INTERNATIONAL UNION OF
GEODESY AND GEOPHYSICS

THAILAND

REPORT ON THE GEODETIC WORK

PERIOD

2011 – 2014

THE ROYAL THAI SURVEY DEPARTMENT

PRESENTED AT THE XXVI GENERAL ASSEMBLY OF

THE INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS

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Prague, Czech Republic

Royal Thai Survey Department

The Royal Thai Survey Department is responsible for land and air surveying activities and producing topographic maps for official and public use. In addition, it is also engaged in the field of Geodesy and Geophysics of which various activities were conducted during the period under review, 2011-2014. These are as follows :

1. Geodesy

1.1 Horizontal Control Network

The Royal Thai Survey Department (RTSD) is responsible for the establishment of Geodetic Network in Thailand. The horizontal networks have been performed by using the Global Positioning System (GPS). The whole network are continuously developed and adjusted in 2002. Later on, the earthquake on December 26, 2004 caused the serious plate motions in the north of Sumatra Island, Indian Ocean which resulted in the national GPS bases by increasing the discrepancy of positioning coordinates and deviated movement. That made the GPS network distorted and too big to calculate the correct error distribution. So RTSD had conducted the new GPS network to replace the previous one since 2005 and completed in 2007. The extensive modifications to the network were simultaneously carried out in order to make the network acquiring high accuracy and reliability in accordance with the international standards and FGCC (Federal Geodetic Control Committee) of the United States. Moreover, RTSD still had continuously inspected and improved the accuracy and up-to-date coordinates of horizontal control network. The development and improvement of the said network during the period 2011-2014 are as follows :

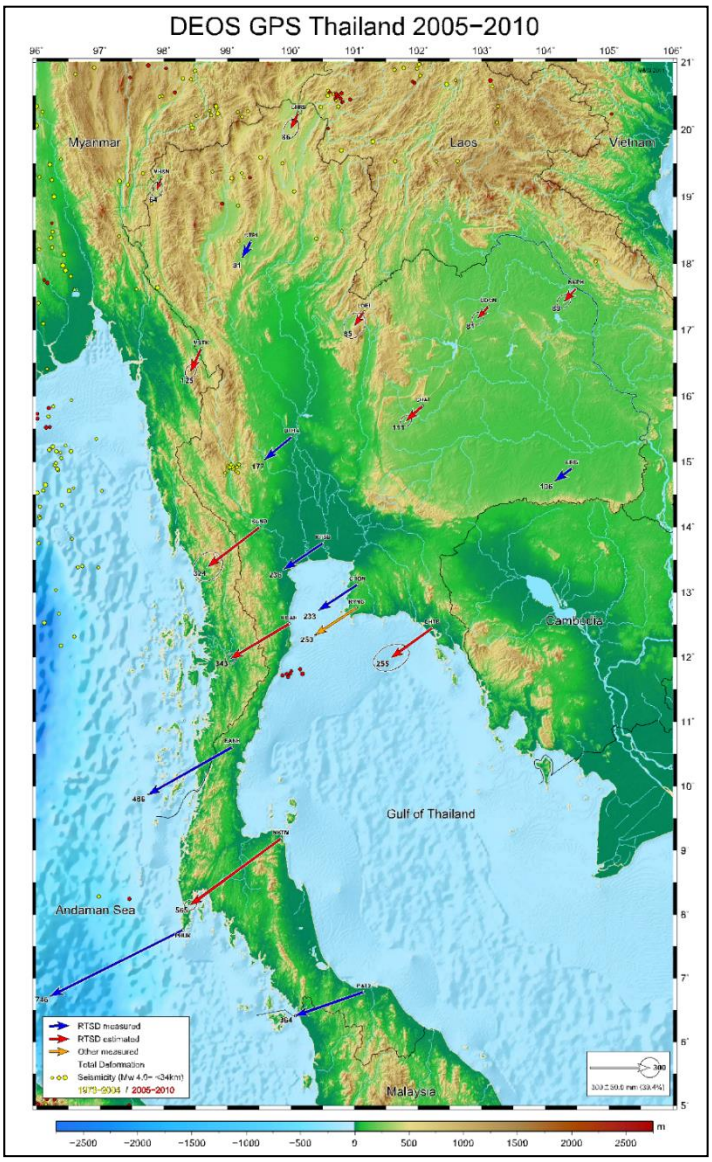

Figure 1 : The movement of plate tectonic in Thailand (W.J.F. Simons, 2010)

1.1.1 Reference Network consisted of 8 stations which their coordinates were classified as a Class A by FGCC. The said stations consist of 2 stations in GEODYSSEA (Geodynamics of the South and South East Asia) project, 5 stations in THAICA (The Thai GPS Campaign Networks) project and 1 GPS base station. All stations simultaneously observed satellite signal 24 hours per day for all 7 days. Observed data were sent to DEOS (Delf University of the Netherlands) for data processing by using GIPSY-OASIS II software program which the reference coordinates were on International Terrestrial Reference Frame (ITRF) 2008 datum (epoch 2013.10). So, the said reference coordinates were continuously used to track the plates tectonic in the area of Thailand every year from 1994 until present year.

1.1.2 Primary Network consisted of 19 stations which their coordinates were classified as a Class B by FGCC standard. Primary Network was coming out from the extension of Reference Network and additional 11 stations in order to cover the whole country of Thailand with the spacing approximate 200 – 250 kilometers. The observation period lasted 12 hours which the data were then processed with Trimble Business Center Software. For the adjustment, Reference Network was tied and fixed to Primary Network. The results of coordinates were continuously used to inspect the distortion of geodetic network every year from 2005 until present year.

1.1.3 Secondary Network consisted of 94 stations including stations in Reference Network and Primary Network. The said network was designed by connecting to new Primary Network after the earthquake on December 26, 2004. Each station had its spacing of 50 – 100 kilometers with observation period of 6 hours. The data were then processed with Trimble Business Center Software. Reference Network and Primary Network were tied and fixed for the adjusted observation. The coordinates from the processing were classified as class B of FGCC standard with loop closure not exceeding 1.0 ppm.

