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GeolocPVT USER GUIDE



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ABBREVIATIONS

API – Application programmable Interface

CNO – Carrier to Noise Ratio

GDOP – Geometric Dilution of Precision

GPS – Global Positioning System

GNSS – Global Navigation Satellite Systems

PRR – Pseudo Range Rate

RINEX – Receiver independent Exchange Format

TDCP – Time Differenced Carrier Phase

TOW – Time Of Week

UTC – Coordinated Universal Time

About the App.

- GeolocPVT is a standalone GNSS navigation application (app) that uses information from raw signals transmitted by visible satellites from GPS, Galileo and Beidou constellation systems to compute user position.
- The app is developed to function without internet connection.
- It consists of 3 fragments namely monitor, map & options.
- Monitor fragment is the default view created when the app is launched. In this fragment you can observe the status of satellites from different constellations, the calculated position in geodetic (Lat, Lon, Alt) and Cartesian (X, Y, Z) coordinates along with date, time in UTC, velocity of the user in m/s.
- In the map fragment you can visualize your current position and the path you took to reach point B from point A.
- In the options fragment you can choose which constellation (GPS/Galileo/Beidou or all 3) to use, with or without corrections, single frequency (L1 only)/multi-frequency (L1/L5)/iono-free solutions, static/dynamic scenario and elevation-noise cutoff to remove any measurements below the threshold.
- The app can be operated in 2 modes: Static & Dynamic.
 - In static mode, position is computed using Weighted Least Squares estimation technique (raw pseudorange is used with or without atmospheric corrections).
 - In dynamic mode, position is computed using Extended Kalman Filter technique [Using Time Differenced Carrier Phase (TDCP) -> PseudoRangeRate (PRR) measured in m/s directly available from the Android API is used for velocity estimation, pseudorange is not used it's a dead reckoning solution].
- It can also be optimized to deliver L1 only single frequency solution, L1-L5 dual frequency solution & L1-L5 iono-free solution
- The measurements are weighted based on carrier to noise ratio (CNO -> signal quality), meaning weight is directly proportional to CNO.
- The user can record detailed data in ASCII text format for position, Ephemeris & other raw data.
- The user can also record raw data in RINEX v3.01 format meant for post processing & other research purposes.

Satellites

	Visible		Trackable		Used	
	L1/L5	L1/L5	L1/L5	L1/L5	L1/L5	L1/L5
GPS	11	3	7	1	6	1
GALILEO	10	6	6	6	2	2
BEIDOU	9	0	6	0	4	0
GLONASS	6	0	1	0	0	0

Coordinates Estimation

Cartesian		Geographic	
X : 4343234.553	Latitude	: 47.15602723	
Y : -124269.808	Longitude	: -1.63891529	
Z : 4653605.845	Altitude	: 38.812	

