MAGICGNSS USER TERMINAL MANUAL

MAGICGNSS

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Code:	GMV-magicGNSS-MAN-0002	
Issue:	1	
Revision:	2	
Date:	05 July 2018	
GMV Code:	GMV 20391/18 V3/18	

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DOCUMENT STATUS SHEET

Issue	Revision	Date	Pages	Changes
1	0	2 February 2018	44	First version of the document.
1	1	20 February 2018	44	Second version of the document, including: • Comments coming from the certification process • Comments coming the training process • Comments from internal reviews Other minor editorial changes
1	2	05 July 2018	44	Third version of the document, aligned with FW+SW version 1.10.0, generated for compliance with EMC Directive 2014/30/EU and RoHS2 Directive 2011/65/EU, and forcing Wi-Fi module always on, and Bluetooth module always off.

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1. INTRODUCTION

1.1. PURPOSE AND SCOPE

This guide provides and overview of the most relevant features and basic instructions for setting un and operating the magicGNSS user Terminal for PPP and SBAS solutions and the installed PPP and SBAS User Terminal Applications, in the context of the Australia and New Zealand Test Bed.

About this Manual:

- Please red this manual carefully before using your device.
- Some of the images and screenshots shown in this manual may differ slightly from those of the final product. Likewise, due to firmware updates, it is possible that some of the information in this manual does not correspond exactly to the operation of your device.
- GMV shall not be held liable for any issues relating to performance or incompatibility resulting from modification of the registry settings by the user.

Icon guide:

Danger: This icon indicates situations that could pose a risk to personal safety or health.

Warning: Situations which pose a risk to the correct functioning of the device but not to personal safety or health.

Tip: Additional information to help you get the best out of your device.

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1.2. DOCUMENT OUTLINE

This document is structured as follows:

- Chapter 1 gives an introduction of this document with its scope and outline.
- Chapter 2 contains the *magicGNSS* User Terminal Device User Manual. This section has been prepared by the *magicGNSS* User Terminal Device manufacturer.
- Chapter 3 contains the *magicPPP* User Terminal Application User Manual.
- Chapter 4 contains the *magicSBAS* User Terminal Application User Manual.

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2. *MAGICGNSS* USER TERMINAL DEVICE USER MANUAL

This information applies to the *magicGNSS* User Terminal device, incorporating firmware version 1.8.0.

2.1. BEFORE YOU START

Box Contents

Before using your magicGNSS User Terminal for the first time, please check the contents of the box. If any of the following items are missing, contact GMV:

- magicGNSS User Terminal
- USB (type A) to micro-USB (type A)

Product Overview

Components not included in the packaging:

- Micro-SIM card
- Adaptor
- Antenna

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The SD card element is not currently in use, but could be exploited in future evolutions of the magicGNSS User Terminal device.

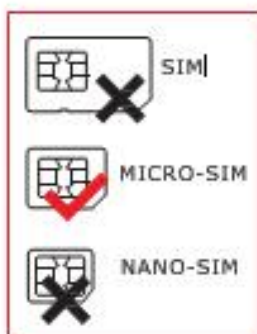## 2.2. GETTING STARTED

<u>Setup Wizard</u>

The first time you switch on your magicGNSS User Terminal, a setup wizard will help you to configure the basic settings for your device:

- Date
- Time

<u>Inserting a SIM card</u>

Your device accepts one micro-SIM card in the slot.

You can access the SIM tray from the exterior of the device.

Remove the cover that protects the micro-SIM and SD slot (located at the right side of your device).

Insert the micro-SIM card into the slot, making sure the metal pins are at the bottom and facing backwards (i.e. towards the back of the device).

Push the card in until you notice a slight click, which indicates that it has been inserted correctly. If the card is not inserted correctly, the device may not recognise it and its content will not be available.

Make sure you replace the protective cover so that dust and dirt cannot enter the device, and to avoid accidentally ejecting the micro-SIM card.

To remove the micro-SIM card, follow the steps above in reverse. Pushing the card in until you notice a slight click. This action will extract the card with your fingers.

Make sure you replace the protective cover so that dust and dirt cannot enter the device, and to avoid accidentally ejecting the micro-SIM card.

⚠ Your magicGNSS User Terminal only accepts micro-SIM card.

The SIM card can be provided by a local cellular network service provider.

⚠ To prevent damaging the equipment insert/remove the micro-SIM card carefully.

Switching the Device On and Off

To switch on your magicGNSS User Terminal press and hold down the power button located on the top of the device for a few seconds.

To switch off your device, hold down the power button for a few seconds. Select **Power off**.

If you have inserted micro-SIM card into your device, you will need to enter the PIN when you switch it on. Every time your device detects a new SIM, a pop-up window will appear informing you to enter the new PIN.


✎ If you briefly press the power button, the screen will switch off but not the device.

Charging the device

Your magicGNSS User Terminal contains a rechargeable (non-removable) 3100 mAh battery, which is charged via the micro-USB port located at the right side of the device. A USB (type A) to micro-USB (type A) cable is provided with the device for charging the battery. To charge it, follow these simple steps:

    a. Using a mains adapter (not included):
        1. Plug the USB cable into the mains adapter.
        2. Connect the mains adapter to any standard plug socket (220 V/50 Hz).
        3. Connect the other end of the cable to the micro-USB port on your device.

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b. Using a laptop or desktop computer:
   1. Connect the USB cable to a compatible USB port on your computer.
   2. Connect the other end of the cable to the micro-USB port on your device.
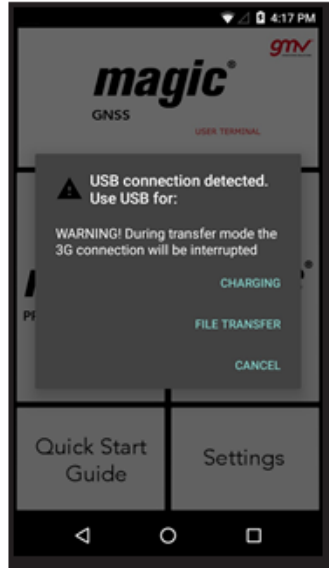
(!) For optimum charging, we recommend using a 5 V 2.1 A charger with your device.

(!) If you foresee that the remaining battery charge could be not enough for completing the SBAS/PPP process, we recommend to connect the device to an external power source and to select the "charge" option before starting the SBAS/PPP execution.

Charging times and recommendations

The battery in your magicGNSS User Terminal is non-removable. If it is removed by anyone other than the magicGNSS User Terminal Technical Support your device could be damaged and the Warranty invalidated.

Allowing the battery to charge fully (approx. 2h 30 min) is recommended when you charge it for the first time as this will help calibrate the battery meter. Bear in mind that some batteries perform better after completing a number of charge/ discharge cycles.

The battery can be charged and discharged hundreds of times, but it will eventually wear out. Use and standby times are estimates only.

Charging times		
USB output port	**Performance**	**Supply time**
5V 2A	UT Device power OFF	143 min
5V 2A	UT Device ON– screen OFF	146 min
5V 1A	UT Device ON– screen OFF	320 min

Battery autonomy	
Performance	**Supply time**
UT Device ON, screen ON, NovAtel ON	120 min

(!) Note: Estimated times using NovAtel card operating and consuming but without a GPS antenna connection.

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The time required to charge your device may vary slightly depending on whether it is charged via the mains adapter or via a computer USB port, affected by, for example, device settings, features being used, battery condition, and temperature.

If you are going to perform a test and to avoid interrupting the work in the middle of the process, keep in mind the following recommendations. Anticipate the duration of the test, and if you foresee that you can exceed the autonomy time of the device (2 h max performance) and will not have a plug nearby, we suggest the use of Powerbanks as an external support.

If the battery is completely discharged, it may take several minutes before the charging indicator is displayed. When your charger is not in use, unplug it from the electrical plug and the device. Do not leave a fully charged battery connected to a charger, as overcharging may shorten the battery's lifetime. If left unused, a fully charged battery will lose its charge over time.

Transferring Files

If you connect your device to a computer using the USB cable, you can also transfer files between the two devices to/from the internal memory. This will allow you to use, copy or store data, images and text documents on one or both devices.

You can select the file transfer mode when you connect your magicGNSS User Terminal to a computer.
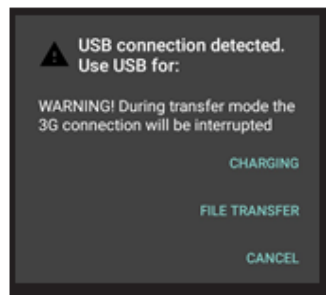
There are a number of ways to transfer files. The steps below will show you how to transfer them via USB:

1. Connect your magicGNSS User Terminal to a computer using the micro-USB to USB cable provided. Insert the micro-USB connector into the corresponding micro-USB port on the device and the generic USB connector into the corresponding USB port on the computer.
2. Select and copy the desired files onto your device or computer.

3G connection will be interrupted during transfer mode. To recover the 3G connection, it is necessary to finish the file transfer process. Once you disconnect USB cable, PIN code will be required.

After having suspended the 3G connection, caused by file transfer mode, it may take up to 1 minute since the USB is disconnected until it is reconnected to the 3G network.

The first time you want to transfer files from your device to a computer running Windows and vice versa, Windows will attempt to install the relevant drivers. Go to Device manager > magicGNSS, select Update driver / Search Driver software manually. From the common hardware list choose Portable devices and select **USB MTP device**.

To transfer files from your device to a computer running Mac OS and vice versa, you will need to download and install the free **Android File Transfer** app to your computer: www.android.com/filetransfer/.

It could be the case that the latest sessions stored on the internal memory seemed to be non-accessible from the USB port. In that case, please turn-off and then turn-on (reboot) the magicGNSS User Terminal device, connect the USB and select the "transfer" mode, and the stored sessions and files will be made accessible.

Do not disconnect the cable while files are being transferred.

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Learning to Use the Multi-Touch Screen

Touch. Touch the screen briefly to select an icon, open an app, activate a text-entry box, etc.

Touch and hold. Touch the screen and hold for approximately 2 seconds to display the menu of available options.
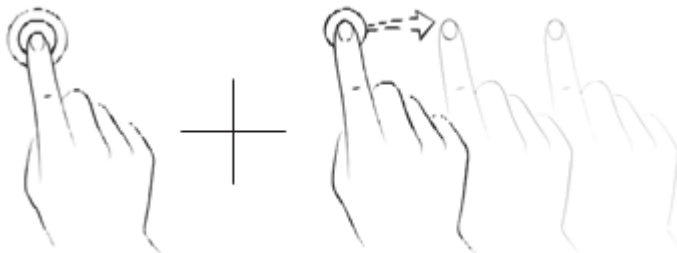
Drag. To move an icon, press and hold down, drag it to the desired position and then release.

Swipe or slide. Press briefly on the Home screen and slide your finger left or right across it to access the extended screens, or slide your finger up and down the screen to scroll through a website, list or menu.
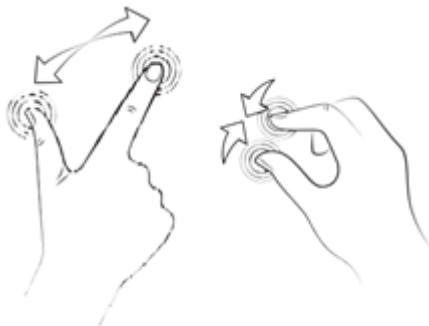
Pinch. Place two fingers on the screen at the same time and move them towards one another or spread them apart to reduce or enlarge an image.