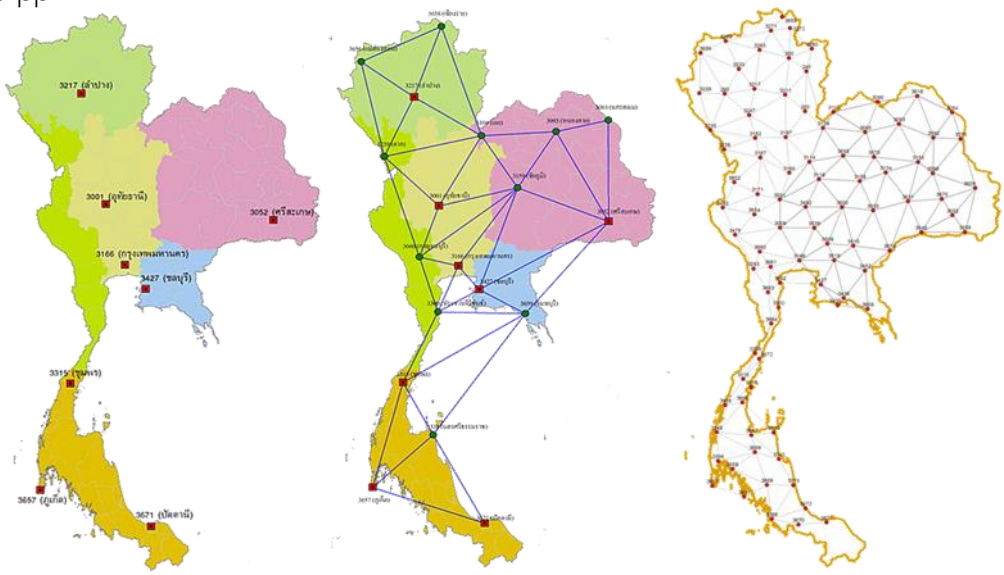

Figure 2 : Reference, Primary and Secondary Networks

The observation and adjustment of Secondary Network have been completed in 2007 which referred to ITRF2000 datum (epoch 2005.7). However, RTSD has continuously tracked the movement of plates tectonic in the area of Thailand and inspect the distortion of geodetic network every year under the cooperation on geodynamics and geodesy with DEOS Institute, Delft University of the Netherlands and Department of Survey Engineering, Faculty of Engineering, Chulalongkorn University. The observed data in 2011 was found that the accumulative magnitude of the movement of plate tectonic during epoch 2005.7 to 2010.11 in the North and the North-East were about 8 – 10 centimeters, in the Central about 20 – 30 centimeters and in the South about 50 – 70 centimeters. The above mention made the national geodetic network distorted in the northeast – southwest direction which was larger than the acceptance criteria of class B (1.0 ppm.) of FGCC standard. Therefore, RTSD had observed and adjusted all 94 stations of the Secondary Network in 2014 on ITRF2008 datum (epoch 2013.10) in order to make the accurate, reliable coordinates of those stations and reduce the effects of the said distortion. So the coordinates of horizontal control network of Thailand are accurate in the present.

1.1.4 Auxiliary Network consisted of 692 stations which were the old GPS observation network affected by the movement of plates tectonic. The approximate spacing of each station was not more than 50 kilometers which the density of stations were sufficient for users. The observation period of 2 hours and the data were then processed with Trimble Business Center Software and the adjustment was tied and fixed by the Primary Network. The coordinates from the processing were classified as class C of FGCC standard with loop closure not exceeding 10 ppm. However, RTSD will start conducting the new observation and adjustment of Auxiliary Network on ITRF2008 datum (epoch 2013.10) in 2015.

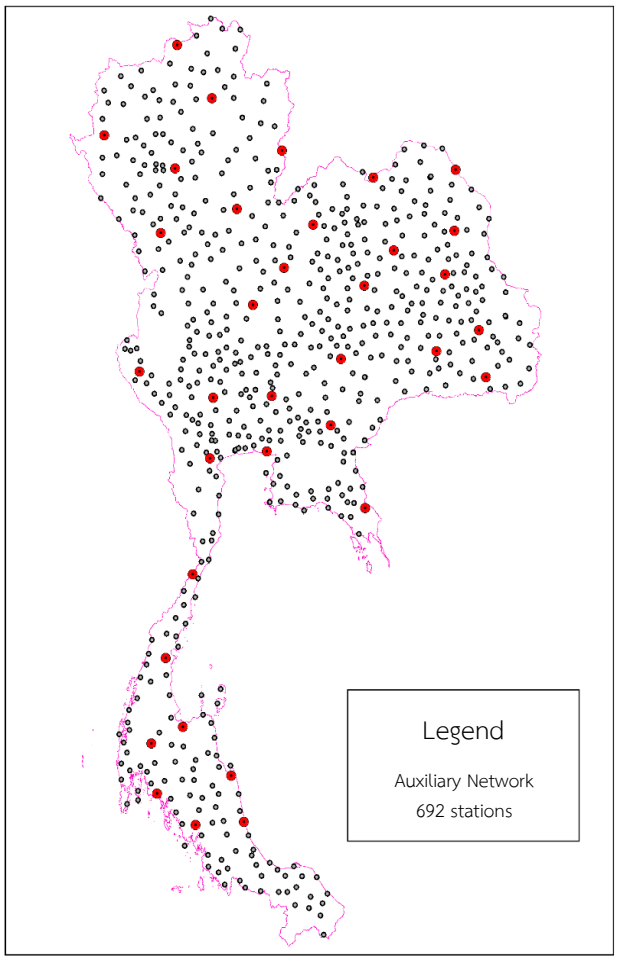

Figure 3 : Auxiliary Network

1.2 Vertical Control Network

RTSD has set up vertical control network since 1912 using mean sea level at Ko Lak , Prachaup Kirikhan province as a vertical reference point and using vertical point of BM.A with the height of 1.4477 meters as a reference point in order to tie with the national first order leveling.

