

GNSS

Android Raw Data Processing

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Android Device for GNSS Raw Data

- **Many Android devices with OS 7.0 or higher can output GNSS Raw Data**
 - These data can be used for RTK post-processing
- **Some devices have Multi-Frequency (L1/L5) GNSS receiver**
 - Multi-System (GPS, GLONASS, GALILEO, BEIDOU, QZSS)
 - Multi-Frequency (L1/E1/B1, L5/E5)
 - Outputs more than 40 channels
 - Some devices output NAV BIT Data and/or AGC values

GNSS Raw Data Compatible Smart-Phones

This List is Old. Please check for New List

S. No.	Model	Android version	System Score Max: 6 (D)	Function Score Max: 5 (E)	Total Score (D + E)	Raw Data output used in System Score					Satellite Systems used in System Score					
						AGC	NAV MSG	Accumulated delta range	HW clock	L5 Support	GPS	GLO	GAL	BDS	QZSS	SBAS
4	Xiaomi Mi 8	8.1	5	4	9	no	yes	yes	yes	yes	yes	yes	yes	yes	yes	no
31	Samsung S8	7	5	3	8	no	yes	yes	yes	no	yes	yes	yes	yes	yes	no
33	Huawei P10	7	5	3	8	no	yes	yes	yes	no	yes	yes	yes	yes	yes	no
42	Huawei Mate 20 X	9	4	4	8	no	yes	yes	yes	yes	yes	yes	yes	no	yes	no
19	Google Pixel 2 XL	8	5	2	7	yes	no	no	yes	no	yes	yes	yes	yes	yes	no
20	Google Pixel 2	8	5	2	7	yes	no	no	yes	no	yes	yes	yes	yes	yes	no
22	Samsung Note 8	7.1	4	3	7	no	yes	yes	yes	no	yes	yes	yes	yes	no	no
1	Pixel 3 XL	9	4	3	7	yes	no	yes	yes	no	yes	yes	yes	yes	no	no
2	Pixel 3	9	4	3	7	yes	no	yes	yes	no	yes	yes	yes	yes	no	no
43	Huawei Mate 20 RS	9	4	3	7	no	no	yes	yes	yes	yes	yes	yes	yes	no	no
44	Huawei Mate 20 Pro	9	4	3	7	no	no	yes	yes	yes	yes	yes	yes	yes	no	no
45	Huawei Mate 20	9	4	3	7	no	no	yes	yes	yes	yes	yes	yes	yes	no	no
10	Huawei P20	8.1	3	3	6	no	yes	yes	yes	no	yes	yes	no	no	yes	no
11	Samsung Galaxy S9	8	3	3	6	no	yes	yes	yes	no	yes	yes	no	no	yes	no
18	Huawei Mate 10 Pro	8	3	3	6	no	yes	yes	yes	no	yes	yes	no	no	yes	no

Check → <https://developer.android.com/guide/topics/sensors/gnss> for Latest Updates

Android Raw Data Logging Tool – 1: GnssLogger

GnsLogger

SET-TINGS LOG POSITION... MAP AGNS S PLOT

- Switch is ON Location
- Switch is ON Measurements
- Switch is ON Navigation Mess...
- Switch is ON GnsStatus
- Switch is ON Nmea
- Switch is OFF Auto Scroll
- Switch is OFF Residual Plot

HELP EXIT

HW Year: 2018 Platform: 8.1.0 Api Level: 27 v2.0.0.1

GnsLogger

SET-TINGS LOG POSITION... MAP AGNS S PLOT

(START CLEAR END)

1.032
 AccumulatedDeltaRangeState = 4
 AccumulatedDeltaRangeMeters = 17041.868
 AccumulatedDeltaRangeUncertaintyMeters = 3.403E38
 CarrierFrequencyHz = 1.57542003E9
 MultipathIndicator = 1
 CarrierFreqHz = 1.57542003E9

GnssMeasurement:
 Svid = 30
 ConstellationType = 1
 TimeOffsetNanos = 0.0
 State = 16
 ReceivedSvTimeNanos = 14861213
 ReceivedSvTimeUncertaintyNanos = 1000000000
 Cn0DbHz = 7.000
 PseudorangeRateMetersPerSecond = 680.972
 PseudorangeRateUncertaintyMetersPerSeconds = 299792458.000

AccumulatedDeltaRangeState = 4
 AccumulatedDeltaRangeMeters = 3461.599
 AccumulatedDeltaRangeUncertaintyMeters = 3.403E38
 CarrierFrequencyHz = 1.57542003E9
 MultipathIndicator = 0
 CarrierFreqHz = 1.57542003E9

GnssMeasurement:
 Svid = 24

Time Remaining: N/A

TIMER START LOG STOP & SEND

GnsLogger

SET-TINGS LOG POSITION... MAP AGNS S PLOT

CNO(dB.Hz) vs Time(s)

History Average of Strongest 4 Satellites: 41.7
 Current Average Of Strongest 4 Satellites: 42.6
 G24: 45
 G15: 42.9
 G5: 42.7
 G21: 39.9
 Total Number of Visible Satellites: 39

GnsLogger

SET-TINGS LOG POSITION... MAP AGNS S PLOT

CNO(dB.Hz) vs Time(s)

All
 GPS
 SBAS
 GLONASS
 QZSS
 BEIDOU
 GALILEO

History Average of Strongest 4 Satellites: 27.8
 Current Average Of Strongest 4 Satellites: 30
 G15: 34.6
 G21: 30.5
 E8: 27.9
 E7: 26.8
 Total Number of Visible Satellites: 36

