Evaluation of L1 Signal GPS Application for Cadastral Survey

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Abstract : Global Positioning System (GPS) technology has developed to the stage where it has become another normal tool for professional surveyor. Commercial products offer user-friendly hardware and software, including advice techniques that can improve productivity with high accuracy. Both government and private services accept the improved GPS positioning and surveying for making a rapid work flow. However, even though some professional surveyors have accepted GPS survey methodology into their business, mainly for engineering and topographic detail task, many of them are still reluctant to investigate the technology. This was due to a number of reasons such as economic cost, misunderstanding of geodesy, confusion about GPS surveying on how to best utilize existing GPS services, information lock, and cadastral surveyors' uncertainty over what is acceptable practice to satisfy current surveying regulation in their state and office. Practically, L1 GPS SOKKIA GSR 1700 CSX and Spractum software is conducted as traditional ground survey, total station, on cadastral survey. For the previous reasons, productivities were verified for limit of the equipment to be used, the observations procedure, the processing technique, map and geodetic reduction, and the suitable practice in statistical analysis to ensure measurement redundancy.

Keywords : Cadastral Survey, GPS, Parcel, Satellite Survey.

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1. Introduction

The satellite signal is free to access existence on the globe and a huge of different receiver type is developed on the market. Using the global positioning system(GPS) operated by the United State Department of Defence is the first choice solution to locate and navigate objects on Earth. Holding a cheapest receiver as small a mobile phone and working it track GPS signals under a clear view of the sky could immediately obtain with an accuracy of better than tens of meters at least his & her current position.[1] More experience geodetic receivers costly along with a careful data analysis scheme could help to determine millimeter-level movement of the ground or manmade constructions. In all applications, the pure positioning coordinate of objects are transformed in to information knowledge of their locations in spatial relation with surroundings on the earth surface. Positioning accuracy , Stratus GPS system and Spectrum survey software, using L1 only receiver via post processing, is used by professional surveyor for cadastral survey for the limited by equipment cost, unfamiliar operational procedure and the current accuracy requirement.[2] This paper attempts to provide users seeking the opportunity to use GPS for their application in the productivities verified the limit of the equipment to be used, the observations procedure, the processing technique, map and geodetic reduction and the suitable practice in statistical analysis to ensure measurement redundancy.

2. Materials and Methods

2.1 GPS Framework

US Department of Defense (US DoD) designed and developed the Global Positioning System(GPS) for navigation purpose giving positions in real time to around 5-20 m accuracy. A constellation of 28 satellites broadcast position and time using ranging codes modulated on L1 and L2 band carrier signals. Geodesists and surveyors realized that measuring simultaneously measuring the GPS satellite signals at two antennas and combining the data, differential or relative positioning with respect to one base station was possible at higher accuracy; a few meter or better when using code or pseudo range observations and cm-level when using the carrier signal phase observations.[3] However, differential positioning required data to be post-processed as a result high accuracy positioning was not available in real-time.

Initialization in differential GPS implies on the process called DGPS, one-way carrier phase simultaneous measurement are lagged at two antennas to the same constellation of satellites. A base satellite has to be identified and formed pairs comprising two satellites and two antennas with the base satellite to all pairs. For example, if there are two stations and five satellites, the four pairs would be formed as one-way carrier phase measurement in the distance between a satellite and antenna. The sum of unknown number of wavelength in GPS signal with a wavelength plus a fraction which is measured and continuously tracked by the GPS receiver. Separating channels in the GPS receiver lock on to separate satellites and count the number of the wavelengths

increasingly or decreasingly for a setting or rising satellite respectively. Any interruption to this counting procedure, such as when a satellite tracking is obstructed by constructions on the front receiver, which is called a circle slip. Combining a least four one-way phase measurement is the process of double differencing and for eliminating the target error source namely receiver and satellite clock bias.

Double differencing is used for computation the unknown number of wavelengths between a satellite and receiver called ambiguity at the moment of the first simultaneous measurement of both GPS receivers. This process is known as ambiguity resolution. Therefore, initialization is the result at a successful ambiguity resolution procedure and can produce centimeter level positioning with respect to a known base station thereafter. If a circle slip occurs, ambiguity resolution must be recomputed for that satellite receiver pair. If all satellites are affected by a circle slip, initialization is repeated.[4]

If the ambiguity resolution procedure can compute the fix number of the L1 wavelength for particular baseline then this is the best solution achievable, the best and limited length around 10-15 kilometers depending on conditions. Due to increasing base length, the atmospheric biases are increased to both ends. Other biases such as multipath and orbit error also contribute.

Cadastral survey is for measurement used to define the location of parcel corners and boundaries. For L1 kinematic survey, it is very important to lock on satellites after performance the initialization. If the performance dose lose lock, the another initialization must perform right away or re-occupy a site as the previous occupied before losing of the lock. It is very good performance to obtain good result, as fixed integer ambiguity solution.

