

Geolocation Accuracy Test Description

To assess the geolocation accuracy of AFC devices, Sporton Lab has developed a comprehensive field trial test plan. This plan employs a standard reference point with a precisely known location to gauge the geolocation accuracy of AFC devices. The measurements were conducted at 5000 sample points, utilizing GPS data, which was recorded during the trial test. Subsequently, 5000 location data points were collected, and the horizontal and vertical location uncertainty was calculated at a 95% confidence level. Horizontal location uncertainty is calculated using both circle (R95) and ellipse (E95) methods. Manufacturers can choose one for their application.

1. Standard Reference Point:

Taiwan Class 1 Level Reference Net was provided by Taiwan Satellite Survey Center, Depart of Land Administration. M.O.I. [1] and the class 1 grade 1 level reference net horizontal results at latitude, longitude and height direction deviation average values are ± 1.4 cm, ± 1.3 cm, and ± 10.9 cm, respectively.

Reference Point Number: 6017

Coordinate System: TWD97

Easting (E): 249570

Northing (N): 2743380

Orthometric Height: 40m

Converted the coordinate TWD97 to WGS84 DD:

Longitude: 120.995747

Latitude: 24.797783

Above Mean Sea Level (AMSL) Height: 40.52m (Test table height: 0.52m)

控制點號	6017	控制點名
控制點等級	一等水準點	
控制點所在位置	新竹市新竹市	
註明		

111年臺灣一等水準網水準測量成果	
公告機關：內政部	
測量坐標系統	TWD97
測量坐標分帶	121
測量坐標X	249570
測量坐標Y	2743380
高程	40



