SINGAPORE
LAND AUTHORITY

Specifications for GNSS Surveys of ISN Markers

Version 2.6

October 2026

SINGAPORE LAND AUTHORITY
SURVEY AND GEOMATICS DIVISION
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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	Update SLA's address and change "Survey Services" to "Land Survey Division". Change "Survey Services" to "Land Survey Division" where applicable. Addition of heading for RTK surveys (item 12). Amend item 4(a) Item (6) – addition of 6 new paragraphs. Amend item (9). Addition of item (12) on RTK surveys. Figure 2: **XML File (.hcp) generated** – 14652 changed to 17001, <LONGITUDE> and <LATITUDE> deleted. "Cross Screw" changed to "Nail" Figure 4 – New photograph inserted and includes the location of the sixth SiReNT reference station at SSMK. Addition of Appendices D, E, F, G & H.
Version 2.5	April 2021	Change document title to "Specifications for GNSS Surveys of ISN Markers". Replace "GPS" with "GNSS" for the whole document. Clarify item (2) by adding additional sentence – "These criteria are applicable to the result of the Gross Error Test at Pillar 7". Consequential changes resulting from the cessation of GNSS job submissions via CORENET on 7 Sep 2018 vide CS Circular 4/2018 and the launch of RS Portal for job submissions on 17 Sep 2018. Adding Registered Surveyors in the Zero Baseline Test.

Version 2.6	October 2026	Update SLA address, change from LEVEL 10 to LEVEL 14. Amend Item (6) – Update RS Portal and SiReNT URL Website References. Clarify Item 7(c) by rephrasing “Observation rate – 15 seconds minimum” to “Data Interval shall be between 1 and 15 seconds (inclusive)”. Addition of Item 7(d) under existing header “GNSS Observation Session”. Amend Item 7(d) and 7(e) – Update to 7(e) and 7(f) respectively. Amend Item (9) – Update RS Portal URL Website Reference. Amend Item 10(a) – Update SiReNT URL Website Reference. Amend Item 10(b) – Update SiReNT Sensor Map. Amend Item 12 – Update Land Surveyors Board URL Website Reference. Amend Appendix E – Update of Sample Zero Baseline Test Certificate. Addition of Appendices G & H.

Specifications for GNSS Surveys of ISN Markers

1. Introduction

This document aims to provide specifications for static GNSS survey (hereinafter known as GNSS 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. The directive is available on the Singapore Land Authority website. URL: http://www.sla.gov.sg/.

These specifications 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. GNSS Data Processing
9. Report Submission and Data Format
10. SiReNT Reference Station Data Support
11. GNSS Survey in the Absence of SiReNT
12. RTK Surveys

These specifications are subject to review as GNSS technology is continually evolving with advancements in technologies and techniques. Please note that these specifications 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 specifications 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 specifications are strictly adhered to when carrying out the GNSS Survey of ISN markers, unless otherwise instructed by the Chief Surveyor, Survey & Geomatics 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 Ellipsoidal Height. These criteria are applicable to the result of the Gross Error Test at Pillar 7.

3. Equipment

GNSS 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) GNSS receiver and antenna

- Zero baseline test

- The GNSS 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 GNSS equipment vendor or the authorised dealers or Registered Surveyors. The northing, easting and the height components of the zero-baseline should all be less than 1 mm. See sample page at Appendix E. (Note: The full Zero Baseline Test certification, which may contain more than one page, must be submitted for each ISN job submission.)

- GNSS Gross Error Test

A gross error test is to be adopted for GNSS 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 tosubmit the report and results of the test to SLA. However, the results must be submitted to SLA upon request. Registered Surveyors need to certify thatthe test was carried out appropriately and submit this certification to SLA witheach ISN job submission. The GNSS test certification is attached in Appendix A.

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

The coordinates of 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 to.
- The adjusted Northing and Easting of Pillar 7 must be within 20 mm on each direction of the fixed coordinates N.38834.121 and E.27135.303.
- Adjusted Ellipsoidal Height of Pillar 7 must be within 60 mm of 26.824 m.

Surveyors are required to suitably archive RINEX data of the observation recorded at Pillar 7; the SiReNT reference station data used in the test; the baseline processing report as well as the adjustment results of the baselines. Surveyors are required to book their calibration date online at SLA's Baseline Calibration Management System (BCMS) website to use Pillar 7.
The Surveyor may use the "GNSS Station Observation Log" to record each observation - see Appendix C.

