Realization of Dubai Emirate Datum on the Reference Frame 2000 (Ditr 2000)

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Salient Feature of ITRF

• ITRF stands for International Terrestrial Reference Frame

• ITRF established by the International Earth Rotation Service (IERS), France. One of the purpose of IERS is to determine Earth rotation parameters

• Its origin is at the center of mass of the whole Earth including oceans

• The implementation of the ITRF is based on the combination of sets of station coordinates (world wide) and velocity derived from observations of space geodetic techniques.

• Datum definition of the ITRF solutions define four datum components (orientation, origin, scale and time evolution)

• 500 Stations and 290 Sites all over the World

Why ITRF ?

• The most precise geocentric ellipsoid has been defined by IERS

• To keep pace with the space geodesy and modern survey technology and to use GPS technology instantaneously·

• To join the International communities in field of Geodesy

• World wide military started using GPS technology and shifting mapping datum to WGS84

• The Geodesist, Astronomers, Geophysist, surveyors, Hydrographer, Research Scholar were in pursuit of precise mathematical ellipsoid, etc.

Why ITRF ?

• World wide mapping and survey communities started to adopt the WGS84 as datum.

• Civil Aviation and Navigation charts were revising on these datum.

• All international Border are defining on ITRS.

• The standard relationship between Geoid and Ellipsoid can be define.

International GPS Service (IGS) Site World Wide

ITRF & WGS84

•The World Geodetic System 1984 is the geodetic reference system which is fixed and static in mode and used by GPS

• ITRF reference frame is same as WGS84 reference but it is Dynamic frame where velocity of the station are to be considered.

• WGS84 was developed for USA-Defense Mapping Agency

•The WGS84 reference frame has been enhanced on several occasions to a point where it is now very closely aligned To ITRF

Slide 1

ITRF & WGS84

• ITRF was created by the civil GPS community, where as WGS84 operate by military organizations.

• Each version of the ITRF is given a year code to identify it the current version for example ITRF93, ITRF2000

• ITRF includes many more stations that the broadcast WGS84 TRF

Slide 2

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 huge mapping activities and subsequent Aerial Photogrammetric mapping in 1983 on Clark1880

Slide 3

Brief History

Adoption of Geocentric Datum in Dubai

• 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 survey control were observed.

• 1995 is the year where Dubai adopted ITRF93 a Geocentric datum. A land mark in the history of Survey of Dubai.

Slide 4

Control on Clark1880 before ITRF93 connection

Slide 5

ITRF93 Stations Established during 1995 in Dubai Emirates

Slide 6

Establishment of Absolute ITRF Station in Dubai

ITRF93 – GPS NETWORK

• 4 Station in Dubai (ET228, ET225, BP5 and ET145)

• 1 (ET152) in Hatta and 1 in Fujera

• 3 IGS Reference Stations (Graz-Austria, Metera-Italy and Kitab-Uzbegisthan)

• Planning, observation and Adjustment by Institute of applied Geodesy(IfAG) and Dubai Municipality.

2

Slide 1

ITRF93
Data acquisition, Processing and Accuracy

Data Acquisition

- GPS campaign in Dubai from 25Jan to 29 Jan 1995(5 days continuously)
- Stations at Hatta and Fujera were observed for few hours
- Trimble SSE receivers, session length 24 hours
- Elevation cut of angle 10 degree , sampling rate 15 seconds

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ITRF93
Data acquisition, Processing and Accuracy

Processing
- Computation of the complete network using the BERNESE Software
- IGS combined orbit in ITRF93 (GPS weeks 0785 and 0786)
- Reference system ITRF-93 epoch 1995.1
- Processing of double-difference measurement based on ionosphere-free phase linear combination L3.
- One troposphere parameter estimated every 2 hours for every session
- Final solution including all days with Graz, Matera and Kitab

Accuracy
- The final estimated accuracy for ITRF coordinates of Dubai is about 5cm, being the internal precision in the range of the 5mm

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Precise Coordinates on ITRF93 in Dubai Emirates

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Why ?   ITRF –2000

- To find out the datum shift parameter between ITRF93 and ITRF2000.
- Necessity for the DVRS stations to be defined on the precise reference system such as on ITRF (latest epoch)
- To derive the precise coordinate for the Hatta region
- To include more IGS stations and the longer duration data of local stations for the final computations
- For Geodynamic aspects
  * Polar motion
  * Crustal movements
  * Earth quake studies, Etc

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March Towards ITRF2000

DITRF2000 - PROJECT
A joint Project between

Dubai Municipality

AND

UNI- Technologies SDN. BHD

Company of Universiti Teknologi - Malaysia

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Slide 6

DVRS Stations

Dubai Virtual Reference System (DVRS) – which operates GPS continuously

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Slide 1

• Eight (8) IGS stations surrounding Middle East have been included in the processing in order to determine the DVRS stations coordinate on ITRS reference frame