GNSS Raw Data Output Format from Smart Phone Device

- #
- # Header Description:
- # Version: v2.0.0.1 Platform: 9 Manufacturer: Xiaomi Model: MI 8
- # Raw,
 - ElapsedRealtimeMillis,TimeNanos,LeapSecond,TimeUncertaintyNanos,FullBiasNanos,
 - BiasNanos,BiasUncertaintyNanos,DriftNanosPerSecond,DriftUncertaintyNanosPerSecond,
 - HardwareClockDiscontinuityCount,Svid,TimeOffsetNanos,State,ReceivedSvTimeNanos,
 - ReceivedSvTimeUncertaintyNanos,Cn0DbHz,PseudorangeRateMetersPerSecond,
 - PseudorangeRateUncertaintyMetersPerSecond,AccumulatedDeltaRangeState,
 - AccumulatedDeltaRangeMeters,AccumulatedDeltaRangeUncertaintyMeters,CarrierFrequencyHz,
 - CarrierCycles,CarrierPhase,CarrierPhaseUncertainty,MultipathIndicator,
 - SnrInDb,ConstellationType,AgcDb,CarrierFrequencyHz
- # Fix,
 - Provider,Latitude,Longitude,Altitude,Speed,Accuracy,(UTC)TimeInMs
- # Nav,
 - Svid,Type,Status,MessageId,Sub-messageId,Data(Bytes)

Sample GNSS Raw Data Output

```

13 # Nav,Svid,Type,Status,MessageId,Sub-messageId,Data (Bytes)
14
15 Nav,96,769,1,-1,13,110,121,9,58,-100,116,-65,-32,-96,100,32
16
17 Raw,86394315,73386000000,,,-1238933520614358644,0.0,6.103678716954078,,0,1,0.0,16431,303193919524422,20,33.86
18 Raw,86394315,73386000000,,,-1238933520614358644,0.0,6.103678716954078,,0,3,0.0,16431,303193916939667,33,27.52
19 Raw,86394315,73386000000,,,-1238933520614358644,0.0,6.103678716954078,,0,10,0.0,16431,303193928480980,27,29.8
20 Raw,86394315,73386000000,,,-1238933520614358644,0.0,6.103678716954078,,0,11,0.0,16392,303193914305357,1000000
21 Raw,86394315,73386000000,,,-1238933520614358644,0.0,6.103678716954078,,0,12,0.0,16431,303193918153504,44,23.9
22 Raw,86394316,73386000000,,,-1238933520614358644,0.0,6.103678716954078,,0,14,0.0,16431,303193929357084,15,37.3
23 Raw,86394316,73386000000,,,-1238933520614358644,0.0,6.103678716954078,,0,16,0.0,16392,303193914613478,1000000
24 Raw,86394316,73386000000,,,-1238933520614358644,0.0,6.103678716954078,,0,20,0.0,16431,303193920851248,58,20.6
25 Raw,86394316,73386000000,,,-1238933520614358644,0.0,6.103678716954078,,0,22,0.0,16431,303193921837227,16,36.6
26 Raw,86394316,73386000000,,,-1238933520614358644,0.0,6.103678716954078,,0,25,0.0,16431,303193926177270,14,38.1
27 Raw,86394316,73386000000,,,-1238933520614358644,0.0,6.103678716954078,,0,26,0.0,16431,303193924152390,31,28.4
28 Raw,86394316,73386000000,,,-1238933520614358644,0.0,6.103678716954078,,0,31,0.0,16431,303193932611146,17,35.4
29 Raw,86394316,73386000000,,,-1238933520614358644,0.0,6.103678716954078,,0,1,0.0,16393,303193919524421,9,29.583
30 Raw,86394317,73386000000,,,-1238933520614358644,0.0,6.103678716954078,,0,3,0.0,16393,303193916939680,11,31.84
31 Raw,86394317,73386000000,,,-1238933520614358644,0.0,6.103678716954078,,0,10,0.0,16393,303193928480980,8,34.70
32 Raw,86394317,73386000000,,,-1238933520614358644,0.0,6.103678716954078,,0,25,0.0,16393,303193926177261,8,33.51
33 Raw,86394317,73386000000,,,-1238933520614358644,0.0,6.103678716954078,,0,26,0.0,16393,303193924152389,24,24.9
34 Raw,86394317,73386000000,,,-1238933520614358644,0.0,6.103678716954078,,0,2,0.0,16491,1935193735,54,30.1594276
35 Raw,86394317,73386000000,,,-1238933520614358644,0.0,6.103678716954078,,0,13,0.0,32995,54775933527780,100,22.5
36 Raw,86394317,73386000000,,,-1238933520614358644,0.0,6.103678716954078,,0,12,0.0,32995,54775933826674,71,26.83
37 Raw,86394318,73386000000,,,-1238933520614358644,0.0,6.103678716954078,,0,11,0.0,32995,54775922474022,58,29.36
38 Raw,86394318,73386000000,,,-1238933520614358644,0.0,6.103678716954078,,0,1,0.0,16491,1927826124,73,26.4779949
39 Raw,86394318,73386000000,,,-1238933520614358644,0.0,6.103678716954078,,0,3,0.0,32995,54775925694722,46,31.992
40 Raw,86394318,73386000000,,,-1238933520614358644,0.0,6.103678716954078,,0,23,0.0,16431,303179924679079,11,32.4
41 Raw,86394318,73386000000,,,-1238933520614358644,0.0,6.103678716954078,,0,24,0.0,16431,303179914451366,11,32.7
42 Raw,86394318,73386000000,,,-1238933520614358644,0.0,6.103678716954078,,0,25,0.0,16431,303179927268994,9,34.37
43 Raw,86394318,73386000000,,,-1238933520614358644,0.0,6.103678716954078,,0,2,0.0,19498,303193919524625,31,28.40
44 Raw,86394319,73386000000,,,-1238933520614358644,0.0,6.103678716954078,,0,3,0.0,19498,303193912298358,25,30.87
45 Raw,86394319,73386000000,,,-1238933520614358644,0.0,6.103678716954078,,0,7,0.0,19498,303193916212787,14,37.91
46 Raw,86394319,73386000000,,,-1238933520614358644,0.0,6.103678716954078,,0,8,0.0,19498,303193927835139,26,32.68
47 Raw,86394319,73386000000,,,-1238933520614358644,0.0,6.103678716954078,,0,13,0.0,16392,303193906638380,1000000
48 Raw,86394319,73386000000,,,-1238933520614358644,0.0,6.103678716954078,,0,25,0.0,16392,303193907109729,1000000
49 Raw,86394319,73386000000,,,-1238933520614358644,0.0,6.103678716954078,,0,26,0.0,19498,303193910514372,39,25.5