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2.3. HOME SCREEN

Adjusting Screen Rotation

For some apps, the screen will rotate automatically from portrait (vertical) to landscape (horizontal) mode and vice versa, depending on how you are holding your device. To lock the screen rotation, go to *Settings > Display > When device is rotated* and select *Stay in current orientation*.
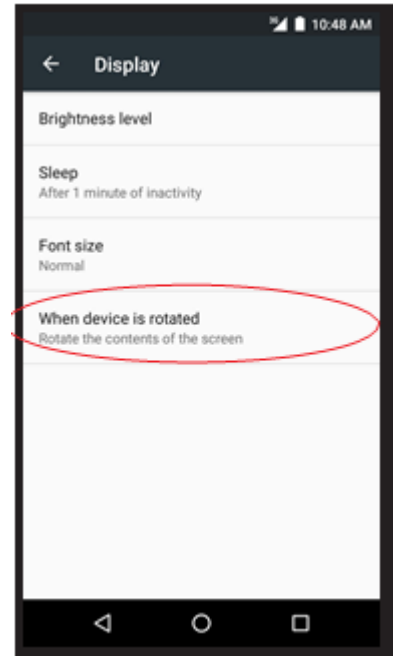
Buttons and Icons

The navbar is shown by default on screen to enable you to navigate through your device more easily.

When using an app, you can return to the previous screen by pressing the **Back** icon ◁.

You can go to the **Home screen** at any time by pressing the Home button ○.

You can access the recent applications list by pressing the **Menu** button □.

Screen Lock

Your device screen will lock itself automatically by default after a prolonged period of inactivity. To configure the screen timeout interval, go to Settings > Display > Sleep and select the desired interval. The default setting time is 1 min. To switch the screen off manually, press the power button briefly.

Having the screen switched off will help to improve battery life reducing power consumption.

Having the screen switched off will help to reduce power consumption without affecting GPS performance, device is able to maintain GPS communications with the screen locked.

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Status Bar

The Status bar contains important information on the device and is always visible at the top of the screen:
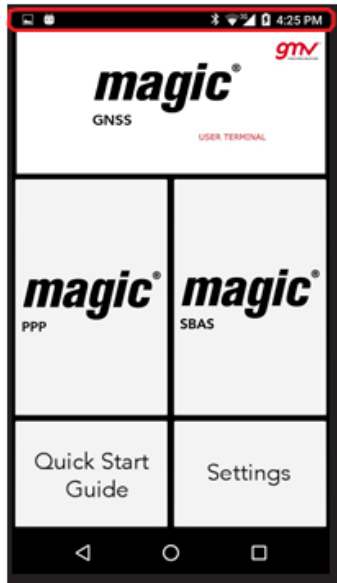
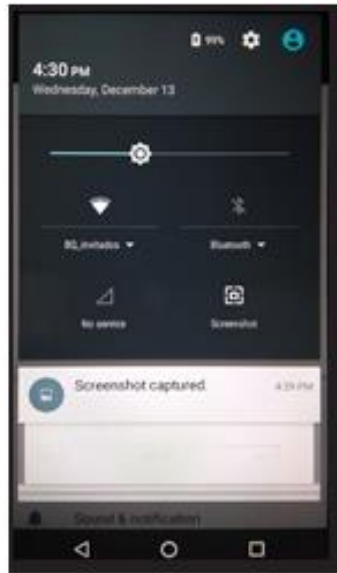|	
	Battery almost empty.
	Battery charging.
	Battery fully charged.
	Wi-Fi enabled and connected to a network.
	Data services enabled (this could be H+, H, 3G, E or G, according to the type of data connection and transfer speed).
	USB connected.

Notifications Bar

To view your notifications, pull the bar down with one finger. Delete all notifications by pressing the icon, or delete them individually by swiping them to the side. Using the icon, you can access the other quick settings and the multi-user option. You can also access this screen by swiping the top bar down with two fingers. The notifications and quick settings have now been integrated into one screen. To go back to the Home screen, slide the bar upwards.

When you swipe the bar down with two fingers, a list of options appears providing quick and easy access to many settings.

The following options can be enabled/

disabled via the pull-down menu:

	Wi-Fi: Allows the selection of the Wi-Fi network.
	SIM: SIM data usage check.
	Screenshot: Take a picture of the screen via the pull-down menu.

Swipe with one finger   Swipe with two fingers

You can access advanced settings for certain functions such as Wi-Fi by touching and holding the corresponding icon on the list.

When automatic brightness is deactivated, you can adjust the brightness level of the screen by sliding your finger to the left or right.

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Keyboard

Pressing on any text field will bring up the virtual keyboard.
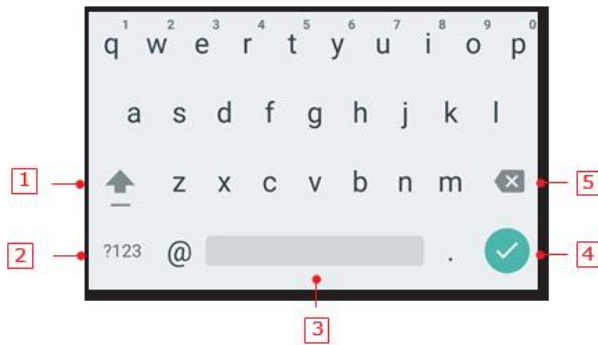
1	Enable/disable caps lock.
2	Change from letters to numbers and symbols, or vice versa.
3	Space.
4	Enter/return.
5	Delete.

The keyboard options may vary depending on which application you are using.

You can find more information on the keyboard settings and languages for text entry via *Settings > Personal > Language & input.*

2.4. SETTINGS

Wi-Fi and Network Settings

Wi-Fi

Go to Settings > Wireless and networks > Wi-Fi.

The Wi-Fi is always enabled. Your device will automatically search for and display a list of available Wi-Fi networks, which updates automatically.
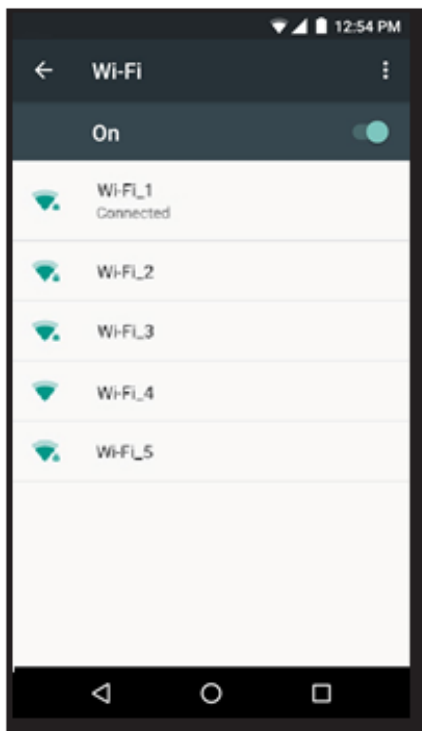
Press the name of the network you want to connect to, enter the password if necessary and press Connect. If it connects successfully, **Connected** will appear below the name of the network.

We recommend selecting the **Show password** option beforehand, so that you can write it quickly and correctly.

The device will automatically connect to the chosen network. Your device will notify you when it detects a network that you have never configured.

Select *Settings > Wi-Fi* to access and configure, tap the icon and select **Advanced Settings**.

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✳ ◯ Data Usage

In this section, you can view each application's statistics for data transfers via Wi-Fi or mobile internet.

You can also **Restrict background data**, **Show data consumption** on the Lock screen and see how much data is consumed by the various resources.

You can also set a limit to mobile data usage. If you set a limit for mobile data usage, the data connection will be disabled once this limit has been reached.

To access Advanced settings, press the ⋮ icon. Here you can turn-off **Auto sync data**, **Show Wi-Fi usage**, **Disable networks** and access **Cellular networks** for which you can enable data roaming.
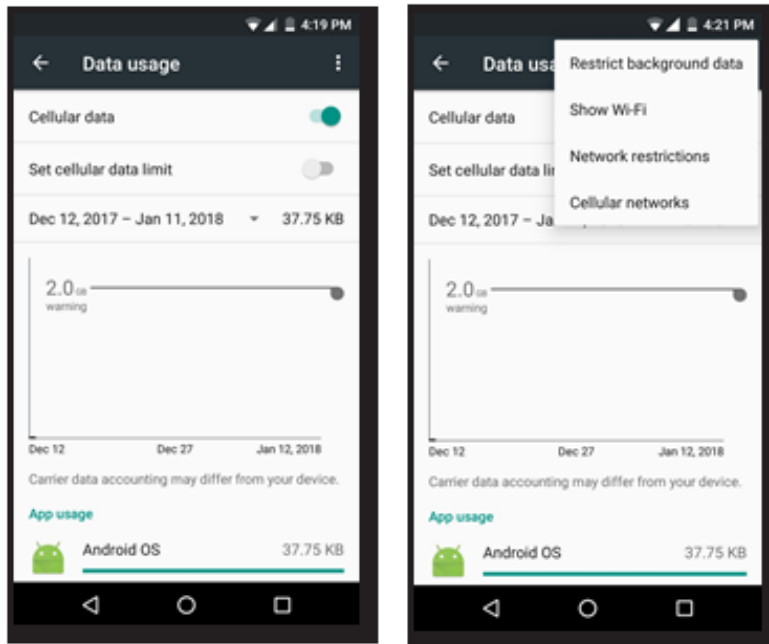
••• More

Here you can enable the following:

Tethering and portable hotspots: You can convert your device into a Wi-Fi or USB access point to share the connection with one or multiple devices.

Cellular networks: Access the settings where you can enable data roaming, select the preferred network type, set up the APN and select a network operator.

Emergency broadcasts: Displays the emergency alerts that you have selected.

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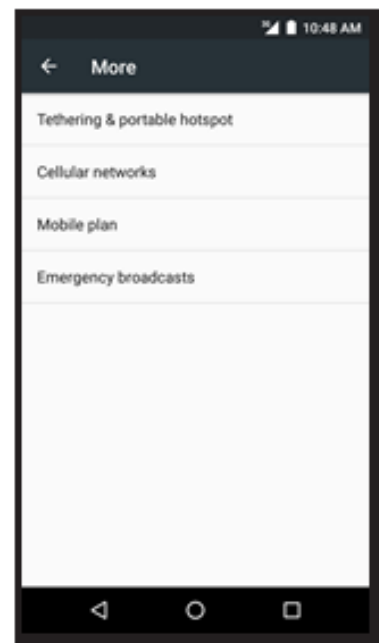
Device Settings

Display

Brightness level: Adjusts the brightness of your screen.

Sleep: Sets the time delay before the screen automatically switches off.

Font Size: Changes the size of the characters (there are four different sizes to choose from).