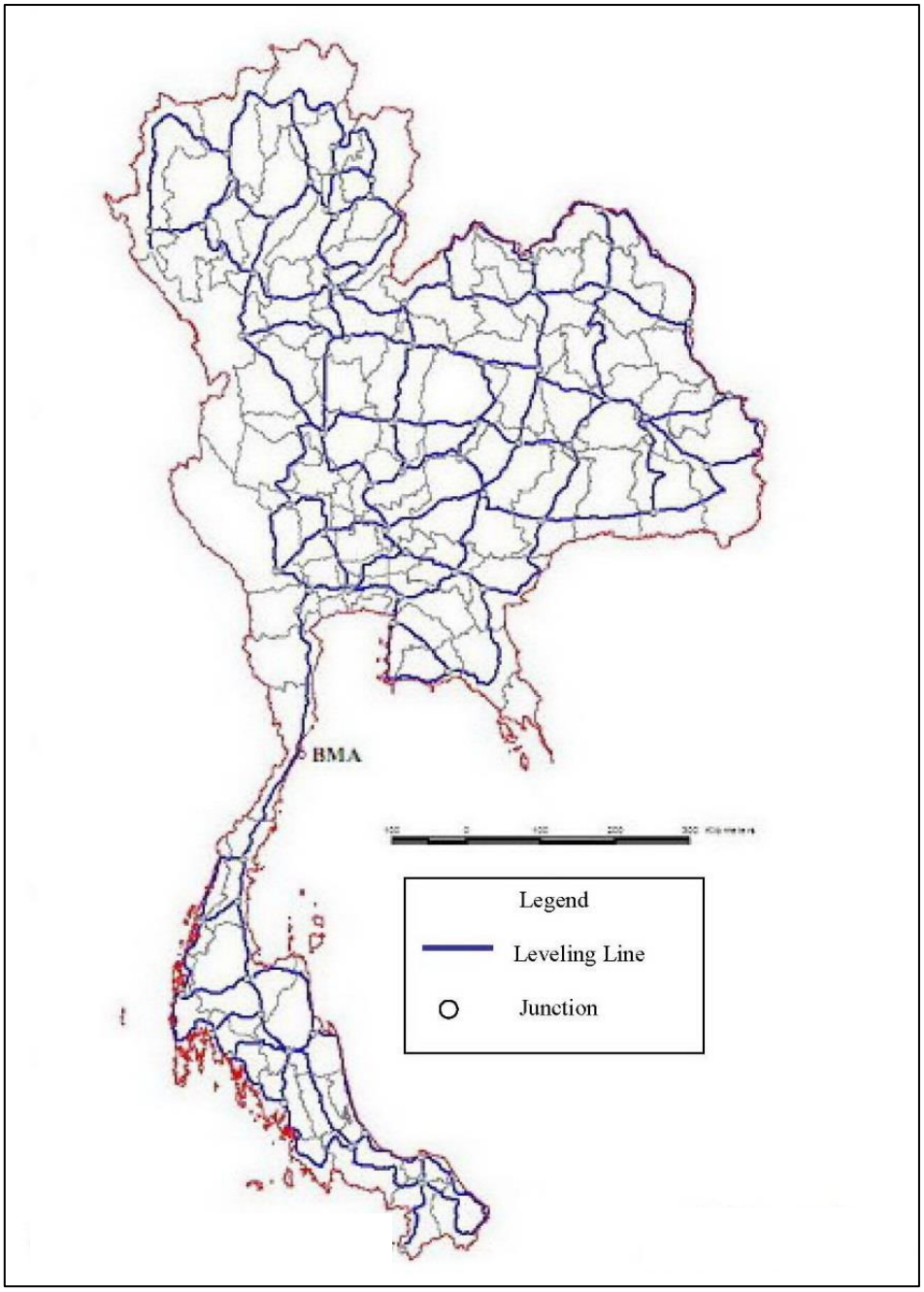

Figure 4 : First Order of Vertical Control Network

In 1981, the first order of vertical control network was firstly adjusted. The network throughout the country was divided into two parts (northern part of Ko Lak and southern part of Ko Lak) due to suitability of geographical locations and unity of the network.

