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Studying the Distortion Impact of the Coordinates as a result of using the Coordinate Extension from Zone to Zone

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Abstract

The transformation between zone to zone is successfully applied to the set of the coordinates of selecting project. When a combat area includes more than one grid zone, transformation may be required. In the UTM grid zones, there are overlap areas; however, transformation is not restricted to these overlap areas. Grid coordinates and azimuths can be transformed from any point in one zone into terms of an adjacent zone.
The problem is solved by using different approved software's like ERDAS Imaging 9.2 and Franson CoordTrans to get the same results for one set of coordinate's extent from UTM-WGS84 –Zone 38N to UTM-WGS84 –Zone 39N in the south of Iraq.
The coordinates of the project is measured on the site by considering the total length of the project (100 Km) lies at the zone 38N while actually only 26 km lays in such zone and nineteen control points as base line points had been distributed along the route including the X and Y coordinates corresponding to the zone 38N.
The measurements were applied by using DGPS instrument, which are considered, as one of the new techniques in surveying Technology. A computer program is developed through using ARC GIS to take into account the input parameters of each zone.
It was found that the distortion in the coordinate of each point measured can be neglected especially in the first 80 km of extension. Also it was concluded that the measurements of the points coordinates at the site affected by different type of factors especially the type of instruments using and the type of post processing.

Keywords: Coordinate Transformation, UTM Grid Zone.

الخلاصة

في هذا البحث تم دراسة التداخل بين نطاقين متجاورين من مسقط مركيتر المستعرض حيث تم تطبيق عملية تحويل الاحداثيات من نطاق 39 شمالا الى نطاق 38شمالا, واعطاء احداثيات موحدة ضمن المشروع الواحد.
المشكلة نشأت عند استخدام جهاز ال Trimble DGPS حيث انه لايتقبل نطاقين مختلفين اثناء عملية التصحيح,وكذلك البرامج المستخدمة لانتاج الخرائط مثل ال ARC GIS و Auto Disk لاتتقبل انتاج خارطة تحتوي

*على نطاقين مختلفين في ان واحد. لقد تم حل مسألة توحيد الاحداثيات وجعلها ضمن نطاق واحد بأستخدام برامجيات معروفة ومعتمدة مثل **ERDAS Imaging 9.2 and Franson CoordTrans** وذلك لتسهيل عملية انتاج الخرائط ضمن نطاق واحد. وقد تم مطابقة نتائج الاحداثيات المحولة في الحقل . حيث تم استخدام الاحداثيات ضمن نطاق 38 شمالا على طول المشروع والبالغ 100 كم وذلك بأعتبار جميع احداثيات المشروع مقيسة ضمن ذلك النطاق , بينما يشكل نطاق 38 شمالا" فقط اول 26 كم من طول المشروع والباقي يمثل نطاق 39 شمالا" .*

*لقد تم نشر 19 نقطة ضبط افقية معلومة الاحداثيات الافقية وتقع ضمن نطاق 38 شمالا واستخدام جهاز **Trimble DGPS** لرصد هذه النقاط. حيث ظهر ان التشوه الحاصل في احداثيات نقاط الضبط الافقية الموجودة في نطاق 39 شمالا" والمقيسة ضمن نطاق 38 شمالا" قابل للاهمال اذا كان مقدار الامتداد لايتجاوز ال 80 كم وتم ايضا" استنتاج تاثر اختلاف الاحداثيات لنقاط الضبط الارضي بعدة عوامل ومنها نوعية الاجهزة المستخدمة في القياس وكذلك تعتمد على نوعية التصحيح .*

Introduction

The UTM grid coordinate systems were designed in an attempt to make our lives easier. Surveying with UTM grid coordinates is much like standard Plane Surveying, but without the complicated math of Geodetic Surveying because they provide a way to tie together adjacent projects over a relatively large area **[1].**

Unfortunately, many people have a hazy grasp of exactly what is going on when using the Extension from Zone to Zone in the UTM grid coordinates, and that can lead to some rather exasperating errors and problems.

These errors can crop up in the design of the project, when an Engineer forgets that the Combining objects from different UTM zones into a map that is projected using only one of those UTM zones will result in distortion in the locations and shapes of the objects that originated in a different zone map.

Objective of This Research

The main objective of this research:

1-Exam the extension process and the validity of extension data used for limited distance (not extend more than 80 Km).

2-Using the DGPS Baseline points in one zone instead of two zones.

3-Presented one topographical map for the whole project area.

4- Exam of baseline points with the different coordinate transformation software and match with site data collected.

Study Area

The study area represent railway route alignment that linking between AL-Basra and AL-Fao cities. The peninsular is generally flat and featureless with seasonal water inundation occurring in the central zone from the Khor Al-Zubair to the Shatt Al-Arab. Following the

Shatt Al-Arab the topography rises slightly and provides a shallow hill of a more stable soil formation and this generally follows the gulf coast line towards Um Qasr town**[2].**

The present coordinate system of the study area is UTM-WGS84, Zone 38N and 39N. Due to the length of the line, the alignment touches Zone 38 and Zone 39 and In order to achieve the work in one system and to facilitate the work it is proposed to transform the Zone 39 information into the Zone 38 and then calculate the correspondence errors value in coordinates transformed due to matching the two zones in one zone (Zone 38N). Figure (1) illustrates the boundary of the study Area on the satellite imagery.

