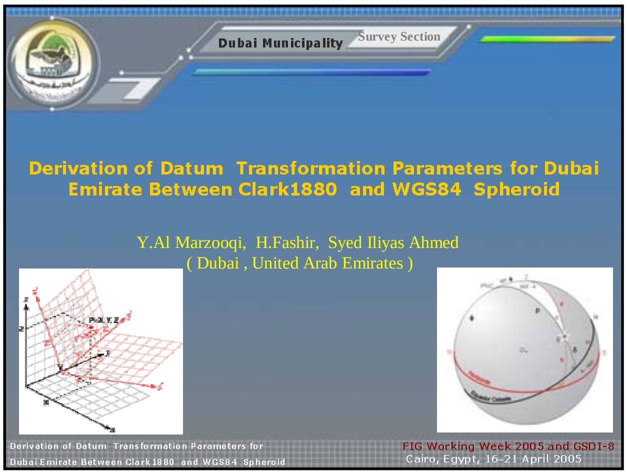
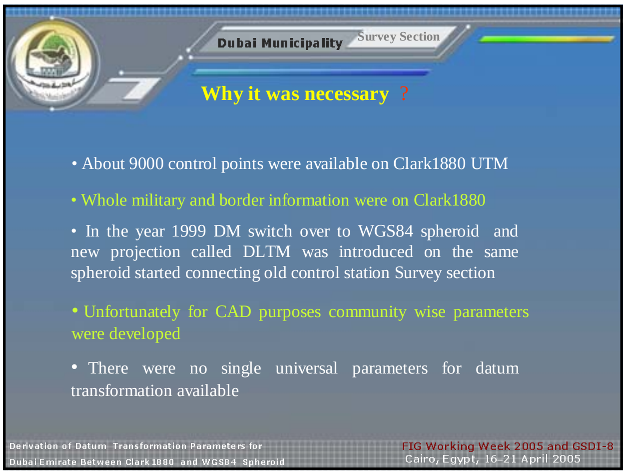


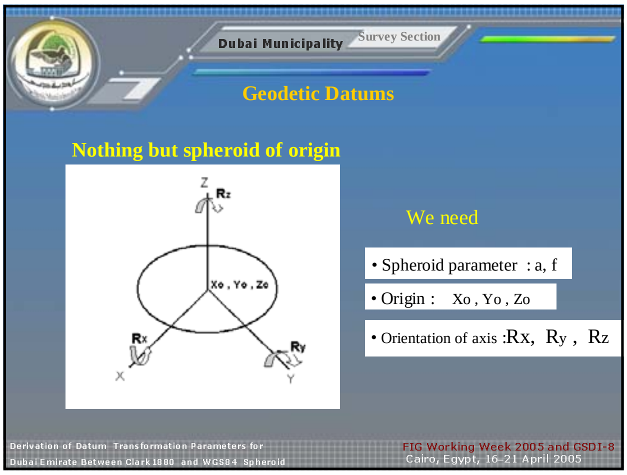
Derivation of Datum Transformation Parameters for Dubai Emirate Between Clark1880 and WGS84 Spheroid

Y.Al Marzooqi, H.Fashir, Syed Iliyas Ahmed
(Dubai , United Arab Emirates)



Why it was necessary ?

- About 9000 control points were available on Clark1880 UTM
- Whole military and border information were on Clark1880
- In the year 1999 DM switch over to WGS84 spheroid and new projection called DLTM was introduced on the same spheroid started connecting old control station Survey section
- Unfortunately for CAD purposes community wise parameters were developed
- There were no single universal parameters for datum transformation available

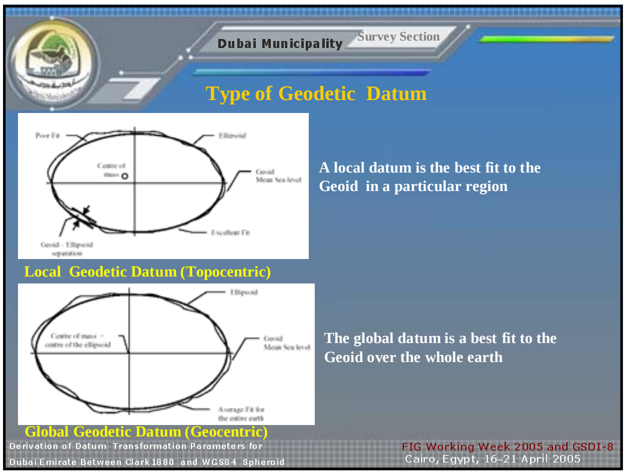


Geodetic Datums

Nothing but spheroid of origin

We need

- Spheroid parameter : a, f
- Origin : Xo , Yo , Zo
- Orientation of axis :Rx, Ry , Rz



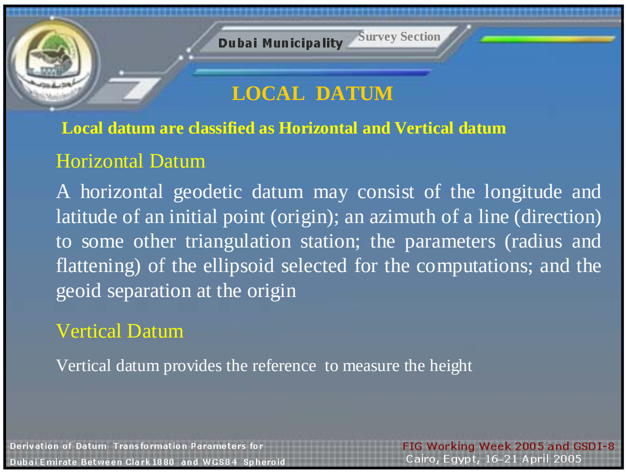
Type of Geodetic Datum

Local Geodetic Datum (Topocentric)

A local datum is the best fit to the Geoid in a particular region

Global Geodetic Datum (Geocentric)

The global datum is a best fit to the Geoid over the whole earth



LOCAL DATUM

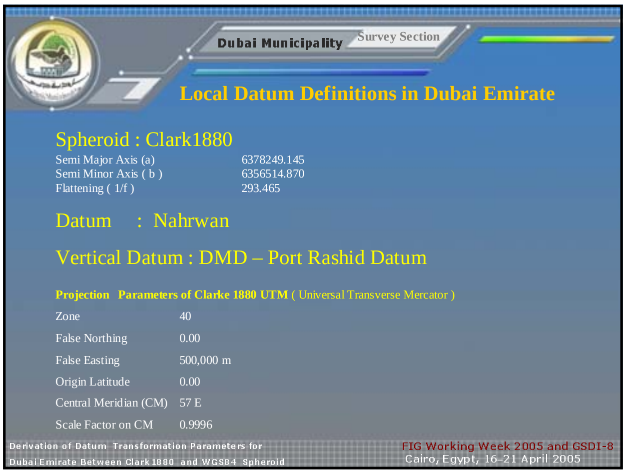
Local datum are classified as Horizontal and Vertical datum

Horizontal Datum

A horizontal geodetic datum may consist of the longitude and latitude of an initial point (origin); an azimuth of a line (direction) to some other triangulation station; the parameters (radius and flattening) of the ellipsoid selected for the computations; and the geoid separation at the origin

Vertical Datum

Vertical datum provides the reference to measure the height



Local Datum Definitions in Dubai Emirate

Spheroid : Clark1880

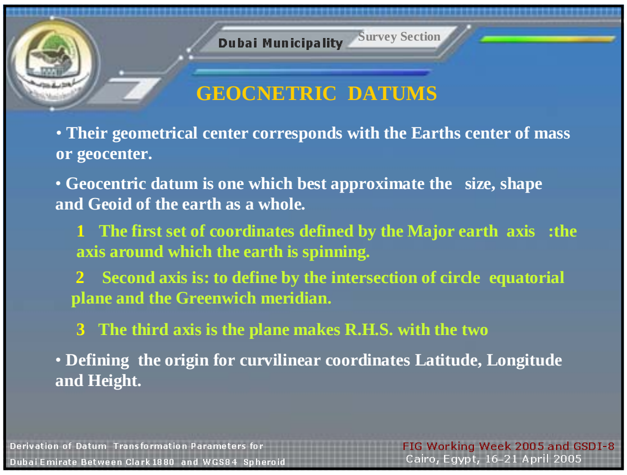
Semi Major Axis (a)	6378249.145
Semi Minor Axis (b)	6356514.870
Flattening (1/f)	293.465

Datum : Nahrwan

Vertical Datum : DMD – Port Rashid Datum

Projection Parameters of Clarke 1880 UTM (Universal Transverse Mercator)

Zone	40
False Northing	0.00
False Easting	500,000 m
Origin Latitude	0.00
Central Meridian (CM)	57 E
Scale Factor on CM	0.9996



Dubai Municipality Survey Section

GEOCNETRIC DATUMS

- Their geometrical center corresponds with the Earths center of mass or geocenter.
- Geocentric datum is one which best approximate the size, shape and Geoid of the earth as a whole.