(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. GNSS 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 GNSS 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 surfaces 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 GNSS equipment.
- The Registered Surveyor must state all lost markers when submitting the newly installed marker in RS Portal (https://app.sla.gov.sg/rsp/)
- New ISN markers for installation by Registered Surveyors can be requested from Survey & Geomatics Division, SLA, through RS Portal (https://app.sla.gov.sg/rsp/)
- Registered Surveyors requesting new ISN markers must have valid SiReNT Post Processing On-Demand accounts. SiReNT website: https://app.sla.gov.sg/sirent/.
- Photograph of ISN marker currently in use is shown in Appendix F.

7. Field Procedures

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

(a) GNSS 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) GNSS Observation Setting
Elevation mask – minimum 15 degrees
Data Interval shall be between 1 and 15 seconds (inclusive).

(d) GNSS Observation Session

- Two independent observation sessions are needed to determine the coordinates of each ISN control point. For each session, the GNSS 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 conditions.

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) GNSS Antenna Set Up

- GNSS 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 GNSS Station Observation Log (Appendix C).
- Antenna height must be measured once before and after each survey and/or each physical reset of the GNSS antenna.

(f) GNSS Station Observation Log

- The field officer must fill up a proper observation log. The log is not required to be submitted, unless requested by SLA (Appendix C).

8. GNSS Data Processing

GNSS data processing involves baselines processing and adjustment. The details are as follows:

(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 GNSS Service for Geodynamics (IGS) web site.
- Each ISN point must be connected to at least two SiReNT reference stations.
- Each of the connections 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 0.020 m and Ellipsoidal Height error less than 0.040 m, for the newly installed ISN marker.
- 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 GNSS survey report of newly installed ISN marker in the RS Portal (https://app.sla.gov.sg/rsp/).

(a) Submission of the GNSS survey must include:

- **GNSS Test Certification** – for test at Pillar 7. See Appendix A.
- **Zero Base Line Test Certification** – see specimen at Appendix E.
- **GNSS Station Obstruction Diagram** – see Appendix B.
- **GNSS Station Observation Log** – This form has been digitalised as an online version in RS Portal. Surveyors are required to key in their data (e.g. instrument heights, date, start time/end time) in the relevant fields provided. Appendix C shows the hardcopy version.
- **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 1 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. See Figure 1.

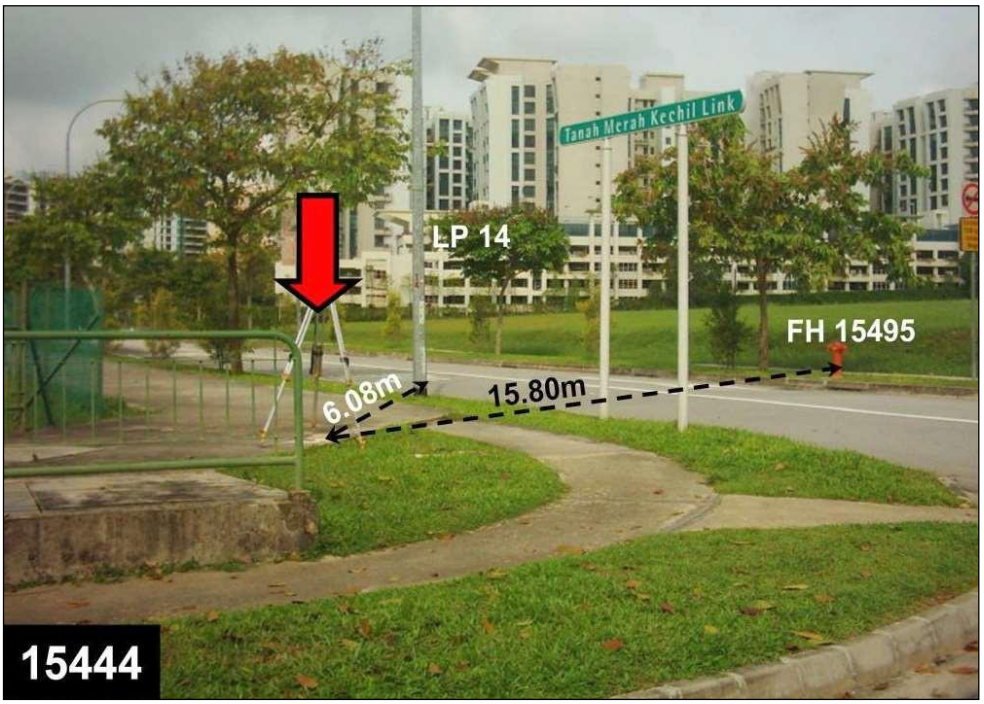
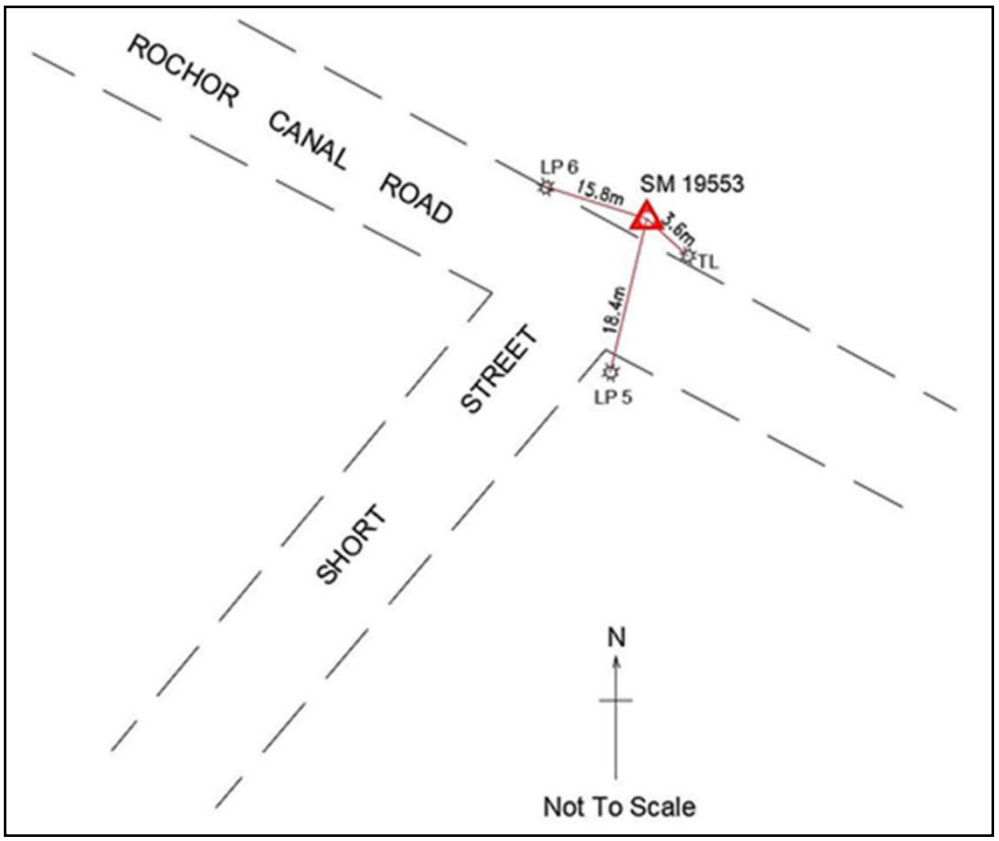