```

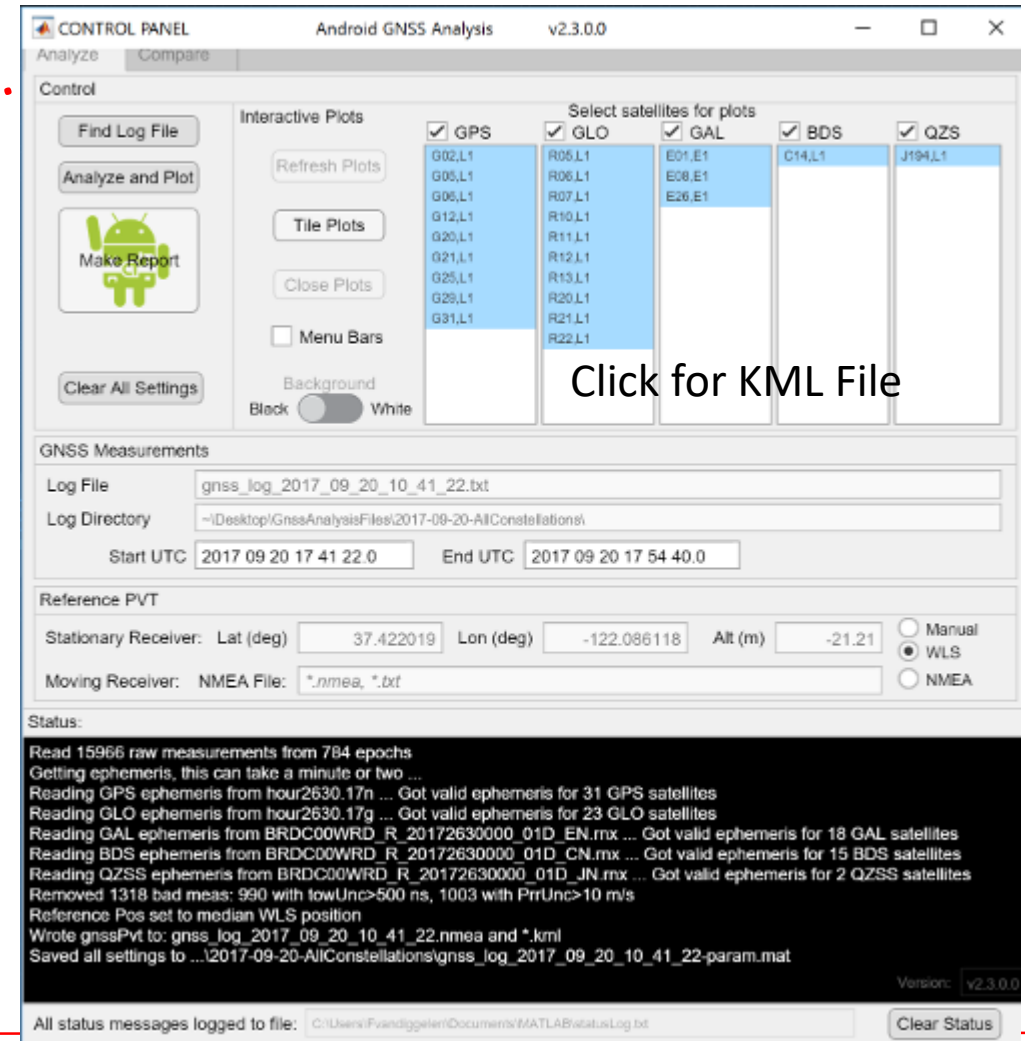
GNSS Raw Data Analysis Tool for GnssLogger

• GNSS Analysis APP

- Matlab-based Tool
- Linux, Windows, MacOS
- Version 2.6.3.0
- [Release Notes:](https://developer.android.com/guide/topics/sensors/gnss#releaseGNSS%20Analysis%20app%20v2.6.3.0)

<https://developer.android.com/guide/topics/sensors/gnss#releaseGNSS Analysis app v2.6.3.0> release notes.

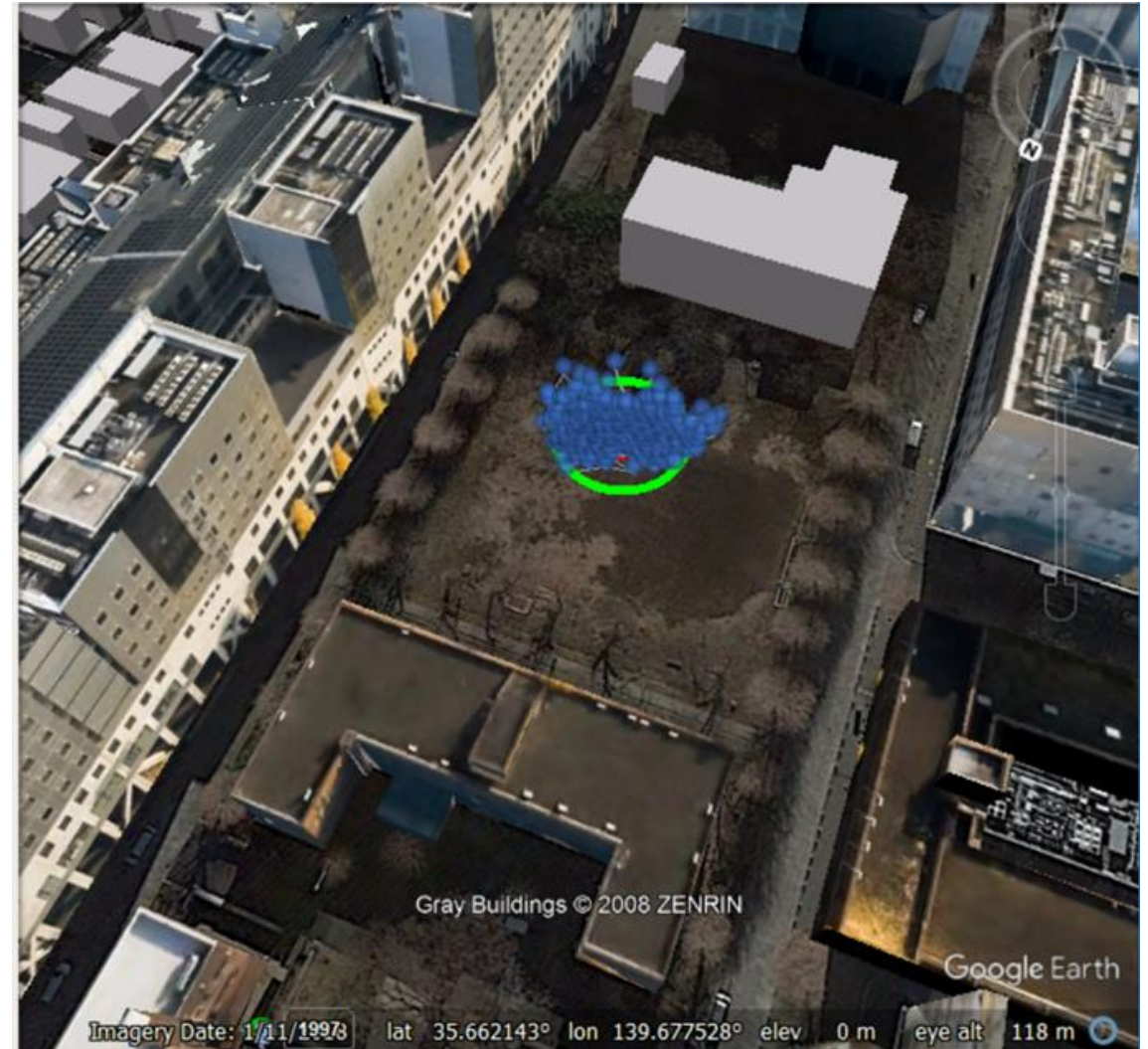
*New Version V4.0.0.0 is available.
Download new version*