Velocity (m/s)	GDOP
E : 0 N : 0 U : -0	2.1

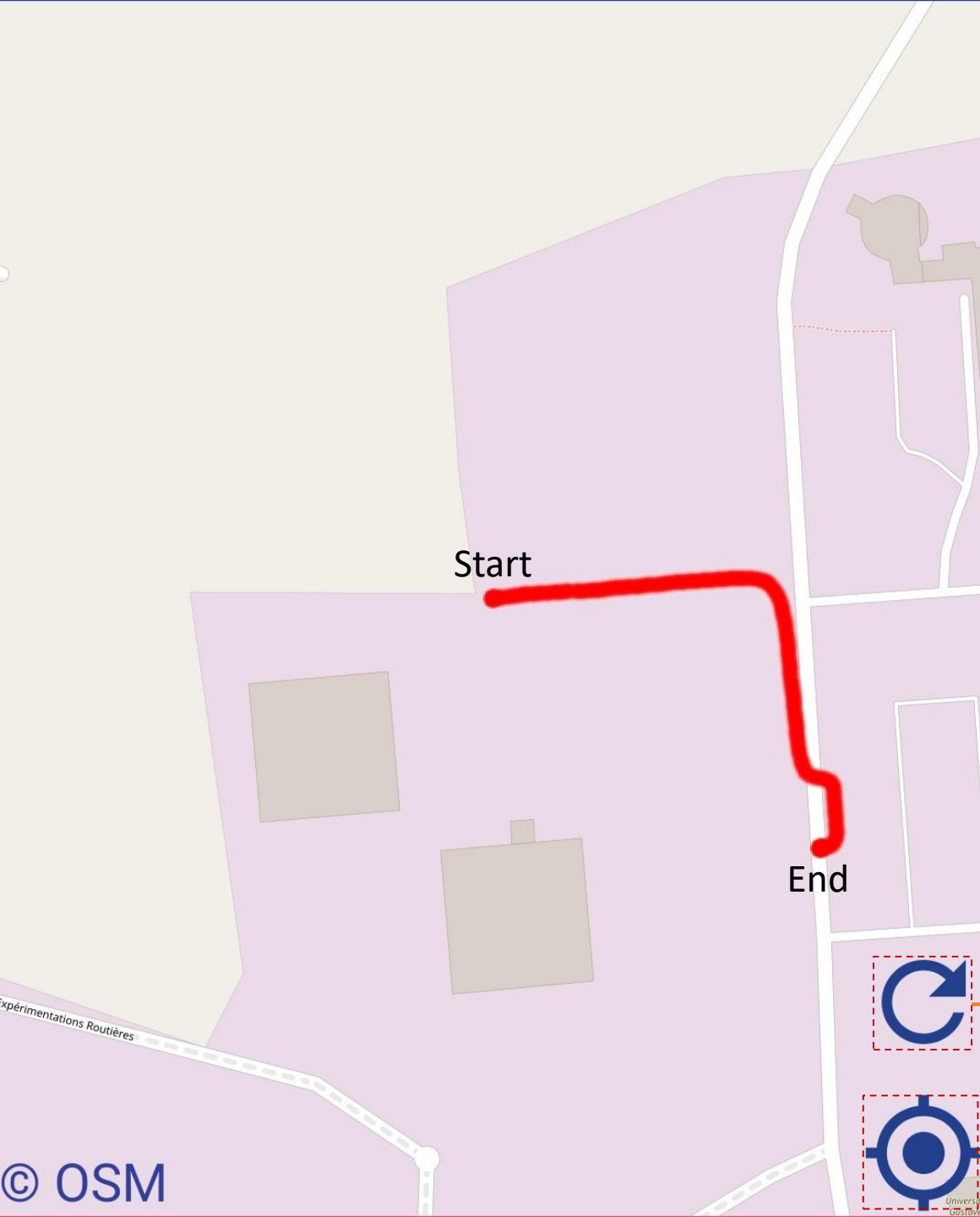
Time

UTC : 08:42:31 14/06/2022

Monitor Fragment

2

- Segment of the monitor fragment that displays the constellation status.
- **Visible**: All the available signals irrespective of the carrier to noise ratio (CNO) and elevation of satellites.
- **Trackable**: Total number of signals that can be tracked meaning, CNO is higher than a pre-defined threshold.
- **Used**: Total number of signals used for position computation. Measurements from these signals are characterized by valid pseudorange [m] & valid PseudoRangeRate (PRR) [m/s] .
- Segment of the monitor fragment that displays computed position in geographic & cartesian co-ordinate system.
- In **cartesian** co-ordinate system, the position is indicated by X, Y, Z measured in meters.
- In **geographic** co-ordinate system, the position is indicated by latitude, longitude & height measured in degree, degree & meters respectively.
- Segment of the monitor fragment that displays computed **velocity** along East (E), North (N), Up (U), overall velocity in [m/s] and Geometric Dilution of Precision (**GDOP**) in [m].
- Also, **time** in UTC and the current date.



- In this fragment, the position computed by the Algorithms are displayed on a map.
- Type of map: Open Street Map with “MAPNIK” tile source, which is shown in the picture on the left.
- The user can keep track of the trajectory/route selected from start to end. An example is shown in the figure on the left. This is only possible if the user stays on the map fragment for the entire duration.
- Any switching between fragments results in map refresh & display starts from the current position.

- Button to refresh the map. This will clear the covered trajectory and display starts from the current position.

- Button to navigate to the current position on the map.

