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ACCURACY ASSESSMENT OF DIGITAL ELEVATION MODEL (DEM) GENERATION FROM WV02 SATELLITE IMAGES: A CASE STUDY OF THE BAGHDAD-AL-WIHDA TOWNSHIP/IRAQ

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ABSTRACT
The digital elevation models (DEM) generated from a pair of WorldView-2(W V02) satellite images, is one of the methods of passive remote sensing. Where this technique depends on the principle of traditional photogrammetry. In this paper include the DEM data produced by a pair of WorldView-2(W V02) satellite images with help Leica Photogrammetry Suite (LPS 2013) software. Generated DEMs were compared for accuracy using different Ground Control Points(GCPs) observed in the field.The result of root mean square error (RMSE) is 0.171 m and the mean error was 0.033m.According to the statistical analysis of the results with the help of SPSS software, it may be argued the mean error of quotient in the DEM derived from a pair of W V02 satellite images can get into every part of the earth's surface, to be similar to the topography of the study area.

INTRODUCTION
Digital elevation model (DEM) is an important tool in civilian applications such as climate study urban planning and civil engineering works and many of applications, furthermore digital elevation model (DEM) in military applications and production of contour maps is used. Basically, there are two categories to produce DEM data which are varied. These categories are ground surveyed elevation data and remotely sensed elevation data (Brad Jordan Gamett, 2010).

Since the 1950s research is still ongoing for the ideal method to create high accuracy DEM to portray the earth's surface form. Use a pair of WorldView-2 (W V 02) satellite images to generate DEM It is one of methods used to generate DEM. WorldView-2 (W V 02) Launching in Sept/Oct 2009, WorldView-2 will be the first high resolution satellite to provide half-meter panchromatic resolution and 1.8 meter multispectral resolution across 8 spectral bands. With unprecedented agility and a collection capacity of 975,000 km2 per day, World View-2 will double the Digital Globe collection capacity and provide worldwide intra-day revisit capabilities.

THE AREA OF STUDY
The area of study is located at the middle of Iraq Republic with flat terrain topography (Figure No.1), Al-Wihda Township (33°11'25.81“N, 44°36'20.1“E) In fact, is a city belonging to the boundaries of the municipality of Baghdad, where away from the center of the capital Baghdad, about 45 kilometers. The total area of the study area is100 km^2.

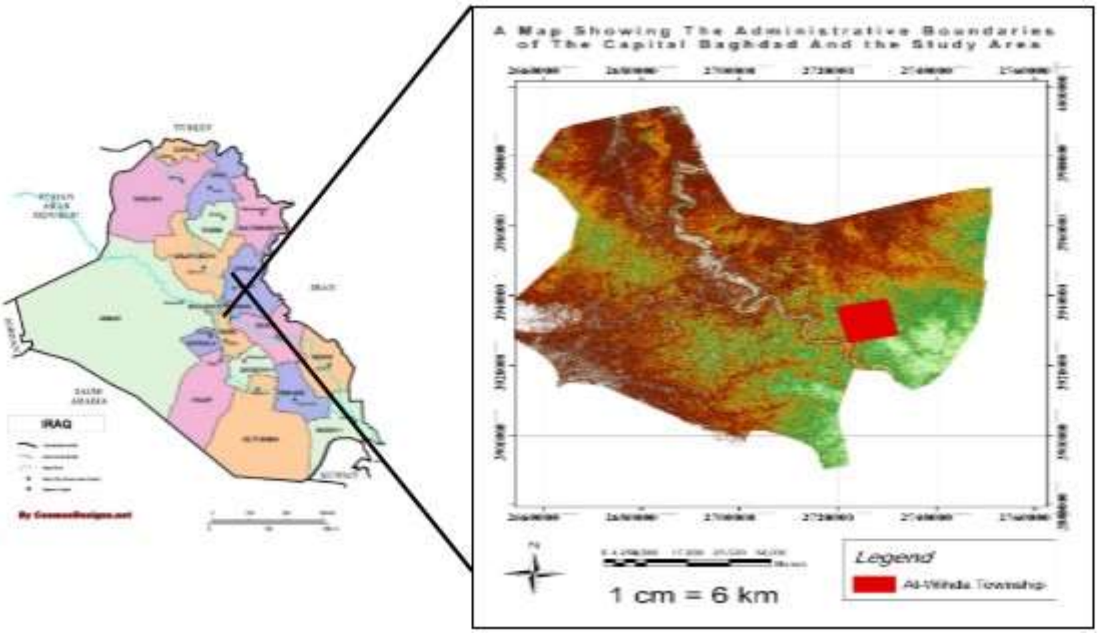

Figure No.1: The study area shown on the map of Iraq administrative.

THE AIM OF RESEARCH

Various methods to create a DEM doubtlessly calls for research and investigation in how accurate these methods, including photogrammetry approach followed in DEM generated from a pair of W V 02 satellite images.