1 The first set of coordinates defined by the Major earth axis :the axis around which the earth is spinning.

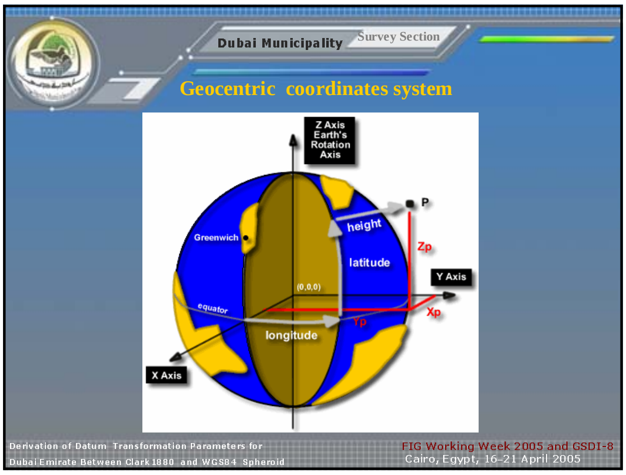
2 Second axis is: to define by the intersection of circle equatorial plane and the Greenwich meridian.

3 The third axis is the plane makes R.H.S. with the two

- Defining the origin for curvilinear coordinates Latitude, Longitude and Height.

Derivation of Datum Transformation Parameters for Dubai Emirate Between Clark 1880 and WGS84 Spheroid

FIG Working Week 2005 and GSDI-8 Cairo, Egypt, 16-21 April 2005



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Geocentric coordinates system

Derivation of Datum Transformation Parameters for Dubai Emirate Between Clark 1880 and WGS84 Spheroid

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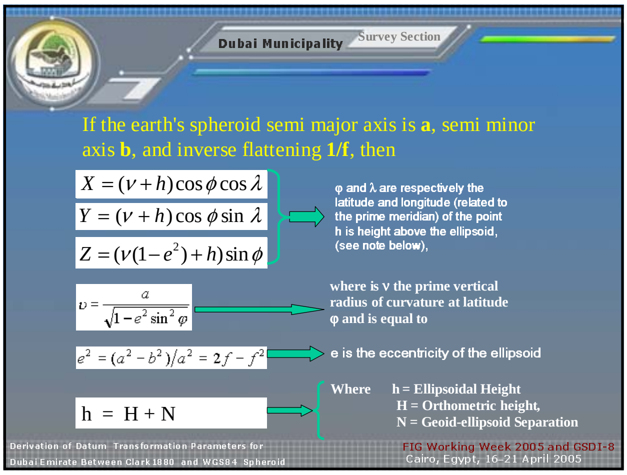

Dubai Municipality Survey Section

If the earth's spheroid semi major axis is **a**, semi minor axis **b**, and inverse flattening **1/f**, then

$$X = (\nu + h)\cos\phi\cos\lambda$$

$$Y = (\nu + h)\cos\phi\sin\lambda$$

$$Z = (\nu(1-e^2) + h)\sin\phi$$

φ and λ are respectively the latitude and longitude (related to the prime meridian) of the point h is height above the ellipsoid, (see note below),

$$\upsilon = \frac{a}{\sqrt{1 - e^2\sin^2\varphi}}$$

where is ν the prime vertical radius of curvature at latitude φ and is equal to

$$e^2 = (a^2 - b^2)/a^2 = 2f - f^2$$

e is the eccentricity of the ellipsoid

h = H + N

Where h = Ellipsoidal Height
H = Orthometric height,
N = Geoid-ellipsoid Separation

Derivation of Datum Transformation Parameters for Dubai Emirate Between Clark 1880 and WGS84 Spheroid

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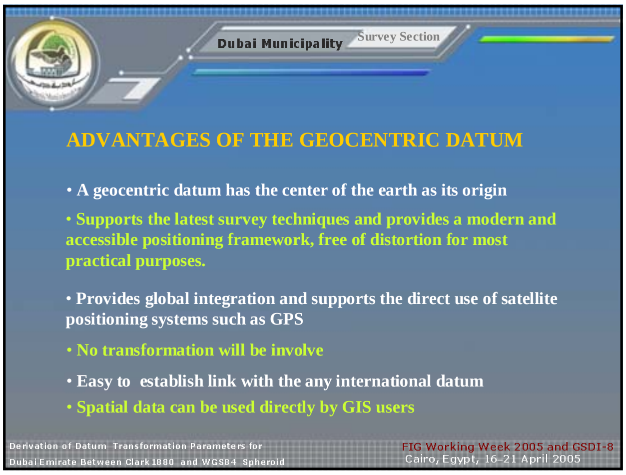


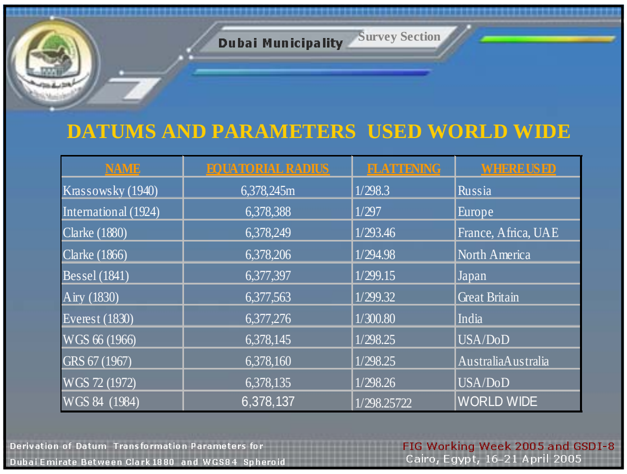
Dubai Municipality Survey Section

ADVANTAGES OF THE GEOCENTRIC DATUM

- A geocentric datum has the center of the earth as its origin
- Supports the latest survey techniques and provides a modern and accessible positioning framework, free of distortion for most practical purposes.
- Provides global integration and supports the direct use of satellite positioning systems such as GPS
- No transformation will be involve
- Easy to establish link with the any international datum
- Spatial data can be used directly by GIS users

Derivation of Datum Transformation Parameters for Dubai Emirate Between Clark 1880 and WGS84 Spheroid

FIG Working Week 2005 and GSDI-8 Cairo, Egypt, 16-21 April 2005



Dubai Municipality Survey Section

DATUMS AND PARAMETERS USED WORLD WIDE

NAME	EQUATORIAL RADIUS	FLATTENING	WHERE USED
Krassowsky (1940)	6,378,245m	1/298.3	Russia
International (1924)	6,378,388	1/297	Europe
Clarke (1880)	6,378,249	1/293.46	France, Africa, UAE
Clarke (1866)	6,378,206	1/294.98	North America
Bessel (1841)	6,377,397	1/299.15	Japan
Airy (1830)	6,377,563	1/299.32	Great Britain
Everest (1830)	6,377,276	1/300.80	India
WGS 66 (1966)	6,378,145	1/298.25	USA/DoD
GRS 67 (1967)	6,378,160	1/298.25	AustraliaAustralia
WGS 72 (1972)	6,378,135	1/298.26	USA/DoD
WGS 84 (1984)	6,378,137	1/298.25722	WORLD WIDE

Derivation of Datum Transformation Parameters for Dubai Emirate Between Clark 1880 and WGS84 Spheroid

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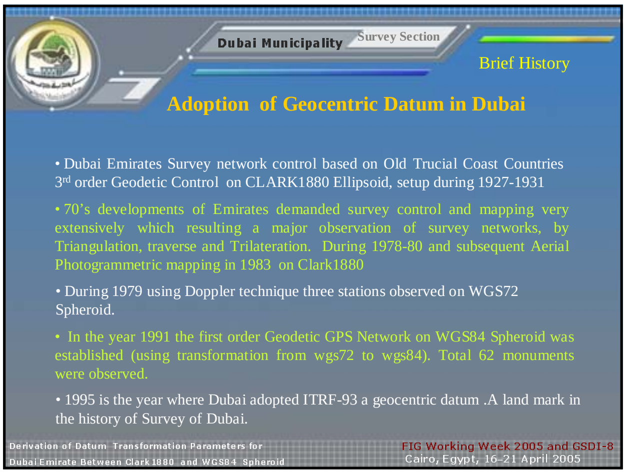