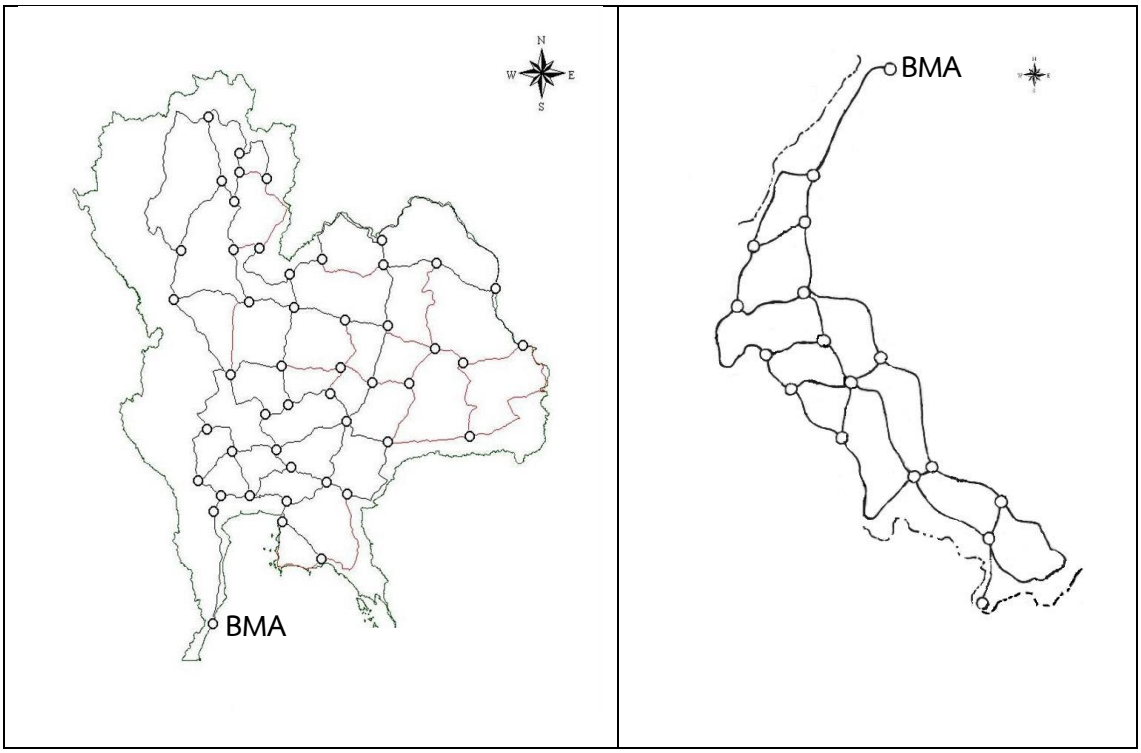

Figure 5 : First Order of Vertical Control Networks : Northern Part of Ko Lak Netwok (Left) and Southern Part of Ko Lak Network (Right)

The implementation from 2011 to 2014, RTSD has surveyed the vertical control network on the northern part of Ko Lak amount 2,058 stations with total distance 3,983 kilometers. The spacing of vertical station was in accordance with the standard of national vertical control network which specified spacing of first order levelling class 1 not exceeding 100 – 300 kilometers. Therefore, the density of stations were sufficient to support for mapping and development of country.

Moreover, RTSD still has endeavored to develop the quality of vertical control network in order to reach FGCC standard by using geopotential data for network adjustment. In 2014, the observation of gravity on the junction of vertical control network was taken for network adjustment. In the present, RTSD is going to carry on the network adjustment.

1.3 Leveling for Investigation of Land Subsidence in Bangkok

The RTSD has carried out the first order leveling in the Bangkok area and nearby vicinity covered the area about 7,000 square kilometers in order to assist the office of the National Environment Board in the investigation of land subsidence caused by the withdrawal of ground water. The Project has been initiated since 1978 until 2014. There were total 36 times of observation which have been repeated over the same area. Especially for the period of 2011-2014, there were 3 times of repeated observation in 1,200 stations with total distance 1,600 kilometers. The result was compared with the past year. It was found that the magnitude of land subsidence, average 1-2 centimeters per year, were insignificantly decreased.