The GNSS Analysis app is built on [MATLAB](https://www.mathworks.com/), but you don't need to have MATLAB to run it. The app is compiled into an executable that installs a copy of the MATLAB Runtime.

Position Output from Android GNSS Receiver, Komaba

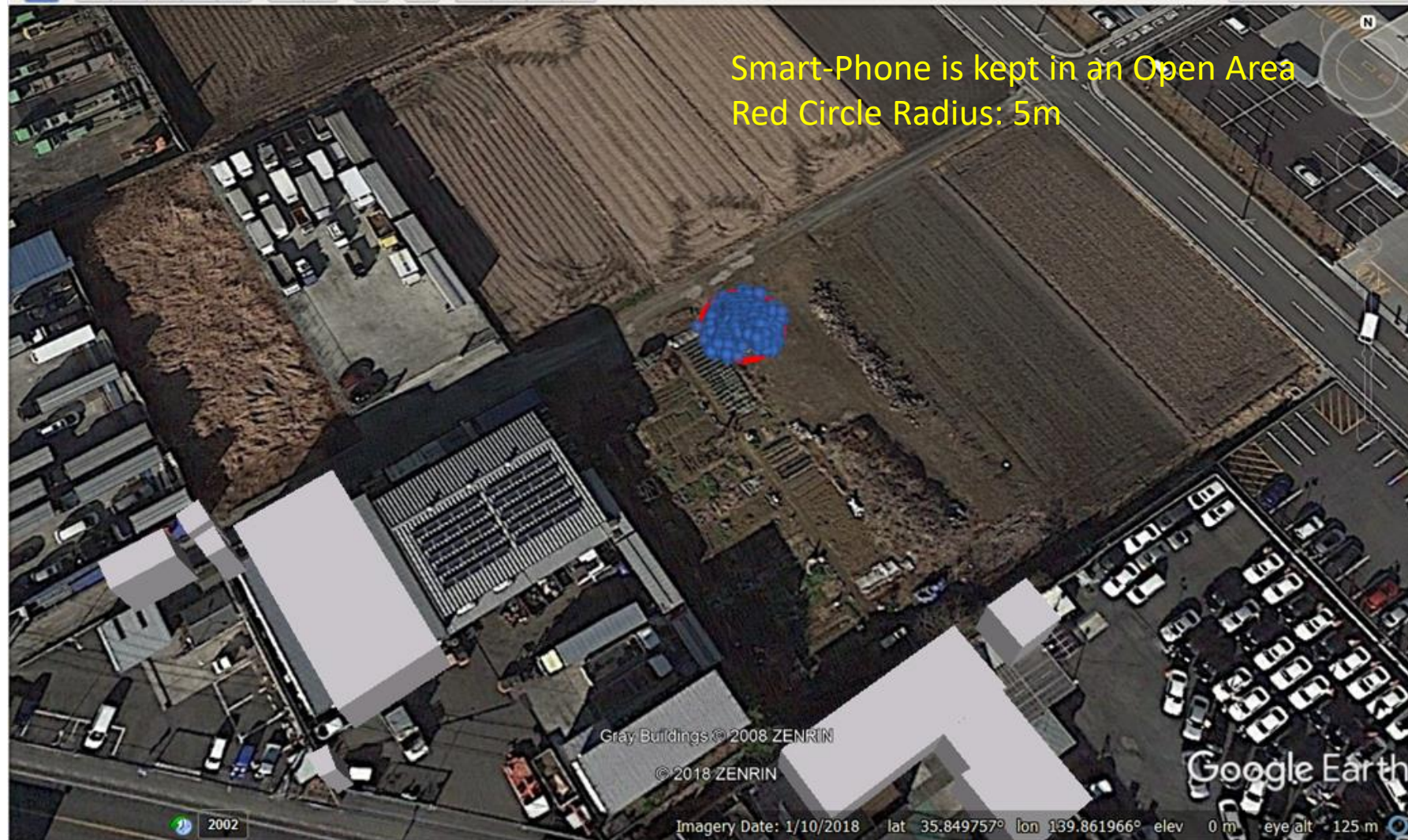
- **Standard Position Computation**
 - No DGPS or RTK Corrections
 - All visible GNSS Satellites are used
 - Frequency : L1/L5/E5
 - Surrounding : Tall Buildings around