Dubai Municipality Survey Section

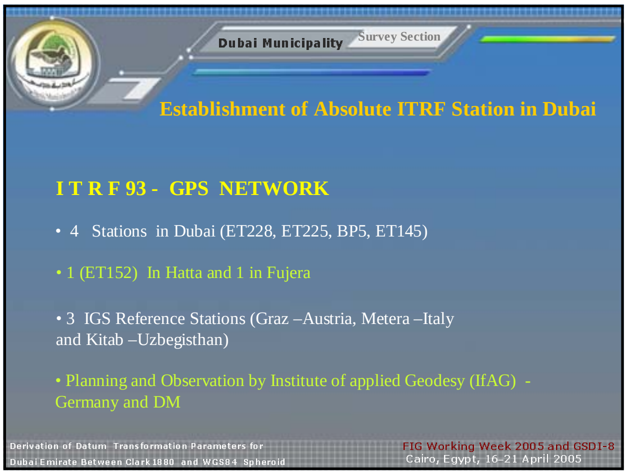
Brief History

Adoption of Geocentric Datum in Dubai

- Dubai Emirates Survey network control based on Old Trucial Coast Countries 3rd order Geodetic Control on CLARK1880 Ellipsoid, setup during 1927-1931
- 70's developments of Emirates demanded survey control and mapping very extensively which resulting a major observation of survey networks, by Triangulation, traverse and Trilateration. During 1978-80 and subsequent Aerial Photogrammetric mapping in 1983 on Clark1880
- During 1979 using Doppler technique three stations observed on WGS72 Spheroid.
- In the year 1991 the first order Geodetic GPS Network on WGS84 Spheroid was established (using transformation from wgs72 to wgs84). Total 62 monuments were observed.
- 1995 is the year where Dubai adopted ITRF-93 a geocentric datum .A land mark in the history of Survey of Dubai.

Derivation of Datum Transformation Parameters for Dubai Emirate Between Clark 1880 and WGS84 Spheroid

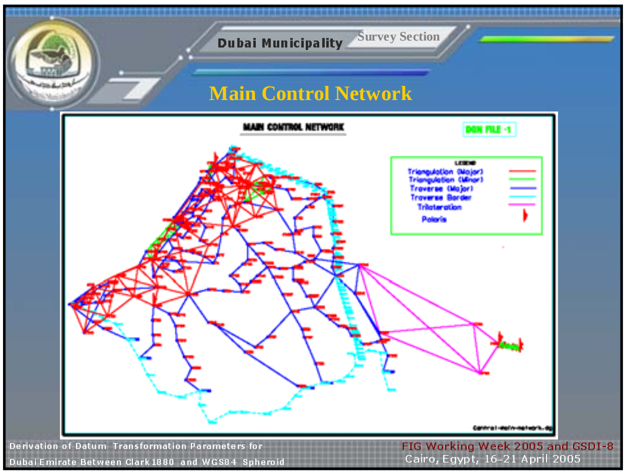
FIG Working Week 2005 and GSDI-8 Cairo, Egypt, 16-21 April 2005



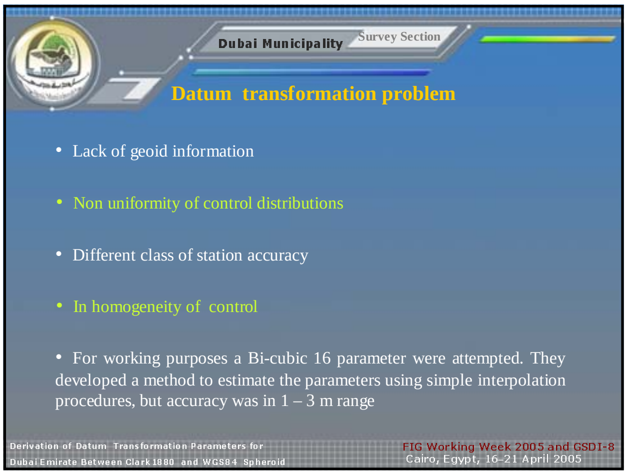
Establishment of Absolute ITRF Station in Dubai

I T R F 93 - GPS NETWORK

- 4 Stations in Dubai (ET228, ET225, BP5, ET145)
- 1 (ET152) In Hatta and 1 in Fujera
- 3 IGS Reference Stations (Graz –Austria, Metera –Italy and Kitab –Uzbegisthan)
- Planning and Observation by Institute of applied Geodesy (IfAG) - Germany and DM

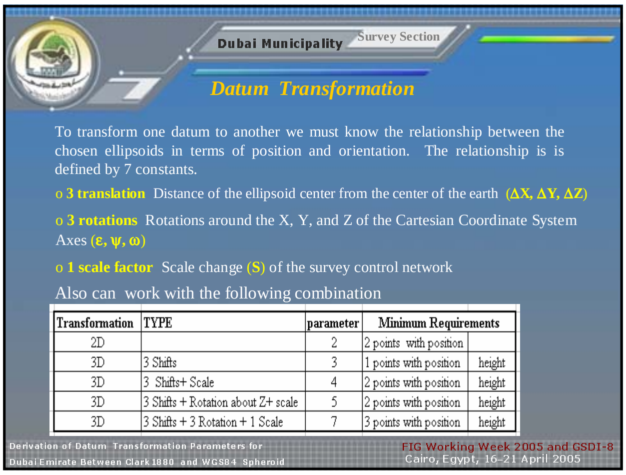


Main Control Network



Datum transformation problem

- Lack of geoid information
- Non uniformity of control distributions
- Different class of station accuracy
- In homogeneity of control
- For working purposes a Bi-cubic 16 parameter were attempted. They developed a method to estimate the parameters using simple interpolation procedures, but accuracy was in 1 – 3 m range



Datum Transformation

To transform one datum to another we must know the relationship between the chosen ellipsoids in terms of position and orientation. The relationship is is defined by 7 constants.

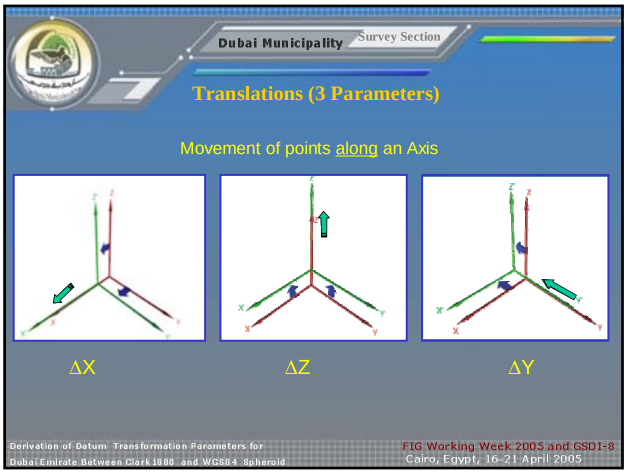
o **3 translation** Distance of the ellipsoid center from the center of the earth (ΔX, ΔY, ΔZ)

o **3 rotations** Rotations around the X, Y, and Z of the Cartesian Coordinate System Axes (ε, ψ, ω)

o **1 scale factor** Scale change (S) of the survey control network

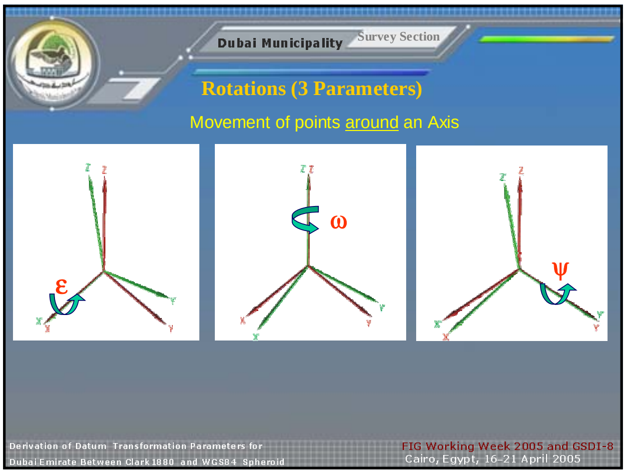
Also can work with the following combination

Transformation	TYPE	parameter	Minimum Requirements	
2D		2	2 points with position	
3D	3 Shifts	3	1 points with position	height
3D	3 Shifts+ Scale	4	2 points with position	height
3D	3 Shifts + Rotation about Z+ scale	5	2 points with position	height
3D	3 Shifts + 3 Rotation + 1 Scale	7	3 points with position	height



