Journal of Engineering and Sustainable Development

Vol. 21, No. 02, March 2017
ISSN 2520-0917
www.jeasd.org

COMPATIBILITY BETWEEN MOBILE GEOPOSITIONS AND LOCAL MAPS IN IRAQ

* Ruba Yousif Hussain

Lecturer, Highway and Transportation Engineering Department, Al-Mustansiriayah University, Baghdad, Iraq.

Abstract: The paper aims to make the coordinates obtained from global positioning systems compatible with local maps in Iraq for mobile locations . Therefore , number of control points have been selected in the study area . Both geographic and map projection coordinates are measured using mobile geopositions based on Universal Transverse Mercator (UTM) projection and World Geodetic System (WGS 1984) datum . The measured geographic coordinates are transformed to map projection in Iraq using geographic information system (GIS) depending on Clarke 1880 ellipsoid . ArcGIS model builder is designed to implement coordinates transformation . Field calculator scripts are written by Python programming language . Differences between the measured and transformed coordinates are determined . The results show that the differences in northing coordinates are about (278.6 m) and the percentage of difference to this value is (0.6 %) , while the differences in easting coordinates reach to (− 287.6 m) with its percentage of difference equals to (0.4 %) in the study area . It is concluded that positions discrepancies should be considered in map production and updating for engineering works .

Keywords: *GeoPosition , WGS 1984 , Clarke 1880 , ArcGIS , Model builder .*

التوافق بين المواقع الارضية للهواتف النقالة والخرائط المحلية بالعراق

الخلاصة: يهدف البحث الى جعل الأحداثيات المستحصلة من أنظمة المواقع العالمية متوافقة مع الخرائط المحلية بالعراق لغرض تحديد مواقع الهواتف النقالة ، لذا أختيرعدد من نقاط الضبط في منطقة الدراسة وقيست الأحداثيات الجغرافية وأحداثيات مسقط الخارطة بأستخدام المواقع الأرضية للهواتف النقالة بالاعتماد على مسقط مركيتر المستعرض العالمي (UTM) وسطح الأسناد للنظام الجيودسي العالمي (WGS 1984) ، وتم تحويل الأحداثيات الجغرافية المقاسة الى مسقط الخارطة بالعراق بأستخدام نظام المعلومات الجغرافي بالأعتماد على المفلطح (Clarke 1880) من خلال تصميم باني النموذج (Model builder) داخل حقيبة البرمجيات (ArcGIS) لتنفيذ تحويل الاحداثيات حيث كتبت برامج حسابات الحقول بلغة البرمجة (Python) ، وتم تحديد الفروقات بين الأحداثيات المقاسة والمحولة وأظهرت النتائج أن فروقات أحداثيات الشمال بحدود (278.6 m) ونسبة الأختلاف المئوية لهذا المقدار (0.6 %) ، بينما وصلت فروقات أحداثيات الشرق الى (− 287.6 m) وبنسبة أختلاف مئوية تساوي (0.4 %) ضمن منطقة الدراسة ، ويستنتج من ذلك وجوب مراعاة فروقات المواقع عند أنتاج وتحديث الخرائط للأعمال الهندسية .

الكلمات المفتاحية: *الموقع الأرضي ، النظام الجيودسي العالمي 1984 ، كلارك 1880 ، نظام المعلومات الجغرافي ، باني النموذج .*

1. Introduction

Two types of coordinate systems are commonly applicable : geographic and map

* engineer.ruba@uomustansiriyah.edu.iq

coordinates . In most works , the geographic coordinates are measured and then transformed into map coordinates . The positions must be measured according to the coordinate system of the country . Each country has datum and ellipsoid . Different datum surfaces and ellipsoids cause different coordinate values . GeoPosition mobile application is used in this study to measure both geographic and map coordinates . Universal Transverse Mercator / Universal Polar Stereographic (UTM / UPS) is selected in the application display window as a map projection .

While a spheroid approximates the shape of the earth, a datum defines the position of the spheroid relative to the center of the earth . A datum provides a frame of reference for measuring locations on the surface of the earth . It defines the origin and orientation of latitude and longitude lines [3] .

A map projection cannot be a perfect representation, because it is not possible to show a curved surface on a flat map without creating distortions and discontinuities [2] .

The topographic map update in many countries is conducted less significantly than it is required . Thus , Iraq is one of those countries, where some of topographic maps at the scale of 1:25,000 , 1:50,000 and 1:100,000 are not updated , and if they are , then only those with the small coverage areas [1] .

The World Geodetic System 1984 (WGS 84) is the global reference frame upon which Global Positioning System (GPS) observations are referenced to . Observations in the frame are in latitudes, longitudes and ellipsoidal heights . For use in a particular locality , it is necessary to convert these into the local coordinate system [5] .

Designing model builder in ArcGIS software simplifies the implementation of coordinate transformation . Model builder is a series of selected tools of ArcGIS , ArcToolBox . On the other hand , Clarke 1880 is the reference ellipsoid used in Iraq because it is fit the real shape and size of the land .

Karbala 1979 was used in conjunction with the UTM system of map projections, as well as with a dedicated TM projection , known as the Iraq National Grid whose area of use is all of onshore Iraq [4] .

2. Iraq Spatial References

The spatial reference of local maps in Iraq is based on Clarke 1880 ellipsoid . It has a point of origin located in Karbala province . At this point the deflection of vertical equals to zero . Origin datum is a point of intersection of the ellipsoid surface with the geoid and not the ellipsoid center . GPS and their associated geoposition software are working on WGS 1984 datum and ellipsoid . Local datum and ellipsoid in Iraq are not identified in these systems . This required coordinate transformation between the WGS 1984 system and Clarke 1880 ellipsoidal parameters .

