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Compute a Unique Transformation Parameters Set for Updating the Egyptian Network

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الملخص

فى عام 1996 أسست هيئة المساحة المصرية الشبكة الارضية المصرية ذات الدقة العالية "HARN" وذلك بأستخدام نظام الملاحة بالأقمار الصناعية (GNSS) وتم ربط تلك الشبكة بالإطار العالمى وقتها (ITRF1994) بأعتبار هذا الإطار ساكن ؛ ولكن مع التوسع فى إنشاء محطات IGS وظهور مفهوم حركة الصفائح التكتونية أصبحت الشبكة الارضية المصرية غير دقيقة حيث تم رصد أختلافات تصل الى 40 سم بين إحداثيات التى تم تأسيس الشبكة عليها و الارصاد الحالية؛ لذلك تم حساب مجموعة من معاملات التحويل (T_x, T_y, T_z) وبأستخدام تلك المعاملات يمكن تحويل الأرصاد التى تتم فى الإطار العالمى الحالى الى نفس إطار شبكة "HARN" المصرية.

Abstract

With the emergence of the idea of using GNSS in establishing High Accuracy Reference N network "HARN", the Egyptian Survey Authority (ESA) established the Egyptian's HARN network and linked it to the international frame (ITRF1994 epoch1996) as a static frame. With the continuous development of the construction of IGS stations and the emergence of the concept of tectonic plate motion, and the concept of Precise Point Positioning technique has a well know precise technique, there were offset in the current coordinates of the HARN network about 40cm, so a set of simple transformation parameters (T_x, T_y, T_z) were calculated and using these parameters can convert the coordinates in ITRF2008 to HARN network (ITRF1994 epoch1996). In this paper two types of models (ITRF2008 Plate Motion Models, and Egypt Deformation model) were used to calculate these parameters.

Keywords: Transformation parameters; ITRF; Rigid Plate Models

1. Introduction

In the traditional sense, a geodetic datum is a reference surface, by and large, an ellipsoid of revolution of adopted size and shape, with origin, orientation, and scale characterized by a geocentric terrestrial frame. When an ellipsoid is picked, coordinates of a point in space can be given in Cartesian or geodetic (curvilinear) coordinates (geodetic longitude, latitude, and ellipsoid height). Static and kinematic geodetic data are two kinds of geodetic datum. A static datum is thought of as a conventional geodetic datum where all sites are expected to have coordinates which are constant with time. This is an inaccurate supposition since the surface of the earth is continuously changing because of tectonic motion. Static datum does not consolidate the effects of plate tectonics and deformation events. Coordinates of static datum are constant at a reference epoch and slowly go out of the date, need to change periodically which is Devastating.

When a national coordinate system is set up by using high accuracy GPS positioning, a procedure designed for its regular upkeep is also required. It is aimed to assure the quality and thoroughness for the GPS control stations as they might be degraded by any intended or natural effects. If the regular upkeep is not made for those GPS sites, the geocentric reference system based on this fundamental GPS network would be disfigured. However, if the upkeep is considerably done for those GPS control stations, it would also result in some difficulties for land planning and management as the coordinates of these control stations should be jointly changed. Therefore, a guideline set up to go on a stable frequency and consistent quality of upkeep for the GPS control stations in Egypt is specially required.

Normally, for the upkeep of GPS tracking stations, the precise coordinates of these GPS tracking stations are resolved in the network adjustments incorporating with part of the IGS stations whose coordinates are frequently kept up with the realization of the ITRF. When long term of coordinate data sets is archived for GPS tracking stations, they can be used to investigate the time evolution. As the coordinates of the first-order GPS control stations are specified by fixing the coordinates of the GPS tracking stations in the network adjustments, the information of time evolution provided by the GPS tracking stations can be used to carry on the upkeep for the first-order GPS control stations (Rabah et al., 2015).