When device is rotated: Enables or disables automatic screen rotation when you turn your device sideways.
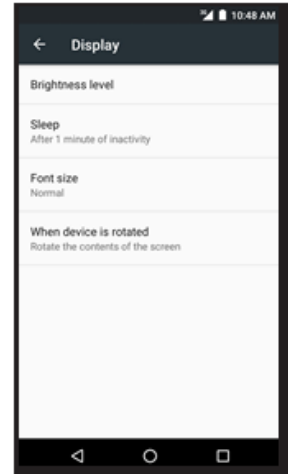
Sound and Notifications
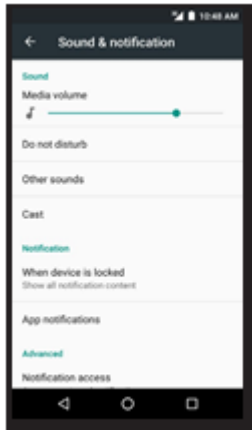
You can adjust the **volume** of your device. To do this, slide the bar to the right or to the left.

Here you can set up notifications sounds and configure the priority of your notifications and create automatic rules. Rules are used to set 'do not disturb' times or events according to your personal circumstances.

Storage and USB
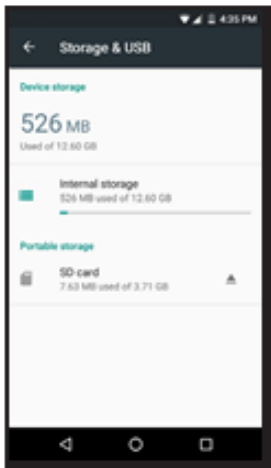
You can query the total and used amount of space on the device. The amount of space taken up by each file type is listed below this information.

This setting includes an internal file browser to explore the contents of your device's internal storage without having to use an external file manager. You can access this browser via *Settings > Storage and USB > Internal storage > Explore*. You can use this file manager to open, delete and copy content to other folders.

- You can delete a file by pressing and holding your finger down on it then tap the 🗑 icon that appears.

- · To share a file, tap ⋮, select **Copy to...** and then select the location where you want to copy it.

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🌐 Language and Input

Here you can set up the system language, activate the spell checker and the personal dictionary. You can also configure the keyboard, text input methods, and pointer speed.

☁ Reset and Storage Mode

Here you can **reset all network settings**, carry out a **factory data reset** and **storage shutdown mode** to use in case we need to maintain the device shutdown for a long period of time.
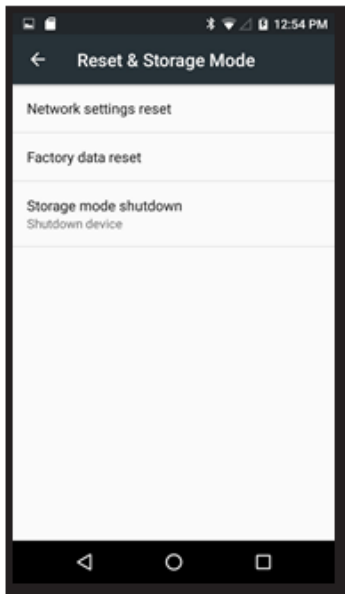
Storage mode shutdown:

It is highly recommended to use storage mode when the device is going to be switched off for a long period of time. Battery life is notably lengthened in such a scenario.

After selecting this shutdown mode, the device must be switched on following these steps:

1. Connect the device to a power supply (mains or a PC microUSB)
2. Press the Power ON button
1. 3. Basic settings (Date and Time) will be required to reconfigure after using this storage mode.

⚠ Just use Storage mode shutdown option if you aren´t going to use the device for a long period of time. To switch off your device hold down the power button for a few seconds and select Power off.

If you restore your device to factory default settings you will delete all the installed programs and apps. It is recommended to save all multimedia files and make backup copies before restoring your device to the factory default settings.

<u>System Settings</u>

🕐 Date and Time
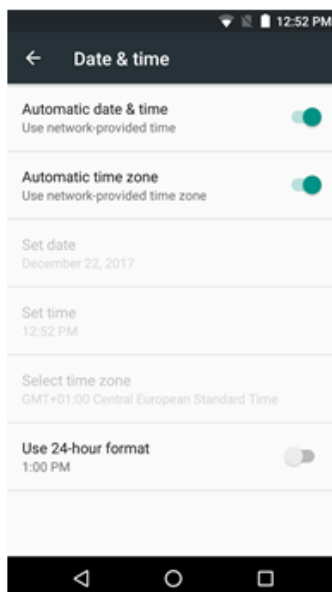
Automatic date & time: Adjusts the time automatically based on location information or the mobile network. Disabling this option will activate manual date and time configuration.

Automatic time zone: Enables/disables the automatic time zone provided by the network. Disabling this means that the Select time zone option will have to be manually configured.

Use 24-hour format: Enables/disables the 24-hour time display format.

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(i) About Device

This section displays the status of the device (battery, SIM data, serial number, etc.), legal information, Android version, model number, baseband, kernel versions and the build number. Here you can manually check for updates (for more information on firmware updates go to **OTA Updates**).

> If you need assistance, you probably need to provide the serial number of the device. You can find it in the original package of your product, or you can also check it on your device by going to *Settings > About phone > Status > Serial Number*.

2.5. TIPS

OTA Updates

OTA stands for "Over the Air", which refers to the way that firmware updates are sent to your device; i.e. via your data connection or Wi-Fi, with minimal intervention required on the part of the user and without the need for complex update procedures.

Having autocheck option activated your device will periodically check for new updates to the operating system (autocheck option is activated by default). If it were not enabled by going to *Settings > About phone > System updates > Update*, this action would have to be done manually. These usually include performance improvements or additional features for your magicGNSS User Terminal.

When the system detects that an update is available, a pop-up window will notify you of this and will request confirmation to install it. We recommend using a Wi- Fi connection to download the update package.

The system will guide you through the installation process to ensure that it is completed as quickly and conveniently as possible. You can also check for updates manually by going to *Settings > About phone > System updates > Update*. A message will appear informing you that the system is searching for available updates. If an update exists, the installation process is the same as described previously.
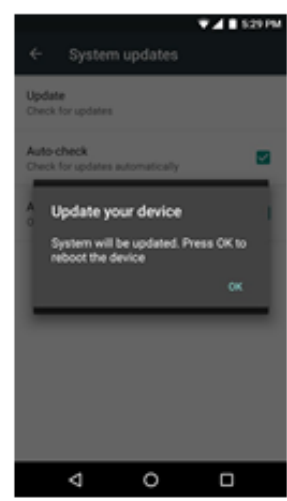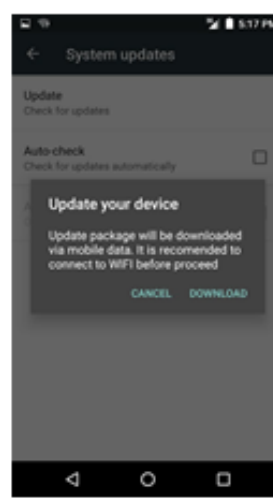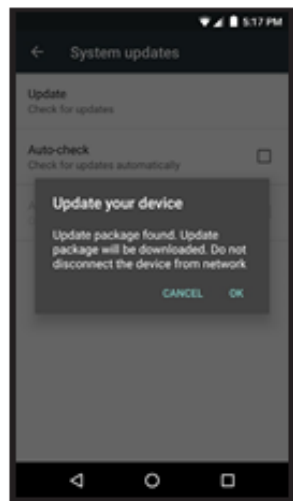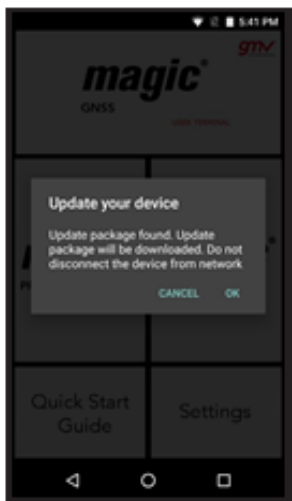
> (!) It is necessary to have connectivity (Wi-Fi or 3G) so that the device can perform the verification update task autonomously.

> (!) If you have a SIM inserted and you are not connected to Wi-Fi, it will allow you to download the OTA by using data but authorization will be requested.
>
> As OTA package is a big a pop up notification will suggest to connect it to the Wi-Fi service to avoid data consumption.

> (!) To complete the update successfully it is necessary to have 30% of battery. If the battery percentage it´s below that value, the process won´t be completed, and a pop-up will request to charge the device.

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2.6. APPENDICES

<u>Appendix A: Cleaning and Safety</u>

Cleaning:

Before cleaning your device, make sure you have switched it off and disconnected all cables and power. After cleaning, make sure the screen is completely dry before reconnecting any cables and switching the device back on. Do not pour or spray any liquids directly onto the device.

Screen: Use a clean, soft, lint-free cloth to remove dust and dirt from the screen. To remove fingerprints and marks, you may apply a small amount of mild cleaning product to the cloth.

Casing: Use a soft cloth with a small amount of mild cleaning product. After cleaning, rinse the cloth in clean water, wring it out thoroughly and wipe the casing to remove any leftover cleaning product.

Safety:

To reduce the risk of an accident, follow these safety instructions:

- Do not use power cables, connectors or plugs that are damaged or contain loose wiring. Do not bend or damage the power cable. Do not touch the power cable with wet hands. Do not pull on the cable to unplug the charger.
- Do not pour or spray any liquids directly onto the device. This device is not water resistant.
- Do not hit the device or cause it to fall.
- You can use the device when you are charging even though the battery will take longer to charge fully. Avoid handling the device with wet hands when charging.
- Do not hit the charger or cause it to fall. For optimum charging, we recommend using a 5 V 2.1 A charger.
- Do not use the device during electrical storms.
- Do not handle Li-ion batteries that are damaged or leaking.
- Your magicGNSS User Terminal contains a rechargeable non-removable battery. The device has a warranty seal, please avoid opening the device cause will invalid the warranty. Defects caused by the fact that the battery has been subjected to a short circuit or the seals on the battery have been broken or show evidence of manipulation will invalid the warranty.
- Do not use the device in the vicinity of a pacemaker. If possible, try to use it at a distance of at least 15 cm from the pacemaker, as it could interfere with the pacemaker's operation. Hold the device on the opposite side to the implant when operating it ⚠.
- Do not use the device in a hospital or in the vicinity of any medical equipment that may be susceptible to radio frequency interference.
- If you regularly use medical equipment, make sure it is protected against radio frequency interference.
- In potentially explosive environments, switch the device off. Always observe regulations, instructions and warning signs ⚠.
- Do not use the device in refuelling areas (e.g. petrol stations), underground parking zones or in the vicinity of flammable and/or explosive chemical products ⚠.
- Do not store or transport flammable liquids, gases or explosive materials in the same compartment as the device or any of its parts or accessories ⚠.
- Switch off the device upon boarding an aeroplane. The electronic components of a motor vehicle may malfunction as a result of radio frequency interference from the device.
- Avoid placing the device near the abdominal and genital area, and in particular pregnant women, children and adolescents ⚠.
- Using or handling a device whilst driving a land motor vehicle is strictly prohibited.
- Use the GNSS function with caution and ensure you are not distracted while driving.
- The use of your device in good reception conditions reduces the amount of signals received. To ensure good reception parameters, check the coverage icon ◢ on the screen.
- This device is designed to operate within a temperature range of -5 to 45 ºC. As this is a high-technology device, extreme climatic conditions have a negative impact on its operation. We advise against using it in ambient temperatures under -5 ºC or above 40 ºC. Doing so may

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cause faults or damage to the device (or even explosions in more extreme cases). It is also inadvisable to use it continually at the limits of this range (internal or ambient temperature under 0 ºC, for example) or in adverse climatic conditions as this may cause performance drops that temporarily affect device functionality and battery life.