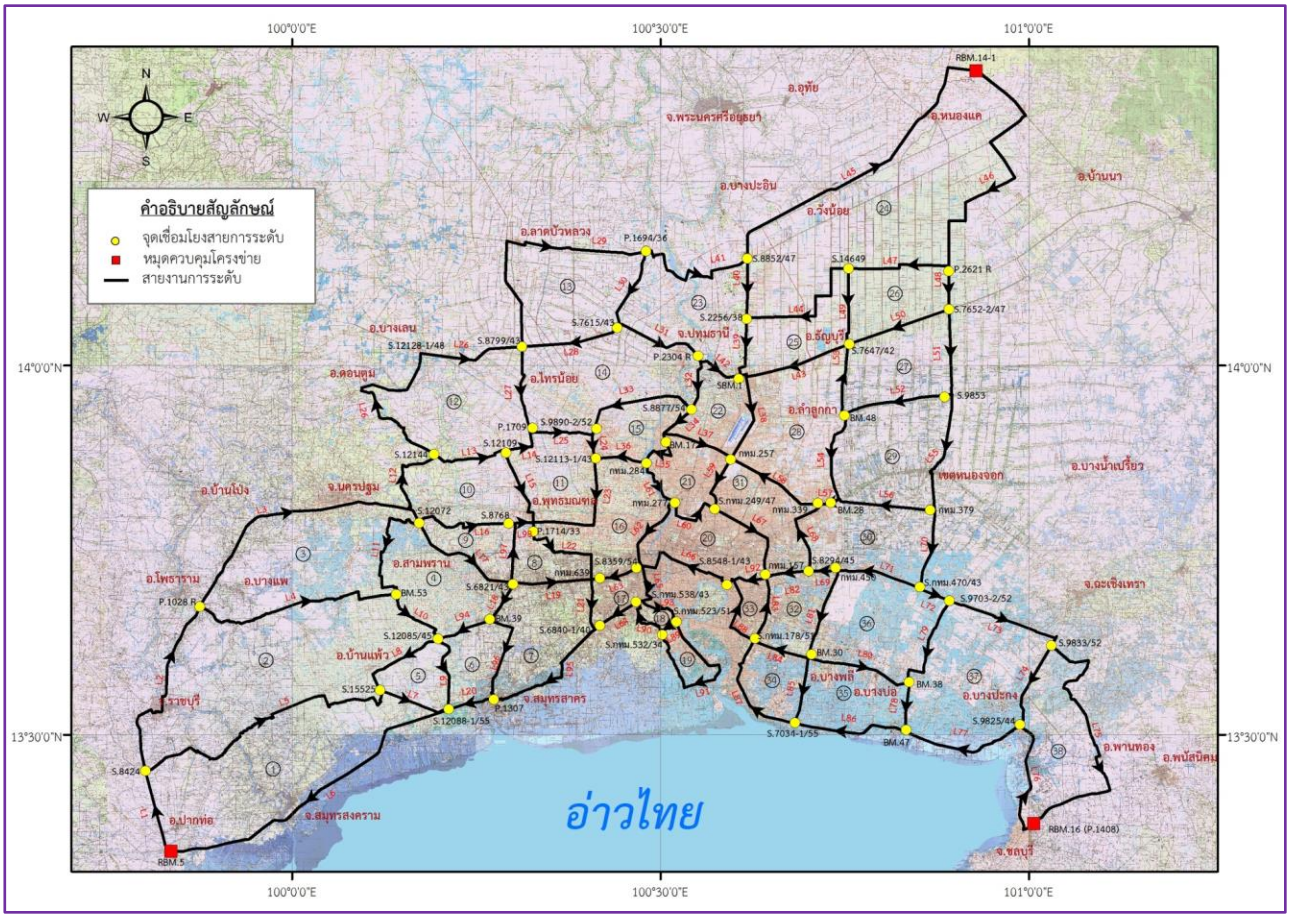

Figure 6 : First Order Leveling for Investigation of Land Subsidence in Bangkok

2. Geophysics

2.1 Land Gravity Survey

RTSD implemented gravity survey in order to compute the deflections of the vertical between geodetic and astronomic coordinates which was initiated since 1937 located in RTSD at Lat 13° 45' 06" N, Long 100° 29' 40" E, and 2.999 meters in height. The Cambridge Pendulum Apparatus was firstly used in observation by the relative method in relation with the absolute gravity station located in Teddington, England. This station is called "g0" which is connected to IGSN71 Network (The International Gravity Standardization Net 1971) Number 06230A as shown in Figure 7.

Figure 7 : First Station of Earth's Gravity

Later, the national gravity network was extended to various parts of the country in order to support the sufficient reference station for users. In 1953, 42 Pendulum gravity stations were established to cover the whole country by connecting to g0. RTSD has established over 40 sub gravity stations with the spacing of 10 kilometers by using the relative method with Lacoste & Romberg gravity meters. Up until 2007 there are about 4,181 sub gravity stations located all over the country as shown in Figure 8. However, it was still limited to carry on the gravity survey mostly in convenient areas such as main roads and levelling line.

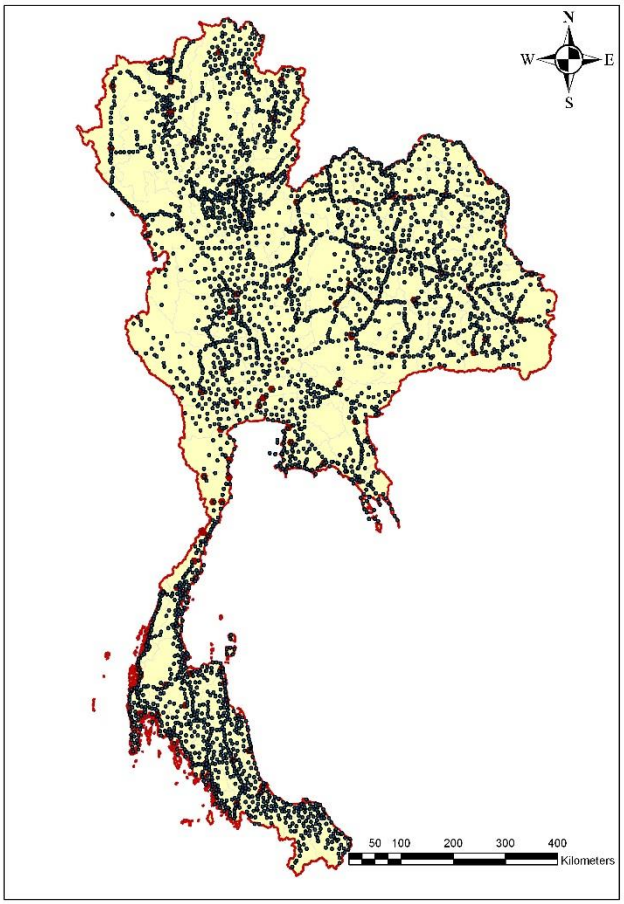

Figure 8 : Sub Earth's Gravity Stations

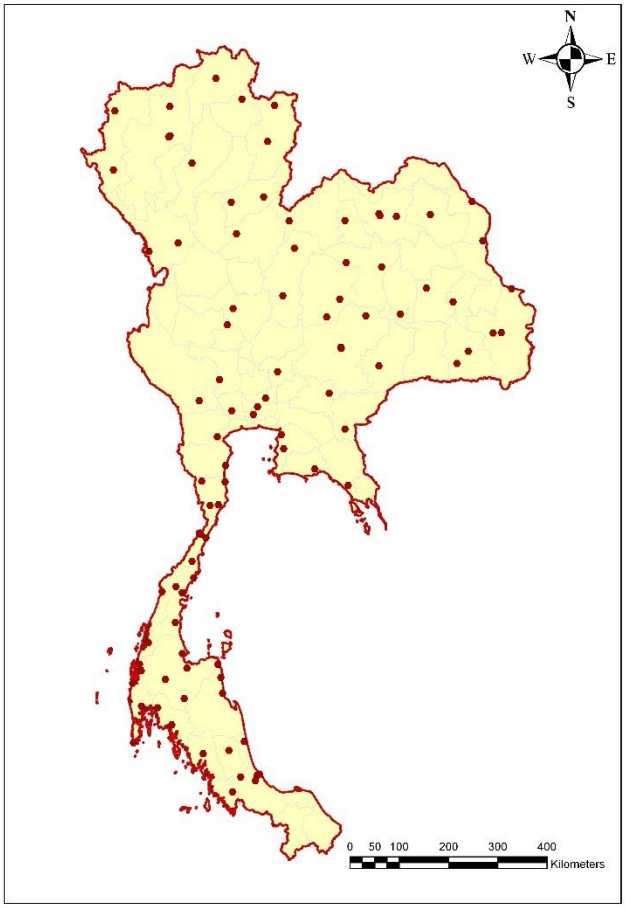

Figure 9 : Primary Earth's Gravity Stations

In 2008, RTSD established new 93 stations of primary gravity network and implemented survey all these stations throughout country due to 42 previous stations were destroyed. There were only 7 stations left. For gravimetric stability evaluation of FGCC standard, re-observation of the 93 stations should be repeated with 5 iterations. So, RTSD had re-observed all stations completely with 5 iterations in 2013. The result of that observation was good gravimetric stability which could be further used by other agencies.

