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ACCURACY ASSESSMENT OF L-BAND ATLAS GNSS SYSTEM IN THAILAND

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ABSTRACT

The L-Band ATLAS GNSS service, a new land and maritime survey technique, is described and field check for accuracy in this study. The L-Band ATLAS GNSS system is a Global Based Augmentation System (GSBAS), developed by Hemisphere GNSS Technology, as a service to enhance real-time orbit and clock generation, dual redundant delivery of corrections from ground reference network via commercial communication satellites. Having significant development of mobile internet communication, GNSS receiver navigation software can utilizeL-Band ATLAS service for land survey and civil construction works. This work, GNSS dual frequency (L1/L2) single receiver is operated in L-Band ATLAS system by static and dynamic positioning measurement modes. This paper demonstrates a system test for L-Band ATLAS system in Thailand (Bangkok and Korat test sites) that monitors and assesses the accuracy of positioning measurement during March and April 2018. The accuracy assessments are based on both International GNSS Service (IGS) and local ground reference network of Department of Land (DOL) of Thailand. Real-Time L band positioning measurement outcomes are compared with Post-Processing results from IGS and DOL by using local map projection as Indian 1975 in different UTM zone 47N (Bangkok) and UTM zone 48N (Korat) in Thailand. The accuracy meets the requirement for GIS and Surveying being 4.1 centimeter in horizontal measurement and 32 cm in vertical measurement as comparing post-processing with IGS system and 17 cm in horizontal measurement in comparing with DOL Thailand system. This paper also discusses the system integration and development for improving GNSS accuracy by using currently available international and local Continuously Operating Reference Stations (CORS) services in Thailand.

1. INTRODUCTION

GPS helps to pinpoint positions and navigations. GPS, by measuring the traveled times from satellites to receivers, can give ranging distances, which in turn are used to compute receivers locations when at least four satellites are in view. Other than GPS of the US, others countries have also developed similar systems, Russia built GLONASS, EU created GALILEO, China assembled BeiDou Navigation Satellite System (BDS), and others. All these systems are made into the so-called Global Navigation Satellite System (GNSS).

For low cost mapping (Anantakarn andYiengveerachon, 2016) and land survey by using GNSS, the two most common satellite positioning methods are static and dynamic (kinematic) positioning measurements (Fotiou et al., 2006). When referenced to a base station networks,static method employing post-processing technique can give results of measurement error possible less than five millimeters (Hemisphere, 2017). Even though giving highest positioning accuracy, static method takes time for raw data collection and involved complicated post-processing software operation. As static beinga reliable source,it is possible to compare accuracy of dynamic method to static method. For real time measurement of DGPS of a moving rover, radio transmission and internet communication can be used, hence the termed Real Time Kinematic (RTK). This method can possible archive the measurement accuracy of a few centimeters (Hemisphere, 2017) depending on the availability of Continuously Operating Reference Stations (CORS) and other factors. Similar to RTK, L-Band Hemisphere ATLAS applies the enhanced real-time orbit and clock generation, dual redundant delivery of corrections from ground reference network via commercial communication satellites. The L-Band Global Correction Service provides centimeter-level accuracy data to all over the world by using TerraStar correction signal broadcasted in L-Band channel on board of Inmarsat telecommunication satellite.

By a single dual-frequency GNSS receiver and mobile internet communication, worldwide userscan possible get higher positioning measurement with accuracy better than 10 centimeters (Hemisphere, 2017). This study demonstrates a system test for L-Band ATLAS system in Thailand (Bangkok and Korat test sites) that monitors and assesses the accuracy of positioning measurement during March and April 2018. The accuracy assessments were based on both International GNSS Service (IGS) and local ground reference network of Department of Land (DOL) of Thailand. Real-Time L band positioning measurement outcomes were compared with post-processing results from IGS and DOL by using local datum as Indian 1975 datum for map projection in different UTM zone 47N (Bangkok) and UTM zone 48N (Korat) in Thailand.

