CHAPTER (6)

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary

The data used in this thesis can be divided into three categories according to their geodetic datum as follows:

- The coordinate sets based on the Old Egyptian Datum, (OED).
- The coordinate sets based on the World Geodetic System 1972, (WGS72).
- The coordinate sets based on the World Geodetic System 1984, (WGS84).

The available Conventional geodetic data sets, Doppler data sets and GPS data sets in Egypt are not all on the same basis because of the different specifications were illustrated in this thesis. This thesis is directed towards the following items:

- Collecting all the available classical geodetic first order control networks, Doppler and GPS coordinate data sets.
- Designing and establishing software package for the coordinate transformation and map projection.
- Unifying all the collected coordinates, once in WGS84 and once more in the Old Egyptian Datum (OED) by defining the transformation parameters between WGS84 and OED all over Egypt.

- Finally, Designing and establishing a data base for the raw data and their history and their description as well as the unified data.

The Practical Work Includes The Following Steps:

- **Step (1):** Collecting the data and determining the common points among the different available data sets.
- **Step (2):** Data filtering;
  This step is directed to filter the data from the odd values which were not consistent with the other values.
- **Step (3):** Transforming the different WGS84-data sets and WGS72-data sets into one WGS84 consistent coordinate set.
- **Step (4):** Computing transformation parameters between WGS84 and OED all over Egypt.
- **Step (5):** Transforming all WGS84 coordinates points into OED.
- **Step (6):** Transforming all OED coordinates points into WGS84.

Those steps were illustrated in this thesis with all details.

6.2 Conclusions

6.2.1 Evaluation for the Design Package

Non familiar users of geodetic datum coordinate transformations, and map projections can use the developed software package easily using the package. The user can do the following easily:

1. Apply **2D-Transformation**, using two different models (Similarity Transformation or Polynomial Method) and then use any of them to transform coordinates from 2D-coordinate system to another one.

2. Apply **3D-Transformation**, as follows:

   - Compute the datum shift parameters and use them to transform coordinates from one system to another one.
   - Convert the form of the coordinates system (φ, λ, h) To (X, Y, Z) and vice versa.
   - Compute the seven transformation parameters using two different models (Bursa-Wolf or Molodensky-Badekas), and then use any of them to transform coordinates from 3D-coordinate system to another one.

3. Apply **Map projection** method to obtain (E, N) from (φ, λ), and vice versa, apply anti- projection method to obtain (φ, λ) from (E, N).

6.2.2 Evaluation for the Solutions (Unification Process)

The transformation between WGS84 and the OED are handled here by using the three shift parameters and mainly once more using the seven transformation parameters.

6.2.2.1 Evaluation for the Solutions Using the Three Shift Parameters

- Five solutions for computing the best three shift parameters between WGS84 and OED depending on number of common points were done, using 40, 33, 27, 22, and 18 as common points.
- Eleven more solutions were done by using the common points in each section, and make for each section separately transformation by the three shift parameters method to test all available data by this method by every possible ways, see table (5-14).

- The results in the above mentioned table show that section two have the smallest three shift parameter in mean values dx=124.854m, dy=-112.61m, dz=12.597m and St.Dev values δ(dx)=0.3193m, δ(dy)= 0.3193m, δ(dz)= 0.3193m.
- The results assure that section two was the best one to get the best three shift parameter. Also, section two has the centered location among the others, Figure (5-4).
- The three shift parameters were computed from the coordinates of the 4-common points of section two were used to test the validity of using the shift parameters against the distance.
- Points around section 2 are divided into 5-groups according to their distances from point (L2) which belong to section 2 and located at the center of this section, and then the shift parameters are done at each point using mean value at (L2), see table (5-15).
- This test was made to assure that the transformation method done by the three shift parameters works successively is at limited distance only.
- The Figure (5-3) shows the relation between the Distance and the Horizontal-Error component which is getting worth with the increasing in the distance.

6.2.2.2 Evaluation for the Solutions Using the Seven Transformation parameters

- Five solutions for computing the best seven transformation parameters between WGS84 and OED depending on number of common points were done. The solutions are using 40, 33, 27, 22, and 18 common points.

- In every transformation, transformation parameters and their standard deviations as well as the residuals at the used common points were computed. Points with the highest residuals which cause big values for the standard deviations of the computed parameters were rejected since the best coverage could be obtained and the computations were done once more.
- The distribution of the used common points was shown in figures (5-4), (5-5), (5-6), (5-7), and (5-8). Residuals of latitudes, longitudes, ellipsoidal heights, horizontal resultants, and spatial resultants at the solution points were computed and their statistics were illustrated in tables (5-16), (5-17), (5-18), (5-19), (5-20), (5-21), (5-22), (5-23), (5-24), (5-25), and (5-26). Those statistics were computed once for the residuals and once more for their absolute values.
- For the easiness of choosing the best transformation set among the five solutions in seven transformation parameters method, the results were re-tabulated.
- From table (5-27) considering the greatest and smallest values of the standard deviation for latitude (max=1.713 and min= 0.837) so solution no (4) is the best one.
- From table (5-28) considering the greatest and smallest values of the standard deviation for longitude (max=3.127 and min= 1.075) so solution no (5) is the best one.
- From table (5-29) considering the greatest and smallest values of the standard deviation for ellipsoidal height (max=3.87 and min= 0.842) so solution no (5) is the best one.

