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EXPERIENCING GNSS ATLAS L-BAND SERVICE IN THAILAND

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ABSTRACT

Many civil engineering and construction tasks require highly accurate land surveying information. The Global Navigation Satellite System (GNSS) provides positioning locations for land surveying and navigation technology. To achieve high accuracy, Real-Time Kinematic (RTK) differential correction method is mainly applied for Differential GNSS measurement. The Royal Thai Survey Department (RTSD) has established many local Continuously Operating Reference Stations (CORS). Information from CORS can be used for RTK differential correction via mobile Internet connection. However, many rural remote areas in Thailand such as forest, agricultural lands have no GSM mobile signal and Internet. The alternative solution is to use the GNSS L-band global correction service that is connected to a satellite communication system. Such system uses precise point positioning (PPP) technology to give corrected data for improving positioning measurement accuracy without internet connection requirement. This study employs is GNSS L-Band Global correction service for many test sites in Thailand and the results are compared with static. The user receiver accessing to GPS, GLONASS and BEIDU satellites, the static comparison study of Atlas L-Band correction and AUSPOS confirms centimeters horizontal accuracy and decimeters height accuracy.

Disciplinary: Multidisciplinary (Geodetic/Navigation Engineering, Civil Engineering, Information Technology).

1. INTRODUCTION

Land survey and cadastral mapping for issuing landowner certificate and rural development play an important role in Thailand, especially in the remote area as mountainous and islands where

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there is no internet communication for applying modern survey equipment. Up to date land surveying technology is mostly used Global Navigation Satellite System (GNSS) that employs GPS United States of America, GLONASS Russia, Galilleo European and Beidu China for a constellation of the satellite to provide positioning location for land surveying and navigation technology (Rajeswari and Christopher, 2020). With the purpose to achieve high accuracy with Root Mean Square (RMS) error with less than 5 centimeters, Real-Time Kinematic (RTK) differential correction method is mainly applied for Differential GPS measurement. Continuously Operating Reference Station (CORS) is a form of RTK differential correction that is done through the use of a cellular modem and base station network (Yanming and Jinling, 2008). The method shows that rather than using the conventional base station and radio to send correction data to a rover, data is sent using the internet to a cellular mobile device in Network Transport of RTCM via Internet Protocol (NTRIP). Virtual Reference Station (VRS) uses a tool of RTK correction that makes the rover to send its position to the VRS network; the network then produces a virtual base near to the rover that is assigned for correction. All the communication is using a radio signal or internet connection, and a radio signal has distance limitation which is replaced by internet communication. Therefore, the Royal Thai Survey Department (RTSD) in Thailand has established the CORS networks that provide VRS/RTK networks via an internet connection to the land surveyor for cadastral mapping and civil engineering development.

The limitation of internet coverage problem in Thailand, many rural and forest areas have no mobile and internet connection. The CORS network of the Royal Thai Survey Department (RTSD) in Thailand provides VRS/RTK networks via an internet connection but many remote areas in Thailand have no GSM mobile signal and internet. These remote areas such as forest, agricultural and rural land are highly required for land development and landowner certificate issuing processes. Without GSM mobile signal and internet connection in these rural areas make it impossible for the surveyor to measure geodetic positioning for land survey and mapping. In order to solve these problems, L-Band Atlas data correction services that can be used for positioning measurement.

2. REVIEWS

The existing CORS operation and services for RTK networks have been developed by some organizations in Thailand. Atlas L-band GNSS measurement for precise point positioning (PPP) is an alternative method for areas where the internet is not available.

2.1 EXISTING AND PLANNING FOR CORS OPERATION AND SERVICES

There are four main government organizations such as the Department of Land (DOL), Royal Thai Survey Department (RTSD), and Department of Public Works and Town & Country Planning (DPT). These organizations have planned to build 276 CORS up to the year 2021, see Table 1.

