Modernizing Geodetic Infrastructure for the Fourth industrial revolution in Vietnam

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SUMMARY:

Report content focuses on assessing the current status of geodetic infrastructure of Vietnam, the necessity and the main content in the completing and modernizing geodetic infrastructure for the fourth industrial revolution in Vietnam in the near furture.

1.MOST RECENT ISSUE

The Law on Survey and mapping has just been approved by Parliament in June 2018. This is the first legal document issued by the National Assembly of Vietnam related to survey and mapping activities, national geospatial data infrastructure (NSDI) after nearly 60 Year of establishment and development of Vietnam Surveying and Mapping industry. In order to implement and realize the provisions of the Law meet the requirements of national development, there is a lot of work to be done, in which the urgent task is improvement and modernization of geodetic infrastructure for the Fouth industrial revolution and respond to climate change.

In the framework of this report, we mentioned geodetic infrastructure included national heigh, coordinate and gravity network. This geodetic infrastructure is flatform for implementing survey and mapping activities uniformly across the country, connecting with international geodetic network, solving the related problems of Earth science, using for navigation, logistics, high-tech agriculture and many other applications.

2. STATUS OF THE GEODETIC INFRASTRUCTURE IN VIETNAM

2.1. National reference and coordinate system

The national coordinate network began to develop from the 1960 on the territory of the North. The network was built on the reference and coordinate system of the former Socialist countries (using Ellipsoid Krasovski with the original points at Punkovo (former Soviet Union). From the last years of the 20th-century, the coordinate network completed by using GPS technology, national reference system and new national coordinate system is set up, called the national reference and coordinate system VN-2000.

The VN-2000 system is using now includes the national coordinate points 0, I, II and III - class with a total of 14,234 points covering the whole country, per administrative

commune unit has 1 national coordinate point. The network of 0 class include 71 points distributed on whole territory, the network of I - class covered only the North, the network of II-class covered the whole territory. The National coordinate system VN-2000 plays an important role in the completion of the system of national topography maps, cadastre map system and the other specialized map in almost 20 years.

Some parameter of the VN-2000:

1. The National Ellipsoid preference is WGS-84 with dimensions:

a. The semi-major axis a = 6378137 m:

b. Flattening: f = 1:298.257223563

c. Axis angle speed: w = 7292115, 0x10 $^{-11}$ rad/s

d. Earth gravity constant: GM = 3986005.10 ^{8} m ^{3} s $^{-2}$

2. Ellipsoid: Using Ellipsoid-WGS-84 positioned consistent with Vietnam's territory on the basis of the GPS points using the long edge leveling level evenly distributed throughout the territory;

3. The National origin coordinate point: N00 Point set in the Campus of Department of Surveying, mapping and Geo-information of Vietnam.

4. The coordinate system: Using UTM coordinate system, be established base on the cylindrical projection, Index sheets under the current system there are references UTM international nomenclature.

Despite the many advantages but the VN-2000 system has not yet to be 3D coordinate system, not yet connected to International Terrestrial Reference Frame (ITRF) that limit the effective exploitation of the potential of GNSS technology in determining the position, data acquisition, data-sharing, international cooperation to solve the problems have regional and global scale in the process of international integration of Vietnam. On the other hand, due to the impact of social-economic development, now according to reports of the local ranges from 35-40% national coordinates landmarks have been lost, were moved and were fluctuating, many points are arranged on the mountain taller not convenient for use.

2.2. National height system

National level system has been built in near 60 years, through many stages, can be summarized as follows:

- Construction of height system in the North (1959-1964): Using the mean sea level of The Hondau-Haiphong with string figures constantly monitoring court trials in 10 years (1955-1964) with value "0" for original height point, called Haiphong height System: Haiphong -1972;

- Height system in the South before 1975 was built base on the original height point in HA TIEN;

- Construction unified height network throughout the country on the stage 1981-1992: Using the mean sea level of The Hondau, from the experimental observation of tide data in 43 years (1950-1992) as the value "0" of original national height point; construction of the original national height point is in Doson town, Haiphong city.

National height network including 11 leveling routes of I - classs with a total length of 5.096km and the 45 leveling routes of II - class with total length 4.515km, which were adjusted in 1996, mean square height error over 1 km in length reached mh = ± 2,9mm.

- Complete the national height system in the period 2001-2008: restore landmarks lost or damaged; measure the entire network designed the 36 closed and 4 hanging routes.

National height network is completed including 1211 points (I-class) with a total length of 5667,6 km; 1119 points of II- class with a total length of 5334,1 km; 4601 points of III-class. In 2008, National height network of I, II class were adjusted and using original national height point in Hon Dau, Do Son - identified in 1992. Mean square heght error on the 1 km length reached mh =±1,04mm for the I-class level and mh = ±2,6mm for II-class height network.