Options

Systems GPS GALILEO BEIDOU
 GLONASS

Ephemeris Nav. message RTCM streams

Corrections

RTCM Corrections Troposphere DCB
 Ionosphere

Processing

SPP PPP
 L1 only L1 / L5 Iono-free
 Static(Least Squares) Dynamic(TDCP - EKF)

Phase smoothing Kalman filter

Elevation cutoff 20 ° Noise cutoff 20 dBHz

Options Fragment

4

Segment of the fragment consisting of check buttons to select single / dual / triple constellation solutions.

Segment of the fragment consisting of one radio button indicating the source of ephemeris. In our case it is the data extracted from the signal itself.

Segment of the fragment consisting of two check buttons that allows users to apply atmospheric corrections (Ionosphere & Troposphere) to raw pseudorange measurements.

Segment of the fragment consisting of six radio buttons that allows users to select various processing options such as SPP + L1 only/(L1/L5)/Iono-free + Static (Least Squares)/Dynamic (TDCP-EKF).

Segment of the fragment consisting of two slide bars that allows users to select cutoff values for satellite elevation angle and CN0.

- Default configuration for optimal operation: GPS + Galileo + Beidou, Nav.message, Ionosphere + Troposphere, SPP + L1/L5 + Dynamic, Elevation cutoff = 20 + Noise cutoff = 20 dBHz

Smartphone used for Development

- Xiaomi Mi 8 [1]: An android based smartphone fitted with Broadcom BCM47755 [2] dual frequency, multi-constellation GNSS chipset.
- The chipset is compatible with GPS, Galileo, Beidou, GLONASS, QZSS & SBAS satellite constellations.
- The chipset is capable of receiving GNSS signals operating in two frequency bands namely L1 (1575.42 MHz) and L5 (1176.45 MHz).
- L5 signal compatibility is restricted to GPS & Galileo constellations only.



< About phone

System update >

Device name Mi Phone >

Device model MI 8

MIUI version MIUI Global 11.0.5 | Stable
11.0.5.0(QEAMIXM)

Android version 10 QKQ1.190828.002

Android security patch level 2020-06-01

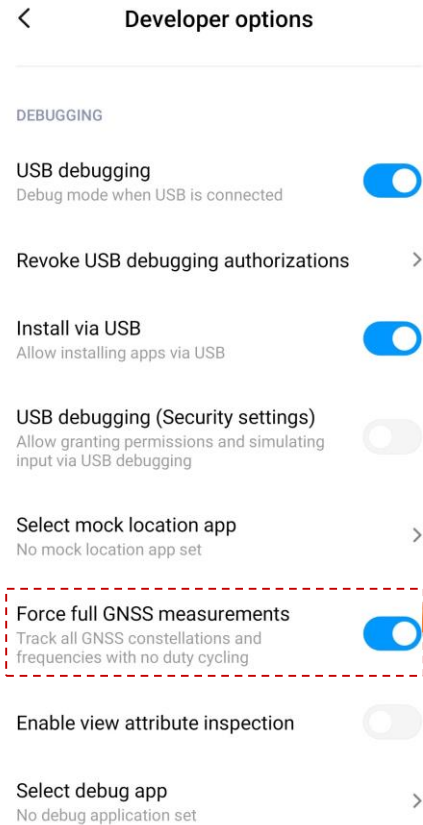
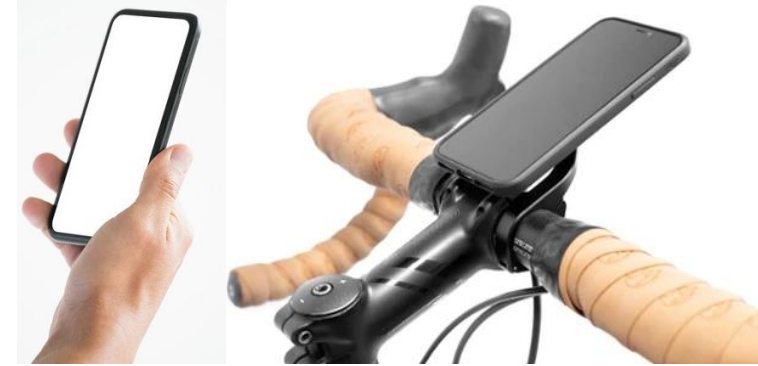
- Android Operating System version 10 was used for development of the app.
- The app was tested on smartphones running Android OS 9 and higher but it should work on smartphones running Android 8.1 (and higher).

