



Guidelines and Specifications for GPS Surveys of ISN Markers

Version 2.4

Mar 2011

SINGAPORE LAND AUTHORITY
LAND SURVEY DIVISION
55 NEWTON ROAD
#12-01 REVENUE HOUSE
SINGAPORE 307987

This document is available on the Singapore Land Authority website.
URL: <http://www.sla.gov.sg/>.

Revision History

Revision	Revision Date	Amendments Made
Version 1.0	24 December 2002	-
Version 2.0	September 2004	Delete “Zero Baseline Test” in Item 4(a)
Version 2.1	December 2004	Insert “Zero Baseline Test in Item 4(a); Substitute “GPS Network Test” in Item 4(a) with “GPS Gross Error Test” Insert samples of GPS Gross Error Test submissions in Appendix B and Appendix C
Version 2.2	June 2006	Amend item (1) by deleting “Part III of the Land Surveyors Act ...” and inserting “the Boundaries and Survey Maps (Conduct of Cadastral Surveys) Rules 2005.” Amend item 4(a) para (6) by substituting 26.925m with 26.824m. Amend item (9) - delete “in CD to SLA” and replace with “by E-submission (CORENET) to SLA.” Amend item (9a) – Delete “Network” in para (1), insert “Zero Base Line Test” at para (2), amend para (5), insert para (6) and (11). Amend item 9(b) – replace “800 x 600 pixels” in para (1) with “1024 x 768 pixels,” insert para (2), amend para (5), delete Table 3 and 4 and insert samples at Figure 1, 2 and 3. Amend Appendix A and Appendix A (sample) by deleting “26.925m” and inserting “26.824m.” Amend Appendix C and Appendix C (sample) by inserting “Receiver Serial No.”
Version 2.3	August 2006	Replace all “SIMRSN” with “SiReNT”. Amend item (10) on SiReNT Reference Station Data Support.

Revision History

Revision	Revision Date	Amendments Made
Version 2.4	March 2011	<p>Update SLA's address and change "Survey Services" to "Land Survey Division".</p> <p>Change "Survey Services" to "Land Survey Division" where applicable.</p> <p>Addition of heading for RTK surveys (item 12).</p> <p>Amend item 4(a)</p> <p>Item (6) – addition of 6 new paragraphs.</p> <p>Amend item (9).</p> <p>Addition of item (12) on RTK surveys.</p> <p>Figure 2: XML File (.hcp) generated – 14652 changed to 17001, <LONGITUDE> and <LATITUDE> deleted. "Cross Screw" changed to "Nail"</p> <p>Figure 4 – New photograph inserted, and includes the location of the sixth SiReNT reference station at SSMK.</p> <p>Addition of Appendices D, E, F, G & H.</p>

Guidelines and Specifications for GPS Surveys of ISN Markers

1. Introduction

This document aims to provide guidelines for static GPS survey (hereinafter known as GPS Survey or the Survey) using the Singapore Satellite Positioning Reference Network (SiReNT) to establish secondary control marks (or ISN markers/points) for cadastral survey. It also describes the submission requirement for the survey as well as the reference station data availability.

The Surveyor must conduct all the survey works in accordance with the Boundaries And Survey Maps (Conduct Of Cadastral Surveys) Rules 2005. The survey works conducted by the Surveyor must also conform to the procedures and standards of accuracy as described in the CS Directive on Cadastral Survey Practices.

These guidelines include the following headings:

1. Introduction
2. Accuracy Standard
3. Equipment
4. Equipment Testing
5. Site Planning and Reconnaissance
6. Planting of ISN Markers
7. Field Procedures
8. GPS Data Processing
9. Report Submission and Data Format
10. SiReNT Reference Station Data Support
11. GPS Survey in the Absence of SiReNT
12. RTK Surveys

These guidelines are subject to review as GPS technology is continually evolving with advancements in technologies and techniques. Please note that these guidelines do not represent the legal traceability of measurement. It is the responsibility of the surveyor to ensure that all equipment used in a measurement will achieve a result in terms of the accuracy required. These guidelines do not guarantee that particular survey accuracy will be attainable. It is the responsibility of the surveyor to ensure that the standards are achieved.

The Surveyor must ensure that these guidelines are strictly adhered to when carrying out the GPS Survey of ISN markers, unless otherwise instructed by the Chief Surveyor, Land Survey Division, SLA.

2. Accuracy Standard

The following standard is the minimally acceptable level of differential relative positional accuracy required for ISN marker survey.

- 95% confidence level less than or equal to 0.020 m for Northing and Easting components and 0.060 m for height component.

3. Equipment

GPS receiver and antenna used in the survey should be of geodetic or survey grade equipment. Listed below are the minimum specifications of receiver and antenna used for the survey:

- Dual frequency
- Carrier phase tracking
- Minimum 16 channels for L1 and L2

4. Equipment Testing

Equipment testing is required in order to ensure that they are in operational condition.

(a) GPS receiver and antenna

- Zero baseline test

The GPS receiver used must be subject to zero baseline test at yearly interval or after service and maintenance. This test is to be carried out by a GPS equipment vendor or the authorised dealers. The northing, easting and the height components of the zero-baseline should all be less than 1 mm. See sample page at Appendix H. (Note: The full Zero Baseline Test certification, which may contain more than one page, must be submitted for each and every ISN job submission.)

- GPS Gross Error Test

A gross error test is to be adopted for GPS receivers and antennae at yearly interval or after service and maintenance. The test is to be carried out at Pillar 7 of Lower Peirce Reservoir. Registered Surveyors are not required to submit the report and results of the test to SLA. However, the results must be submitted to SLA upon request. Registered Surveyors need to certify that the test was carried out appropriately and submit the certification to SLA together during each and every ISN job submission. The GPS test certification is attached in Appendix A.

Field procedures stated in para 7(a), 7(b) and 7(c) must be adhered.

The coordinates of the Pillar 7 are to be computed using the following criteria and procedures:

- Minimum one-hour session of observation; with reference to at least 2 SiReNT reference stations.
- The baseline acceptance criteria in Table 2 must be adhered.
- The adjusted Northing and Easting of Pillar 7 must be within 20mm on each direction of the fixed coordinates N.38834.121 and E.27135.303.
- The adjusted Ellipsoidal Height of Pillar 7 must be within 60mm of 26.824m.