2. STUDY AREA

The study area covers two cities, Bangkok located in central Thailand and Korat in Nakhon Ratchaisima province located in North Eastern of Thailand. The Bangkok sites includes five landmarks built by Department of Thailand (DOL) that locate from longitude 100° 12' to 101° 00' East and from Latitude 13°36' to 14° 00' North. The Bangkok site is set in Indian 1975 map project zone 47N for positioning measurement. The Korat sites includes five landmarks built by DOL that spread from longitude 101°36' to 102°48' East and from Latitude 14°24' to 15° 26' North. The Korat site is located in Indian 1975 map projection zone 48N for positioning measurement. The field work for the two sites is conducted in dry season in March and April 2018 and all the landmarks has open sky for maximizing satellite views and GNSS data collection.

3. METHODOLOGY

The work will emphasize on setting up static positioning measurement for post-process and dynamic positioning measurement for RTK and L-Band ATLAS using Internet communication, *see* Figure 1. The static data for Post- processing is recordedwith 1-second intervals acquisitions while data for RTK and L-Band are real time processed via internet communication.

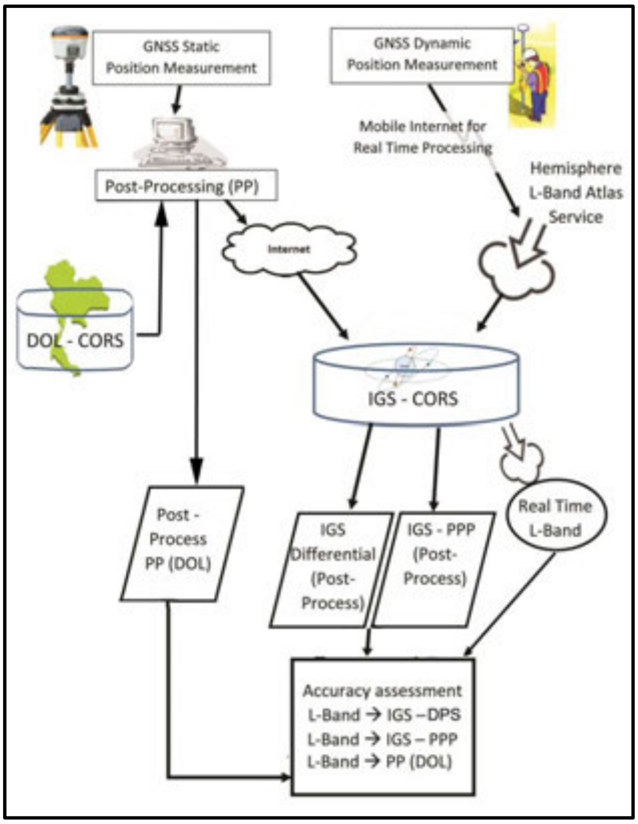

Figure 1: Workflow for this research.

3.1 POST-PROCESSING TECHNIQUE

Static method has employed post-processing technique that results measurement error less than five millimeters (Hemisphere, 2017). Because it is time consuming for static raw data collection and complicated post processing software operation, this method obtains highest positioning accuracy and becomes the reliable source for dynamic measurement accuracy to compare with.

3.2 PRECISE POINT POSITIONING (PPP)

Since International GNSS Service (IGS) products are used, hence the term precise point positioning (PPP) is employed to analysis of a single GNSS receiver (Wichayangkoon and Segantine, 1999) that took global correction data from IGS products (Zumberge et al., 1997). This method can be conducted in both Real-time and Post-process that bring precise satellite orbits and clock information from IGS products to correct the error GNSS signal (Wichayangkoon, 2000) for improving the accuracy of positioning measurement (Mullerschoen et al., 2001).