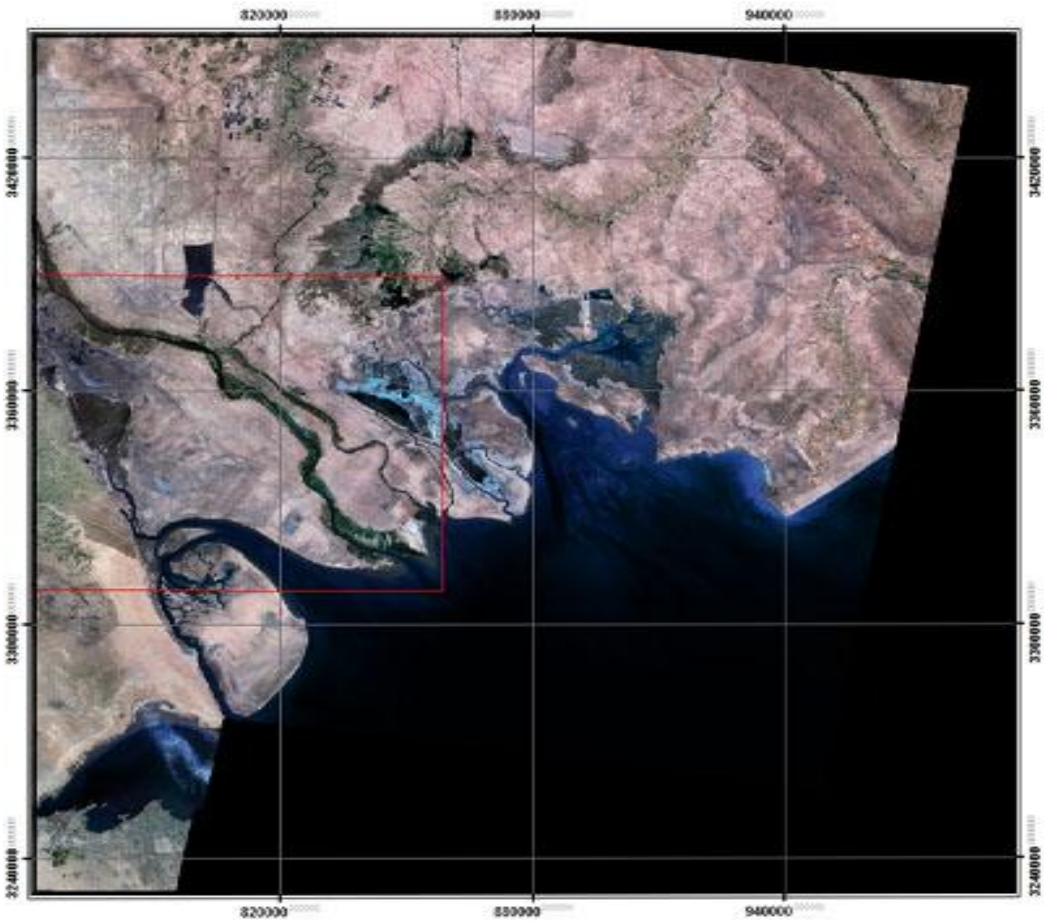


Figure (1): Boundary of the Study Area

Coordinate System and Map Projection

The coordinate system which is used in surveying data and map representation is UTM-WGS84, which is selected to be capable with all new images and maps received from adopted sources. The World Geodetic System 1984 (WGS84) is the datum used by the most Global Positioning System (GPS). The datum is defined and maintained by the United States National Geospatial-Intelligence Agency (NGA). Coordinates computed from GPS receivers are likely to be provided in terms of the WGS84 datum and the heights in terms of the WGS84 ellipsoid.For most practical purposes the WGS84 geodetic datum is coincident with the NZGD2000 and RSRGD2000 geodetic datum's. Therefore coordinates in these systems can normally be assumed to be coincident and a description of the WGS84 datum **[3]** is as table (1):

***Table (1): A description of the WGS84 datum* [3]**

Ellipsoid reference	Semi-major axis a	Semi-minor axis b	Inverse flattening (1/f)
WGS 84	6,378,137.0 m	≈ 6,356,752.314 245 m	298.257 223 563

Map projection

All GPS receivers can provide position information in terms of latitude, longitude, and height, and usually in a variety of selectable geodetic datum's. For many purposes, position information in this format is more than adequate. However, when plotting position information on maps or carrying out supplemental calculations using the position coordinates, it can be advantageous to work instead with the corresponding grid coordinates on a particular map projection **[4].**

One of the most widely used map projection and grid systems is the universal transverse Mercator (UTM) system. Many GPS receivers can directly out put position information in UTM coordinates.

Universal Transverse Mercator (UTM) coordinates are used in surveying and mapping when the size of the project extends through several state plane zones or projections.

The UTM projection differs from the TM projection in the scale at the central meridian, origin, and unit representation. The scale at the central meridian of the UTM projection is 0.9996. In the Northern Hemisphere, the northing coordinate has an origin of zero at the equator. In the Southern Hemisphere, the southing coordinate has an origin of ten million meters (10,000,000 m). The easting coordinate has an origin five hundred thousand meters (500,000 m) at the central meridian. The UTM system is divided into sixty (60) longitudinal zones. Each zone is six (6) degrees in width extending three (3) degrees on each side of the central meridian. The accuracy of any Transverse Mercator projection quickly decreases from the central meridian. Therefore, it is strongly recommended to restrict the longitudinal extent of the projected region when using Universal Transverse Mercator projections to +/- 6 degrees from the central meridian (Figure2). Most of Iraq area lies at zone 38N and the rest area distributed at zone 37N in west of Iraq at AL- Anbar governorate and at zone 39N in far south of Iraq at Basrah governorate (Figure3).

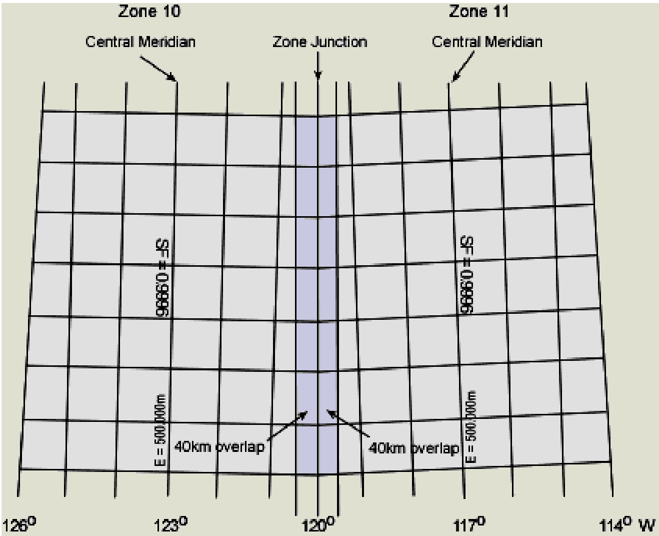


Figure (2): UTM projection illustrated the geographical coordinates [5]

