CORS NETWORKS AND INVESTIGATION OF POINT POSITIONING ACCURACY OF KONYA PERMANENT GNSS NETWORK (KOSAGA)

Ayhan CEYLAN

Selcuk University
Faculty Of Engineering, Department of Geomatic Engineering

aceylan@selcuk.edu.tr

1.INTRODUCTION

Today, in geodetic and cadastral applications instead of static GNSS, it has been used conventional RTK or Net-RTK calculations more and more. To perform Net-RTK applications, CORS network which has national or regional coverage areas, in addition, to continuously operating reference stations are required. To meet these compulsory requirements, different countries built their CORS network: NGS Cors network (USA), Sopos Cors network (Germany), Geonet Cors network (Japan), Ksa Cors network (Saudi Arabia) ve Cors-Tr network (Turkey), etc. Also in Turkey, municipalities built regional networks in addition to national Cors-Tr. Konya permanent GNSS network (Kosaga) is one of them.

In this study, point positioning accuracy of permanent GNSS Network in Konya (Kosaga) were investigated.

2.TUSAGA-AKTİF (Cors.Tr)

TUSAGA-Aktif (Cors-TR) is a running project covering all Turkey, Istanbul Culture University as the executive institution, General Command of Mapping and General Directorate Acknowledgements of Land Registry and Cadastre as the joint customers. The aim of the projects is to build 146 permanent GPS stations (Figure 1) to implement Real-Time Kinematic (RTK) correction of data. And using obtained data will provide a real-time, positioning at cm-level accuracy and more accurate transformation parameters between different coordinate systems (ITRF-ED50); which will enable, principally, cadastral, cartographic, and geodetic applications, and also assist national security and progress.

2.TUSAGA-AKTİF (Cors.Tr)

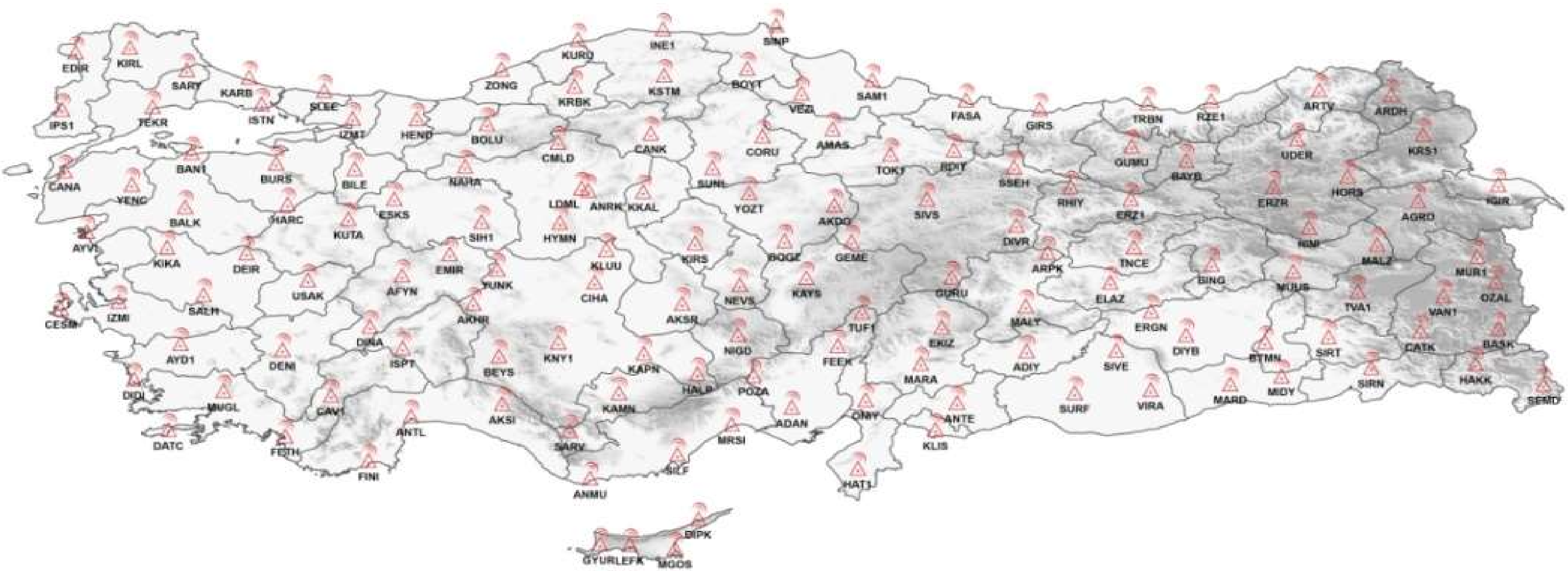


Figure 1.Cors.Tr Network

3.Konya Permanent GNSS Network (KOSAGA)

In order to make use of the satellite systems effectively and economically, as in developed countries, in our country local networks consisted of real time fixed reference stations have been established by Municipalities/Authorities. The 5-point Konya Permanent GNSS Network (KOSAGA) established in 2014 by the Konya Metropolitan Municipality can be shown as examples for these.

Fixed GNSS station (KONB) to be used in RTK measurements in Konya has been established in 2009 on the roof of municipality building by the Konya Metropolitan Municipality.