- From table (5-30) considering the greatest and smallest values of the standard deviation for the horizontal-resultant (max=2.441 and min= 0.786) so solution no (4) is the best one.
- From table (5-31) considering the greatest and smallest values of the standard deviation for spatial resultant (max=3.368 and min= 0.837) so solution no (4) is the best one.
- From table (5-32) considering the greatest and smallest values of the standard deviation for seven transformation parameters (max values for Shift dx=0.463 m, Shift dy= 0.463 m, Shift dz=0.463 m, Rotation about x=0.292′, Rotation about y=0.425′, Rotation about z=0.556′ and Scale factor=1.293 ppm) and (min values for Shift dx=0.213 m, Shift dy=0.213 m, Shift dz=0.213 m, Rotation about x=0.127′, Rotation about y=0.198′, Rotation about z=0.255′ and Scale factor=0.567 ppm) so solution no (5) is the best one.
- The results assure that solution (5) by using 18-common point is the best one to get the best seven transformation parameters and solution by using the seven transformation parameters is better than the three shift parameters on large area.
- Set of the seven transformation parameters resulted from solution (5) were used in transforming collected data file which called "WGS84 all" which includes 1408 points into the OED as a reference datum.
- Those parameters also were used in transforming the 219 collected data file which called "OED all" into WGS84 as a reference datum.

6.3 Recommendations

From the above results, analysis and conclusions, the following recommendations are suggested:

- Non-availability of data is the most common factor affecting the accuracy of results, scientific research and the economic development. So the availability and the integrity of data are highly recommended.
- To give the obvious disparities in the data sources and the methods of observing and to tie those points which naturally affect the accuracy of resulted coordinates. So, it is recommended to standard methods of observing and tying points in all of the becoming projects for getting points with its accurate standard homogeneous coordinates on the datum which was being deal with.
- It is recommended to re-observe the first Egyptian network or some of its points using GPS techniques and tying these points to IGS to compare the effects of different transformation elements between the case study and this case and to derive the difference.
- The accuracy of the transformation between the Old Egyptian Datum (OED) and World Geodetic System 1984 (WGS84) can never be more than the accuracy of OED which obviously less than GPS accuracy. If the transformation done using seven transformation parameters higher than OED accuracy then this accuracy is not real and shall be down to the accuracy of OED. Known accuracy of old ten sections is 1:100,000.

- There is no need for the GPS network adjustment in case of tying the regional GPS networks on the HARN stations.
- Encourage researchers to participate in designing scientific programs in their field especially, in geodetic computations. Compare the results of those programs to other commercial soft wares to proof their efficiency, and this provides an innovation opportunity.
- The same concepts of geodetic operations (transformation and map projection) in this thesis can be programmed using other programming languages different to visual basic in order to detect the effect of changing on results.
- Complete what is missing in the developed programme.
- Dense common points with good quality, coverage and distribution will lead to solve the transformation problem in Egypt in the accuracy of network.
- Transformation of data sets that have been mentioned in chapter (5), are not homogeneous with WGS84-data set 1, this lead to significantly affected on the accuracy of the final results of the transformation parameters. It is recommended to use data directly and not transformed data sets.
- Similarity transformations models should be used when the available common points are not many.
- Polynomials should be used when intensive common points are available.
- Datum shift model can be used in small area around the initial point of the network to avoid large distortion.

- After unification, 1627 GPS stations cover Egypt in good geometry, densification and precision and they are related to the coordinate system of HARN which is WGS84. So it is recommended here that all other new GPS projects done in Egypt should be unified in the same way with HARN to be consistent with the specification of the national work in ESA and the international cooperation when it is needed alternatively, new GPS network can be tied to IGS stations and observed accurately as HARN. It is also recommended that in any new GPS work, users should use stations of the final unified GPS network as a reference stations in their work.
- Egyptian survey authority (ESA) should adopt the adjusted coordinates of the different transformed and untransformed datasets. These values are available in the Egyptian universities. This will help in improving the transformation process in Egypt so much.
- As regards the stability of GPS reference frame, it is evident the importance of permanent GPS tracking networks like the world wide IGS network. These networks supply a very good reference frame providing at least two permanent stations which are included into the establishing control networks, whose data are conveniently used to improve the accuracy.
- The database used in this thesis is designed to store, accessed in a simple way, produce data comparisons and/or answer any analysis questions about the data as quickly as structured. So it is recommended to transfer all the geodetic data in all organizations into a digital databases format.