2. GPS Measurement Data:

Sporton only captures GPS data and does not use GNSS, SABS, Galileo, Quasi-Zenith and BeiDou. Examples of source material are provided below. \$GPGGA is the GPS log output. Sporton captures that the second through fifth digits represent horizontal position and the 9th digit represents altitude.

```

$GPGGA,032511.000,2447.8727,N,12059.7463,E,1,8,0.95,71.6,M,15.0,M,,*6E
$GPGGA,032512.000,2447.8727,N,12059.7463,E,1,8,0.95,71.6,M,15.0,M,,*6D
$GPGGA,032513.000,2447.8727,N,12059.7463,E,1,7,0.95,71.6,M,15.0,M,,*63

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3. 5000 Samples:

Referring to [2], errors were analyzed for series comprising 600 measurements (over a 10-minute duration) up to 44,500 measurements (over a 12-hour duration). Position radius errors converged after capturing 4,800 samples during an 80-minute measurement period. For the Sporton test report, 5,000 samples were chosen with a measurement duration of 120 minutes.

k	$\sqrt{k}$	σ_x	σ_y	CEP	DRMS	Δ_R
-	-	m	m	m	m	m
600	24,5	1,98	2,01	2,36	2,82	1,85
1200	34,6	2,88	2,97	3,45	4,14	1,28
1800	42,4	2,97	3,55	3,86	4,63	1,36
2400	49,0	3,45	3,62	4,18	5,00	1,26
3000	54,8	3,16	3,35	3,85	4,61	1,31
3600	60,0	2,95	3,76	3,98	4,78	1,87
4200	64,8	2,86	3,95	4,05	4,88	0,98
4800	69,3	3,21	4,46	4,56	5,50	1,13