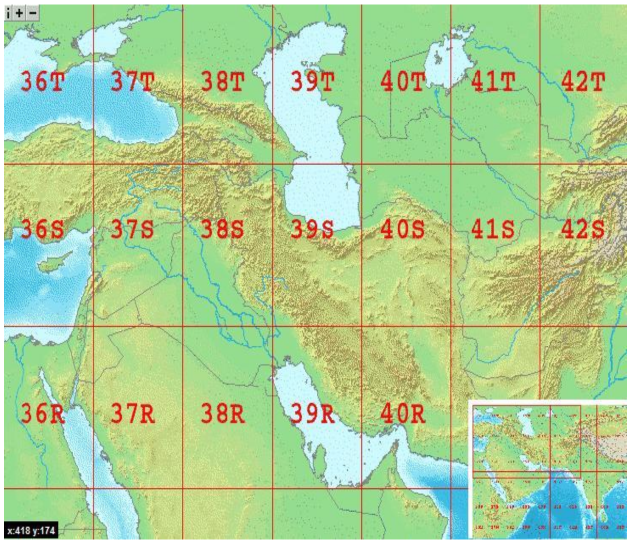


Figure (3): Iraq Zones

GPS Real Time Kinematic

Real Time Kinematic (RTK) satellite navigation is a technique used in land survey and in hydrographic survey based on the use of carrier phase measurements of the GPS, GLONASS and/or Galileo signals where a single reference station provides the real-time corrections[6]. RTK GPS using two or more GPS receivers — a reference (base) receiver and one or more roving receivers communicating together via a radio link. The reference receiver takes measurements from the satellites in view and transmits those measurements, along with the position of the reference receiver, in real-time to the roving receiver. The roving receiver also take measurements from the satellites in view, and process them in real-time with the measurement data and location from the reference receiver [7]. The result is measurement vectors in the WGS84 datum and zone 39 from the reference receiver to the rover receiver. Using these measurement vectors, coordinates for the points occupied by the rover can be computed figure (4).

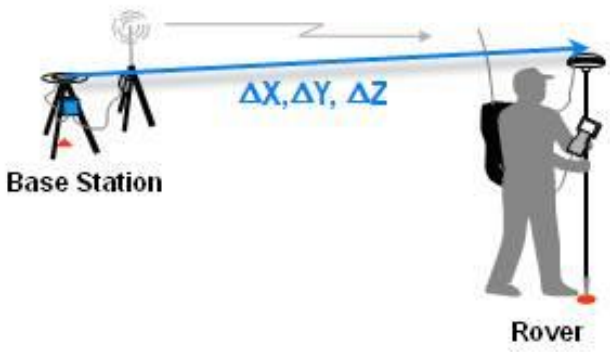


Figure (4): RTK (Real-Time Kinematic)

Methodology of Study

1- DGPS Data Collection and Processing

1.1-Base Station Point Observation

The aim of the study is to establish the appropriate baseline points by using DGPS in specific location according to the study area limit.

The study operation done by connect the local coordinate system based on Clark Ellipsoid (UTM-Clark 1880) with the world Geodetic System based on WGS84 Ellipsoid by taken an observations on Iraq local System which numbered (38065), figure (5) represent the trigonometric point and figure (6) represent Iraq Geospatial Reference System point **[8].**and figure (7) illustrate the location of these points on the satellite imagery.

Figure (5): Iraq Local System Trigonometric Point 38065

Figure (6): Iraq UTM-WGS84-BA12

The Fast Static survey style was used to determine the coordinates of control point by setting the Base Receiver on a fixed point (Iraq Geospatial Reference System) which numbered (BA12) and its coordinates(E:772979.277, N:3379441.642) see appendix(A) and the rover receiver was setting on the local trigonometric Point.
After the processing operations is done by using TGO (Trimble Geomatics Office Software). The coordinates of Iraq Local system-Control Point was determined with respect to UTM (WGS84) zone 38N coordinate system table (2).

Table (2): The resultant coordinate of observed local trigonometric point with WGS84 Datum Zone 38