Table 1: Thailand GNSS 276 CORS networks (Source: DOL 2019)

Years	DOL	RTSD	DPT	Total
2015	11		15	26
2016	51			51
2017	30	80		110
2018	36			36
2019	6			6
2020	47			47
Total		276		

2.2 L-BAND ATLAS SERVICES

Modern L-Band GNSS receivers are cost-efficient devices having hand-held size. Such receivers can be used for land and water surveying applications (Anantakarn and Witchayangkoon, 2019). Using an external GNSS antenna, the receiver includes free Land Survey App and post-processing software. L-Band data correction service is a low-cost solution for all survey applications and data collection types such as Real-Tme Kinematic (RTK), Post-Process Kinematic, and static measurement (Anantakarn et al., 2019; Witchayangkoon, 2000).

At the time being, some equipment brands are used L-Band global correction services such as Atlas (Hemisphere), CenterPoint RTX (Trimble; Ken et al., 2013), StarFire (Nacom) and SmartLink (Leica GeoSystem). This method can achieve 4-centimeter accuracy positional measurement by precise point positioning (PPP). The system infrastructure is based on a global network of GNSS receivers (Ken et al., 2013) of Continuously Operating Reference Stations (CORS). The CORS operates around the clock for collecting the GNSS data measurements from the GNSS satellites. At the processing facilities, the network data is combined with other auxiliary data and is processed, aiming to generate satellite precise information. That information for precise point positioning (PPP) includes the satellite orbits, the clock errors, and other quantities from the International GNSS Service (IGS) networks that are used for high-accuracy global positioning (Yoichi and Takashi, 2007).

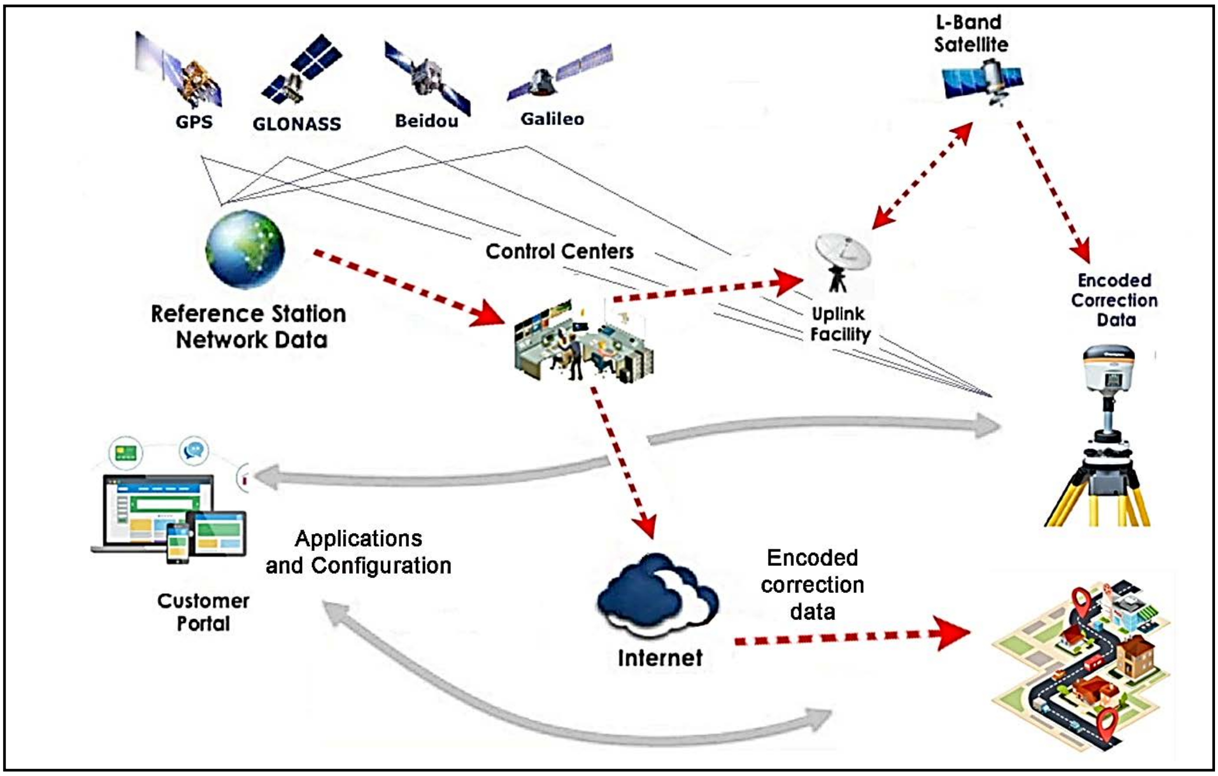

Figure 1: Operation of Atlas L-Band services (Source: Hemisphere GNSS 2018)