METHODOLOGY

Figure No.2 shows the methodology used in this paper in general. Where Will be described in this research assess the accuracy according to The National Standard for Spatial Data Accuracy (NSSDA), American Society of Photogrammetry and Remote Sensing (ASPRS) and National Map Accuracy Standard (NMAS), As well as the analysis of the results according to those standards. The statistical analysis of the results will be using Statistical Package for the Social Sciences (SPSS). DEM generated from a pair of W V 02 satellite images would be with help Leica Photogrammetry Suite (LPS 2013) software.

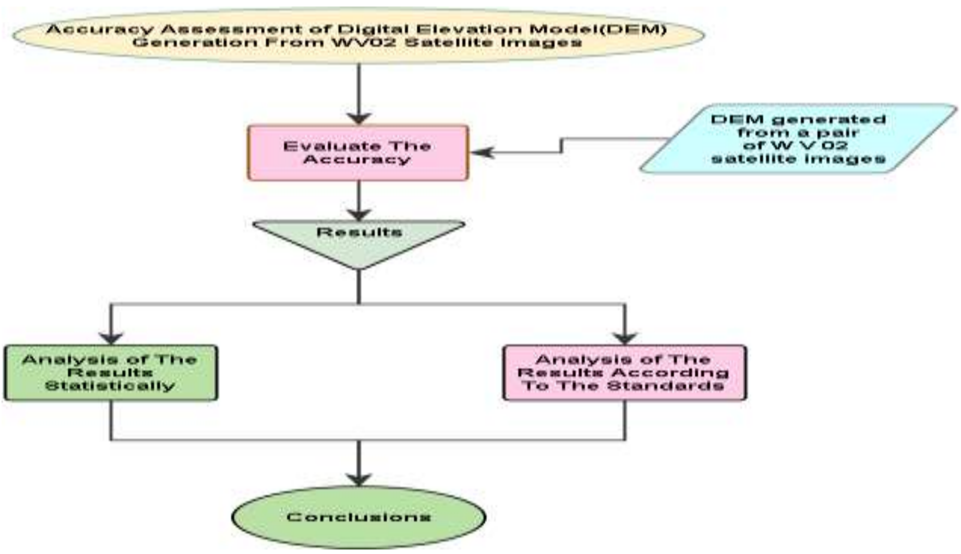

Figure No.2: The methodology work.

DEM Generation from WV02 Satellite Images

The Photogrammetric Approach is the method used to extract DEM, by collecting RGB image stereo pairs which can extract DEM .The traditional photogrammetric method of transforming from object space to image space is using the collinearity equations. The generic term for the model used is an image geometry model. The method is highly suited to frame cameras and non-linear effects caused by lens distortion, film distortion or atmospheric effects (for example) are dealt with by additional parameters or by corrections after the linear transformation. The introduction of push broom sensors cannot be so easily dealt with by the collinearity equations as each line on the image has different elements of exterior orientation. These have been dealt with by either using iterative methods (Gugan and Dowman 1988) or by generating a three dimensional grid of 'anchor points' and interpolating between these (Konecnyet al, 1987).

