Planimetric Maps Production

Abstract- *A planimetric map of scale 1:10,000 meets the requirements of a large segment of user's maps for instance urban city planners and various GIS implementations. Nowadays, a very high-resolution satellite images, such as World View02 (WV02) with spatial resolution of 0.5 m, are very important to produce planimetric maps or update existing ones. Main aim of this research is the assessment of WV02 image for production of the planimetric photomap of scale 1:10,000 with class 1 according to ASPRS standards (ASPRS give accuracy tolerances for map scales at 1:20,000 or larger, this accuracy reported as Class 1, 2, or 3). The investigation includes, studying the best-fit mathematical model (order of polynomial transformation model) that can be used to perform geometric correction for the used image. As well as, examine the effect of the ground control points (GCPs) configuration on the accuracy that can reached from photomap by using the best polynomial order. The Root Mean Square Error (RMSE) resulting at the checkpoints (CPs) will be evaluated. Before the study of impact of the mentioned effects, will be studying the possibility of obtaining a photomap with scale of 1:10,000 and determining the class of this map by using raster satellite image directly (raw image). Through it will compare the coordinates of GCPs observed by using Differential Global Positioning System (DGPS) on the raster WV02 satellite image with respect to its true position on the ground. Taking into consideration this comparison will be conducted according to international standards (National Standard for Spatial Data Accuracy (NSSDA) and American Society for Photogrammetry and Remote Sensing (ASPRS) standards). Evidenced by the results that have been accessible, it cannot obtained on photomap with scale of 1:10,000 of class1 according to ASPRS standard from raw WV02 satellite image, because the RMSE was 4.709 m, this value is largest of allowable error value for this class of the scale. Further, the extracted results showed that using a 1st order polynomial for WV02 image correction with the 14 GCPs that well distributed is slightly superior to other order polynomials (2nd and 3rd order) with a total RMSE of 0.790 m at the 8 ground CPs. On the other hand, using 13 GCPs well distributed (covers the wholly raster of the used image) for the correction process with the same polynomial order, the total RMSE obtained is 0.894 m obtained at 9 CPs, which is less than the value of two pixel size (user-threshold value) of WV02 image. As well as, according to NSSDA and ASPRS standards, this result satisfies the requirements of large-scale maps production accuracy (larger than 1:10,000). In addition, by decreasing the number of the GCPs (using 9 GCPs until 4) the reliability of the results decreases (i.e., the horizontal error increased, approximately 1.4 m are obtained at CPs), but at the same time can get a photomap within scale of 1:10,000.*

Keywords- *Planimetric Map, Map Production, Satellite Imagery, Accuracy Assessment, Best-fit mathematical model.*

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1. Introduction

Imagery acquired by remote sensing techniques (satellite sensors) provides an important source of information for mapping and monitoring the natural and manmade features on the land surface. Currently, with the appropriate of spectral and spatial resolution availability, the application of remote sensing data for urban development plans could mainly be for assessment of natural resources, land use monitoring, planning, and map-making. A little system is apposite for cartographic representation or has even been sophisticated for such purposes. A base map of the city center (or for limiting area), indicating objects including major roads network, buildings and rivers, etc., can be ready rapidly with the benefit from satellite imageries of high and very high spatial resolution, [8]. To study the appropriateness of the WorldView-2 imagery for the upgrading and production of the planimetric maps with scale of 1:10,000, the effect of polynomial order, configuration of

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2412-0758/University of Technology-Iraq, Baghdad, Iraq

ground control points (GCPs) on the used image will be discussed. As well as, determine the relationship between these effects and photomap scale that can be obtained.

2. Maps Production Techniques

The techniques used in the process of the maps production in rapid and continual development. The new technologies for map production from satellite imagery and laser-scanning techniques, in addition to advanced GNSS offer, are both rapid and accurate in observation process of topo data .

A continuously developing range of field and remote data gathering methods include that map production flow lines must be capable of handle spatial data changing in source, scale, format, reliability, quality and area of encasement. Digital or paper maps can be produced using various techniques, including, [3]:

•Field surveying .
•Digital photogrammetry and
•Remote sensing .

Field surveying is an accurate production technique, however it is very slowly and expensive. On the other hand, digital photogrammetry is the most adopted worldwide technique for maps production. However, in spite of its advantages, such the highly accuracy, it cannot map areas which is constrained without limiting flight planning, [3]. However, in Iraq and due to security rules, maps production from aerial platforms is unavailability as well as the high cost of hardware and software needed to produce these maps. Thus, during the past several years, high-resolution satellite imagery has been used for maps production. It has the advantage of less than one meter of resolution, short revisit time, and capabilities of getting stereo images. Moreover, this technique makes it possible and easy to map an area without determine the flight planning required by photogrammetric method. Further, it becomes a suitable tool for digital maps production and updating in many countries.