3.Konya Permanent GNSS Network (KOSAGA)

As per "Metropolitan Municipality Law" dated 2012, the service area of the Konya Metropolitan Municipality was increased to 2000 km^2 and 40000 km^2.

In the measurements made by taking as reference the KONB station problems have been encountered with in generating position data because, the distance was increased due to the new extended boundaries. In order to solve the problem, to determine Real-Time Kinematic (RTK) positioning for the cartographic and infrastructural purposes, 4 new GNSS stations have been established by the Konya Metropolitan Municipality in Beyşehir, Ilgın, Oğuzeli and Hotamış districts, has been established (Figure 2).

3.Konya Permanent GNSS Network (KOSAGA)

The system can generate position data by means of various measuring techniques such as static, rapid static, RTK, DGNS based on code and phase measurements (Ustun, 2014). In terms of network correction, KOSAGA transmits only VRS (Virtual Referance Stations) correction (NET RTCM3,NET CMR+). Nevertheless, all the stations can transmit RTK correction independently to work in the classic RTK system.

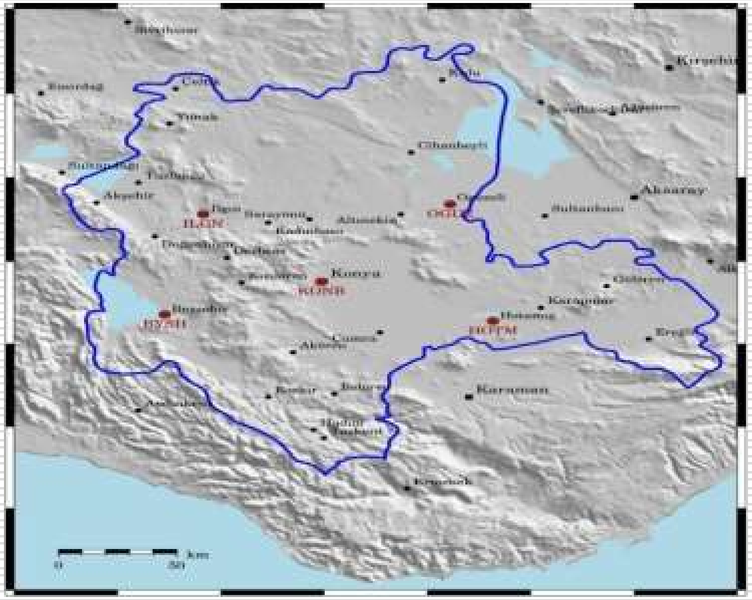


Figure 2. Kosaga Network (Ustun, 2014)

4.APPLICATIONS

4.1. Test Network

Test network was established 10 trig stations and 20 traverse points in Selcuk University, Alâeddin Keykubat Campus Area (Figure 3).

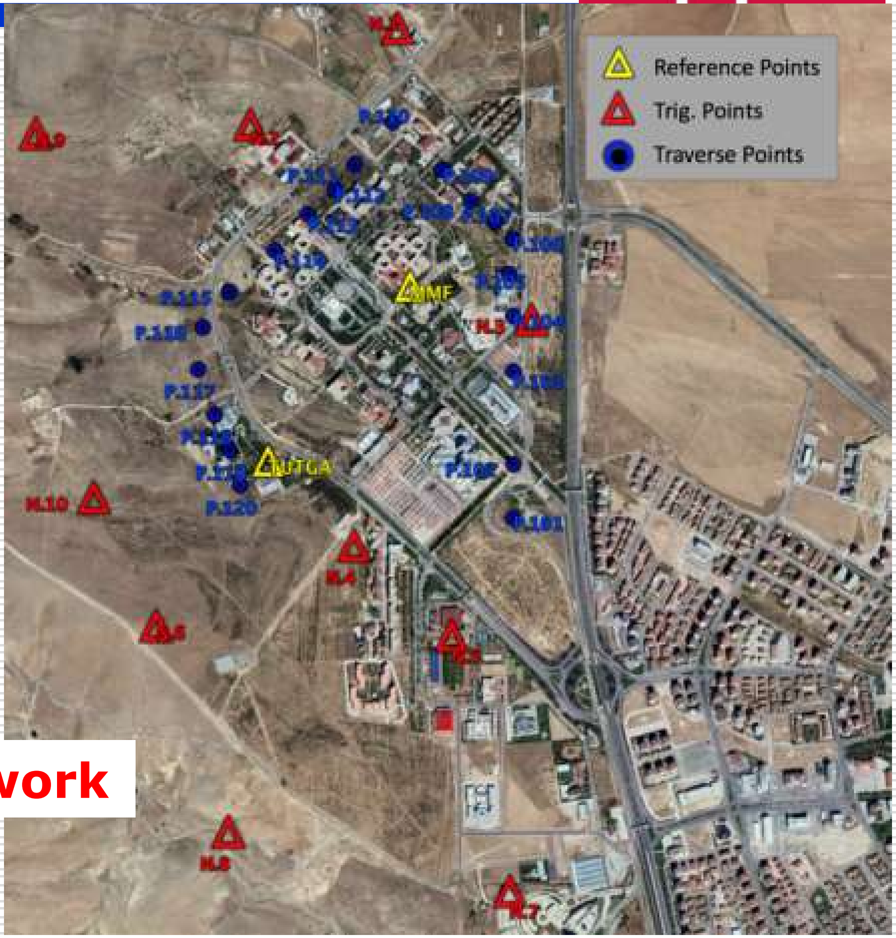


Figure 3. Test Network

4.APPLICATIONS

4.2. GPS Measurements and Evaluation

GPS observations executed at 3 campaigns.