The national height network also has more than 12,000 coordinate points of III – class measured by GPS technology, the height is calculated based on the geoid model (completed in 2012) with an accuracy equivalent to leveling of IV-class.

Construction Geoid model: In year 2001, the Department of surveying, mapping and geo-infomation has completed the construction of the geoid model with standard grilles gravity (3 ' x 3 ') in the Plains and Midlands, base on more than 1038 GPS and leveling points and near 30,000 detail gravity points and EGM2008. This geoid have an accuracy of about 8 cm for the Plains, about 20 cm for the Midlands and mountain region does not yet have the test data. This geoid model was used to determine the height by GNSS technology on the territory of Vietnam.

The national level network is built in a long time, through many stages, most of the landmarks are buried near the road and along highways. So, in the process of building, expanding the road system to meet the needs of socio-economic development have led to so

many landmarks in the field was lost, damaged. In 2016, DOSMVN has conducted the survey of 2330 leveling points of l and II-class and find 810 landmarks being lost, damaged and unusable about 35.02%.

On the other hand, due to the speed of economic and social development and the process of urbanization takes place quickly, with a heavy influence of climate change and excessive underground water has been taking place, leading to serious subsidence phenomenon occurs on the wide in places with weak ground, particularly in large coastal cities and deltas. According to figures measured subsidence monitoring at the national height points of I, II-class in the Ho Chi Minh City and the Mekong Delta by the DOSMVN made in the years from 2014 to 2017 was discovered near 56% of the National height points have sunk on 5 cm compare with the data in 2005, and 14% of the National height points have sunk on 10 cm.

Vietnam has the 3260 km coast line with many different tidal characteristics in the different water area. The difference of high sea level in The Hatien with the water of the sea in The Hondau is about 17cm; With the difference such as the above, it is necessary to use seawater monitoring data at the naval station in various areas to a new level the main improvements ensure the precision serve building, planning and socio-economic development in various areas, especially in the southern region.

2.3. About the national gravity system

National gravity network in Vietnam was building, finishing and modernized through the phases as follows:

The period 1973-1978: since 1971 The state Department of surveying, maping (former) with the help of the Soviet Union (former) began to build gravity networks with accuracy for I, II - class is the first on the North then all over the country, had built the original gravity point in Lang (Hanoi) connected with the origin Postdamt of the international gravity system through the measurement point connected with the Liodovo (Moscow, Russia). The error of determining the value of the original point of gravity compared with the Postdam points is ± 0.04 μGal. Network of gravity of the I-class included 25 points evenly distributed throughout the country, including on some islands. The gravity network comprises 148 points evenly distributed throughout the country with accuracy of gravitational acceleration values of not lower than ± 64 μGal. From 1978-1981 500 gravity points III and IV class were built about gravity in the northern and Southern delta with a density of 20-30 km/1 point.

The period of 1987-1989: with the help of the Soviet Union has undertaken to modernize the national gravity network with content: build the base gravity network included 4 points (Lang, Hanoi; Da Nang; Nha Trang and Ho Chi Minh city). Original gravity points in

Hanoi and Ho Chi Minh were connected with Liodovo point with accuracy mg=± 30 μGal. 10 gravity points of I class with accuracy (± 26-29) μGal were built in this time.

The period of 2003-2011: with the development of manufacturing technology of absolute gravity meter for gravity measurements with very high accuracy ± 1-5 μGal, the country can build high-precision gravity system without connection with International gravity. The catch is that trend, already underway and construction complete national gravity system foundations score including 11 basic gravity points which has 4 old points, 31 gravity points of I-class, 106 satellite gravity points. The basic gravity points and the I-class gravity points measured by the absolute gravity meter GBL-Russia' with accuracy around ±5 μGal, some I-class points reached about accuracy ± (10-14) μGal. The satellite gravity points measured by the relative gravity ZLS with line accuracy ±(10-14) μGal (each basic point gravity has 4 satellite points, each I-class point of gravity has 2 satellite points).

2.4. Satellite navigation system

Since 1996-2008, The Ministry of Natural resources and Environment (MONRE) has built 6 satellite navigation stations (DGPS) provides amendment eviation with relatively high accuracy for multiple purposes. Among them there are 4 satellite navigation stations: Dien Bien, Do Don, Vung Tau and Quang Nam was built according to international standards for GNSS positioning permenent stations, the 2 remaining stations in Ha Giang and Cao Bang was built to serve the demarcation for Vietnam-China boundary on the Mainland.

The Defence Ministry also built 6 DGPS stations MSK Beacon in Mong Cai, Da Nang, Phu Quoc, Truong Sa, Cua Lo and Cam Ranh and some Continuously Operating Reference Stations (CORS).