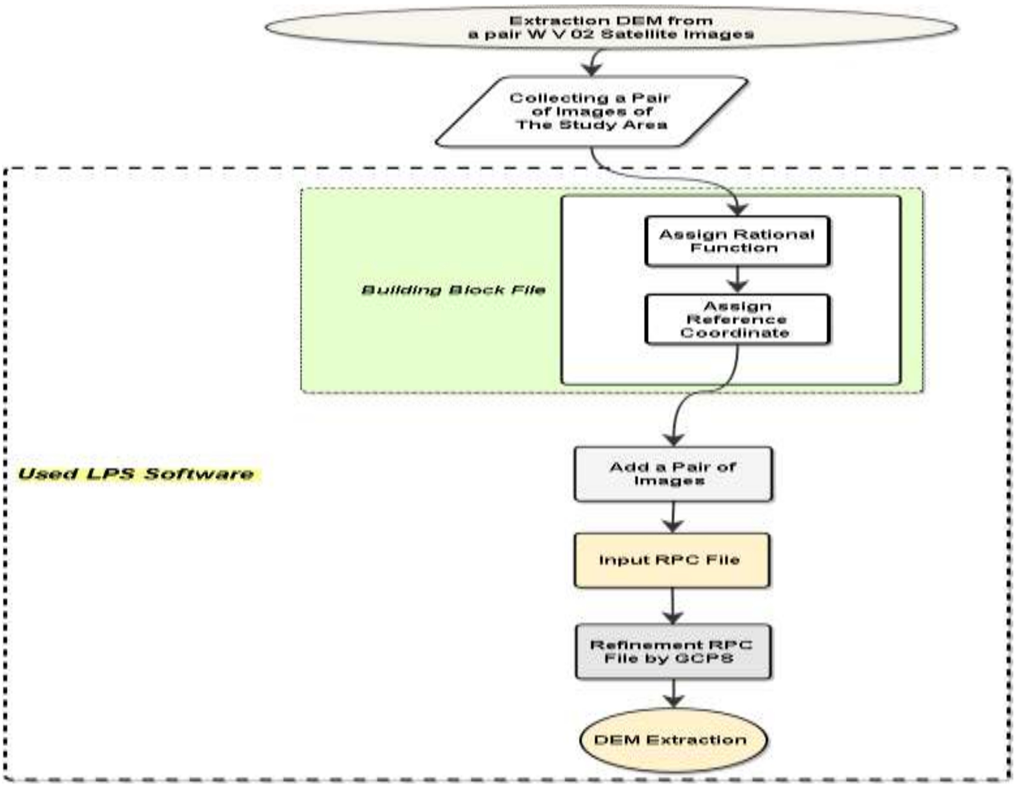

Figure No.3: The methodology used DEM extraction

A critical issue is the choice of a sensor model for HRSI to acquire high-accuracy 3D object point determination. In general, sensor models are classified into two categories: physical sensor models and alternative generalized models (Tao and Hu, 2001). A physical sensor model, based on the collinearity condition, describes the rigorous imaging geometric relation-ship between the image point and the homologous ground point, with parameters of physical meanings. However, rigorous physical sensor models are complicated, and vary with different sensor types. Moreover, parameters used in the physical models are kept confidential by some commercial satellite image providers as they reveal the camera model information and metadata relating to the ephemeris and satellite attitude. These parameters thus may not be available to users. In contrast, the rational function model (RFM), one of the most popular generalized models, has drawn wide attention and investigation in the civilian photogrammetric and remote sensing community. The RFM supplied with commercial satellite image data with eighty rational polynomial coefficients (RPCs), ex-presses image coordinates as a ratio of two polynomials with variables of ground coordinates. In practice, the RFM is widely used to replace physical sensor models due to its capability of maintaining the accuracy of the physical sensor models, its unique characteristic of sensor independence, and real-time calculation.

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The DEM generation is a very complex process and requires high accuracy in inputs and data handling. The methodology adopted in this thesis is shown in Figure No.3 .Word View2 (W V02) 0.5m resolution Stereo-pair of Al-Wihda Township is acquired. Stereo-pair is used for Digital elevation Model (DEM) with the assistance of Leica Photogrammetry Suite (LPS) software. Building Block file is the first step in the production of DEM, Where Block file (*.blk) is an extension file that stores all the steps of processing for DEM extraction. This file stored the information of assigned projection, interior and exterior orientation, GCPs information (Tie, Control, and Check).Coordinates signing system important one of the steps building block file. UTM chose, zone 38N and WGS84 datum is Iraq location for UTM Projection. Although that (RPC) file be enough in some cases to generate the DEM (Salman Nasir, 2015), but for procuration the desired accuracy in generating DEM, RPC file must be strengthened by utilize GCPs (table 1).

Table 1. GCPs in Al-Wihda Township

oint	oordinates (unit of measurement is a meter)		
CP1	1311.454	73142.428	.608
CP2	1292.412	73215.198	.755
CP3	2483.934	74944.106	.212
CP4	6671.915	74583.147	.413
CP5	5898.046	69451.874	.338
CP6	4821.543	71904.245	.997