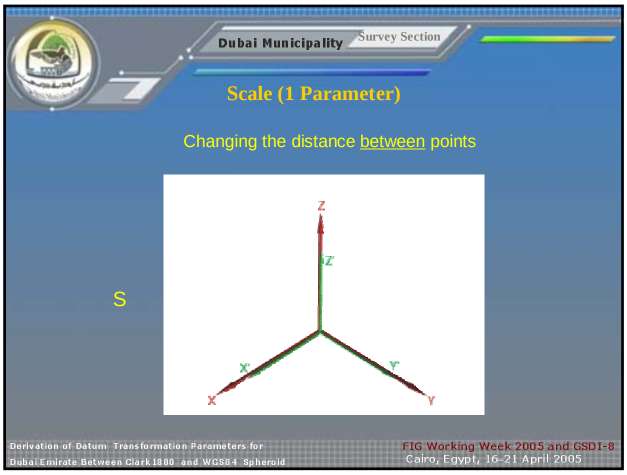
Translations (3 Parameters)

Movement of points along an Axis



Rotations (3 Parameters)

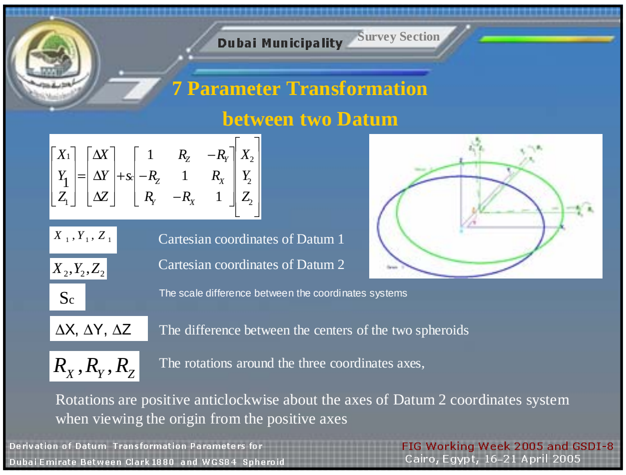
Movement of points around an Axis



Scale (1 Parameter)

Changing the distance between points

S

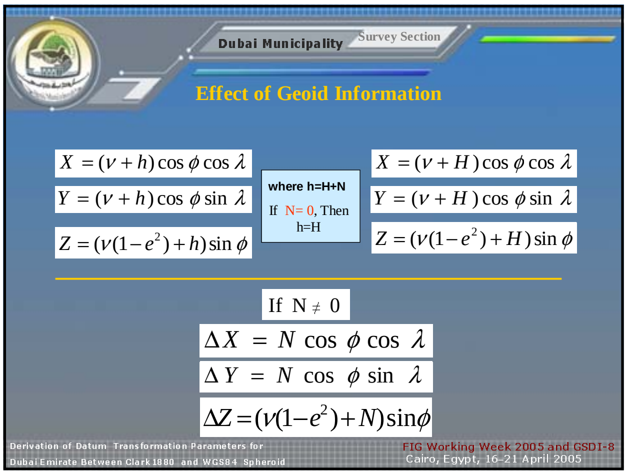


7 Parameter Transformation between two Datum

$$\begin{bmatrix} X_1 \\ Y_1 \\ Z_1 \end{bmatrix} = \begin{bmatrix} \Delta X \\ \Delta Y \\ \Delta Z \end{bmatrix} + Sc \begin{bmatrix} 1 & R_Z & -R_Y \\ -R_Z & 1 & R_X \\ R_Y & -R_X & 1 \end{bmatrix} \begin{bmatrix} X_2 \\ Y_2 \\ Z_2 \end{bmatrix}$$

X_1, Y_1, Z_1	Cartesian coordinates of Datum 1
X_2, Y_2, Z_2	Cartesian coordinates of Datum 2
Sc	The scale difference between the coordinates systems
ΔX, ΔY, ΔZ	The difference between the centers of the two spheroids
R_X, R_Y, R_Z	The rotations around the three coordinates axes,

Rotations are positive anticlockwise about the axes of Datum 2 coordinates system when viewing the origin from the positive axes



Effect of Geoid Information

$$X = (\nu + h)\cos\phi\cos\lambda$$
$$Y = (\nu + h)\cos\phi\sin\lambda$$
$$Z = (\nu(1-e^2) + h)\sin\phi$$

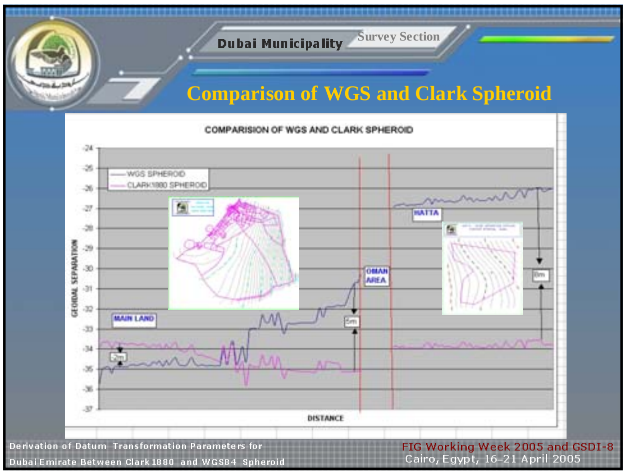
where h=H+N

If N= 0, Then h=H

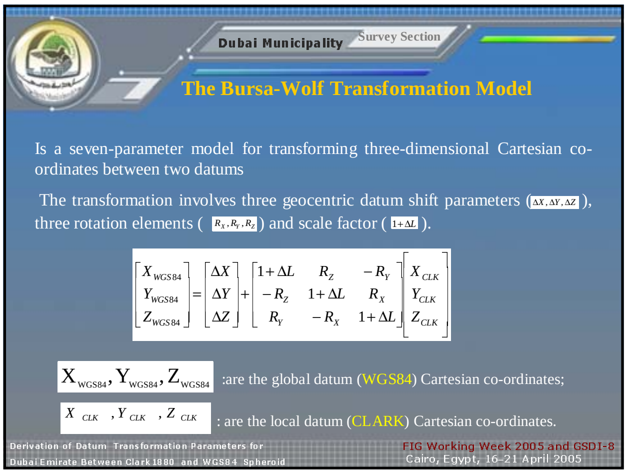
$$X = (\nu + H)\cos\phi\cos\lambda$$
$$Y = (\nu + H)\cos\phi\sin\lambda$$
$$Z = (\nu(1-e^2) + H)\sin\phi$$

If N ≠ 0

$$\Delta X = N\cos\phi\cos\lambda$$
$$\Delta Y = N\cos\phi\sin\lambda$$
$$\Delta Z = (\nu(1-e^2) + N)\sin\phi$$



Comparison of WGS and Clark Spheroid



The Bursa-Wolf Transformation Model

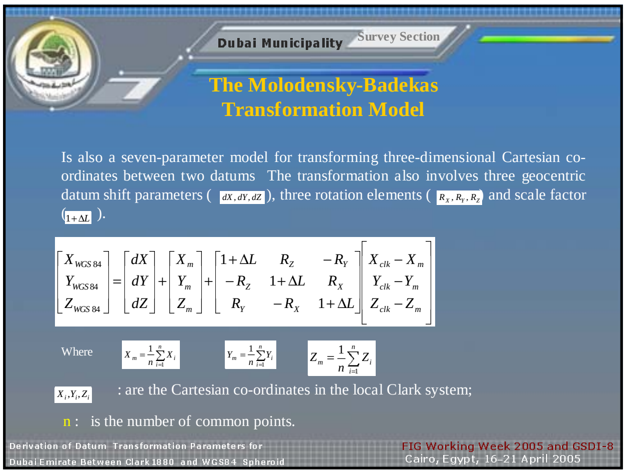
Is a seven-parameter model for transforming three-dimensional Cartesian co-ordinates between two datums

The transformation involves three geocentric datum shift parameters ($\Delta X, \Delta Y, \Delta Z$), three rotation elements (R_X, R_Y, R_Z) and scale factor ($1+\Delta L$).

$$\begin{bmatrix} X_{WGS84} \\ Y_{WGS84} \\ Z_{WGS84} \end{bmatrix} = \begin{bmatrix} \Delta X \\ \Delta Y \\ \Delta Z \end{bmatrix} + \begin{bmatrix} 1+\Delta L & R_Z & -R_Y \\ -R_Z & 1+\Delta L & R_X \\ R_Y & -R_X & 1+\Delta L \end{bmatrix} \begin{bmatrix} X_{CLK} \\ Y_{CLK} \\ Z_{CLK} \end{bmatrix}$$

$X_{WGS84}, Y_{WGS84}, Z_{WGS84}$:are the global datum (WGS84) Cartesian co-ordinates;

$X_{CLK}, Y_{CLK}, Z_{CLK}$: are the local datum (CLARK) Cartesian co-ordinates.