Surveyors are required to suitably archive RINEX data of the observation recorded at Pillar 7; the SiReNT reference station data used in the test; baseline processing report as well as the adjustment results of the baselines. Surveyors are required to contact SLA for the arrangement to use the Pillar 7. He may use the “GPS Station Observation Log” to record each observation.

(b) Tribrachs

- Tribrachs (all plumbing/centering equipment) should be periodically checked.

5. Site Planning and Reconnaissance

Site Planning and Reconnaissance is required for the establishment of ISN markers. GPS survey requires good visibility of the sky in order to receive signals from as many satellites as possible during survey.

Site Planning and reconnaissance is carried out to ensure that:

- The location of the intended ISN marker is well located in terms of ground stability, accessibility, clear sky views, protection from vandalism and disturbance.
- The GPS surveys are conducted during periods when the maximum number of satellites is in view, and the value of PDOP is at its minimum.

6. Installation of ISN Markers

The ISN markers should be planted on / at

- Concrete surface such that the stability and reasonable permanency for the marker is assured.

- A site which is safe from potential vandalism and disturbance.
- A site which is well away from human traffic, as a safety precaution, to avoid the marker posing as a tripping hazard to pedestrians.
- A site with good sky view for maximum satellite visibility.
- A site with minimum multipath effects.
- A site where there are no existing ISN markers in the vicinity of 300 metres radius, to avoid marker proliferation and improve on the existing network.
- A new marker can be planted to replace a lost marker only after a thorough search has been made for the lost marker, using suitable aids such as a measuring tape, total station or GPS equipment.
- The Registered Surveyor must confirm that the marker is lost, in the “Other Remarks” section of form “Submission of ISN GPS Observation” (QP-LSV-11-F02) - see Appendix E.
- New ISN markers for installation by Registered Surveyors can be requested from Land Survey Division, SLA, through CORENET.
- Registered Surveyors requesting new ISN markers must have valid SiReNT Post Processing On-Demand accounts.
- Photograph of ISN marker currently in use is shown in Appendix G.

7. Field Procedures

Surveyors should adhere to the following guidelines in the course of conducting the field observation of the GPS surveys:

- (a) GPS Satellites Availability
 - Number of satellites observed – minimum 5 satellites all the time.
 - PDOP (Position Dilution of Precision) – less than or equal to 6 all the time.
- (b) Weather
 - Observations during heavy rain are not recommended.
- (c) GPS Observation Setting
 - Elevation mask – minimum 15 degrees
 - Observation rate – 15 seconds minimum

(d) GPS Observation Session

- Two independent observation sessions are needed to determine the coordinates of each ISN control point. For each session, the GPS receiver (and tripod) has to be physically reset.
- Refer to Table 1 for the duration of observation session for different baseline lengths.
- Duration of observation is subject to site condition.

Table 1: Observation time for different baseline length

Baseline Length (km)	Recommended Minimum Observation Time (minutes)
0 – 5	30
5 – 10	40
10 – 15	50
15 – 20	60
20 – 30 (Not recommended)	120

(e) GPS Antenna Set Up

- GPS antenna is not required to be oriented to true north.
- Antenna height must be measured (to nearest mm) and must be precisely documented in the GPS Station Observation Log (Appendix C).
- Antenna height must be measured once before and after each survey and/or each physical reset of the GPS antenna.

(f) GPS Station Observation Log

- The field officer must fill up a proper observation log to be submitted to SLA (Appendix C).

8. GPS Data Processing

GPS data processing involves baselines processing and adjustment. The details are as follow:

(a) Baseline Processing

- Carrier phase observation processing is required for the survey.
- Broadcast ephemeris can be used for baseline processing, but precise ephemeris is recommended for long baseline (more than 10 km). The precise orbit data can be obtained from the International GPS Service for Geodynamics (IGS) web site.

- Each ISN point has to be connected to at least two SiReNT reference stations.
- Each of the connection should be observed in two sessions as described in 7(d).
- It is recommended to accept short baselines.
- Baselines may be accepted based on the criteria listed in Table 2.

Table 2: Baseline acceptance criteria

Baseline Length (km)	Baseline Fix Type	RMS (m)	Ratio
< = 5	L1 fix	< 0.015	> 3
> 5	Ionosphere free fix	< 0.020	> 3

(b) Adjustment

- Only accepted baseline will be used in the network adjustment.
- No outliers in observations.
- Northing and Easting error less than 0.020m and Ellipsoidal Height error less than 0.040m.
- The adjustment must pass the statistical test (e.g. Chi-square, F-test).

9. Report Submission and Data Format

The Surveyor is required to submit the GPS survey report by E-submission (CORENET) to SLA.

(a) Submission of the GPS survey must include:

- **GPS Test Certification** – for test at Pillar 7. See Appendix A.
- **Zero Base Line Test Certification** – see specimen at Appendix H.
- **GPS Station Obstruction Diagram** – see Appendix B.
- **GPS Station Observation Log** – see Appendix C.
- **Unretouched colour digital photograph** in JPEG format of the ISN marker location, taken during the hours of daylight.
- **Edited colour digital photograph** in JPEG format of the ISN marker location, taken during the hours of daylight.

Picture size: 1024 x 768 pixels (Landscape orientation only). See Figure 3 for a sample. File size – not more than 1MB

Red arrow with black trim, pointing vertically down at marker location.

Black box at the bottom left corner indicating the ISN marker number in white font. (Font : Arial; Bold : Yes; Size : 18)

The ISN marker must be referenced to 2 permanent structures, e.g. lamp posts, fire hydrants or electric boxes (to record all identification numbers). In the absence of such structures, the ISN marker is to be referenced to corner of buildings, walls, fences, gates, manholes and other suitable points. The reference distances (to 2 decimal places of a metre, font size:12) must be shown.

Indicator arrows specifications: dashed, with arrow heads at both ends, 1.5 point thickness.