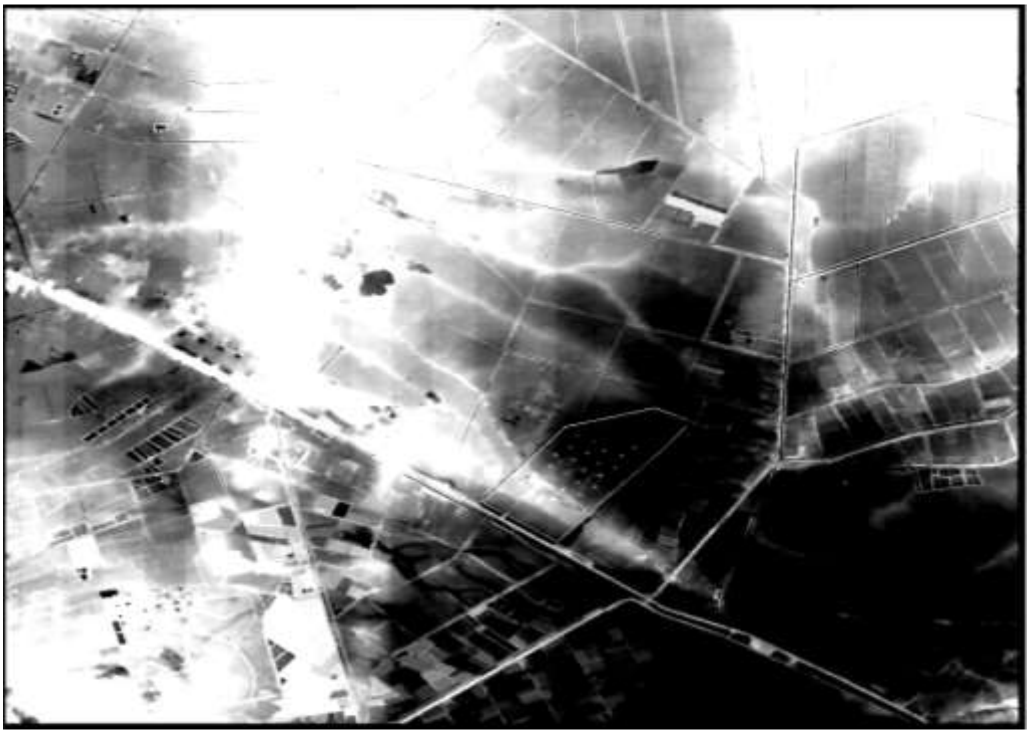

Figure No 4: The final output of DEM to Al-Wihda Township

It should be noted that the ground control points observed using DGPS type Topcon model GR3 and the field surveying is executed are Scientific of Engineering Consulting Bureau/University Technology-Baghdad. Extreme care should be taken in selecting the GCPs, because the accuracy of the resulting DEM is highly dependent on them The final step is using all the parameters of interior and exterior orientation in Leica Photogrammetry Suite (LPS).A 1m resolution DEM is generated for land square area with dimensions of 10 x 10 kilometers in the study area Al-Wihda township (Figure No 4).

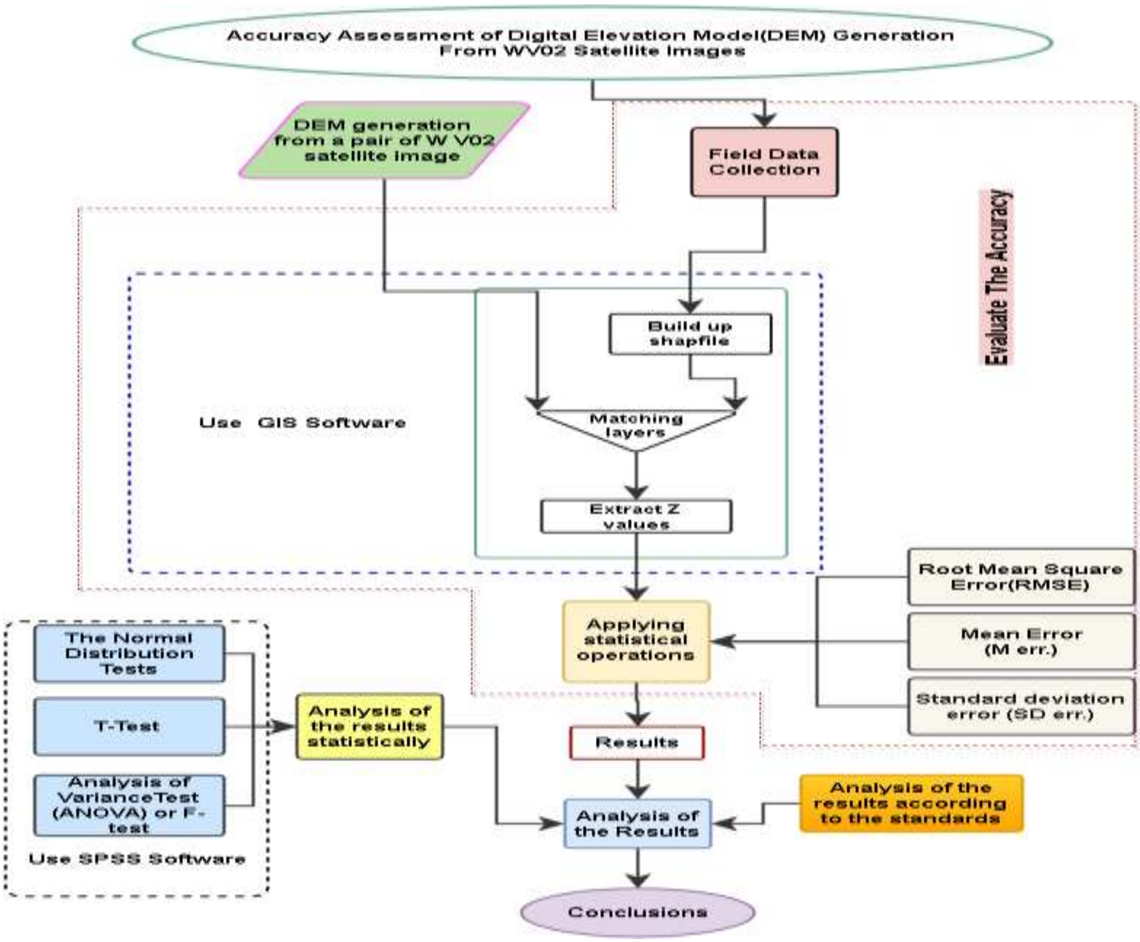

Figure No 5: Chart showing the main steps of the process of assessing the accuracy and the rest of the operations in detail