The Molodensky-Badekas Transformation Model

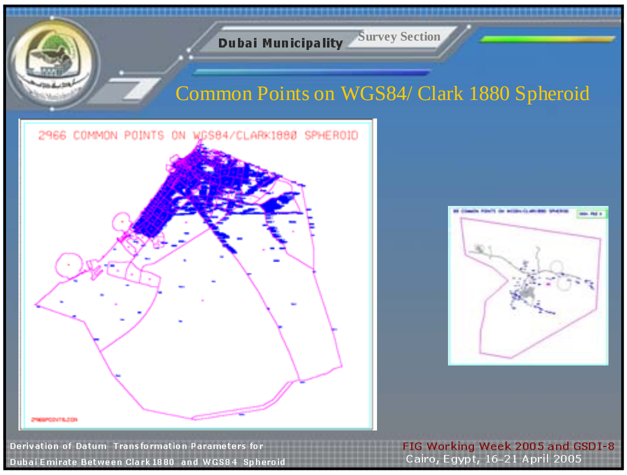
Is also a seven-parameter model for transforming three-dimensional Cartesian co-ordinates between two datums The transformation also involves three geocentric datum shift parameters (dX, dY, dZ), three rotation elements (R_X, R_Y, R_Z) and scale factor ($1+\Delta L$).

$$\begin{bmatrix} X_{WGS84} \\ Y_{WGS84} \\ Z_{WGS84} \end{bmatrix} = \begin{bmatrix} dX \\ dY \\ dZ \end{bmatrix} + \begin{bmatrix} X_m \\ Y_m \\ Z_m \end{bmatrix} + \begin{bmatrix} 1+\Delta L & R_Z & -R_Y \\ -R_Z & 1+\Delta L & R_X \\ R_Y & -R_X & 1+\Delta L \end{bmatrix} \begin{bmatrix} X_{clk} - X_m \\ Y_{clk} - Y_m \\ Z_{clk} - Z_m \end{bmatrix}$$

Where $X_m = \frac{1}{n}\sum_{i=1}^{n} X_i$ $Y_m = \frac{1}{n}\sum_{i=1}^{n} Y_i$ $Z_m = \frac{1}{n}\sum_{i=1}^{n} Z_i$

X_i, Y_i, Z_i : are the Cartesian co-ordinates in the local Clark system;

n : is the number of common points.



Dubai Municipality Survey Section

Common Points on WGS84/ Clark 1880 Spheroid

Derivation of Datum Transformation Parameters for Dubai Emirate Between Clark 1880 and WGS84 Spheroid

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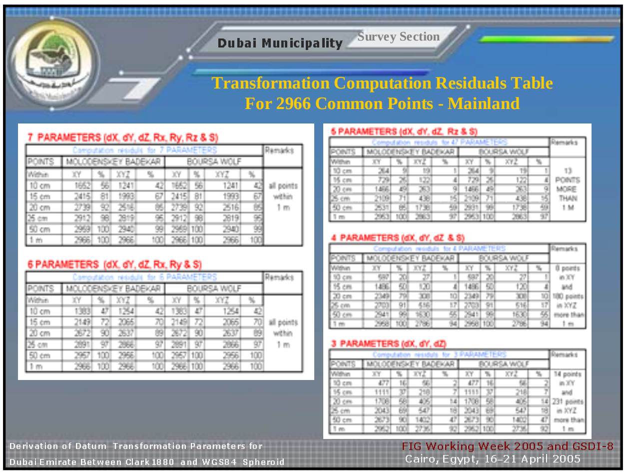
Cairo, Egypt, 16–21 April 2005



Dubai Municipality Survey Section

Transformation Computation Residuals Table For 2966 Common Points - Mainland

7 PARAMETERS (dX, dY, dZ, Rx, Ry, Rz & S)

Computation residuals for 7 PARAMETERS									Remarks
POINTS	MOLODENSKEY BADEKAR				BOURSA WOLF				
Within	XY	%	XYZ	%	XY	%	XYZ	%	
10 cm	1652	56	1241	42	1652	56	1241	42	all points within 1 m
15 cm	2415	81	1993	67	2415	81	1993	67	
20 cm	2739	92	2516	85	2739	92	2516	85	
25 cm	2912	98	2819	95	2912	98	2819	95	
50 cm	2959	100	2940	99	2959	100	2940	99	
1 m	2966	100	2966	100	2966	100	2966	100	

6 PARAMETERS (dX, dY, dZ, Rx, Ry & S)

Computation residuals for 6 PARAMETERS									Remarks
POINTS	MOLODENSKEY BADEKAR				BOURSA WOLF				
Within	XY	%	XYZ	%	XY	%	XYZ	%	
10 cm	1383	47	1254	42	1383	47	1254	42	all points within 1 m
15 cm	2149	72	2065	70	2149	72	2065	70	
20 cm	2672	90	2637	89	2672	90	2637	89	
25 cm	2891	97	2866	97	2891	97	2866	97	
50 cm	2957	100	2956	100	2957	100	2956	100	
1 m	2966	100	2966	100	2966	100	2966	100	

5 PARAMETERS (dX, dY, dZ, Rz & S)

Computation residuals for 47 PARAMETERS									Remarks
POINTS	MOLODENSKEY BADEKAR				BOURSA WOLF				
Within	XY	%	XYZ	%	XY	%	XYZ	%	
10 cm	264	9	19	1	264	9	19	1	13 POINTS MORE THAN 1 M
15 cm	729	25	122	4	729	25	122	4	
20 cm	1466	49	263	9	1466	49	263	9	
25 cm	2109	71	438	15	2109	71	438	15	
50 cm	2531	85	1738	59	2931	99	1738	59	
1 m	2953	100	2863	97	2953	100	2863	97	

4 PARAMETERS (dX, dY, dZ & S)

Computation residuals for 4 PARAMETERS									Remarks
POINTS	MOLODENSKEY BADEKAR				BOURSA WOLF				
Within	XY	%	XYZ	%	XY	%	XYZ	%	
10 cm	597	20	27	1	597	20	27	1	8 points in XY and 100 points in XYZ more than 1 m
15 cm	1486	50	120	4	1486	50	120	4	
20 cm	2349	79	308	10	2349	79	308	10	
25 cm	2703	91	516	17	2703	91	516	17	
50 cm	2941	99	1630	55	2941	99	1630	55	
1 m	2958	100	2786	94	2958	100	2786	94	

3 PARAMETERS (dX, dY, dZ)

Computation residuals for 3 PARAMETERS									Remarks
POINTS	MOLODENSKEY BADEKAR				BOURSA WOLF				
Within	XY	%	XYZ	%	XY	%	XYZ	%	
10 cm	477	16	56	2	477	16	56	2	14 points in XY and 231 points in XYZ more than 1 m
15 cm	1111	37	218	7	1111	37	218	7	
20 cm	1708	58	405	14	1708	58	405	14	
25 cm	2043	69	547	18	2043	69	547	18	
50 cm	2673	90	1402	47	2673	90	1402	47	
1 m	2952	100	2736	92	2952	100	2736	92	

Derivation of Datum Transformation Parameters for Dubai Emirate Between Clark 1880 and WGS84 Spheroid

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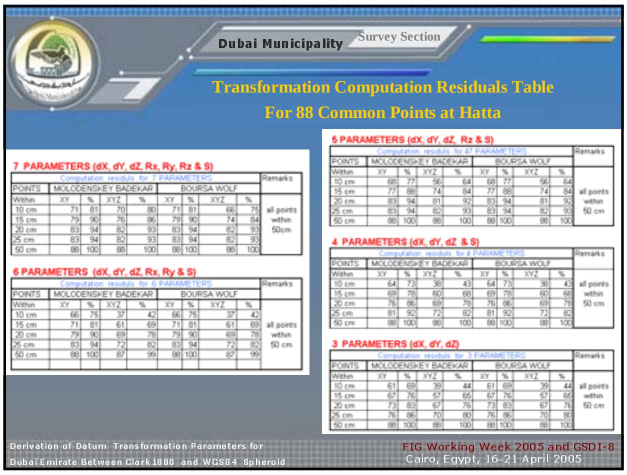
Cairo, Egypt, 16–21 April 2005



Dubai Municipality Survey Section

Transformation Computation Residuals Table For 88 Common Points at Hatta

7 PARAMETERS (dX, dY, dZ, Rx, Ry, Rz & S)

Computation residuals for 7 PARAMETERS									Remarks
POINTS	MOLODENSKEY BADEKAR				BOURSA WOLF				
Within	XY	%	XYZ	%	XY	%	XYZ	%	
10 cm	71	81	70	80	71	81	66	75	all points within 50cm
15 cm	79	90	76	86	79	90	74	84	
20 cm	83	94	82	93	83	94	82	93	
25 cm	83	94	82	93	83	94	82	93	
50 cm	88	100	88	100	88	100	88	100	