GPS has been widely used in Egypt to establish geodetic control networks for a wide range of surveying and mapping applications. Notwithstanding, majority of these networks are limited in coverage and availability. The most vital GPS network in Egypt is the so-called High Accuracy Reference Network (HARN). The HARN network has been set up by the Egyptian Survey Authority (ESA) in the 1994. The HARN network is divided into two sub-networks: HARN order-A, and HARN order-B. The HARN order-A network, Figure 1, comprises of 30 stations covering the Egyptian region with an average spacing of approximately 200 km. Its relative accuracy estimate is 1:10,000,000. Furthermore, HARN order-B, or what is usually known by the Notational Agricultural Cadastral network (NACN) covering the Nile Valley and Delta of Egypt in the separations of around 30 to 40 Km. NACN is comprised of 112 GPS stations covering, Nile valley of Egypt. NACN inter-station distances were between 40 km and 60 km with 1:1000000 distance accuracy (**figure1**).

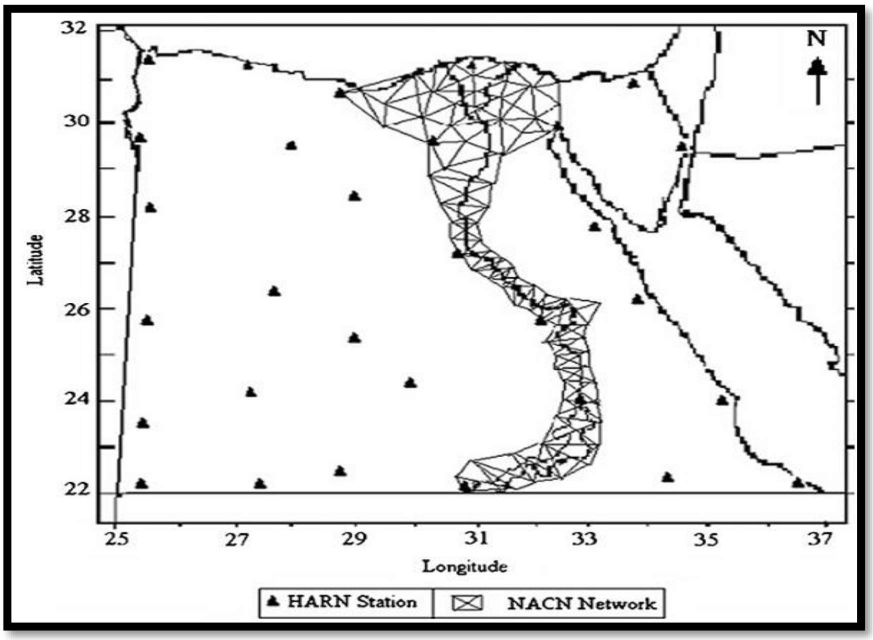

Figure1. The HARN and NACN Networks

The Egyptian Survey Authority (ESA) started monitoring the HARN in 1996, utilizing GPS to observe these stations and tie them to International Terrestrial Reference Frame 1994 (ITRF94), as it considered the most neoteric reference frame. The ITRF1994 was transferred to Egypt's HARN network by connecting it with four IGS stations, namely MATE (Italy), KIT3 (Uzbekistan), HART (South Africa) and MASP in (Canary Island), depicted in figure (2). Each HARN's station was monitored for six sessions, every session was 6 hours with 30 seconds epoch interval. The outcomes of analyzing both were defined in ITRF1994 epoch 1996 (Scott, 1997).

Figure 2. Connecting parts of Egyptian HARN with four stations of IGS

Since the establishment of the HARN network and so far, no update or development or upkeep has been made to that network, considering ITRF94 as a static geodetic datum. With the absent role of datum upkeep of Egypt networks, one can easily say that the majority of the stations in or near the cities of HARN and NACN networks, are destroyed and ruined. Figure 3 shows one of the HARN stations that are partially destroyed and most likely in a few years will be crushed. Additionally, the rest held HARN stations are difficulty to get to them in nominated areas for security reasons or far away from the project's sites.

So, the need to compensate the surveying community in Egypt with an economic, precise and easy alternative technique is a fantastic objective. However, Rabah et al. (2015) proposes a Precise Point Positioning technique to be utilized as the promising technique that covers all the needs of the Surveyors in Egypt. On the other side, by using PPP the resulted reference frame is fully different from the official geodetic datum defined by ESA. To optimize the using of PPP in Egypt, a transformation parameters determination between the currently used ITRF and the ITRF94 epoch 1996 is the main objective of the current study.