Evaluate the accuracy

Evaluating the accuracy of DEM extracted from a pair of W.V02 satellite images is the essence of research as a matter of knowing the accuracy of DEM extracted from a pair of W.V02 satellite images and find out the acceptability of this DEMs for survey work and other applications .where DEM extracted from a pair of W.V02 satellite images is used as an influence to show results close to reality. It will be applied according to the chart below**(** Figure No 5).

Field data collection

To achieve the 95 percent (95%) confidence level, there are require to collect thirty Ground Control Point (30 GCPs) for study area (Figure No 6). According to The National Standard for Spatial Data Accuracy (NSSDA), American Society of Photogrammetry and Remote Sensing (ASPRS) and National Map Accuracy Standard (NMAS) requirements, choose those points in open areas-free residential buildings in low-gradient land, in addition to its proximity to the facilities of an important nature, Intersections on roads and major transportation.
This 30 ground control points have been collected for study site (Al-Wihda Township), by the Bureau of the consultant engineering at the university technology-Baghdad (Table 2)). Using a global positioning system (GPS) type Topcon instrument model GR-3.

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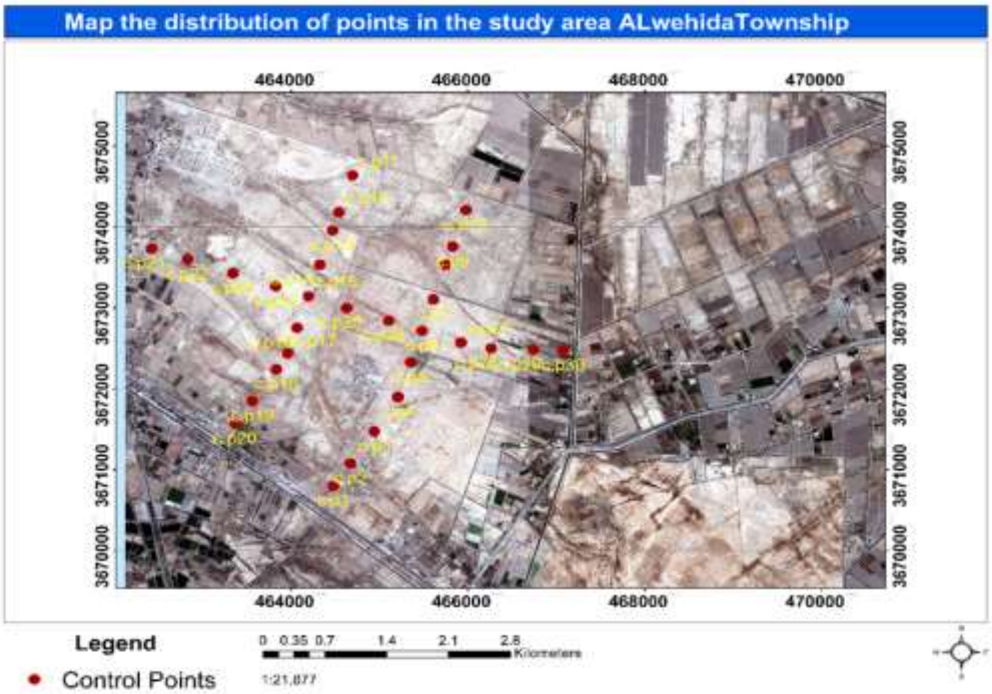

Figure No 6: Ground Control Points located on Satellite image of Al-wahda Township

Table 2. Ground control Point in Al-Wihda Township

Name Point	Coordinates (the unit of measurement meter)		
	X	Y	Z
GCP1	464478.142	3670802.201	30.140
GCP2	464671.010	3671080.989	30.250
GCP3	464943.814	3671475.321	28.790
GCP4	465209.126	3671900.791	28.820
GCP5	465352.197	3672331.131	29.170
GCP6	465481.070	3672718.770	29.360
GCP7	465609.944	3673106.409	29.150
GCP8	465752.068	3673533.903	29.230
GCP9	465826.364	3673757.376	29.240
GCP10	465977.637	3674212.389	29.710
GCP11	464693.732	3674639.234	30.530
GCP12	464542.459	3674184.221	30.760
GCP13	464468.163	3673960.748	30.130
GCP14	464326.039	3673533.254	30.000
GCP15	464197.165	3673145.615	29.940
GCP16	464068.292	3672757.977	29.910
GCP17	463960.879	3672441.690	30.110
GCP18	463834.419	3672242.813	30.240
GCP19	463561.615	3671848.481	30.970
GCP20	463368.747	3671569.694	31.630
GCP21	462421.531	3673735.940	32.100
GCP22	462830.703	3673599.907	31.310
GCP23	463342.652	3673429.706	30.590

