

***Water Resources and Surveying Engineering***

**Positional Accuracy Assessment for Updating Authoritative Geospatial Datasets Based on Open Source Data and Remotely Sensed Images**

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**ABSTRACT**

OpenStreetMap (OSM) represents the most common example of online volunteered mapping applications. Most of these platforms are open source spatial data collected by non-experts volunteers using different data collection methods. OSM project aims to provide a free digital map for all the world. The heterogeneity in data collection methods made OSM project databases accuracy is unreliable and must be dealt with caution for any engineering application. This study aims to assess the horizontal positional accuracy of three spatial data sources are OSM road network database, high-resolution Satellite Image (SI), and high-resolution Aerial Photo (AP) of Baghdad city with respect to an analogue formal road network dataset obtained from the Mayorality of Baghdad (MB). The methodology of, U.S. National Standard Spatial Data Accuracy (NSSDA) was applied to measure the degree of agreement between each data source and the formal dataset (MB) in terms of horizontal positional accuracy by computing RMSE and NSSDA values. The study concluded that each of the three data sources does not agree with the MB dataset in both study sites AL-Aadhmiyah and AL-Kadhumiya in terms of positional accuracy.

**Keywords:** Positional accuracy, authoritative road data, OSM data quality.

**تقييم الدقة الموقعية لتحديث البيانات المكانية المنتجة من المؤسسات الرسمية باستخدام البيانات المجانية.**

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**الخلاصة**

مشروع OSM يعتبر المثال الاكثر شيوعا لتطبيقات رسم الخرائط التطوعية المتوفرة على الانترنت. معظم البيانات المكانية المتوفرة بشكل حر على الانترنت تجمع بواسطة متطوعين غير متخصصين باستخدام طرق جمع البيانات المكانية المختلفة. OSM يهدف الى انشاء خارطة رقمية لكل العالم. عدم التجانس في طرق جمع بيانات مشروع OSM جعلت دقة هذه البيانات غير موثوق بها ويجب ان يتم التعامل معها بحذر لاي تطبيق هندسي. هذه الدراسة تهدف الى تقييم الدقة الموقعية الافقية لثلاثة مصادر بيانات مكانية لشبكة الطرق في مدينة بغداد هي، بيانات طرق مشروع OSM، صورة جوية ذات وضوح

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مكاني 0.10m، وصورة فضائية ذات وضوح مكاني 0.50m. عملية التقييم لهذه المصادر الثلاثة تم عن طريق مقارنتها مع مجموعة بيانات رسمية مماثلة تم الحصول عليها من امانة بغداد (Mayorality of Baghdad (MB). الهدف الاساسي لهذه المقارنة هو تحديد درجة التوافق بين كل مصدر من مصادر البيانات الثلاثة وبين مجموعة بيانات امانة بغداد الرسمية (MB) من حيث الدقة الموقعية الافقية. تم اجراء فحص الدقة الموقعية الافقية عن طريق تطبيق منهجية المعيار الامريكي الاكثر استخداما والاكثر حداثة (NSSDA) National Standard for Spatial Data Accuracy. الدراسة استنتجت ان اي من المصادر الثلاثة الغير رسمية المفحوصة لا يتوافق مع مجموعة البيانات الرسمية لامانة بغداد من حيث الدقة الموقعية الافقية. **الكلمات الرئيسية:** تقييم الدقة الموقعية، بيانات طرق رسمية، جودة بيانات OSM، صور عالية الوضوح المكاني، بغداد.

## 1. INTRODUCTION

The latest developments of Web2 techniques over the last three decades have enabled users to create, share, download, embed, and edit their own generated content to the related Web2 platforms, such as Facebook, YouTube, Flickr, etc, (AL-Bakri, 2015 and O'Reilly, 2007). In terms of the geospatial information, users can freely share and download their local spatial information to the open-access Web2 mapping projects such as OSM project, Google Maps, Wikimapia, Google Earth, Yahoo! Imagery, and others (Haklay, 2008). All of these geospatial platforms that are considered an open-licensed source data were grouped under the term Volunteered Geographical Information (VGI) by Mike Goodchild in 2007 (Haklay, 2008).

Online geographic information usually were creating by users using a set of techniques and tools that fall outside the realm of traditional Geographic Information Systems (GIS) (Turner, 2006). Moreover, the latest advancements in geospatial data collection methods have helped the non-experts users to pick up their spatial data rapidly and easily using their portable GPS devices. Therefore, (Turner, 2006), defined this technology as 'Neogeography', which means geography without geographers. Most of the available collaborative geographical data services on the internet are creating and sharing by volunteer contributors, who have little experiences in surveying works, (Haklay, 2010). Therefore, these data were defined as a sort of User Generated Content (UGC) (Antoniou, 2010).

The different geospatial data collection methods and unequal experience levels of users have made the accuracy of VGI is questionable and unreliable and need to be examined before using them for any engineering application. Therefore, the related researchers started to investigate the quality of those online freely available geographical data services such as OSM project. (Zielstra1 and Zipf, 2010) compared the positional accuracy between OSM datasets and Tele Atlas datasets in Germany in terms of positional accuracy and completeness. The Tele Atlas data is usually measured using the laser scanner and GPS techniques, therefore, the positional horizontal accuracy of these data can reach up to 1 meter. The results showed that the contributions made by the volunteers in Germany were very effective, so the OSM project is expected to outperform the Tele Atlas data in the near future. Moreover, the results showed that the bigger cities have higher completeness than the medium and small-sized cities. (Haklay, 2010) assessed the completeness and the positional accuracy of OSM road data in five selected areas in London /UK by comparing OSM datasets with an analog dataset from Ordnance Survey (OS) Master Map. The estimated positional horizontal accuracies in each area were 6.77, 8.33, 6.04, 3.17, and 4.83m. This means that the positional horizontal accuracy of OSM data differs between the different regions in London, this is due to the digitization method, data collection skills, and the sabra of the contributor who conducted the work. (AL-Bakri and Fairbairn,