Figure 1: Colour digital photograph of ISN Marker in JPEG format

- **GNSS Station Location Sketch** – Size: 1024 x 768 pixels (Landscape orientation only). The sketch should not have any borders. The North Point should be shown. See Figure 2.

Figure 2: GNSS Station Location Sketch



- **GNSS Processing Reports** (Network Adjustment Report – See Appendix G, Baseline Report – See Appendix H), including processing parameters (e.g. information of GNSS 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 D.
- **LandXML file** containing final SVY21 coordinates and other information of the new ISN point. The file shall follow the SG LandXML mapping and structure published in SLA website. URL: http://www.sla.gov.sg/. See Figure 3 for **LandXML file** sample.

TAS-SVY3584-2019-HC001.xml

```
<?xml version="1.0" encoding="utf-8"?>
<LandXML xmlns="http://www.landxml.org/schema/LandXML-1.2" version="1.4.0" date="2018-11-20" time="14:50:24" xmlns:x
    <Units>
        <Metric linearUnit="meter" temperatureUnit="celsius" volumeUnit="cubicMeter" areaUnit="squareMeter" pressure
    </Units>
    <CoordinateSystem datum="SVY21" horizontalDatum="SVY21" verticalDatum="SHD" />
    <Application name="ISN Marker(Beta)" version="v2018.0.0(Beta)" manufacturer="GNSS Lands (Singapore) Pte Ltd" manuf
<CgPoints>
    <CgPoint name="1" desc="final" code="L01" latitude="1.213414007" longitude="103.592633518" ellipsoidHeight="16.9
</CgPoints>
<Monuments>
    <Monument name="SM19888" pntRef="1" type="NL" state="new" featureRef="1" desc="CHANGI ROAD (NEAR LP 100)"/>
    <Feature name="1">
        <Property label="Remarks" value="SM18559 is lost"/>
    </Feature>
</Monuments>
<Survey>
    <SurveyHeader name="3584-2019" jurisdiction="Singapore" surveyorFirm="TAN AH SENG REGISTERED SURVEYOR PTE. LTD.">
        <Personnel role="Surveyor" name="TAN AH SENG />
        <Personnel role="Authorised Assistant" name="LIM AH BENG" />
        <AdministrativeDate adminDateType="Commenced" adminDate="2018-10-10" />
        <AdministrativeDate adminDateType="Completed" adminDate="2018-10-10" />
    </SurveyHeader>
</Survey>
    <FeatureDictionary name="SGReferenceDataContext" version="1">
        <DocFileRef name="xml-gov-sg-sglx-referencedata-1.0.xml" location="http://www.sla.gov.sg/Portals/0/SurveySer
    </FeatureDictionary>
</LandXML>
```

Figure 3: LandXML file illustration

- Any other report and information deemed necessary by SLA.