2.2 Cadastral survey Framework

Cadastral survey is provided for stable position and security of title or parcel through appropriate location and delineation of real-property boundaries. Surveyor has to perform land surveying under any continuous change taking place in land information system and surveying technology, both classical and modern surveying method as GPS accommodations are related to creation, establishment, retracement , or resurvey of properly boundaries for public or private land. Therefore, professional surveyor must know and understand the field data collection, processing, and output as the paper objectives.

Single frequency receivers has the weak point in the longer to resolve integer ambiguities at the beginning of an observation session and after a cycle slip, but it is cost less than double frequency receivers as a half price. However, it is still higher than total station theodolite and worked faster which it is the point to investigate the single frequency receivers for GPS surveying techniques. The techniques could be adapted to cadastral survey for enhancement of L1 GPS condition.

The base station receiver is set up and left operating autonomously whist the survey operate the roving receiver. From a technique operation manual, the base station should be located with an open sky and viewed to maximize the number of satellites for receiving signal. Through double

differential GPS is other participate simultaneous observation to the same constellation of satellites. If the base station is located such the only 6 satellites as visible and the rover has received the same satellites. The base should be located in multipath free environment a way from potentially reflective material, moreover the base station would place obviously on control mark with knowing UTM coordinate.[5]

2.3 Experimental surveying

Field test were performed on site where there was a sample parcel created by 4 corners peg marks for cadastral purpose, length and bearing of boundaries known by traditional surveying. For horizontal control, there were two bench marks those were defined by GPS method as geodetic method with L1 and L2 frequency signals. Those were assumed to be reference framework on UTM system. For evaluation, the GPS method as static and post processing were used for L1 which were reference to L1&L2 the control.

Post-processing differential GPS observation technical was used to determine position by the carrier phase range or distance of satellite from the receiver location on the earth. Differential technique between the moving satellite and two ground-base receivers can eliminate the effect of errors e.g. GPS signal, satellite ephemeris, satellite clock bias, large amount of satellite orbit and atmospheric delays.[6]

For differential carrier phase observation resolved the cycle ambiguity, base line vector is called a “Fixed” solution if a range of cycle ambiguities is known. When the baselines are processed, the out put file should be reviewed among software vendor and used to evaluate the boundaries quality. The procedure depending on software algorithm should has output statistic and analysis of reliability.

The distances between pegs as the reference points on a parcel were measured by traditional surveying method, close traverse. The data, angles and distance, were measured by total station for digital data input. The digital field data were flow to process for coordinate output by compass rule and least square method which were adjusted for making sure the distances correct or the most probable value which are the results of mathematics and stochastic model, respectively. The horizontal distance were showed and compared in number and figure as parcel. The coordinate of points are not considered which the original cadastral survey, meters and bounds system, is concentrated on a parcel as geometry, area and size, even they were showed on those processing as close traverse. Boundaries distance were comparing to show accuracy approximately measurement.

Currently, the digital cadastral mapping and multipurpose cadastral mapping are very useful on surveying work. The cadastral survey has to be changed to coordinate system on a theoretical map projection on the specific geodetic datum.

By technical method for GPS surveying method, single differencing between receivers to eliminate click bias was measured for coordinate on the mark as previous traditional close traverse. Sokkia GSR 1700 CSX and Spectrum commercial software were operated and processed by L1

carrier phases. The environmental factors as a clear sky and elevation mask to avoid multipath, the base line was not too far in the distances where base and rover station can be received signal that have gone through almost the same atmospheric conditions and considering the same amount of correction in GPS surveys. It is important to check of the reliability of result in GPS survey, the sufficient redundancy in data processing is done by following;

Re-initialization at a known point observed station by the change antenna height for integer number.

Reoccupy observed point by waiting long time for the satellite geometry to change for independent check.

Traverse closure check as a loop or network for working correctly.

On this job, combination of those checking were done on the same mark as traditional cadastral survey in difference results, coordinate and boundary distance. Relative position method is investigated for long time receiving satellite data without specification data type, GNNS and GLONSS, and survey planning for best satellites position. There were three GPS surveying methods for UTM coordinate on WGS84, in all method, boundaries are checked in the distance for metes and bounds system.

3. Results and Discussion

GPS surveying methods were radiation, closure loop and network, relative difference technique without preprocessing. There were only two L1 GPS receivers for vector observation between two points, one known coordinates and unknown coordinate. Post processing software from the importing observed data through editing of the station names, reference coordinate to be used in the procedure. The sample reports are viewed for quality assurance and control information.