5400	73,5	3,36	4,52	4,68	5,63	1,15
6000	77,5	3,61	4,68	4,92	5,91	1,22
43200	207,8	3,82	4,84	5,14	6,17	1,15

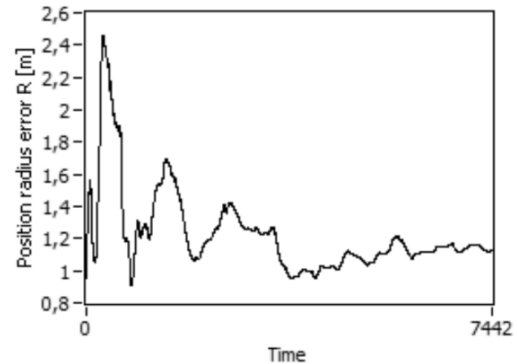


Fig. 10. Position radius error Δ_R in meters versus time of measurement in seconds

4. Radius of the 95% Probability Circle (R95) Error (XY):

R95 Error represents the radius of the circle encompassing 95% of the position-determining results.

Calculation of R95 Error is performed using the following formula:

$$R95 \text{ Error} = 2.08 \times (0.56\sigma_x + 0.62\sigma_y) \quad [2]$$

Where σ_x and σ_y are the standard deviations from the known position in the directions of the coordinate axes.

At a 95% confidence level:

$$95\% \text{ Confidence Level} = R95 \text{ Error} + \text{Mean Error}$$

Mean Error is calculated as Mean Point – Standard Point.

5. Confidence 95% Ellipse (E95) Error (XY):

E95 Error, which is the ellipse error comprising 95% of the position determining results is following formula:

In our case, the length of the axes are defined by the standard deviations σ_x and σ_y of the data such that the equation of the error ellipse becomes:

$$\left(\frac{x}{\sigma_x}\right)^2 + \left(\frac{y}{\sigma_y}\right)^2 = s = 5.991 \quad [3] [4] [5]$$

where s defines the scale of the ellipse chi-square distribution number.