Recently, the rapid advancement in satellite sensor development enhances the capability in image acquisition with improved spatial, spectral and temporal resolutions, [2]. This can be noticed in the radiometric resolution of the recently launched satellite sensor, for example WV02, where four more spectral bands, including coastal (400-450 nm), yellow (585-625 nm), red-edge (705-745 nm) and infrared red (IR), can be found in addition to the existing red, green, blue and near IR bands, [5]. It is able to capture 46 cm panchromatic imagery, and it is the first commercial satellite to provide 1.84 m resolution, 8-band multi-spectral imagery, [1]. Table 1 shows characteristics of WorldView-2 spacecraft and imaging system.

3. Area of Study and Data Set

Wasit governorate is located in the middle part of Iraq. Its geographical coordinates are (44°32`-46°36`) longitude and (31°57`-33°25`) latitude and an average elevation of about 20 meters. It is bordered by Baghdad and Diyala from the north, Maysan and Dhi Qar from the south, Al Qadisiyah and Babil from the west, and the international boundaries with Iran from the east.

AL-Kut is the capital city of the governorate, which is laying to the south of Baghdad and keeps a central location among its surrounding cities with Amara, Nasiriya to the south, Diwanya, and Hilla to the west. In this, research the center of the Kut city as the study area. Study area is bounded by coordinates of (45°48`-45°51`) longitude and (32°30`- 32°33`) latitude. The total area of approximately (27 square kilometers) is considered flat terrain.

In this research, World View-2 satellite imagery with spatial resolution of 50 cm was used. Acquisition date for the used image is 23/05/2014. The data are projected to UTM projection, Zone 38N on the WGS84 ellipsoid (Figure 1).

Table 1: Characteristics of the WorldView-2 sensor.

Specification	Value
Sensor Bands	Panchromatic: 8 Multispectral (4 standard colors: red,blue, green, near-IR), 4 new colors: red edge,coastal, yellow, near-IR2.
Sensor Resolution	Ground Sample Distance Panchromatic: 0.46meters GSD at Nadir, 0.52 meters GSD at20° Off-Nadir. Multispectral: 1.84 meters GSD at Nadir,2.4 meters GSD at 20° Off-Nadir.
Revisit Frequency	1.1 days at 1 meter GSD or less 3.7 days at 20° Off-Nadir or less (0.52 meter GSD).
Swath Width	16.4 kilometers at nadir.

Figure 1: WV02 satellite imagery used in the study (cover the center of the Kut city)

4. Methodology

Recorded satellite image by sensors on satellites contains geometric and radiometric errors. The latter, it can resulted from the used recording instrumentation, influence of the atmosphere and from insolation. Many factors can increase image geometry errors, for example, the curvature of the ground, relative motions of the spacecraft, and uncontrolled alterations in the location and altitude of the platform. Used satellite image was provided corrected from radiometric errors. Geometric errors are corrected by a computational procedure. Two techniques that can be used to correct geometric errors in satellite image data. The first is to model the quality and quantity of the sources of errors and use these models to gain correction formula. This method is operative when the kinds of errors are well categorized, such as that caused by earth revolution. The else method relies upon founding mathematical relationships by comparing the position of clear points on the image with its location on the ground, [4]. In this investigate; the later method is used to perform the geometric correction process for WV02 image .

The methodology followed in this research (as shown in Figure 2) is to determine the possibility of the benefiting from WorldView-2 satellite imagery in the upgrading and production of the planimetric maps with scale of 1:10,000 or larger.