Note

- Irrespective of the Android OS the functionality of the app depends on the smartphone' embedded GNSS chipset.
- For instance, on some smartphones the GNSS chipset might be configured to operate only on GPS single frequency (L1 only). In such cases the app works only with GPS.
- In some smartphones the app may not work at all because of configuration issues.
- Bottom line the app works with whatever data that is available from the API whether it is GPS only / GPS + Galileo / GPS + Galileo + Beidou.

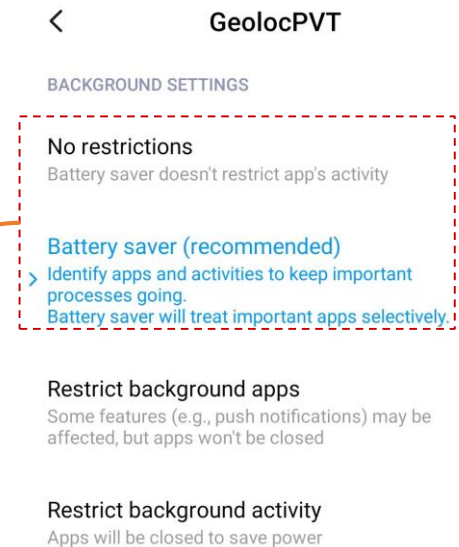
Important Points to Note

- The smartphone should be held in hand or attached to a suitable holder so that the GNSS antenna is not masked.
- Smartphone's location service should be turned "ON" before using the app.



- It is necessary to enable "Force Full GNSS Measurements" option in the developer options
- Enable Developer options, under Debugging section find the above option & enable it.
- Enabling this option allows the app to get continuous measurements without interruption.

- The app' background usage settings should be set to "Battery saver / No restrictions". It is recommended to use "No restrictions" option, but it also works with "Battery saver" option.



Satellites

	Visible		Trackable		Used	
	L1/L5	L1/L5	L1/L5	L1/L5	L1/L5	L1/L5
GPS	4	2	4	2	0	0
GALILEO	0	0	0	0	0	0
BEIDOU	0	0	0	0	0	0
GLONASS	0	0	0	0	0	0

Coordinates Estimation

Cartesian		Geographic	
X: 0.0	Latitude	: 0.000000	
Y: 0.0	Longitude	: 0.000000	
Z: 0.0	Altitude	: 0.000	
Velocity (m/s) 0.0	GDOP		
E: 0.0 N: 0.0 U: 0.0		0.0	

Time

UTC: 00:00:00 11/07/2022

Logger

- Pseudorange Position
 Ephemeris IMU

START

STOP



Monitor



Map



Options

- When the app is launched for the very first time, it requests users permission to access location and storage.
- Without it, the app can't work because GNSS raw data can only be accessed through location API and to store the log files the app needs permission to access storage.
- After successful launch, the default view will be a combination of monitor fragment + logger interface + respective buttons to access one of the three fragments.
- The user can switch between Monitor/Map/Options fragments at anytime during usage.
- It is recommended to switch to the Map fragment & stay there once first position fix is available and start navigating to the desired location.
- To save the data, check one or more of the three available options (Pseudorange, Position and Ephemeris), then press Start. The IMU option is not available at this time.
- The data can be logged only after first position fix is available.
- Users are free to start and stop the logging any time they want.
- This segment of the view is called the logger interface.
- A navigation bar that allows users to navigate/switch between fragments.
- The logger interface & navigation bar are part of the common view for all three fragments.

