KINEMATIC AND PSEUDO-KINEMATIC GPS SURVEYING (TEST DESCRIPTION AND RESULTS)

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1.0 INTRODUCTION

In the 1st Quarterly 1992 issue of "The Surveyor", a preliminary writing on the Kinematic and Pseudo-Kinematic GPS survey was published prior to the completion of tests. Both methods enable the GPS surveyors to expedite their operations. It was also stressed the need to perform tests to determine the capabilities and survey procedures for both methods.

This article is written to give a description of the test results obtained.

2.0 DESCRIPTION OF TESTS

The kinematic and pseudo-kinematic tests were performed at the Universiti Teknologi Malaysia (UTM) EDM calibration baseline. The baseline was established in 1986, consisting of five pillars (designated as BL01 to BL05) covering a distance of approximately 900 metres (see Figure 1). The distances between pillar were measured using the GEOMENSOR CR234 EDM which is capable of measuring distances up to 10 kilometres with an accuracy of ±0.1 mm + 0.1ppm (Kamarudin, M.N. 1992).

2.1 Kinematic Survey Tests

The Kinematic method requires an initialization process at the beginning of the survey in order to determine the initial integer ambiguities. After the initialization process, the rover receiver occupies new stations for a short period of observation, typically 2 to 4 minutes. This requires continuous phase lock to a minimum of 4 satellites throughout the survey.

Two kinematic tests were performed, designated as KIN1 and KIN2. Planning was done using the Ashtech Mission Planning software to determine the observation window prior to field tests. The following observation window was chosen for both the kinematic test on 3rd. March 1992:

i) Observation session from 21:00 hour to 24:00 hour.
ii) 7 to 8 satellites available.
iii) PDOP factor below 5.