10. SiReNT Reference Station Data Support

There are currently 9 permanent GNSS 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 2.10, 2.11 and 3.02 format.
- Data rate – 1, 5, 10, 15, 30 and 60 seconds.
- Data from the SiReNT reference stations can be obtained through Post Processing On-Demand service. Upon signing up, users will be able log in using their CorpPass or SingPass to download RINEX files from the SiReNT website at https://app.sla.gov.sg/sirent/.
- 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.

(b) Operational Status of SiReNT

- The operational status of all the reference stations are shown in a Sensor Map. See Figure 4.
-

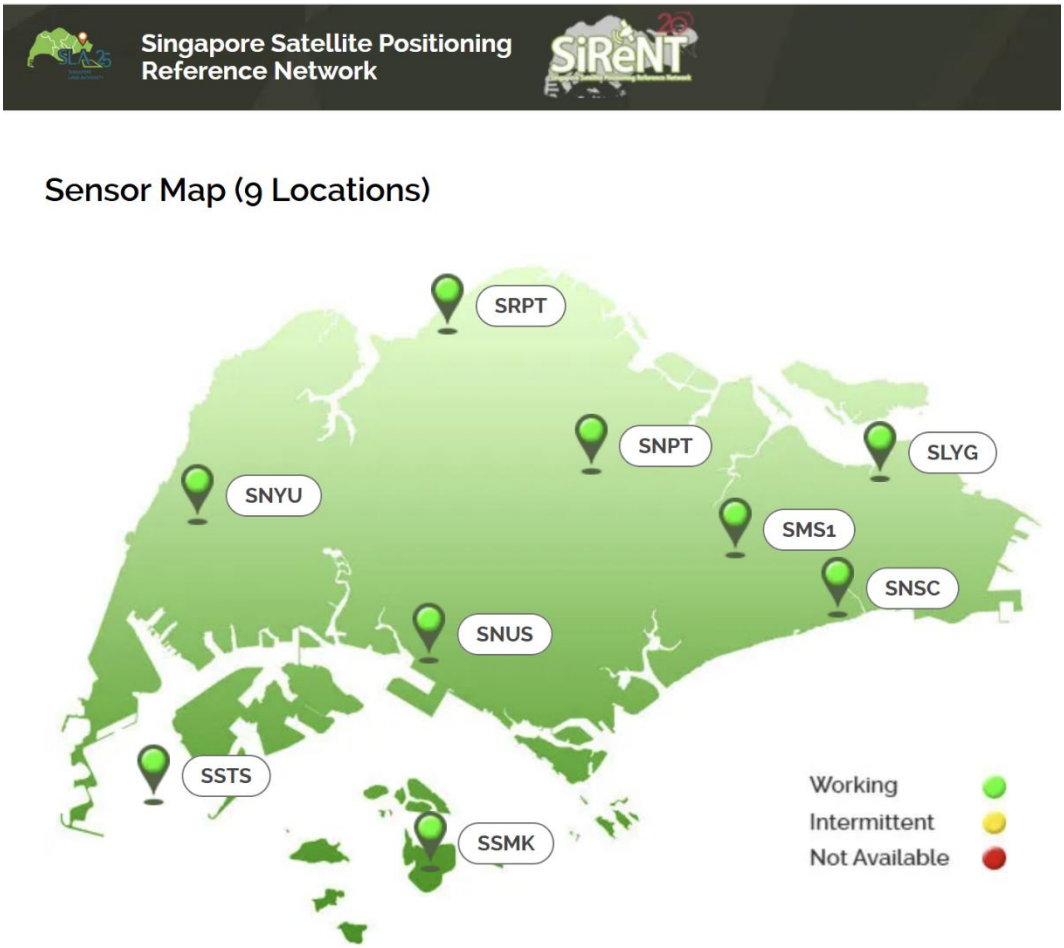


Figure 4: SiReNT reference station coverage

(c) Quality and Data Gaps

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

11. GNSS 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, GNSS receiver and antenna, and GNSS data processing apply as above.

12. GNSS RTK Survey

Currently, only static GNSS 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: https://lsb.mlaw.gov.sg/.