Warning!
This product must be used with a power supply with the following specifications:
INPUT: 100-240 V ~ 50/60 Hz   0.3 A máx.
OUTPUT: 5.0 V ⎓ 2.1 A
Polarity must be set as follows:

Micro-USB

Pin 1 "+"
Pin 5 "-"

The use of power sources other than those indicated may damage your device and pose a Risk to the safety of people and property.

Appendix B: Disposing of this Product Correctly

| | (Electrical and electronic waste). |
| | (Applies within the European Union and in European countries with selective waste collection systems). |

If this symbol is on the product, or any of its accessories or informative material, this means that when it reaches the end of its useful life, you must not throw away the product or its electrical accessories (charger, cables, etc.) with domestic waste.

To prevent any damage to the environment or human health, separate these products from other types of waste and recycle them correctly. If you do this you are encouraging the sustainable recycling of material resources and preventing finite resources from depleting.

Domestic users should contact the vendor that they purchased the product from or the relevant local authorities to find out how and where they can recycle this product safely, without harming the environment.

Business users should contact their supplier and consult the terms and conditions of the purchase agreement. This product and its electronic accessories should not be disposed of with other commercial waste.

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3. *MAGICPPP* CLIENT APPLICATION USER MANUAL

3.1. THE MAGICPPP OVERVIEW

The *magicPPP* client application installed in the magicGNSS User Terminal device is a flexible SW tool providing real-time PPP solutions. It processes real-time observations provided by the built-in GNSS receiver or remote data sources, and navigation data and real-time corrections obtained from different provision channels. The *magicPPP* engine generates a real-time PPP solution in the ITRF14 reference frame, together with other complementary and ancillary outputs.

3.2. FIRST STEPS WITH MAGICPPP

magicPPP User Terminal application first launch will show to the user the Status and Control panel of the application. This view allows the selection of the receiver to be used, launch the application, recording sessions and visualize the status of the processing. In other words, it allows to perform most of the typical operations performed during the test execution.
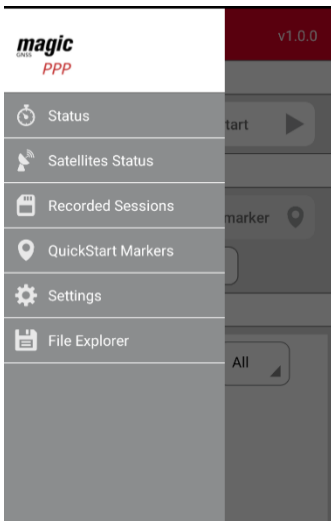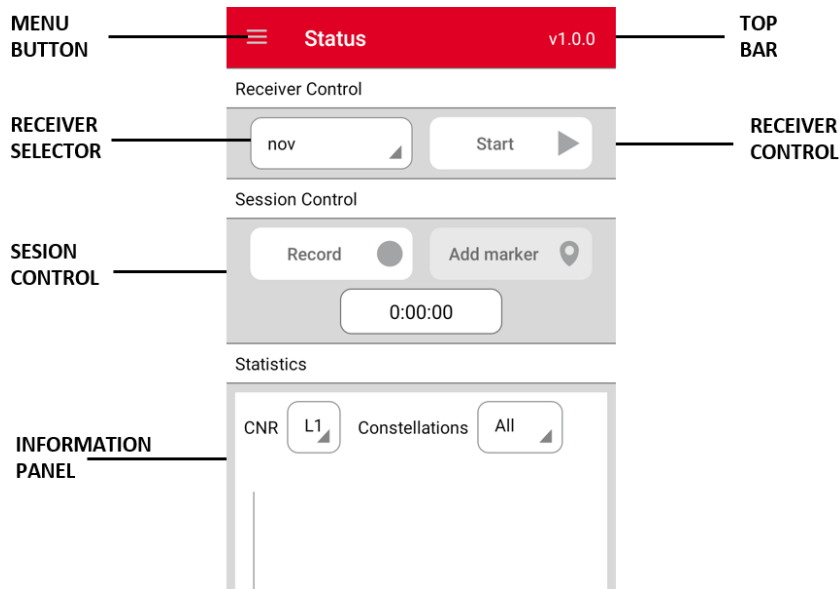
Top Bar and Menu Button

The application top bar indicates the view being visualized in each moment, the version of the application under execution and in the top-left the Menu Button (▤) can be found.

The Menu Button (▤) is a key element for the customer since it allows to navigate through the different control, configuration and monitoring panels of the application, mainly:

1. Status and Control
2. Satellite Status
3. Recorded Sessions
4. QuickStart Markers
5. Settings
6. File Explorer

The features and capabilities of each view are described below.

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Status and Control View

The status and control view is divided into two sub frames. The top subframe - called the control panel - allows the user to select one of the configured receivers as well as launching and stopping the PPP processing. Once the session is running operator can start/stop recording the session and store specific positioning markers in the application memory to be later used and exported. Record the session means making positions available for being exported to a KML file and having the option to save some them as markers. Output files are generated and stored even if the Record option has not been activated.

The bottom subframe is used to present information about the processing in real time. In particular it contains five different visualizations:

1. PPP processing status
2. Receiver Observations CNR
3. User skyplot
4. PPP Horizontal Displacement
5. PPP Vertical Displacement
6. PPP Protection Levels
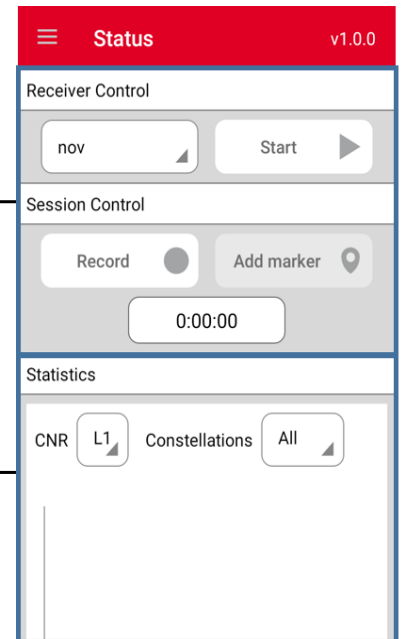
The user can browse between the different option of the bottom frame just sliding left and right the frame view.

Statistics. Last update: 7:32:14 AM

PPP Status	OK
SBAS Link	MT 26
Lat	-37.80386495
Long	144.96682199
Alt [m]	62.944
Time	07:32:14
Satellites	5
PL Hor [cm]	637.3
PL Ver [cm]	1002.4

The PPP Status Summary presents the evolution of the PPP solution in real-time. The following fields are depicted:

- **PPP Status** provides a global indicator of the PPP processing (e.g.: Ok, Missing orbits, low number of corrections)
- **SBAS Link** provides a global indicator of the SBAS (GEO or SISNET) status
- **Latitude** presents the positioning latitude for the last processed epoch
- **Longitude** presents the positioning longitude for the last processed epoch
- **Altitude** presents the positioning altitude for the last processed epoch
- **Time** provides the GPSt (Global Positioning System time) of the last processed epoch
- **Satellites** shows the number of satellites used in the last processed epoch
- **PL Horizontal** indicates the horizontal protection level
- **PV Vertical** indicates the vertical protection level

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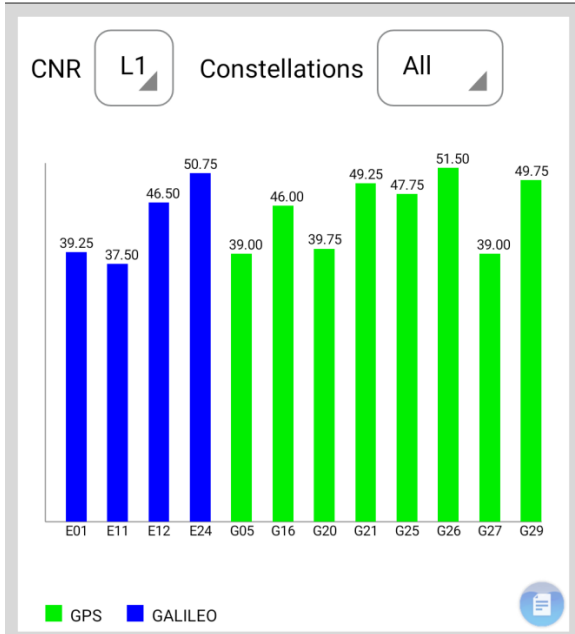
Statistics

The CNR (Carrier-to Noise Ratio) frame shows the CNR values for each satellite in view being processed by the PPP. The CNR for the different avaiable frequencies can be chosen i.e L1, L2, L5.

Statistics
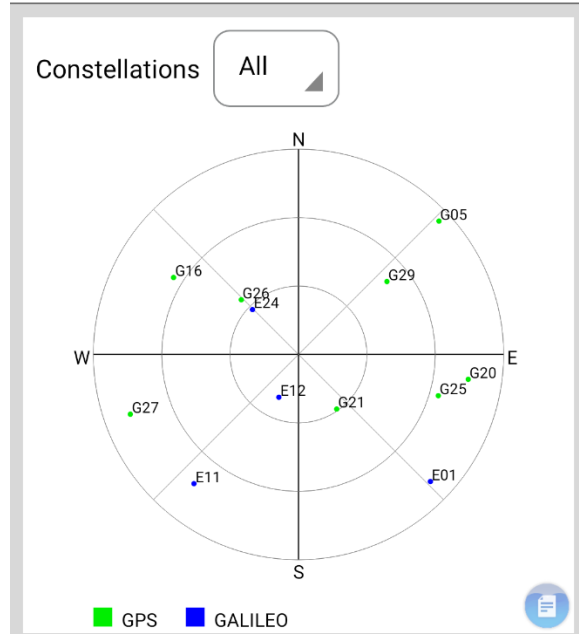
The skyplot shows the geometry distribution of the satellites in the sky (azimuth and elevation for each of them).

Statistics. Last update: 12:35:36 AM
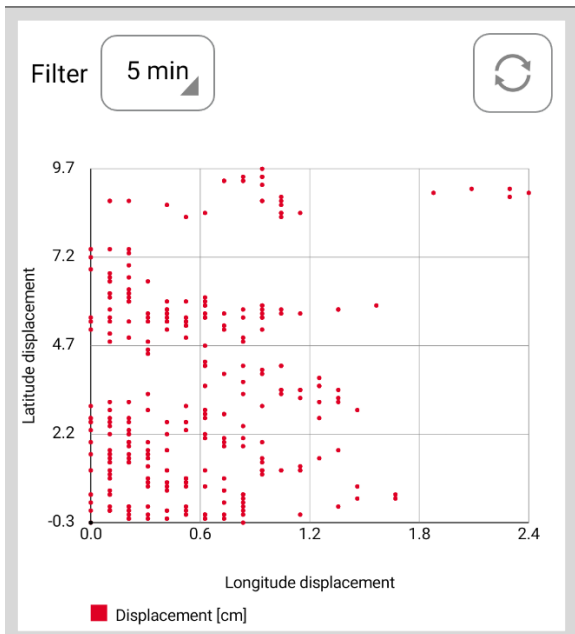
The horizontal displacement frame shows a sliding window with the displacement for the latest epochs. The number of epochs can be filtered by the user through the time of the sliding window.

