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ЕВРАЗИЙСКИЙ НАЦИОНАЛЬНЫЙ
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Представленные ГОСТ и СНиП расчеты при определении допусков на изготовление деталей, разбивочные работы и строительно-монтажные работы не учитывают характеристики строительной индустрии, технологии производства, геодезическое обеспечение, и конечно же эксплуатационные особенности зданий и сооружений со сроком его долговечности.

Несовершенство расчета допустимых отклонений в перечисленных ГОСТ и СНиП, приводит к новым научным поискам и разработке методов в определении точности на изготовление деталей, разбивку, монтаж конструкции.

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DEFORMATION MONITORING OF HIGH-RISE BUILDINGS USING GLOBAL POSITIONING SYSTEMS

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Abstract. Deformation of engineering structures is often measured in order to ensure that the structure is exhibiting a safe deformation behaviour. For example, the deformation of high-rise building can be monitored by using geodetic method such as Global Positioning System (GPS). This paper discusses the monitoring of high-rise building using the GPS methods. The case study is the фиг Dhabi Plaza building, in Astana, Kazakhstan. Eleven control points have been established whereby four of them is located out of the building itself, and the others are located at the Abu Dhabi Plaza compounds. The field measurements have been carried out in two different epochs, July 2013 and February 2015. The GPS observation and deformation data have been processed and analysed by using the Autodesk softwares, respectively. The results showed that there is some movements occurred in the building.

Introduction

Engineering structures (such as dams, bridges, high rise buildings, etc.) are subject to deformation due to factors such as changes of ground water level, tidal phenomena, tectonic phenomena, etc. Cost is more than offset by savings and by improvements in safety both during and after constructions. As a result, the design, execution and analysis of such surveys are a matter of considerable practical importance. Expanded resource development, the trend towards potentially-deformation-sensitivity engineering and construction projects, and growing geosciencetific interest in the study of crustal movement have all combined to increase awareness of the need for a comprehensive integrated approach to the design and analysis of such deformation surveys. Deformation refers to the changes of a deformable body (natural or man-made objects) undergoes in its shapes, dimension and positio. Therefore it is important to measure this movements for the purpose of safety assessment and as well as preventing any disaster in the future. Deformation measurement techniques generally can be divided into geotechnical, structural and geodetic methods (Teskey and Poster, 1988). The geodetic methods (highly understood by land surveyors) that can be used are Global Positioning System (GPS), close range photogrammetry, total station (terrestrial survey), very long baseline interferometry and satellite laser ranging. The survey methods can be further subdivided into the survey network method and direct measurement methods. In geodetic method there are two types of geodetic networks, namely the reference (absolute) and relative network (Chrzanowski et. al., 1986).

The selection of most appropriate technique or combination of techniques for any particular application will depend upon cost, the accuracy required, and the scale of the survey involves. Therefore several aspects related to the optimal design of the networks, measurement and analysis techniques suited to the monitoring surveys have to be considered. The design of monitoring scheme should satisfy not only the best geometrical strength of the network but should primarily fulfill the needs of subsequent physical interpretation of the monitoring results. Selection of monitoring techniques depends heavily on the type, the magnitude and the rate of the deformation. Therefore, the proposed measuring scheme should be based on the best possible combination of all available measuring instrumentation. A common feature for both geodetic and satellite methods in monitoring scheme involves the following three stages:

- The development of a network configuration,
- The execution process that runs a designed network into reality which deals with both the documentation of the proposed network stations and the actual field measurement techniques, and
- The network analysis that deals with the processing and analysis of the collected geodetic data.

GPS Background and Structural High Rise Building

GPS is satellite based positioning system, which has been developed by the US Department of Defense (DoD) for real time navigation since the end of the 70’s. It has made a strong impact on the geodetic world. The main goal of the GPS is to provide worldwide, all weather, continuous radio navigation support to users to determine position, velocity and time throughout the world. It consists of three segments: the space, control and user segment. The GPS can be used for absolute and relative geodetic point positioning. Its primary task is to measure distances between 24 satellites in known orbits about 20,000 km above the earth and provide the user with the information of determining user’s position, expressed in the geocentric 3D coordinate system (WGS84).