The spatial reference properties for WGS 1984 and Clarke 1880 ellipsoids are illustrated in Table 1 [3] . Seven parameters must be determined for datum transformation. These parameters include three translation parameters , three rotation parameters , and one scale factor . The first step of geopositions is to obtain geographic coordinates (latitude and longitude) referenced to specific ellipsoid and datum . The second step is to project these coordinates to the map (northing and easting) using equations of map projection . UTM zone 38 north is a common map projection used in

Iraq . This transformation requires knowledge of five projection elements . These elements are false northing , false easting , latitude of origin , central meridian , and scale factor .

Table 1. Spatial references of local maps in Iraq

	Geographic Coordinate System	
Spheroid	WGS 1984	Clarke 1880
Datum	WGS 1984	Karbala 1979 Polservice
Semimajor axis (a)	6378137.0 m	6378249.145 m
Semiminor axis (b)	6356752.314 m	6356514.869 m
Inverse flattening (1 / f)	298.257	293.465
Eccentricity (e^2)	0.00669438	0.006803511
	Map Coordinate System	
Projection	UTM of Zone 38 North	
False northing	0 m	
False easting	500000 m	
Latitude of origin	0°	
Central meridian	45°	
Scale factor	0.9996	

3. Study Objective

World countries are seeking to produce and update local maps within the framework of reference internationally certified of the WGS 1984 . Base maps available in some government departments in Iraq depend on the ellipsoid of Clarke 1880 , which require linked to the global system . The emergency of up to date digital maps grows especially after the availability of modern technologies of multiple mobile phones , multiple receivers of global positioning systems , remote sensing images , and the use of geopositions to measure coordinates . These information are projected on maps taking into account the compatibility with the local country system . For this purpose , the study aims to convert between different coordinate systems and analysis the amount of differences when adopting two ellipsoids and datum surfaces using ArcGIS software package .

4. Data and Applications

The point locations are obtained using GeoPosition application and ArcGIS software package. GeoPosition is installed on mobile from its application . GeoPosition application is used to measure coordinates in the field . These measurements are entered to ArcGIS to create layers . ArcGIS is preferred in map preparation and coordinate transformation . Fig. 1 shows the study area plan of engineering college of Al-Mustansiriayah university in Bab Al-Moatham . The plan is drawn using ArcGIS , ArcMap program . The selected region lies in Baghdad city in Iraq . The boundaries are extended in WGS 1984 system by (

3690335 m − 3690535 m) northing and (442710 m − 442925 m) easting . The area is about (43000) square meters . Eight control points are marked on the plan . The study area comprises mostly of buildings and agricultural areas.

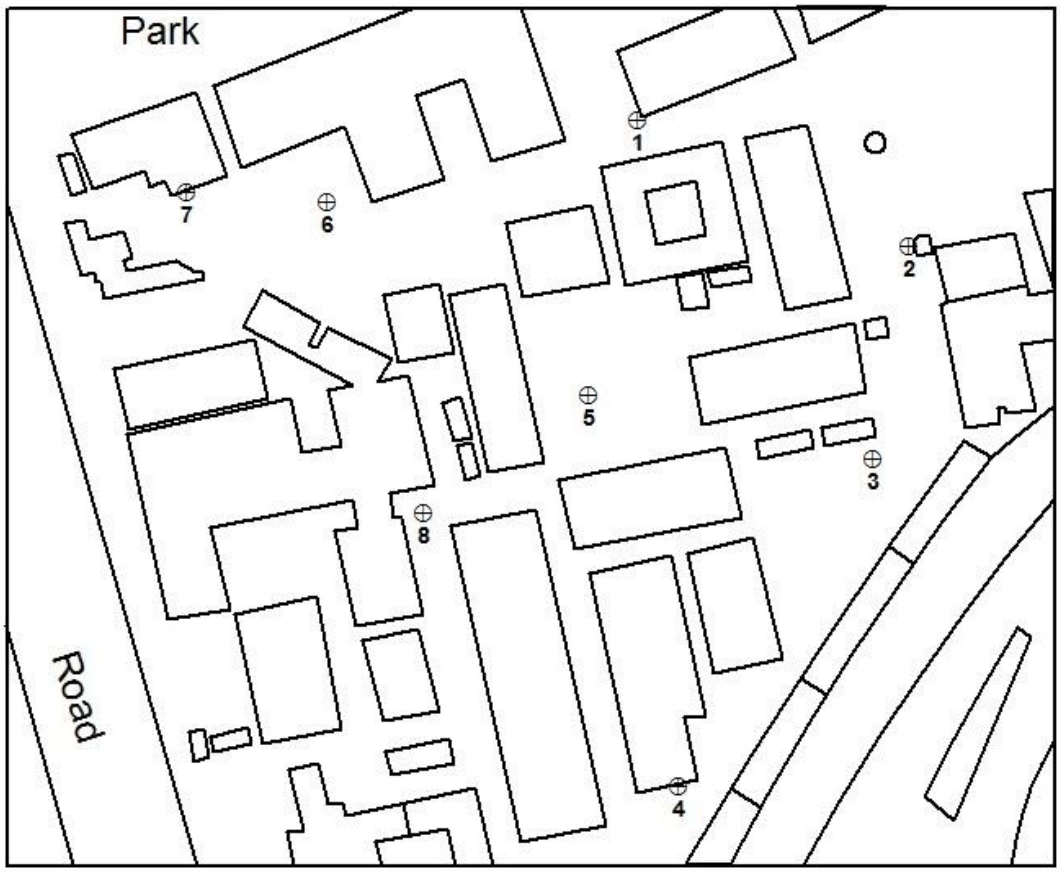

Figure 1. Study area plan and control points of engineering college in Bab Al-Moatham in Baghdad city