In 2014, the gravity of 179 stations located on the junction of vertical control network, were observed by RTSD. These gravity values could be used for calculation and adjustment in order to improve better accuracy of orthometric height.

The new experience in the use of absolute gravimeter

RTSD purchased absolute gravimeter “Micro - g Lacoste model A-10” from the United States in July 2014 and attended the training and trial operation in our office and went to Micro - g Lacoste company in Colorado, USA in August 2014.

Figure 10 : Absolute Gravimeter “Micro – g Lacoste Model A–10”

The said new instrument is the first absolute and portable gravimeter in Thailand. It will be used for gravity observation in the field as quicker than using relative gravimeter. However, this new instrument is sensitive and the sequence must be followed strictly. There are connected parts to control unit while observation is taken and more weight. So, it is inconvenient for movement and restriction in the field which differs from relative gravimeter that RTSD have been used for a long time. Therefore, the gravitational stations that RTSD has completely observed with 5 iterations, then may need to be updated and given new stations on more suitable location. This gravimeter will be used for maximum benefit of geophysics in the future.

2.2 Geomagnetic Survey

Geomagnetic survey has been firstly carried out by RTSD on May 5, 1906 in Nakornsrithammarat province to observe three geomagnetic elements using the DIP CIRCLE and Indian Pattern Magnetometer. Those geomagnetic elements namely magnetic declination, magnetic inclination and horizontal intensity.

In 1959, magnetic observed areas in Thailand had divided into 5 regions. The observation was conducted per region per year by using GSI Precise (First Order) Magnetometer from Japan. Until 1996, MAG-01H Fluxgate Declinometer / Inclinometer from England was purchased to substitute the old existing one which was defective due to long used. So the observed magnetic stations from the beginning until 1996 are total 324 stations. Currently, the most stations are destroyed and some stations have been changed surrounding areas which make them unsuitable for magnetic observation.

In 2009, RTSD purchased another MAG-01H Fluxgate Declinometer / Inclinometer from England. So RTSD has two magnetometers for using until present. In addition, new 71 stations throughout country were designed in order to replace the original stations which were lost, destroyed or located in inconvenient places for observing. The said new stations are re-observed every 3 years in order to inspect the change of three geomagnetic elements. The results are plotted as geomagnetic chart of each element.