- **GPS Station Location Sketch** – see Appendix D.
- **Submission Of ISN GPS Observation form** – see Appendix E. Any ISN markers that are lost are to be mentioned here, under the “Other Remarks” section.
- **GPS Processing Reports** (Network Adjustment Report, Baseline Report), including processing parameters (e.g. information of GPS data used in the processing), Adjustment and Statistical Testing Reports.
- Results of consistency check or data verifications. (e.g. agreement between repeated baselines).
- **Observation Data (RINEX format)** for the ISN point surveyed, clearly labelled, with the antenna height shown – see Appendix F.
- **XML file (*.hcp)** containing final SVY21 coordinates and other information of the ISN point. A HTML tool is provided by SLA to generate the XML file to be submitted. The HTML tool can be downloaded from SLA’s website (<http://www.sla.gov.sg>): Circulars -> Land Survey -> Chief Surveyor Directive, Services, Guidelines and Specifications -> HTML Tool for ISN Markers Submission. The HTML tool and the XML files are described below in Figure 1 and Figure 2.
- Any other report and information deemed necessary by SLA.

Horizontal Control Point(HCP) Data Creation Form

SLA SINGAPORE LAND AUTHORITY

HCP Number (e.g. 14652): 13936 File Name (e.g. 14652.hcp): 13936.hcp

Northing (e.g. 30576.862): 38888.888 Easting (e.g. 6606.902): 38888.888

Ellipsoidal Height (e.g. 12.654): 12.345 Location (max 250 characters): Tai Hwan Heights (LP 2 & LP 4)

Registered Surveyor (max 50 characters): Tan Ah Teck

Authorized Assistant (max 50 characters): Lim Ah Beng

Date of Survey : 8 January 2005

Description of HCP : Cross Screw

Output File Path (e.g. C:\HCP\): X:\Coord_Cada\HCP_Data_Creation_f

Remarks (max 500 characters):

Create HCP Clear Form Help

Figure 1: HTML Tool for XML file creation

Surveyors need to key in all values in the form shown above and then click on the “Create HCP” button to generate the XML file (*.hcp), which can be viewed using NotePad or other text viewers. For help, please click “Help” button at the bottom of the form.

```
<?xml version="1.0" ?>
<ControlPoint>
<CP_NUMBER>17001</CP_NUMBER>
<NORTHING>30576.862</NORTHING>
<EASTING>6606.902</EASTING>
<EHEIGHT>12.654</EHEIGHT>
<SURVEYOR>Peter Tan</SURVEYOR>
<ASSTSURVEYOR>John Lee</ASSTSURVEYOR>
<DATE_OF_SURVEY>13/04/2005</DATE_OF_SURVEY>
<LOCATION>Geylang East Avenue 2 (LP 14)</LOCATION>
<DESC_CP>Nail</DESC_CP>
<REMARKS></REMARKS>
</ControlPoint>
```

Figure 2: XML File (.hcp) generated

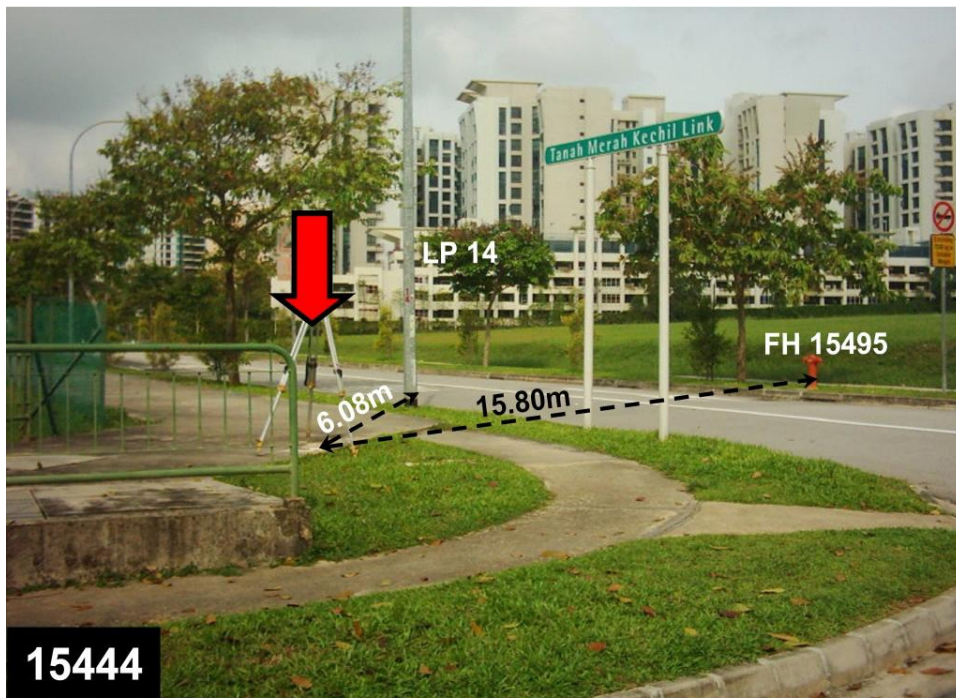


Figure 3: Colour digital photograph of ISN Marker in JPEG format

10. SiReNT Reference Station Data Support

There are currently 6 permanent GPS reference stations in SiReNT. The SiReNT reference station coverage is shown in Figure 4.

(a) Data Availability

- The reference station data are available in RINEX 2.11 format or compact RINEX (HATANAKA) format.
- Data rate – 1, 5, 10 and 15 seconds.
- Data from the SiReNT reference stations can be obtained through Post Processing On-Demand service of SiReNT. Upon signing up, users would be issued UserID and Password to download RINEX files from SiReNT website at <http://www.sirent.sla.gov.sg>. Users can specify the date, time and data rate of RINEX files to be purchased.
- RINEX data of 1-year-old from date of request is available for download from SiReNT website.

(b) Operational Status of SiReNT

- The operational status of the reference stations will be available on the Internet.

(c) Quality and Data Gaps

Effort will be made to ensure smooth operation of the reference stations. SLA is not liable for any claims whatsoever arising from data errors or missing data.