Statistics. Last update: 12:35:31 AM
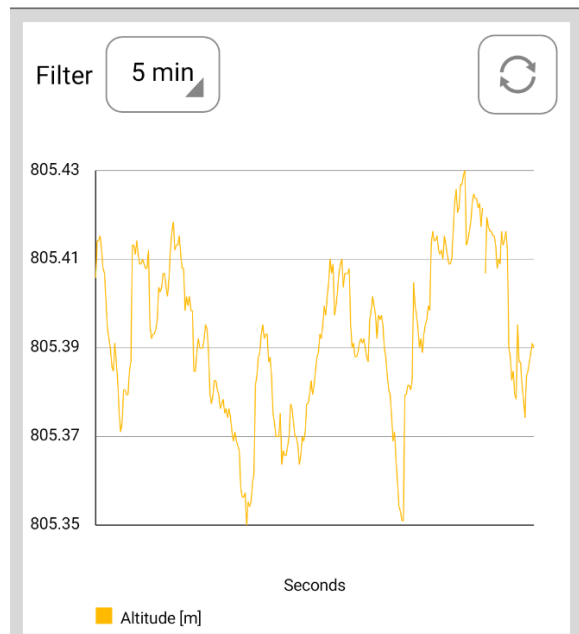
The vertical displacement frame shows a sliding window with the vertical evolution for the latest epochs. The number of epochs shown can be filtered by the user through the time of the sliding window.

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Statistics. Last update: 12:35:02 AM
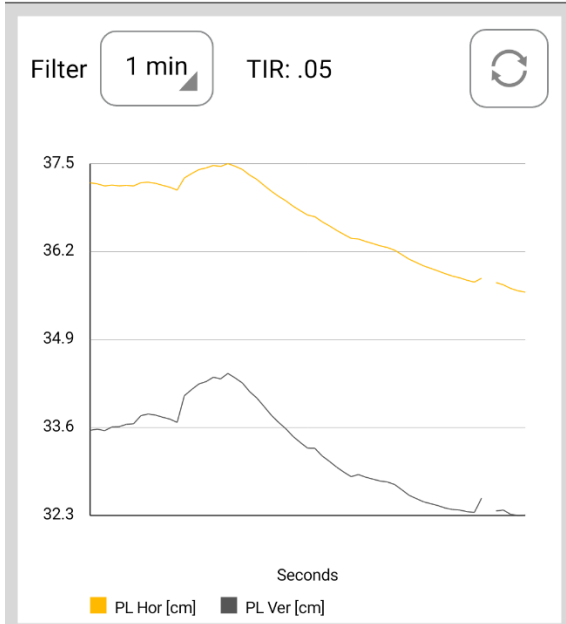
The protections level frame presents the horizontal and vertical protection levels calculated for a given Target Integrity Risk (TIR), in the example 0.05.

Target Integrity Risk value can be configured in the settings tab by the user previous to the execution start. Note that different applications may require different TIR, so a TIR of 0.05 is noticeably less restrictive than a TIR of 0.001.

The refresh button allows the user to delete all previous positions/PLs and consider subsequent positions/PLs only for being plotted. This action cannot be undone, in the sense that once the refresh button has been touched, deleted position/PL cannot be recovered for being plotted. However, they are still available in the output position files.

Satellite Status

Satellite status view provides the real time status of the PPP processing in a per satellite basis. In this sense the view presents a grid with all the satellites in operation per constellation, and highlights the satellites with different colours depending on the status at the last processed epoch. The legend distinguishes between four different status:

- No observation: Typically this happens when the satellite is not in view or the signal status flag is not healthy. This satellite is not used in the PPP computation.
- Observation available: Observations for the satellite are received, but no valid navigation data is available, hence the satellite cannot be used in the PPP processing.
- Observation and Navigation available: Observations and valid navigation is available for the satellite, nevertheless there is not corrections to augment the orbit and clock. In this conditions the satellite is not used in the PPP processing.
- Observation, navigation and corrections available: all the required information to use the satellite in the PPP processing is avaiable.

Recorded Sessions

The recorded session view allows the user to see the list of recorded sessions during the PPP processing. Sessions information can be extracted, edited and removed.

The extraction of the session information is done in KML format compatible with mapping applications like Google Earth. The KML includes all the epochs and positions estimates associated to the timestamp as well as the land markers introduced by the user. The KML is exported to the user terminal storage

and can be retrieved by the user through a USB connection. In order to generate the KML file, export button is to be pressed, and the process begins (this action may take several minutes depending on the session size).

When editing the session information, the user will be able to rename the session from the default name based on date and time of the recording and also check the list of markers recorded and manage them. Markers can be renamed, removed or upgraded to quick-start markers.

In order to delete a certain session, keep touching the session until its colour changes to red, and then just touch the trash icon in the Top Bar.

QuickStart Markers
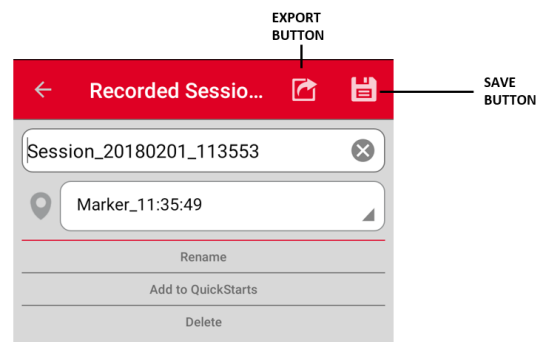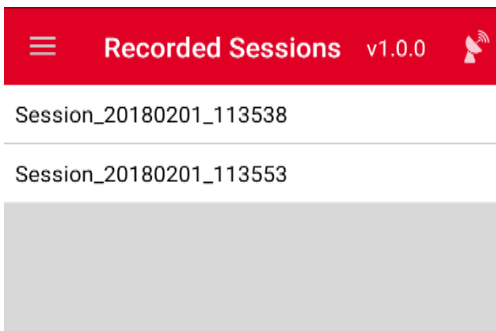
The quickstart (QS) markers are calibrated landmark places (centimetre-level accuracy) which can be used by the user to speed-up the convergence process of the PPP engine.

A QS marker can be created while running the PPP (with the possibility of using current position), or while stopped by upgrading a simple marker from a session previously recorded or by introducing the latitude/longitude/height parameters.

In order to delete a certain QS marker, keep touching the marker name until its colour changes to red, and then just touch the trash icon in the menu bar.

They can be accessed from the Recorded Sessions menu, choosing the session in which the marker was created and selecting from the available markers drop-down list.

When a new PPP execution is started, the user is asked to select between both options: a cold-start run or warm-start using one of the a-priori known positions.
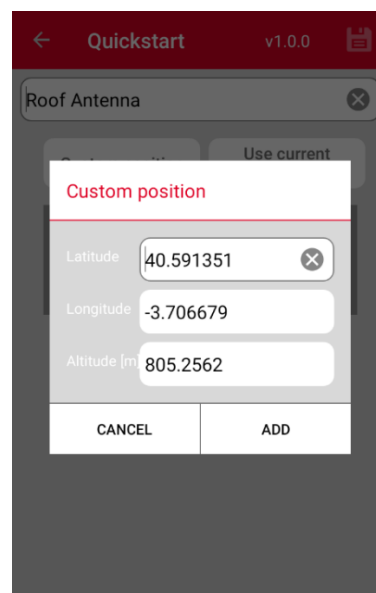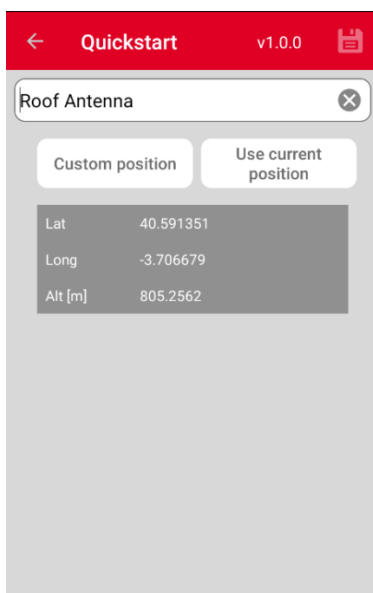
Quickstart markers are really useful when the user typically starts working from the same location, since it will reduce the convergence period from several minutes to a few seconds.

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Settings

magicPPP application settings allows to configure three different set of options: the receivers, the processing configuration and the signals.
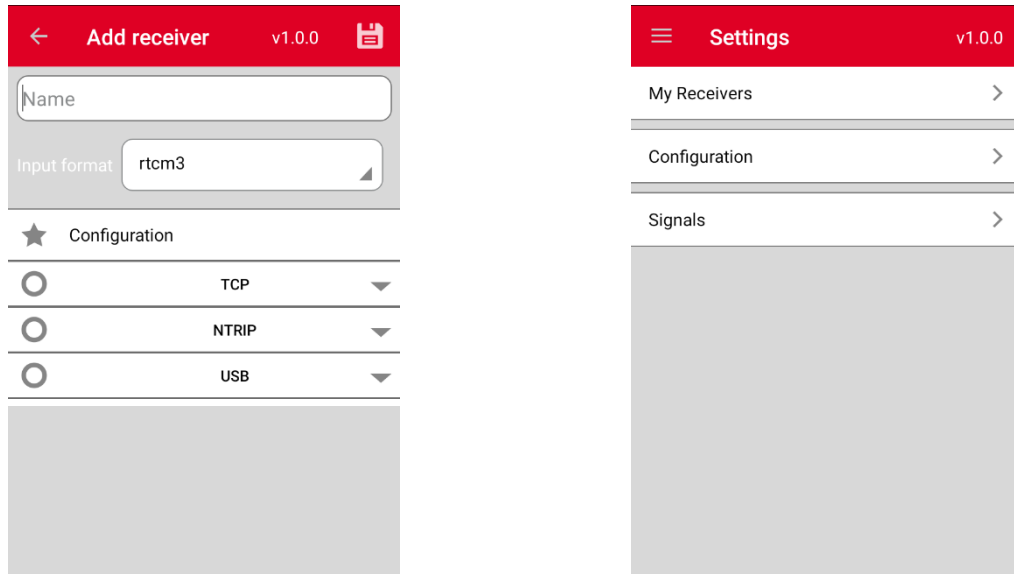
Receivers Panel

The User Terminal contains a built-in receiver which provides all the capabilities needed to exploit the magicPPP engine.

In addition to this, the magicPPP application allows the configuration of external GNSS receivers. There are four different modes to connect a external receiver to the user terminal:

1. TCP: An IP and port are configured and the application connects to the given address using a TCP Client.

2. NTRIP: An IP, port, user, password and mountpoint are configured. The application connects to the ntrip caster using an ntrip client and starts retrieving the information.

3. USB: A direct connection with an USB-OTG interface can be also established. It shall be noted that this option is not recommended as specfic drivers may be required for each receiver model, so it is possible to find limitations with this mode.