From the year 2016, the DOSMVN began implementing the project "Building the network of global positioning stations by satellite on the territory of Vietnam" with a total of 65 stations including 6 stations of DGPS managed by MONRE, in which 24 Geodetic CORS stations was distributed in the territory of Vietnam, is the station's most objective, will be used as a frame of reference GNSS Vietnam, put some stations join with the IGS; 41 NRTK CORS are distributed in the some northern provinces, the Highland and southern provinces; Control and management center is located at the headquarters of DOSMVN. There are 17 stations including the Control and Management Center were built and tested in March 2018. The project is expected to be completed before September 2019. This is important project especially to modernize the geodetic infrastructure of Vietnam, promoting GNSS technology powerful applications to surveying and mapping activities complete step-by-step national coordinate and reference system.

CORS was designed with the following characteristics:

- Landmarks of the Geodetic stations are drilled and poured concrete to bearing rocks, have landmark drilled to 68m (Hatien), average depth of 24 landmark is 44m depending on the geological structure. Base and body landmark was poured the concrete to ensure stable, long-term, firmly against subsidence, the landmark was used as a national reference framework in a dynamic 3D reference, used to study the Earth's crust shifted and the other sciences;

- There are 38 landmarks of NRTKCORS has been built on solid concrete base with the size 2,5mX1,5mX1,5 m; There are 3 landmarks NRTK CORS was placed on the house roof.

- Most of the landmarks is placed in campus of organizations of MONRE. It will be convenient for manage and maintenance. There are 55 landmarks placed in the meteorological stations, 7 landmarks are located in campus managed of DOSMVN.

-The distance between the NRTKCORS stations is 50-80 km; between the Geodetic CORS stations is 150-200 km.

- Using of technology and software of Leica to receive and process data.

- Coordinate real time accuracy from 2-4 cm; high accuracy reached 7-10 cm for the plain areas and 15-20 cm for the mountains, ensure for making cadastral 1:500 scale and topography map 1:500 scale.

3. IMPROVING AND MODERNIZING THE GEODETIC INFRASTRUCTURE

3.1. The need to improve and modernize the geodetic infrastructure

Vietnam is developing countries have continuous growth many years is very high in the world, is developing towards the goal to become the industrial country after the year 2020. Vietnam is actively building e-Government, building a strategy to promote the effective application of the achievements of the industrial revolution, many cities of Vietnam are toward the goal of building a smart town. On the other hand, Vietnam is heavily influenced by climate change, sea-level rise, destruction of natural resources, pollution of the environment. All the contents are all relevant and required modern infrastructure of the spatial geographical data, provide timely, complete, accurate for management service with smart, sustainable development planning , resource monitoring, responding to climate change, defense and security. Want to do that, we must first build the modern, precision geodetic infrastructure, which will be a platform to collect, process and build national geospatial data.

Surveying and mapping Law in effect from 1/1/2019 regulate: MONRE set up, organize, build and submite the original national geodetic data, national coordinate system, national height system and national gravity system to the Prime Minister for announcing and

using in the country; establish and publish the parameters conversion between national coordinate system and the international coordinate system.

From the situation of geodetic infrastructure of Vietnam are presented, derived from actual requirements, the improvement and modernization of the geodetic infrastructure is the urgent task.

3.2. The main content of the improvement and modernization of geodetic infrastructure in the coming time

a. Improve the national reference and coordinate systems

VN2000 system has been built and used for almost 20 years. In the this time, science and technology and GNSS technology has made great progress, open up new opportunities for the exploitation of GNSS technology for the purpose of surveying and mapping.

The Ministry of natural resources and the environment has appvoved the project for improve the national reference and coordinate system, the project is being actively implemented in recent times.

The goal of the project is building a national coordinate system 3D dynamic, there is a minimum number of landmarks buried on field, meet the needs of surveying and map of Vietnam, guaranteed inheritance VN2000, connected with the ITRF, to solve the problems of global and regional.

The modern national reference and national coordinate system must be included traditional local reference and high precision GNSS stations belong to ITRS, which can be use for national GNSS frame.

The main contents of the improve national reference system and national coordinate system include:

- Construction the reference frame of GNSS Vietnam including satellite navigation stations with high accuracy associated with the ITRF on the base combined with the system of national satellite navigation station, some stations associated with IGS for geodynamic researchs;

- Improve 3D national GNSS point mesh cover whole territory, including the land, the sea and the island, with the minimum number of points needed to bury the landmaeks on field, make sure the connection and calculate turn on VN2000 coordinates with precision uniformity throughout the country; the 3D national GNSS points belong to ITRS system and also belong to VN2000.

-The adjustment overall 3D national GNSS networks, determine Parameter transfer calculation with coordinates VN2000.