3.3 REAL TIME L-BAND ATLAS SERVICE HEMISPHERE GNSS TECHNOLOGY.

Figure 2 explains the real time L-bandcorrection services,a modality of GNSS positioning as part of a global correction service system. The receiver uses L-band frequency (microwave wavelength) for sending its measurement data to the communication satellite INMARSAT with TerraStar channel. This satellite contacts with the processing facilities where the network data is combined with other auxiliary data and is processed, aiming to generate satellite precise information. That information includes the satellite orbits, the clock errors, and other quantities that are relevant for high-accuracy global positioning.

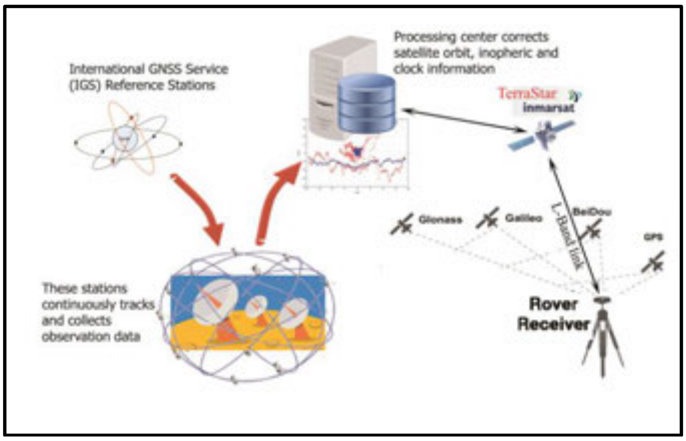

Figure 2: The correction data can be sent to end-users via L-Band satellite transmission (after Hemisphere, 2017).

3.4 CONTINUOUSLY OPERATING REFERENCE STATIONS (CORS)

CORS station data can be used to enhance accuracy positioning measurement of many applicationsincluding geodesy, land survey, maritime and aviation (Evans et al, 2002). In this method, the rover unit can communicate in real-time or post-process with these station networks by using internet connection. GNSS signal is then corrected by using Networks RTK such as Virtual Reference Station (VRS) and Master-Auxiliary Concept (MAC). These software network models have different utilizations depending on the size of survey area and volume of processed data from each network (Takac and Zelzer, 2008).

3.5 THAILAND DEPARTMENT OF LAND CONTINUOUSLY OPERATING REFERENCE STATIONS (THAI DOL CORS)

Up to now, Thailand DOL has set up 62 CORS stations allocated entire Thailand(http://dol-rtknetwork.com). CHC Navtech Thailand Company has been in charge of maintaining and administering Server and RTK Network System, on behalf of Department of Land (DOL, 2017).

3.6 INTERNATIONAL GNSS SERVICE AND DIFFERENTIAL GLOBAL POSITIONING SYSTEM (IGS DGPS)

One of the online post-processing in the Pacific and Asia region are the Australian Regional GPS Network (http://www.auslig.gov.au/geodesy/argn) using software AUSPOS Version 2.3. It is a simple operation as uploading GNSS static measurement raw data in RINEX format. Then the server collects and processes simultaneous data from IGS stations for DGPS data correction. The report of data processing including positioning coordinate and baseline ranges among the references stations is then sent backto email. This system has some disadvantages as raw data requirement for more than two hours static measurement by dual frequency only and sometime DGPS data from reference stations is not available in the region. To fill these gaps, IGS PPP method is an alternative method for post-processing to achieve precise positioning coordinates.

3.7 INTERNATIONAL GNSS SERVICE AND PRECISE POINT POSITION (IGS PPP)

GNSS Analysis and Positioning Software (GAPS) Canada offers free of charge service for PPP based on IGS products.Being a data service center in the University of New Brunswick, the system processes our static and dynamic raw data that uploads to the server. Then atmospheric, ionosphere, satellite orbit and receiver clock from IGS reference stations are collected and processed to give very high accuracy of position coordinates. All these measurement information are included in a coordinate report that sends back to users by email after the process finish.

This research field work conducts static positioning measurement and then the RINEX data is sent to ASPOS for processing as described in Figure 3. In Figure 3, the survey point D3327 measured by carrier phase with residual 2 cm and Pseudo-phase residual 5 m are also plotted.