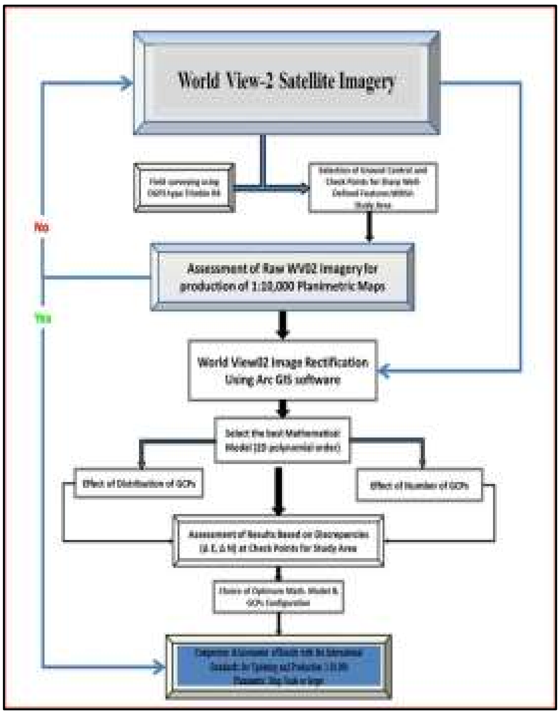

Figure 2: Methodology workflow

I. Ground Control Points Acquisition

Generally, the employments of the ground survey techniques to obtain the required ground control points (GCPs) in order to achieve the dereferencing process. Ordinarily, these surveying practices can be performed by using DGPS or Total station device. However, in order to meet the requirements of this research, it is important to observe a great numeral of GCPs to facilitate examination the impact of configuration (number and allocation) of ground control points, also the influence of using different polynomials (1st, 2nd, and 3rd order). Accordingly, observation twenty-five ground control points using Trimble GPS receiver R4. The horizontal accuracy of this device is about (0.003m) in the fast static technique. Fast static technique is used to get coordinates of all GCPs with high accuracy. GCPs were selected at sharp features (well-defined point) and well distributed over the study area, as well as can be easily identified on the satellite image and at the same time on the ground. Most of these points are corners of buildings and according to NSSDA standard, the distribution of GCPs must be at least 20 percent of the point's site in each quadrant of the study area. GCPs spacing may be allocated, whereas those points are spaced at intervals of at least 10 percent of the diagonal distance across the study area, [6]. Because the number of GCPs are twenty-five points, so the distribution of these points will be even on study area (array 5x5). Based on that will be distributed ground control points on the satellite image on a regular shape as shown in Figure 3, then the GCPs will be moved to the nearest location of well-defined points on the ground (Figure 4).

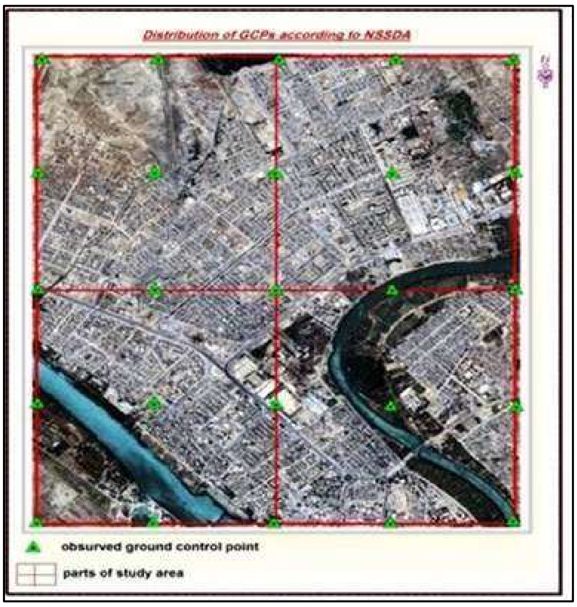

Figure 3: Regular distribution of 25GCPs.

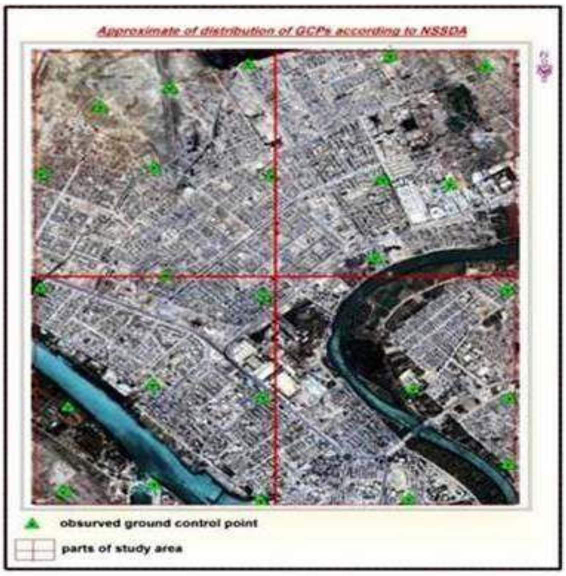

Figure 4: 25 GCPs near well-defined points.

In this study, the base station (ISKU) located in the Kut city as shown in Figure 5, and was localized within the study area. This station was utilized as the main base station for DGPS records in this study. Table 2 shows the coordinates of base station (ISKU).

The GPS is a system contains two parts (stationary part and rover part) the stationary was continues operating reference (ISKU station) and the rover (Trimble R4) will be at the required point. The master and rover units should be operate at the same time and the receivers will receive the information from GPS satellites and then will be installed in computer to process the data to get more results that are accurate.

The GPS (Trimble R4) crew starts with ground control point (Ku01, 02, 03, 04,...,25) and the process continues for about (30) minute for each point to ensure the accuracy in the monitoring process. Then, the correction of the GPS data was done in the Trimble Business Centre software for survey by post processing process. The coordinates of 25 GCPs after correction as follows:

Figure 5: Show the location of ISKU station.

Table 2: ISKU station coordinates (IGS08 position Epoch2005)

DATUM		SPHEROID	PROJECTION		
ITRF08(Epoch2005)		WGS84	UTM		
Name	WGS84 Latitude	WGS84 Longitude	Grid Easting (m)	Grid Northing (m)	Std Dev Hz (m)
ISKU	32° 30 06.81192" N	45°48 30.15148" E	575937.585	3596356.721	0.000

Table 3: Coordinates of 25GCPS after correction.