6 PARAMETERS (dX, dY, dZ, Rx, Ry & S)

Computation residuals for 6 PARAMETERS									Remarks
POINTS	MOLODENSKEY BADEKAR				BOURSA WOLF				
Within	XY	%	XYZ	%	XY	%	XYZ	%	
10 cm	66	75	37	42	66	75	37	42	all points within 50 cm
15 cm	71	81	61	69	71	81	61	69	
20 cm	79	90	69	78	79	90	69	78	
25 cm	83	94	72	82	83	94	72	82	
50 cm	88	100	87	99	88	100	87	99	

5 PARAMETERS (dX, dY, dZ, Rz & S)

Computation residuals for 47 PARAMETERS									Remarks
POINTS	MOLODENSKEY BADEKAR				BOURSA WOLF				
Within	XY	%	XYZ	%	XY	%	XYZ	%	
10 cm	68	77	56	64	68	77	56	64	all points within 50 cm
15 cm	77	88	74	84	77	88	74	84	
20 cm	83	94	81	92	83	94	81	92	
25 cm	83	94	82	93	83	94	82	93	
50 cm	88	100	88	100	88	100	88	100	

4 PARAMETERS (dX, dY, dZ & S)

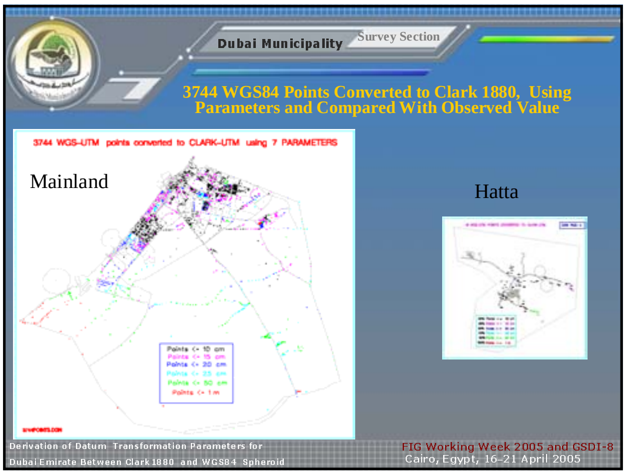
Computation residuals for 4 PARAMETERS									Remarks
POINTS	MOLODENSKEY BADEKAR				BOURSA WOLF				
Within	XY	%	XYZ	%	XY	%	XYZ	%	
10 cm	64	73	38	43	64	73	38	43	all points within 50 cm
15 cm	69	78	60	68	69	78	60	68	
20 cm	76	86	69	78	76	86	69	78	
25 cm	81	92	72	82	81	92	72	82	
50 cm	88	100	88	100	88	100	88	100	

3 PARAMETERS (dX, dY, dZ)

Computation residuals for 3 PARAMETERS									Remarks
POINTS	MOLODENSKEY BADEKAR				BOURSA WOLF				
Within	XY	%	XYZ	%	XY	%	XYZ	%	
10 cm	61	69	39	44	61	69	39	44	all points within 50 cm
15 cm	67	76	57	65	67	76	57	65	
20 cm	73	83	67	76	73	83	67	76	
25 cm	76	86	70	80	76	86	70	80	
50 cm	88	100	88	100	88	100	88	100	

Derivation of Datum Transformation Parameters for Dubai Emirate Between Clark 1880 and WGS84 Spheroid

FIG Working Week 2005 and GSDI-8
Cairo, Egypt, 16–21 April 2005

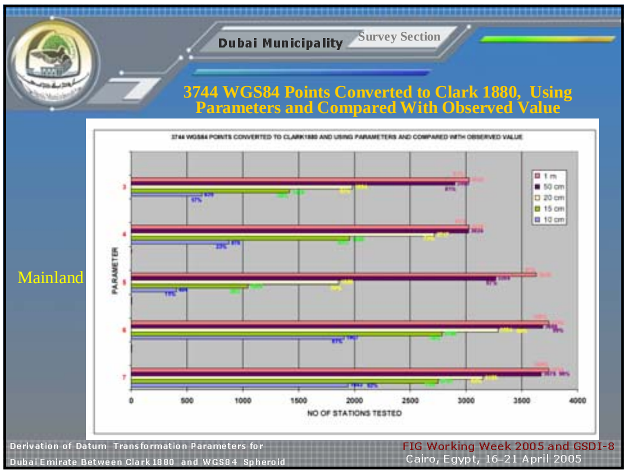


Dubai Municipality Survey Section

3744 WGS84 Points Converted to Clark 1880, Using Parameters and Compared With Observed Value

Derivation of Datum Transformation Parameters for Dubai Emirate Between Clark 1880 and WGS84 Spheroid

FIG Working Week 2005 and GSDI-8
Cairo, Egypt, 16–21 April 2005

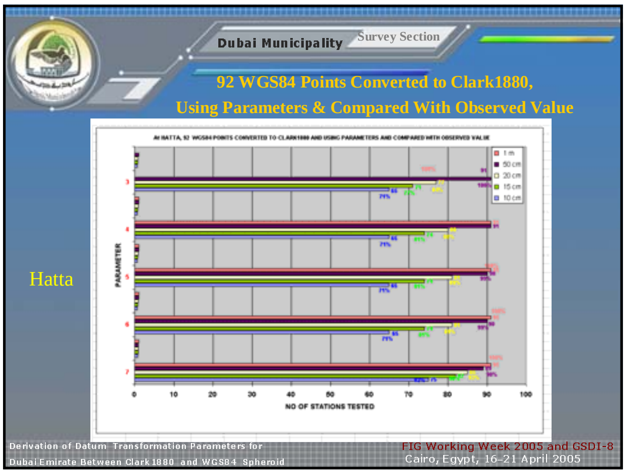


Dubai Municipality Survey Section

3744 WGS84 Points Converted to Clark 1880, Using Parameters and Compared With Observed Value

Derivation of Datum Transformation Parameters for Dubai Emirate Between Clark 1880 and WGS84 Spheroid

FIG Working Week 2005 and GSDI-8
Cairo, Egypt, 16–21 April 2005

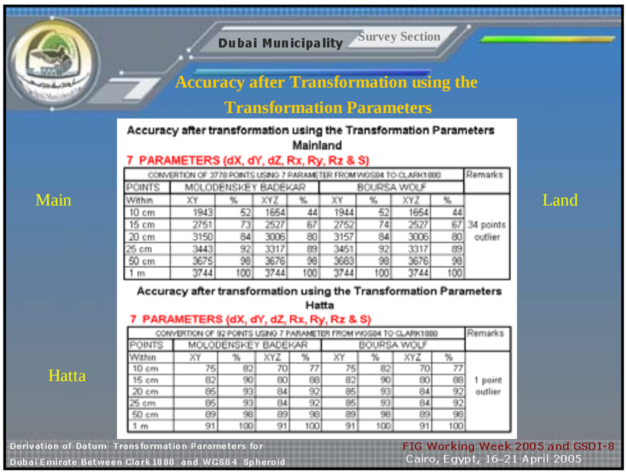


Dubai Municipality Survey Section

92 WGS84 Points Converted to Clark1880, Using Parameters & Compared With Observed Value

Derivation of Datum Transformation Parameters for Dubai Emirate Between Clark 1880 and WGS84 Spheroid

FIG Working Week 2005 and GSDI-8
Cairo, Egypt, 16–21 April 2005



Dubai Municipality Survey Section

Accuracy after Transformation using the Transformation Parameters

Main Land

Accuracy after transformation using the Transformation Parameters
Mainland

7 PARAMETERS (dX, dY, dZ, Rx, Ry, Rz & S)

CONVERTION OF 3778 POINTS USING 7 PARAMETER FROM WGS84 TO CLARK1880									Remarks
POINTS	MOLODENSKEY BADEKAR				BOURSA WOLF				
Within	XY	%	XYZ	%	XY	%	XYZ	%	
10 cm	1943	52	1654	44	1944	52	1654	44	34 points outlier
15 cm	2751	73	2527	67	2752	74	2527	67	
20 cm	3150	84	3006	80	3157	84	3006	80	
25 cm	3443	92	3317	89	3451	92	3317	89	
50 cm	3675	98	3676	98	3683	98	3676	98	
1 m	3744	100	3744	100	3744	100	3744	100	