Thus, the 95% confidence ellipse can be defined similarly to the axis-aligned case, with the major axis of length $2\sqrt{s\lambda_1}$ and the minor axis of length $2\sqrt{s\lambda_2}$, Where λ_1 and λ_2 represent the eigenvalues of the covariance matrix.

To obtain the ellipse orientation:

$$\alpha = \arctan \frac{V1(y)}{V1(x)}$$

where $V1$ is the eigenvector of the covariance matrix that corresponds to the largest eigenvalue.

$$95\% \text{ confidence level} = E95 \text{ Error} + \text{Mean Error}$$

$$\text{Mean Error} = \text{Mean point} - \text{Standard point}$$

6. 95% Probability Height Error (Z):

Height Error represents the range encompassing 95% of the position-determining results in the Z-axis.

Calculation of Z Error is performed using the following formula:

$$Z \text{ Error} = 1.96 \times \sigma_z \quad [6]$$

Where σ_z is the standard deviation from the known position in the Z-axis.

At a 95% confidence level:

$$95\% \text{ Confidence Level} = Z \text{ Error} + \text{Mean Error}$$

Mean Error is calculated as Mean Point – Standard Point.

References:

[1] Class 1 Level Reference Net by Satellite Survey Center, Depart of Land Administration. M.O.I.

https://gps.moi.gov.tw/sscenter/Introduce_E/IntroducePage_E.aspx?Page=GPS_E8

[2] AN EXPERIMENTAL INVESTIGATION INTO THE POSITIONING ACCURACY OF LOW-COST GPS RECEIVERS