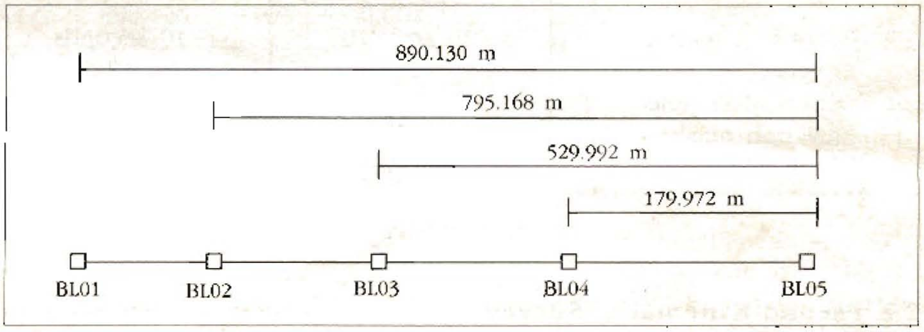


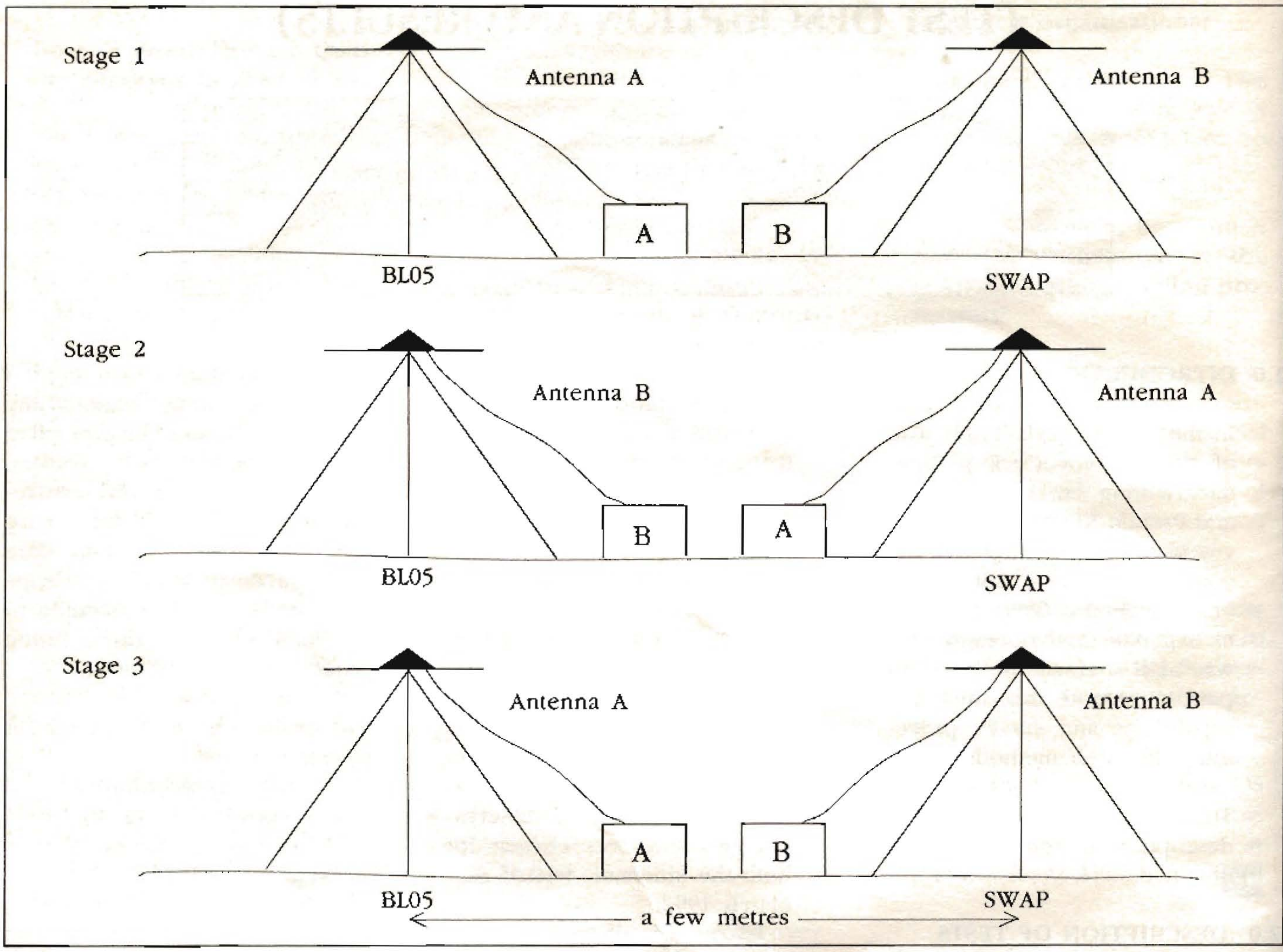
Figure 1 : The Baseline used in the tests

Pillar BL05 (known coordinates) was fixed as a base station and a swap point was established nearby using a tripod. Initialization was carried out to determine the ambiquities using the antenna swap method (see Figure 2). After performing the swap sucessfully without any cycle-slip. the roving receiver was moved to other pillars, while the master receiver remain stationary at the base throughout the session. Care was taken to avoid cycle slips by proper mission planning to minimized obstructions during transit between stations.

Both the tests were carried out with different receiver setting, ie. different recording interval and epochs setting (observation period). Details of the tests are given in Table 1.

The recorded data for each test were downloaded into the laptop personal computer and post processed using the Ashtech Geodetic Post Processing Software (GPPS). The computed baseline distances were obtained and later compared with distances from terrestrial and static GPS measurements.

Figure 2: Antenna Swapping



Receiver Setting	Tests	
	KIN1	KIN2
Recording Interval	10 seconds	10 seconds
Epochs	24	12
Observation time	4 minutes	2 minutes
Elevation mask	15°	15°
PDOP factor	below 5	below 5

Table 1 : Kinematic Tests Details

2.2 Pseudo-Kinematic Survey Tests

Pseudo-kinematic survey tests were also performed at the EDM calibration baseline. The pseudo-kinematic GPS survey requires twice observations at a pillar separated by a time period of about 1 hour (first and second visits). The observation time at each pillar is about 5 to 10 minutes. This method does not require continuous phase lock during transit between pillars.