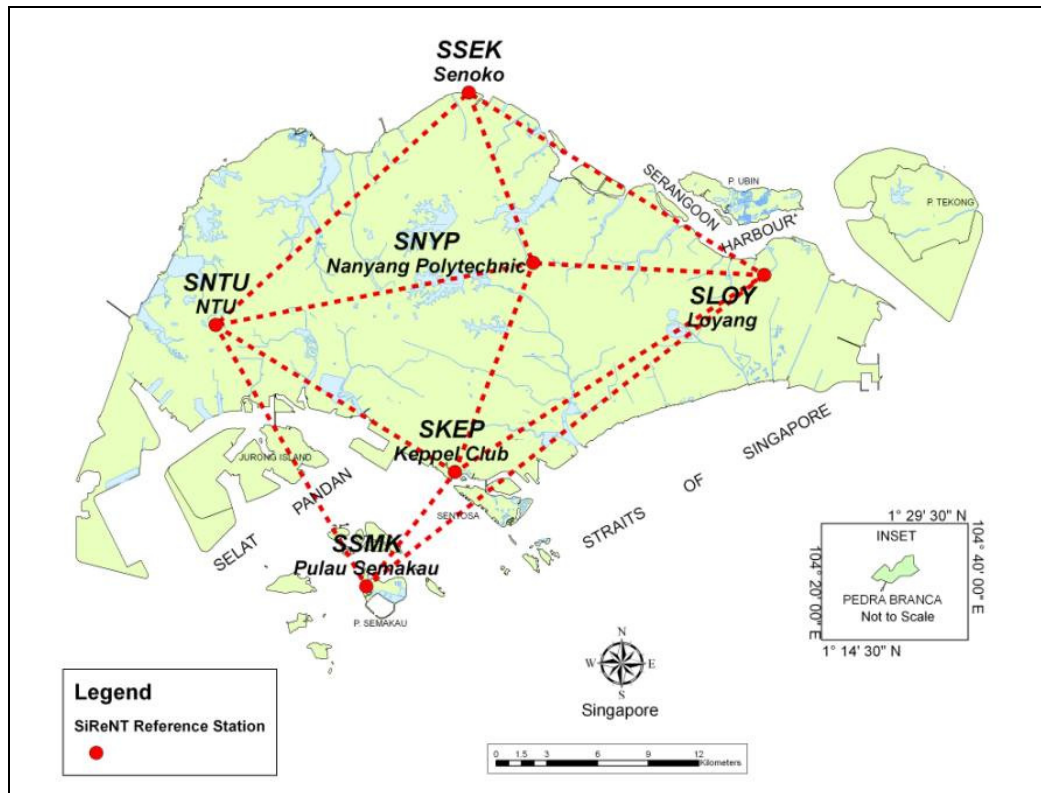


Figure 4: SiReNT reference station coverage

11. GPS Survey in the Absence of SiReNT

In the event that SiReNT is unavailable for whatever reasons, the following procedures must be adhered to when surveying the ISN markers.

- (a) The ISN marker survey will be carried out with reference to primary control marks.
- (b) At least 2 reference stations should be set up over any 2 primary control marks.
- (c) The 2 local reference stations should preferably not to be set up more than 10 km apart.
- (d) Each independent baseline should preferably not to be more than 6.5 km.

- (e) Receivers and antennae of different models and manufacturers may be used in the same survey provided that the measurement types can be combined during processing. However, the use of the same type of receivers and antennae on same survey is recommended in order to minimise antenna phase centre biases.
- (f) The rest of the guidelines for field procedures, GPS receiver and antenna, and GPS data processing apply as above.

12. GPS RTK Survey

Currently, only static GPS surveys using the Singapore Satellite Positioning Reference Network (SiReNT) is accepted by SLA for establishment of secondary control marks (or ISN markers/points) for cadastral surveys.

The use of RTK for engineering & Hydrographic surveys are covered by “LSB Directives On Engineering & Hydrographic Survey Practices”, issued by Land Surveyors Board Singapore. These Directives are available at URL: <http://www.minlaw.gov.sg/lb>.

GPS Test Certification

Version 2.4

Test Date : _____ / _____ / 20_____			
Observed By : _____			
Agency/Company : _____			
Pillar 7	Known Value	Survey Value	Difference
Northing	N. 38834.121		
Easting	E. 27135.303		
Ellipsoidal Height (measured from baseplate)	26.824m		

Receiver Type/Model : _____	
Receiver Serial No. : _____	
Receiver Firmware Version : _____	
Antenna Type/Model : _____	
with ground plane choke ring	<input type="checkbox"/> <input type="checkbox"/>
without ground plane with radome	<input type="checkbox"/> <input type="checkbox"/>
Antenna Serial No. : _____	

Certification:

I certify that the GPS gross error test was carried out by me or under my supervision at the Pillar 7, Lower Peirce Reservoir and the result of the test is acceptable within the limit set out in the "Guidelines and Specifications for GPS Surveys of ISN Markers". I will also adhere to the following procedures.

- Surveyors are required to suitably archive RINEX data of the observation recorded at the Pillar 7; the SiReNT reference station data used in the test; baseline processing report as well as the adjustment results of the baselines.
- The report and results of the test must be submitted to SLA upon request.

Signature

Date

Registered Surveyor : _____

GPS Test Certification

Version 2.4

Test Date : 9 / 12 / 2004
Observed By : Jimmy Tan Chwee Hock
Agency/Company : Singapore Land Authority

Pillar 7	Known Value	Survey Value	Difference
Northing	N. 38834.121	N. 38834.129	+0.008
Easting	E. 27135.303	E. 27135.300	-0.003
Ellipsoidal Height (measured from baseplate)	26.824m	26.824m	0.000

Receiver Type/Model : Trimble 5700
Receiver Serial No. : 0220188888
Receiver Firmware Version : 1.24
Antenna Type/Model : Zephyr
with ground plane ☐ without ground plane ☒
choke ring ☐ with radome ☐
Antenna Serial No. : 11909888

Certification:

I certify that the GPS gross error test was carried out by me or under my supervision at the Pillar 7, Lower Peirce Reservoir and the result of the test is acceptable within the limit set out in the "Guidelines and Specifications for GPS Surveys of ISN Markers". I will also adhere to the following procedures.