IN LABVIEW ENVIRONMENT by Politechnika Gdańska Wydział Elektrotechniki i Automatyki Gdańsk 2015

[3] <https://www.visiondummy.com/2014/04/draw-error-ellipse-representing-covariance-matrix/>

[4] Two-Dimensional Measures of Accuracy in Navigational Systems by Gerald.Y. Chin Transportation Systems Center Cambridge, MA 02142

[5] BORG, F, 2002. The Confidence 95 Ellipse [online]. Finland [cit. 2017-01-07].

[6] Normal Distribution | Examples, Formulas, & Uses by Pritha Bhandari.

<https://www.scribbr.com/statistics/normal-distribution/>

Geolocation Accuracy Test Report

Equipment : GPS Module

Brand Name : Ublox

Model Name : ZOE-M8G

Applicant : Cisco Systems Inc
125 West Tasman Drive San Jose California United States 95134-1706

Manufacturer : Cisco Systems Inc
125 West Tasman Drive San Jose California United States 95134-1706

Sample Received : Oct. 25, 2023

Start Test Date : Dec. 25, 2023

Final Test Date : Dec. 26, 2023

Standard : FCC KDB 987594 D01v02



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History of this test report

[illegible]

Summary of Test Result

Conformance Test Specifications				
Report Clause	Description	Radius 95%+ Uncertainty+ Error (m)	Ellipse 95%+Error X (m) / Y (m) / Orientation(°)	Probability 95%+ Uncertainty+ Error Z (m)