Hatta

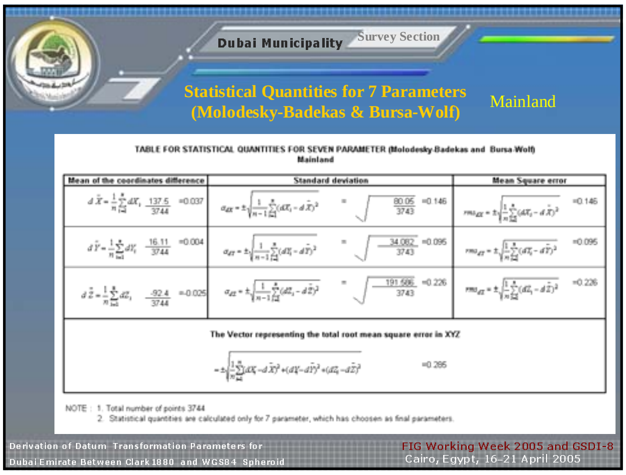
Accuracy after transformation using the Transformation Parameters
Hatta

7 PARAMETERS (dX, dY, dZ, Rx, Ry, Rz & S)

CONVERTION OF 92 POINTS USING 7 PARAMETER FROM WGS84 TO CLARK1880									Remarks
POINTS	MOLODENSKEY BADEKAR				BOURSA WOLF				
Within	XY	%	XYZ	%	XY	%	XYZ	%	
10 cm	75	82	70	77	75	82	70	77	1 point outlier
15 cm	82	90	80	88	82	90	80	88	
20 cm	85	93	84	92	85	93	84	92	
25 cm	85	93	84	92	85	93	84	92	
50 cm	89	98	89	98	89	98	89	98	
1 m	91	100	91	100	91	100	91	100	

Derivation of Datum Transformation Parameters for
Dubai Emirate Between Clark1880 and WGS84 Spheroid

FIG Working Week 2005 and GSDI-8
Cairo, Egypt, 16-21 April 2005



Dubai Municipality Survey Section

Statistical Quantities for 7 Parameters (Molodesky-Badekas & Bursa-Wolf)

Mainland

TABLE FOR STATISTICAL QUANTITIES FOR SEVEN PARAMETER (Molodesky-Badekas and Bursa-Wolf)
Mainland

Mean of the coordinates difference	Standard deviation	Mean Square error
$d\bar{X} = \frac{1}{n}\sum_{i=1}^{n} dX_i \quad \frac{137.5}{3744} = 0.037$	$\sigma_{dX} = \pm\sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(dX_i - d\bar{X})^2} = \sqrt{\frac{80.05}{3743}} = 0.146$	$rms_{dX} = \pm\sqrt{\frac{1}{n}\sum_{i=1}^{n}(dX_i - d\bar{X})^2} = 0.146$
$d\bar{Y} = \frac{1}{n}\sum_{i=1}^{n} dY_i \quad \frac{16.11}{3744} = 0.004$	$\sigma_{dY} = \pm\sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(dY_i - d\bar{Y})^2} = \sqrt{\frac{34.082}{3743}} = 0.095$	$rms_{dY} = \pm\sqrt{\frac{1}{n}\sum_{i=1}^{n}(dY_i - d\bar{Y})^2} = 0.095$
$d\bar{Z} = \frac{1}{n}\sum_{i=1}^{n} dZ_i \quad \frac{-92.4}{3744} = -0.025$	$\sigma_{dZ} = \pm\sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(dZ_i - d\bar{Z})^2} = \sqrt{\frac{191.586}{3743}} = 0.226$	$rms_{dZ} = \pm\sqrt{\frac{1}{n}\sum_{i=1}^{n}(dZ_i - d\bar{Z})^2} = 0.226$

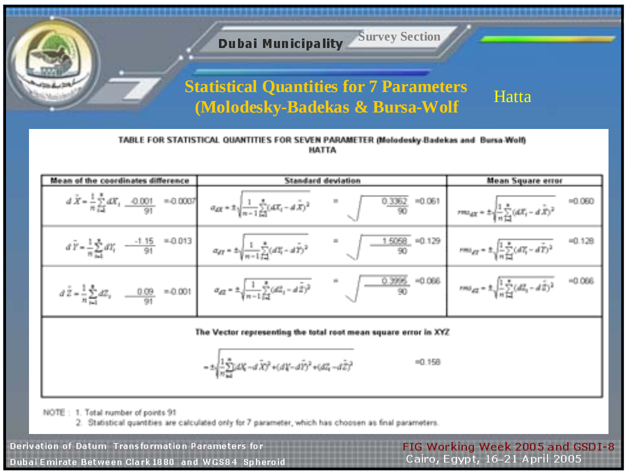
The Vector representing the total root mean square error in XYZ

$$= \pm\sqrt{\frac{1}{n}\sum_{i=1}^{n}(dX_i - d\bar{X})^2 + (dY_i - d\bar{Y})^2 + (dZ_i - d\bar{Z})^2} = 0.285$$

NOTE : 1. Total number of points 3744
2. Statistical quantities are calculated only for 7 parameter, which has choosen as final parameters.

Derivation of Datum Transformation Parameters for
Dubai Emirate Between Clark1880 and WGS84 Spheroid

FIG Working Week 2005 and GSDI-8
Cairo, Egypt, 16-21 April 2005



Dubai Municipality Survey Section

Statistical Quantities for 7 Parameters (Molodesky-Badekas & Bursa-Wolf

Hatta

TABLE FOR STATISTICAL QUANTITIES FOR SEVEN PARAMETER (Molodesky-Badekas and Bursa-Wolf)
HATTA

Mean of the coordinates difference	Standard deviation	Mean Square error
$d\bar{X} = \frac{1}{n}\sum_{i=1}^{n} dX_i \quad \frac{-0.001}{91} = -0.0007$	$\sigma_{dX} = \pm\sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(dX_i - d\bar{X})^2} = \sqrt{\frac{0.3362}{90}} = 0.061$	$rms_{dX} = \pm\sqrt{\frac{1}{n}\sum_{i=1}^{n}(dX_i - d\bar{X})^2} = 0.060$
$d\bar{Y} = \frac{1}{n}\sum_{i=1}^{n} dY_i \quad \frac{-1.15}{91} = -0.013$	$\sigma_{dY} = \pm\sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(dY_i - d\bar{Y})^2} = \sqrt{\frac{1.5058}{90}} = 0.129$	$rms_{dY} = \pm\sqrt{\frac{1}{n}\sum_{i=1}^{n}(dY_i - d\bar{Y})^2} = 0.128$
$d\bar{Z} = \frac{1}{n}\sum_{i=1}^{n} dZ_i \quad \frac{0.09}{91} = 0.001$	$\sigma_{dZ} = \pm\sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(dZ_i - d\bar{Z})^2} = \sqrt{\frac{0.3995}{90}} = 0.066$	$rms_{dZ} = \pm\sqrt{\frac{1}{n}\sum_{i=1}^{n}(dZ_i - d\bar{Z})^2} = 0.066$

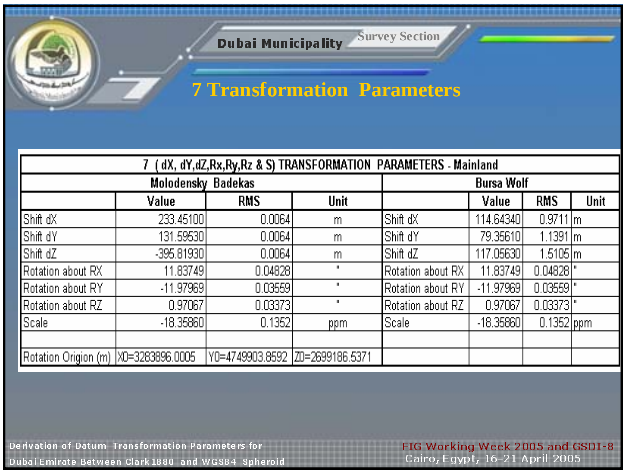
The Vector representing the total root mean square error in XYZ

$$= \pm\sqrt{\frac{1}{n}\sum_{i=1}^{n}(dX_i - d\bar{X})^2 + (dY_i - d\bar{Y})^2 + (dZ_i - d\bar{Z})^2} = 0.158$$

NOTE : 1. Total number of points 91
2. Statistical quantities are calculated only for 7 parameter, which has choosen as final parameters.