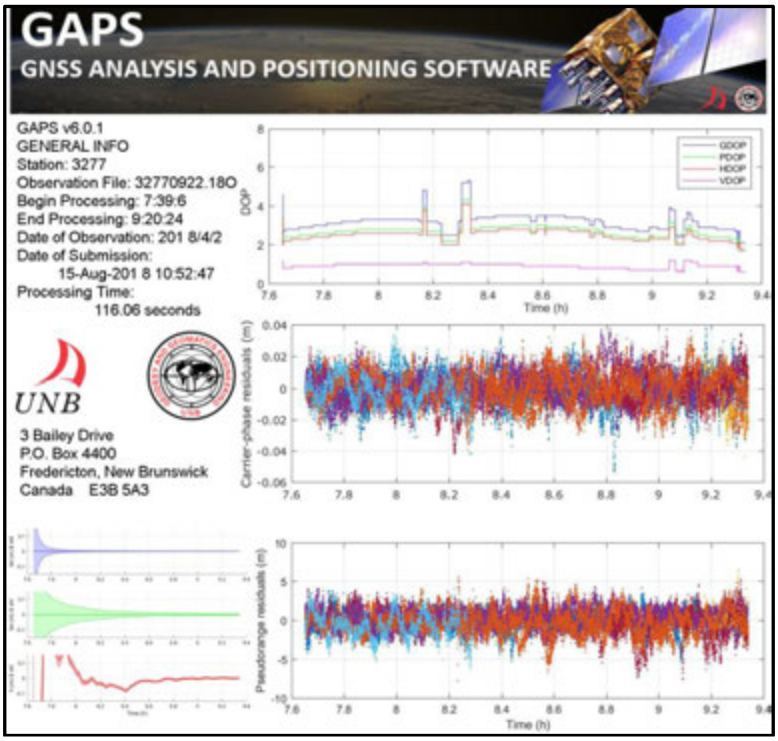

Figure 3: GAPS PPP Online GNSS Processing Service report.

4. RESULTS AND DISCUSSION

The accuracy assessment of L-Band ATLAS Real time was compared to Static positioning measurement by CORS data from DOL Thailand and IGS data Post-possessing technique. The L-Band ATLAS Real time measured in 30 minutes duration for each survey point.

Static measurement conducted in 90 minutes duration for each survey point and the data was converted in to RINEX format. These data was then uploaded to IGS website for on-line Post-processing by long base-line DGPS and PPP technique. The referenced GPS data from DOL were assessed and downloaded in the format of RINEX which is compactable with GNSS software for post-processing.

4.1 DEPARTMENT OF LAND (DOL) AND POST-PROCESS

One of the survey landmark for Post-process as point ID as 102454 is located in the open sky with good construction and DOL landmark information. Static measurement conducted in 90 minutes duration for each survey point and the data was converted in to RINEX format. The survey points were then employed by Post-processing technique has been conducted with the referenced positions from the Department of Land (DOL) with base lines and network adjustment as presented in Figure 4.The accuracy of Post-process from DOL as RMS North as 1.6 cm, RMS East as 1.6 cm and

RMS Height 11.5 cm,is summarized in Table 1.