In all this modes, the PPP engine supports standard *rtcm3* format.

Created receivers and their associated info are stored in the application and can be selected in the Status and Control View for the PPP processing configuration.

Configuration Panel

The second panel for configuration is related to the augmentation inputs and generated outputs. The application supports the following sources of augmentation information:

- PPP Server: a direct connection to the PPP augmentation information thought the internet is used in this mode. The main benefit is the zero-delay in the reception of the information due to the absence or minimal bandwidth limitation in the channel. This option is recommendable to obtain the better performances when an internet link (Wi-Fi/3G) is available. For choosing this option, the corresponding IP address and port number shall be configured and the user shall be previously registered in the server side.

- SISNET Server: a direct connection to the GEO-like augmentation information thought the internet is used in this mode. Main benefit is the simulation of similar conditions as when working with the GEO except for the signal blocking and fading. This option can be used when

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an internet link (Wi-Fi/3G) is available. For choosing this option, the corresponding signal frequency (L1, L5), IP address, port number, user and password shall be configured.

- SBAS Receiver: this option relies on the built-in receiver capabilities to track both SBAS L1 and SBAS L5 information being transmited by an SBAS satellite. This option can be used in the region where a GEO is augmenting PPP. For using this option, the corresponding signal frequency shall be configured (L1, L5).

The PPP application generates a solution stream in NMEA format. The output stream is published twofold: in a local port in the device and a TCP client can send it to a remote server when an internet connection is avaiable. The NMEA information provided is standard GPGGA message and a proprietary message, PGMVP, with extended information later described in the *PPP Outputs* section.

Target Integrity Risk (TIR) used for the calculation of the PPP protection Levels can be also configured. It shall be noted that the PLs for all the available TIRs are calculated and dumped in files for post-processing purposes but the one herein configured will be monitored in the Status views of the application interface. Following TIR values are supported: 0.05, 0.01, 1e-3, 1e-5 and 1e-7.

This view also allows to switch between INFO and DEBUG mode. Nominally the application shall be configured as INFO, and only if requested by the helpdesk the debug mode shall be activated.
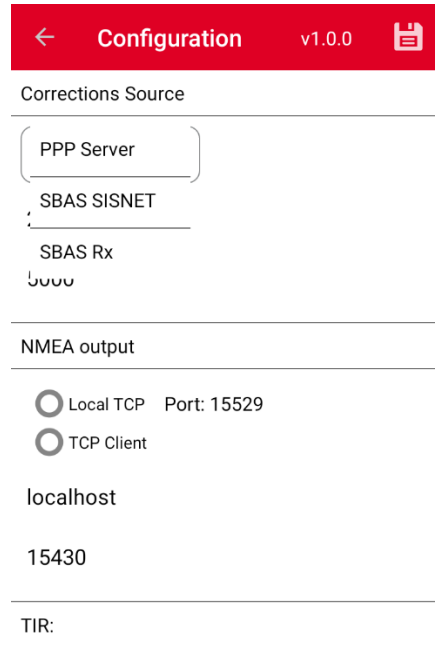
Signals Panel
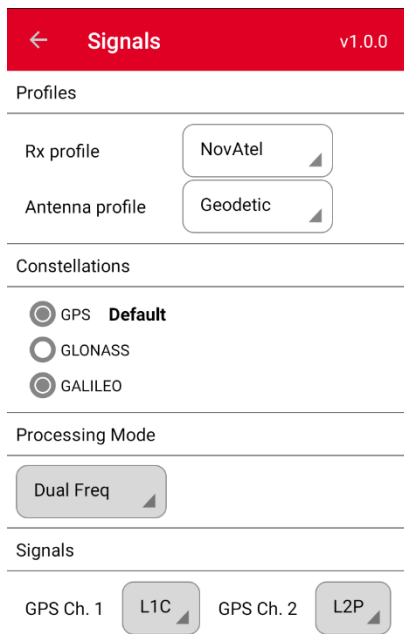
The signals view allows the user to configure the receivers and antenna profiles.

For the receiver preset profile is configure for the NovAtel built-in receiver. For the antenna the user can select between high-end geodetic antenna, and patch mass market antenna. This information is used to tune the alogorithm set up.

Second configurable option allows to choose the constellations to be used. Noted that this configuration is limited by the constellations supported by the used receiver. i.e., for the built-in one, only GPS and Galileo is processed.

Processing mode is set to Dual Frequency as the NovAtel receiver is providing at least two frequencies information for each constellation. Only at least dual-frequency receivers are supported. If receiving single-frequency data, PPP will not start.

Finally, the signals used for each constellation and channel can be selected and the Galileo navigation services can be configured (F/NAV by default, I/NAV optional).

As stated above, the preconfigured profiles fix most of this options. When using a different configuration the user shall check the receiver configuration and modify the PPP configuration accordingly through the Custom Rx profile, configuring Constellations, Signals and Services.

File Explorer

A File Explorer is available to browse in the internal storage of the user terminal device at any moment of the configuration, during processing or after it has finished.

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3.3. FOUR MAIN STEPS FOR THE FIRST EXECUTION OF THE MAGICPPP APPLICATION

This user manual provides a detailed description of the relevant features and instructions for using the *magicPPP* application with the built-in receiver. The nominal operation requires four main steps are:

o **Step 1** Configuration of *magicPPP* application.
o **Step 2** Launching the PPP process.
o **Step 3** Stopping the PPP process.
o **Step 4** Collecting output data.

3.3.1. STEP 1 - CONFIGURATION THE MAGICPPP APPLICATION

The configuration of the user terminal and *magicPPP* is done in two stages:

1- HW set-up: The UT requires the connection of an external GNSS antenna to the SMA port at the user terminal.
2- Application set-up: Configuration of the application properties.

For the second stage, the user shall go the Settings panels by tapping the Menu Button in the application Top Bar and selection "Settings". After that the signal and configuration views shall be carefully reviewed to ensure that the configurations are correctly introduced.

In the configuration panel, the user shall select the source of augmentation data to be used, and in case of extra information is needed fill the required fields. This information can be the address to the PPP server or SISNET servers. The generated NMEA gateway shall be also configured, selecting the subset of channels to be used. Again extra information may be needed. Finally, the Target Integrity Risk is selected among the available choices.

Once the configuration is completed, the user shall browse to the "Signals" view. In this panel it is important to configure the NovAtel receiver profile which will autoselect most of the configuration parameters. In addition, the type of antenna is to be selected and the constellations to be used.

3.3.2. STEP 2 - LAUNCHING THE PPP PROCESSING

The user shall ensure that the NovAtel (i.e. "Internal" in the spinner) receiver is configured to be used in the PPP processing. For that, the spinner under the receiver control box can be used to select the "Internal" receiver.
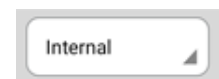
Once the receiver is selected, the "Start" button in the Receiver Control box should be pressed in order to launch the configured session. Once touched, the "Start" button is replaced by a "Stop" button, which allows the user to stop the PPP session.

Just after the "Start" button is selected, a dialog box is displayed on the screen, allowing the user to choose between a standard cold start, or selecting one of the previously configured Quick Start points. The start command can be invalidated by touching the "Cancel" button. In this example, the "Cold Start" option is selected.
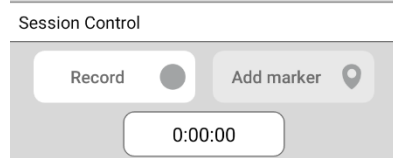
Once the PPP process has been started, the user can access the Session Control options in the Status & Control view. The Record option, when selected, starts recording the PPP session output. When the Record option is active, the timer below will show the duration of the recorded period. The session recording can be stopped at any time during the PPP process without stopping it.

While the recording is on-going, the user will be able to add land markers at any time during the PPP processing. When the "Add marker" button is touched, a window is displayed on the screen for the insertion. In the window, the user will be able to proceed with the generation of the marker or cancel it. In case the user proceeds with the generation, it may be recorded either with an automatic identifier containing the hour of the epoch corresponding to the maker location, or with a specific identifier selected by the user. Markers created this way, will be kept as session markers unless they are converted to QuickStart marker in the session menu. Alternatively, QuickStart markers will be able to be directly created via the QuickStart Markers menu by touching the "use current position button".

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Once the PPP process has been started, the user can access the Statistics data and plots in the Status menu. The available statistics, data and plots are described in the previous section and briefly summarised below:

1. Summary table which includes overall PPP processing flag, latitude (N, degrees), longitude (E, degrees), altitude (meters), time (GPST), number of satellites being processed by the PPP, horizontal protection level (meters), vertical protection level (meters).
2. CNR (Carrier to Noise Ratio) plot.
3. Sky-plot of the satellite in view.
4. Longitude(X)-Latitude(Y) displacement plot, in centimeters, with respect to a reference position. The first epoch position is used as reference.
5. Altitude: absolute height, in metres.
6. Horizontal and Vertical Protection levels, in centimetres, for the configured Target Integrity Risk (displayed at the chart).

Note that in the Longitude(X)-Latitude(Y) displacement, Altitude and PLs plots, the plot axes are rescaled when the time window filter is changed. The options for the time window filter are: 30 sec, 1 min, 5 min, 10 min, 30 min and 60 min. The refresh button on the right, allows the user to delete all previous positions/PLs and consider subsequent positions/PLs only for being plotted. This action cannot be undone, in the sense that once the refresh button has been touched, deleted position/PL cannot be recovered for being plotted. However, they are still available in the output PPP position/PL files.

As the PPP process is running, the real-time positions are accessible through a specified TCP/IP port, and distributed via Wi-Fi/3G following the standard NMEA format. These positions can be used for feeding a further user application, running on a different device (tablet, PC, etc.), accepting and using real-time NMEA format positions for different purposes, such as kinematic vehicle location, topography, etc.

Other actions that are compatible with the PPP processing are:

- Charging the *magicGNSS* User Terminal device internal battery, via micro-USB port.
- Transferring files, via micro-USB port.
- Taking screenshots, by pulling down the notification panel to reach the setting option, and touching the screenshot icon. Screenshots are stored in the default pictures path (i.e. Internal storage/Pictures/Screenshots).

⚠ During transfer mode the 3G connection will be interrupted. The user will need to reinsert SIM PIN to connect again once the transfer has been deactivated.

3.3.3. STOPPING THE PPP PROCESS

When a PPP process is running, the user can stop it by touching the "Stop" button of the Receiver control option in the Status View.

3.3.4. COLLECTING THE OUTPUT DATA

Once the PPP process is finished, all the generated output data files can be found in a dedicated folder in the user terminal (Internal storage/rtppp/sessions/), identified with the following naming convention "PPP_YYYY-MM-DD_HHMMSS", where:

- YYYY-MM-DD is the last session epoch date (year in 4 digits, month and date in 2 digits)
- HHMMSS is the last session epoch hour (local hour, minute and second in 2 digits each).

The list of generated files and description is specified below.

The session KML and landmarks can be extracted from the Session View as explained before.