GPS techniques have several advantages as a monitoring tool. The surprisingly high accuracies of relative GPS measurements are finding an application in monitoring surveys in areas where stations require intervisibility and weather conditions. Currently, with the deployment of the full satellite constellation, continuous and automated monitoring using GPS will become increasingly practical and cost-effective. Thus, the potentials of GPS as a super positioning tools brought a fresh air to the field of monitoring surveys, especially in areas where quick results could save lives and property. In principle, the monitoring of high-rise building using GPS can be performed episodically (epoch intervals) or continuously. Current GPS accuracy estimates range from 1–2 ppm for regional baseline vectors determined using commercial production software (DeLoach,1989).

High-rise building is defines as a multistory building tall enough to require the use of a system of mechanical vertical transportation such as elevators. Although originally designed for commercial purposes, many high-rise buildings are now planned for multiple uses. They arose in urban areas where increased land prices and great population densities created a demand for buildings that rose vertically rather than spread horizontally, thus occupying less precious land area.

The foundation of high-rise buildings must support very heavy gravity loads and they usually consist of concrete piers, piles or caissons that are sunk into the ground.

The most important factor in the design of high-rise buildings is the building's need to withstand the lateral forces imposed by winds and potential and ground movements. Most high-rise buildings have frames made of high strength steel and concrete. Their frames are constructed of columns (vertical-support members) and beams (horizontal-support members). Cross bracing or shear walls may be used to provide structural frame with greater lateral rigidity in order to withstand wind stress. Even more stable frames use closely spaced columns at the building's perimeter, or they use the bundled-tube system, in which a number of framing tubes are bundled together to form exceptionally rigid columns. Curtain walls enclose high-rise buildings; these are non-load-bearing sheets of glass, masonry, stone or metal that is affixed to the building's frame through a series of vertical and horizontal members called mullions and muntins.

Case Study. Aldar Properties has appointed a consortium consisting of CCC and Arabtec to develop the new Abu Dhabi Plaza planned by the firm for Astana in Kazakhstan. The plan involves the construction of five towers, the tallest of which will be 320m, on a 500,000m^2 site. The mixed-use development will contain 556 luxury apartments, 107,000m^2 of office space, a five-star hotel with serviced apartments and a 50,000m^2 retail podium with four large basement car parks. The project originally was assigned to another contractor in 2007 and then recently taken over by CCC. One of the most important challenges at this stage is to review the work which has been done by the previous contractor. The inspection of the existing construction helps the engineers to decide whether to carry on or to modify it.

The observation network consists of 5 base stations, and 4 monitoring stations. Two observation campaigns are made for this study: The first campaign was carried out in July 2013 and the other in February 2015. All stations were surveyed by using 3 units of Leica 300 dual-frequency receivers. Static GPS surveying mode with relative positioning was used for all stations. In this study, geodetic control survey has been carried out to identify the stability of the monitoring stations T7, T8, T9, T10 and T3 from the GPS observation. In order to achieve the maximum possible accuracy in deformation surveys, we try to keep all possible systematic errors constant by using only the same type of receiver in all survey campaign, use the same software, try to use similar geometry of satellites in the repeated measurements of individual baselines, and finally try to conduct all survey campaign in similar environmental conditions.

Result and Analysis. The coordinate system for the project is defined by parameters of the Astana City Coordinate System (ACCS).

On this datum, points T7, T8, T9, T10, T3 were handed over to the main contractor on 8 July 2013. These points are located on the foundation raft and have values as follows:

CP	X	Y
T7	340.660	-5244.474
T8	408.911	-5279.107
T9	446.913	-5232.723
T10	473.178	-5252.519
T3	552.076	-5240.853

The level datum for the Project is Baltic Sea Datum 1977 (BSD). The level datum for the project is defined by points T7, T8, T9, T10, T3 handed over to the main contractor on 8 July 2013. These points have values as follows:

BM	H
T7	330.666
T8	330.681
T9	330.681
T10	330.703
T3	347.389

All setting out for Block R tower will be on this datum (L1 SSL = 347.575m BSD)

Perimeter Survey Control (Horizontal) Using survey control handed over for the works, additional survey control points ADP1 - ADP6 have been established around the perimeter of the site. Two of these points (ADP3 and ADP4) located external to the site, i.e. beyond the influence of excavation and construction will be adopted as Reference Control Points.