In the first campaign:

SLCK and MMF points in the campus area were taken as reference points, and GNSS observations were carried out at trig stations of the test network as sessions taking 30 minutes, using the static method; and at traverse points, as sessions taking 10 minutes, using the rapid-static method. In this study, 2 TOPCON GR5 and 3 Javad Triumph-1 GPS receivers were used.

4.APPLICATIONS

4.2. GPS Measurements and Evaluation

In the second campaign,

GNSS measurement has been made with 1 Topcon GR5 receiver at traverse points by means of Net-RTK (Cors-Tr_Vrs system) method.

In the third campaign,

GNSS measurement has been made with 1 Topcon GR5 receiver at traverse points by means of Net-RTK (Kosaga_Vrs system) method.

In Cors.Tr and Kosaga, RTK measurements were performed with 5 epoch with 1 second recording interval for two sessions.

4.APPLICATIONS

Table 1. GNSS measurements campaigns

	Points	Reference points	Method	Time (min)	Equipment
Campaign-I	Trg. stations	SLCK	Static	30	3 Topcon GR5 2 Javad Trium-1
	Traverse points	MMF	Rapid static	10	
Campaign-II	Traverse points	Cors.Tr_Vrs	Net-RTK	5 epoch	1 Topcon GR5
Campaign-III	Traverse points	Kosaga_Vrs	Net-RTK	5 epoch	1 Topcon GR5

4.APPLICATIONS

4.2. GPS Measurements and Evaluation

Point coordinates of test network were calculated at ITRF96/2005.0

Data for reference stations were obtained from Cors.Tr website (**tusaga-aktif**.tkgm.gov.tr) and Kosaga data were obtained from Konya Metropolitan Municipality, Directorate of Construction Affairs and Urban Planning, Department of Cartography.

4.APPLICATIONS

4.2. GPS Measurements and Evaluation

The point coordinates of test network were calculated in 3 different ways;

Firstly, SLCK (ITRF96/2005.0) and MMF (ITRF/2005.0) points in campus area were taken as reference points,

Secondly, BYS and KNY1 points connected to Cors-Tr were taken as reference points,

Thirdly, two points connected to Kosaga (BEYSEHIR and KONB points) were taken as reference points.

Evaluation were carried out by Leica Geosystems Office Software.

4.APPLICATIONS

4.2. GPS Measurements and Evaluation

By taking as basis the coordinates calculated by static/rapid static method; the coordinate differences and the ellipsoidal height differences have been calculated by means of the following equalities:

$$dy = \overline{Y} - Y$$
$$dx = \overline{X} - X \qquad (1)$$
$$dh = \overline{h} - h$$

In these equations; $\overline{Y}, \overline{X}, \overline{h}$ represent the coordinates obtained by the static/rapid static method and X,Y, h represent the coordinates dermined by means of other methods.

4.APPLICATIONS

4.2. GPS Measurements and Evaluation

By making use of the coordinate and ellipsoidal height differences in equation (1); the root means square errors in the directions of x, y and h have been calculated by means of the following equations;

$$m_y = \pm\sqrt{\frac{[dy.dyx]}{n}} \;;\quad m_x = \pm\sqrt{\frac{[dx.dx]}{n}} \;;\quad m_h = \pm\sqrt{\frac{[dh.dh]}{n}} \qquad (2)$$

$$m_p = \pm\sqrt{m_y^2 + m_x^2}$$

4.APPLICATIONS

Coordinate differences and Rms (m_x, m_y, m_h) for trig station were calculated as in Figure 3-4-5.