2010) tested the positional accuracy and the shape quality of OSM data in the UK by comparing them with OS data and an accurate Field Survey (FS) dataset. The study concluded that the positional discrepancies between the OSM dataset and each of the two other datasets were very large. Also, the shape quality evaluation which was measured by using the invariant moment method indicated that the OSM dataset does not conflict with each of the two other datasets OS and FS in each of the two study sites, the urban site, and the rural site. The outcomes showed that the (TT) and OSM datasets have high positional accuracy and therefore they can be used to produce maps with medium and small scales. (Goudarzi, 2017) assessed the Google Earth horizontal positional accuracy in Canada, Montreal using an accurate GPS dataset. The findings showed that the positional accuracy was about 0.1 m in the south and about 2.7 m in the north. The study discussed the displacement problem which can occur due to the topography of the earth and the angle of view of the imaging satellite. (Zhang and Malczewski, 2018) assessed OSM street network data quality in terms of positional accuracy and completeness accuracy by comparing these data with a dataset from the national road network database in Canada, the Digital Mapping Technologies Inc. (DMTI) which published on Sept. 1, 2015. DMTI has a positional accuracy ranges from 0.6m (urban) to 30m (rural). The study concluded that the positional horizontal accuracy of OSM data was 25m with respect to DMTI. Moreover, the study showed that the urban areas received more contributions than rural areas.

The diversity in the accuracy of data acquisition methods and the degree of experience of the keen volunteer's contributors to OSM project, make the accuracy of OSM project datasets is unreliable and questionable. In this research, the accuracy of the horizontal position has been assessed for three different spatial data sources for Baghdad city, OSM project road network data, Satellite Image (SI) with 0.50m resolution, and Aerial Photo (AP) with 0.10m resolution. The assessment process was carried out by comparing these three different datasets with an analogue authoritative geospatial dataset obtained from the official road network mapping agency of Baghdad city, the Mayoralty of Baghdad (MB). Different techniques and procedures were followed and applied to evaluate OSM dataset quality as well as the two raster datasets to determine the usability of each data source for updating the road network databases in Baghdad city for serving the collaborative mapping between the formal and informal datasets.

## 2. METHODS

### 2.1 Case Study Description and Data Collection

Two study sites were selected in Baghdad city, the first study site is a part from AL-Aadhamiyah town which is in AL-Rusafa side and the second study site is a part from AL-Kadhumiyyah town which is in AL-Karkh side as shown in the **Fig. 1,a** and **Fig. 1,b**. In this study, the areas of the two used parts are 17km<sup>2</sup> and 12km<sup>2</sup> of AL-Aadhamiyah and AL-Kadhumiyyah, respectively. Each of these two study sites contains official and private buildings, residential areas, agricultural areas, main roads, highway roads, secondary roads, streets, pedestrian routs, parks, green lands, markets, and many other land use landscapes. The proportion of agricultural and wet areas in the study site of AL-Kadhumiyyah town is larger than it in the study site of AL-Aadhamiyah town. These areas were extracted from the assessment process due to the absence of clear and systematic road intersection points in such these areas. Each of the two study sites is