Appendix A

GNSS Test Certification

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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 ☐ without ground plane ☐

choke ring ☐ with radome ☐

Antenna Serial No. : _____

Certification:

I certify that the GNSS 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 "Specifications for GNSS 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 :_____

GNSS Test Certification

Version 2.6

Test Date : 9 / 12 / 2026

Observed By : SAMPLE OBSERVER

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 GNSS 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 "Specifications for GNSS 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 (SAMPLE) 9.12.2006

Signature Date

Registered Surveyor : SAMPLE REGISTERED SURVEYOR

Appendix B

GNSS Station Obstruction Diagram

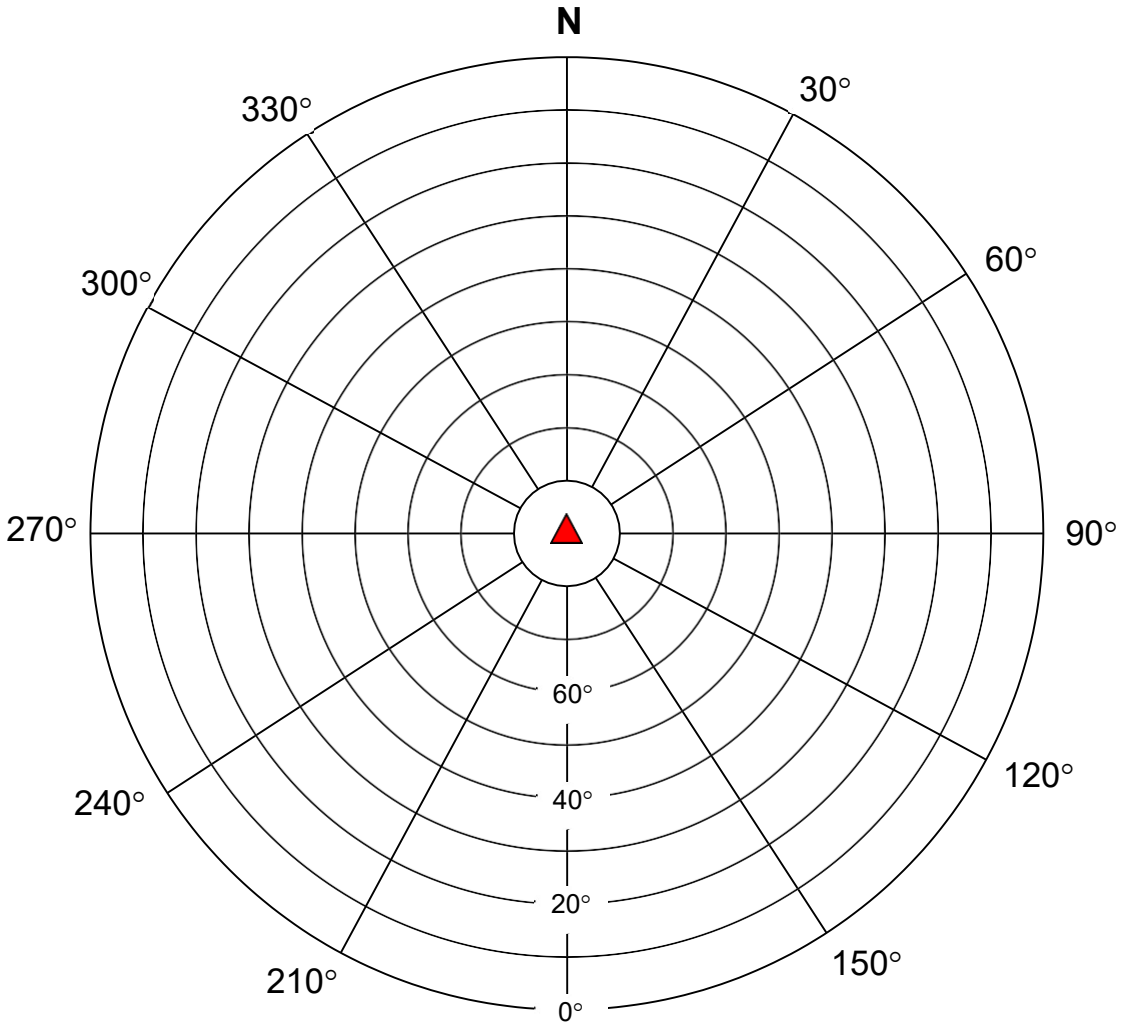
Version 2.6

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.