Example of the Recorded Data

```

3.01 OBSERVATION DATA M: Mixed RINEX VERSION / TYPE
GeolocPVT_V1 GEOLOC/IFSTTAR 17-MAY-22 15:03:34 PGM / RUN BY / DATE
XIMI MARKER NAME
10000M000 MARKER NUMBER
NON_GEODETTIC MARKER TYPE
GEOLOC/IFSTTAR OBSERVER / AGENCY
Xiaomi Mi8 BROADCOM REC # / TYPE / VERS
Xiaomi Mi8 INTEGRATED ANT # / TYPE
0.0000 0.0000 0.0000 APPROX POSITION XYZ
0.0000 0.0000 0.0000 ANTENNA: DELTA H/E/N
1 1 WAVELENGTH FACT L1/2
G 8 C1C L1C D1C S1C C5X L5X D5X S5X SYS / # / OBS TYPES
E 8 C1C L1C D1C S1C C5X L5X D5X S5X SYS / # / OBS TYPES
2022 5 17 13 3 52.9990000 GPS TIME OF FIRST OBS
DBHZ SIGNAL STRENGTH UNIT
END OF HEADER
> 2022 5 17 13 3 52.9999363 0 5
G07 24416509.202 91420.360 826.485 26.550
G18 22907068.866 -490760.246 -3623.506 41.647
G10 22516632.959 270906.754 1964.933 32.379 22516629.062 341134.963 1467.274 26.257
G23 21838530.000 22011.358 118.015 42.215
G27 20320997.366 71563.929 505.044 20.089 20320929.913 72254.671 373.954 26.571

```

Recorded RINEX file

- RINEX Header: containing global information of the entire file [3].
- RINEX Data: Contains pseudorange, carrier phase, doppler shift and signal strength (CNO) for all signals used.
- For more information, please refer to [3].

```

17-05-2022_13-03-33_pos.txt - Notepad
File Edit Format View Help
# Header Description:
# Tow(s),Latitude,Longitude,Altitude(m),Nb of satellites used
# L1/L5, GPS+GALILEO,
219832.999936256, 47.15602281336, -1.64025656747,72.5179, 5
219833.999936256, 47.15602267322, -1.64025673528,72.4767, 5
219834.999936256, 47.15602255307, -1.64025709342,72.4224, 5
219835.999936256, 47.1560223179, -1.64025614836,72.3992, 5
219836.999936256, 47.1560220927, -1.64025584894,72.3605, 5
219837.999936256, 47.15602186831, -1.64025585274,72.3394, 5
219838.999936256, 47.15602167827, -1.64025557584,72.3137, 5
219839.999936256, 47.15602141778, -1.64025559574,72.2765, 5
219840.999936256, 47.15602129072, -1.64025574762,72.2349, 5
219841.999936256, 47.15602102198, -1.64025580048,72.2018, 5
219842.999936256, 47.15602082797, -1.64025514385,72.1916, 5
219843.999936256, 47.15602066003, -1.64025512996,72.1715, 5
219844.999936256, 47.15602048519, -1.64025512503,72.1644, 5
219845.999936256, 47.15602026373, -1.64025522368,72.1419, 5
219846.999936256, 47.15602002544, -1.64025553121,72.1094, 5
219847.999936256, 47.15601974477, -1.64025549357,72.0867, 5
219848.999936256, 47.15601959129, -1.64025555533,72.0529, 5
219849.999936256, NaN,0,NaN, 4
219850.999936256, 47.15601913608, -1.64025610991,72.0195, 5

```

Position estimates tagged with GNSS time stored in an ASCII text file

- GNSS time is the Time of Week (TOW) measured in seconds.
- Latitude & Longitude measured in degrees and altitude in meters.
- Along with number of satellites used for position computation.
- The file also provides information on constellation & signals used for computation. Although a separate file “date_time_configuration.ini” will provide detailed information.
- Filename format: “date_time_parameter.txt”, parameter -> pos, pseudo, satpos, ephem, corr & configuration.ini.
- The app creates a folder “GeolocPVT_Logger” and stores all the files in this folder filtered by date.