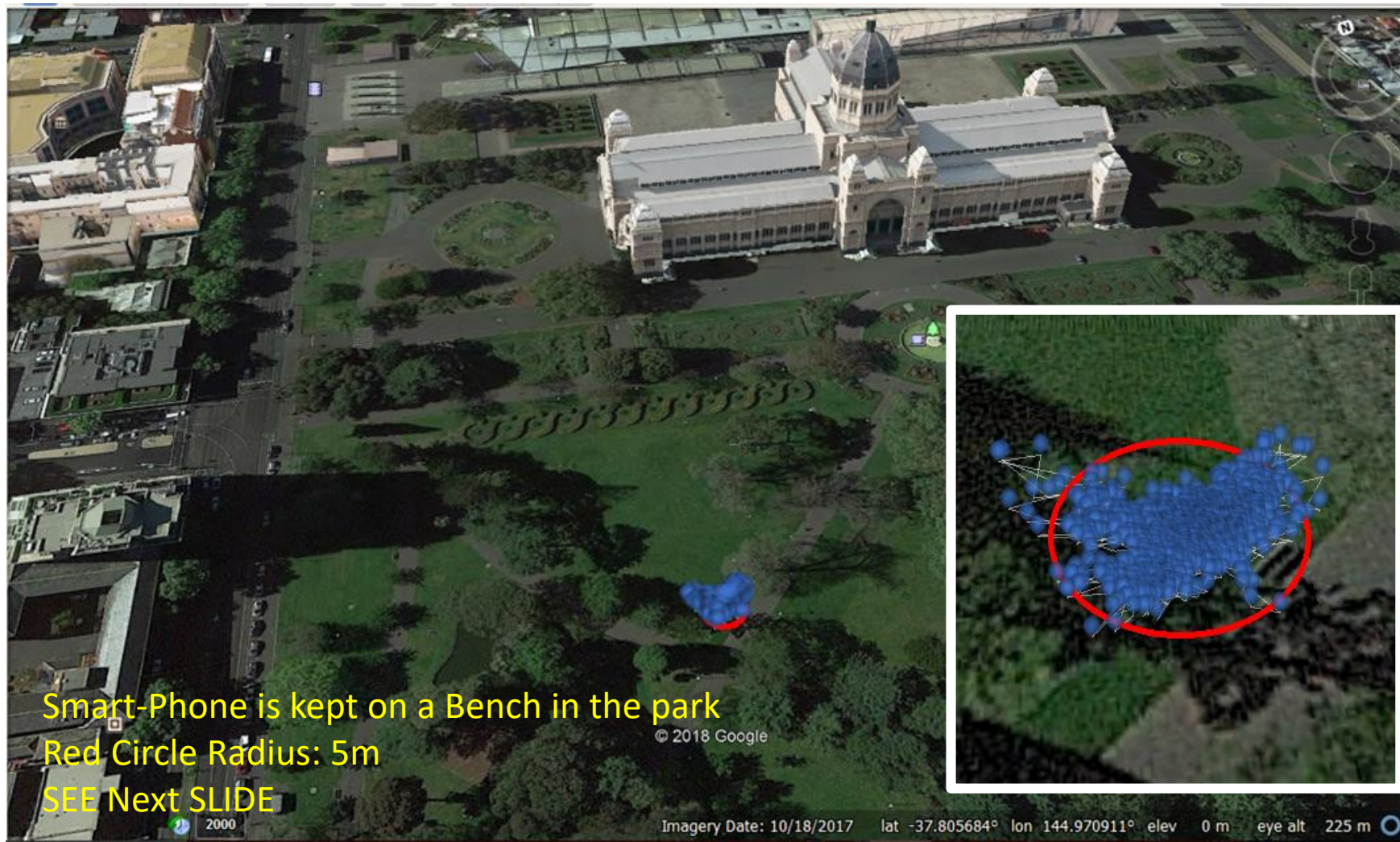
Position Output from Android GNSS Receiver, Hongo



Position Output from Android GNSS Receiver



Position Output from Android GNSS Receiver, Melbourne





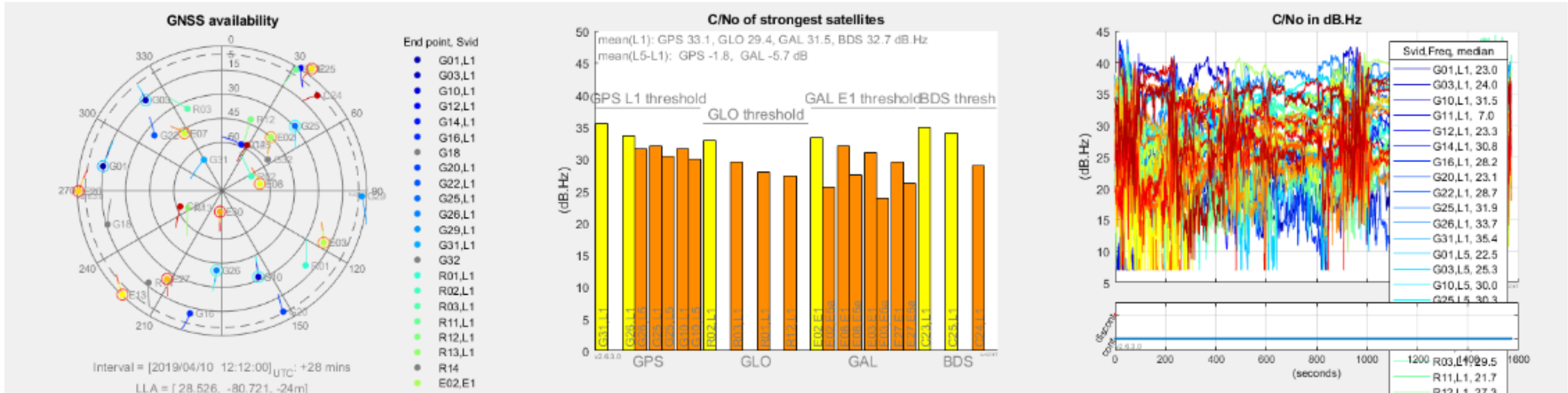
Smart-Phone is kept on a Bench in the park
Red Circle Radius: 5m