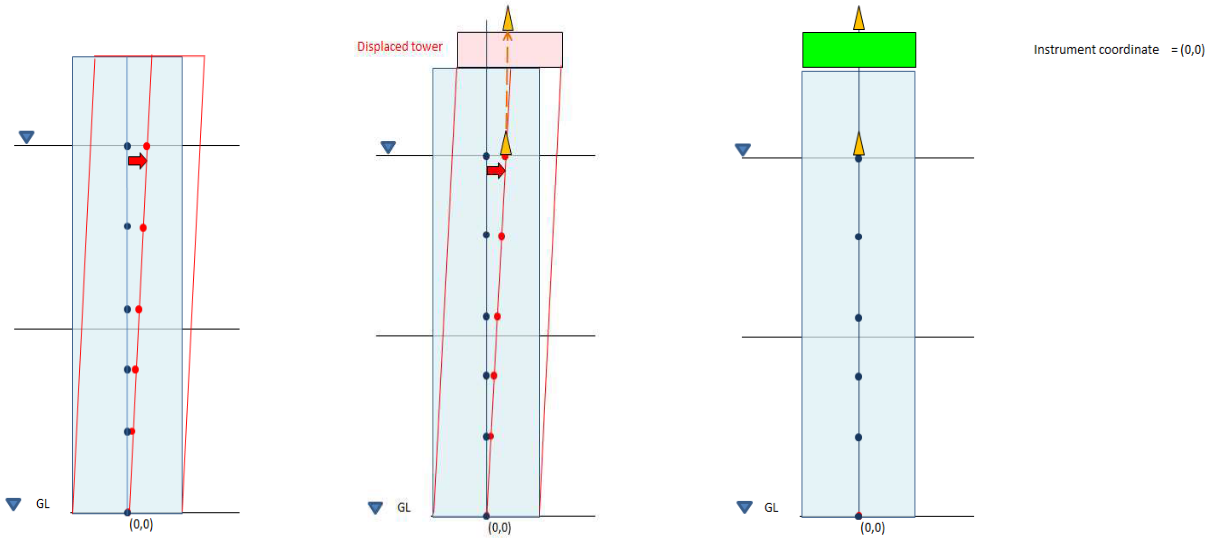
Monthly check surveys will be carried out between all perimeter survey control points to monitor point integrity. These monitoring surveys will be run from Reference Control Points. Least squares network adjustment methods will be used for traverse adjustment. These regular check surveys will determine whether there is a trend of movement of survey control, in which case coordinates may be revalued.

Further surveying will be carried out to install additional points around the perimeter of the site, and within the site area for the setting out of the works. Perimeter Survey Control (Vertical) From Benchmarks (BMs) handed over for the works, additional survey control points ADP1 - ADP6 have been established around the perimeter of the site.

Two of these points (ADP3 and ADP4) located external to the site, i.e. beyond the influence of excavation and construction will be adopted as Reference Benchmarks.

Check surveys will be carried out monthly between all Primary BMs to determine any heave or settlement. These monitoring surveys will be closed loop and run from Reference BMs. Monitoring will determine whether there is a trend of movement of Primary BMs, in which case levels may be revalued.