Figure 3. A sample of the partly destroyed HARN station

2. International Terrestrial Reference Frame (ITRF)

The International Terrestrial Reference System (ITRS) is the complete conceptual definition for terrestrial coordinates to satisfy the highest possible accuracy. It defines the origin and the orientation of fundamental planes or axes of the system and also includes scale, physical constants and models such as, the size, shape and orientation of the reference ellipsoid. This reference system is a mathematical abstraction while its practical realization through geodetic observations is known as a reference frame. Accordingly, the International Terrestrial Reference Frame (ITRF) means the practical realization of a reference system through Cartesian coordinates and linear velocities of a global set of sites equipped with various space geodetic observing systems [Boucher et al., 1990]. This frame has the center of mass of the earth as its geo-center. The parameters for such reference frame are determined by the combination of worldwide tracking sites of VLBI, SLR, DORIS and GNSS.

The ITRF has continuous changes related to the temporal variations of reference network coordinates and their velocities. These temporal variations are resultant from the effects of crustal motion, earth orientation, polar motion and other geophysical phenomena such as earthquakes and volcanic activity (Altamimi, Z., 2012). The ITRF is updated regularly in order to account for the dynamics of the earth and now sufficiently refined to ensure that the change between successive ITRF versions is in the order of 1-2 cm. The common early versions of this frame i.e., ITRF92, ITRF93, and ITRF94 were produced with the limited distribution and availability, and performance of the reference network stations known by fiducials. With the introduction of ITRF96 on March 1998, the set of fixed fiducials was expanded and improved to 47 sites, and later to 51 with ITRF97 on 1999.

The realization of ITRF2005 was done with increased number of stations, about 800 stations at about 500 locations. The ITRF2008 solution was published on 2010. ITRF2008 consists of sets of station positions and velocities with their variance/covariance matrices. It has been computed using solutions from four difference space geodetic techniques: VLBI (Very Long Baseline Interferometry), SLR (Satellite Laser Ranging), DORIS (Doppler Orbitography and Radio positioning Integrated by Satellite), and GPS (Global Positioning System).

3. Transformation Parameters Using Rigid Plate Rotation Model

The Earth's surface is consisting of a number of tectonic plates. These plates collide, rift apart, or slip past adjoining plates along the plate margins at rates of up to several centimeters a year. Major earthquakes and volcanic activity mostly occur within these plate boundary zones. Tectonic plates are internally rigid and stable away from the boundaries of the plate. Baselines estimated between any two geologically and structurally stable geodetic stations situated on a rigid plate are probably not going to change by more than a few mm/yr. Transformation parameters from kinematic ITRF to a static geodetic datum are classical done by either using the site velocity (using a plate motion model) to calculate the displacement between the reference and current epochs.

Rigid Plate movement is defined by a rotation rate about a Euler Pole (Φ,Λ and ω). Where Φ, Λ are the latitude and longitude of the pole, and ω is the rate of rotation of the plate around the pole in degrees per million years.

Ω_X, Ω_Y and Ω_Z are Equivalent rotation rates about the Cartesian axes, computed from the Euler pole definition using equations (1-3) (Φ, Λ and ω) are first converted from decimal degrees to radians) (Stanaway and Robert 2009):

$$\Omega_X = cos(\Phi)\, cos(\Lambda)\, \omega \qquad (1)$$

$$\Omega_Y = cos(\Phi)\, sin\, (\Lambda)\, \omega \qquad (2)$$

$$\Omega_Z = \sin(\Phi)\omega \qquad (3)$$

($X^{\cdot}$, $Y^{\cdot}$, $Z^{\cdot}$) are Cartesian format for site velocity can be computed for any location

(X, Y, Z in meters) on a rigid plate defined by (Ω_X, Ω_Y, Ω_Z in radians per million years) using:

$$\begin{bmatrix} X^{\cdot} \\ Y^{\cdot} \\ Z^{\cdot} \end{bmatrix} = \begin{bmatrix} \Omega_Y Z - \Omega_Z Y \\ \Omega_Z X - \Omega_X Z \\ \Omega_X Y - \Omega_Y X \end{bmatrix} . \text{1E-6} \qquad (4)$$