For subscribe users, each receiver in the network is linked to a satellite communication system via L-Band, and receives corrected data for its improving measurement accuracy for land and maritime survey. L-Band with the frequency between 1,525-1,646.5 MHz has some advantages over other frequencies, as it is good for poor weather conditions, such as heavy rain (Rajeswari and Christopher, 2020). The obvious advantage is its connection is using L-Band frequency instead of the Internet connection. Therefore, this L-Band correction service can be employed in the remote areas where Internet connection is not required.

Being a worldwide differential correction service, L-band GNSS offers the most advanced corrections via Atlas L-band satellites. Users can have improved accuracies, from meters level to sub-meter, decimeters and centimeters. L-band option for precise point positioning (PPP) from Hemisphere GNSS 2012 provides worldwide decimeter positioning to smartphones, tablets or notebook computers, as described in Figure 1. There have been about 200 IGS reference stations worldwide and L-Band satellites distributing coverage from 75°N to 75°S, all of the earth's landmass is covered (Ken et al., 2013).

Atlas Hemisphere has provided three levels of service as H100 with 1m 95% (50 cm RMS), H30 with 30cm 95% (15 cm RMS), and H10 with 8cm 95% (4 cm RMS).

GNSS data are collected from IGS CORS located all over the world. Data is then processed at the Control Centers and corrections are up-linked to the geostationary satellites. Each satellite broadcasts corrections for its region over specific for precise point positioning (PPP) L-band frequencies.

2.3 COORDINATE DIFFERENCE BETWEEN LOCAL AND IGS SYSTEM

There is a difference in coordinate measurement between local CORS and IGS CORS system. This coordinate difference makes local surveyors having trouble when they use L-band or Post-processing techniques by referring to IGS CORS.

The study objective is to provide L-Band Atlas data correction service to use in the areas where the internet is not available for RTCM data communication by RTK method. This solution contributes many benefits to land surveyors who work for forestry and agriculture in a remote area without internet communication.

3. METHODOLOGY

The ATLAS L-band GNSS system has an advantage of using L-Band frequency 1545.855MHZ to connect to the communication satellite and it does not use the internet connection that can be used in the remote area where internet connection is not available.

The L-Band measurement from Atlas service is collected in 45 minutes until to get the fixed mode to be sure that corrected data is met the sufficient accuracy requirement (Yoichi M. and Takashi T., 2007). The L-Band frequency 1545.855MHZ data measurements for precise point positioning (PPP) with the CORS mobile are evaluated for its accuracy by relative comparing with the static measurement at the same survey points (Suelynn et al., 2015). The static measurement is collected for 2 hours and is then post-processed by using RINEX for online processing on AUSPOS services provided by Geoscience Australia at http://www.ga.gov.au/bin/gps.pl. The L-Band measurement data is relatively compared with the results of post-processing static data for evaluating the accuracy of positioning.

3.1 L-BAND ATLAS DATA COLLECTION

L-band data measurement is collected by using the dual-frequency receiver Hemisphere Smart Antenna model S321 with L-Band Atlas frequency 1545.855MHZ service type of H10 with 8cm 95% (4 cm RMS). The data is collected for 45 minutes from single to fixed mode as shown in Table 2. The average of 200 epochs is applied for the result of the measurement for each site. This

L-Band data results are relatively compared with post-processing static data for accuracy assessment.