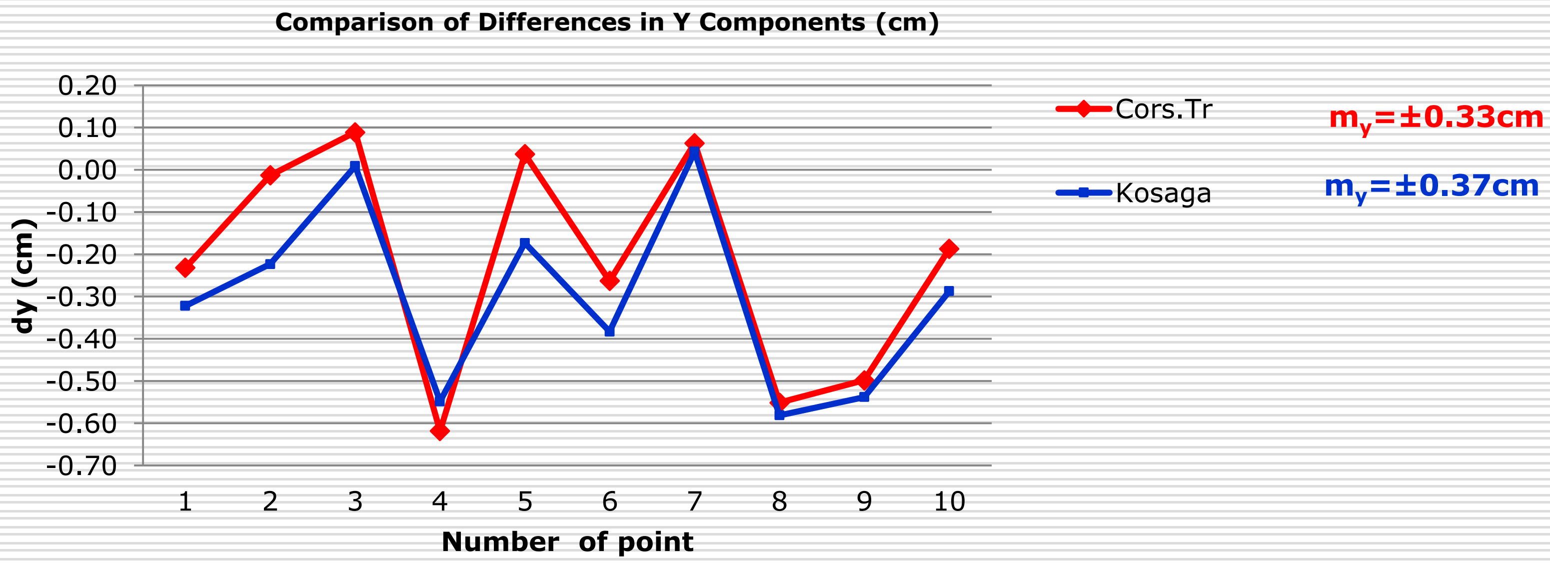


Figure 3. Coordinate differences in Y components

4.APPLICATIONS

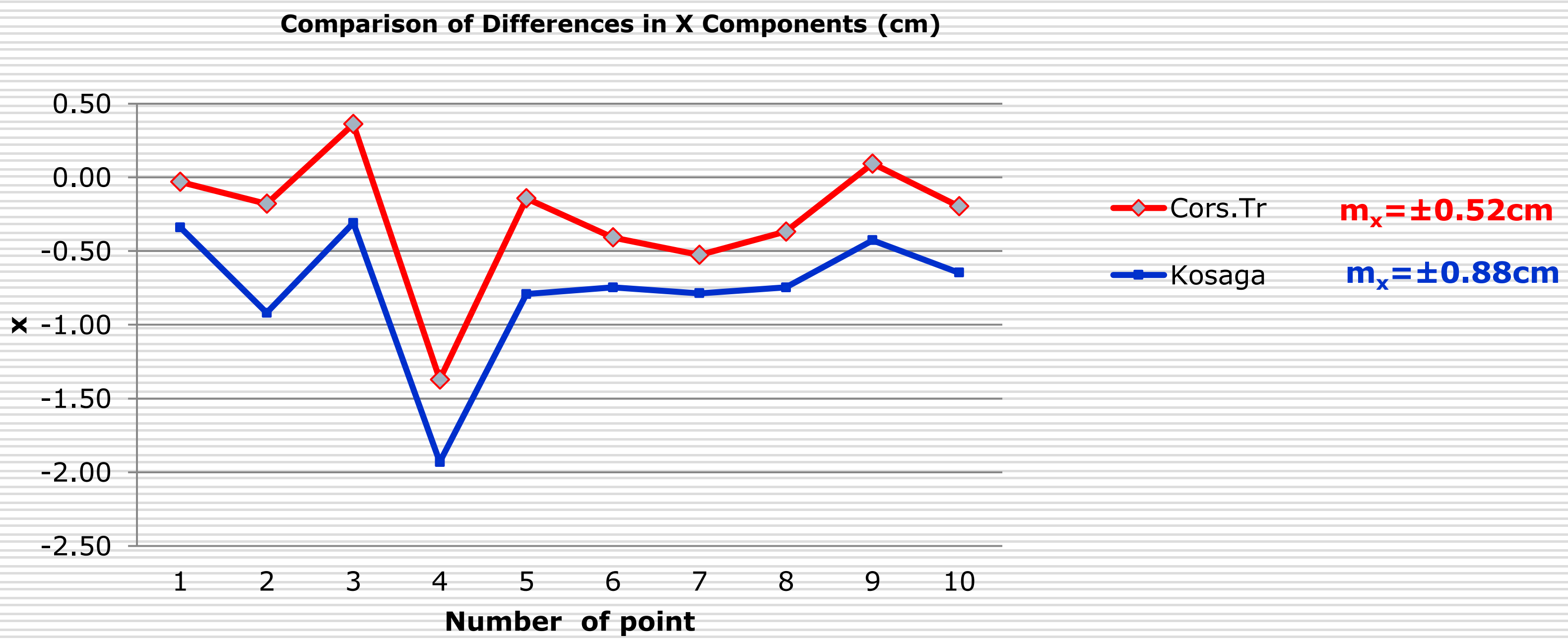


Figure 4. Coordinate differences in X components

4.APPLICATIONS