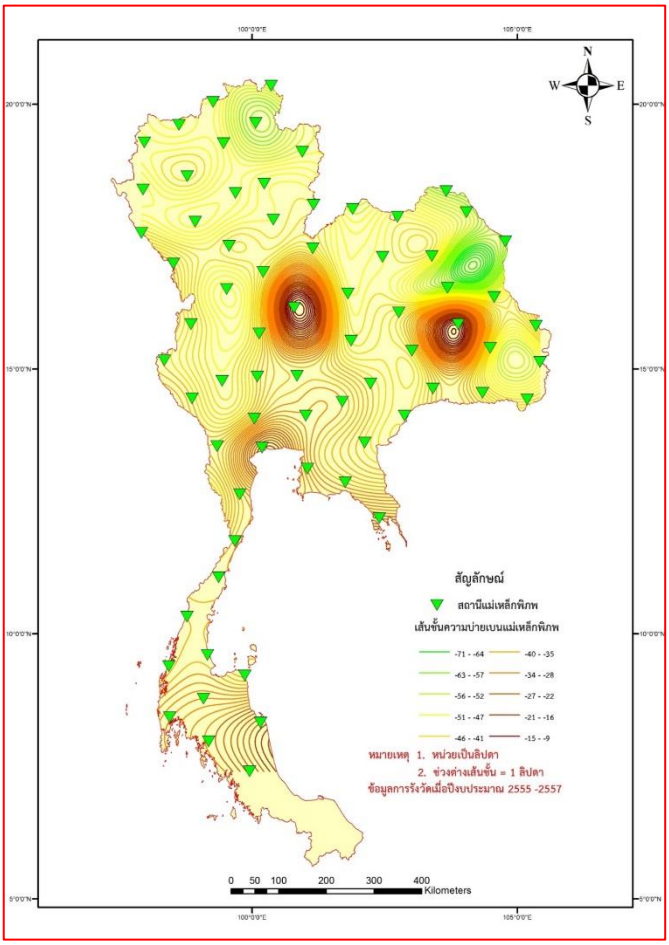

Figure 11 : Isogonal Chart

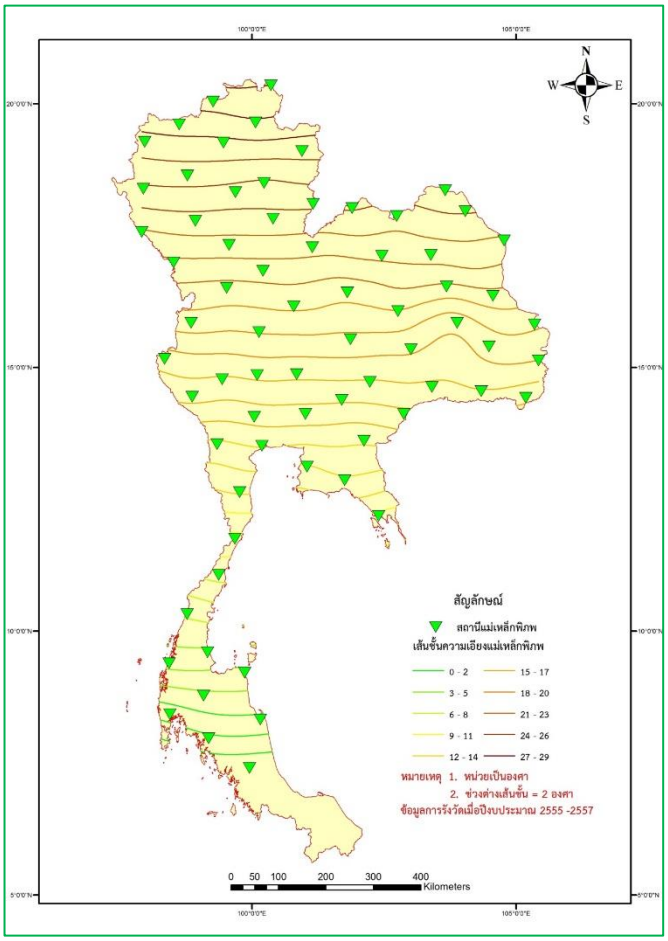

Figure 12 : Isoclinal Chart

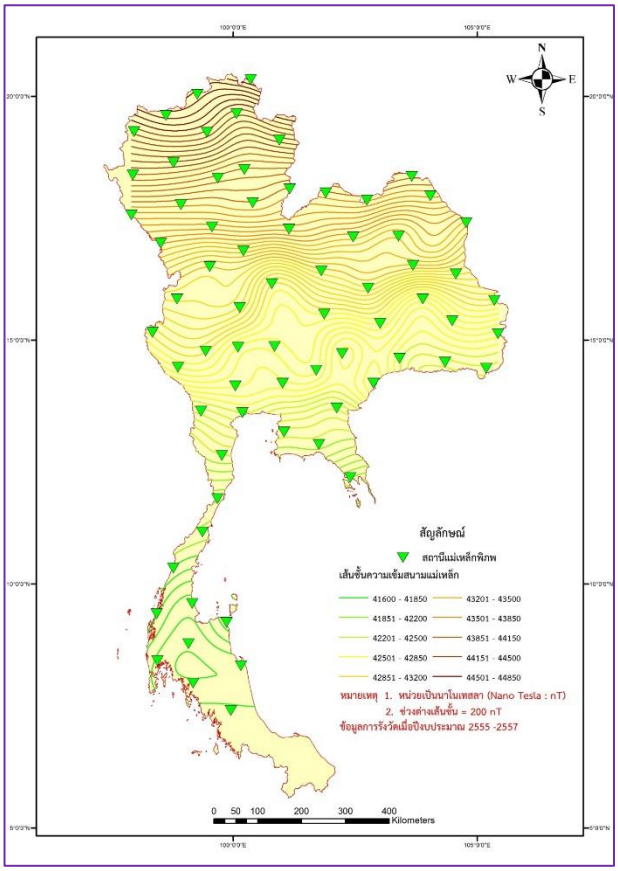

Figure 13 : Total Intensity Geomagnetic Chart

For geomagnetic surveyed by RTSD, the results are used directly for mapping and supporting to other agencies. Currently, Thailand has focused on geomagnetic survey even more. It can help to determine the mineral resources and also determine the variability of the Earth's magnetic field from the movement of tectonic plates that cause earthquakes several times. This will affect the magnetic field of the earth in this region.

3. Academic Tasks

RTSD has the academic task of geodesy and geophysics in 2011-2014 as the study title "The observation for inspecting the movement of tectonic plates around Phayao fault in case of earthquake at Phan District, Chiang Rai Province" which is summarized as below.

Incidence of the earthquake on 5 May, 2014 at Phan District, Chiang Rai Province as coordinate Lat. 19.6557 N, Long. 99.6696 E and depth of 7 kms with 6.3 magnitude, its tremor caused damage to the buildings located within the distance of 30 km from the epicenter. Such violence may affect to geodetic network in the area of Chiang Mai, Chiang Rai, Phayao, Nan, Phrae and Lampang Provinces. Therefore, RTSD had sent the GPS observation team for inspecting the impact of earthquake in order to confirm the accuracy of the horizontal geodetic network that also can be used as reference stations in surveying and mapping or not.

The total length of Phayao fault is about 90 km which divided into north and south parts. For the north part, the fault lies in a northeast – southwest direction and lies in the north - south direction for the south part. There are total 17 sub-faults in group of Phayao fault as shown in Figure 14.

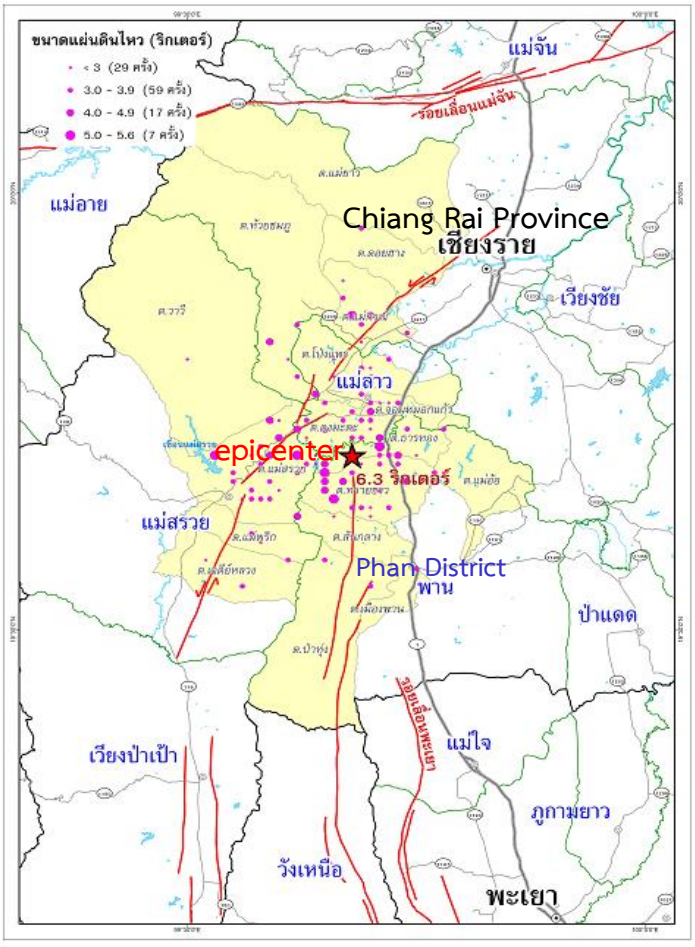

Figure 14 : Phayao Fault (Red lines) Around Epicenter of Earthquake at Phan District, Chiang Rai Province on 5 May, 2014

The implementation was conducted by using static technique of the GPS observation with period of 6 hours on 6 stations. Relative technique was used for data processing and comparison. The baselines which were calculated from the coordinates (X, Y, Z) of Secondary Network with different ITRF such as ITRF1996 epoch 1996.3, ITRF2000 epoch 2008.11 and ITRF2008 epoch 2013.10 and the coordinates which had been free adjusted by using data observed on 7-8 June, 2014.