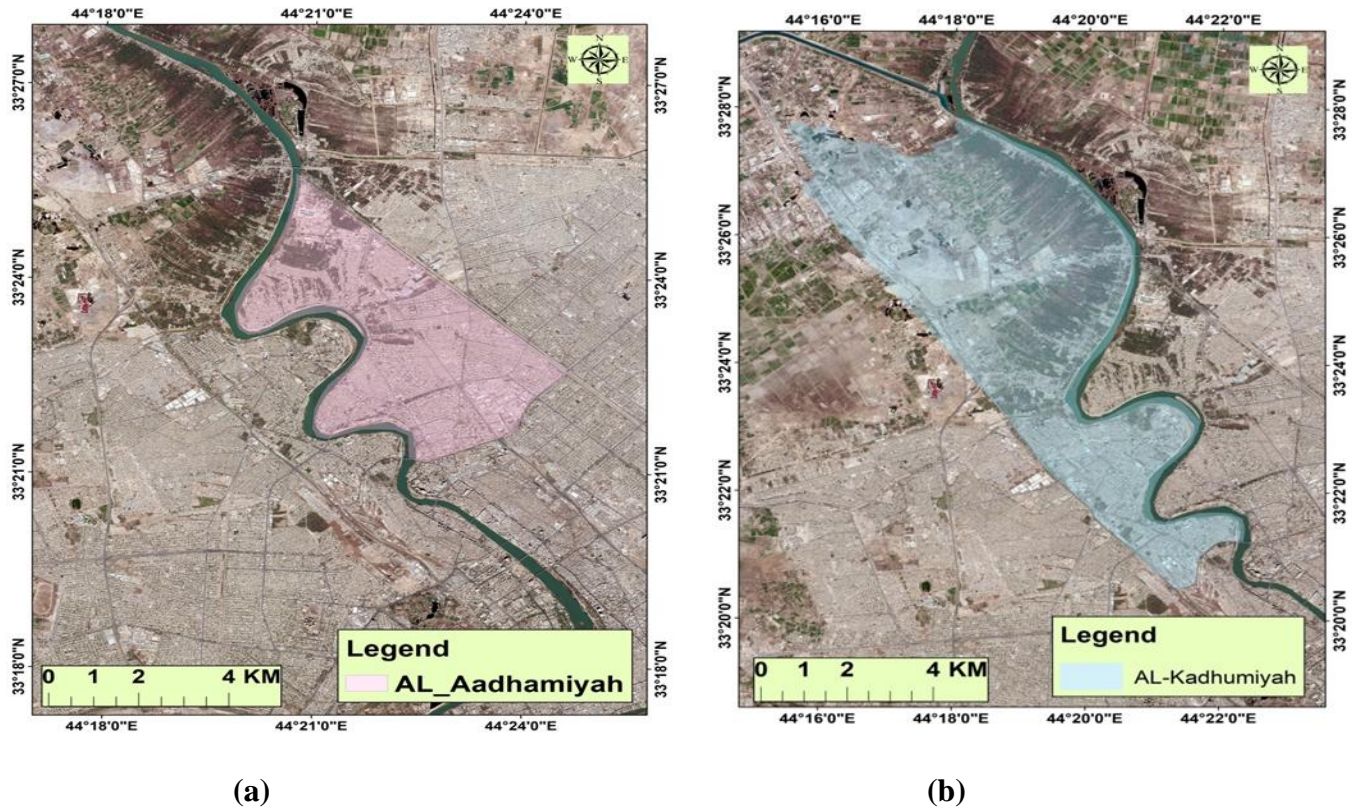


considered an important commercial and religious center in Baghdad city and attracts a lot of visitors for religious tourism and shopping in addition to their an indigenous population density. So the road network needs constant maintenance and development in order to avoid any problem in terms of congestion.

Four different road network data sources of the two selected study sites in Baghdad city were used to carry out this research, three of them are informal data sources, while the fourth source is a formal data source. The three informal datasets are the open-source OSM road network shapefile, Aerial Photo (AP) with spatial resolution of 0.10m and a Satellite Image (SI) with a spatial resolution of 0.50 m. To achieve the aims of this research, similar boundaries were taken for all datasets to ensure high level of assessment positional accuracy. For conducting the assessment, these three evaluated points datasets AP, SI, and OSM were compared with an analogue authoritative dataset as reference dataset obtained from Mayoralty of Baghdad (MB), the official road network mapping agency in Baghdad city. MB roads network dataset was traced from QuiqBird satellite images with resolution of 0.60 m using GIS software techniques which are referenced to the spheroid WGS84 and the projection UTM zone 38N. By contrast, most of OSM road data for Iraq are mapped by tracing the information from different resolution satellite images such as Yahoo! Satellite images, LANDSAT images, Esri satellite images, and more others (AL-Bakri, 2015).

OSM data has many thematic layers which were created by Frederik Ramm on his website Geofabrik using OSM tags. The OSM project data are available as free online source and can be downloaded with Esri shapefile format from Geofabrik website (<http://geofabrik.de.com/>). Geofabrik website is an open-source application was created by Frederik Ramm to process the contributed OSM datasets by the volunteers to provide a free digital map of all the world. OSM digital maps consist of many thematic layers including buildings, land use, rivers, roads, railways, waterways, nature, points, places, etc (Haklay, 2008).