3.3.4.1. Configuring an External Receiver

3.3.4.1.1. TCP/IP

From the Add Receiver panel (Settings/My Receivers/Add receiver), select TCP, and a panel will expand with the Host (IP or URL) and Port fields, to be filled by the user. Once filled, the user shall touch the "Test" button, and the app will indicate whether the connection was successful or not. Once properly filled and checked, the user shall name the receiver and click the Save button i.e. disk in the Top Bar.

3.3.4.2. PPP Outputs

NMEA GPGGA definition:

Standard GPGGA NMEA (please see standard NMEA reference for this message):

- Timestamp
- Latitude
- Longitude
- Latitude direction
- Longitude direction
- GPS Quality Indicator
- Number of Satellites in Use

- Horizontal Dilution of Precision
- Antenna altitude above sea level
- Units of altitude
- Geoidal separation
- Units of geoidal separation
- Age of DGPS data
- DGPS reference station id

Example:

```
$GPGGA,235942.00,4035.48110204,N,00342.40079690,W,9,11,0.0,753.094,M,51.938,M,,*7F
```

NMEA PGMVP definition:

Same as GPGGA with extended fields:

- Timestamp
- Latitude
- Longitude
- Latitude direction
- Longitude direction
- GPS Quality Indicator
- Number of Satellites in Use
- Horizontal Dilution of Precision
- Antenna altitude above sea level
- Units of altitude
- Geoidal separation
- Units of geoidal separation
- Age of DGPS data

- DGPS reference station id.
- Kalman Sigma North [m]
- Kalman Sigma East [m]
- Kalman Sigma Up [m]
- Clock Bias [ns]
- Tropospheric Zenith Delay [m]
- Horizontal Protection Level [m]
- Vertical Protection Level [m]
- Number of GPS satellites used
- Number of GLONASS satellites used
- Number of Galileo satellites used
- Number of BeiDou satellites used
- Number of QZSS satellites used

Example:

```
$PGMVP,235942.00,4035.48110204,N,00342.40079690,W,9,11,0.0,753.094,M,51.938,M,,,0.0028
90,0.003533,0.006412,8.373966,2.223864,0.152078,0.197840,7,0,4,0,0*5B
```

NMEA PGMVA definition:

Same as GPGGA with protection levels in meters:

- Timestamp
- Latitude
- Longitude
- Latitude direction
- Longitude direction
- GPS Quality Indicator
- Number of Satellites in Use
- Horizontal Dilution of Precision

- Antenna altitude above sea level
- Units of altitude
- Geoidal separation
- Units of geoidal separation
- Age of DGPS data
- DGPS reference station id.
- Horizontal Protection Level [m]
- Vertical Protection Level [m]

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Example:

```
$PGMVA,084854.00,3748.23268630,S,14458.01523430,E,9,09,0.0,45.496,M,4.672,M,,,4.285554
,3.993219*68
```

GPGGA, PGMVA and PGMVP are all sent in real time via local TCP port and TCP client according to the configuration options (as seen in the Configuration panel).

PPP File-based Outputs

Nominally the PPP Engine generates the following information:

- Observation RINEX (RINEX v3.03) logging information for all the received measurements, even if they have not been used in the process execution.
- Input navigation RINEX (RINEX v3.03)
- SBAS EMS 2.0
- Standard NMEA file containing positioning data (GPGGA)
- Proprietary NMEA extension file containing positioning and integrity data (protection levels) (PGMVP)
- PPP Positions file
- KML file containing positioning data and landmark positions
- Navigation Corrections file, containing information about navigation data and corrections, per satellite and epoch
- PPP Summary files containing measurements residuals both by satellite and by iteration, in addition to information related to measurement outlier detection and rejection.
- PPP Indicators file containing information of the PPP process on an epoch basis.
- PPV Indicators file containing information of the pre-processing and validation of the observation measurements.

* Debug option shall be only activated on helpdesk request to investigate potential issues or improvements.

Further information about the output files generated under the Info option, is provided next. For standard format files, links to the formats descriptions are provided. For relevant proprietary formats, detailed descriptions are included.

- Observation RINEX (RINEX v3.03) logging information for all the received measurements, even if they have not been used in the process execution. The generated output file follows the RINEX 3.03 standard format, which can be consulted here: https://kb.igs.org/hc/en-us/article_attachments/202583897/RINEX_303.pdf. File naming convention following the mentioned standard directives.
- Input navigation RINEX (RINEX v3.03). As for the observation RINEX files, see format at https://kb.igs.org/hc/en-us/article_attachments/202583897/RINEX_303.pdf. File naming convention following the mentioned standard directives.
- Receiver clock estimation RINEX (RINEX v3.03). As for previous files, see format at https://kb.igs.org/hc/en-us/article_attachments/202583897/RINEX_303.pdf. File naming convention following the mentioned standard directives.
- SBAS EMS 2.0. See format here: http://www.egnos-pro.esa.int/ems/EMS_UID_2_0.pdf. File naming convention following the mentioned standard directives.
- Standard NMEA file containing positioning data. For further information about NMEA format: https://www.nmea.org/content/nmea_standards/nmea_0183_v_410.asp. File naming convention: GPGGA_yyyymmdd.txt, e.g. GPGGA_20180119.txt.
- Proprietary NMEA extension file containing positioning and integrity data (protection levels). Format. File naming convention: PGMVA_yyyymmdd.txt, e.g. PGMVA_20180119.txt
- PPP Positions file, containing the following information:

Parameter	Description	Units
Year	Year of position solution	
Mth	Month of position solution	
Day	Day of position solution	
Hou	Hour of position solution	
Min	Minutes of position solution	

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Parameter	Description	Units
Sec	Seconds of position solution	
X	PPP positioning solution X in ECEF	m
Y	PPP positioning solution Y in ECEF	m
Z	PPP positioning solution Z in ECEF	m
Lat	PPP positioning solution Latitude	ddd mm ss.sssss
Lon	PPP positioning solution Longitude	ddd mm ss.sssss
Hei	PPP positioning solution Height above the ellipsoid	m
SigLat	Sigma of PPP positioning solution Latitude	m
SigLon	Sigma of PPP positioning solution Longitude	m
SigHei	Sigma of PPP positioning solution Height	m
Clock	Estimated clock bias	ns
Tropo	Tropospheric delay	m
All	Number of total satellites used	-
SVG	Number of GPS satellites used	-
SVR	Number of GLONASS satellites used	-
SVE	Number of GALILEO satellites used	-
SVC	Number of Beidou satellites used	-
SVJ	Number of QZSS satellites used	-
SVI	Number of IRNSS satellites used	-
DEGRADED	Flag indicating if the solution is degraded. 1 indicates degraded solution. 0 indicates valid solution.	-
VALID_PL	Flag indicating the validity of Protection Levels (PLs). 1 indicates valid PL. 0 indicates not valid PL.	
PL_H (5e-02)	Horizontal protection level at 0.05% target integrity risk.	m
PL_V (5e-02)	Vertical protection level at 0.05% target integrity risk.	m
PL_H (1e-02)	Horizontal protection level at 0.01% target integrity risk.	m
PL_V (1e-02)	Vertical protection level at 0.01% target integrity risk.	m
PL_H (1e-03)	Horizontal protection level at 0.001% target integrity risk.	m
PL_V (1e-03)	Vertical protection level at 0.001% target integrity risk.	m
PL_H (1e-04)	Horizontal protection level at 0.0001% target integrity risk.	m
PL_V (1e-04)	Vertical protection level at 0.0001% target integrity risk.	m
PL_H (1e-05)	Horizontal protection level at 0.00001% target integrity risk.	m
PL_V (1e-05)	Vertical protection level at 0.00001% target integrity risk.	m
PL_H (1e-07)	Horizontal protection level at 0.0000001% target integrity risk.	m
PL_V (1e-07)	Vertical protection level at 0.0000001% target integrity risk.	m

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- KML file containing positioning data and landmark positions, able to be opened with Earth browsers such as Google Earth. See https://developers.google.com/kml/. File naming convention: same as the session with .kml extension.
- Navigation Corrections file, containing information about navigation data and corrections, per satellite and epoch. Format. File naming convention "nav_yyyymmdd.txt".
- PPP Summary file containing measurements residuals both by satellite and by iteration, in addition to information related to measurement outlier detection and rejection. These files are mainly used for helpdesk debugging purposes. PPP Indicators file containing information of the PPP process on an epoch basis. These files are mainly used for helpdesk debugging purposes.
- PPV Indicators file containing information of the pre-processing and validation of the observation measurements. These files are mainly used for helpdesk debugging purposes.

3.4. TROUBLESHOOTING

Here you can find the most common problems that can occur while using the *magicPPP* application, and some hints for solving them:

Problem	Solution
After touching the "Start" button the PPP process does not begin.	Please check that the signals configured are correct with respect to the receiver and it gives information about two frequencies.
	When working with *PPPServer* or SISNET check the availability of internet connection.
	If not using neither PPP Server nor SISNET corrections source, check if the receiver is sending both observations, navigation data and SBAS information.
CNRs are presented, but no position nor time is given	Please check your internet connection if using PPP Server or SISNET. If you are using the SBAS GEO option, check the signal availability of it in your area.
Battery runs out while the PPP process is running.	Data should be stored until the moment of the shutdown.
Geoid file not present message	Please contact our helpdesk.
Configuration not present or corrupted	Configuration files should not be edited by the user, they are automatically managed by the app. Please contact our helpdesk.
PPP already running message	Please reset the *magicPPP* application.
The *magicPPP* application, after showing nominal behaviour for a long time period, starts providing non expected results.	It could be the case the device temperature exceeds some thresholds, above which the microprocessor is forced to slow down the processing velocity. Please check that the device is not running under direct sunlight or near some heat source.
The number of tracked satellites seem to be low, or the performances are not as good as expected.	Please check that the antenna is not being shadowed by any obstacle, or that there is no reflecting surface close to it which can be severely increasing the effect of the multipath. The antenna has to be installed in a location which maximizes the sky view and thus the satellite sight.

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The *magicPPP* solution is noisier than expected.	Please check the following tables for typical PPP convergence time and typical accuracy (RMS):

PPP Mode	Convergence Time
SBAS L5 GPS + Galileo	40 min
SBAS L1 GPS	50 min
Internet GPS + Galileo	30 min
Internet GPS	45 min

PPP Mode	Height RMS	North RMS	East RMS
SBAS L5 GPS + Galileo	10 - 20 cm	5 - 15 cm	5 - 15 cm
SBAS L1 GPS	10 - 30 cm	10 - 20 cm	10 - 20 cm
Internet GPS + Galileo	10 - 15 cm	5 - 10 cm	5 - 10 cm
Internet GPS	10 - 20 cm	5 - 15 cm	5 - 15 cm

In order to improve the PPP attainable performances, please consider the following recommendations:

- Please define the minimum test duration as double the length of the convergence time (e.g. 80 min duration for a PPP through SBAS with GPS and Galileo test).
- Convergence period is especially significant in kinematic tests. Please make sure that during the convergence period, the receiver is a relatively clean environment, so that when the kinematic tests begins, the PPP starts from a converged position.
- Please use the quick start functionality if convergence is not a critical issue in the context of your test. Note that a well calibrated initial position is needed.
- Please use the internet connection, if available, as corrections transmission method, rather than through the satellite, especially in urban and sub-urban scenarios, where the GEO lines of sight can be easily obstructed by buildings.

magicPPP application support

For *magicPPP* application support, please contact magicgnss@gmv.com.