Point	Easting(m)	Northing(m)
38065	760 915.799	3 351 521.037

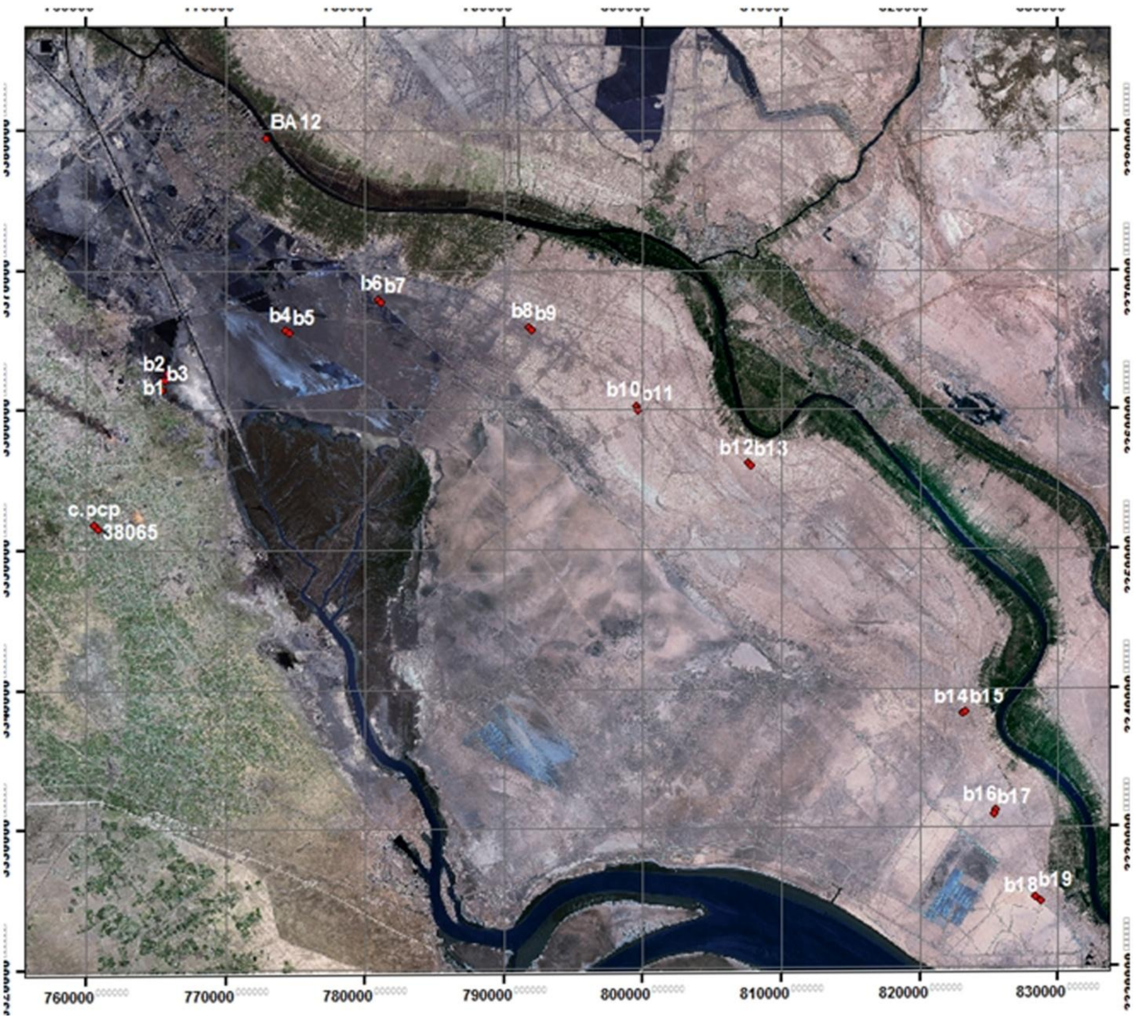


Figure (7): Represent the locations of Base line pointes on the Satellite Image

1.2-Base line pointes observation and processing

After obtaining the coordinate of base station in UTM WGS84 zone 38N, base line point's observation began with two receivers (Base and Rover). One receiver was fixed on the base station (ILS-Trigonometric Control Point (38065)) and the other roving was over base line points each observations of base line points continued 45 minutes to get most accurate coordinates. The Fast Static procedure was used for observing the base line points then the raw data processes began using Trimble software and the coordinates of base line points determined according to UTM WGS 84 zone 38N. Figures (8) and (9) shows the processing of raw data, figure (10) illustrate the zone junction between zone 38 and zone 39 at longitude 48. Table (3) illustrate the Trimble software report and the final results of base line point's observation.

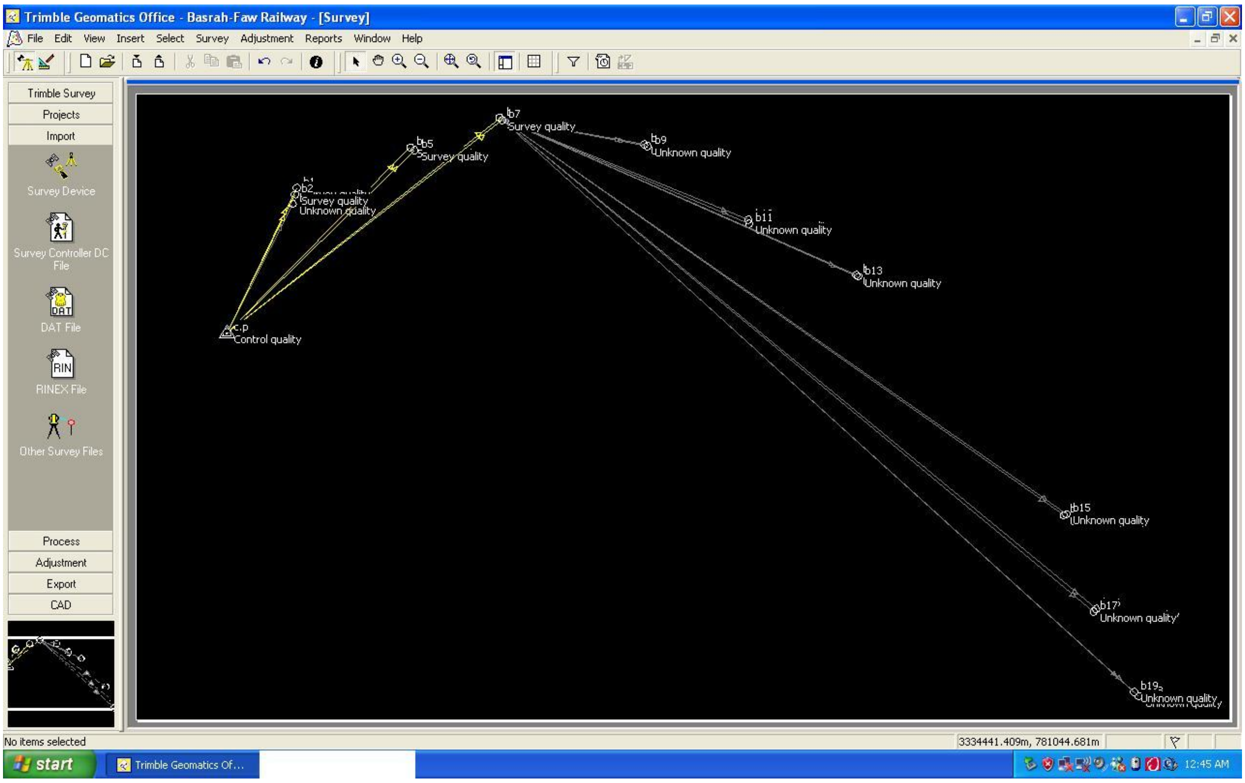


Table (4) illustrate the coordinates of base line points.