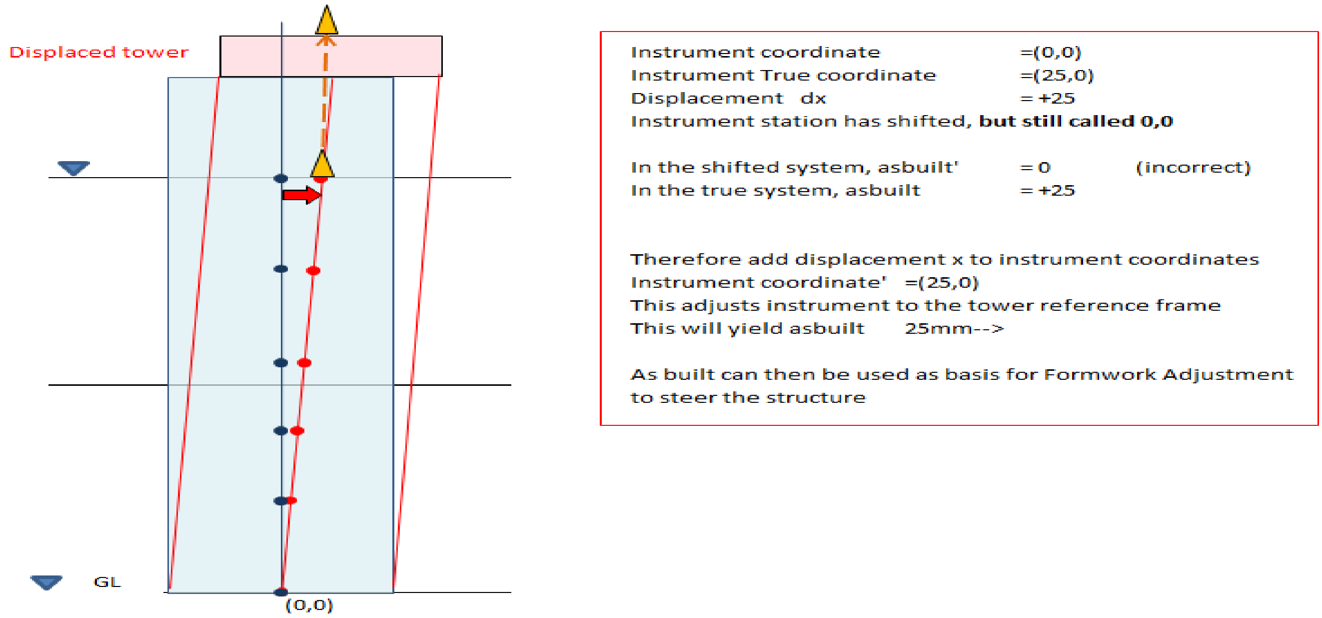
Further surveying will be carried out to install additional points around the perimeter of the site, and within the site area for the setting out of the works.



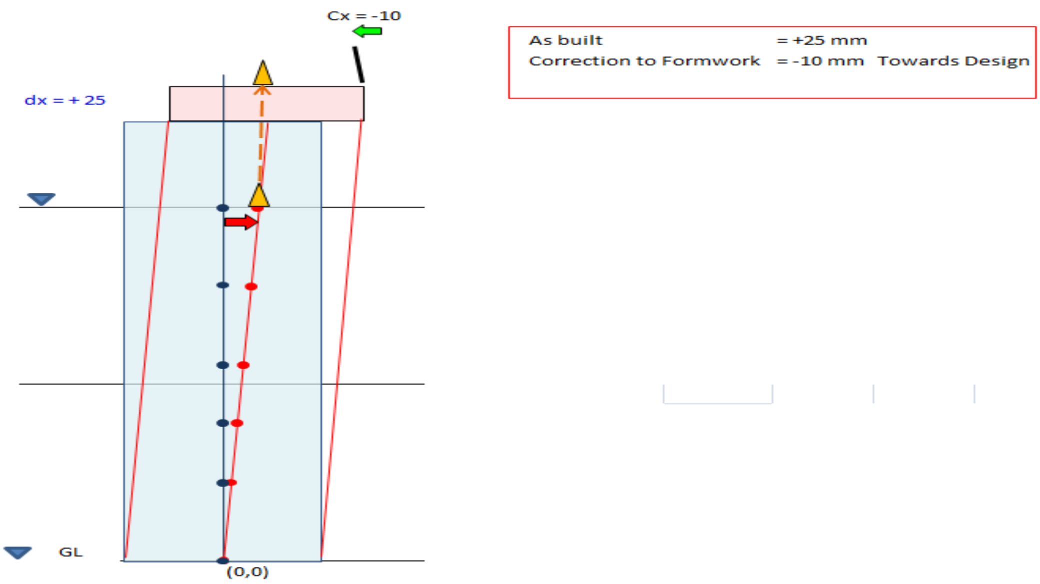
Sketch 1. Corewall displacement.

In order to correct the corewall and hence steer the tower towards the design vertical, a full and continuous program of core wall adjustment will be implemented as the work proceeds by use of discrete adjustments to formwork where necessary at each level as the building rises.

For this purpose, a corewall as-built survey will be carried out and as-built report prepared (as above). The report will show departure and direction of all corewall elements from design position. Data from the as-built report will be used to determine the required adjustment towards the design vertical of formwork for the next rise of corewall concrete. This method of formwork adjustment is the most ideal method of control of upper tower vertical alignment.