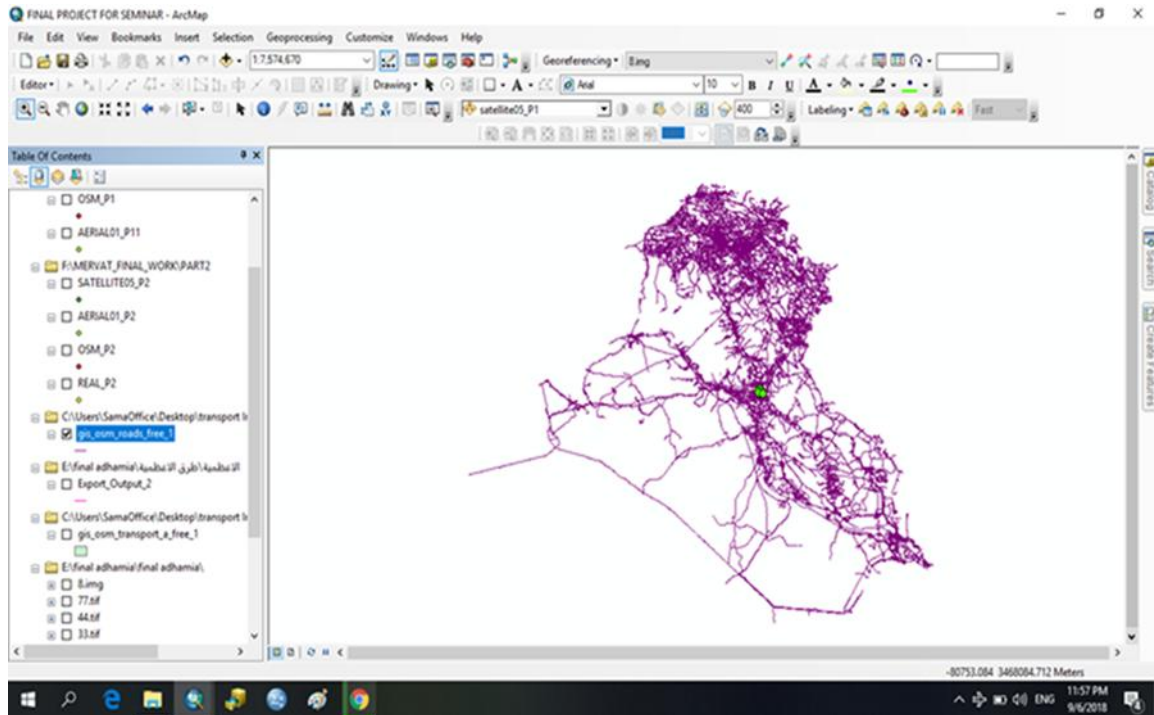




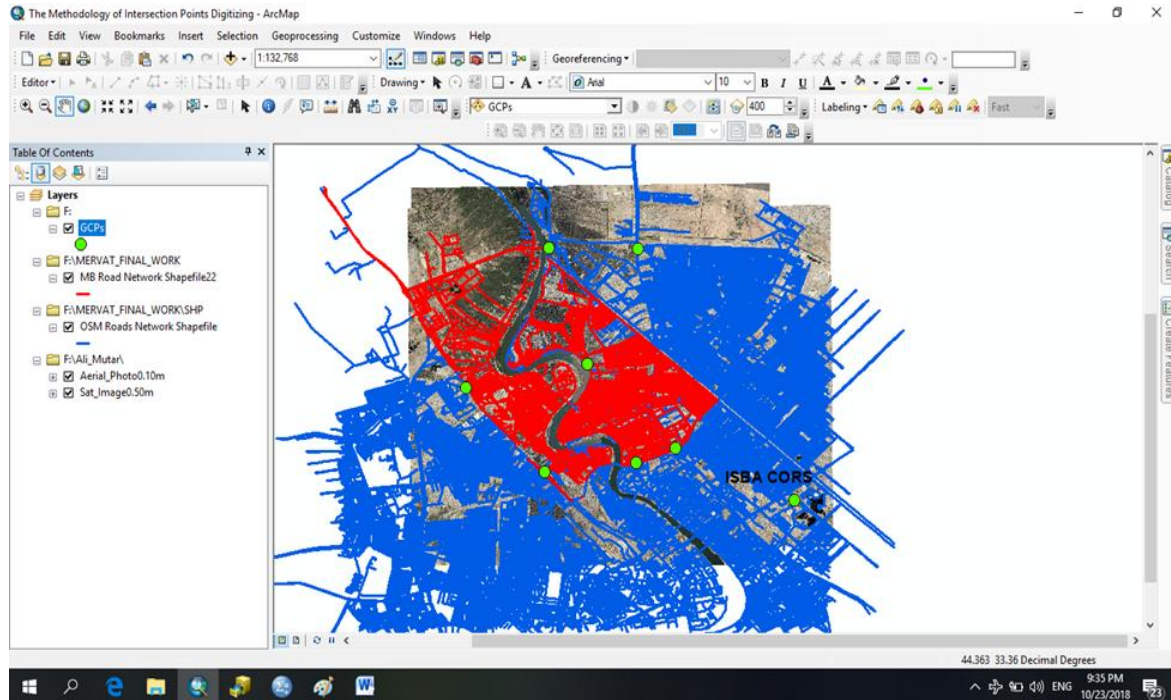
**Figure.1** Boundaries of the Two Study Areas in Satellite Image 0.50m Format  
(a) AL-Aadhamiyah Area (b) AL-Kadhumiyah Area (source: General Directorate of Surveying)

OSM data file has been downloaded for all the parts of Iraq with a file size of 35.8 MegaByte and the latest date modified was 17/4/2018. The downloaded file consists of a number of shapefiles, which are compatible with GIS package. Although, the OSM project data has many thematic layers, however, only road network layer was selected and displayed on GIS interface to conduct the assessment process as shown in **Fig. 2**.

In terms of the two raster data sources, one georeferenced scene of each of the satellite image and the aerial photo was used to cover the two study sites. The georeferencing process was performed by ArcMap10.4.1 software using (7) ground control points, which were observed using PPK GPS technique around the two study areas. **Fig. 3** illustrates the four different data sources in georeferenced vision in the ArcMap interface, where the red color shapefile represents MB road database while the blue color shapefile represents OSM road database. To conduct this study OSM road network shapefile which is in blue was extracted only for the selected two study areas, as shown in **Fig. 3**. ArcMap 10.4.1 software was used to extract the coordinates of the selected road intersection point datasets from the Aerial Photo (AP), the Satellite Image (SI), OSM shapefile, and MB shapefile for each study area. Moreover, **Fig. 3** illustrates ISBA CORS point location with respect to the 7 GCPs locations.



**Figure. 2** OpenStreetMap Road Network Data for All Iraq in GIS Interface.  
Source (<http://download.geofabrik.de/asia/iraq.html>).



**Figure. 3** The Four Georeferenced Data Sources and The Seven GCPs in GIS Interface.



### 2.3 Digitizing Intersection Point Datasets

The four intersection point datasets, MB, SI, AP, and OSM were digitized and saved in the projected reference coordinate system WGS48/UTM zone 38N using ArcMap10.4.1 software. The number of points, which were selected for each case study was, 1018 points in case of study one, AL-Aadhmiyah, while 377 points in case study two, AL-Kadhumiya. Using large sample size is very important to conduct this study due to using too small sample size may lead to failure in detecting the differences between the two compared datasets that may be large and important, Felicien, 2017. Fig. 4 displays a sample of the digitized intersection points on the different four data sources with same IDs.