Figure (8): Processing of Base line pointes (b1, b2, b3, b4, b5, b6, b7) by using Trimble software

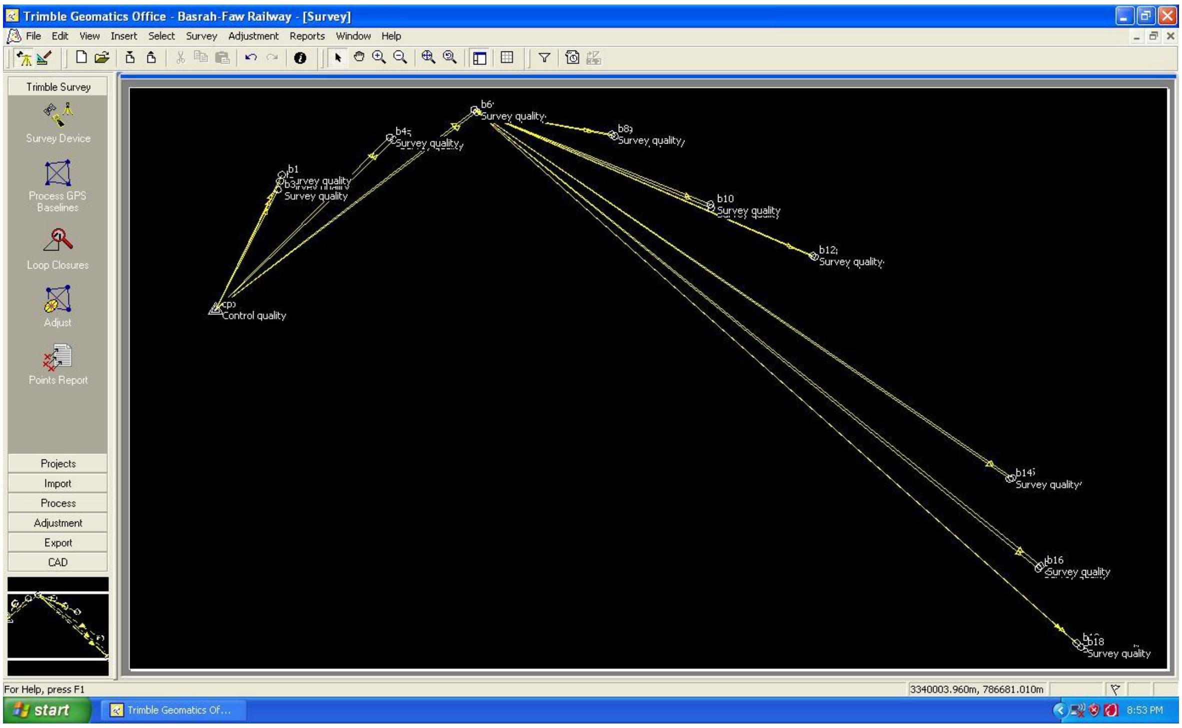
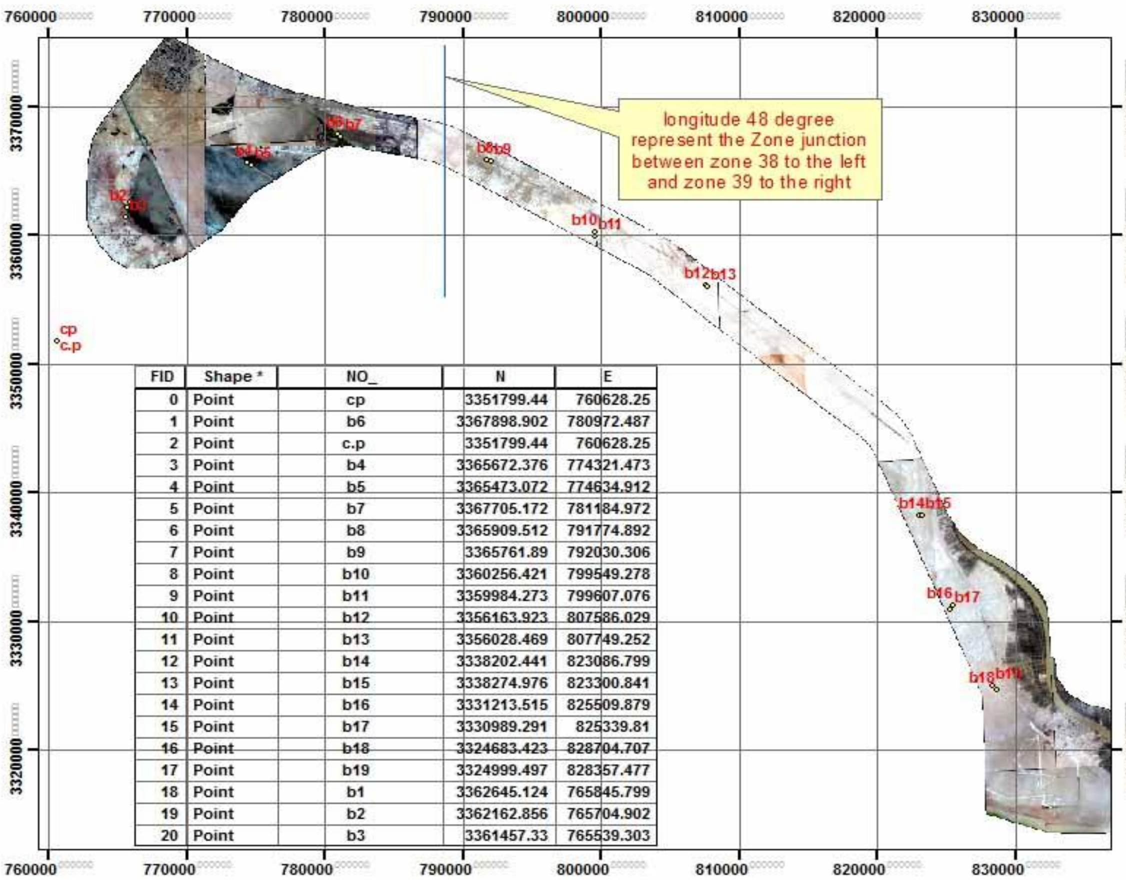


Figure (9): Processing of all Base line pointes by using Trimble software



FID	Shape *		NO_	N	E
0	Point		cp	3351799.44	760628.25
1	Point		b6	3367898.902	780972.487
2	Point		c.p	3351799.44	760628.25
3	Point		b4	3365672.376	774321.473
4	Point		b5	3365473.072	774634.912
5	Point		b7	3367705.172	781184.972
6	Point		b8	3365909.512	791774.892
7	Point		b9	3365761.89	792030.306
8	Point		b10	3360256.421	799549.278
9	Point		b11	3359984.273	799607.076
10	Point		b12	3356163.923	807586.029
11	Point		b13	3356028.469	807749.252
12	Point		b14	3338202.441	823086.799
13	Point		b15	3338274.976	823300.841
14	Point		b16	3331213.515	825509.879
15	Point		b17	3330989.291	825339.81
16	Point		b18	3324683.423	828704.707
17	Point		b19	3324999.497	828357.477
18	Point		b1	3362645.124	765845.799
19	Point		b2	3362162.856	765704.902
20	Point		b3	3361457.33	765539.303