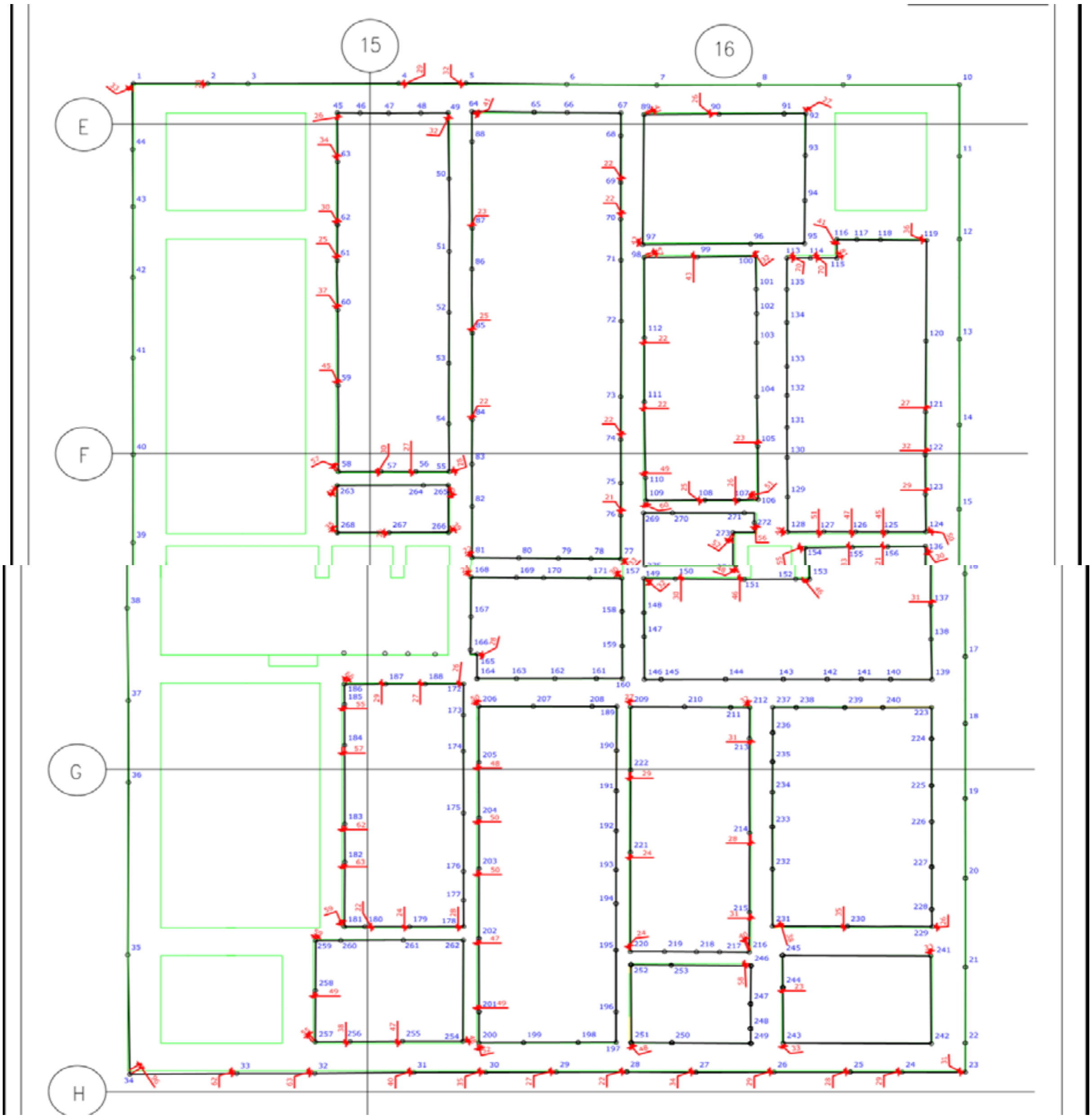
Sketch 2. Corewall Displacement adjustment.



Sketch 3. Corewall Displacement adjustment.

Conclusion

The monitoring network is properly adjusted and analysed before the results are used in the deformation analysis. The SKI TM software has been used to process all GPS observation data. While, the analysis of deformation survey for the GPS observation has been carried out by using the Autodesk software. The preliminarily presented results of the test surveys demonstrate that GPS survey has the potential to be used in monitoring of high-rise building. More research is required , however, to fully understand all sources of errors and their influence on GPS results for high precision deformation surveys because some anomalies in the GPS results still occur in geodetic measurements which cannot yet be fully explained.