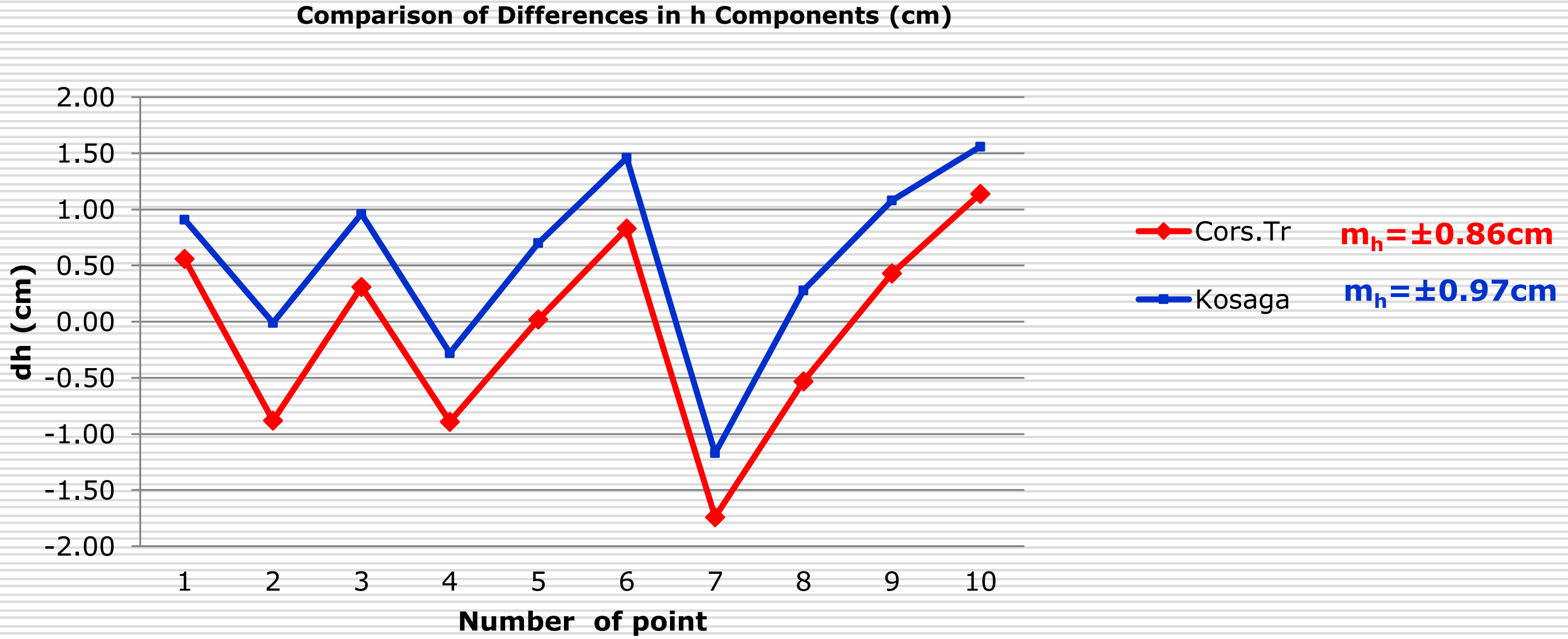


Figure 5. Coordinate differences in h components

4.APPLICATIONS

Coordinate differences and Rms (m_x, m_y, m_h) for traverse points were calculated as in Figure 6-7-8.