2.1.3	Field Trial Test Result	11.19	10.19 / 6.98 / 40.34	21.26

Note: There are additional cables between the GPS antenna and the product, GPS cable length is not taken into account in the test results and should be evaluated by the manufacturer.

1 General Description

1.1 Information

1.1.1 General Information

General Description	
GPS Type:	
☒	Build-in GPS is part of the device certification
	GPS Chip Manufacturers: u-blox
☐	Independent GPS is not part of the device certification
	GPS Provider: ☐ Single Provider; ☐ Multi Provider
	GPS Manufacturers:
	GPS chip manufacturers:
	GPS Models:
	Types of GPS devices: USB Dongle / handsets / tablets
Installation Environment:	
☐	Indoor
☒	Outdoor
Altitude Definition:	
☒	The altitude is determined and entered by the professional installer.
☐	The altitude is determined by GPS Altitude.
Supported Software Product IDs	
IW9167EH-B - Industrial Wireless 9167 AP IW9167EH-B-AP - Wi-Fi mode IW9167EH-B-URWB - URWB mode IW9167EH-B-WGB - WGB mode IW9167EH-ROW - Industrial Wireless 9167 AP IW9167EH-ROW-AP - Wi-Fi mode IW9167EH-ROW-URWB - URWB mode IW9167EH-ROW-WGB - WGB mode IW9165E-B-WGB IW9165E-B-URWB IW9165E-B-AP IW9165DH-URWB IW9165DH-B-AP	

1.1.2 GPS Antenna Information

Antenna Category	
☐	Integral antenna (antenna permanently attached)
☒	External antenna (dedicated antennas)