The distance between the points within the GNSS reference frame of Vietnam is from 150km to 200 km (24 points), the average distance between the points of the 3D national GNSS is about 30 km (about 450 points)

Content and technology solutions selected to improve the national reference and coordinate system must ensure the inheritance results from the VN2000, due not transfer huge volumes measurement data and the maps currently in use, inheritance results of project "Building the network of global positioning stations by satellite on the territory of Vietnam", built the dynamic national reference and coordinate system, ensure the transfers calculation into VN2000 has uniform precision throughout the country. The complete reference and national coordinate system must be done simultaneously with the construction of the network of global positioning stations by satellite on the territory of Vietnam and to complete and improve the precision Geoid models used on the free territory to bring the desired effect.

b) Complete and modernize the national height system

On the basis of the General trends of the world and the reality of Vietnam national height system, complete and modernization the national height system will be set height system in three dimensions (3D) , with the main content as follows:

- Determine the value "0" of original height point through the calculation of the average sea level in Hondau using the tide data chain in 18.6 year. Determine the value "0" of the nation deep roots determine the value "0" depth for specific waters through monitoring data at the Naval Station.

- Build and improve the national height network has high accuracy and the national height points were solidified to ensure stable and long-term use, the primary focus for I-class I and II class height network. In the big cities, special landmark must built solidly, drilling deep to pour the concrete to bearing rock strata to ensure not sunk, not lost called the century landmark. Those landmarks will be used for many different purposes, serving the core planning background, weak monitoring of the municipality.

- Connect to the national coordinate system to synchronise and unite the different reference surfaces.

- Build high precision geoid models ensure the use of GNSS technology to determine height with cm precise.

- Calculation and publishment expected in the end of 2021.

c) complete and enhance the precision Geoid models used on the territory of Vietnam

Build models of high precision geoid is always an important task in the program of modernization of the system of each country. For VietNam targeted is inherited and accurated the Global Geoid model as well as the Geoid models have build in Vietnam to complete and improve the precision geoid models for determining altitudes with high accuracy by alternative GNSS technology for hydraulic conductivity measurement technology of traditional standards with desired accuracy 5 cm in plain area, 10 cm in mountains area.

The basic content of the complete and advanced precision Geoid models used on the territory of Vietnam include:

- Additional measuring gravity in mountain areas, the plain, collect, standardized gravity data in islands and sea areas, also in Laos and Cambodia. These areas need detail gravity measuring including Northwest, west of Thanh hoa, Nghe an, and some Highland areas with total area of about 150.000km^2. In the plain areas, to ensure every standard grid: 2'x2' has 1 detail gravity point with 2mGal accuracy. In the islands and sea areas, to ensure every standard grid: 1'x1' has 1 detail gravity point with 4mGal accuracy, in the mountain areas to deploy gravity measurements with 3mGal accuracy.

- Additional measure some GPS-TC points (around 70 points), ensure the distance between points from 10-30 km/point; additional measuring gravity at the century landmarks and landmarks of CORS stations; additional GNSS measurements at the century landmarks (around 90 points).

- Construction of digital elevation model (DEM) consistent with the grid 30mx30m. This DEM was built base on topographic map at 1/10,000 scale, the area outside of Vietnam territory used global DEM with grid 30mx30m, it will be used to calculate gravity correction and data processing.

- Select method to calculate and to set up the geoid model consistent with the territory of Vietnam.

- Reviews the accuracy and publication to use uniformly across the country.

d) Improve satellite navigation systems (VNGEONET)

By the end of 2019, Vietnam will have 65 national satellite navigation stations covering mainly Hanoi, Ho Chi Minh City and some the provinces in Northern, Southern delta and Highland areas. To covering the entire territory and the big islands need additional building about 75-80 stations.

Basic content to improve the system of national satellite navigation station includes:

- Build additional satellite positioning stations to covering the territory. Those station could be use funded by private sector.

- Improve mechanisms and policies to attract investment in management, operation, exploitation, effective use of the system. Promoting the conversion of technology users to use the services offered by satellite navigation systems.

4. CONCLUSION

Improving and modernizing the geodetic infrastructure in Vietnam today is an important and urgent task comes from the country's development requirements. The contents of modernization should be developed at the same time and sync effects to promote surveying and mapping industry of Vietnam to reach the level of advanced countries in the region. The above proposed contents to improve and modernize the geodetic infrastructure in Vietnam are necessary, feasible, has science-based and in accordance with practice. It is also important to implemen the provisions of the Law on Surveying and mapping./.

REFERENCE

[1] The Law on Surveying and mapping;

[2] The project “Completement of national reference and national coordinate system of Vietnam” (Ministry of Natural resources and Environment, 2018);

[3] The project “Modernization of the national height system to serve the planning, building, socio-economic development and respond to climate change in some big cities and coastal areas” (Ministry of Natural resources and the Environment , 2018);

[4] The project “Building the network of global positioning stations by satellite on the territory of Vietnam” (Ministry of natural resources and environment, 2016).