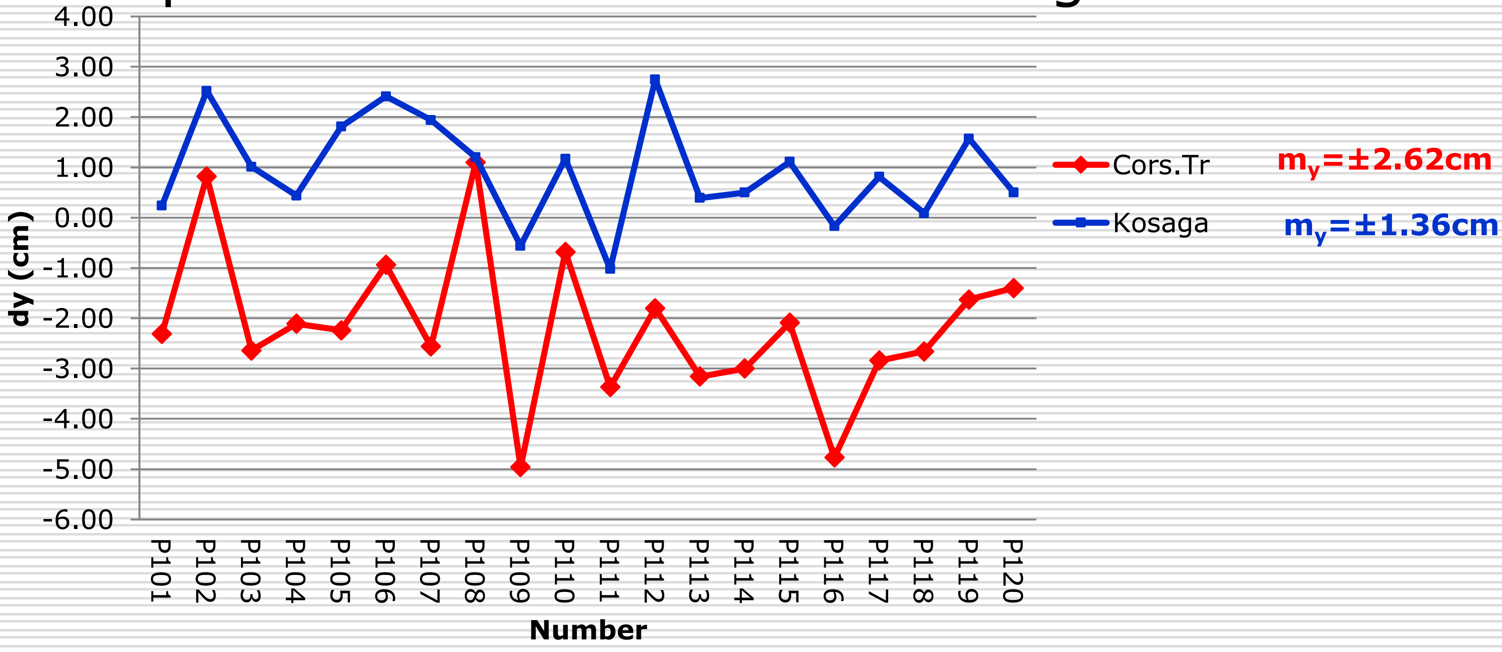
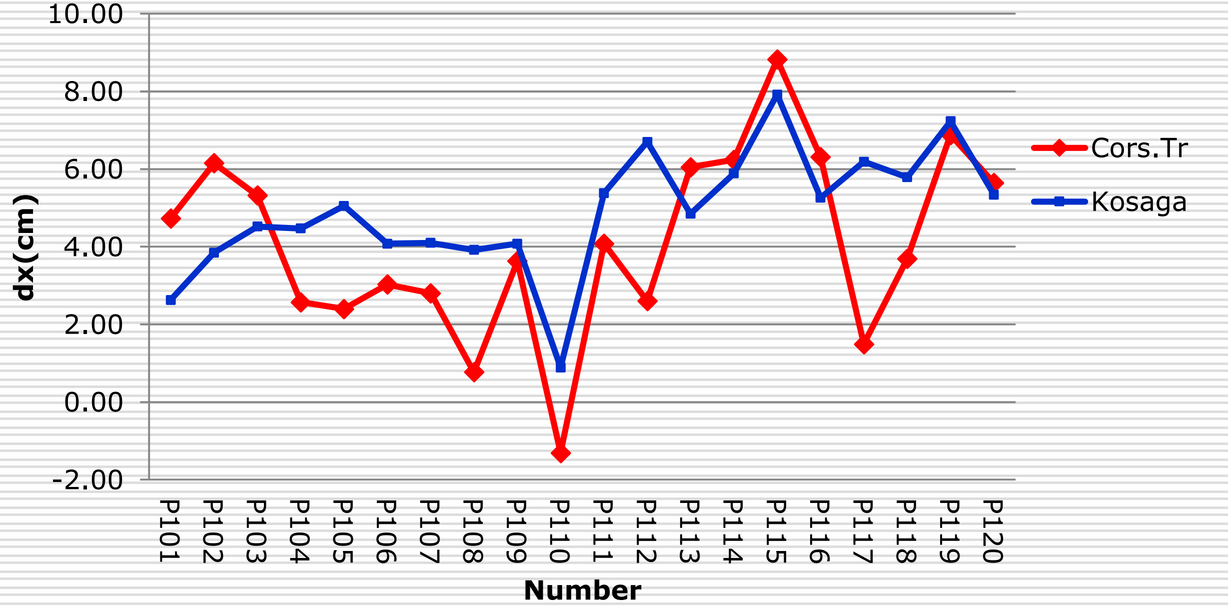