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Google Earth

Imagery Date: 8/2014 lat -37.806114° lon 144.970363° elev 0 m eye alt 3 m

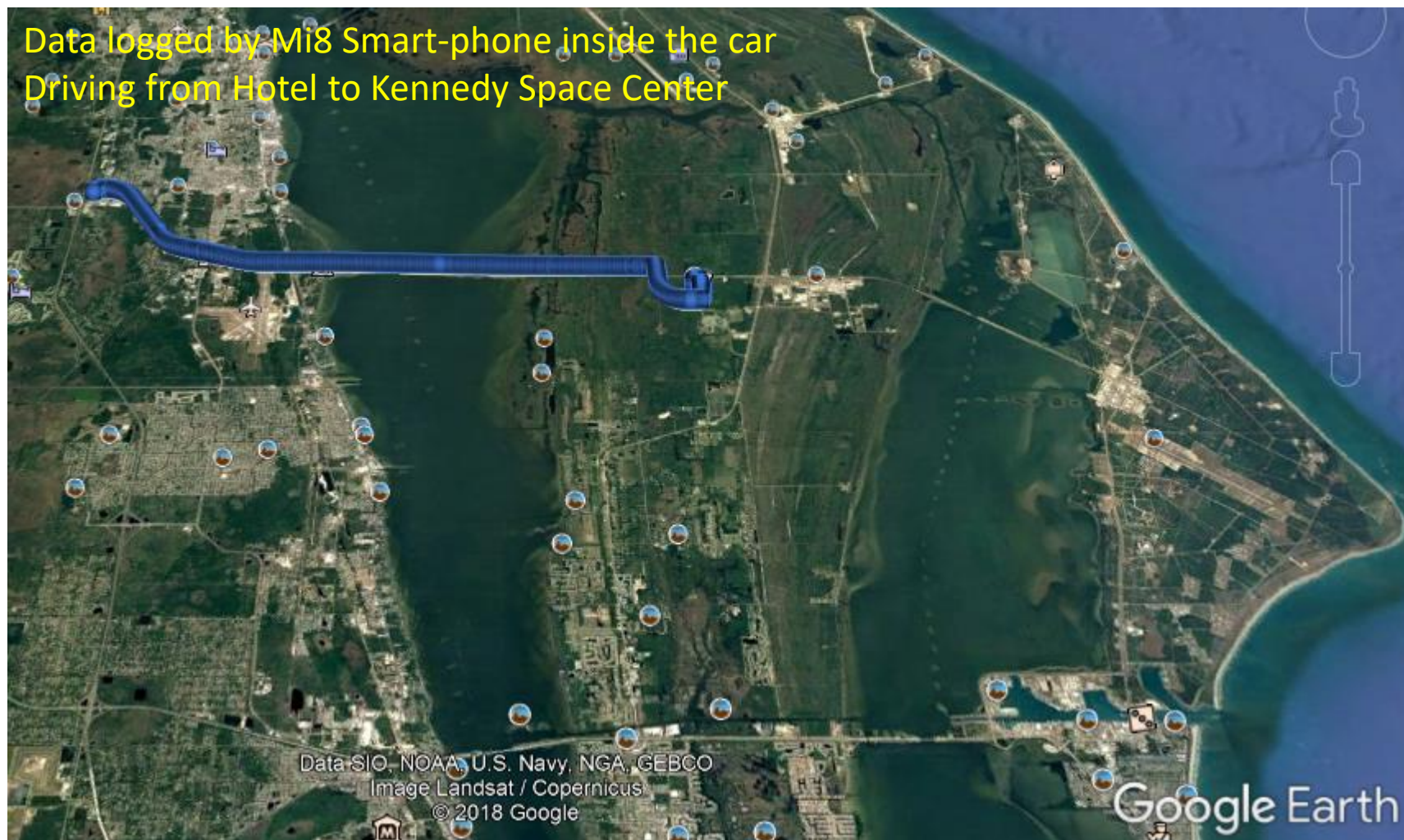
Output from GNSS Analysis Tool, Data Logged by GNSSLogger



Data logged by Mi8 Smart-phone inside the car

Output from GNSS Analysis Tool, Data Logged by GNSSLogger

Location:
Kennedy Space Center
Florida



Output from GNSS Analysis Tool, Data Logged by GNSSLogger



GNSS Position Data from Mi8 Android Device

Yellow Circles : Mi8 Device
White Circle : 5m Radius



Location: SUVA, FIJI

GNSS Position Data from P20 Android Device

Red Circles : P20 Device
White Circle : 5m Radius



Location: SUVA, FIJI

GNSS Position Data from Mi8 & P20 Android Devices

Red Circles : P20 Device
Yellow Circles : Mi8 Device
White Circle : 5m Radius



Location: SUVA, FIJI

Xiaomi Mi11 Lite 5G Screen Shots

13:38 ▲

Status

Lat: 35.85
Long: 139.8
Alt (MSL): 8.3 m
Speed: 0.0 m/s
S. Acc: 0.1 m/s
PDOP: 0.5

Time: 13:38:26
TTFF: 2 sec
E/H/V Acc: 3.8/2.5 m
Sats: 43/55/64
Bearing:
B. Acc:
H/V DOP: 0.3/0.4

ID	GNSS	CF	C/N0	Flags	Elev	Azim
10	L1	43.0	AEU	39°	220°	
10	L1	37.0	AE	39°	220°	
12	L1	33.3	AEU	48°	48°	
23	L1	46.2	AEU	19°	188°	
23	L5	40.2	AEU	19°	188°	
24	L1	32.5	AEU	20°	74°	
24	L5	32.4	AEU	20°	74°	
25	L1	30.8	AEU	82°	106°	
25	L5	32.6	AEU	82°	106°	
26	L1	24.4	AE	3°	221°	
26	L5	20.2	AE	3°	221°	
29	L1	30.9	AEU	18°	142°	
31	L1	41.4	AEU	26°	277°	
32	L1	37.1	AEU	60°	319°	
32	L5	29.2	AEU	60°	319°	
2	L1	A	A	2°	154°	
3	L1	46.0	AEU	52°	164°	
4	L1	35.9	AEU	68°	313°	
5	L1	33.7	AEU	16°	329°	
13	L1	20.1	A U	32°	33°	
14	L1-C	38.6	AE	66°	306°	
15	L1	41.1	AEU	26°	246°	
22	L1	A	A	2°	29°	
23	L1	21.7	A	2°	85°	
2	E5a	26.3	AE	88°	260°	
3	E1	40.2	AEU	54°	136°	
3	E5a	33.5	AEU	54°	136°	
5	E1	18.4	A	3°	135°	
5	E5a	16.8	A	3°	135°	
7	E1	21.6	A U	16°	314°	