Three tests were performed and designated as PKIN1, PKIN2 and PKIN3. The tests were carried out in three consecutive days. Proper mission planning was needed to determine an observation window which permits phase lock to at least four common satellites at both visits.

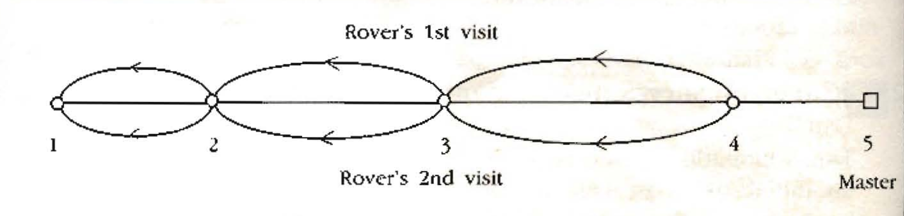


Figure 3 : Pseudo-Kinematic Survey

Receiver Setting	Tests	
	PKIN1/PKIN3	PKIN2
Recording Interval	10 seconds	10 seconds
Epochs	60	30
Observation time	10 minutes	5 minutes
Elevation mask	15°	15°
PDOP factor	below 5	below 5

Table 2: Pseudo-Kinematic Tests Details

Baseline From	To	Kinematic Distance (m)	Terrestrial Distance (m)	Differences (m)
BL05	BL04	179.970	179.972	–0.002
BL05	BL03	529.987	529.992	–0.005
BL05	BL02	795.173	795.168	–0.005
BL05	BL01	890.127	890.130	–0.003

Table 3: Comparison of KIN1 Test and Terrestrial Baseline Distances

Baseline From	To	Kinematic Distance (m)	Terrestrial Distance (m)	Differences (m)
BL05	BL04	179.959	179.972	–0.013
BL05	BL03	529.991	529.992	–0.001
BL05	BL02	795.168	795.173	–0.005
BL05	BL01	890.126	890.130	–0.004

Table 4: Comparison of KIN2 Test and Terrestrial Baseline Distances

Baseline From	To	Static Distance (m)	Kinematic Distance (m)		Differences (m)	
			KIN1	KIN2	Test 1	Test 2
BL05	BL02	795.162	795.173	795.168	0.011	0.006
BL05	BL01	890.122	890.127	890.126	0.005	0.004

Table 5: Comparison of Static and Kinematic GPS Baseline Distances

The following observation window was used for the test:

i) Observation session from 11:00 hour to 14:00 hour
ii) At least 4 common satellites available for both observation sessions at each pillar.
iii) PDOP factor below 5.

A master receiver remained at BL05 throughout the survey, while the rover receiver visited other pillars consecutively (BL04, BL03, BL02, and BL01) as shown in Figure 3. Observation period at each pillar are as shown in Table 2. After about an hour, the receiver returned to BL04 and consequently revisited each pillar for about 5 or 10 minutes.

3.0 RESULTS AND ANALYSIS

The baseline distances obtained from the kinematic and pseudo-kinematic tests are then compared with distances measured by the GEOMENSOR EDM (terrestrial) and static GPS (static).

3.1 Kinematic Survey Results and Analysis

The length of the baselines obtained from KIN1 and KIN2 tests are first compared with terrestrial measurements (known values). Table 3 and 4 shows the differences between kinematic and terrestrial measurements respectively.

Table 3 indicates that the differences between kinematic and terrestrial measurements are in order of millimetres. The test was carried out with an observation period of about four minutes per station (with 10 seconds recording interval and 24 measurement epochs).