No.	Station Id	Station Name	Country
1	MATE	Matera, Telespazio S.p.A.	Italy
2	KIT3	Kitab, Ulugh Beg Astro. Institute	Uzbekistan
3	MALI	Malli, ESA / ESOC	Kenya
4	LHAS	Lhasa, BKG	China/Tibet
5	IISC	Indian Institue of Science	India
6	BAHR	Bahrain GPS Station, NIMA	Bahrain
7	AMMN	Amman, Royal Jordanian Geographic Centre	Jordan
8	NICO	Nicosia-Athalassa	Cyprus

Slide 2

Data Acquisition

Receiver and antenna type for DVRS station

No.	Station	Station ID	Receiver	Antenna	Ant. Height (m)
1	Cattle Market	DRS1	LEICA	LEIAT504_SCIS	1.516
2	Lu Say Li	DRS2	LEICA	LEIAT504_SCIS	0.516
3	Marqab	DRS3	LEICA	LEIAT504_SCIS	0.516
4	Shk. Zayed Road	DRS4	LEICA	LEIAT504_SCIS	0.516
5	Hatta	DRS5	LEICA	LEIAT504_SCIS	1.516

Slide 3

Data Acquisition

• **Data acquisition from GPS weeks 1160 to 1177**
• **For 5 DVRS Stations**
• **For 4 ITRF93 Stations**
• **Data downloaded from 8 IGS stations**

Slide 4

Data Processing

• Bernese GPS Processing software V4.2 is used
• Processing strategy were included computing of daily and weekly solutions
• The final combined solution consists of 18 weekly and 13 stations (8 IGS stations and 5 DVRS stations).
• The Average resolved ambiguity for the DVRS stations processing from GPS week 1160-1177 (6 months) is around 85%
• A free network adjustment with the introduction of Helmert Transformation is to adjust the weekly normal equation free and later transform using seven IGS stations.

Slide 5

RMS and Accuracy of 5 DVRS stations

Slide 6

Station	North (mm)	East (mm)	Up (mm)
DVRS1	0.9	1.4	3
DVRS2	1.1	1.5	3.2
DVRS3	0.8	1.6	3.1
DVRS4	0.7	1.6	2.6
DVRS5	1	1.8	3.2

• **The internal accuracy of the DVRS stations from the free network adjustment is less than 2mm in the horizontal component and less than 5.5 mm in the height component.**

• **The accuracy of the DVRS stations with respect to IGS2000 reference frame within 6 to 13mm in the horizontal component and 15mm in height.**

4

Slide 1

Final Adjusted Coordinates

STATION		CAR-COORDINATES	RMS	GEO- COORDINATES		RMS
DRS1	X	3277208.6069	0.0001	HEIGHT	-21.3074	0.0003
	Y	4749644.0761	0.0002	LATITUDE	25 17 8.594514	0.0001
	Z	2707717.1811	0.0001	LONGITUDE	55 23 40.915639	0.0000
DRS2	X	3319217.2714	0.0001	HEIGHT	-8.5351	0.0002
	Y	4741062.5522	0.0002	LATITUDE	24 55 32.823600	0.0001
	Z	2671617.8228	0.0001	LONGITUDE	55 0 14.902802	0.0000
DRS3	X	3278838.6452	0.0001	HEIGHT	67.829	0.0002
	Y	4764817.8836	0.0002	LATITUDE	25 0 8.362749	0.0000
	Z	2679336.3436	0.0001	LONGITUDE	55 28 0.383241	0.0001
DRS4	X	3274290.1397	0.0001	HEIGHT	157.1452	0.0002
	Y	4778425.9625	0.0002	LATITUDE	24 49 7.732528	0.0001
	Z	2660937.2772	0.0001	LONGITUDE	55 34 48.498795	0.0000
DRS5	X	3228235.6245	0.0001	HEIGHT	289.9841	0.0002
	Y	4809892.7029	0.0002	LATITUDE	24 49 2.081327	0.0001
	Z	2660835.2036	0.0001	LONGITUDE	56 7 54.615708	0.0000

Slide 2

CONNECTION   BETWEEN

ITRF 1993   &   **ITRF 2000**

To established the relationship between ITRF93 and ITRF2000

- **FOUR- ITRF stations was observed on 11th May 2002**
- **Six hours data gathered along with DVRS stations.**
- **The Helmert Transformation parameters were derived.**

Slide 3

Processing

- **The GPS data was processed using Bernese 4.2 software**
- **Five (5) DVRS stations processed together with four (4) established triangulation station (ITRF93), namely ET145, ET228, BP5 and ET152**
- **Results are shown with RMS**