Appendix B (Sample)

GNSS Station Obstruction Diagram

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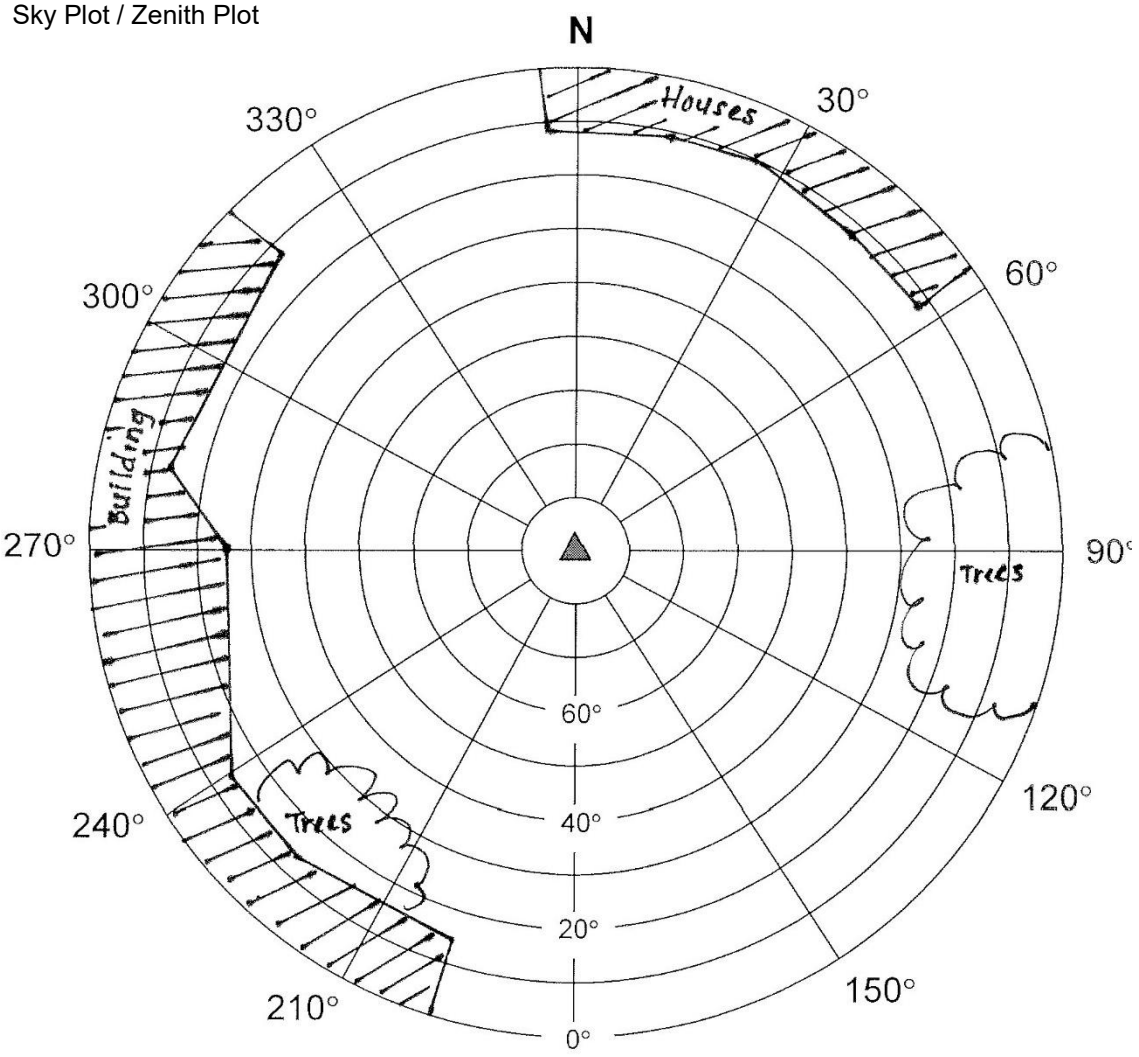
Date : 9/12/2026 Sketched By : SAMPLE OBSERVER

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.

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Appendix C

GNSS Station Observation Log

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Date : ___/___/ 20___ Surveyed By : _____