5. Field Work

The field work is started by site reconnaissance and establishment of ground control points. Eight ground control points are selected covering study area . The geographic and map projection coordinates are measured in the field using mobile GeoPosition receiver . Table 2 shows the measured geographic coordinates while Table 3 shows the measured map projection coordinates . The screen display of mobile GeoPosition application for each point is illustrated in Fig. 2 , Fig. 3 , Fig. 4 , Fig. 5 , Fig. 6 , Fig. 7 , Fig. 8 , and Fig. 9 .

The mobile works are similar to global positioning system receivers . It receives positions from location service without internet connection . Location service must be turned on before measurement . The green color beside use current position field indicates that the accuracy is suitable for measurement . The observation time for each point is about (30 minutes) . It starts at (8 : 30 AM) and end at (12 : 30 PM) . The geographic coordinates (latitudes and longitudes) are measured in degrees , minutes , and seconds by selecting WGS 1984 datum . The map projection coordinates are measured according to UTM / UPS projection and WGS 1984 datum and ellipsoid of zone 38 north . The latitude band (S) letter is selected in the field right northing . Local maps in Iraq is defined by Clarke 1880 ellipsoid and Karbala 1979 datum point . GeoPosition application does not contain Clarke 1880 ellipsoid in the menu options . ArcGIS software is used to transform geographic coordinates to local map projection in Iraq .

Table 2. Measurement of WGS 1984 geographic coordinates

Point	Measurement Time	GeoPosition Geographic Coordinates	
		Latitude (φ)	Longitude (λ)
1	9 : 00 AM	33º 21' 08.567" N	44º 23' 08.418" E
2	9 : 30 AM	33º 21' 07.343" N	44º 23' 11.075" E
3	10 : 00 AM	33º 21' 05.449" N	44º 23' 10.743" E
4	10 : 30 AM	33º 21' 03.048" N	44º 23' 08.854" E
5	11 : 00 AM	33º 21' 06.128" N	44º 23' 07.855" E
6	11 : 30 AM	33º 21' 07.619" N	44º 23' 05.415" E
7	12 : 00 PM	33º 21' 07.736" N	44º 23' 04.015" E
8	12 : 30 PM	33º 21' 05.141" N	44º 23' 06.330" E

Table 3. Measurement of WGS 1984 map coordinates

Point	Measurement Time	GeoPosition Map Coordinates	
		Northing (N m)	Easting (E m)
1	9 : 00 AM	3690521.368	442840.776
2	9 : 30 AM	3690483.276	442909.224
3	10 : 00 AM	3690425.005	442900.302
4	10 : 30 AM	3690351.334	442851.052
5	11 : 00 AM	3690446.340	442825.781
6	11 : 30 AM	3690492.642	442762.989
7	12 : 00 PM	3690496.461	442726.823
8	12 : 30 PM	3690416.179	442786.193