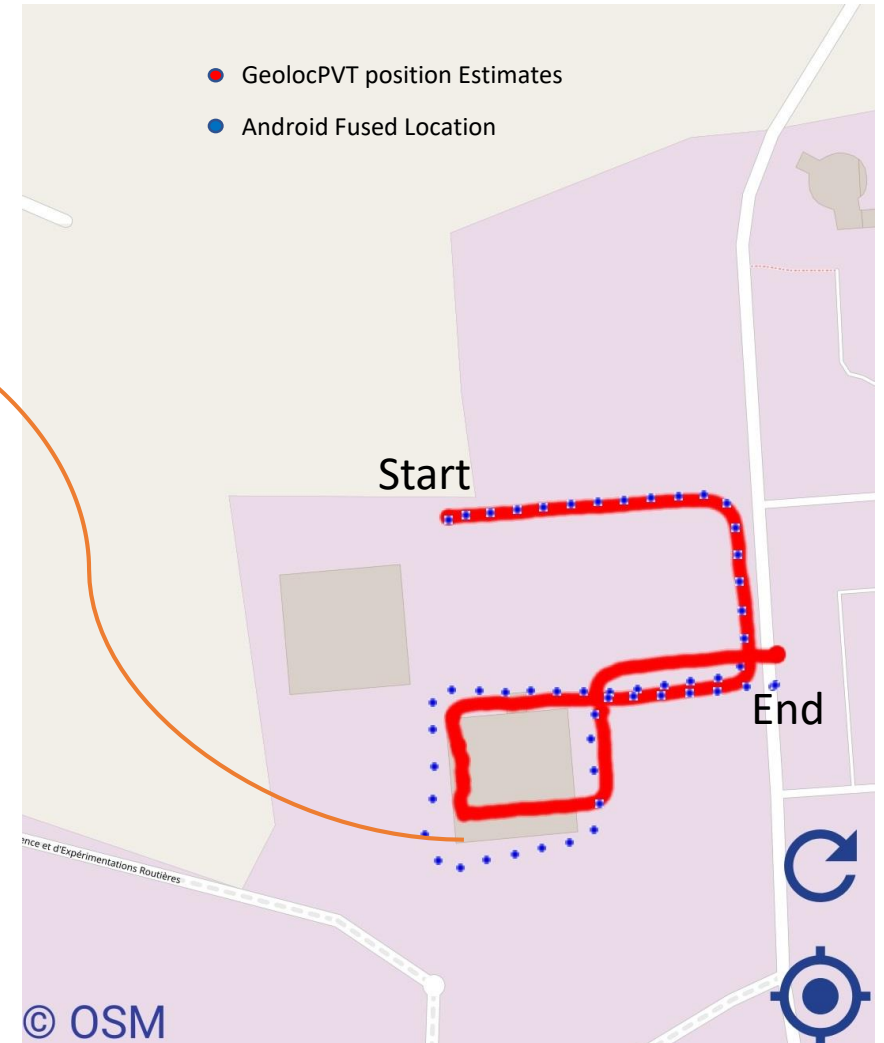
Usage and Limitations

Usage

- After first position fix is available, the app can be used for as long as the user wants.
- To exit the app press the back button twice (pressing it once will display the message “press back again to exit”).

Limitations

- GeolocPVT is a dead reckoning based navigation system which results in drift overtime that persists throughout the duration.
- The app is solely based on the raw measurements coming from the Android location API, so if the measurements are affected it can be clearly seen in the position estimate.
- In deep urban canyon type environments where the measurements are severely affected by the surrounding structures you may experience complete loss of positioning or bad estimates.
- The app works without internet connection but to see the position estimates on a map internet is needed.
- Due to complexity involved in implementing offline maps, this version of the app shall not feature it.
- The app refresh' automatically 30 seconds after first launch because the measurements coming from the API is not usable. This is a temporary fix but the next version of the app will feature a permanent solution.



Required App. Permissions

- Location
- *Storage*

How to Contribute to the Project

- GeolocPVT is an open source application, more information on this project: <https://geoloc.univ-gustave-eiffel.fr/en/hardware/android-application-geolocpvt>
- To participate in the code development: <https://gitlab.com/TeamGEOLOC/geolocpvt>
- Share your comments & queries: geoloc@univ-eiffel.fr

References

- [1] <https://www.mi.com/global/mi8/specs/> -> Scroll to navigation and positioning section
- [2] <https://www.broadcom.com/products/wireless/gnss-gps-socs/bcm47755>
- [3] RINEX Version 3.01 Description <https://kb.igs.org/hc/en-us/articles/115003864627-RINEX-3-01>

Additional Reference:

White Paper on using GNSS Raw Measurements on Android devices

https://www.euspa.europa.eu/system/files/reports/gnss_raw_measurement_web_0.pdf

GeolocPVT project: <https://geoloc.univ-gustave-eiffel.fr/equipements/android-application-geolocpvt>