GCP24	463826.133	3673268.968	30.110
GCP25	464628.455	3673002.229	29.720
GCP26	465106.242	3672843.385	29.580
GCP27	465923.273	3672571.756	28.590
GCP28	466261.793	3672504.709	28.890
GCP29	466741.007	3672488.140	28.800
GCP30	467077.306	3672476.513	28.860

Extract Value from DEM extracted from a pair of W.V02

The stage extraction value of Z, articulated an important stage to assess the accuracy of DEM extracted from a pair of W V02. Four basic steps to extract the value of Z **:**(1)Data entry, (2) data management, (3) analysis and (4) output data, for that, the GIS environment is ideal to complete the task (Robert J. Peckham,2007). Enter the different layer of the DEMs simultaneously with creation of shapefile (shp*) that contains thirty Ground controller points information (Enter and data management stage). Matching layers**(** DEM layers and feature point layer), use Spatial Analyst Tools to extract the Z value (Table 3).It is the stage of analysis and data output.

Table 3. The value Z extracted from DEM extracted from a pair of W.V02 satellite images

point	Z GPS(m)	Z W.V02(m)
GCP1	30.140	30.074
GCP2	30.250	30.403
GCP3	28.790	28.977
GCP4	28.820	28.843
GCP5	29.170	29.766
GCP6	29.360	29.637
GCP7	29.150	29.193
GCP8	29.230	29.109
GCP9	29.240	29.099
GCP10	29.710	29.364
GCP11	30.530	30.653
GCP12	30.760	30.643
GCP13	30.130	30.071
GCP14	30.000	29.866
GCP15	29.940	29.791
GCP16	29.910	29.860
GCP17	30.110	30.401
GCP18	30.240	30.349
GCP19	30.970	31.013
GCP20	31.630	31.667
GCP21	32.100	32.066
GCP22	31.310	31.227
GCP23	30.590	30.608
GCP24	30.110	30.072
GCP25	29.720	29.734
GCP26	29.580	29.483
GCP27	28.590	28.684
GCP28	28.890	28.921
GCP29	28.800	28.855
GCP30	28.860	28.994

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APPLYING STATISTICAL OPERATIONS

The definition of the concept of bias: It is the extent of gap and variation data from each other, if bias meter close to zero can say that this kind of data is homogeneous (Ahmed Abdelsamie,2008)

Measures of dias:

$Range_Z=MAX_Z- MIN_Z$ (1)

Equation 17 Depends on maximum and minimal value only and this may cause problems when abnormal values (Bosaha Horiaa,2008) wherefore use the Mean error, Standard deviation error and Root mean square error formula:

$$Merr. = \frac{\sum_{i=1}^{n} Z_{dff(i)}}{n} \quad (2).$$

$$STD_{err} = \sqrt{\frac{\sum_{i=1}^{n}(Z_{dff}-ME)^2}{n-1}} \quad (3).$$

$$RMSerr. = \sqrt{\frac{\sum_{i=1}^{n}(Z_{dff(i)})^2}{n-1}} \quad (5).$$

Where:

$$Z_{ddf} = Z_{DEM} - Z_{GCP} \quad (6).$$

n=the number of samples (points).

RESULT

The DEM extracted of a pair of W V02 satellite images recorded 0.596 m as maximum value error, and -0.346 m as minimum error value. Was also a standard deviation error amounted is found to be 0.172m and the mean error was 0.033m, It was also the Root Mean Square Error(RMSE) value is 0.171 m(Figure No 7).