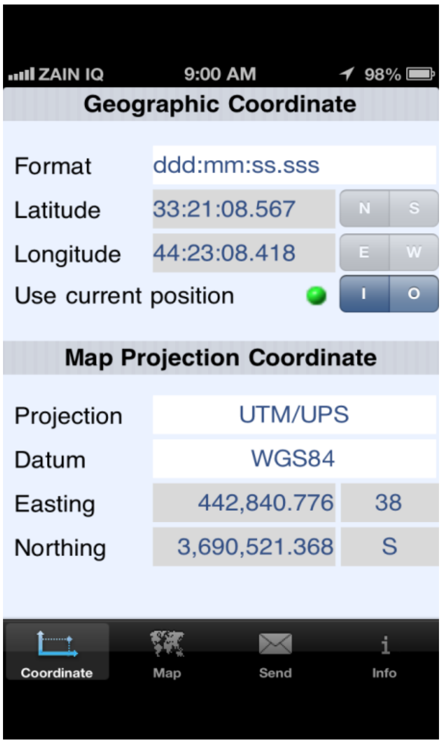

Figure 2. Point 1

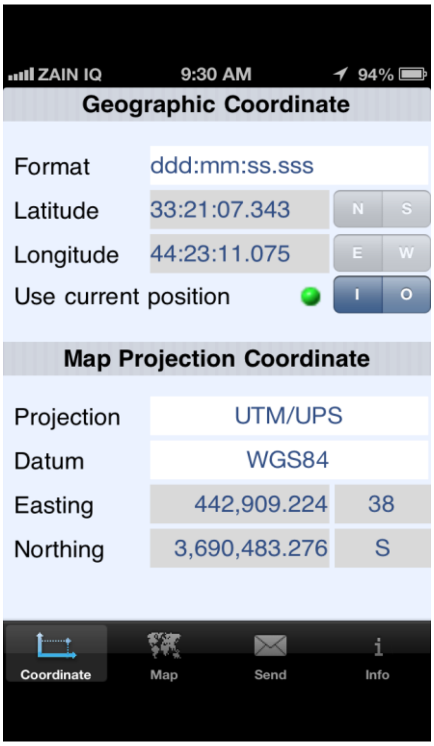

Figure 3. Point 2

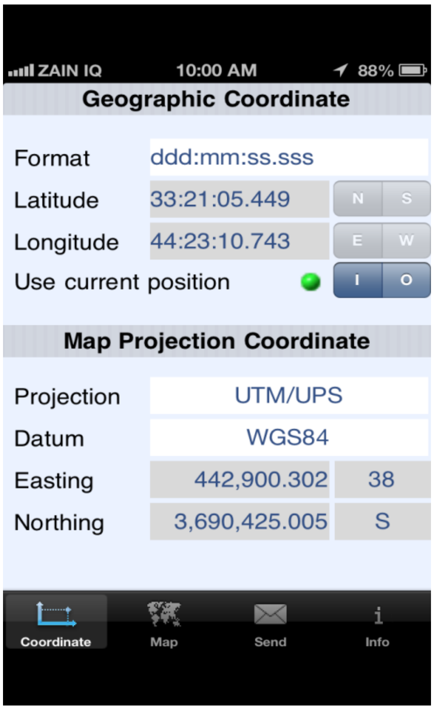

Figure 4. Point 3

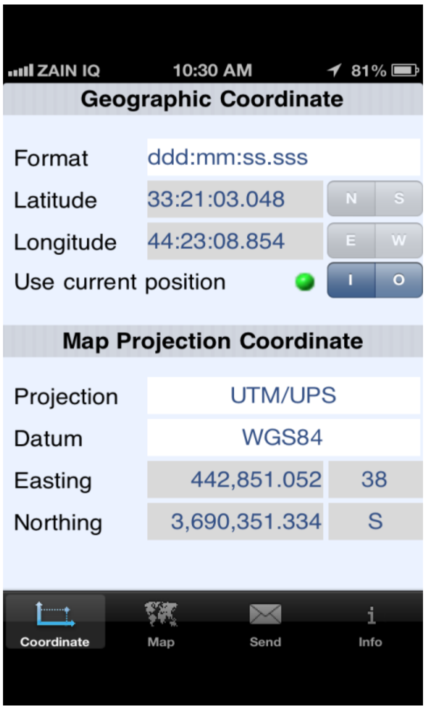

Figure 5. Point 4

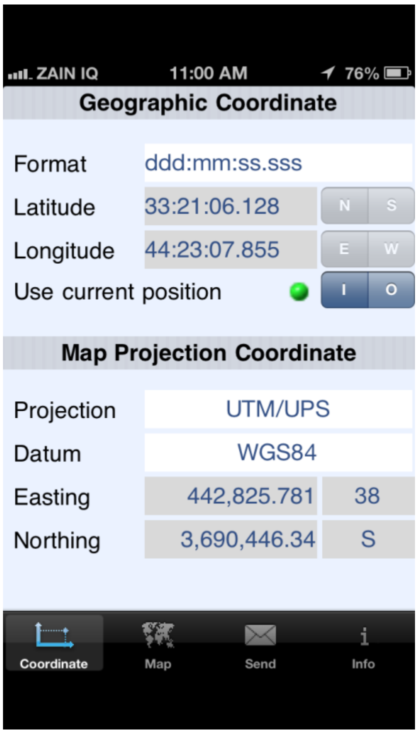

Figure 6. Point 5

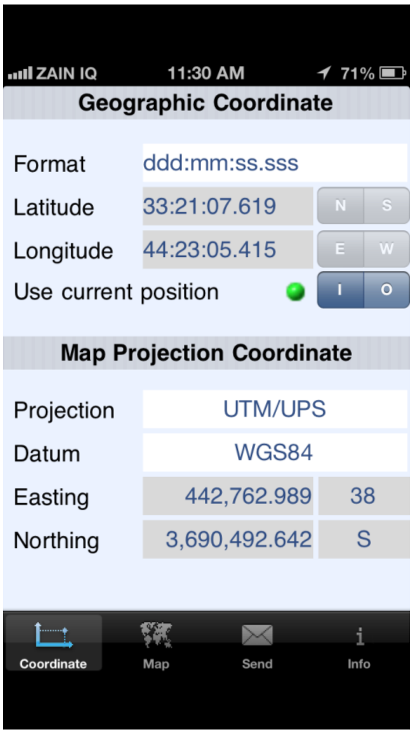

Figure 7. Point 6

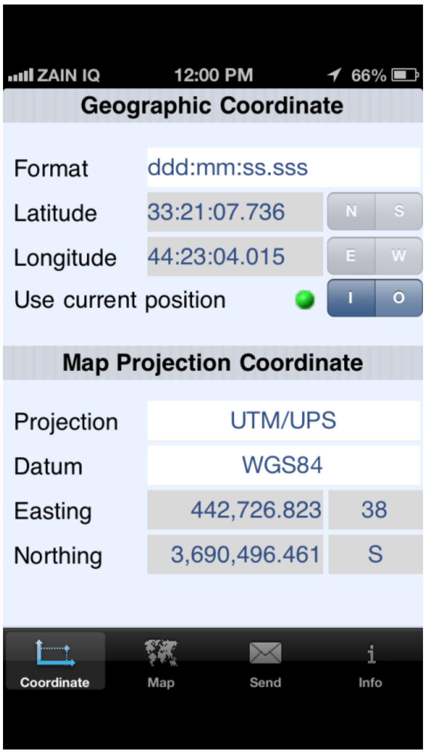

Figure 8. Point 7

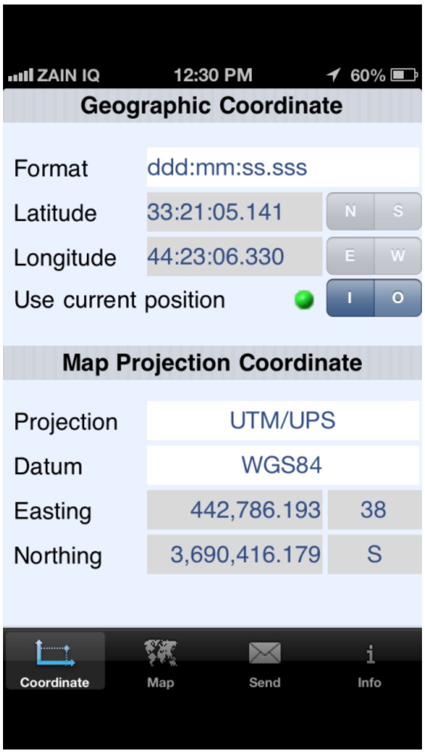

Figure 9. Point 8

6. Design of Model Builder

The computations of coordinate transformation are implemented by designing model builder . The model has been built in ArcGIS software by connecting tools of

ArcToolbox (Fig. 10) . All field calculations are written by Python programming language . The designed model is used to transform a table of geographic coordinates to map coordinates in Iraq . The first step is to convert the measured latitudes and longitudes from degrees , minutes , and seconds to decimal degrees by adding two fields (Lat , Long) . Point shapefile is created from database table