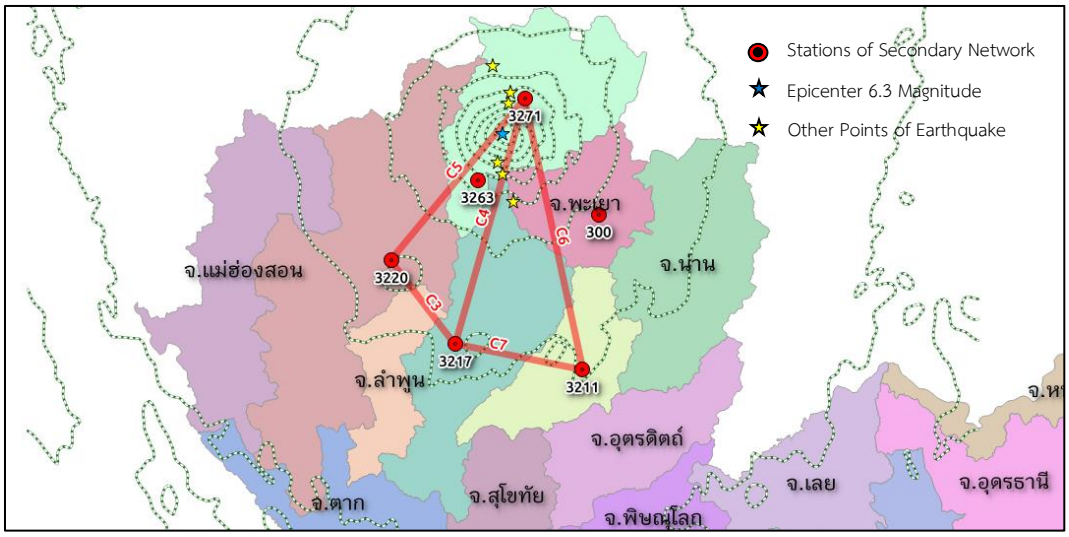

Figure 15 : Stations of GPS Observation for Inspecting the Impact of Earthquake on 7-8 June 2014 and Baselines used for Comparing

The base lines will be compared with cartesian coordinate system (X, Y, Z). If the results pass the criteria, it means that the secondary network is not affected by earthquake on 5 May, 2014 and no need to re-observe or re-process data. The said criteria consists of two cases as 1) the magnitude of changes in length of the baselines per distance not exceeding 1 ppm which is in accordance with criteria of Class B by FGCC standard, 2) the magnitude of changes in length of the baselines between the baselines calculated from the secondary network on ITRF2008 epoch 2013.11 (before the earthquake) and baseline calculated from new data observed on 7-8 June, 2014 (after the earthquake) are less than 5 cm which coincides with the diameter of 5 cm of benchmark. It means that the impact is not significant to the position of geodetic network.

For the results of data processing, the different distance of baselines in 4 periods were maximum value of 0.0083 ppm which was less than 1 ppm (Long Baseline 193 km) based on testing criteria set and the different distance of baselines between before and after the earthquake were maximum value of -0.027 m (2.7 cm), which was less than 5 cm of criteria set. For the conclusion, in both cases were no impact on the coordinates of existing secondary network that had been adjusted in 2014 (ITRF2008 epoch 2013.10) according to the criteria set of above inspection.

4. Trend in the Development of Geodesy and Geophysics of RTSD

4.1 The establishment of 80 base stations of automated GNSS satellite observation throughout country during budget year 2015 – 2017, this project focuses on the development of infrastructure in order to support the survey of the coordinates of positions with high accuracy. It provides the corrected parameters immediately as surveying that will enhance the capability to perform the coordinates quickly and reduce costs and staffs but still maintain the accuracy of works. Also we can take advantage of the obtained satellite data for studying the weather too.

4.2 The development of high precision geoid model of Thailand during budget year 2015 – 2017, this is project to survey data for the development of first local geoid model of Thailand which can be used together with positioning technology of GNSS satellite observation in order to determine height above mean sea level quickly. For the preparation of geoid model, the good gravity data will be processed together with heights calculated from leveling data and the coordinates from GPS satellite observation coverage throughout the country adequately. The goal of this project is to create geoid model with accuracy of 10 centimeters or equivalent to the third order leveling which is enough accurate for usages in security, construction, mapping, GIS applications, development of infrastructure and planning and preventing the risk of natural disasters such as floods, tsunamis and earthquakes.

5. Conclusion

For past four years, RTSD has conducted survey on geodesy and geophysics regularly and monitored the incidences on the earth which has changed over time especially the disaster of the earthquake and the movement of tectonic plates these directly affect to the stations of national geodetic network. Therefore, RTSD needs to inspect and monitor the impact of said incidences in order to improve the up-to-date and reliable coordinates of those stations for supporting further to government and civilian agencies.

Over the next four years, RTSD will continue to participate in the research project on geodesy and geophysics with educational institution and involved agencies. Especially, national main projects which RTSD will be responsible for the implementation such as the establishment of base stations of automated GNSS satellite observation throughout country and the development of high precision geoid model of Thailand. It is expected that the success of both projects will result in a change of surveying for national infrastructure and it can also be used to prepare to cope with natural disasters that may could happen to Thailand in the future.

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