Station ID/No. : _____ Monument Type : _____

Station Location : _____

Weather Condition : _____ Agency : _____

RINEX File : _____ JPEG File: _____ Yes ☐ No ☐

Receiver Type/Model : _____

Receiver Serial No : _____

Receiver Firmware Version : _____

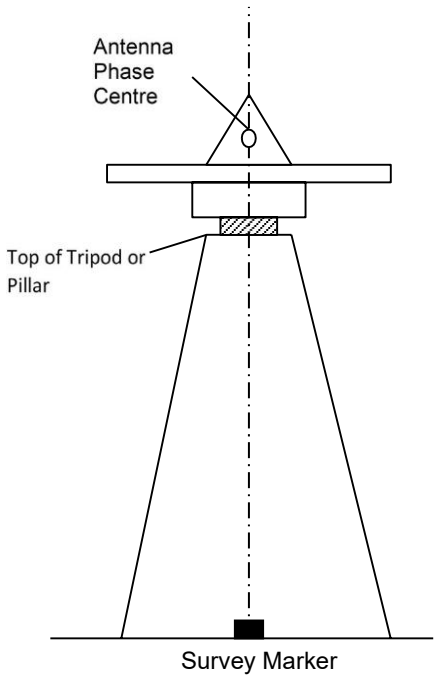
Antenna Type/Model : _____

with ground plane ☐ without ground plane ☐

choke ring ☐ with radome ☐

Data Rate : 1 sec ☐ 5 sec ☐ 10 sec ☐ 15 sec ☐ 30 sec ☐

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: _____

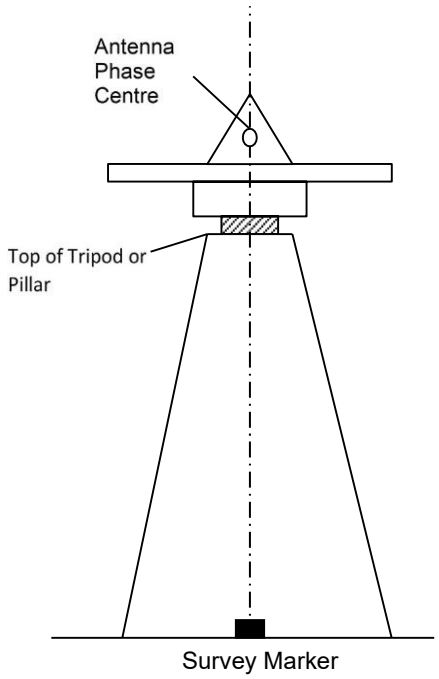
GNSS Station Observation Log

Version 2.6

Date :	9 /12 / 2026	Surveyed By :	SAMPLE OBSERVER
Station ID/No. :	14351	Monument Type :	Cross screw
Station Location :	Harvey Crescent (LP 9 & LP 24)		
Weather Condition :	Clear	Agency :	Singapore Land Authority
RINEX File :	71182640/71182641	JPEG File:	Yes ☒ No ☐

Receiver Type/Model :	Trimble5700		
Receiver Serial No :	022017118		
Receiver Firmware Version :	1.22		
Antenna Type/Model :	Zephyr		
	with ground plane ☐	without ground plane ☒	
	choke ring ☐	with radome ☐	
Data Rate :	1 sec ☐	5 sec ☐	10 sec ☐ 15 sec ☒ 30 sec ☐

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:	11.01 am	
End Time:	12.02 pm	
Instrument Height:		
Before	1.606	m
After	1.606	m
Mean	1.606	m
Measure To:	Top of notch	

Session 2

Start Time:	12.08 pm	
End Time:	1.09 pm	
Instrument Height:		
Before	1.638	m
After	1.638	m
Mean	1.638	m
Measure To:	Top of notch	