GCPs Nu.	Observation from...to	solution type	Grid_Eventu (m)	Grid_Nventu (m)	H. Prec.(m)
Ku01	ISKU --- ku01	Fixed	574894.233	3600227.521	0.006
Ku02	ISKU --- ku02	Fixed	576012.397	3600312.477	0.005
Ku03	ISKU --- ku03	Fixed	576175.466	3601293.929	0.008
Ku04	ISKU --- ku04	Fixed	576946.925	3601600.141	0.007
Ku05	ISKU --- ku05	Fixed	578351.684	3601692.167	0.015
Ku06	ISKU --- ku06	Fixed	577174.864	3600201.325	0.005
Ku07	ISKU --- ku07	Fixed	578279.217	3600157.009	0.010
Ku08	ISKU --- ku08	Fixed	578941.948	3600100.191	0.006
Ku09	ISKU --- ku09	Fixed	578317.909	3599091.752	0.005
Ku10	ISKU --- ku10	Fixed	578571.491	3597560.699	0.093
Ku11	ISKU --- ku11	Fixed	579509.689	3598789.500	0.005
Ku12	ISKU --- ku12	Fixed	579518.239	3596620.832	0.065
Ku13	ISKU --- ku13	Fixed	579526.780	3597444.079	0.005
Ku14	ISKU --- ku14	Fixed	575116.372	3596289.943	0.003
Ku15	ISKU --- ku15	Fixed	575155.419	3597337.820	0.005
Ku16	ISKU --- ku16	Fixed	576010.990	3596374.344	0.002
Ku17	ISKU --- ku17	Fixed	578524.702	3596159.971	0.004
Ku18	ISKU --- ku18	Fixed	577092.43	3597456.616	0.004
Ku19	ISKU --- ku19	Fixed	574884.914	3598818.570	0.006
Ku20	ISKU --- ku20	Fixed	576126.740	3598971.622	0.003
Ku21	ISKU --- ku21	Fixed	579294.717	3601565.950	0.006
Ku22	ISKU --- ku22	Fixed	577097.362	3598709.196	0.005
Ku23	ISKU --- ku23	Fixed	575995.835	3597606.328	0.004
Ku24	ISKU --- ku24	Fixed	575479.256	3601068.310	0.008
Ku25	ISKU --- ku25	Fixed	577069.221	3596173.824	0.004

II. Accuracy Assessment

A planimetric accuracy can be delivered by determining of the discrepancies of easting and northing coordinates of ground checkpoints (CPs), which are positioned on the used image covering the whole investigation area. By comparing the E, N coordinates of raster image with the corresponding ones derived from DGPS observations. The Root Mean Square Error (RMSE) in E and N directions and the total RMSE will be calculated (as shown in equations 1 , 2, and 3). According to ASPRS standard, the allowable error is (0.25 mm x map scale), [7]. The RMSE is the square root of the average of the set of squared differences between data set (image) coordinate values and coordinate values obtained from the GPS (Trimble R4) observations for a set of points. Using an RMSE determination, it is assumed that the systematic errors have been eliminated and that error is normally distributed [6].

$$RMSEE = sqrt[(E\ image,i - Echeck,i)^2 /n] \quad (1)$$

$$RMSEN = sqrt[(N\ image,i - Ncheck,i)^2 /n] \quad (2)$$

$$TRMSE = sqrt[(RMSEE)^2 + (RMSEN)^2] \quad (3)$$

Where :
E image, i, N image, i : are the coordinates of the i^{th} CP in the image.
Echeck, i, Ncheck, i : are the coordinates of the i^{th} CP observed using DGPS (the GPS (Trimble R4).
n : is the number of CPs tested.
i : is an integer ranging from 1 to n.
RMSEE = RMS error in the east direction.
RMSEN = RMS error in the north direction.
Moreover, by using the following equations can be compute the planimetric accuracy (horizontal accuracy) for any dataset according to NSSDA, **[6]**:
If RMSEE = RMSEN,
AccuracyNSSDA = 1.7308 * TRMSE, and If RMSEE ≠ RMSEN,
AccuracyNSSDA = 2.4477 * 0.5 * (RMSEE + RMSEN).
When (RMSEmin/RMSEmax) is between 0.6 and 1.0 (where RMSEmin is the smaller value between RMSEE and RMSEN and RMSEmax is the larger value.
Before the study of impact of the mentioned effects (polynomial order and configuration of GCPs), will be studying the possibility of obtaining a photomap with scale of 1:10,000 and determining the class of this map by using raster satellite image directly (raw image). It will compare the coordinates of GCPs observed (using DGPS) on the raster satellite image with respect to its true position on the ground. Take into consideration that the comparison will be conducted according to NSSDA and ASPRS standards. Table below shows the obtained results:
It can be seen from above table, the RMSE is 4.709 m, this means that a photomap with scale 1:10,000 of class2 according to ASPRS standard can be produced from raw satellite image. Further, the value of the horizontal accuracy is 7.988 m, according to the NSSDA at 95% confidence level which can be remove one point from 25 GCPs, because the number of points is 25 and 95% of those points is 24.
However, in the Table 4 one point (Ku04) has an error exceeds the allowable error value according to NSSDA standard. As a result, it will study the possibility of excluding this point or any other that could effect on the accuracy of rectification process significantly. After selecting the best mathematical model, the geometric correction process for the used image can be applied. This can test the effect of the configuration (number and allocation) of ground control points and also the scale of photomap that can be obtained. Depending on the results which are accessible the best case will be chosen. To the desired purpose, a possibility of obtaining a planimetric photomap with scale 1:10,000 of class1 from rectified WV02 satellite image in order to benefit from them in the process of production and/or upgrading. At the same time taking into account the limits of accuracy allowed in the rectification process for used satellite image which must not exceed twice of its spatial resolution (i.e., ≤ 1m).