Slide 4

ITRF93   and IGS2000

Num	Station	Par.	ITRF93 Coordinates	RMS	IGS2000 Coordinates	RMS
1	ET145	Latitude	24° 56′ 29″.091655	.0002	24° 56′ 29″.100200	.0002
		Longitude	55° 14′ 06″.394970	.0003	55° 14′ 06″.402339	.0002
		Height	33.9275 m	.0011	33.8377 m	.0019
2	ET228	Latitude	25° 15′ 52″.526020	.0002	25° 15′ 52″.534672	.0002
		Longitude	55° 18′ 43″.449964	.0003	55° 18′ 43″.458036	.0002
		Height	2.7387 m	.0011	2.6679 m	.0013
3	OPB5	Latitude	25° 12′ 36″.474185	.0002	25° 12′ 36″.482736	.0002
		Longitude	55° 37′ 45″.625708	.0003	55° 37′ 45″.633848	.0002
		Height	50.2503 m	.0011	50.1931 m	.0013
4	ET152	Latitude	24° 49′ 13″.565180	.0024	24° 49′13″.573133	.0002
		Longitude	56° 08′ 11″.345577	.0024	56° 08′ 11″.353143	.0002
		Height	317.3228 m	.0026	317.1499 m	.0016

Slide 5

Between ITRF93 and ITRF2000

Difference between ITRF93 and ITRF2000

Slide 6

Transformation parameters between IGS2000 to ITRF93

- Bursa-Wolf 3D model have been used (SIX and SEVEN set)
- It 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 ($1+\Delta L$).

$$\begin{bmatrix} X_{2000} \\ Y_{2000} \\ Z_{2000} \end{bmatrix} = \begin{bmatrix} \Delta X \\ \Delta Y \\ \Delta Z \end{bmatrix} + \begin{bmatrix} 1+\Delta L & R_Z & -R_Y \\ -R_Z & 1+\Delta L & R_X \\ R_Y & -R_X & 1+\Delta L \end{bmatrix} \begin{bmatrix} X_{1993} \\ Y_{1993} \\ Z_{1993} \end{bmatrix}$$

$X_{2000}, Y_{2000}, Z_{2000}$:are the global datum (WGS84) Cartesian co-ordinates;

$X_{1993}, Y_{1993}, Z_{1993}$: are the local datum (CLARK) Cartesian co-ordinates.

5

Dubai Municipality Survey Section

Parameters

Transformation parameters between IGS2000 to ITRF93

• SIX set of Transformation Parameters

```
Dx   =   -0.79046 +-  1.52816 m
Dy   =    5.14964 +-  3.78552 m
Dz   =   -7.95080 +-  2.20140 m
Rx   =   -0.28399 +-  0.06204 "
Ry   =    0.07519 +-  0.05969 "
Rz   =    0.08915 +-  0.04278 "

Stand. Error of unit Weight    So =    0.013

Point           vx         vy         vz

0BP5          0.0046     0.0165     0.0132
E228         -0.0123    -0.0127    -0.0088
E145          0.0103     0.0028    -0.0023
E152         -0.0026    -0.0066    -0.0021

Point           N          E          U

0BP5          0.005      0.006      0.020
E228         -0.001      0.003     -0.020
E145         -0.005     -0.007      0.006
E152          0.001     -0.002     -0.007
```

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Dubai Municipality Survey Section

Parameters

Transformation parameters between IGS2000 to ITRF93

• Seven set of Transformation Parameters

```
Dx   =   -0.68703 +-  1.76248 m
Dy   =    5.30057 +-  1.19260 m
Dz   =   -7.86582 +-  2.44841 m
Rx   =   -0.28399 +-  0.06774 "
Ry   =    0.07519 +-  0.06518 "
Rz   =    0.08915 +-  0.04671 "
S    =   -0.03165 +-  0.17377 ppm

Stand. Error of unit Weight    So =    0.014

Point           vx         vy         vz

0BP5          0.0049     0.0166     0.0127
E228         -0.0128    -0.0120    -0.0094
E145          0.0093     0.0033    -0.0019
E152         -0.0013    -0.0079    -0.0013

Point           N          E          U

0BP5          0.005      0.005      0.020
E228         -0.001      0.004     -0.020
E145         -0.005     -0.006      0.006
E152          0.002     -0.003     -0.007
```

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CONCLUSION

• Now Dubai Emirates has got 5 stations which are defined on ITRF2000 reference frame

• Their accuracy is an order of 6 to 13mm in the horizontal components and 15 mm in height

• Transformation Parameters are computed between ITRF93 and ITRF2000

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on the reference frame 2000
FIG Working Week 2005 and GSDI-8
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