using Make XY Event Layer tool. Spatial reference of WGS 1984 is selected . The second step includes datum transformation from WGS 1984 geographic coordinates to geographic coordinates of local maps . The shapefile is projected to Clarke 1880 ellipsoid and karbala datum point using Project tool. Convert Coordinate Notation tool is used to calculate Clarke 1880 geographic coordinates . The third step is to convert latitudes and longitudes to northing and easing coordinates . Project tool is used again to project the geographic coordinates to map coordinates . Northing and easing fields are added to attribute table . The values are obtained by writing python script in the field calculator .

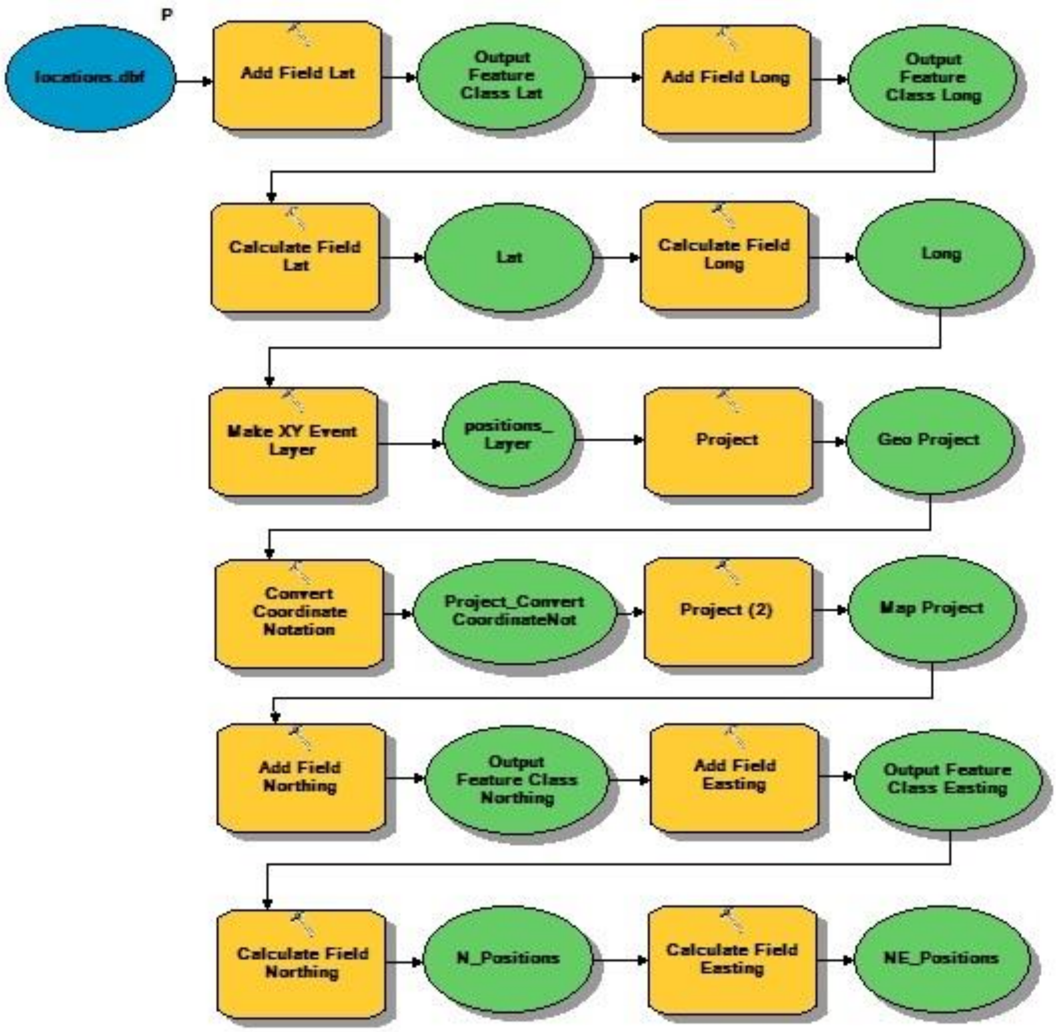

Figure 10. Model Builder for coordinate transformation

The resulted data view and attribute table are shown in Fig. 11 after running the model . Model builder is implemented in ArcMap , ArcGIS . Table 4 shows the resulted map projection coordinates of local Iraqi maps . The designed model can be rerun for any input coordinate file.