In Table 4, the discrepancies between kinematic and terrestrial measurements are also in the magnitude of millimetres except for baseline BL05 to BL04 which shows a larger discrepancy of 13mm. Tests KIN2 was carried out with 10 seconds recording interval for 12 observation epochs, thus the observation period was only two minutes per station.

Table 5 shows the differences between the kinematic and static GPS measurements for two baselines ie. BL05 to BL02 and BL05 to BL01.

The table shows that the discrepancies between the static and kinematic baseline distances are small in magnitude. The largest being 11 millimetres.

Accuracy comparable with static GPS method can be achieved with the kinematic method which requires very short station occupation time. However the unknown initial integer ambiguities has to be carried forward throughout the survey (Ses et.al, 1992).

Comparable accuracy can also be achieved with 2 to 4 minutes occupation time. This can

Baseline From	Baseline To	Kinematic Distance (m)	Terrestrial Distance (m)	Differences (m)
BL05	BL04	*	179.972	*
BL05	BL03	529.993	529.992	-0.005
BL05	BL02	795.166	795.168	-0.005
BL05	BL01	890.128	890.130	-0.003

Note: * baseline omitted due to observation error

Table 6: Comparison of PKIN1 Test and Terrestrial Baseline Distance

Baseline From	Baseline To	Kinematic Distance (m)	Terrestrial Distance (m)	Differences (m)
BL05	BL04	179.967	179.972	-0.003
BL05	BL03	529.802	529.992	-0.190
BL05	BL02	795.891	795.168	-0.723.
BL05	BL01	890.179	890.130	-0.049

Table 7: Comparison of KIN2 Test and Terrestrial Baseline Distances

Baseline From	Baseline To	Kinematic Distance (m)	Terrestrial Distance (m)	Differences (m)
BL05	BL04	179.966	179.972	-0.006
BL05	BL03	529.980	529.992	-0.012
BL05	BL02	795.155	795.168	-0.013
BL05	BL01	890.113	890.130	-0.017

Table 8: Comparison of PKIN3 Test and Terrestrial Baseline Distances

Baseline From	Baseline To	Static (S)	P. Kinematic			Differences		
			PKIN1	PKIN2	PKIN3	Test 1	Test 2	Test 3
BL05	BL02	795.162	795.166	795.891	795.155	0.004	0.729	0.007
BL05	BL01	890.122	890.128	890.179	890.130	0.006	0.057	0.008

Table 9: Comparison of Static and P. Kinematic Baseline Distances

Baseline	No. Of Measurements		
	PKIN2	PKIN1	PKIN3
BL05 - BL04	166	*	359
BL05 - BL03	118	417	416
BL05 - BL02	177	447	476
BL05 - BL01	200	476	461

Table 10: Number of Measurements
(see Table 2 for details on receiver setting)

be shown from Table 4 and 5, where the discrepancey for the tests are less than 1 centimeter in magnitude.

PDOP factor (kept below five) plays an important part in obtaining the above test results. At least four satellites must be tracked at all times, and a poor geometrical configuration reduces the accuracy of the work substantially. It may also mean that if reception of the signal from a satellite is temporarily interupted, the new ambiguity for that satellite cannot be satisfactorily determined. Care must thus exercised in choosing the observing window, and in moving between stations, in such a way as to minimise the cycle slips which can be fatal to the survey. The use of Mission Planning Software packages is vital when planning Kinematic GPS Surveys.

3.2 Pseudo-Kinematic Survey Results and Analysis

Pseudo-kinematic test results were also compared to terrestrial baseline distances. Table 6, 7 and 8 show the comparison for each test.

From the tables, the differences obtained from PKIN2 test is comparatively larger than those obtained from PKIN1 and PKIN3. The discrepancy for PKIN1 test is ranging from 3mm to 5mm, while differences in PKIN3 test is larger than 10mm.

Table 9 indicates that the discrepancies between the static and psuedo-kinematic baseline distances for PKIN1 and PKIN3 tests are less than 1 centimeter.