Figure (10): illustrate the zone junction between zone 38 and zone 39 at longitude 48

Table (3) Illustrate the Trimble software report and the final results of base line points observation

Coordinate System	UTM	**Zone**	38 North
Datum	WGS 1984		
Vertical Datum		**Geoid Model**	EGM96 (Global)
Coordinate Units	Meters		
Distance Units	Meters		
Height Units	Meters		

From Point Name	To Point Name	DeltaX	DeltaY	DeltaZ	Slope Distance	Root mean Square Error	Ratio	Reference Variance
cp	b4	-14988.232m	4349.217m	11663.333m	19483.227m	0.017m	21.5	1.777
cp	b5	-15146.060m	4634.052m	11485.067m	19564.875m	0.015m	13.2	1.317
cp	b6	-20657.558m	8071.739m	13435.503m	25930.685m	0.014m	13.2	2.274
cp	b7	-20743.937m	8285.392m	13263.814m	25978.595m	0.007m	31.7	0.676
c.p	b1	-7702.147m	-334.400m	9235.016m	12029.980m	0.011m	14.3	1.622
c.p	b2	-7426.120m	-257.312m	8822.629m	11534.827m	0.01m	11	0.811
b6	b8	-7209.204m	8042.961m	-1959.533m	10977.322m	0.006m	30.2	0.455
b6	b9	-7343.579m	8269.204m	-2092.468m	11255.502m	0.007m	23.8	0.475
b6	b10	-10895.293m	15332.203m	-7014.484m	20074.532m	0.009m	14.7	0.648
b6	b11	-10840.506m	15468.581m	-7250.481m	20232.722m	0.008m	39.1	0.545
b6	b12	-15339.148m	22232.785m	-10736.297m	29066.377m	0.007m	12.8	0.311
b6	b13	-15410.789m	22391.532m	-10857.075m	29270.278m	0.007m	38.5	0.677
b6	b14	-20350.506m	39097.912m	-26623.692m	51493.794m	0.009m	12	0.805
b6	b15	-20534.127m	39216.307m	-26566.679m	51627.101m	0.006m	26.2	0.275
b6	b16	-19656.197m	43211.431m	-32724.097m	57658.133m	0.009m	23	0.545
b6	b17	-19451.514m	43176.120m	-32913.608m	57670.134m	0.008m	37.5	0.648
b6	b18	-19697.736m	47677.989m	-38451.206m	64340.397m	0.010m	26.5	1.037
b6	b19	-19553.661m	47332.115m	-38168.940m	63871.299m	0.009m	13.9	0.969
c.p	b3	-7052.614m	-117.673m	8217.908m	10829.922m	0.011m	15.4	1.54

Table (4) Illustrate the coordinates of base line points

Coordinate System	**UTM**	**Zone**	**38 North**
Datum	**WGS 1984**		
Vertical Datum		**Geoid Model**	**EGM96 (Global)**
Coordinate Units	**Meters**		
Distance Units	**Meters**		
Height Units	**Meters**		
Name	**Northing**	**Easting**	**Elevation**
cp	3351799.440	760628.250	25.400
b6	3367898.902	780972.487	2.889
c.p	3351799.440	760628.250	25.400
b4	3365672.376	774321.473	2.984
b5	3365473.072	774634.912	3.629
b7	3367705.172	781184.972	2.839
b8	3365909.512	791774.892	2.932
b9	3365761.890	792030.306	3.300
b10	3360256.421	799549.278	2.307
b11	3359984.273	799607.076	2.310
b12	3356163.923	807586.029	2.302
b13	3356028.469	807749.252	2.319
b14	3338202.441	823086.799	2.266
b15	3338274.976	823300.841	1.879
b16	3331213.515	825509.879	1.724
b17	3330989.291	825339.810	1.591
b18	3324683.423	828704.707	2.084
b19	3324999.497	828357.477	2.088
b1	3362645.124	765845.799	2.372
b2	3362162.856	765704.902	3.237
b3	3361457.330	765539.303	3.437

1.3-Convert the Field Coordinates of the Baseline points from zone 38N to zone 39N by Using Different Software (ERDAS Imaging 9.2 and Franson CoordTrans software's).

To Exam the different software and match with site data the coordinates of baseline points has been transformed from UTM WGS84 zone 38 to UTM WGS84 zone 39 by using ERDAS Imaging 9.2 and Franson CoordTrans software's and then the results were compared. Tables (5)and (6) illustrate the transformation process of the coordinates.

Table (5) Illustrate the coordinates Transformation process of the base line points by using Franson CoordTrans software

Point	UTM zone 38		UTM zone 39		Geographic coordinate	
	Northing	Easting	Northing	Easting	Lat.	Long.
cp	3351799.440	760628.250	3353278.63	183380.09	30°16'11.6"	47°42'32.8"
b6	3367898.902	780972.487	3368282.89	204552.95	30°24'37.5"	47°55'28.9"
c.p	3351799.44	760628.250	3353278.63	183380.09	30°16'11.6"	47°42'32.8"
b4	3365672.376	774321.473	3366411.75	197792.25	30°23'30.8"	47°51'17.8"
b5	3365473.072	774634.912	3366196.08	198094.75	30°23'24.3"	47°51'29.3"
b7	3367705.172	781184.972	3368078.15	204754.89	30°24'31.1"	47°55'36.6"
b8	3365909.512	791774.892	3365723.66	215235.01	30°23'23.8"	48°2'11.25"
b9	3365761.890	792030.306	3365562.72	215482.23	30°23'18.8"	48°2' 20.6"
b10	3360256.421	799549.278	3359667.51	222698.41	30°20'13.5"	48° 6 ' 56.3"
b11	3359984.273	799607.076	3359392.73	222741.72	30°20'4.6"	48° 6'58.2"
b12	3356163.923	807586.029	3355156.77	230505.85	30°17'53.5"	48°11'52.5"
b13	3356028.469	807749.252	3355012.92	230661.65	30°17'49.0"	48°11'58.5"
b14	3338202.441	823086.799	3336410.25	245032.76	30 °7' 56.5"	48°21'12.1"
b15	3338274.976	823300.841	3336471.4	245250.22	30°7' 58.6"	48°21'20.1"
b16	3331213.515	825509.879	3329307.25	247084.32	30° 4' 7.5"	48°22'34.8"
b17	3330989.291	825339.810	3329092.37	246902.81	30°4' 0.4"	48°22'28.0"
b18	3324683.423	828704.707	3322622.23	249930.81	30°0' 32.6"	48°24'26.6"
b19	3324999.497	828357.477	3322955.87	249600.8	30°0' 43.2"	48°24'14.1"
b1	3362645.124	765845.799	3363837.05	189165.88	30°21'59.4"	47°45'57.8"
b2	3362162.856	765704.902	3363362.77	188999.6	30°21'43.9"	47°45'52.0"
b3	3361457.330	765539.303	3362666.77	188796.81	30°21'21.1"	47°45'45.2"