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Status

2	E5a	28.2	AE	88°	260°
3	E5a	35.5	AE	54°	136°
5	E1	17.0	A	3°	135°
7	E1	25.6	A U	16°	314°
7	E5a	15.4	A	16°	314°
8	E1	37.2	AEU	68°	313°
8	E5a	34.2	AEU	68°	313°
25	E1	31.6	AEU	36°	43°
25	E5a	27.7	AEU	36°	43°
30	E1	38.0	AEU	35°	224°
30	E5a	40.0	AEU	35°	224°
193	L1	39.9	AEU	66°	177°
193	L5	34.2	AE	66°	177°
194	L1	33.2	AEU	76°	183°
194	L5	25.5	AE	76°	183°
195	L5	24.4	AEU	7°	174°
1	B1	35.4	AEU	47°	172°
2	B1	33.6	A U	19°	248°
3	B1	41.2	AEU	37°	223°
4	B1	A	A	42°	148°
6	B1	33.1	AEU	52°	315°
7	B1	37.6	A	19°	206°
8	B1	A	AE	8°	226°
9	B1	31.7	AEU	41°	308°
10	B1	26.0	AEU	8°	210°
12	B1	23.9	A U	9°	109°
13	B1	41.3	AEU	9°	233°
14	B1	31.7	AEU	29°	168°
16	B1	36.7	AEU	60°	325°
23	B1	30.2	AE	19°	252°
23	B2a	22.7	AE	19°	252°
23	B2a	33.6	AE	19°	252°
24	B1	32.8	AEU	43°	46°
24	B2a	22.1	AE	43°	46°
24	B2a	29.7	AE	43°	46°
25	B1	35.8	AEU	64°	288°
25	B2a	32.5	AEU	64°	288°
25	B1C	33.2	AEU	64°	288°
26	B1	A	A	1°	62°

13:38 ▲

Status

26	B2a	A	1°	62°	
32	B1	A	7°	323°	
32	B2a	19.8	A	7°	323°
32	B1C	27.4	A	7°	323°
33	B1	47.0	AEU	52°	189°
33	B2a	40.2	AE	52°	189°
33	B1C	50.5	AEU	52°	189°
34	B1	A	6°	135°	
34	B2a	20.5	A U	6°	135°
34	B1C	20.7	A	6°	135°
35	B1	A	A	A	A
35	B2a	18.5	A	A	A
38	B1	A	4°	210°	
38	B2a	22.4	A	4°	210°
39	B1	36.3	AEU	66°	334°
39	B2a	24.3	AEU	66°	334°
39	B1C	34.0	AEU	66°	334°
40	B1	43.0	AEU	27°	192°
40	B2a	41.1	AEU	27°	192°
40	B1C	41.2	AEU	27°	192°
41	B1	40.0	AEU	52°	291°
41	B2a	34.4	AEU	52°	291°
41	B1C	43.7	AEU	52°	291°
42	B1	28.2	A U	8°	158°
42	B2a	23.3	A U	8°	158°
42	B1C	31.5	A	8°	158°
44	B1	A	A U	11°	85°
44	B2a	21.9	A U	11°	85°
44	B1C	35.1	A U	11°	85°
56	B1	A	A	12°	210°
59	1602.000	47.1	A	49°	179°
60	1602.000	44.0	AE	14°	249°
61	B1	A	A	37°	223°
62	B1	A	A	48°	171°
4	L5	30.1	AEU	39°	222°
9	L5	15.8	A	12°	288°

ID	SBAS	CF	C/N0	Flags	Elev	Azim
128	L1	42.0				
137	L1	38.2				

13:39 ▲

Sky

Avg C/N0 (dB-Hz)

Legend

- - NAVSTAR GPS (USA)
- - GLONASS (Russia)
- ▲ - Galileo (European Union)
- ◆ - BeiDou/COMPASS (China)
- - QZSS (Japan)
- - IRNSS/NavIC (India)

13:39 ▲

Sky

Avg C/N0 (dB-Hz)

Legend

- - NAVSTAR GPS (USA)
- - GLONASS (Russia)
- ▲ - Galileo (European Union)
- ◆ - BeiDou/COMPASS (China)
- - QZSS (Japan)
- - IRNSS/NavIC (India)