- Surveyors are required to suitably archive RINEX data of the observation recorded at the Pillar 7; the SiReNT reference station data used in the test; baseline processing report as well as the adjustment results of the baselines.
- The report and results of the test must be submitted to SLA upon request.



9.12.2004

Signature

Date

Registered Surveyor : Chan Fook Onn

GPS Station Obstruction Diagram

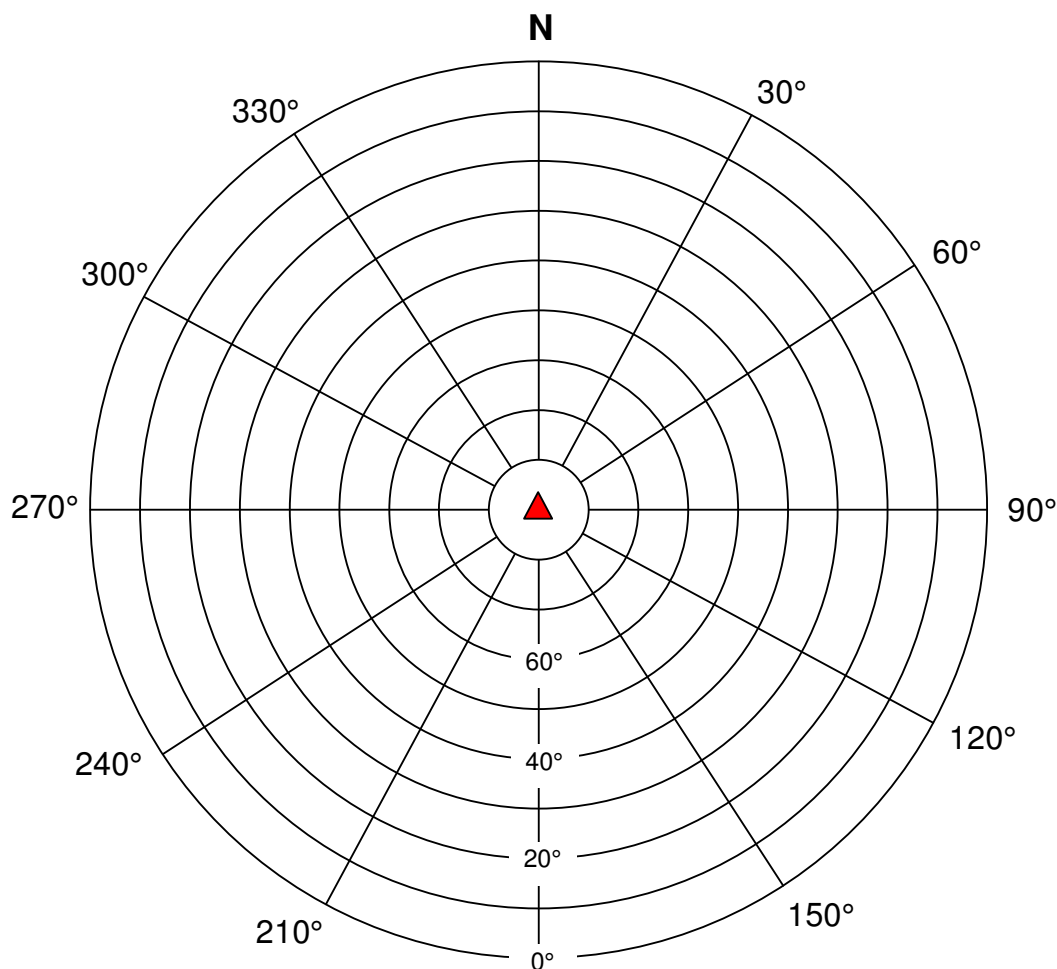
Version 2.4

Date : _____ Sketched By : _____

Station Name/No. : _____ JPEG File : _____

Station Location : _____

Sky Plot / Zenith Plot



Note:

- * Identify obstructions and their elevation angle as seen from the station mark.
- * If possible, indicate the distance to any metallic structure or reflective surface.