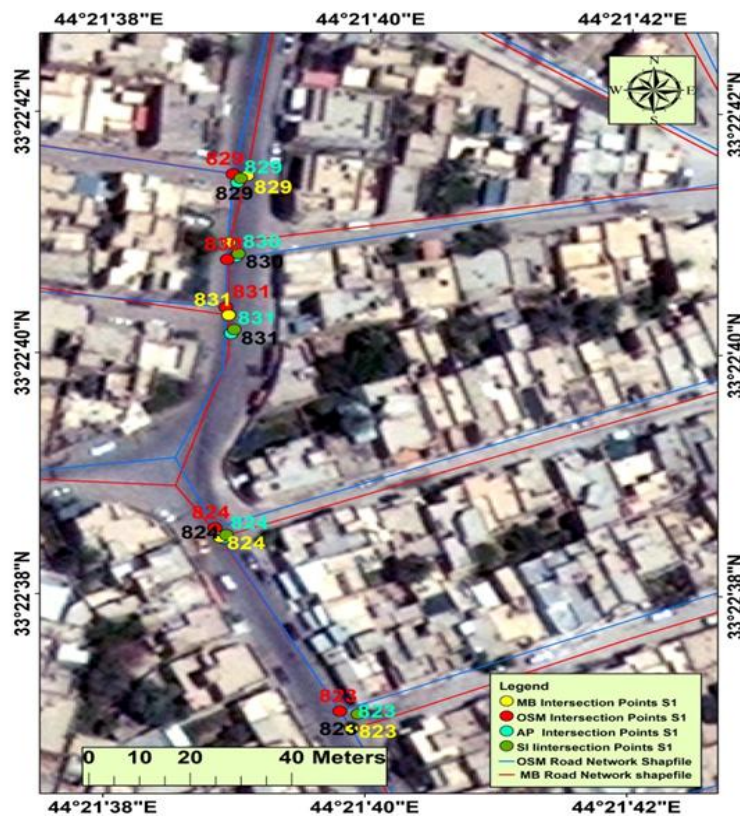


Figure. 4 A Sample of Digitized Road Intersection Points with Same IDs.

### 2.4 Horizontal Positional Accuracy Analysis

After digitizing the selected intersection points, the coordinates were exported in Excel format in order to apply the statistical tests. The Easting and the Northing discrepancies ( $\Delta E$ ,  $\Delta N$ ) between the MB dataset point coordinates and the corresponding coordinates in each of the three datasets AP, SI, and OSM were calculated using the following equations:

$$\Delta E = E_m - E_t \tag{1}$$

$$\Delta N = N_m - N_t \tag{2}$$

Three Easting discrepancies datasets and three Northing discrepancies datasets for each case study were computed and exported in excel format for statistical analysis.



The horizontal discrepancies datasets were analyzed using the statistical analysis software Minitab 17 by finding the descriptive statistics for each dataset in order to describe the distribution pattern of the discrepancies values around the mean value. The findings indicated that the values of means and medians were close to each other for each dataset; this gives a good indication that all the datasets of horizontal discrepancies are normally distributed.

Several standards have been designed and established to assess the positional accuracy of spatial data. All these standards were helpful but did not consider the digital geospatial data that can be easily manipulated and reproduced in varying scales and formats. Therefore, a new standard has been designed by the U. S. Federal Geographic Data Committee (FGDC) in 1996 as a comprehensive standard. This standard was known as the U. S. National Standard Spatial Data Accuracy (NSSDA) (FGDS, 1996). NSSDA allows users to investigate the positional accuracy of digital datasets by comparing them with spatial datasets have higher accuracy. This standard assesses the positional horizontal accuracy of geographical datasets by computing the Root Mean Square Error and NSSDA accuracy using confidence interval of 95% and significant level of 5% of these datasets (Congalton and Green, 2009).

The strategy of NSSDA uses the following algorithms in order to assess the horizontal positional accuracy of geospatial datasets (Greenwalt, 1962).

$$RMSE_E = \sqrt{\frac{1}{n} \sum_{i=0}^n (E_m - E_t)^2} \tag{3}$$

$$RMSE_N = \sqrt{\frac{1}{n} \sum_{i=0}^n (N_m - N_t)^2} \tag{4}$$

n: the size of sample

$E_m, N_m$ : the coordinates of reference dataset points

$E_t, N_t$ : the coordinates of tested dataset points

$$TOTAL\ RMSE = \sqrt{(RMSE_E)^2 + (RMSE_N)^2} \tag{5}$$

If  $RMSE_E = RMSE_N$  then,

$$TOTAL\ RMSE = \sqrt{2(RMSE_E)^2} = 1.4142 * RMSE_E = 1.4142 * RMSE_N$$

$$NSSDA = 1.7308 * (TOTAL\ RMSE) \tag{6}$$

$$NSSDA = (1.7308) * (1.4142) * RMSE_E = (1.7308) * (1.4142) * RMSE_N$$

$$NSSDA = 2.4477 * RMSE_E = 2.4477 * RMSE_N$$

If  $RMSE_E \neq RMSE_N$

$$TOTAL\ RMSE = \sqrt{(RMSE_E)^2 + (RMSE_N)^2} \tag{7}$$

$$NSSDA = (0.5) * (2.4477) * (RMSE_E + RMSE_N) \tag{8}$$





RMSE<sub>E</sub>, RMSE<sub>N</sub>, TOTAL RMSE, and NSSDA accuracy values were computed for each point dataset in each case study using **Eq. (3)**, **Eq. (4)**, **Eq. (7)** and **Eq. (8)**. **Table 1** and **Table 2** summarize the results of the two study areas AL-Aadhamiyah and AL-Kadhumiya, respectively.