III. Effects of the Polynomial Transformation Model

The method adopted to correct the World View-2 satellite image to product photomap is a 2D polynomial order, using georeferencing tools of Arc GIS program as work environment of correction. The polynomial of the first order (6 parameters) let for correcting a translation in easting (E) and northing (N) directions, a rotation, scaling in both directions. The second order (12 parameters) let for correction, moreover the antecedent parameters, convolution and gibbosity in both directions. The third polynomial order (20 parameters) let for correction of the same deformations as a second order function with others, which do not necessarily correspond to any physical reality of the image acquisition system. Table 5 shows the minimum number of GCPs necessary to achieve a transformation for (1st) through (3rd) order transformation.

Table 4: Compute of horizontal error, RMSE and accuracy according to NSSDA

ID	Point	E_Raw data (m)	N_Raw data (m)	E_DGPS (m)	N_DGPS (m)	Residual _E	Residual _N	Hor. error of GCP (m)	Residual
1	im01	574188.384	3800224.487	574094.233	3800227.521	16.443	8.207	6.007	42.690
2	im02	576008.880	3800308.498	576012.397	3800312.477	10.459	15.845	6.803	46.280
3	im03	576178.482	3801300.419	576177.466	3801285.820	8.820	42.188	7.341	53.080
4	im04	576907.182	3801595.969	576946.925	3801600.341	31.784	17.494	9.859	98.188
5	im05	578346.394	3801688.070	578351.694	3801692.307	28.413	18.218	6.215	38.631
6	im06	577171.770	3800399.444	577274.864	3800201.325	9.574	3.538	3.821	13.111
7	im07	578274.526	3800356.447	578270.217	3800157.009	22.008	6.561	5.345	28.571
8	im08	578998.229	3800098.408	578841.948	3800100.391	11.850	3.181	4.124	17.030
9	im09	578315.381	3599900.449	578317.909	3599981.752	6.032	1.098	2.843	8.080
10	im10	578570.957	3597560.948	578571.400	3597560.699	0.285	0.062	0.599	0.347
11	im11	578597.955	3598788.072	578909.688	3598789.500	3.360	0.279	1.908	3.642
12	im12	579524.141	3598825.103	579518.239	3598820.812	34.834	18.758	7.321	53.591
13	im13	579524.885	3597444.098	579528.788	3597444.879	3.590	0.845	2.306	4.436
14	im14	575122.958	3596290.388	575116.372	3596289.942	43.379	19.588	7.815	62.965
15	im15	579159.931	3597337.642	579155.418	3597337.820	0.262	0.015	0.520	0.277
16	im16	578008.868	3596375.944	578010.908	3596374.344	1.258	0.160	1.391	1.418
17	im17	578523.685	3596095.260	578524.702	3596185.871	1.034	1.670	1.844	2.704
18	im18	577098.858	3597455.611	577062.430	3597456.616	2.473	1.010	1.866	3.482
19	im19	574879.604	3598817.620	574884.914	3598818.570	28.196	0.001	5.306	28.097
20	im20	576125.383	3598968.971	576126.748	3598971.822	1.842	7.027	2.578	8.869
21	im21	579291.338	3601563.405	579294.717	3601565.959	11.554	6.175	4.211	17.730
22	im22	577095.332	3598707.954	577097.362	3598709.196	4.122	1.542	2.380	5.664
23	im23	579994.356	3597605.518	579995.835	3597606.228	2.187	0.670	1.699	2.857
24	im24	579482.634	3601065.655	575479.236	3601065.310	11.410	0.418	3.419	11.827
25	im25	577068.346	3596173.982	577069.223	3596173.824	0.016	0.025	0.202	0.041
					Sum	385.295	168.179		554.474
					TRMSE	3.926	2.601		4.987
					RMSEmin/ RMSEmax				0.7
					Accuracy NSSDA	By using equation below (2.4477*0.5*(RMSEx+RMSEy))			7.088

Table 5: Minimum Number of Ground Control Points per Polynomial Order

Order of Polynomial	Minimum GCPs Required
1	3
2	6
3	10

To investigate the impact of the mathematical model that used for georeferencing process on the precision of the corrected WV02 image, a 1st, 2nd and 3rd order transformations were tested. After reducing the points that have horizontal error approximately equivalent or exceed the allowable error value computed according to NSSDA, bringing the number of remaining points is equal to 22 points. In addition, by using 14 GCPs to make of geometric correction for satellite image in the three polynomials order, and then used 8 GCPs (Figure 6) as check points to assessment of the planimetric accuracy of polynomial transformation. The goal is to determine the best-fit mathematical model (order of polynomial transformation) that can be used to examine the influence of the number and distribution of GCPs. Arc GIS (v10.3) program will be used to achieve geometric correction and compute the coordinates of CPs on an image after correction process for all the study cases. Table 6 gives a summary for the results.