Ant.	CISCO's Brand Name	CISCO's Model Name	Antenna	Connector	Gain
	Manufacturer's Brand Name	Manufacturer's Model Name	Type		(dBi)
1	CISCO	ANT-GNSS-OUT-TNC=	Patch	TNC Male	2.5
	Pulse	W4053T4572	Antenna		

Note: The above information was declared by manufacturer.

1.1.3 Table for Multiple Listing of Host

The EUT (GPS Module) will be installed on the host following.

The differences in host model names are listed in the following table.

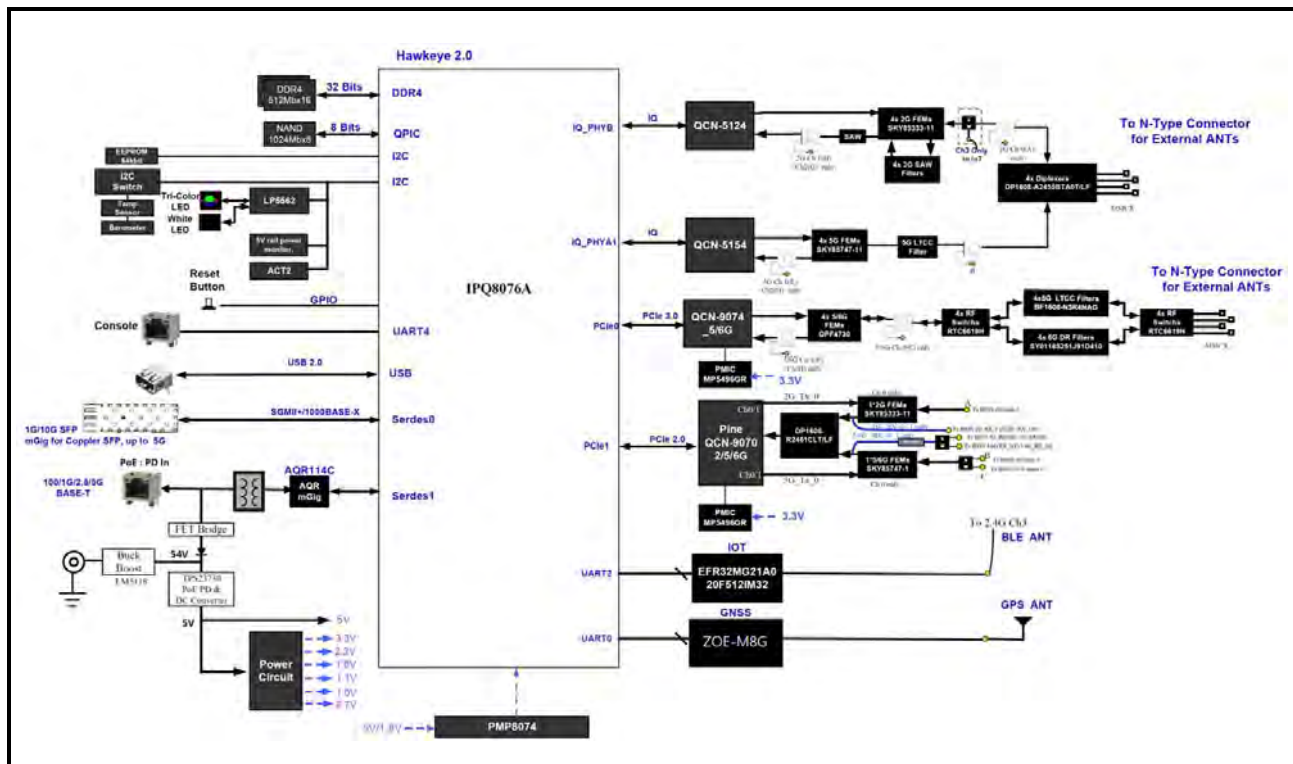
Host Brand Name	Host Model Name	Description for GPS
CISCO	IW9167EH-B	Using the same GPS Chip and GPS Antenna.
	IW9167EH-ROW	
	IW9165E-B	
	IW9165DH-B	

Note 1: From the above models, host model: IW9167EH-B was selected as representative model for the test and its data was recorded in this report.

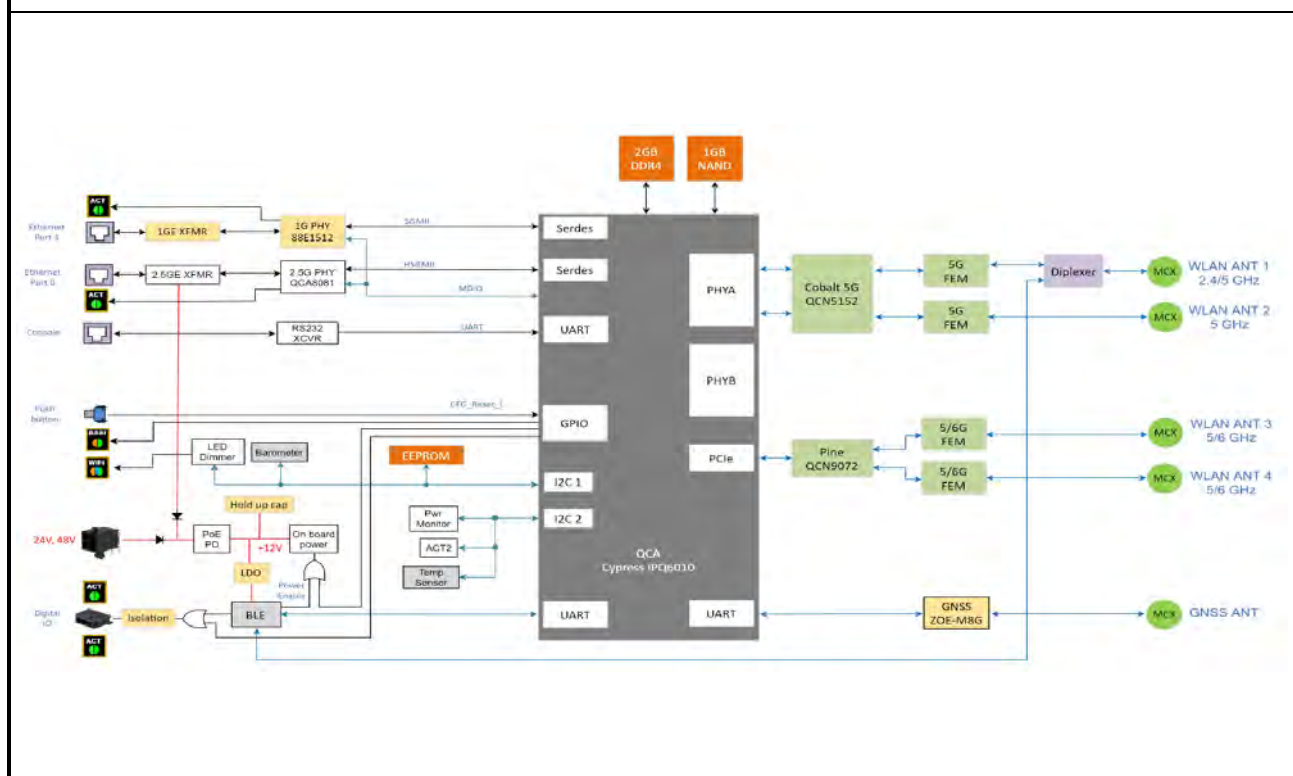
Note 2: The above information was declared by manufacturer.

1.1.4 Geolocation System Block Diagram

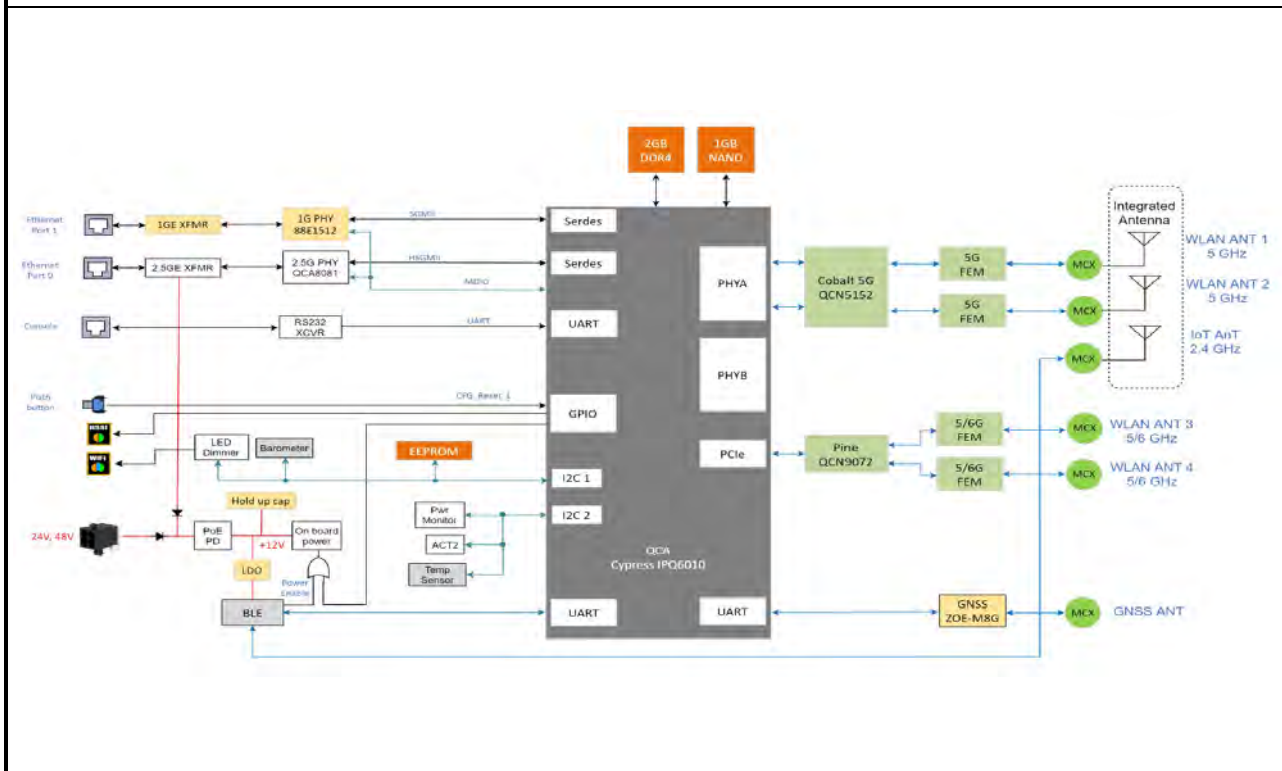
System Block
Host Model Name: IW9167EH-B and IW9167EH-ROW



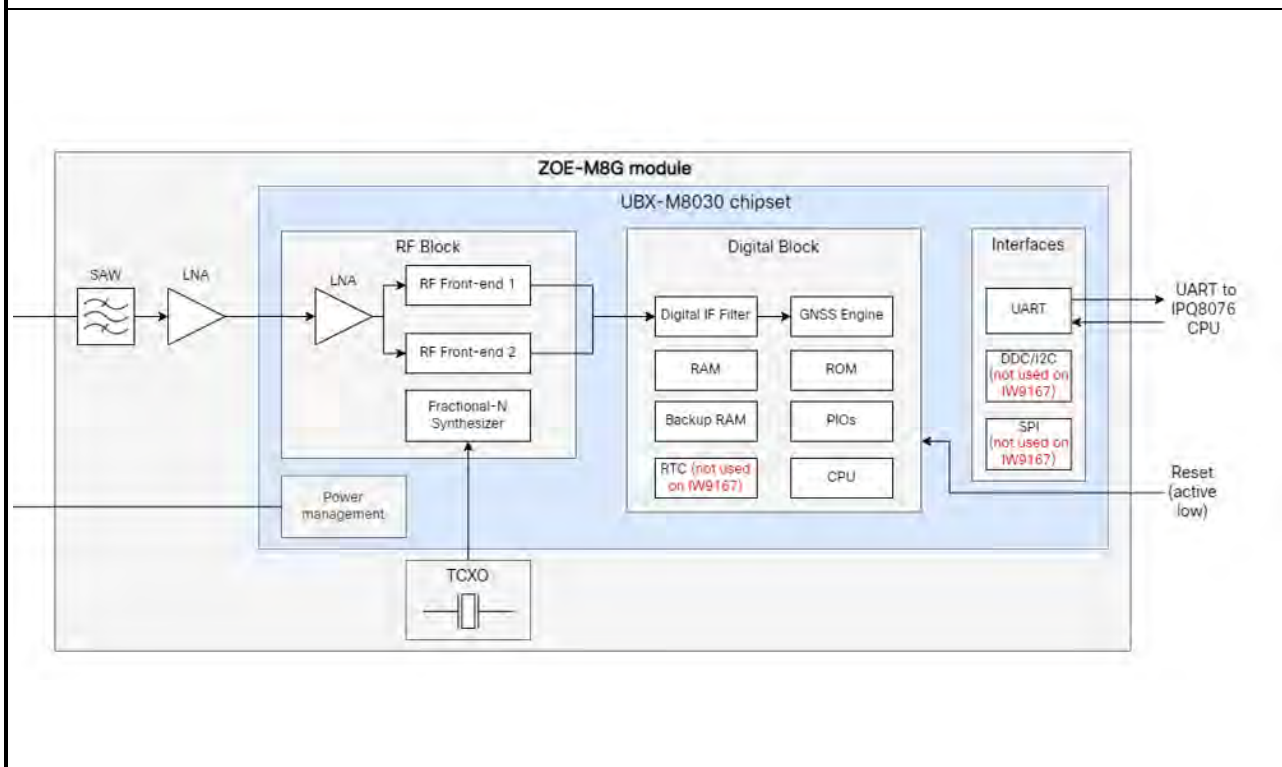
Host Model Name: IW9165E-B



Host Model Name: IW9165DH-B



GPS Block



1.2 Testing Location Information

Testing Location Information				
Test Lab. : Sporton International Inc. Hsinchu Laboratory				
Hsinchu ADD: No.8, Ln. 724, Bo'ai St., Zhubei City, Hsinchu County 302010, Taiwan (R.O.C.)				