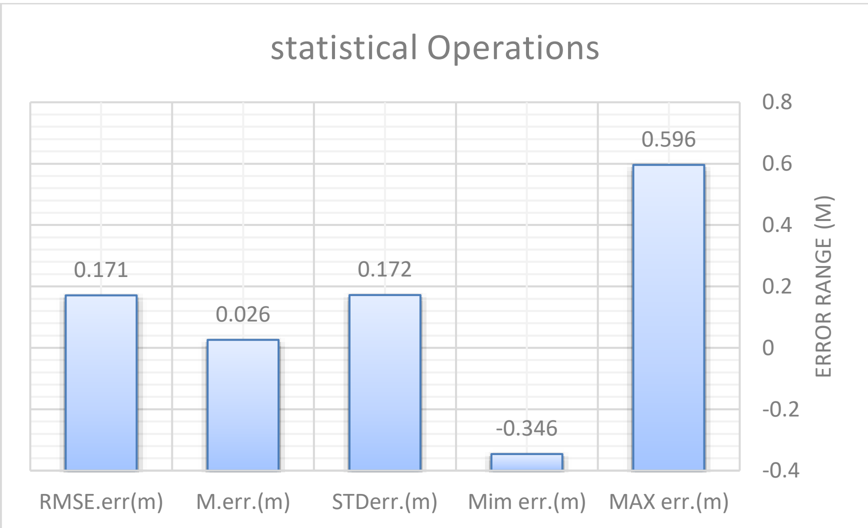

Figure No 7: Diagrams shows the results of statistical operations conducted on DEM extracted of a pair of W.V02 satellite images

ANALYSIS OF THE RESULTS STATISTICALLY

Normal Distribution Tests

Differences or errors between the Z-GPS (or actual) and Z-DEM, amount of error can be measured using the following equation (6):

$$Z_{ddf} = Z_{DEM} - Z_{GCP} \quad (6)$$

Or

$$Z_{error} = Z_{DEM} - Z_{GCP} \quad (6)$$

Indeed SPSS software provides distribution of the normal testing in three methods: Diagram method, Shapiro-Wilks test and Kolmogorov-Smirnov test.

Shapiro-Wilks test and Kolmogorov-Smirnov test Depends on the formulation of the null hypothesis (H_0) and the alternative hypothesis (H_1), in this research the null hypothesis (H_0) and the alternative hypothesis (H_1) will be:

- H_0= Follows a normal distribution if level of significance$(\alpha/2)>0.025$.
- H_1= Does not follow a normal distribution if level of significance$(\alpha/2)<0.025$.

At a certain level of confidence 95%. Normal distribution test results shown in the (table 4), Where the value of the level of significance$(\alpha/2)$ is 0.179 depending on testing Kolmogorov-Smirnova **.** On the other hand the value of the level of significance$(\alpha/2)$ is 0.029 depending on testing Shapiro-Wilk. In both cases, we infer that the samples follow a normal distribution pattern. Note figure No8.

Table 4. Result of Tests of Normality of DEM extracted of a pair of W.V02 satellite images

DEM Source	Tests of Normality	
	level of significance at a confidence level 95%	
	Kolmogorov-Smirnova	Shapiro-Wilk
A pair of W.V02 satellite images	0.179	0.029

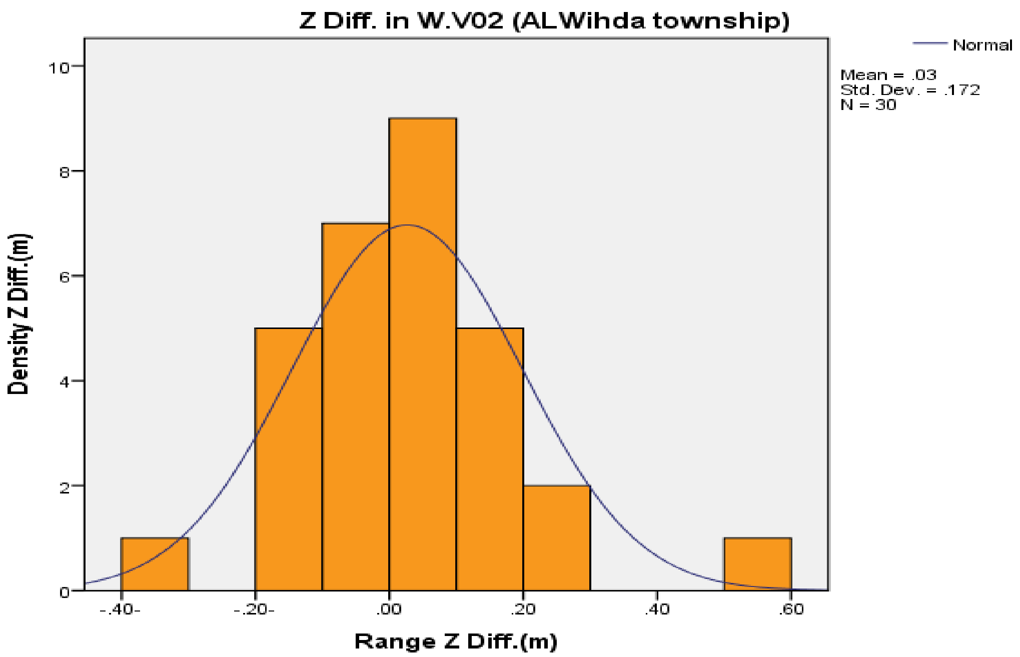

Figure No.8: Histogram showing the distribution pattern of errors

T-Test

A paired t-test is used to compare two population means where you have two samples in which observations in one sample can be paired with observations in the other sample (Gassan Yousif Alkutiti, 2009).t-Test is one of the hypotheses tests, null (H_0) and the alternative (H_1) hypothesis:

- Null hypothesis (H_0): Equal to mean for groups.
- Alternative hypothesis (H_1): Unequal mean.