From Table 5, results showed that using a first order polynomial with the best 14 well distributed GCPs is slightly superior to other polynomials order resulted with a TRMSE of 0.790 m at the ground CPs. This result satisfies the requirements of the 1:2,000 of class2 and 1:4000 of class1 or smaller scale of planimetric maps according to ASPRS standard. As well as, reveal from results, RMSE computations based on ground control points used in the transformation can be very misleading. Therefore, it should be noted that the total RMSE at check points always be more reliable (Figure 7). On the other hand, a small change (approximately, 30-40 cm) refer to that the polynomial order making few impact particularly if enough number of GCPs was used. But, the accuracy were obtained using the first order model not exceed the limits of ground sample distance (GSD) of the used satellite image (less than two pixel size, <1 m), unlike the rest of the polynomials order which exceeded the limits of spatial resolution for the used image.

Depending on the obtained results, the first order transformation model was selected to further investigate that includes; study the influence of configuration of ground control points on the reliability of photomap scale that can be obtained from WV02 satellite imagery rectification.

IV. Effects of the Number of GCPs

From the results, a first order of polynomial transformation model will be used to examine the influence of decreasing the number of ground control points on the photomap scale that can be obtained. In this step, four case studies will be examined, in each one the number of ground control points was changed, taking into consideration the well distribution for these points so as to cover all parts of the study area (across the WV02 satellite image) starting using 13, 9, 6, and 4 GCPs (Table 7 and Figure 8).

The resulting of total RMSE was calculated at the GCPs for each case study, as well as at the 9 ground CPs. In addition to, calculates the accuracy at the CPs according to NSSDA standard as a guide. Then, from the RMSE value at check points the scale of map can determined and with any class according to ASPRS standard. Table 8 gives a summary for the results obtained.

Table 6: Total RMSE at both GCPs and CPs (effect of polynomial transformation

Polynomial Order	Total Root Mean Square Error	
	At GCPs (m)	At CPs (m)
First Order	1.367	0.790
Second Order	1.012	1.103
Third Order	0.831	1.517

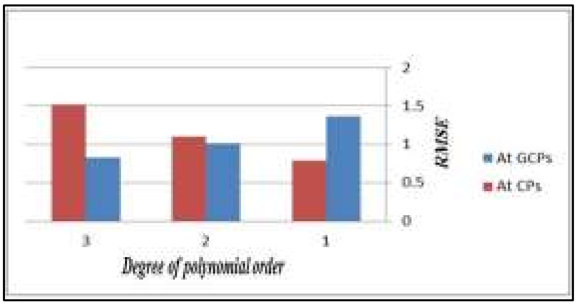

Figure 7: Effects of the Polynomial Transformation Model

Table 7: Number of GCPs and CPs for each case study.

Case study	Nu. Of correction points	Nu. Of checkpoints
Case_1	13	9
Case_2	9	9
Case_3	6	9
Case_4	4	9

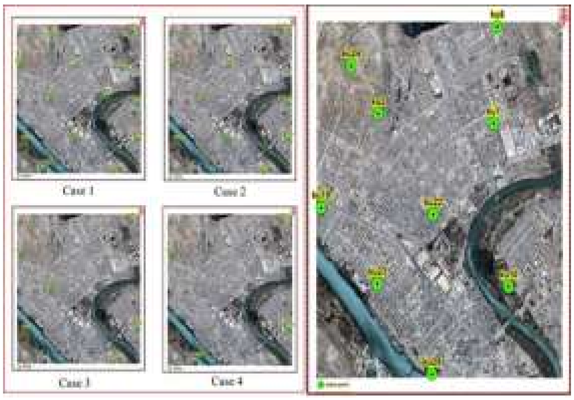

Figure 8: Shows the number Of GCPs and CPs for each case study

Table 8: TRMSE at GCPs and CPs, NSSDA accuracy, and ASPRS map scale and class

Case study	Total Root Mean Square Error		RMSE at CPs		[redacted]	ASPRS Map Scale and Class			
	At GCPs (m)	At CPs (m)	RMSEx	RMSEy					
Case_1	1.253	0.894	0.511	0.734	1.524	1:2,000 Class 2	1:4,000 Class 1	1:5,000 Class 1	1:10,000 Class 1
Case_2	1.289	1.268	0.616	1.098	2.123	1:2,000 Class 3	1:4,000 Class 2	1:5,000 Class 2	1:10,000 Class 1
Case_3	1.313	1.403	0.677	1.227	2.330	1:2,000 Class 3	1:4,000 Class 2	1:5,000 Class 2	1:10,000 Class 1
Case_4	0.786	1.450	0.809	1.137	2.492	1:2,000 Class 3	1:4,000 Class 2	1:5,000 Class 2	1:10,000 Class 1