Applying equation (5) with a reference epoch t_o and an epoch of measurement t (epochs in decimal years), the ITRF coordinates of any point on a rigid plate at a reference epoch (X_o, Y_o, Z_o in meters) can be computed from the coordinates at epoch t (X_t, Y_t, Z_t in meters) in same frame using:

$$\begin{bmatrix} X_0 \\ Y_0 \\ Z_0 \end{bmatrix} = \left[\begin{bmatrix} X_t \\ Y_t \\ Z_t \end{bmatrix} + \begin{bmatrix} \Omega_Y Z_t - \Omega_Z Y_t \\ \Omega_Z X_t - \Omega_X Z_t \\ \Omega_X Y_t - \Omega_Y X_t \end{bmatrix} . (t_0 - t)1E - 6 \right] \qquad (5)$$

The above equations are accurate within rigid plate zones, however within deforming zones additional parameters derived from deformation models (e.g. Finite Element Model and Fault Locking models) are required in order to maintain consistency between different epochs (Dow et al., 2009). In addition, co-seismic and post seismic terms need to be added, (Tx, Ty, Tz) can be adding to the transformation model to account for the translation of the ITRF origin from the datum at the reference epoch using:

$$\begin{bmatrix} X_0 \\ Y_0 \\ Z_0 \end{bmatrix} = \begin{bmatrix} T_X \\ T_Y \\ T_Z \end{bmatrix} + \left[\begin{bmatrix} X_t \\ Y_t \\ Z_t \end{bmatrix} + \begin{bmatrix} \Omega_Y Z_t - \Omega_Z Y_t \\ \Omega_Z X_t - \Omega_X Z_t \\ \Omega_X Y_t - \Omega_Y X_t \end{bmatrix} . (t_0 - t)/1000000 \right] \qquad (6)$$

Where:

(X_o, Y_o, Z_o) are the ITRF Cartesian coordinates at the reference epoch t_0.

(X_t, Y_t, Z_t) are instantaneous ITRF Cartesian coordinates at epoch t (epoch in decimal years).

(Tx,Ty, Tz) are the translation parameters of the reference frame origin (from ITRF to a local system)

$(\Omega_X,\Omega_Y,\Omega_Z)$ are the Cartesian rigid plate/block rotation parameters.

Therefore, the translation parameters of the reference frame origin (from ITRF to a local system) (Tx,Ty, Tz) can be computed as:

$$\begin{bmatrix} T_X \\ T_Y \\ T_Z \end{bmatrix} = \begin{bmatrix} X_0 \\ Y_0 \\ Z_0 \end{bmatrix} - \left[\begin{bmatrix} X_t \\ Y_t \\ Z_t \end{bmatrix} + \begin{bmatrix} \Omega_Y Z_t - \Omega_Z Y_t \\ \Omega_Z X_t - \Omega_X Z_t \\ \Omega_X Y_t - \Omega_Y X_t \end{bmatrix} . (t_0 - t)/1000000 \right] \tag{7}$$

Applying Equation (4) into Equation (7), a simple form can be obtained as:

$$\begin{bmatrix} T_X \\ T_Y \\ T_Z \end{bmatrix} = \begin{bmatrix} X_0 \\ Y_0 \\ Z_0 \end{bmatrix} - \left[\begin{bmatrix} X_t \\ Y_t \\ Z_t \end{bmatrix} + \begin{bmatrix} X^{\cdot} \\ Y^{\cdot} \\ Z^{\cdot} \end{bmatrix} . (t_0 - t) \right] \tag{8}$$

Where: $(X^{\cdot}, Y^{\cdot}, Z^{\cdot})$ are Cartesian format for site velocity for any location (X, Y, Z in meters) on a rigid plate

In general, the African continent is divided into two major tectonic plates (Nubian Plate and Somalian Plate). Most of Africa, west of the East African Rift lies on the Nubian Plate. The Somalian Plate lies east of the African Rift. A very small section of North Africa along the Maghreb coast in Algeria and Morocco lies on the Eurasian Plate and the Dankalia region of Eritrea lies on the Arabian Plate (figure 5).