3.2 STATIC GNSS MEASUREMENT

The GNSS data static was collected as raw data in more than two hours during the L-band measurement mode as described in Table 2. The antenna height was measured and recorded for the Post-processing technique. Then this static data was on-line post-processing by using AUSPOS - Online GPS Processing Service. The post-process AUSPOS is a free-of-charge online differential GPS data processing facility provided by Geoscience Australia. It uses both the IGS CORS networks and the IGS product types. The International GNSS Service (IGS) has open access, it has combined high-quality GNSS data products since 1994. These products can be accessed for scientific, educational, and commercial applications with the definitive global reference frame. The post-process AUSPOS has operated with data collected around the world. Static measurement data is online submitted in dual-frequency geodetic quality GPS RINEX by any internet browser at http://www.ga.gov.au/scientific-topics/positioning-navigation/geodesy/auspos. The results of post-process static data are applied for evaluating the accuracy of the L-Band Atlas measurement data.

Table 2: Description of data collection

Sites	Observation Date dd/mm/yyyy	Observation time hh:mm-hh:mm		Satellite: GPS, GLONASS and BEIDU (cut-off angle 10°)			
		Static/raw data RINEX	L-band Atlas 200 (1 sec. per epoch)	No. sat.	PDOP	HDOP	VDOP
AYA	18/02/2020	13:58-16:09	16:00-16:46	27	1.206	0.500	1.106
BKK	29/01/2020	13:46-16:03	15:32-16:26	28	1.100	0.500	0.902
CBI	13/02/2020	15:36-17:38	16:00-17:54	29	1.22	0.52	1.100
KRI	20/02/2020	17:18-19:41	18:50-19:37	28	1.000	0.500	0.809
NYK	14/03/2020	11:24-13:42	12:10-13:35	27	1.200	0.500	1.100
NPT	09/01/2020	10:37-13:43	14:35-15:25	29	1.000	0.600	0.828
PTE	18/02/2020	09:43-12:02	11:53-12:38	27	1.000	0.552	0.800
RBR	15/02/2020	19:18-21:29	21:02-21:55	28	1.050	0.550	0.900
SRI	15/03/2020	09:48-12:05	11:55-12:59	29	1.000	0.500	0.900
SPB1	14/03/2020	17:06-19:18	18:10-19:14	27	1.033	0.532	0.900
SKM	15/02/2020	14:44-16:51	16:04-16:55	28	1.300	0.600	1.100
SKN	15/02/2020	10:52-13:00	12:03-12:56	30	1.00	0.500	0.832
SPB	15/03/2020	15:06-17:19	16:13-17:16	28	1.100	0.500	0.900

3.3 THE STUDY AREA

The Atlas L-band GNSS and GNSS RTK data were collected in the central of Thailand and they were located as in Figure 3. There are nine test sites in rural and urban areas where GNSS RTK from RTSD can be measured as reference data. The field survey was conducted from 09 January to 15 March 2020 in the drying season. Twelve provinces in the central of Thailand was selected as the test sites because they can be easy to travel and access from Bangkok as listed in Table 3. The coordinate system used in this study is WGS 84 UTM zone 47 N and geoid height EGM96.