From the results in the above table, it can be noted the total RMSE at GCPs that used for transformation process (geometric correction) which increased with the decreased number of points for cases 2 and 3. While, by using only 4 GCPs (case 4), the TRMSE at the ground control points was decreased. This does not refer to it the excellence of the resulting accuracy but is merely the result of no enough redundancy, because the total root mean square error at the nine CPs for the same case significantly indicates the deteriorating results with a value of 1.450 m. Further, by decreasing the number of the ground control points the credibility of the results decreases and the value of somewhat higher the two pixel size of the used image or approximately 1.4 m are obtained at CPs for the cases of 2, 3, and 4. However, results showed no clearly change in the accuracy that computed according to NSSDA standard. The maximum difference in the computed accuracy is around 1 m between cases 1 and 4. Moreover, from all case studies it can be obtain on photomap with scale of 1:10,000 of class1 according to ASPRS standard. But from the above results showed that using 13 GCPs (i.e., case1) resulted in a total RMSE of 0.894 m at the CPs, this results satisfies the requirements of large scale maps production accuracy (i.e., 1:2,000 of class2, 1:4,000 and 1:5,000 of class1 or smaller of the planimetric map scale). As well as, this value is fewer than the value of 1 m (less than the twice spatial resolution (or pixel size) of the used satellite image). It is certainly better as compared with the remainder of the other cases.

V. Effects of the Distribution of GCPs

Depending on the previous results that have been obtained, it is clear that the best number of GCPs in which they can accomplish of the geometric correction process in more accurate for WV02 satellite image is thirteen ground control points. Therefore, in this step to examine the impact of allocation of the ground control points on the accuracy that can be obtained from rectification process (georeferencing) for the used satellite image, three different case studies will be evaluated. For each one, the number of ground control points well be constant (13 GCPs) and ground CPs (9 CPs) and by using the same polynomial order (1st order), while the only change was the distribution of ground control points and CPs (Figure 9). Summary for the pattern of distribution for the three cases as shown in Table 9. In each case study, the resulting TRMS errors were computed at CPs in addition at GCPs (Table and Figure 10).

It should be noted here that the case 3 in this section represents a return to the same results obtained by using case 1 in the previous section. Because, it represents a better distribution for the ground control points (covered all parts of the used satellite image), which will be applied to compared with the cases 1 and 2. Table 10 gives a summary for the results.

Table 9: Distribution of GCPs and CPs over used image

Case study	Distribution of GCPs	Distribution of CPs
Case 1	13 GCPs distributed only in the left half of the World View02 image	9 CPs distributed only in the right half of the World View02 image
Case 2	13 GCPs distributed only in the upper half of the World View02 image	9 CPs distributed only in the lower half of the World View02 image
Case 3	13 GCPs distributed all over the World View02 image	9 CPs distributed all over the World View02 image

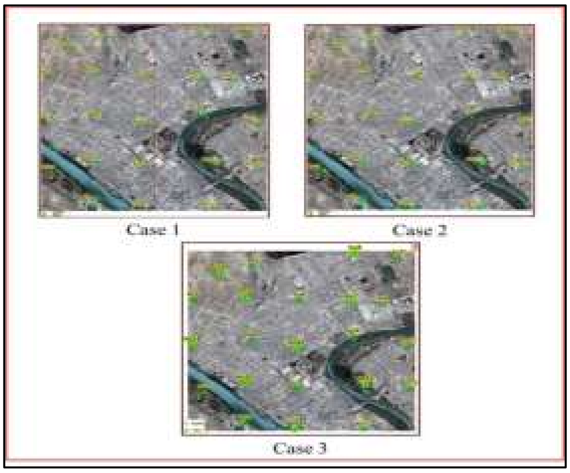

Figure 9: Distribution of GCPs and CPs for each case study.

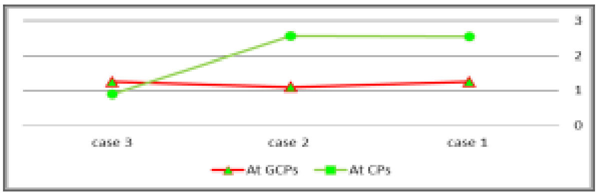

Figure 10: Effect of the distribution of GCPs.