Figure 7. Coordinate differences in Y components

4.APPLICATIONS

4.2. GPS Measurements and Evaluation



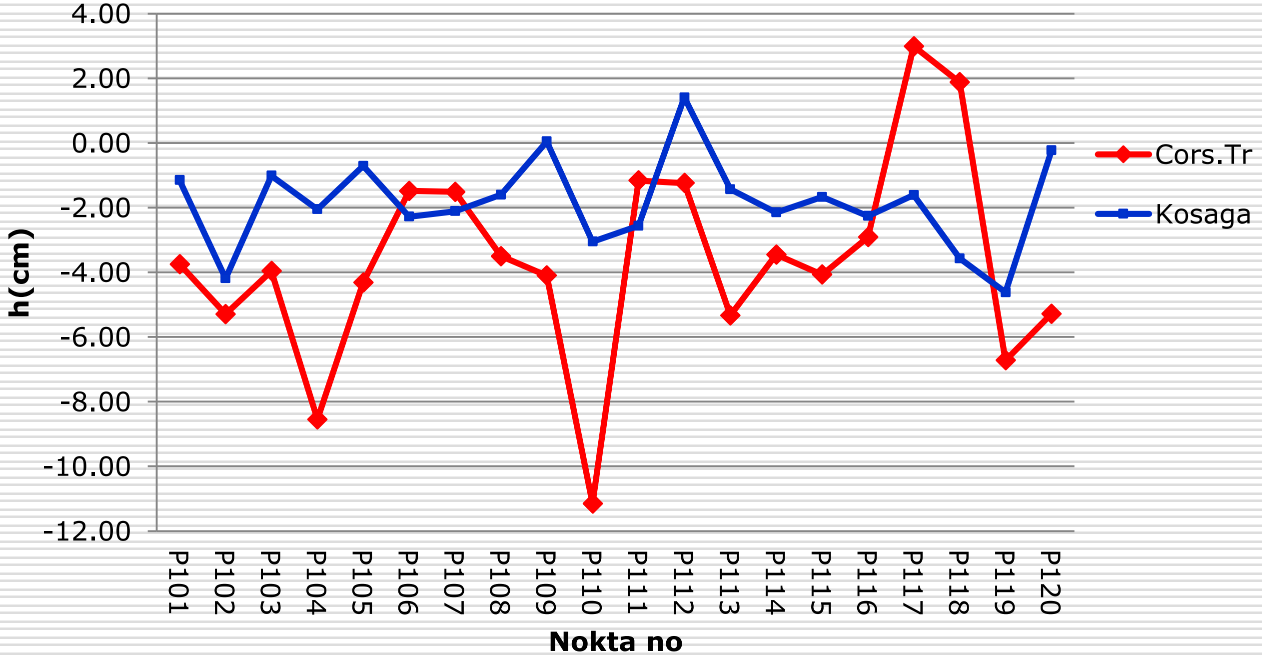
$m_x=\pm 4.72cm$

$m_x=\pm 5.14cm$

Figure 8. Coordinate differences in X components

4.APPLICATIONS

4.2. GPS Measurements and Evaluation



$m_h=\pm 4.80cm$

$m_h=\pm 2.30cm$

Figure 9. Coordinate differences in h components

4.APPLICATIONS

4.2. GPS Measurements and Evaluation

Coordinate differences (Max, Min, Average) for coordinates obtained from Cors.Tr and Kosaga, root mean square errors and point positioning accuracies are summarized in Table 2.

Table 2. Coordinate differences for trig stations and Rms

METHODS	Cors.Tr-Static(30^m)			Kosaga-Static(30^m)		
Differences	dY(cm)	dX(cm)	dh(cm)	dY(cm)	dX(cm)	dh(cm)
Max.	0.09	0.36	1.14	0.04	-0.31	1.56
Min.	-0.62	-1.37	-1.74	-0.58	-1.93	-1.17
Averaga	-0.22	-0.28	-0.07	-0.30	-0.76	0.55
Rms	±0.33	±0.52	±0.86	±0.37	±0.88	±0.97
m_p	±0.62			±0.95		

4.APPLICATIONS

4.2. GPS Measurements and Evaluation

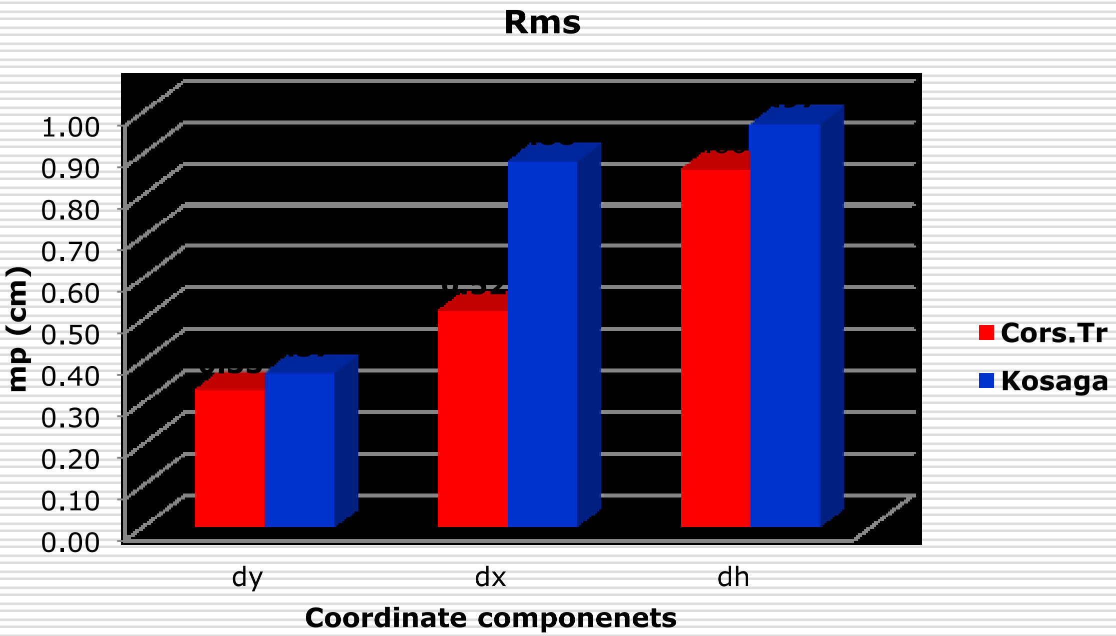


Figure 10. Root mean sequare in Y, X and h components (Trig Station)