Since, Egypt is located in the north-eastern part of the Africa continent and it is laid in the Nubian Plate. Rabah et al., 2015 extracted the Nubian parameters from the Plate Motion Model "PMM" developed by (Altamimi, Z., 2012) and Egyptian Deformation Model "EGY-DM" developed by (Saleh, M. et al. 2015). The Nubian parameters is given in table (1) so Nubian parameters shown in the table (1), can be used for computing velocity of the points

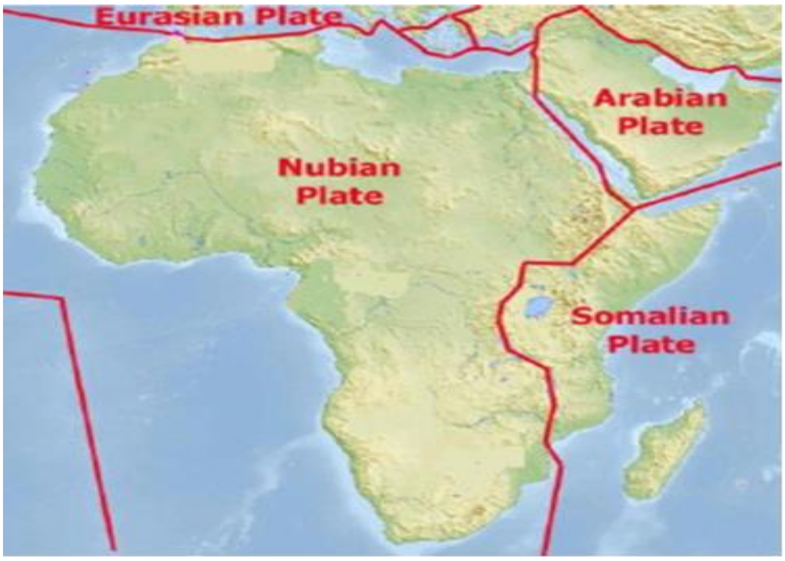

Figure 5. African tectonic plates

Table1. The Cartesian angular velocity of Nubian plate (M.Rabah et al., 2015)

Deformation model	Absolute Pole Cartesian angular Velocity for Nubian Plate		
	ΩX (Rad/Ma)	Ωy (Rad/Ma)	Ωz (Rad/Ma)
PMM	0.000461	−0.002899	0.003505
EGY-DM	0.000419	-0.002930	0.003580

4. Computing simple transformation parameters from ITRF2008 to ITRF 1994 (current geodetic datum used in Egypt)

High precision GNSS positioning and navigation is quickly featuring highlighting the divergence between global kinematic reference frames such as ITRF and WGS84, and conventional static geodetic datum. The dissimilarity is brought about by the increasingly widespread utilize of PPP and the affectability of these techniques to deformation of the Earth due to plate tectonics. In order for precision GNSS techniques to continue to deliver temporally stable coordinates within a localized reference frame. The precision of many GNSS systems presently in widespread use is sufficient to disclose this movement over short periods of time. Unless this motion is modelled accurately, repeat surveys using the same technique over a span of a year or more will become deviated. With the continuous modernization of the construction of IGS stations around the world, a new concept of international frame has emerged that the international frame is a kinematic frame, not a static one, as the majority thought. The latest realization of ITRF(s) is ITRF2014 but most of the factors that are differ from ITRF08 are related mainly to the very active seismic areas which are far away from our region. Additionally, the precise ephemeris and related satellite clock offset that are connected with our available data are still defined in ITRF2008, and consequently, ITRF2008 will be used as the latest reference frame for recent observations.

As it is commonly known, the key to PPP solution is merging the precise ephemeris and Satellite Clock offsets data into the processing to reduce the effect of the satellite positioning errors and satellite clock offsets. Since the precise orbits and satellite clock is till the day of observation campaign is defined in ITRF08, IGb08. Thus, the majority of PPP, global GNSS post-processing and RTK services (e.g. OmniStar, AUSPOS and OPUS) initially produce coordinates in either ITRF or WGS84 reference frames. Additionally, with use these service in Egypt and to satisfy the ESA requirements, the surveying committee need to transform the coordinates into a local static geocentric datum such as ITRF94 epoch 1996 using a kinematic model, positional coordinates will also be kinematic, changing by up to several cm a year as a result of motion of the underlying tectonic plate.

To compute the required set of simple transformation parameters to convert point coordinates from ITRF08 defined at any epoch to ITRF94 epoch 1996, the velocities of those points should be known. So, a crustal deformation model should be available to describe quantitively the velocities of any crustal point on the earth surface. ITRF2008 plates Motion Model (PMM) and Egyptian deformation model (EGY-DM) were used to calculate the velocity of those points. To evaluate the performance of these models on the Egypt territories, a set of observatory points were observed and processed.