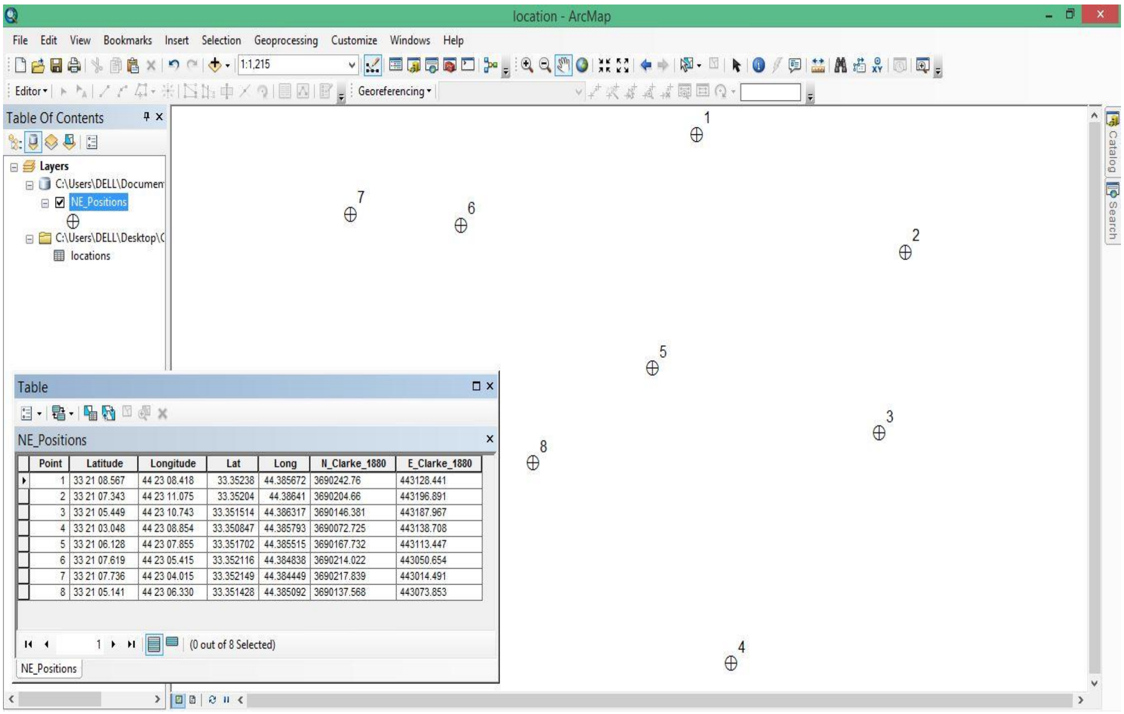

Figure 11. Implementation of model in ArcMap , ArcGIS

Table 4. Transformed map coordinates of Clarke 1880 ellipsoid

Point	Northing (m)	Easting (m)
1	3690242.760	443128.441
2	3690204.660	443196.891
3	3690146.381	443187.967
4	3690072.725	443138.708
5	3690167.732	443113.447
6	3690214.022	443050.654
7	3690217.839	443014.491
8	3690137.568	443073.853

7. Analysis and Results

Map coordinates are more applicable for engineering projects . The differences between WGS 1984 and Clarke 1880 map projection coordinate sets are calculated in Table 5. Fig. 12 and Fig. 13 show northing and easting coordinates respectively . Northing and easting of local maps of Clarke 1880 ellipsoid at eight stations are subtracted from mobile GeoPosition of WGS 1984 positions to give a difference in northing (DN) and a difference in easting (DE) . The differences in northing coordinates reach to (278.6

m) and the percentage of northing differences is (0.6 %) . Easting coordinate differences are about (− 287.6 m) and the percentage of easting differences is (0.4 %). Fig. 14 and Fig. 15 show northing and easting coordinate differences respectively. The maximum of northing differences is (278.624 m) and the minimum of northing differences is (278.608 m) . The maximum of easting differences is (− 287.668 m) and the minimum of easting differences is (− 287.656 m) .

The transformation formulas between WGS 1984 and Clarke 1880 coordinate systems can be deduced from model builder results . The designed model builder can be used to convert between any coordinate systems just by replacing the parameters . Equations (1) and (2) give approximate local map coordinate transformation in the study area . Northing and easting differences may be changed in case of adapting another region .