The report on post processing shows information results as the solution of field GPS data in vector of one base station to rover station. The sample reports are the first part showed the project path on computer, the type of coordinate system, the datum, the units for the processing. The second part gives information of base and remote station of point occupation properties, type of antenna height and coordinate of point in WGS84 and UTM. The last part gives vector result indicated; the solution type has to be fixed in L1 ambiguities, time span and processing interval, observation in numbers and used, the percentage of the data used of the total collection of the particular occupation and the ratio of best solution to the next-best solution. The difference in Cartestial coordinate of the vector are showed including the standard deviation, root mean square and the grid distance on UTM.

On radiation method is stand for reoccupy observed point, base station SV01 and rovers station on parcel marks. SV01 is control point defined in higher accuracy than cadastral work. Traverse and network are un constrain adjustment. The UTM coordinate are showed as;

Table 1. **UTM Coordinates By GPS Survey**

Station	Radiation Method(A)	
	E (m)	N (m)
SV01	666299.385	1516776.345
Point 001	665855.749	1516368.737
Point 002	665841.453	1516376.778
Point 003	665817.767	1516366.96
Point 004	665794.348	1516351.674
Point 005	665803.066	1516334.234

Station	Close Traverse Method(B)	
	E (m)	N (m)
Point 001	665855.749	1516368.737
Point 002	665841.457	1516376.773
Point 003	665817.772	1516366.959
Point 004	665794.349	1516351.679
Point 005	665803.068	1516334.242
Station	Network Method(C)	
	E (m)	N (m)
Point 001	665855.749	1516368.737
Point 002	665841.456	1516376.773
Point 003	665817.77	1516366.959
Point 004	665794.349	1516351.678
Point 005	665803.07	1516334.24

The numbers are not difference too much, just in millimeter but they are difference from traditional survey by total station on plane which they are displayed as;

Table 2. **UTM Coordinates By Total Station**

Station	Traditional Survey(D)	
	E (m)	N (m)
Point 001	665855.749	1516368.737
Point 002	665870.3016	1516376.292
Point 003	665875.0732	1516401.487
Point 004	665875.1182	1516429.451
Point 005	665855.7454	1516431.71

But the boundaries distance are not difference too much as;

Table 3. **Boundaries Distance in Meters**

STA	(A)	(B)	(C)	(D)
Point 001	16.402	16.396	16.397	16.397
Point 002	25.640	25.638	25.639	25.643
Point 003	27.966	27.966	27.965	27.964
Point 004	19.498	19.495	19.497	19.504
Point 005	62.976	62.970	62.969	62.973
Point 001	16.402	16.396	16.397	16.553

Analysis of Result

Single L1 GPS is not new technology, it is for low accuracy and not high cost but it can navigate and locate positioning via the processing of carrier phase measurement. Two receivers are utilized with single frequency, L1, both GNSS and GLNOSS which they can not be selected by receiver capacity. The effect of troposphere refraction is removed by short distance both station. The integer ambiguity number is fixed in measurement for longer time to converge to a decimeter level positional solution.

The relative positioning is used by two receivers, vector base is a result. This is the condition of this study for economics cost, but positioning of parcel mark is fulfilled. The absolute position on base station is displayed by carrier phase distance directly and rover or remote station are showed on the post processing report verified WGS84 and UTM84 with low variance in millimeter from processing. In addition, the distance as vector result are displayed as difference in cartstiant coordinate, 3 dimension, and root means square error. The last part of the report is showed variance matrix for statistic model and test, not in this evaluation.

For surveying method, a base station can be reference to remote station so that one reference station more accuracy reference station than cadastral work is used for each remote station as parcel mark. With software along to GPS hardware, The close traverse and network are composed of vector result to adjust by least square method. Those adjustments are not component of GPS processing, they are computed by GPS data selected vector length.

The datum of map projection is significant about +/- 0.001 m percision to notify, the result in both of coordinate systems are very close and not significant difference. When the GPS coordinate are reference to traditional survey as plane coordinate, UTM, the large difference in number are not significant the same. The vector length of GPS processing and distance of traditional survey is significant equal.

4. Conclusion

The method on this work has been tested by only two GPS receivers for L1 signal GPS which are not good practice in real GPS application but in theory is explained that L1 signal can be utilized as more precise GPS signal. Long time receiving L1 signal has to be done and processed with suitable software and good correction model. In this work, the cheap L1 GPS SOKKIA GSR 1700 CSX and Spractum software is evaluated on cadastral survey. We found that hardware and software

can be worked properly to standard GPS report and GPS measurement with time longer than 30 minutes those are low cost in investment and high cost in operation. For the previous reasons, the precision can be archived but the accuracy can be not produced by two receivers without higher reference control. Cadastral survey, meters and bounds, can be verified without datum reference which is not investigated that the coordinate positions without constrain are significant difference on the same datum but missed plane without datum. So the area could not verified. Moreover, commercial processing software can not analysis in statistical researcher, just for statistical results only. Finally, standard guide line in the specific application is need being a good practice.

Nomenclature

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