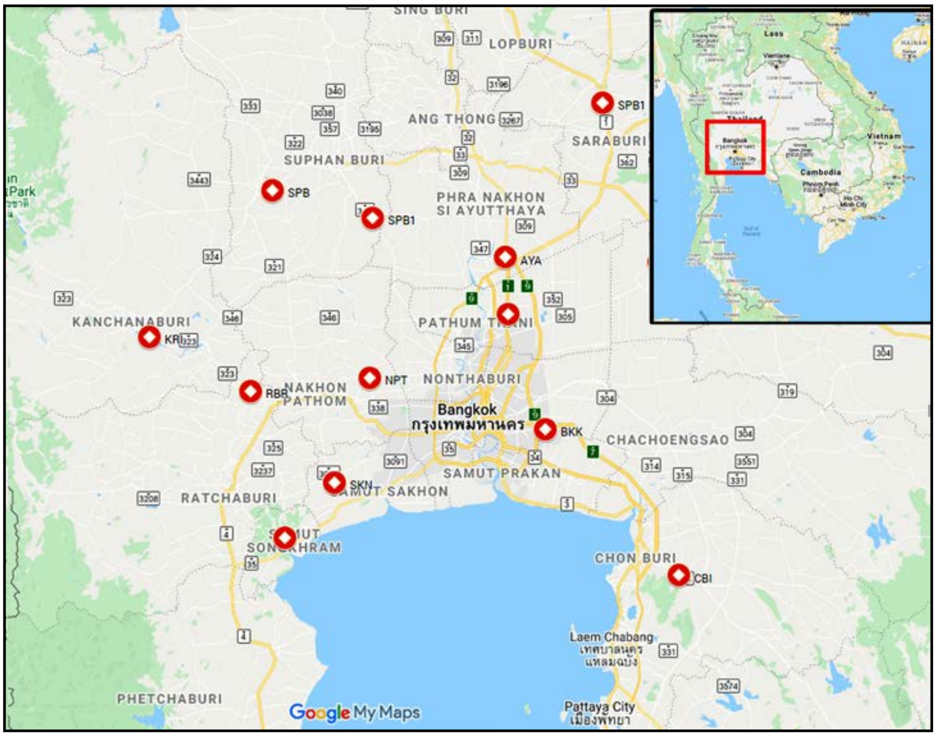

Figure 3: The Atlas L-band GNSS and GNSS RTK data collection in the central of Thailand (Courtesy of Google).

4. RESULT AND DISCUSSION

The results include the processing of L-Band frequency 1545.855MHZ measurement data for accuracy assessment in comparing with post-processing static data.

4.1 L-BAND MEASUREMENT DATA FOR ACCURACY ASSESSMENT

The results of the AUSPOS post-process of static data were used as the source of benchmarks for comparing Atlas L-band GNSS results. The results of the AUSPOS post-process of static data are presented in Table 3. The post-process AUSPOS has operated with data collected from CORS in Asia with Orbit type as IGS rapid data. Orbit type IGS rapid data is available after 48 hours after the observation time. All coordinates are based on the IGS realization of the ITRF2014 reference frame with geoid height EGM2008 geoid.

Table 3: L-band GNSS measurement compared with the AUSPOS post-process

Provinces	Site ID	Atlas GNSS L-band		
		Diff. N	Diff. E	Diff. H
Ayuthaya	AYA	0.018	0.066	0.140
Bangkok	BKK	0.014	0.133	0.071
Chonburi	CBI	0.022	0.056	0.177
Kanchanaburi	KRI	0.015	0.041	0.105
Nakhon Nayok	NYK	0.050	0.024	0.299
Nakhon Pathom	NPT	0.007	0.019	0.277
Pathumthani	PTE	0.005	0.018	0.219
Ratchaburi	RBR	0.047	0.010	0.004
Saraburi	SRI	0.024	0.035	0.234
Suphanburi	SPB1	0.026	0.060	0.107
Samut Songkham	SKM	0.010	0.077	0.222
Samut Sakhon	SKN	0.026	0.080	0.307
Suphanburi	SPB	0.005	0.081	0.041
RMS		0.021	0.054	0.169
Confident level (C.L. 95%)		0.009	0.021	0.060

Atlas L-band GNSS frequency 1545.855MHZ measurement results are relatively very good compared with the AUSPOS post-process of static data as displayed in Table 3. With the average of 200 epochs measurement for each site, the RMS differences of L-band data are 0.021m, 0.054m and 0.169m in North, East, and Height respectively.

5. CONCLUSION

The study describes the new methodology for applying Atlas L-band GNSS measurement for precise point positioning (PPP) by using a GNSS dual-frequency rover alone. The total test sites are conducted in eleven provinces in the central of Thailand from 09 January to 15 March 2020. The measurement is applied in different survey modes for accessing the accuracy such as Atlas L-band, RTK GNSS with reference to RTSD CORS, and static data for post-processing

In comparing with the results from static post-processing from AUSPOS, the RMS differences of L-band data are centimeters for North, East, and decimeters for Height respectively. The Atlas L-band GNSS data is referenced to IGS CORS.

6. AVAILABILITY OF DATA AND MATERIAL

Data in this study can be provided upon contacting the corresponding author.

7. ACKNOWLEDGMENT

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