4.APPLICATIONS

Table 3. Coordinate differences for traverse points and Rms

METHODS	Cors.Tr-R-statik(10')			KOSAGA-R-statik(10')		
Diffrences	**dY(cm)**	**dX(cm)**	**dh(cm)**	**dY(cm)**	**dX(cm)**	**dh(cm)**
Max. (cm)	1.10	8.80	-1.20	2.70	7.90	0.05
Min. (cm)	-5.00	0.80	-11.10	-1.00	0.90	-4.62
Averaga (cm)	-2.20	4.10	-3.60	0.90	4.90	-1.80
Rms	**±2.61**	**±4.72**	**±4.8**	**±1.36**	**±5.14**	**±2.30**
m_p	**±5.39**			**±5.32**		

4.APPLICATIONS

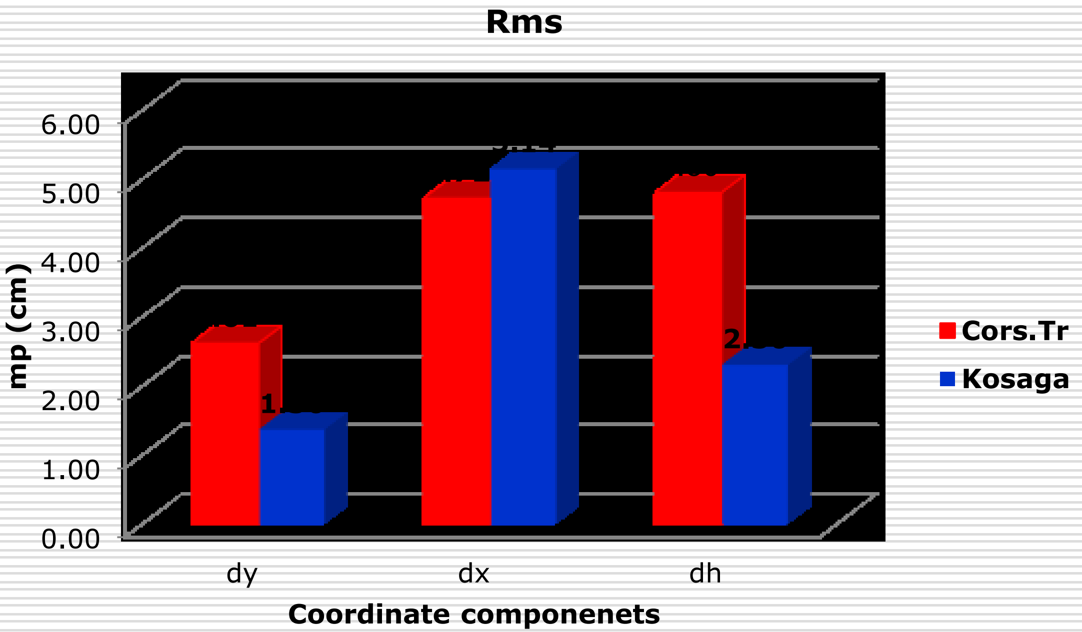


Figure 11. Root mean sequare in Y, X and h components (Traverse points)

5.CONCLUSION

Today, real-time point coordinates are determined at cm-level accuracy by GNSS observation. Determination of real-time point position with RTK-GNSS is carried out; by using data of point position from phase observation obtained from satellites by rover receivers and using corrected data obtained from a reference station by the same rover receivers, simultaneously. Restriction of distance between the reference station and rover receiver (<15-20 kms) and correction of data dependent to a single point are some disadvantages of classic RTK-GNSS method.

5.CONCLUSION

Net-RTK was developed during elimination process of those disadvantages. By this development, dependency to single reference station was removed and data from multiple reference stations made it possible to calculate point positioning from longer base distances (<50-100 kms) at high accuracy level. Following the trend in the world, General Directorate of Land Registry and Cadastre of Turkey established Cors-Tr national network and some municipalities established regional permanent GNSS networks, one of which is Konya permanent GNSS (Kosaga) network established by The Metropolitan Municipality of Konya

5.CONCLUSION

In this study, to analysepoint-positioning accuracy of Kosaga system, a test network including 10 trig stations and 20 traverse points in Selcuk University, AlaaeddinKeykubat Campus area was set up. After measurements and analysis, accuracies of point positioning were compared.

As it can be seen in Table 2, the most accurate point positioning for trig stations ($m_p=\pm0.62$ cm) was obtained from Cors-TR system. Root Mean Square Errors were $m_y=\pm0.33$ cm, $m_x=\pm0.52$ cm and $m_h=\pm0.86$ cm.

5.CONCLUSION

Table 3 shows that point positioning accuracies for traverse points obtained from both systems were too close to each other (Cors.Tr and Kosaga) (m_p=±5.39 cm and m_p=±5.32 cm). Root Mean Square Errors for Kosaga were m_y=±1.36 cm, m_x=±5.14 cm and m_h=±2.30 cm.

When the results obtained are evaluated together, it is being considered that KOSAGA could be used in fields such as cadastral studies, geodetic and real time applications etc., as it is in RTK and CORS-TR.

Thank you for your attention….