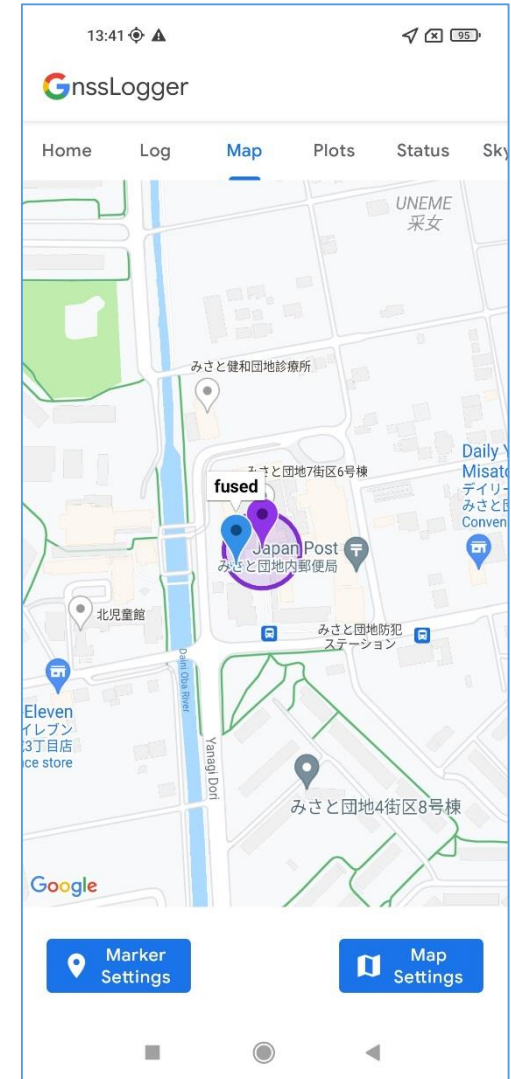
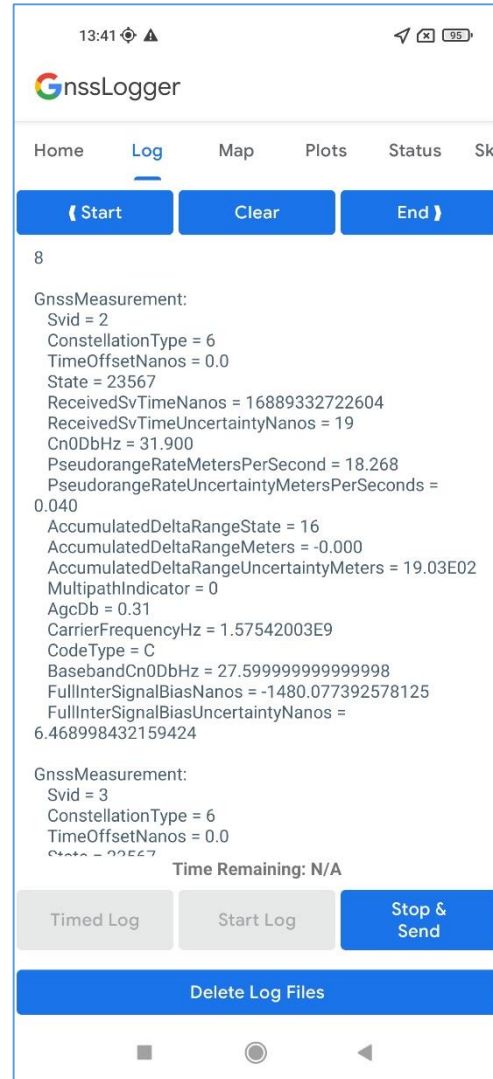
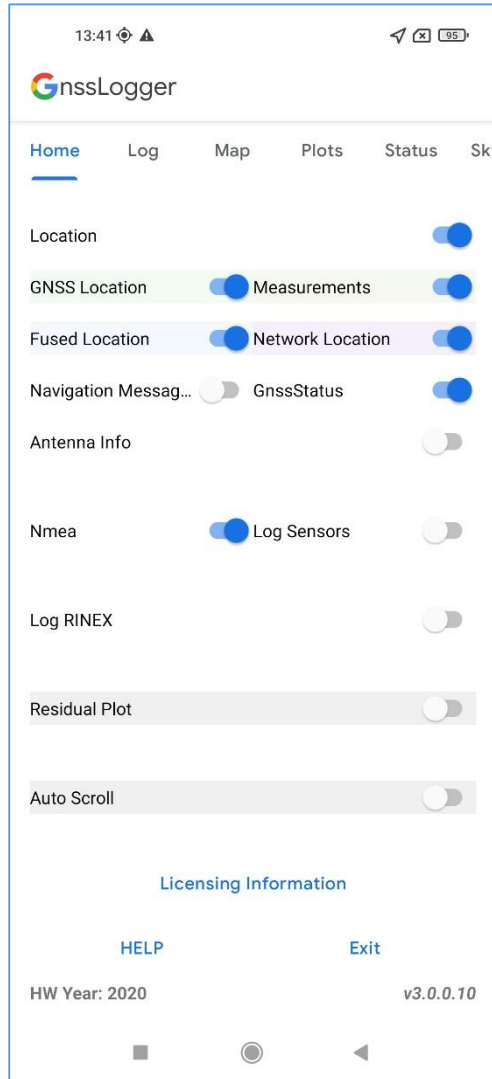
Satellite-based Augmentation Systems (SBAS)

- ◆ - WAAS (USA)
- ◆ - EGNOS (European Union)
- ◆ - GAGAN (India)
- ◆ - MSAS (Japan)
- ◆ - SDCM (Russia)
- ◆ - BDSBAS/SNANS (China)
- ◆ - SACCSSA (ICAO)

Signal Availability

- - Not in view of device
- - In view
- - Used in fix

Xiaomi Mi11 Lite 5G Screen Shots



Sample GNSS Raw Data from Mi11 Lite 5G

Sample GNSS raw data can be downloaded from the following website:

https://home.csis.u-tokyo.ac.jp/~dinesh/GNSS_Train.htm

Data were taken at the same time by using 4 or 5 different types of devices.

This will help to compare accuracy from different devices as well.

	Smart-Phone Data					
	Xiaomi Mi8 (a)	Xiaomi Mi8 (b)	Xiaomi Mi8 (c)	Xiaomi Mi11 Lite 5G	OppoReno 3 A	
Day 1	Data 01	Data 02	Data 03	Data 08 Data 09	Data 10	
Day 2	Data 04	Data 05 Data 06	Data 07			

(Possible) Applications of Android GNSS Raw Data

- **High-Accuracy Positioning**
 - Multi-System, Multi-Frequency
- **Interference and Jamming Detection**
 - Crowd Sourcing
- **Spoofing Detection and Signal Authentication**
- **Atmospheric Parameter Estimations**
 - Ionosphere and Troposphere
- **Space Weather**
- **Scientific Applications**

References

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 - https://home.csis.u-tokyo.ac.jp/~dinesh/GNSS_Raw_files/GNSS%20102%20Measurements%20from%200Phones%20Short%20Course%20Slides.pdf
- **GPS Receiver Signal Processing background information file:**
 - https://home.csis.u-tokyo.ac.jp/~dinesh/WEBINAR_files/MGA_W08_RawDataMeasurement_Background.pdf
- **Video record of GNSS Raw Signal Measurement MGA WEBINAR held on 6th DEC 2018.**
 - https://www.youtube.com/watch?v=S217xg--O_Q&feature=youtu.be
- **Sample Data**
 - **Sample GNSS Raw Data from Android Device**
 - <https://home.csis.u-tokyo.ac.jp/~dinesh/WEBINAR.htm>