Sample RINEX Observation File

```
     2.11           OBSERVATION DATA    G (GPS)             RINEX VERSION / TYPE
DAT2RINW 3.10 001  SAMPLE OBSERVER    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  SAMPLE OBSERVER    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 Zero Base Line Test certificate

GK8G-6271-QC/OH
ISO 9001:2015
ISO 45001:2018

N 1° 20' 57"
E 103° 50' 26"

Customer's Name	: Singapore Land Authority
Contact Person	: Mr Chan
Project / Site / Office	: Office
Make / Model	: Trimble R10
Serial No.	: 5325438877
Report No.	: GPS – 5325438877
Date of Zero Base Test	: 03 September 2025
Next Zero Base Test Due	: 02 September 2026

Baseline Processing Report

Session Details

Rover - Base (10:48:31 am-11:59:41 am) (S2)

Baseline Observation:	Rover --- Base (B3)
Processed:	3/9/2025 4:17:49 pm
Solution Type:	Fixed
Frequency used:	Multiple Frequencies
Horizontal Precision:	0.001 m
Vertical Precision:	0.001 m
RMS:	0.003 m
Maximum PDOP:	0.947
Ephemeris used:	Broadcast
Antenna Model:	NGS Absolute
Processing Start Time:	3/9/2025 10:48:31 am (Local: UTC+8hr)
Processing Stop Time:	3/9/2025 11:52:44 am (Local: UTC+8hr)
Processing Duration:	01:04:13
Processing interval:	1 second

Vector Components (Mark to Mark)

From:	Base				
Grid		**Local**		**Global**	
Easting	28809.243 m	**Latitude**	N1°20'58.28510"	**Latitude**	N1°20'58.28510"
Northing	36848.985 m	**Longitude**	E103°50'26.12450"	**Longitude**	E103°50'26.12450"
Elevation	43.202 m	**Height**	52.988 m	**Height**	52.988 m
To:	Rover				
Grid		**Local**		**Global**	
Easting	28809.243 m	**Latitude**	N1°20'58.28510"	**Latitude**	N1°20'58.28510"
Northing	36848.985 m	**Longitude**	E103°50'26.12450"	**Longitude**	E103°50'26.12450"
Elevation	43.201 m	**Height**	52.987 m	**Height**	52.987 m

Vector:					
ΔEasting	0.000 m	**NS Fwd Azimuth**	188°53'26"	**ΔX**	0.001 m
ΔNorthing	0.000 m	**Ellipsoid Dist.**	0.000	**ΔY**	-0.001 m
ΔElevation	-0.001 m	**ΔHeight**	-0.001	**ΔZ**	0.000 m

Standard Errors

Vector Errors:					
σ ΔEasting	0.000 m	**σ□NS Fwd Azimuth**	52°15'43"	**σ ΔX**	0.000 m
σ ΔNorthing	0.000 m	**σ□Ellipsoid Dist.**	0.000 m	**σ ΔY**	0.001 m
σ ΔElevation	0.001 m	**σ ΔHeight**	0.001 m	**σ ΔZ**	0.000 m

Aposteriori Covariance Matrix (Meter^2)

	X	Y	Z
X	0.0000000499		
Y	-0.0000000274	0.0000002753	
Z	-0.0000000059	0.0000000161	0.0000000365

Occupations

	From	To
Point ID:	Base	Rover
Data File:	2509030200I.T02	88772460.T04
Receiver Type:	Alloy	R10
Receiver Serial Number:	6117R40094	5325438877
Antenna Type:	Zephyr Geodetic	Built In
Antenna Serial Number:	--------	--------
Antenna Height (Measured):	0.000 m	0.000 m
Antenna Method:	Bottom of antenna mount	Bottom of antenna mount

The above mention GPS Receiver passes the **Zero-Base-Line Test**.

Signature (SAMPLE)

SAMPLE AUTHORISED PERSON

Note: Zero-Base-Line Test is a test for the consistency of the precision of the GPS receiver. The quality of the resulting processed baseline should be not more than 1mm for the Horizontal and Vertical Component respectively.

Sample of an Integrated Survey Network (ISN) marker



Sample of Baseline Processing Report

Project file data		Coordinate System	
Name:	C:\Users\SLAISSSLA-L000763A\Desktop \TBC\ ABC_20365\SM_20365.vce	Name:	Singapore/SVY21
Size:	71 KB	Zone:	SVY 21
Modified:	15/10/2026 10:12:24 am (UTC:8)	Datum:	WGS 1984
Time zone:	Malay Peninsula Standard Time	Global reference datum:	WGS 1984
Reference number:		Global reference epoch:	
Description:		Geoid:	Singapore Geoid Model 2009
Comment 1:		Vertical datum:	
Comment 2:		Calibrated site:	
Comment 3:			

Baseline Processing Report

Processing Summary

Observation	From	To	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
SLYG --- SNSC (B1)	SLYG	SNSC	Fixed	0.0040	0.0242	189°41'01"	6615.9151	-35.9665
SNSC --- SM20365 (B4)	SNSC	SM20365	Fixed	0.0070	0.0358	92°19'19"	6863.7127	-1.5012
SNSC --- SM20365 (B2)	SNSC	SM20365	Fixed	0.0060	0.0460	92°19'19"	6863.7137	-1.5493
SLYG --- SM20365 (B5)	SLYG	SM20365	Fixed	0.0078	0.0398	139°48'18"	8901.9408	-37.4737
SLYG --- SM20365 (B3)	SLYG	SM20365	Fixed	0.0070	0.0530	139°48'18"	8901.9427	-37.4893

Acceptance Summary

Processed	Passed	Flag	Fail
5	5	0	0

1

Sample of Network Adjustment Report

Project File Data		Coordinate System	
Name:	C:\Users\SLAISSSLA-L000763A\Desktop\TBC\ ABC _20365\SM_20365.vce	Name:	Singapore/SVY21
Size:	71 KB	Zone:	SVY 21
Modified:	15/10/2026 10:12:24 am (UTC:8)	Datum:	WGS 1984
Time zone:	Malay Peninsula Standard Time	Global reference datum:	WGS 1984
Reference number:		Global reference epoch:	
Description:		Geoid:	Singapore Geoid Model 2009
Comment 1:		Vertical datum:	
Comment 2:		Calibrated site:	
Comment 3:			

Network Adjustment Report

Adjustment Settings

Set-Up Errors

GNSS

Error in Height of Antenna: 0.0020 m

Centering Error: 0.0020 m

Covariance Display

Horizontal:

Propagated Linear Error [E]: U.S.

Constant Term [C]: 0.0000 m

Scale on Linear Error [S]: 1.960

Three-Dimensional