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ҚАЗАҚСТАН РЕСПУБЛИКАСЫНЫҢ МЕМЛЕКЕТТІК ГЕОДЕЗИЯЛЫҚ ЖЕЛІНІ ЖАҢҒЫРТУ ЖӘНЕ МӘСЕЛЕЛЕРІН ТАЛДАУ

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Жердің физикалық бетін бөлшектеп зерттеуге арналған координатты геодезиялық негіз триангуляция, полигонометрия, геометриялық және тригонометриялық нивелирлеу тәсілдері мен жоспарлы және биіктік геодезиялық желілерді салу арқылы жасалады. Қазақстан Республикасының мемлекеттік геодезиялык желісі жалпы мемлекеттік және арнайы топографиялық түсірілімдер және карталар жасау үшін арнайы мақсаттағы желілерді дамыту үшін геодезиялық негіз болып табылады және геодезияның ғылыми міндеттерін шешуге экономика мен қорғаныс саласының инженерлік-геодезиялық қатынастағы қажеттіліктерін қанағаттандыру үшін қызмет етеді.

Қазақстан Республикасының аумағында мемлекеттік геодезиялық желіні (1942 жылғы, Балтық координаттар жүйесін) бір координаттар жүйесі мен биіктігі пайдаланады. Алайда, қазіргі заманғы талаптарға сай, біз қолданып, пайдаланып отырған мемлекеттік геодезиялық желіні қайта қарастыру, кейбір аудандарда оның дәлдігін бағамдау және жаңарту керек. Шетелде көптеген елдерде кездесетін жаңа координаттар жүйесін құру мәселесі бойынша басқа елдерде проблемаларды шешу тәсілдерін зерттеу өте пайдалы болып табылады.

Қазіргі кезеңде екінші буынның үш: – американдық, еуропалық және ресейлік жүйелер қолданылуда, яғни, американдық жерсеріктік жүйесі – Global Positioning System (GPS) және ресейлік ГЛОНАСС (ғаламдық навигациялық жерсеріктік жүйесі) жүйесі қолдануда. Бүгінгі таңда Еуропалық GALILEO атты жүйесі өз жұмысын атқаруда. Сонымен қатар қазақстандық КазSAT–1 жерсерігі ғарышқа ұшырылды, бірақ ол сәтсіздікке ұшырап, осы орайда КазSAT–2 жер серігі ұшырылды.

1980 жылы, интеграциялық үдерістердің дамуына байланысты GPS-өлшеу жұмыс істей бастады. 16 Еуропа елдерінің ғаламдық геодезиялық желімен бірге EUREF қысқартылған атауы ETRS-89 координаттар жүйесі алған Еуропалық геодезиялық анықтамалық желіні құрды. Бір GPS пайдалана отырып, 93 негізгі нүкте тізбегі координаттар жүйесі ITRF анықтап өлшеніп, 150 тұрақты түрде жұмыс істейтін станциялар кеңейтілді. Сонымен қатар, EUREF мынадай талаптарға [1] сәйкес болуы тиіс.

- Кез келген жоғары дәлдіктегі геодезиялық және Еуропадағы геодинамикалық жобаларды геоцентрлік жүйесін есептеуді ұсынуға;
- Дәл есеп жүйесі құрылуға, ол WGS-84 жақын және Еуропадағы (ауада, теңізде, жер бойынша) барлық түрлерін геодезия және навигациялық міндеттерді шешу үшін пайдаланылады;
- Бұдан былай Еуропадағы пайдаланылатын координаттар мүлдем басқаша ұлттық жүйесін (геодезиялық реперлік) үлкен санына негізделген болуы мүмкін. Еуропа заманауи кадрдың біріктірілген сандық карта деректер базасын құру үшін сілтеме болып табылады.

GPS пен ГЛОНАСС қазіргі жүйелерінің әрқайсысы 24 спутниктен (21 жұмыс істеп тұрған және 3 резервтегі) тұрады, олар шеңбер орбиталардың барлығы бойынша дерлік Жерді айналады. GPS спутниктерінің орбиталары алты жазықтықта әрқайсысына 4