**Table .1** The RMSE and NSSDA Values in AL-Aadhamiyah Case Study.

DATASETS	Easting RMSE(m)	Northing RMSE(m)	TOTAL RMSE(m)	NSSDA ACCURACY(m)
MB – AP	3.399	3.381	4.794	8.298
MB - SI	3.666	3.315	4.943	8.544
MB - OSM	4.423	4.397	6.237	10.794

**Table .2** The RMSE and NSSDA Values in AL-Kadhumiya Case Study.

DATASETS	Easting RMSE(m)	Northing RMSE(m)	TOTAL RMSE(m)	NSSDA ACCURACY(m)
MB-AP	5.243	3.598	6.359	10.820
MB-SI	5.275	4.007	6.624	11.359
MB-OSM	5.082	4.865	7.035	12.174

**2.5 Horizontal Shift Analyzing**

The horizontal shifts (Euclidean Distances) between the point locations of formal MB dataset and the corresponding point locations that extracted from each of the three informal data sources Aerial Photo with resolution of 0.10m (AP), Satellite Image with resolution of 0.50m (SI), and OSM road network shapefile (OSM) were calculated by applying the following equation:

$$Horizontal\ shift = \sqrt{\Delta E^2 + \Delta N^2} \tag{9}$$

Where:

$\Delta E$ : the Easting difference between MB dataset points and the corresponding points of each of the other three datasets.

$\Delta N$ : the Northing difference between MB dataset points and the corresponding points of each of the other three datasets.

**2.5.1 Descriptive Statistics Method**

Descriptive statistics method was performed using Minitab 17 statistical software to analyze the horizontal positional shift datasets in each case study. The results are illustrated in **Table 3** and **Table 4** for AL-Aadhamiyah and AL-Kadhumiya, respectively.



**Table. 3** Descriptive Statistics of Horizontal Shift of AL-Aadhamiyah Case Study.

The Items of Descriptive Statistics	Horizontal Positional Shift (m)		
	AL-Aadhamiyah Case Study		
	MB-AP	MB-SI	MB-OSM
Mean	3.892	4.000	4.960
Median	3.213	3.142	3.926
95% CI	(3.719,4.064)	(3.822,4.179)	(4.727,5.193)
Std. Deviation	2.801	2.904	3.782
Maximum Shift	19.252	19.376	24.166
Minimum Shift	0.000	0.111	0.068

**Table. 4** Descriptive Statistics of Horizontal Shift of AL-Kadhumiyah Case Study.

The Items of Descriptive Statistics	Horizontal Positional Shift (m)		
	AL-Kadhumiyah Case Study		
	MB-AP	MB-SI	MB-OSM
Mean	5.495	6.284	6.162
Median	4.895	5.915	5.745
95% CI	(5.171,5.820)	(5.922,6.645)	(5.818,6.506)
Std. Deviation	3.203	3.571	3.398
Maximum Shift	20.633	20.529	18.321
Minimum Shift	0.384	0.337	0.075

**Table 3** and **Table 4** show that the mean values of each dataset are within the 95% CI and the mean and median values are approximately close to each other for each case study. This is a remarkable indication that the datasets are normally distributed. **Table 3** and **Table 4** show that the dispersion items which are Std. Deviation, Maximum Shift, and Minimum Shift for each dataset are close to each other in each case study. This indicates that the three datasets flow the same dispersion pattern.

### 2.5.2 One-Sample T-Test Method

One-sample t-test is a hypothesis test used often to compare the means of two or more homogenous and normal distributed datasets, the first dataset is called the population dataset while the second dataset is called the tested dataset (**Black, 2011**). One-sample t-test assumes two hypotheses to compare the means, the first is the null hypothesis, which states ( $H_0: \bar{x} = \mu$ ), the second hypothesis is the alternative hypothesis, which states ( $H_a: \bar{x} \neq \mu$ ). Where ( $\mu$ ) is the mean of population and  $\bar{x}$  is the estimated mean value of the tested dataset. In this study, the population dataset is represented by the Mayoralty of Baghdad (MB) dataset. While the tested datasets are the three positional horizontal shift datasets MB-AP, MB-SI, and MB-OSM. Minitab 17 statistical software has been used to perform one-sample t-test (two-tailed test) for each of the three positional horizontal shift datasets MB-AP, MB-SI, and MB-OSM for each case study in order to compare the mean ( $\bar{x}$ ) of each tested dataset and the mean of population ( $\mu$ ). **Table 5**



and **Table 6** summarize the results of one-sample t-test of the two study sites AL-Aadhamiyah and AL-Kadhumiya, respectively.

**Table 5.** One-Sample T-Test Results for Horizontal Shift Datasets in AL-Aadhamiyah Case Study.

One Sample T-Test items	MB-AP dataset	MB-SI dataset	MB-OSM dataset
T-Value(calculated)	37.490	37.36	36.78
P-Value	0.000	0.000	0.000
Mean diff.(m)	3.291	3.400	4.360

**Table 6.** One-Sample T-Test Results for Horizontal Shift Datasets in AL-Kadhumiya Case Study.

One Sample T-Test items	MB-AP dataset	MB-SI dataset	MB-OSM dataset
T-Value(calculated)	29.677	30.899	31.782
P-Value	0.000	0.000	0.000
Mean diff.(m)	4.895	5.684	5.562

2.5.3 OSM Data Analysis

The two-sample t-test is a hypothesis test that often used to compare the arithmetic means of two or more normally distributed homogeneous datasets. Therefore, this test was performed in this study to investigate the mean difference between the two MB-OSM horizontal shift datasets in the two study sites in order to assess the positional horizontal accuracy of OSM data in different study areas in Baghdad city. Two-sample t-test assumes that the arithmetic means values of the two tested datasets are equal in its null hypothesis ( $H_0 : \mu_1 - \mu_2 = 0$ ) while in its alternative hypothesis, it is assumed that the two means are not equal ( $H_a: \mu_1 - \mu_2 \neq 0$ ) (**Black, 2011**). In this study,  $\mu_1$  and  $\mu_2$  represent the mean values of MB-OSM horizontal shift datasets in AL-Aadhamiyah town and AL-Kadhumiya town, respectively. The results of the two-sample t-test are summarized in **Table 7**.