Table (6) Illustrate the coordinates Transformation process of the base line points by using ERDAS Imaging 9.2

Point	UTM zone 38		UTM zone 39		Geographic coordinate	
	Northing	Easting	Northing	Easting	Lat.	Long.
cp	3351799.440	760628.250	3353278.63	183380.09	30°16'11.6"	47°42'32.8"
b6	3367898.902	780972.487	3368282.89	204552.95	30°24'37.5"	47°55'28.9"
c.p	3351799.44	760628.250	3353278.63	183380.09	30°16'11.6"	47°42'32.8"
b4	3365672.376	774321.473	3366411.75	197792.25	30°23'30.8"	47°51'17.8"
b5	3365473.072	774634.912	3366196.08	198094.75	30°23'24.3"	47°51'29.3"
b7	3367705.172	781184.972	3368078.15	204754.89	30°24'31.1"	47°55'36.6"
b8	3365909.512	791774.892	3365723.66	215235.01	30°23'23.8"	48°2'11.25"
b9	3365761.890	792030.306	3365562.72	215482.23	30°23'18.8"	48°2' 20.6"
b10	3360256.421	799549.278	3359667.51	222698.41	30°20'13.5"	48° 6 ' 56.3"
b11	3359984.273	799607.076	3359392.73	222741.72	30°20'4.6"	48° 6'58.2"
b12	3356163.923	807586.029	3355156.77	230505.85	30°17'53.5"	48°11'52.5"
b13	3356028.469	807749.252	3355012.92	230661.65	30°17'49.0"	48°11'58.5"
b14	3338202.441	823086.799	3336410.25	245032.76	30 °7' 56.5"	48°21'12.1"
b15	3338274.976	823300.841	3336471.4	245250.22	30°7' 58.6"	48°21'20.1"
b16	3331213.515	825509.879	3329307.25	247084.32	30° 4' 7.5"	48°22'34.8"
b17	3330989.291	825339.810	3329092.37	246902.81	30°4' 0.4"	48°22'28.0"
b18	3324683.423	828704.707	3322622.23	249930.81	30°0' 32.6"	48°24'26.6"
b19	3324999.497	828357.477	3322955.87	249600.8	30°0' 43.2"	48°24'14.1"
b1	3362645.124	765845.799	3363837.05	189165.88	30°21'59.4"	47°45'57.8"
b2	3362162.856	765704.902	3363362.77	188999.6	30°21'43.9"	47°45'52.0"
b3	3361457.330	765539.303	3362666.77	188796.81	30°21'21.1"	47°45'45.2"

2-Stake out the coordinates of the base line points that converted from zone 38 to zone 39 by using RTK (Real Time Kinematic) GPS and calculate the error values from the extension process.

In this research the Real-Time Kinematic RTK GPS was used to stake out the base line coordinates that converted from zone 38 to zone 39 on the ground according to the reference point located in zone 39.

The base station represents (Iraq Geospatial Reference System) which numbered (BA13) and located in zone 39 at AL-FAW city with coordinate (254134.78E, 3318307.79N) see appendix (A), while the points of the base line that staking out represent (b15, b16, b17, b18, b19). The first issue for staking out these base line points on the ground due to it located originally in the zone 39 and the second issue is a proximity to the point BA13 which allows us to calculate the maximum closing error values. Where table (7) Represents the amount of the difference in easting and northing between the coordinates that staking out by using RTK GPS and the converted coordinates by using software's and figure (11) illustrate the location of the base station (BA13) and the base line points (b15, b16, b17, b18, b19) at zone 39.

Table (7): Represents the amount of the difference in easting and northing between the coordinates that staking out by using RTK GPS and the converted coordinates by using software's

Point	The coordinates that converted from zone 38 to zone 39 by using software's		The coordinates that staking out by using RTK GPS		Difference in Northing	Difference in Easting
	N	E	N	E		
b15	3336471.4	245250.22	3336471.391	245250.218	0.009	0.002
b16	3329307.25	247084.32	3329307.245	247084.314	0.005	0.006
b17	3329092.37	246902.81	3329092.364	246902.801	0.006	0.009
b18	3322622.23	249930.81	3322622.219	249930.802	0.011	0.008
b19	3322955.87	249600.8	3322955.857	249600.789	0.013	0.011