4.1 Data Sets

Three days campaigns were conducted in June 2015 from 3 to 6, to connect a specified part of HARN & NACN networks, namely Stations 0Z20, 0Z18 and 0Z91 to a part of the Egyptian Permanent GPS Network (EPGN) established by NRIAG in 2006, 12 stations, see figure 6. The processing was performed twice by TBC version 3.9 (TRIMBLE). The first run of processing was done based on using station Helwan as a reference for the whole network, where its reference position was determined by utilizing Precise Point positioning technique, as specified by (Rabah et al, 2016). Thus, the whole position coordinates of the used stations are defined in ITRF2008 epoch 2015.14. The second run was done to transfer the ITRF94 epoch 1996 to the network by choosing 0Z20, defined with its initial value in ITRF94 epoch 1996 given by Scott 1997. 10 stations of the data sets will be used for determining the required transformation parameters and the rest of the points will be used for verification.

4.2 Computing simple transformation parameters (Tx,Ty, Tz) using ITRF2008 Plate Motion Model (PMM)

By using the specified PMM's Absolute Pole Cartesian angular Velocity for Nubian Plate (Ω_X,Ω_Y,Ω_Z) in table (1) and applying them in equation (4) to compute velocity of the points in ITRF2008 epoch 2015.4. The velocities of the specified station are given in table (2).

Table 2. The velocity of points in ITRF2008 epoch 2015.4 using PMM model

Point ID	V_x (m/y)	V_y (m/y)	V_z (m/y)
ALAM	-0.0194	0.0154	0.0153
ARSH	-0.0201	0.0144	0.0146
ASSUIT	-0.0189	0.0156	0.0154
ASWN	-0.0186	0.0160	0.0157
BORG	-0.0189	0.0152	0.0151
MNSR	-0.0195	0.0149	0.0149
MSLT	-0.0191	0.0153	0.0151
MTRH	-0.0183	0.0155	0.0152
SAID	-0.0198	0.0147	0.0147
SLUM	-0.0177	0.0157	0.0153

Figure 6. Distribution of 15 selected stations in ITRF2008 epoch 2015.4

So, by compensating the obtained velocities, table 2, in equation (8), the translation parameters (Tx,Ty, Tz) of the reference frame origin (from ITRF2008 to a ITRF94, epoch 1996) (Tx,Ty, Tz) can be computed for every common station of the two data sets. The results are demonstrated in the table 3.

Table 3. the translation parameters (Tx,Ty, Tz) between ITRF2008 epoch 2015.4 and ITRF1994 epoch 1996 based on PMM

Point ID	**Δx (m)**	**Δy (m)**	**Δz (m)**
ALAM	-0.0922	-0.0945	-0.0553
ARSH	-0.0710	-0.0732	-0.0341
ASSUIT	-0.1042	-0.1012	-0.0581
ASWN	-0.1121	-0.1091	-0.0658
BORG	-0.1021	-0.0940	-0.0482
MNSR	-0.0846	-0.0844	-0.0392
MSLT	-0.0974	-0.0942	-0.0486
MTRH	-0.1158	-0.1011	-0.0520
SAID	-0.0796	-0.0792	-0.0375
SLUM	-0.1330	-0.1123	-0.0587
Mean	-0.0992	-0.0943	-0.0497

So, the mean values of the obtained translation parameters (Tx,Ty, Tz) = (0.0992, 0.0943, and 0.0497) to be used to define the simple transformation parameters (Tx,Ty, Tz).

4.3 Computing simple transformation parameters (Tx,Ty, Tz) using Egyptian deformation model (EGY-DM)

The same procedures that were used in deriving translation parameters (Tx,Ty, Tz) using PMM are used in computing mean values for translation parameters (Tx,Ty, Tz) using the specified EGY-DM's Absolute Pole Cartesian angular Velocity for Nubian Plate (Ω_X,Ω_Y,Ω_Z) in table (1). The results of the velocities and the values of the obtained translation parameters (Tx,Ty, Tz) for each point are illustrated in table (4) and table (5).