**Table 7.** T-o Sample T-Test Parameters of MB-OSM Horizontal Shift Datasets in AL-Aadhamiyah and AL-Kadhumiya.

Two-Sample T-Test Parameters	Resulted Value
The Estimated Difference Between Means	1.202
95% Confidence Intervals for Mean Difference	(1.617, 0.787)
T-Value	5.69
P-Value	0.000
DF	742



## 8. RESULTS AND DISCUSSION

1- It is clear from **Table 1** that the NSSDA values are 8.298m, 8.544m, and 10.794m for MB-AP, MB-SI, and MB-OSM datasets, respectively. This indicates that 95% of the points in each of these three datasets have an error equal to or smaller than 8.298m in MB-AP dataset, 8.544m in MB-SI dataset, and 10.794m in MB-OSM dataset. While, 5% of the points have error values larger than 8.298m, 8.455m, and 10.794m in the datasets MB-AP, MB-SI, and MB-OSM respectively. Whereas the total RMSE values are 4.794m, 4.943m, and 6.237 for MB-AP, MB-SI, and MB-OSM datasets, respectively.

Moreover, **Table 2** shows that the NSSDA values are 10.820 m, 11.359m, and 12.174m for MB-AP, MB-SI, and MB-OSM datasets, respectively. This indicates that 95% from the points in each of these three datasets have an error equal to or smaller than 10.820m, 11.359m, and 12.174m, respectively. While 5% of the points have an error value larger than 10.820m, 11.359m, and 12.174m, respectively. Whereas the total RMSE values were 6.359m, 6.625m, and 7.031m for the datasets MB-AP, MB-SI, and MB-OSM, respectively.

The relatively large values of TOTAL RMSE and NSSDA accuracy indicate that the positional horizontal accuracy of each of the three tested datasets AP, SI, and OSM does not agree with the positional horizontal accuracy of the authoritative MB dataset. The most important reason for this disagreement may be the inaccurate image georeferencing process. It is clear from **Table 1** and **Table 2** that the TOTAL RMSE and NSSDA accuracy values of OSM dataset are larger than those of the other two datasets AP and SI. The most important reason in this large mismatching between MB dataset and OSM dataset is the diversity in data acquisition methods of OSM project by inexpert volunteers either by field surveying works such as real-time GPS trucks or by tracing the spatial information from the different resolution satellite images and aerial photos. Moreover, most of OSM datasets in terms of Iraq are traced from visually georeferenced satellite and aerial images without using GCPs (**AL-Bakri and Fairbrain, 2013**). Moreover, **Table 1** and **Table 2** indicate that the total RMSE and NSSDA values of the two datasets MB-AP and MB-SI are approximately close to each other in each case study. This indicates that the positional horizontal accuracy of these two datasets is approximately close to each other in both study areas. The most important reason of this approximated geometric matching between the two raster datasets AP and SI is conducting an accurate georeferencing process of these two rasters using an adequate number of GCPs.

2- **Table 5** shows that the P-value for each dataset is 0.000 and the t-values are 37.490, 37.360, and 36.780 for MB-AP, MB-SI, and MB-OSM datasets, respectively, in AL-Aadhamiyah case study. **Table 6** shows that the P-value for each dataset is 0.000, while the t-values are 29.677, 30.899, and 31.782 for MB-AP, MB-SI, and MB-OSM datasets, respectively, in AL-Kadhumiyyah case study. These findings are significant indications to reject the null hypothesis and accept the alternative hypothesis. Moreover, the values of Mean diff., are relatively considered large and do not allow matching between MB dataset and each of the other datasets AP, SI, and OSM.





**3- Table 7** shows that the estimated difference between means is (1.202). The 95% confidence interval for difference are (1.617, 0.787). The confidence interval is a range of likely values for the difference. Since, the true value of this difference is unknown, the confidence interval helps to guess its value based on the sample data. The difference between sample means provides an estimate of  $(\mu_1 - \mu_2)$ , and the samples' standard deviations are used to determine how the estimate of difference might be far off (**Heiman, 2013**). Moreover, the calculated t-value is 5.69, and the p-value is 0.000 for degree of freedom 742 and t-critical (tabulated) 1.962. This indicates that the t-value is not within the acceptance region and the p-value is less than 0.05; therefore, the null hypothesis must be rejected, this indicates that the difference mean is not equal to zero. This leads that the horizontal positional accuracy of the OSM road data is not similar in the two case studies AL-Aadhamiyah and AL-Kadhumiyyah due to the difference mean which is estimated by 1.202m

## 9. CONCLUSIONS

**1-** After investigating the normal distribution of the horizontal shift datasets, which were computed between the formal dataset (MB) and each of the other used three datasets AP, SI, and OSM, NSSDA methodology was applied in order to measure the horizontal positional accuracy for each of the three datasets. The study concluded that each of the three tested datasets does not match MB dataset in both selected study areas in Baghdad city. Therefore, the study concluded that the geometric matching between such these large scale datasets is impossible and that the three informal data sources are not appropriate for updating the road network database in Baghdad city.