Table 10: Effects of the distribution of GCPs and CPs over used image

Case study	Total Root Mean Square Error		ASPRS Map Scale and Class			
	At GCPs (m)	At CPs (m)				
Case 1	1.250	2.556	-	1:4,000 Class 3	1:5,000 Class 3	1:10,000 Class 2
Case 2	1.103	2.571	-	1:4,000 Class 3	1:5,000 Class 3	1:10,000 Class 2
Case 3	1.253	0.894	1:2,000 Class 2	1:4,000 Class 1	1:5,000 Class 1	1:10,000 Class 1

From the results shown in the Table 10, demonstrates significantly the necessity to evaluates the accuracy of geometric correction process according to only ground CPs. Whereas the total RMSE from all cases appears to be approximately fixed according to the TRMS error obtained at GCPs (red line) as shown in figure (10). The TRMSE at the CPs (green line, see figure (10)) indications to fully dissimilar conclusion. Cases (1 and 2) gives definitely undesirable results, because it cannot be obtained a photomap of scale 1:10,000 with class 1 from rectified of WV02 satellite image (with spatial resolution 50 cm). On the other hand, for case (3) seems to be agreeable resultant, because in this case the well distribution for GCPs is certainly the most appropriate from other cases. For that reason, it must be taken into consideration the regular distribution for the GCPs that are used in geometric correction process to cover all parts of the WV02 image .

Therefore, from the results obtained, a 1st order with 13 ground control points that well distributed covers the wholly raster of WV02 image give acceptable results to achieve georeferencing process for the used image (TRMSE = 0.894 m) which is smaller than of 1 m (TRMSEat CPs < two pixel size) of the World View-2 satellite image (with spatial resolution 0.50 m). In addition to, according to ASPRS standard, this result satisfies the requirements of large scale maps production accuracy (larger than 1:10,000).

5. Conclusion

The research includes different operational approaches to study the appropriateness of the WorldView-2 imagery to produce of the planimetric photomaps with scale of 1:10,000. The method adopted to correct the World View-2 satellite image to product photomap is a 2D polynomial order, using georeferencing tools of Arc GIS software as work environment of correction. From the results which were accessed, the following conclusions can be drawn:

1. Evidenced by the results, it can produce a photomap with scale of 1:10,000 of class 2 according to ASPRS standard from raw WV02 satellite imagery.
2. Results showed that using a first order polynomial with the best 14 GCPs that well distributed is considerably superior to other order polynomials resulted in a total RMSE of 0.79 m at the CPs. This result satisfies the requirements of the 1:2,000 of class2 and 1:4000 of class1 or smaller scale of planimetric phtomap according to ASPRS standard.
3. By decreasing the number of the ground control points the credibility of the results decreases and the value of somewhat higher than two pixel size of the used image (WV02). However, results showed no clearly change in the accuracy that computed according to NSSDA standard. Moreover, by using 9, 6, or 4 GCPs can be obtain on photomap scale of 1:10,000 with class 1 according to ASPRS standard. This is a right so long as the accuracy of the ground control points is regular and is good allocation on wholly the raster image. But from the results, showed that the amount of TRMS error exceeded the value of two times (i.e., > 1 m) of the spatial resolution of WV02 image. On the other hand, using 13 ground control points resulted in a total root mean square error of (0.894 m) which is

fewer than the value of (1 m). Moreover, according to ASPRS and NSSDA standards, these results satisfies the requirements of large scale maps production accuracy (larger than 1:10,000) that necessitate 95% of all CPs be accurate within 0.025 cm at the map scale, which is equal to 2.5m for the 1:10,000 map scales.

4. From the results demonstrates significantly the necessity to evaluate the accuracy of geometric correction process according to only ground CPs. Because, the value of the RMSE that computations depending on GCPs used in the georeferencing can be very misguiding. As well as, the influence of ground control points allocation override the effect of the number of GCPs so long as sufficient redundancy exist and assuredly increases the polynomial order.

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Authors Biography

Name: Abbas Z. Khalaf
Place and date of birth: Baghdad/1955
Nationality: Iraq
Address: Baghdad- Iraq
Workplace: Building and Construction Department Engineering, University of Technology.

Educational Background:

- B.Sc (Civil Engineering / University of Basra / Iraq / 1976)
- MSc. (Civil Engineering / Surveying / University of Washington / America / 1980).
- Ph.D. (Civil Engineering / Surveying / University of Washington / America / 1984).

Name: Imzahm A. Kareem Alwan
Place and date of birth: Baghdad/1974
Nationality: Iraq
Address: Baghdad- Iraq
Workplace: Building and Construction Department Engineering, University of Technology.

Educational Background:

- B.Sc (Civil Engineering / University of Technology / Iraq / 1996)
- MSc. (Civil Engineering / Remote Sensing / University of Technology / Iraq / 2002).
- Ph.D. (Civil Engineering / Remote Sensing / University of Technology / Iraq / 2006).

Name: Tahseen A. Kadhum
Place and date of birth: Wasit /1986
Nationality: Iraq
Address: Kut - Iraq
Workplace:

Educational Background:

- B.Sc (Survey Engineering / Technical Engineering College-Baghdad / Iraq / 2007)
- MSc. (Civil Engineering / Geomatics / University of Technology / Iraq / 2015).