Table 4. The velocity of points in ITRF2008 epoch 2015.4 using EGY-DM model

Point ID	**V_x (m/y)**	**V_y (m/y)**	**V_z (m/y)**
ALAM	-0.0197	0.0159	0.0153
ARSH	-0.0204	0.0149	0.0146
ASSUIT	-0.0192	0.0161	0.0154
ASWN	-0.0189	0.0165	0.0157
BORG	-0.0192	0.0157	0.0151
MNSR	-0.0198	0.0154	0.0149
MSLT	-0.0194	0.0158	0.0152
MTRH	-0.0186	0.0160	0.0152
SAID	-0.0201	0.0151	0.0147
SLUM	-0.0180	0.0162	0.0154

Table 5. the translation parameters (Tx,Ty, Tz) between ITRF2008 epoch 2015.4 and ITRF1994 epoch 1996 based on EGY-DM

Point ID	Δx (m)	Δy (m)	Δz (m)
ALAM	-0.0857	-0.1035	-0.0554
ARSH	-0.0646	-0.0825	-0.0343
ASSUIT	-0.0982	-0.1106	-0.0586
ASWN	-0.1059	-0.1183	-0.0662
BORG	-0.0962	-0.1036	-0.0489
MNSR	-0.0785	-0.0938	-0.0396
MSLT	-0.0914	-0.1037	-0.0492
MTRH	-0.1102	-0.1109	-0.0528
SAID	-0.0734	-0.0886	-0.0379
SLUM	-0.1277	-0.1221	-0.0598
Mean	-0.0932	-0.1038	-0.0503

So, the mean values of the EGY-DM based translation parameters (Tx,Ty, Tz) = (0.0932, 0.1038, and 0.0503) to be used to define the simple transformation parameters (Tx,Ty, Tz).

5. Verify the Computed Translation Parameters

The mean values of the translation parameters (Tx,Ty, Tz) that are computed based on using the velocities derived by the PMM and EGY-DM are given in table (6).

Table 6. The computed translation parameters

Model type	**Translation Parameters**		
	T_X	T_y	T_Z
PMM	0.0992	0.0943	0.0497
Egypt DM	0.0932	0.1038	0.0503

By substituting the specified translation values and related Deformation Model's Absolute Pole Cartesian angular Velocity for Nubian Plate (Ω_X,Ω_Y,Ω_Z), specified in table (1) for the station in equation (6), the required ITRF Cartesian coordinates at the reference epoch t_o can be obtained. Thus, to verify the feasibility of the computed transformation parameters, the following points are used (table 7).

Table 7. The data points that are used for verification

Point ID	ITRF 2008,Epoch 2015.4			ITRF 1994, epoch 1996 (Scott, 1997).		
	xt	Yt	Zt	xo	Yo	Zo
0Z18	4657081.826	2807150.073	3322370.171	4657082.290	2807149.869	3322369.922
0Z20	4796793.735	2651830.759	3250924.995	4796794.204	2651830.557	3250924.750
0Z91	4745737.289	2795140.363	3205858.824	4745737.755	2795140.160	3205858.578
PHLW	4728141.22	2879662.63	3157147.184	4728141.687	2879662.426	3157146.938
0Z89	4739314.553	2828743.544	3186027.199	4739315.089	2828743.36	3186026.976

Where:

(X_o,Y_o,Z_o) are the ITRF Cartesian coordinates at the reference epoch t_0.

(X_t, Y_t, Z_t) are instantaneous ITRF Cartesian coordinates at epoch t .

Table 8. The differences between the original coordinate's values & its transformed values based on the used deformation Models

Point ID	ITRF2008 PMM			Egypt DM		
	∆X (m)	∆Y (m)	∆Z (m)	∆X (m)	∆Y (m)	∆Z (m)
0Z18	**-0.013**	**-0.012**	**-0.012**	**-0.012**	**-0.011**	**-0.011**
0Z20	**0.007**	**0.001**	**-0.001**	**0.006**	**0.0007**	**-0.001**
0Z89	**0.065**	**0.016**	**0.019**	**0.062**	**0.012**	**0.016**
0Z91	**-0.006**	**-0.007**	**-0.007**	**-0.003**	**-0.003**	**-0.004**
PHLW	**-0.006**	**-0.005**	**-0.004**	**-0.005**	**-0.001**	**-0.003**

As it is shown in table (8), the two models give similar results, the differences between them is just a few mm. In spite of the transformation parameters computed based on the EGY-DM model give the best solution compared with the Parameters determined based on PMM model based on the original published values of the data points that are used for verification. Additionally, table (8) shows what accuracy can both the computed translation parameters in the transformation process from ITRF2008 to ITRF1994 Epoch 1996. The most critical values were assigned for 0Z89, mostly for the limited observation time compared with other points (Only about six hours for power supply defect).