**2-** For further investigating one-sample t-test have been performed to measure the horizontal positional accuracy for each data source. The resulted t-values from one-sample t-test for the three tested datasets are very closed to each other in each case study, as shown in **Table 3** and **Table 4**. The closed calculated t-values to each other indicate that the horizontal positional accuracies of the three tested datasets are approximately similar. However, the relatively large mean difference values between MB dataset and the three tested datasets AP, SI, and OSM indicate that these three datasets are very far off from the authoritative MB dataset in terms of horizontal positional accuracy. Therefore, this study concludes that the three tested spatial data sources cannot be appropriate for updating road network databases in Baghdad city.

**3-** The results of two-sample t-test which is performed to determine the degree of geometric matching between the two OSM datasets in the two selected study areas in Baghdad city led to reject the null hypothesis and accept the alternative hypothesis. Moreover, the study concluded from performing the two-sample t-test that the horizontal positional accuracy of OSM road network datasets is different in the two selected study areas in Baghdad city by estimated mean difference of about 1.202m. The major reasons for this difference are the varying accuracies of the different data acquisition methods by un-experts volunteers as well as the resulted errors from the transformation processes between the different coordinate reference systems.



## 10. RECOMMENDATIONS

1- Investigating the horizontal positional accuracy of OSM databases in other study areas throughout Iraq to determine the usability (fitness of use) of these databases for updating the authoritative road network databases in each municipality for serving the collaborative mapping.

2- For future works, it is recommended to compare the OSM road network data and remotely sensed road network data with an accurate road intersection point datasets obtained from a field survey using an accurate GPS positioning techniques. This accurate comparison can accurately assess the free available OSM data and remotely sensed images and photos. This can serve the collaborative mapping between the official agencies and the promising OSM project to save costs, efforts, and consuming time of the traditional mapping methods.

3- For future works, it is recommended to evaluate the positional accuracy of other road networks databases provided by other VGI services such as Google Maps, Wikimapia, ESRI road network databases, Google Earth Maps, etc.

4- For future works, it is recommended to evaluate the usability of other types of remotely sensed images that are freely available on the internet such as Google Earth images, Esri satellite imagery, Yahoo! Aerial imagery, etc and addressing the usability of each source for serving the collaborative mapping.

## 11. REFERENCES

- Al-Bakri, M., Fairbairn, D., 2010, *Assessing the Accuracy of Crowdsourced Data and Its Integration with Official Spatial Data Sets*. In Proceedings of Accuracy, Ninth International Symposium on Spatial Accuracy Assessment in Natural Resources and Environmental Sciences, Leicester, UK, 20–23 July 2010, pp. 317–320.
- AL-Bakri, M., Fairbairn, D., 2013, *Using Geometric Properties to Evaluate Possible Integration of Authoritative and Volunteered Geographic Information*. ISPRS International Journal of Geo-Information.
- Al-Bakri, M., 2015, *Ten Years of OpenStreetMap Project: Have We Addressed Data Quality Appropriately? – Review Paper*. Journal of Engineering /Baghdad University, Volume 21, 4, PP: 158-175.
- Antoniou, V., Morley, J., and Haklay, M., 2010, *Web 2.0 Geotagged Photos: Assessing the Spatial Dimension of the Phenomenon*, *Geomatica*. The Journal of Geospatial Information, Technology, and Practice, Vol. 64, PP.99-110.
- Black, K., *Business Statistics: For Contemporary Decision Making*. 2011, Available from, <http://books.google.com.iq/books?id=fdQQwEc6bYC>.
- Congalton, R., and Green, K., 2009, *Assessing the Accuracy of Remotely Sensed Data: Principles and Practices*. USA, CRC Press / Taylor & Francis Group.



- Felicien, N., 2017, *Comparative Performance of Multi-Source Reference Data to Assess the Accuracy of Classified Remotely Sensed Imagery: Example of Landsat 8 OLI Across Kigali City-Rwanda*. International Journal of Engineering Works, Kambohwell Publisher Enterprises, 4 (1), 10-20.
- Federal Geographic Data Committee (1996) Geospatial positioning accuracy standards, Part 3: *National standard for spatial data accuracy*. Report.
- Greenwalt, C., Shultz, M., 1962, *Principles of Error Theory and Cartographic Applications*, Aeronautical Chart and Information Centre, St Louis, MO, USA.
- Goudarzi, A., Landry, R., 2017, *Assessing Horizontal Positional Accuracy of Google Earth Imagery in the City of Montreal Canada*. Geodesy and Cartography, ISSN, VOLUME 43(2): 56-65.
- Haklay, M., 2010, *How Good is Volunteered Geographical Information? A Comparative Study of OpenStreetMap and Ordnance Survey Datasets*, Environment and Planning B: Planning and Design, Vol. 37, 682-703.
- Haklay, M., Singleton, A. and Parker, C., 2008, *Web Mapping 2.0: The Neogeography of the GeoWeb*, *Geography Compass*, Vol. 2, 2011-2039.
- Haklay, M., 2008, *How good is Volunteered Geographical Information? A comparative study of OpenStreetMap and Ordnance Survey datasets for London and the rest of England* submitted to Environment and Planning B.
- O'Reilly Tim, 2007, *What Is Web 2.0: Design Patterns and Business Models for the Next Generation of Software*, MPRA Paper 4578, University Library of Munich, Germany.
- Turner A., 2006, *Introduction to Neogeography*, O'Reilly Media, Inc.
- Zhang H., Malczewski J., 2018, *Accuracy Evaluation of the Canadian OpenStreetMap Road Networks*, International Journal of Geospatial and Environmental Research, Vol. 5, No. 2, Article 1.
- Zielstra D., Zipf A., 2010, *A Comparative Study of Proprietary Geodata and Volunteered Geographic Information for Germany*, 13th AGILE International Conference on Geographic Information Science.