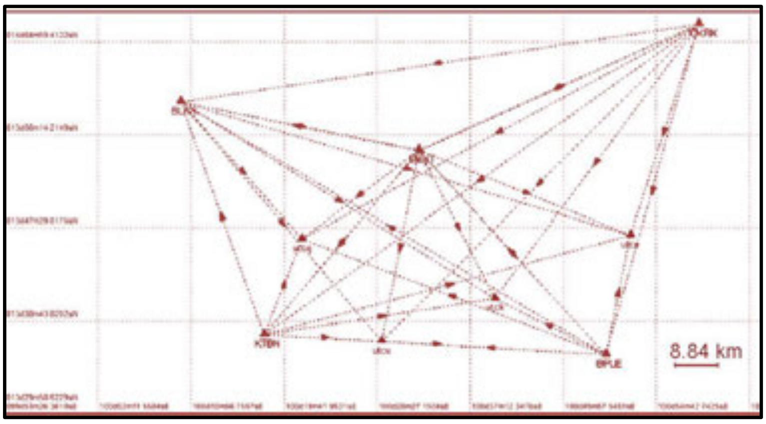

Figure 4: Post-processing results with base lines and network adjustment

Table 1: Post-process accuracy

Post-Process	RMS (m)		
	North	East	Height
IGS-PPP	0.005	0.004	0.004
IGS-DGPS	0.023	0.052	0.112
DOL	0.016	0.016	0.115

4.2 THE ACCURACY OF IGS POST-PROCESS PPP (VIA GAPS SERVICE)

The accuracy of IGS Post-Process PPP ranges errors caused by signal strength, ionospheric effects, multipath etc. Carrier phase residual values as 2 cm and Pseudo-phase residual as 5 m were also plotted in Figure 5. The accuracy of post-process from IGS - PPP as RMS North as 5 mm, RMS East as 4 mm and RMS Height 4 mm is summarized in Table 1.

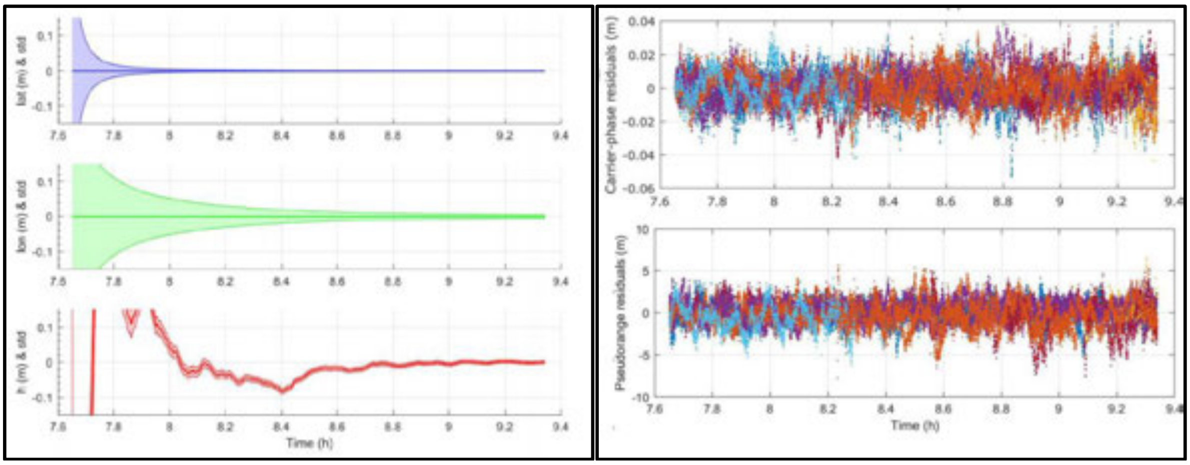

Figure 5:The accuracy of IGS Post-Process PPP

4.3 THE ACCURACY OF IGS - DGPS

The raw data for more than two hours static measurement by dual frequency was process by AUSPOS ver. 2.3 with DGPS data from reference stations in the region. The accuracy of Post-process from IGS - DGPS as RMS North as 2.3 cm, RMS East as 5.2 cm and RMS Height 11.2 cm is summarizes in Table 1.

4.4 THE ACCURACY OF L-BAND CORRECTION ATLAS

The L-Band ATLAS Real time measured in 30 minutes duration for each survey point. The accuracy of L-Band Correction ATLAS is measured at horizontal RMS 4.3 centimeter and vertical RMS 6.2 cm as displayed in Real Time at the moment of survey, *see* Figure 6.