TEL: 886-3-656-9065 FAX: 886-3-656-9085				

Test Condition	Test Site No.	Test Engineer	Test Environment (°C / %)	Test Date
Radiated (Field Trial Test)	-	Jeff Wu	21.6~22.1 / 65~68	Dec. 25, 2023~ Dec. 26, 2023

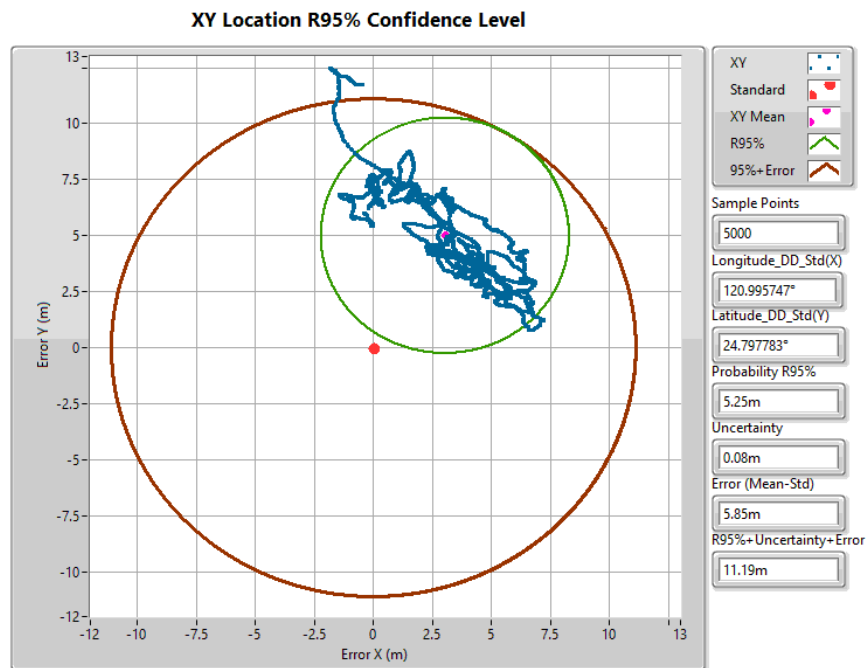
1.3 Support Equipment

Support Equipment				
No.	Equipment	Brand Name	Model Name	FCC ID
A	Notebook	DELL	E4300	N/A
B	AC adapter	LITEON	PA-1600-1C	N/A

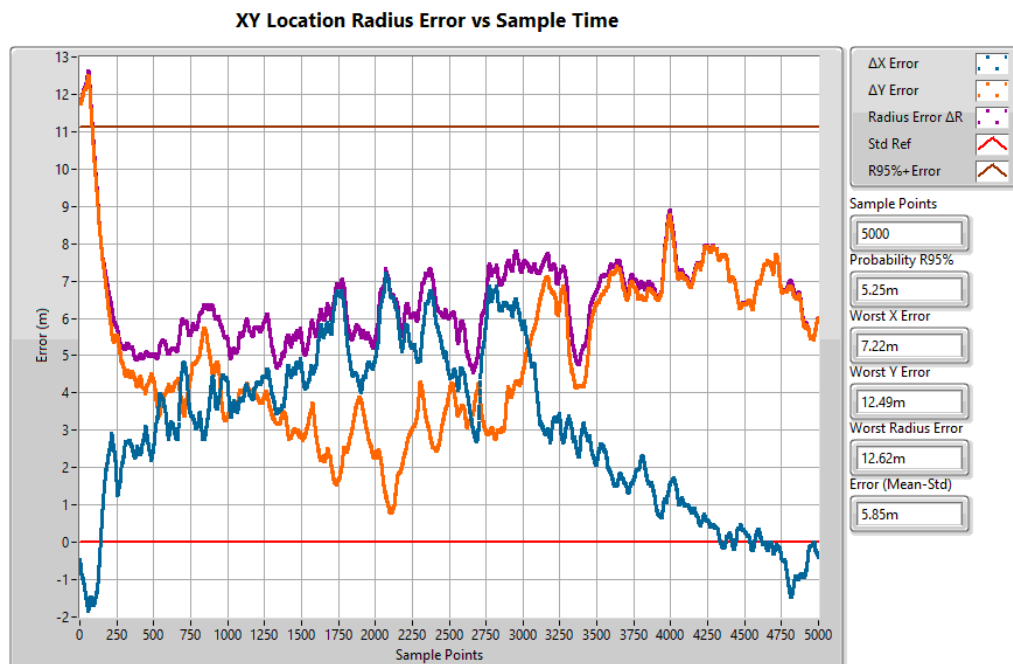
2 Test Result

2.1 Field Trial Test Result

Radius XY 95% Confidence Level

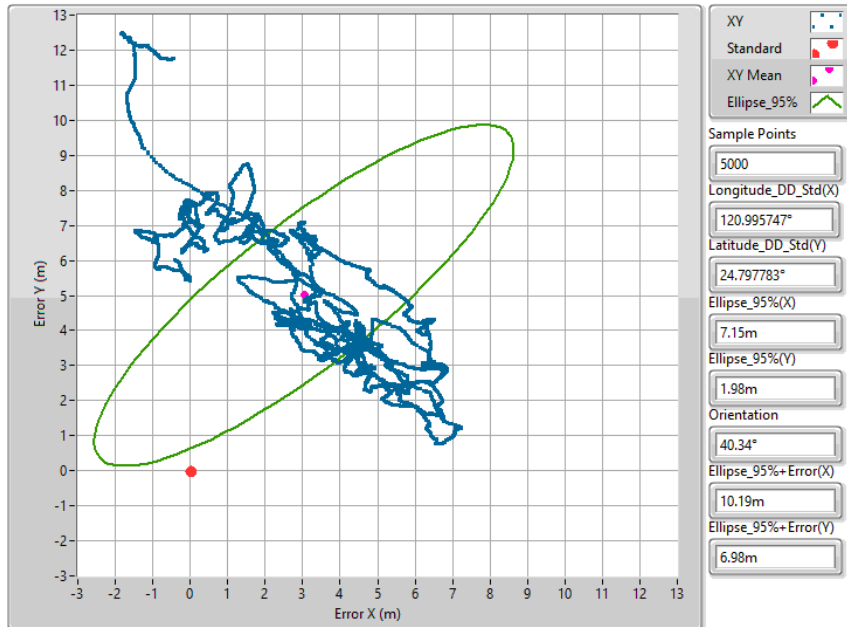


Radius XY Error vs Sample Time



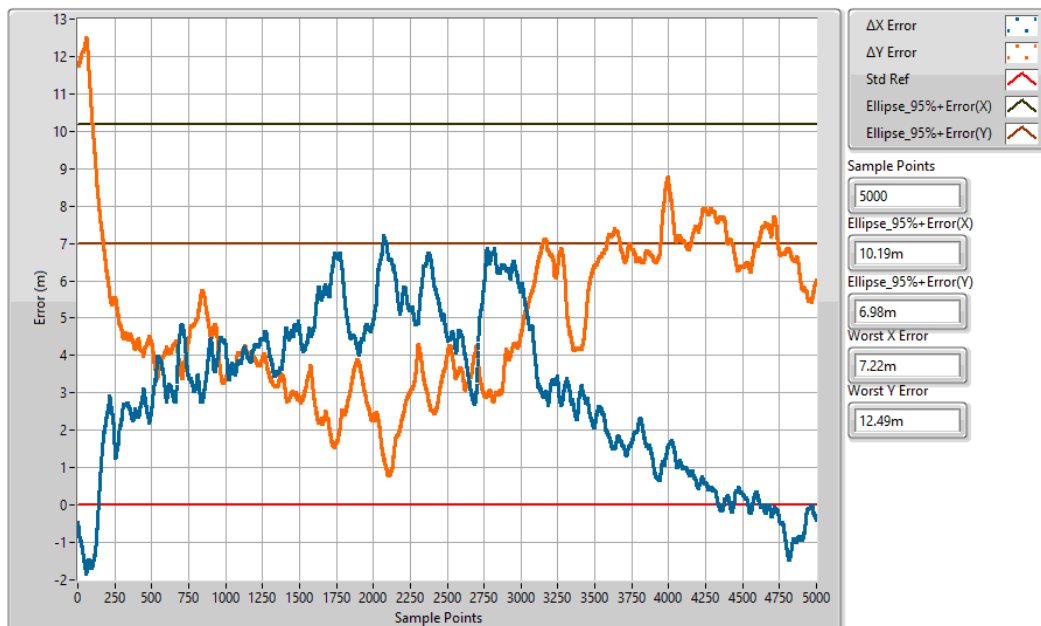
Ellipse XY 95% Confidence Level

XY Location E95% Confidence Level



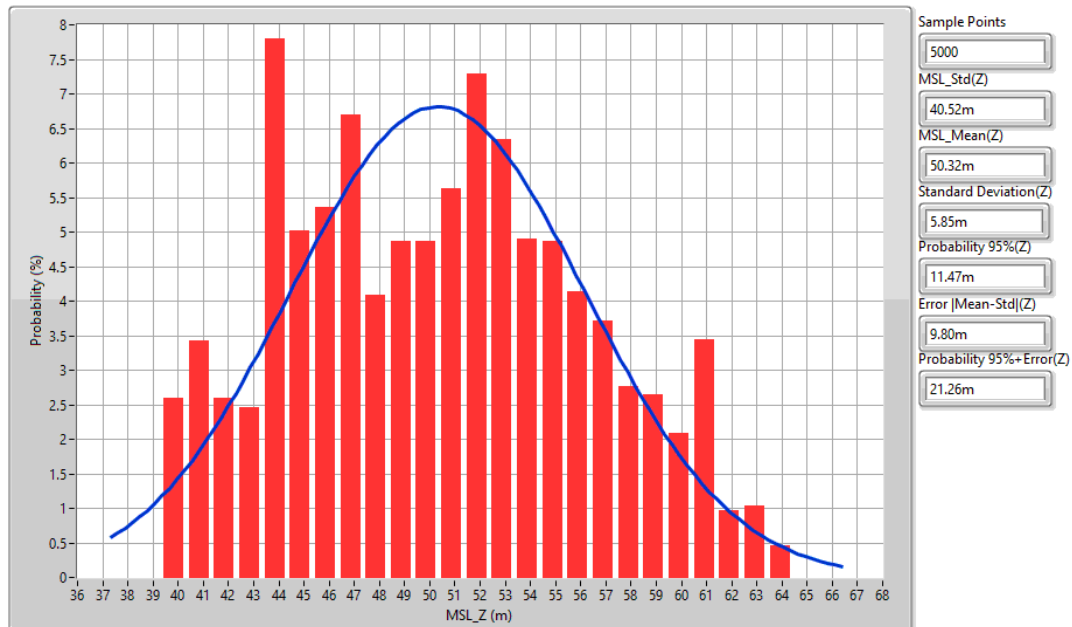
Ellipse XY Error vs Sample Time

XY Location Ellipse Error vs Sample Time



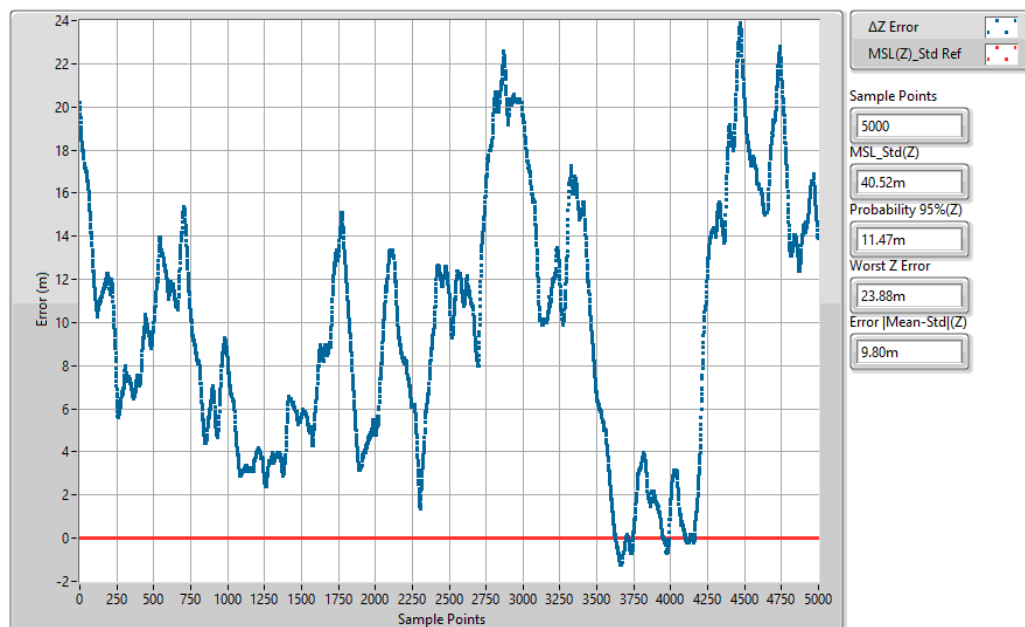
Z 95% Confidence Level

Above Mean Sea Level Histogram



Z Error vs Sample Time

Z Location Error vs Sample Time





3 Test Equipment and Calibration Data

Instrument	Manufacturer	Model No.	Serial No.	Spec.	Calibration Date	Calibration Until	Remark
Test software	SPORTON	SENSE-GPS XYZ	V1.3	N/A	N.C.R.	N.C.R.	Radiation

Note: NCR means Non-Calibration required.

4 Test Photo

FRONT VIEW



————THE END————