At level of significance(α) and a certain level of confidence. Mean of error in the sample of DEM It is similar occurred in all regions the same level of the sample, or this error is pure coincidence cannot be said that this error is common. The amount of the Mean error in the Z- DEM extracted of a pair of W V02 satellite images is 0.026 m, Will be the Mean error is the same for all the land is similar topography of the study area; or this error is pure coincidence. Therefore the null hypothesis (H_0) and the alternative hypothesis (H_1) will be:

- H_0= Mean error represents community if level of significance($\alpha/2$)>0.025.
- H_1= Mean error represents sample only if level of significance($\alpha/2$)<0.025.

Where tests showed the value of the significance level ($\alpha/2$) is 0.406, evidence that the acceptance of the null hypothesis (H_0) that the Mean error in the Z- DEM extracted of a pair of W V02 satellite images a Mean of error the world for the same terrain study area.

Analysis of Variance Test (ANOVA) or F-test

Analysis of Variance (ANOVA) is a statistical method used to test differences between two or more means (Sherbini, 2007). Analysis of Variance (ANOVA) test is applied to Z-GPS and Z-DEM extracted of a pair of W.V02, to see if there is a discrepancy between samples. On the other hand Post Hoc Tests precisely the LSD (Least Significant Difference) test it provides detailed information about sampling variation among themselves. Therefore the null hypothesis (H_0) and the alternative hypothesis (H_1) will be:

- H_0= There is variation between group if level of significance($\alpha/2$)>0.025.
- H_1= There is no variation between group if level of significance($\alpha/2$)<0.025.

Where tests showed the value of the significance level ($\alpha/2$) is 0.972, evidence that the acceptance of the null hypothesis (H_0) that the There is variation between Z- DEM extracted of a pair of WV02 satellite images and Z-GPS,

And the lack of difference between them (table 5).

Table 5. Result of F-test and Post Hoc Tests (LSD).

F-test	Post Hoc Tests (LSD)		
level of significance($\alpha/2$)	Group(I)	Group(J)	level of significance($\alpha/2$)
0.972	Z-GPS	Z-W.02 DEM	0.907

ANALYSIS OF THE RESULTS ACCORDING TO THE STANDARDS

American Society of Photogrammetry and Remote Sensing (ASPRS) Accuracy standards for digital geospatial data divides the vertical data accuracy to ten categories, As well as take into consideration the topography of the land and is it an agricultural area or free of weeds (barren).

The Non-vegetated Vertical Accuracy (NVA), i.e., vertical accuracy at the 95% confidence level in non-vegetated terrain, is approximated by multiplying the RMSEz (in non-vegetated land cover categories only) by 1.96(table 6). This includes survey check points located in traditional open terrain (bare soil, sand, rocks, and short grass) and urban terrain (asphalt and concrete surfaces). The NVA, based on an RMSEz multiplier, should be used in non-vegetated terrain where elevation errors typically follow a normal error distribution.

Table 6.Vertical Accuracy Standards for Digital Elevation Data in NV

Vertical Data Accuracy Class	1.96* RMSEz Non-Vegetated Vertical Accuracy (NVA) at 95% Confidence Level (cm)
I	2.0
II	4.9
III	9.8
IV	19.6
V	24.5
VI	39.2
VII	65.3
VIII	130.7

IX	196.0
X	653.3

The Root Mean Square Error (RMSE) value is 0.171 m of DEM extracted of a pair of W.V02 satellite images, so the DEM extracted for a pair of W.V02 satellite images classified in the first category according to the ASPRS standard.

The Equivalent Contour Interval (E.C.I) of DEM extracted of a pair of W.V02 satellite images is 0.609m according to National Map Accuracy Standards (NMAS). According to The National Standard for Spatial Data Accuracy (NSSDA) the E.C.I of DEM extracted of a pair of W.V02 satellite images is 0.304m (table 7).

Table 7. Analysis of the results according to the standards

DEM Source	Classified according to the ASPRS standard	E. C. I according to the NMAS standard	E. C. I according to the NSSDA standard
A pair of W.V02 satellite images	I	0.609m	0.304m

CONCLUSION
In the open land with low terrain, the digital elevation models (DEM) derived from a pair of W V02 satellite images Achieved with high precision. According to the standards can produce contour map with contour interval amount is almost half a meter. On the other hand, according to the statistical analysis the mean error of quotient in the DEM derived from a pair of W V02 satellite images can get into every part of the earth's surface, to be similar to the topography of the study area.

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