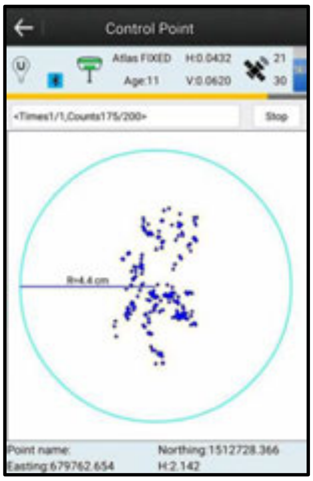

Figure 6: L-Band Correction ATLAS Real time measurement

The accuracy of L-Band ATALS meets the requirement for GIS and Surveyingas illustrated in Figure 7 by Real time measured in 30 minutes duration.

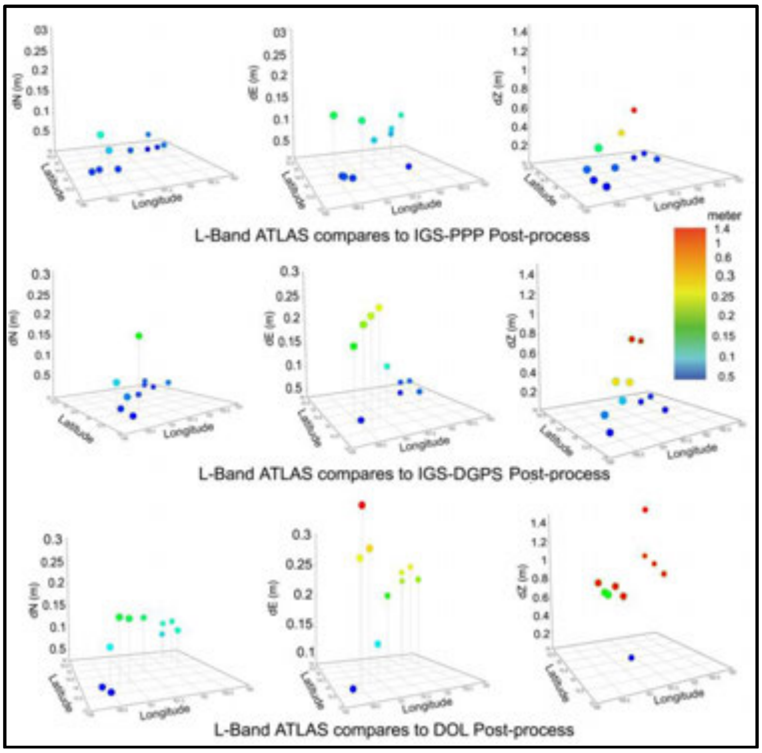

Figure 7: The accuracy of L-Band Correction ATLAS

The accuracy is resulted as 4.1 centimeter in RMS horizontal measurement and 32 cm in RMS vertical measurement as comparing post-processing with IGS system while 17 cm in RMS horizontal measurement and 83 cm in RMS vertical measurement in comparing with DOL Thailand system.

Based on the above results, L-Band ATLAS system has been integrated and developed for improving GNSS accuracy by using currently available international and local Continuously Operating Reference Stations (CORS) services in Thailand.

5. CONCLUSION

This study demonstrates a system test for L-Band ATLAS system in Thailand (Bangkok and Korat test sites) to monitor and assess the positioning measurement accuracy. The accuracy assessments arereferenced to both International GNSS Service (IGS) and local ground reference network of Department of Land (DOL) of Thailand. Real-Time L band positioning measurement outcomes are compared with Post-Processing results from IGS and DOL by using local map projection (Indian1975) in different UTM zones 47N (Bangkok) and 48N (Korat). The accuracy meets the requirement for GIS and Surveying being 4.1 centimeter in horizontal measurement and 32 cm in vertical measurement as comparing post-processing with IGS system and 17 cm in horizontal measurement in comparing with DOL Thailand system. This paper also discusses the system integration and development for improving GNSS accuracy by using currently available international and local Continuously Operating Reference Stations (CORS) services in Thailand.

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