Table 5. UTM coordinate differences

Point	N (m) WGS 1984	E (m) WGS 1984	N (m) Clarke 1880	E (m) Clarke 1880	DN (m)	DE (m)
1	3690521.368	442840.776	3690242.760	443128.441	278.608	− 287.665
2	3690483.276	442909.224	3690204.660	443196.891	278.616	− 287.667
3	3690425.005	442900.302	3690146.381	443187.967	278.624	− 287.665
4	3690351.334	442851.052	3690072.725	443138.708	278.609	− 287.656
5	3690446.340	442825.781	3690167.732	443113.447	278.608	− 287.666
6	3690492.642	442762.989	3690214.022	443050.654	278.620	− 287.665
7	3690496.461	442726.823	3690217.839	443014.491	278.622	− 287.668
8	3690416.179	442786.193	3690137.568	443073.853	278.611	− 287.660

DN (Mean) = 278.615 m
DE (Mean) = − 287.664 m

$$N\ (\text{Clarke 1880}) = N\ (\text{WGS 1984}) - DN\ (\text{Mean}) \quad (1)$$

$$E\ (\text{Clarke 1880}) = E\ (\text{WGS 1984}) - DE\ (\text{Mean}) \quad (2)$$

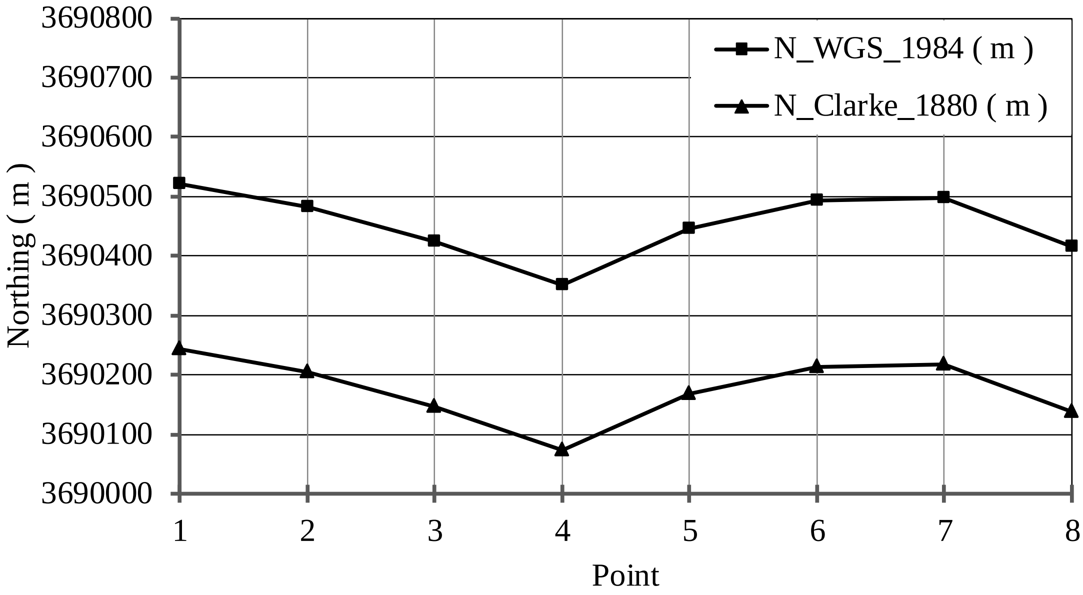

Figure 12. Northing Coordinates

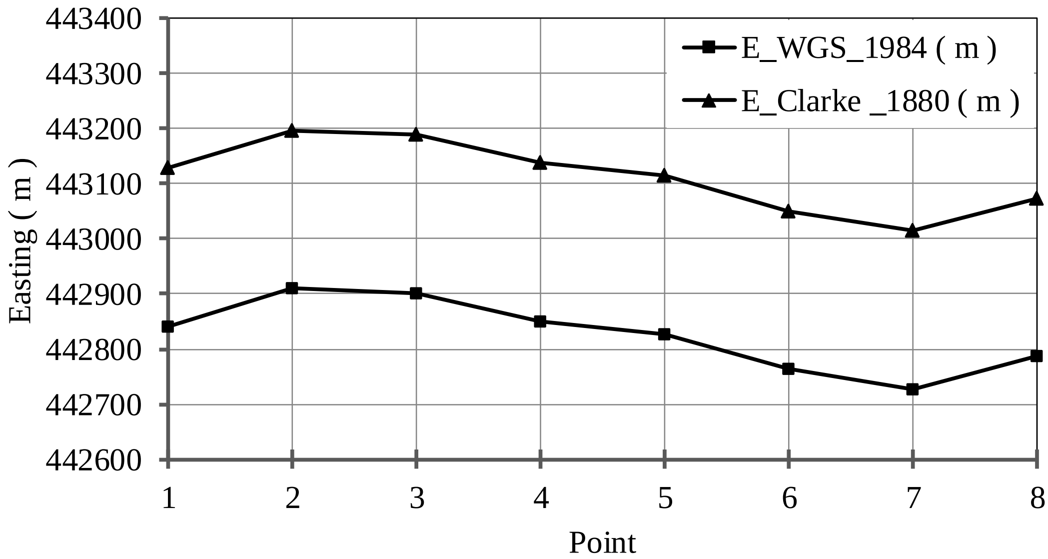

Figure 13. Easting Coordinates

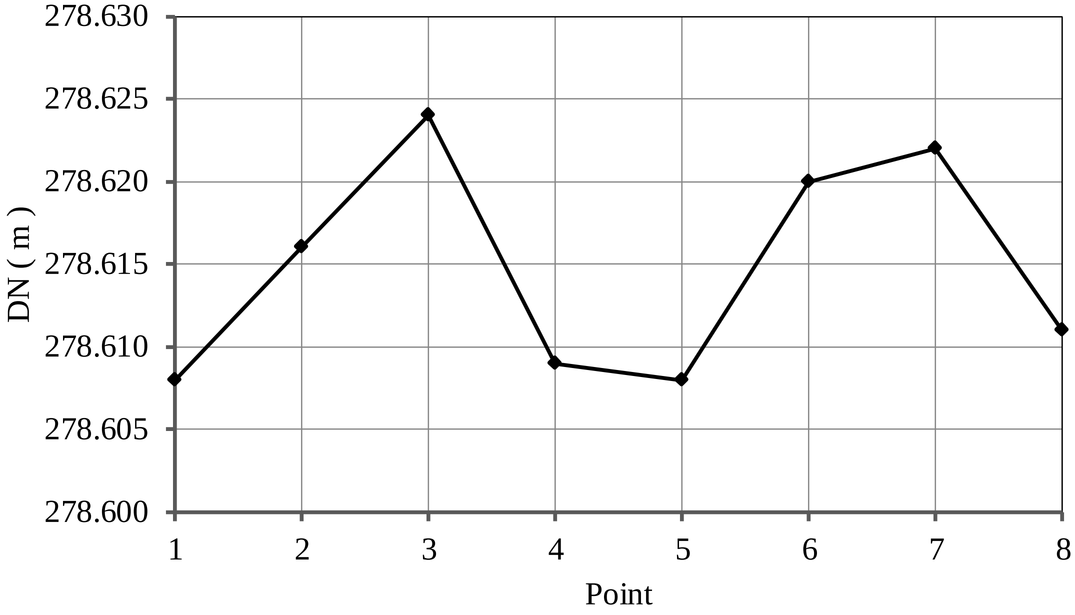

Figure 14. Northing Differences

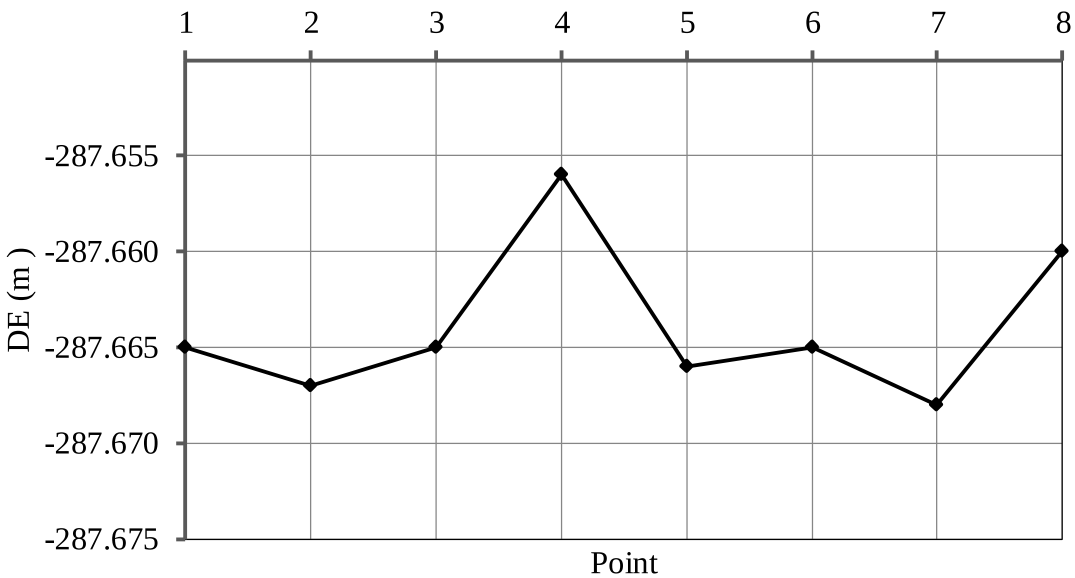

Figure 15. Easting Differences

8. Conclusions

1. There are different datum options in GPS receivers and their associated software applications. The user should select local datum and ellipsoid before measuring coordinates . Local datum in Iraq is not available in GeoPosition mobile application. The coordinates are measured with respect to WGS 1984 spatial reference and then transformed to Clarke 1880 ellipsoid and Karbala datum using ArcGIS software .

2. Designing model builder in ArcGIS package simplifies coordinate transformation . The designed model is flexible and able to convert between different datum surfaces and ellipsoids. This is may be done by replacing the input parameters . When a country amends the ellipsoid parameters , it is called local datum at that region .