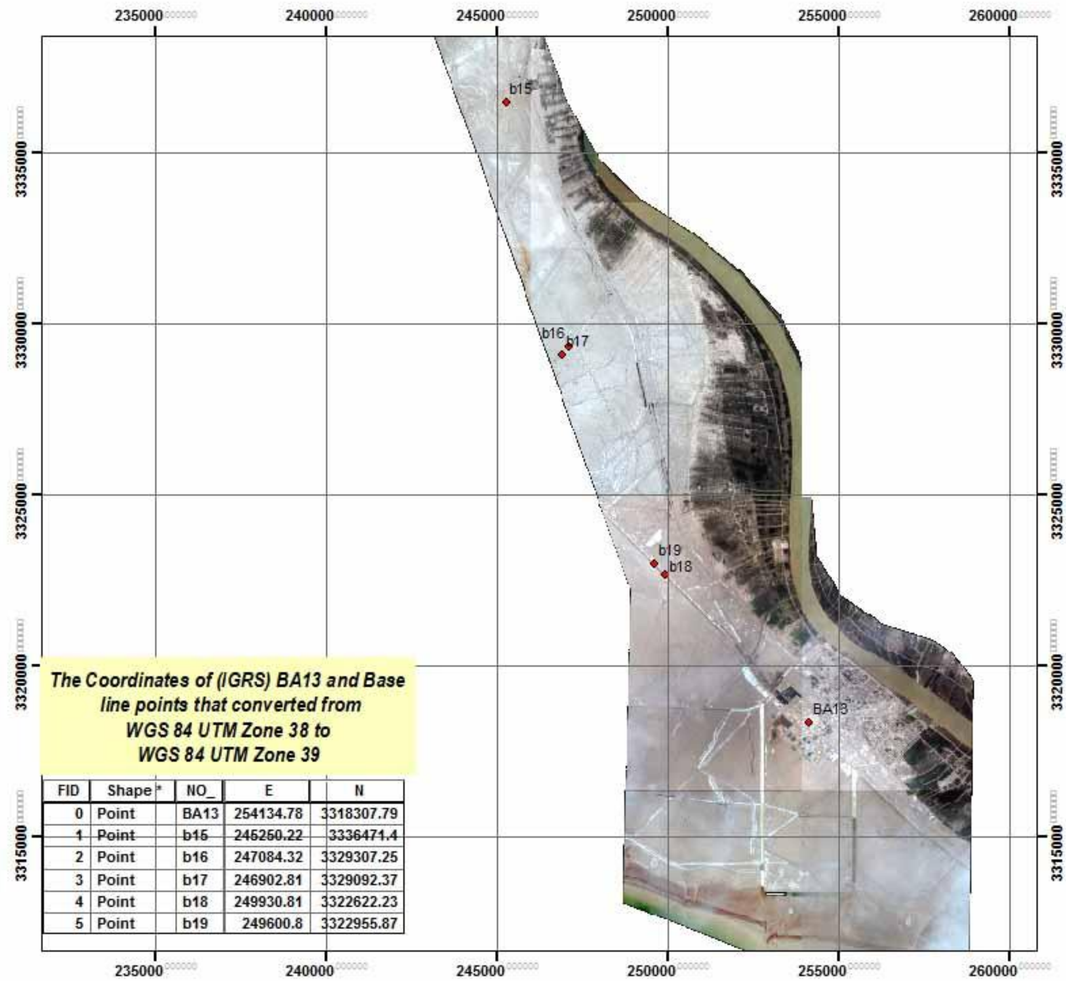


Figure (11): illustrate the location of the base station (BA13) and the base line points (b15, b16, b17, b18, b19) at zone 39.

Conclusions

The main conclusions that can be drawn from this research are summarized as follows:

1- The transformation capability of coordinates by using relevant different software's from zone to zone proved to be effective tools to convert the coordinates in various UTM grid zones and giving us the exact coordinates of the point corresponding to the original location on the ground.

2- The DGPS not accepted two zones when it processing so that the transformation from zone to zone must be applied and produce one set of coordinate's.

3- It has been found that the using of one zone coordinate a long any infrastructure project like (roads, Railways, Pipeline routes…..etc) lies in different two zones is a very good approach to stake out the coordinates of such project in one zone and producing one topographical map for the whole project area.

4- The extension procedures which it examed can be applied and it will be valid only for limited distance (not more than 80 km) and only if the level of the project will be less than 30 m above mean see level in order to avoid the level scale factor correction.

5- The maximum error values achieved from the extension process were 11mm in easting and 13mm in northing on the point **b19** and this error logically and practically is acceptable in such kind of Topo surveying works.

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Appendix (A)

IGRS INFORMATION

Table (A-1)

TOPOGRAPHIC SURVEY CONTROL POINT RECORD FOR BA12 [9]

STATION LONG NAME	**BA12**
STATION NUMBER	**BA12**
COUNTRY	IRAQ
LOCATION	AL BASRAH
SURVEYING AGENCY	IGRS
DATE (OF DESCRIPTION)	09 AUG 2005

Table (A-2)

OFFICE COORDINATE VALUES
WGS 84 ADJUSTED VALUES AS AT: 25 Aug 05

LATITUDE N	30° 30’ 58.71537”
LONGITUDE E	047° 50’ 40.59020”
SPHEROIDAL HT (M)	-13.195
ORTHOMETRIC HT (M)	-15.427
VERTICAL DATUM	WGS 84
GEOID MODEL USED	EGM 96
GRID ZONE DESIGNATOR	38R
UTM / MGRS GRID	QU 72979 79441
RELATIVE TO	CORS STATIONS
RELATIVE POSITION ACCURACY (M)	0.012
RELATIVE HEIGHT ACCURACY (M)	0.026
ADJUSTING AGENCY	OPUS
ADJUSTMENT DATE	25 AUG 2005

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Table (A-3)

TOPOGRAPHIC SURVEY CONTROL POINT RECORD FOR BA13 [9]

STATION LONG NAME	**BA13**
STATION NUMBER	**BA13**
COUNTRY	IRAQ
LOCATION	AL FAW
SURVEYING AGENCY	IGRS
DATE (OF DESCRIPTION)	09 AUG 2005

Table (A-4)

OFFICE COORDINATE VALUES
WGS 84 ADJUSTED VALUES AS AT: 25 Aug 05

LATITUDE N	29° 58' 15.71752"
LONGITUDE E	048° 27' 07.04050"
SPHEROIDAL HT (M)	-13.712
ORTHOMETRIC HT (M)	-16.128
VERTICAL DATUM	WGS 84
GEOID MODEL USED	EGM 96
GRID ZONE DESIGNATOR	39R
UTM / MGRS GRID	39R TP 54137 18312
RELATIVE TO	CORS STATIONS
RELATIVE POSITION ACCURACY (M)	0.018
RELATIVE HEIGHT ACCURACY (M)	0.015
ADJUSTING AGENCY	OPUS
ADJUSTMENT DATE	25 AUG 2005

PHOTO SKETCH