GPS Station Obstruction Diagram

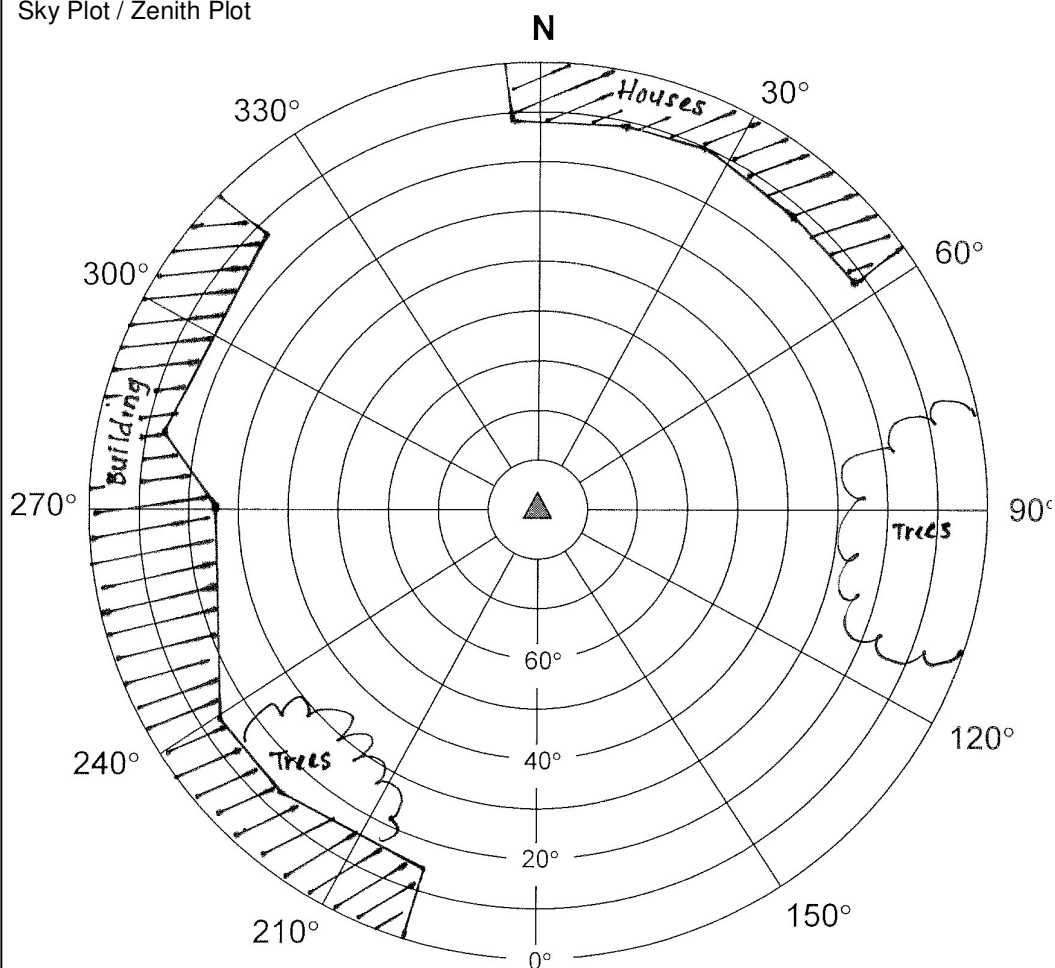
Version 2.4

Date : 9/12/2004 Sketched By : Jimmy Tan Chwee Hock

Station Name/No. : 14980 JPEG File : Yes

Station Location : Harvey Crescent

Sky Plot / Zenith Plot



Note:

- * Identify obstructions and their elevation angle as seen from the station mark.
- * If possible, indicate the distance to any metallic structure or reflective surface.

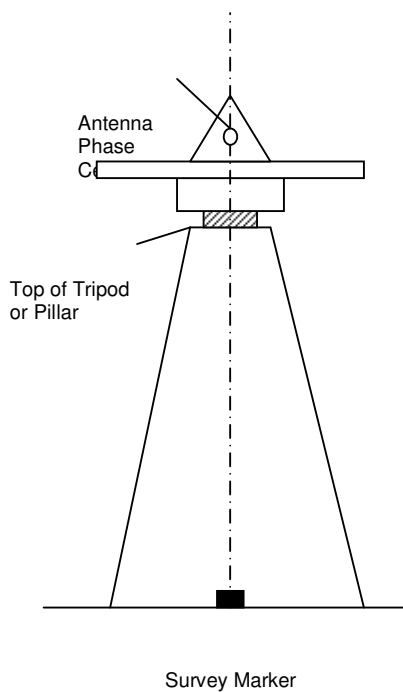
GPS Station Observation Log

Version 2.4

Date :	____ / ____ / 20____	Surveyed By :	_____
Station ID/No. :	_____	Monument Type :	_____
Station Location :	_____		
Weather Condition :	_____	Agency :	_____
RINEX File :	_____	JPEG File:	_____ Yes <input type="checkbox"/> No <input type="checkbox"/>

Receiver Type/Model :	_____				
Receiver Serial No :	_____				
Receiver Firmware Version :	_____				
Antenna Type/Model :	_____				
	with ground plane	<input type="checkbox"/>	without ground plane	<input type="checkbox"/>	
	choke ring	<input type="checkbox"/>	with radome	<input type="checkbox"/>	
Data Rate :	1 sec <input type="checkbox"/>	5 sec <input type="checkbox"/>	10 sec <input type="checkbox"/>	15 sec <input type="checkbox"/>	30 sec <input type="checkbox"/>

Show on sketch measurements taken to derive the antenna height. If slant measurements are taken, make measurement on two opposite sides of the antenna. Make measurements before and after observing session.



Session 1

Start Time: _____
End Time: _____

Instrument Height:
Before _____ m
After _____ m
Mean _____ m

Measure To: _____

Session 2

Start Time: _____
End Time: _____

Instrument Height:
Before _____ m
After _____ m
Mean _____ m

Measure To: _____

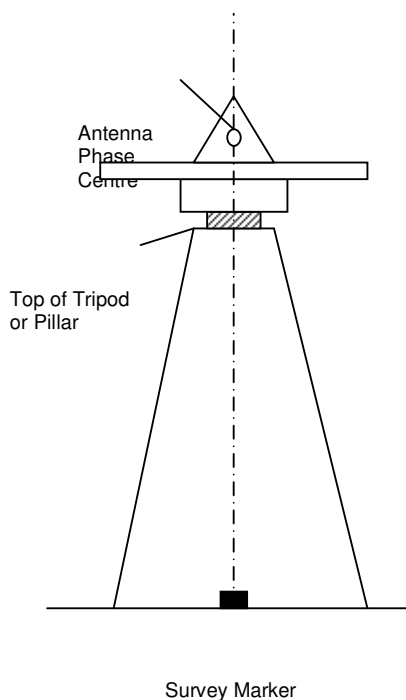
GPS Station Observation Log

Version 2.4

Date :	<u>9 / 12/ 2004</u>	Surveyed By :	<u>Jimmy Tan Chwee Hock</u>
Station ID/No. :	<u>14351</u>	Monument Type :	<u>Cross screw</u>
Station Location :	<u>Harvey Crescent (LP 9 & LP 24)</u>		
Weather Condition :	<u>Clear</u>	Agency :	<u>Singapore Land Authority</u>
RINEX File :	<u>71182640/71182641</u>	JPEG File:	<u>Yes <input checked="" type="checkbox"/> No <input type="checkbox"/></u>

Receiver Type/Model :	<u>Trimble 5700</u>		
Receiver Model No.	<u>022017118</u>		
Receiver Firmware Version :	<u>1.22</u>		
Antenna Type/Model :	<u>Zephyr</u>		
	with ground plane choke ring	<input type="checkbox"/>	without ground plane with radome
		<input type="checkbox"/>	<input checked="" type="checkbox"/>
Data Rate :	1 sec <input type="checkbox"/>	5 sec <input type="checkbox"/>	10 sec <input type="checkbox"/>
			15 sec <input checked="" type="checkbox"/>
			30 sec <input type="checkbox"/>

Show on sketch measurements taken to derive the antenna height. If slant measurements are taken, make measurement on two opposite sides of the antenna. Make measurements before and after observing session.