3. Coordinate differences between WGS 1984 and Clarke 1880 are resulted from three translations , three rotations , and one scale factor parameters . These differences are relatively close in small area of land . Care should be taken into account between the two coordinate systems . Coordinate differences are changed from region to another and increased in large areas .

9. Recommendations

The study focuses on the two dimensional transformation from WGS 1984 to Clarke 1880 coordinate systems . It is recommended that the geoid undulations are adapted for future works . Geoid undulations represent the differences between ellipsoidal and orthometric heights . GeoPosition application gives plane coordinates . Another receivers of global positioning systems may be used to measure heights .

10. References

1. Abdallah, R. (2015). *" Assessment Accuracy of the Topographic Raster Maps – Iraq* ". Lviv Polytechnic National University Institutional Repository , pp. 152 - 155 , http://ena.lp.edu.ua .
2. A guide to coordinate systems in Great Britain , An introduction to mapping coordinate systems and the use of GPS datasets with Ordnance Survey mapping . (2015). D00659 v 2.3 , Crown , pp. 1 - 43 .
3. ArcGIS Help . (2010). ESRI Inc. http : // www.esri.com .
4. Guidance Note 22 Geodetic referencing in Iraq . (2015). International Association of Oil & Gas Producers , Report 373-22 .
5. Yakubu , I. and Kumi-Boateng , B. (2015). " *Ramification of Datum and Ellipsoidal Parameters on Post Processed Differential Global Positioning System (DGPS) Data – A Case Study* " . Ghana Mining Journal , Vol. 15 , No. 1 , pp. 1 - 9 .