From Table 10, it can be concluded that Pseudo-kinematic with observation period of five minutes per occupation (PKIN2 test) will not yield good results (less number of measurements). With observation time of ten minutes per occupation (PKIN1

Baseline	PKIN2	PKIN1	PKIN3
BL05 – BL04	3,12,17,23	*	3,12,17,(20),(23)
BL05 – BL03	3,12,17	3,12,17,20,(23)	3,12,17,(20),(23)
BL05 – BL02	3,12,17,23	3,12,17,20,23	3,12,17,20,23
BL05 – BL01	3,12,17,23	3,12,17,20,23	3,12,17,20,23

Table 11: Satellites Used in Processing (SV)

Pillar	Time Separation (Hour : Min)		
	PKIN1	PKIN2	PKIN3
BL04	*	0:48	1:09
BL03	1:16	0:46	1:07
BL02	1:11	0:44	1:04
BL01	1:08	0:41	1:02

Table 12: Time Separation Between Two Visits

Instrument Setting	Kinematic GPS	P. Kinematic GPs
Recording Interval	10 seconds	10 seconds
Observation Epochs	12	60
Observation Time	2 minutes	10 minutes
Elevation Mask	15 degree	15 degree
PDOP Factor	Below 5	Below 5
Interval between occupation	*	1 hour

Note : * not applicable

Table 13: Recommended Specifications

and PKIN3), better results can be obtained.

The number of satellites used in processing will have a significant effect on the computed baselines. The use of 5 satellites in PKIN1 and PKIN3 yielded better results. Meanwhile in PKIN2 test, satellite SV 20 was omitted (see Table 11). Time separation between two occupations which enables a change in satellite geometry is the basic requirement of the pseudo-kinematic method. Table 12 shows that separation between two visits of more than one hour (PKIN1 and PKIN3 tests) yielded better results.

4.0 CONCLUSION AND RECOMMENDATIONS

From the tests conducted at the EDM calibration baseline, the accuracy of the two methods compared to terrestrial measurement by the GEOMENSOR EDM and static GPS measurement were ascertained. Differences of 3 to 5 millimetres were obtained from Kinematic test as compared to terrestrial baseline distances. The differences of 3 to 17 millimetres were obtained from Pseudo-Kinematic tests. It has been shown that the Kinematic and Pseudo-Kinematic GPS techniques are capable of achieving accuracy comparable to Static GPS surveying.

From the tests conducted the following specifications as shown in Table 13 are recommended for carrying out the Kinematic and Pseudo-Kinematic GPS surveying.

Results from the tests indicate that the two GPS surveying techniques have potential applications in Malaysia. The Kinematic GPS requires a phase lock to at least four satellites throughout the survey. This is quite difficult to achieve in the developed area where trees, buldings and other obstructions are unavoidable. However with proper survey and route planning this method is still feasible. As for the Pseudo-Kinematic method, though it avoids the need for continuous tracking of satellites, it is constrained by drive time economics. This method can be said to be limited to surveys where transit time between points are short and accessibility to points are not a problem.

Because of the enormous time savings when compared to static GPS surveys, kinematic and pseudo-kinematic GPS make available the accuracies of GPS methods for work such as detail survey. Open sites such as green field development sites, airports, and jetties are ideal for kinematic and pseudo-kinematic GPS. Other potential uses of the technique could include control for road survey and the provision of photo control.

Kinematic and pseudo-kinematic GPS should be treated as another tools which are available to the surveyor and, like any other tools, should be used when the circumstances of the task can make full use of its advantages with its disadvantages being less important.

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REFERENCES

Kamarudin, M.N., "Mengesan Pergerakan Pillar Garis Dasar EDM di Kampus UTM". Unpubl. research report, Universiti Teknologi Malaysia, 1992.

Ses, S. and G.Y.J. Julian, Kinematic & Pseudo-Kinematic GPS Surveying in Malaysia. The Surveyor, Vol 29, No. 4, 1992.