Session 1

Start Time:	<u>11.01 am</u>
End Time:	<u>12.02 pm</u>
Instrument Height:	
Before	<u>1.606</u> m
After	<u>1.606</u> m
Mean	<u>1.606</u> m

Measure To: Top of notch

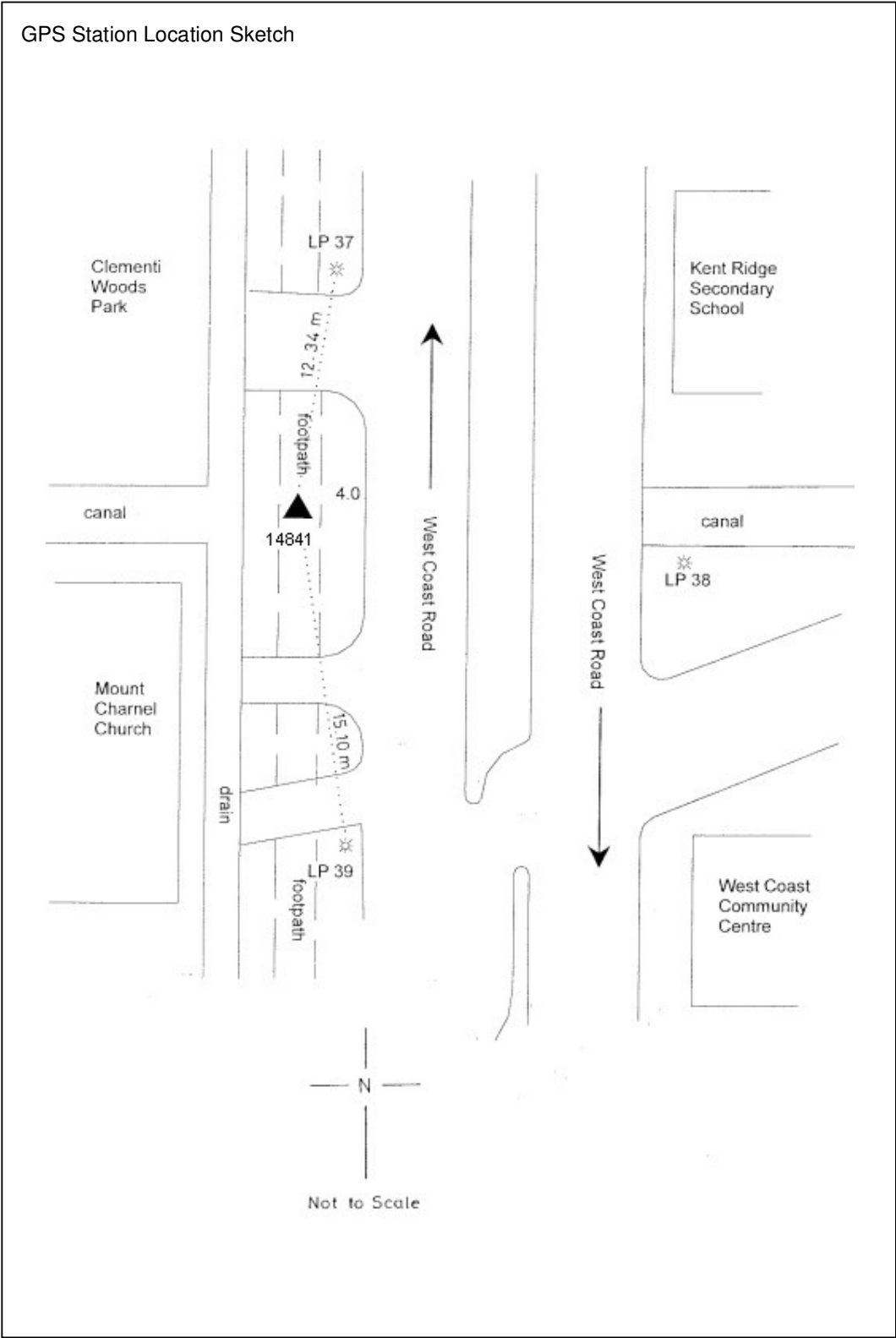
Session 2

Start Time:	<u>12.08 pm</u>
End Time:	<u>1.09 pm</u>
Instrument Height:	
Before	<u>1.638</u> m
After	<u>1.638</u> m
Mean	<u>1.638</u> m

Measure To: Top of notch

Version 2.4

GPS Station Location Sketch



Submission of ISN GPS Observation

This form may take you 10 minutes to fill in.

ISN Marker No. :

Documents submitted

Document Type	File Name
GPS Test Certification (Gross Error Test)	
Zero Base Line Test Certification	
GPS Station Obstruction Diagram	
GPS Station Observation Log	
GPS Station Location Sketch	
Digital Photograph of ISN Marker in Jpeg format	
GPS Processing Report (Adjustment and Statistical)	
Observation Data (RINEX format)	
Horizontal Control Point (HCP) Data (XML file)	

Other Remarks (also to mention any ISN markers that are lost)

Certification by Registered Surveyor

I certify that the above-mentioned ISN mark has been established on ground under my immediate supervision.

Signature:
(Digitally signed)

Registered Surveyor's Name:

Date (dd/mm/yyyy):

For Official Use

Accepted ☐ / Rejected ☐ by:

Name:

Date (dd/mm/yyyy):

Submission of ISN GPS Observation

ISN Marker No. :	16902
------------------	-------

Documents submitted	
Document Type	File Name
GPS Test Certification (Gross Error Test)	GET_Trimble R6 Model 2_2009
Zero Base Line Test Certification	ZBT_Trimble R6 Model 2_2009
GPS Station Obstruction Diagram	16902_Obstruction Diagram
GPS Station Observation Log	16902_Observation Log
GPS Station Location Sketch	16902_Location Sketch
Digital Photograph of ISN Marker in Jpeg format	16902_Original, 17888_Edited
GPS Processing Report (Adjustment and Statistical)	16902_Network Adjustment Report, 16902_Baseline Report_B1, 16902_Baseline Report_B2, 16902_Baseline Report_B3, 16902_Baseline Report_B4.
Observation Data (RINEX format)	75112160.08n, 75112160.08o, 75112161.08n, 7511216.08o
Horizontal Control Point (HCP) Data (XML file)	16902_HCP

Other Remarks (also to mention any ISN markers that are lost)

(a) I confirm that ISN marker 01495 is lost .