6. Conclusions

High precision GNSS positioning and navigation is very rapidly highlighting the disparity between global kinematic reference frames such as ITRF and WGS84, and traditional static geodetic datum. The disparity is brought about by the increasingly widespread use of PPP, global GNSS post-processing and RTK services (e.g. OmniStar, AUSPOS and OPUS) and the sensitivity of these techniques to deformation of the Earth due to plate tectonics as well as they initially produce coordinates in either ITRF or WGS84 reference frames. On the other hand, the Egyptian GPS network adopted ITRF94 epoch 1996 as the reference epoch for the HARN networks and related geodetic datum. As this datum is static, coordinates of stations do not change with time, ignoring both the tectonic motion and the different definition for all the following ITRF realizations.

With the absent role of datum upkeep of Egypt networks, one can easily say that most of the stations in or near the cities of HARN networks are destroyed and demolished. Additionally, the rest reserved HARN stations are difficulty to access them in certain areas for security reasons or far away from the projects sites. So, the need to compensate the surveying society in Egypt with an economic, precise and easy alternative technique is the main objective of the current study.

Precise Point Positioning technique was proposed to be used as a promising technique that covers all the needs of the Egyptian Surveying Committee. On the other hand, by using PPP the resulted reference frame is completely different from the official geodetic datum defined by ESA. To optimize the PPP using in Egypt, a simplified transformation parameters determination (only translation) between the currently used ITRF and the ITRF94 epoch 1996 is computed based on utilizing a global deformation model (PMM) and a national deformation model (EGY-DM). The resulted transformation parameters show a similar and accurate solution for both sets. Of course, the local transformation parameters based on the EGY-DM give more precise and accuracy than the set based on the PMM. The differences between both Transformation Parameters sets are just in a few mm.

References

Altamimi, Z., Métivier, L. and Collilieux, X. (2012); ITRF2008 Plate Motion Model. Journal of Geophysical Research, 117, B07402.

Altamimi Z, Collileux J, Legrand J, Garayt B, Boucher C (2007); ITRF2005: A new release of the International Terrestrial Reference Frame based on time series of station positions and Earth Orientation Parameters, Journal of Geophysical Research, Vol. 112, B09401, doi:10.1029/2007JB004949

Boucher, C., Wilkins, G. (eds.) (1990), Earth rotation and coordinate reference frames. IAG Symposium No. 105, Edinburgh, August 10-11, 1989. Springer- Verlag, NewYork-Berlin

Dow J.M., Neilan R. E., and Rizos C., (2009), The International GNSS Service in a changing landscape of Global Navigation Satellite Systems. *J. Geodesy,* 83(3-4):191–198, DOI: 10.1007/s00190-008-0300-3

Ferland, R. and Kouba, J., (1996): IGS ITRF Realization and Transformations. Geodetic Survey Division Natural Resources Canada (NRCan) Ottawa, Canada K1A OE9.

Saleh, M. and M. Becker (2013), A new velocity field from the analysis of the Egyptian Permanent GPS Network (EPGN) Arab J Geosci DOI 10.1007/s12517-013-1132-x

Scott, M. (1997): Results of Final Adjustment of New National Geodetic Network, Geodetic Advisor for the Egyptian Survey Authority

Stanaway, R. and Roberts, C. (2009), A Simplified Parameter Transformation Model from ITRF2005 to Any Static Geocentric Datum (e.g. GDA94). Proceedings from International Global Navigation Satellite Systems Society IGNSS Symposium 2009, Surfers Paradise, 1-3 December 2009.

Rabah M, Shaker A, Farhan M (2015); Towards a Semi-Kinematic Datum for Egypt, *Scientific Research Publishing Inc,* Vol.6 No.3, DOI: 10.4236/pos.2015.63006

Rabah M, Elmewafey M, Farhan. M (2016); Datum maintenance of the main Egyptian geodetic control networks by utilizing Precise Point Positioning ‘‘PPP’’ technique, NRIAG Journal of Astronomy and Geophysics, Volume 5, Issue 1, June 2016, Pages 96-105