Derivation of Datum Transformation Parameters for
Dubai Emirate Between Clark1880 and WGS84 Spheroid

FIG Working Week 2005 and GSDI-8
Cairo, Egypt, 16-21 April 2005



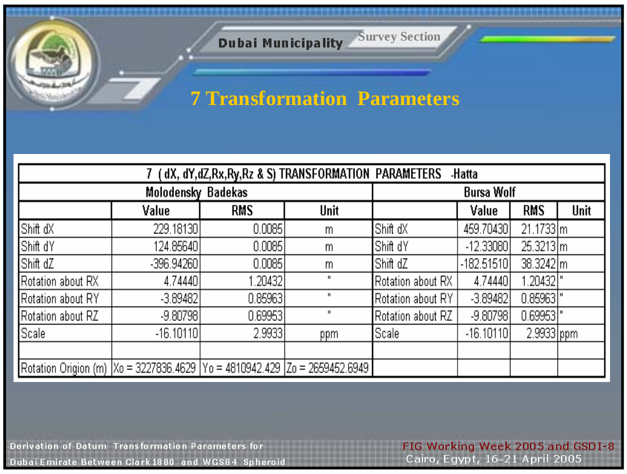
Dubai Municipality Survey Section

7 Transformation Parameters

7 (dX, dY,dZ,Rx,Ry,Rz & S) TRANSFORMATION PARAMETERS - Mainland							
Molodensky Badekas				Bursa Wolf			
	Value	RMS	Unit		Value	RMS	Unit
Shift dX	233.45100	0.0064	m	Shift dX	114.64340	0.9711	m
Shift dY	131.59530	0.0064	m	Shift dY	79.35610	1.1391	m
Shift dZ	-395.81930	0.0064	m	Shift dZ	117.05630	1.5105	m
Rotation about RX	11.83749	0.04828	"	Rotation about RX	11.83749	0.04828	"
Rotation about RY	-11.97969	0.03559	"	Rotation about RY	-11.97969	0.03559	"
Rotation about RZ	0.97067	0.03373	"	Rotation about RZ	0.97067	0.03373	"
Scale	-18.35860	0.1352	ppm	Scale	-18.35860	0.1352	ppm
Rotation Origion (m)	X0=3283896.0005	Y0=4749903.8592	Z0=2699186.5371				

Derivation of Datum Transformation Parameters for
Dubai Emirate Between Clark1880 and WGS84 Spheroid

FIG Working Week 2005 and GSDI-8
Cairo, Egypt, 16-21 April 2005



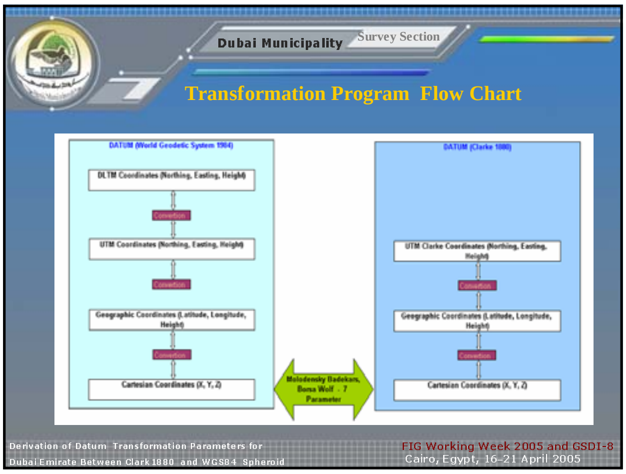
Dubai Municipality Survey Section

7 Transformation Parameters

7 (dX, dY,dZ,Rx,Ry,Rz & S) TRANSFORMATION PARAMETERS -Hatta							
Molodensky Badekas				Bursa Wolf			
	Value	RMS	Unit		Value	RMS	Unit
Shift dX	229.18130	0.0085	m	Shift dX	459.70430	21.1733	m
Shift dY	124.85640	0.0085	m	Shift dY	-12.33080	25.3213	m
Shift dZ	-396.94260	0.0085	m	Shift dZ	-182.51510	38.3242	m
Rotation about RX	4.74440	1.20432	"	Rotation about RX	4.74440	1.20432	"
Rotation about RY	-3.89482	0.85963	"	Rotation about RY	-3.89482	0.85963	"
Rotation about RZ	-9.80798	0.69953	"	Rotation about RZ	-9.80798	0.69953	"
Scale	-16.10110	2.9933	ppm	Scale	-16.10110	2.9933	ppm
Rotation Origion (m)	Xo = 3227836.4629	Yo = 4810942.429	Zo = 2659452.6949				

Derivation of Datum Transformation Parameters for
Dubai Emirate Between Clark1880 and WGS84 Spheroid

FIG Working Week 2005 and GSDI-8
Cairo, Egypt, 16-21 April 2005



Dubai Municipality Survey Section

Transformation Program Flow Chart

DATUM (World Geodetic System 1984)

DLTM Coordinates (Northing, Easting, Height)

Convertion

UTM Coordinates (Northing, Easting, Height)

Convertion

Geographic Coordinates (Latitude, Longitude, Height)

Convertion

Cartesian Coordinates (X, Y, Z)

Molodensky Badekas, Bursa Wolf - 7 Parameter

DATUM (Clarke 1880)

UTM Clarke Coordinates (Northing, Easting, Height)

Convertion

Geographic Coordinates (Latitude, Longitude, Height)

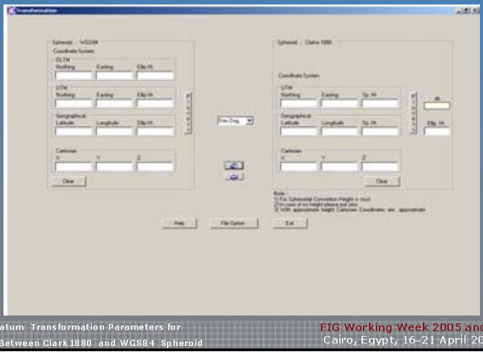
Convertion

Cartesian Coordinates (X, Y, Z)

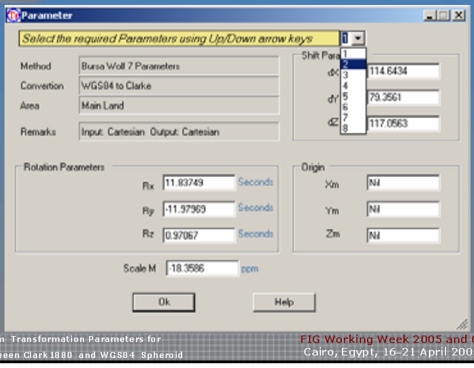
Derivation of Datum Transformation Parameters for
Dubai Emirate Between Clark1880 and WGS84 Spheroid

FIG Working Week 2005 and GSDI-8
Cairo, Egypt, 16-21 April 2005

Transformation program Main menu



Transformation program Parameter Menu



Method: Bursa Wolf 7 Parameters
Convertion: WGS84 to Clarke
Area: Main Land
Remarks: Input: Cartesian Output: Cartesian
dX: 114.6434
dY: 79.3561
dZ: 117.0563
Rx: 11.83749 Seconds
Ry: -11.97969 Seconds
Rz: 0.97067 Seconds
Xm: Nil
Ym: Nil
Zm: Nil
Scale M: -18.3586 ppm

Parameters for Transformation from WGS 84 To DLTM

DLTM
⇩
Dubai
Local
Transverse
Mercator

PARAMETERS FOR TRANSFORMATION FROM WGS84 TO DLTM

DLTM and WGS84 UTM Projections are on WGS84 Spheroid / Datum, with only changes in Central Meridian and Scale Factor. The other projection parameters are as follow.

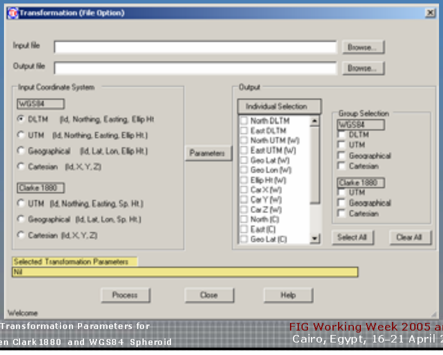
Parameters of WGS84 UTM are as follow.

Projection	UTM (Universal Transverse Mercator)
Zone	40
False Northing	0.00
False Easting	500,000
Origin Latitude	0.00
Central Meridian (CM)	57 E
Scale Factor on CM	0.9996
Semi Major Axis (a)	6378137.0
Semi Minor Axis (b)	6356752.314245179
Flattening (1/f)	298.257223563

Parameters of DLTM are as follow.

Projection	TM (Transverse Mercator)
False Northing	0.00
False Easting	500,000
Origin Latitude	0.00
Central Meridian (CM)	55 20 E
Scale Factor on CM	1.000
Semi Major Axis (a)	6378137.0
Semi Minor Axis (b)	6356752.314245179
Flattening (1/f)	298.257223563

Transformation program
Out put and File option menu



Selected Transformation Parameters: Nil

Conclusion

- The optimal transformation parameter sets computed for main land and Hatta Dubai
- The full Seven parameters set is recommended using Molodensky Badekas model
- For any WGS84 ellipsoidal points a conversion can be carried out up to 10 cm precision, where as for any Clark1880 points conversion precision between 10 –50 cm