(b) No photography allowed as site is within a restricted area.

Certification by Registered Surveyor

I certify that the above-mentioned ISN mark has been established on ground under my immediate supervision.

Signature:
(Digitally signed)

Registered Surveyor's Name: Teo Kee Hock

Date (dd/mm/yyyy): 15/03/2010

For Official Use

Accepted ☐ / Rejected ☐ by:

Name: _____ Date (dd/mm/yyyy): _____

Sample RINEX Observation file

```

2.11      OBSERVATION DATA  G (GPS)      RINEX VERSION / TYPE
DAT2RINW 3.10 001  Lin Fen      20MAR09 16:24:43  PGM / RUN BY / DATE
Neo Pek      E K Tan Survey Consultants      OBSERVER / AGENCY
220167511    TRIMBLE 4800      Nav 1.20 Sig 1.43  REC # / TYPE / VERS
20167511      TRM41249.00      ANT # / TYPE

----- COMMENT
Offset from BOTTOM OF ANTENNA to PHASE CENTER is 53.3 mm  COMMENT
----- COMMENT
16902      MARKER NAME
16902      MARKER NUMBER
-1522591.0489 6191796.3786 155253.8494      APPROX POSITION XYZ
1.3886      0.0000      0.0000      ANTENNA: DELTA H/E/N
*** Above antenna height is from mark to BOTTOM OF ANTENNA. COMMENT
----- COMMENT
Note: The above offsets are CORRECTED.      COMMENT
Raw Offsets: H= 1.4430 E= 0.0000 N= 0.0000  COMMENT
----- COMMENT
1 1 0      WAVELENGTH FACT L1/2
4 L1 C1 L2 P2      # / TYPES OF OBSERV
15.000      INTERVAL
2008 8 5 15 36 30.0000000      TIME OF FIRST OBS
2008 8 5 17 7 15.0000000      TIME OF LAST OBS
0      RCV CLOCK OFFS APPL
8      # OF SATELLITES
2 146 146 91 91      PRN / # OF OBS
4 38 38 0 0      PRN / # OF OBS
10 364 364 364 364      PRN / # OF OBS
12 13 13 0 0      PRN / # OF OBS
15 98 98 98 98      PRN / # OF OBS

```

Sample RINEX Navigation File

```

2.11      NAVIGATION DATA  G (GPS)      RINEX VERSION / TYPE
DAT2RINW 3.10 001  Lin Fen      20MAR09 16:24:43  PGM / RUN BY / DATE
----- COMMENT
.4657D-08 .1490D-07 -.5960D-07 -.5960D-07      ION ALPHA
.7782D+05 .4915D+05 -.6554D+05 -.3277D+06      ION BETA
.000000000000D+00 -.177635683940D-14 405504 1491 DELTA-UTC: A0,A1,T,W
14      LEAP SECONDS
END OF HEADER
2 08 8 5 18 0 0.0 .197017099708D-03 -.272848410532D-11 .000000000000D+00
.990000000000D+02 .658437500000D+02 .499592234249D-08 -.717582557988D+00
.351667404175D-05 .874014792498D-02 .611506402493D-05 .515375755310D+04
.237600000000D+06 -.119209289551D-06 -.142533271775D+01 -.221654772758D-06
.942568695370D+00 .256687500000D+03 .261956133522D+01 -.841035063814D-08
.241081460350D-09 .100000000000D+01 .149100000000D+04 .000000000000D+00
.340000000000D+01 .000000000000D+00 -.172294676304D-07 .990000000000D+02
.231318000000D+06 .400000000000D+01
4 08 8 5 18 0 0.0 -.134478323162D-03 -.103455022327D-10 .000000000000D+00
.450000000000D+02 .661875000000D+02 .502699526450D-08 .203180806665D+01
.341981649399D-05 .820281670894D-02 .629946589470D-05 .515356496429D+04
.237600000000D+06 -.149011611938D-06 -.140655535814D+01 .353902578354D-07
.941856700455D+00 .253125000000D+03 .384409765078D+00 -.840642133682D-08
.122147944537D-09 .100000000000D+01 .149100000000D+04 .000000000000D+00
.240000000000D+01 .000000000000D+00 -.605359673500D-08 .450000000000D+02
.231006000000D+06 .400000000000D+01

```

Sample of an Integrated Survey Network (ISN) marker



N 1° 20' 57"
E 103° 50' 26"

Customer's Name	: Singapore Land Authority
Contact Person	: Mr. Wong Poh Weng
Project / Site / Office	: Office
Make / Model	: Trimble R8
Serial No.	: 4526152678
Report No.	: GPS – 4526152678
Date of Zero Base Test	: 8 March 2010
Next Zero Base Test Due	: 7 March 2011

Baseline Summary For Zero Base Line Test

Baseline Summary B1 (Base to Rover)

Processed:	Wednesday, Mar 10, 2010 09:37:13AM
Solution type:	L1 fixed
Solution acceptability:	Solution acceptable
Ephemeris used:	Broadcast
Met Data:	Standard
Baseline slope distance:	0.000m
Elevation mask:	15 degrees
Variance ratio:	15.5
Reference variance:	0.245
RMS:	0.002m
Horizontal Precision 1-sigma (scaled):	0.000m
Vertical Precision 1-sigma (scaled):	0.000m
Start time (GPS Time):	10/03/08, 07:00:00.000 1574, 111600.000
Stop time (GPS Time):	10/03/08, 07:59:59.000 1574, 115199.000
Occupation time:	00:59:59.000