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4. *MAGICSBAS* USER MODULE APPLICATION USER MANUAL

4.1. THE MAGICSBAS USER MODULE APPLICATION OVERVIEW

The *magicSBAS User Module (UM)* application installed in the *magicGNSS* User Terminal device is a SW tool providing real-time SBAS solutions. It processes real-time observations provided by the *magicGNSS* User Terminal device internal GNSS receiver, navigation data and SBAS augmentation information to generate real-time SBAS positions.

4.2. THE MAGICSBAS UM GRAPHICAL INTERFACE

When accessing *magicSBAS UM* through the *magicGNSS* User Terminal launcher the main application display is shown.
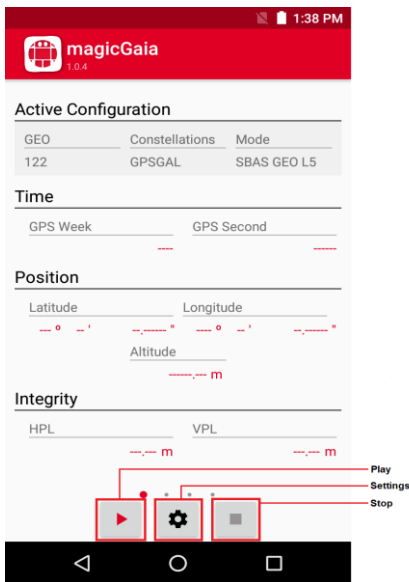

This display is arranged into different sections:

- o **Active Configuration**: Shows a summary of the current configuration.
- o **Time**: Shows the GPS time computed.
- o **Position**: shows the position computed.
- o **Integrity**: shows the protection levels computed

At the bottom, control buttons are displayed:

- o **Play**: starts the execution.
- o **Settings**: opens the configuration interface.
- o **Stop**: stops the execution.

This buttons are available in all display windows of the tool except in configuration.

From this window it is possible to swipe to the right to open the sky polar view:
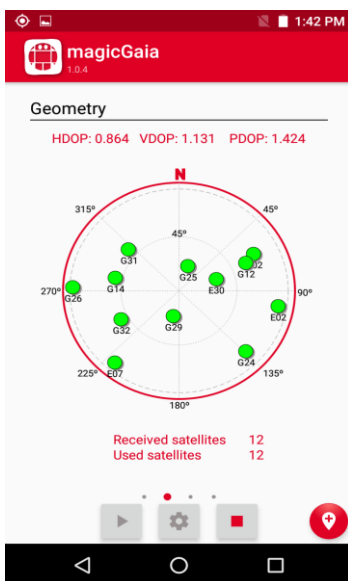
In this window, when a position can be computed, the values of the Dilution of Precision (DOP) are shown for horizontal, vertical and positioning dimensions.

On the centre of the screen, a polar view of the satellites in view is shown. Satellites are identified with a letter ("G" for GPS and "E" for Galileo) and a number (the PRN of the satellite).

Satellites plotted in green are those satellites that have been used in the computation of the solution. Those plotted in red are visible but have not been used in the computation of the solution.

Below the polar plot the number of visible and used satellites is displayed.

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The next screen on the right displays information about the received signals.
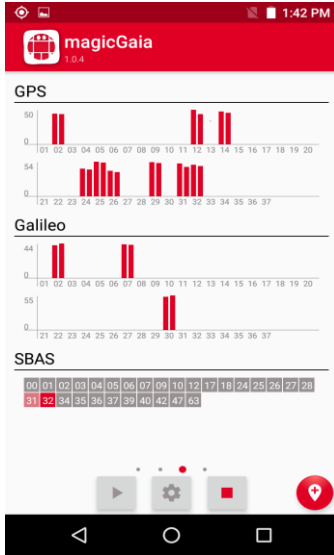
It is divided into three sections. The first two sections show the carrier to noise ratio (CN0) of the signals received from each satellite in dB-Hz. For each PRN two bars appear corresponding to the configured primary and secondary signals.

At the bottom, the sequence of received SBAS messages is shown. The message at present epoch is shown in dark red. Those messages that have not been received or being received have time-out are shown in grey. Finally, messages received in the past which remain valid in the present epoch are shown in light red.

When position can be computed, a new button appears at the bottom of the screen.

When touched, the current position and time are stored in Real-Time in the landmark output file. An additional comment can be added during this process. Please, note that to be able to store landmark the outputs files has to be enabled. The landmark position correspond with the position computed in the moment that the landmark button ( ) is pressed, not with the position at the moment the ADD button is pressed.

The next screen on the right displays information about the position.
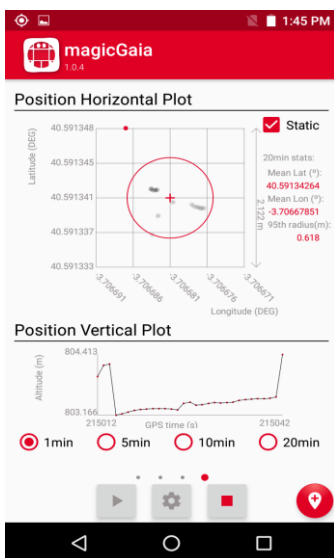
It is divided into three sections. The first two sections show the historical horizontal and vertical positon.

The current and previous horizontal positions are displayed in a latitude versus longitude plot. For static scenarios the "Static" checkbox can be selected to include some statistics as the mean latitude, the mean longitude and the radius of the 95th percentile for the samples computed for the latest 20 min. Below this graph, it is plot the temporal evolution of the vertical positions.

At the bottom, the time length to be plotted on the previous graphics can be configured.

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4.3. THE MAGICSBAS UM SETTINGS

While the application is not computing the navigation solution, it is possible to access to the tool configuration through the Settings button (⚙).
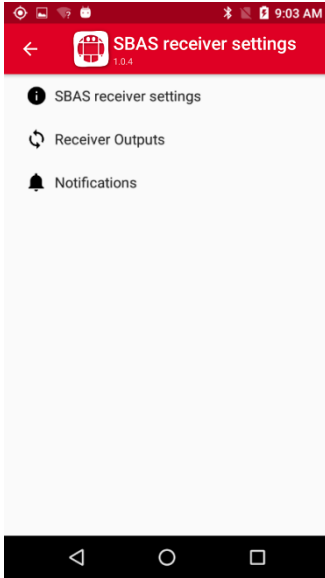
This will open the main settings window that is arranged into three sections:

- **SBAS receiver settings**: Contains all configuration parameters related with the navigation solution computation.
- **Receiver Outputs**: Allows configuring the different outputs that the tool can produce.
- **Notifications**: enables the configuration of the notifications generated by the tool.

Each of these sections is detailed in the following sections

4.3.1. SBAS RECEIVER SETTINGS

By entering to this menu, it is possible to configure several navigation solution related options.
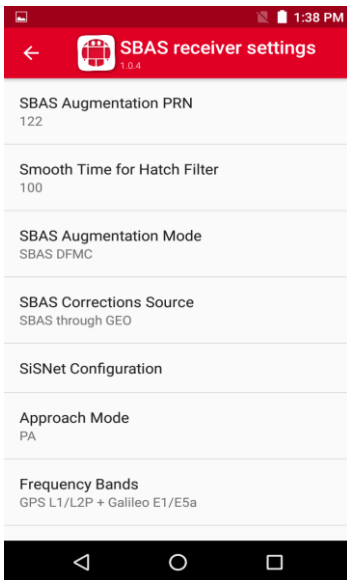
- **SBAS augmentation PRN**: Allows the selection of the SBAS PRN to be used for augmentation. It will depend on the location and SBAS service provided. For instance, during Australia testbed, the PRN 122 will be used. However this PRN will not be usable in other regions such as Europe.

- **Smooth Time for Hatch Filer**: Allows the user to configure the minimum time needed to smooth pseudorange measurements using the phase measurements. For aeronautical users this value shall be set to 100.

  However, this value can be very restrictive for urban users which may need to reduce it in order to increase the availability of the position computation.

- **SBAS augmentation mode:** allows the selection of one of the supported augmentation modes:
  - SBAS L1
  - SBAS DFMC
  - SBAS Enabled L1[1]
  - SBAS Enabled DFMC[2]
- **SBAS corrections source:** allows the selection of the source of the augmentation between:
  - **SBAS through SiSNet:** SBAS information is obtained through internet using SiSNet protocol
  - **SBAS through GEO:** SBAS information is obtained through the signal in space broadcast by the GEO.
- **SiSNet configuration:** in case SBAS through SiSNet is configured, this option allows the user to configure the SiSNet server IP and port and the user log name and password.
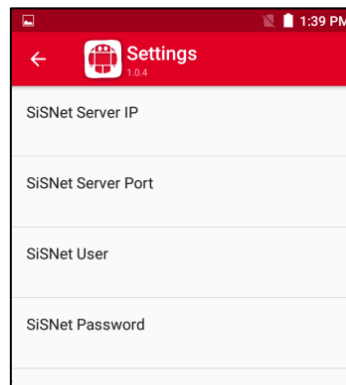
- **Approach Mode:** allows to select between PA and NPA types of approach
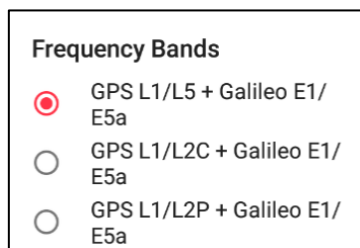- **Frequency bands:** selects the frequency bands that will be tracked by the receiver. It is highlighted that this bands are used to configure the internal receiver but the final bands used will depend on other configuration parameters such as the SBAS augmentation mode or the enable/disable of the Galileo satellites processing.

- **Enable Galileo processing**: enables/disables the processing of the Galileo signals.
- **Galileo Navigation:** allows the selection of the Galileo navigation message (INAV/FNAV) to be used in the navigation solution computation

---

[1] SBAS Enabled L1 is a mixed solution which uses the SBAS L1 information for accuracy when it is available. This solution if focused on increasing the availability and accuracy of the position computation in environments with degraded satellite visibility (urban environments for instance). No integrity is computed in this solution.

[2] SBAS Enabled DFMC is a mixed solution which uses the SBAS DFMC information for accuracy when it is available. This solution if focused on increasing the availability and accuracy of the position computation in environments with degraded satellite visibility (urban environments for instance). No integrity is computed in this solution.

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4.3.2. RECEIVER OUTPUTS

This menu allows configuring which outputs will be produced by *magicSBAS UM*.
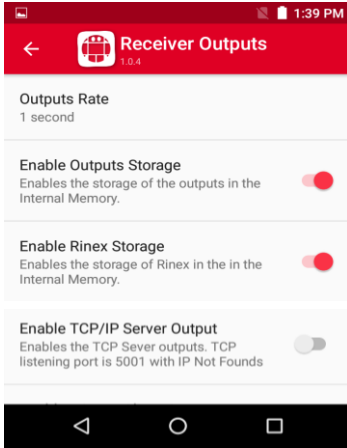
- **Output Rate**: configures the rate at which outputs are generated. It affects to all NMEA outputs produced by the tool.
- **Enable Outputs Storage**: It is a general flag to allow the generation of output files in the internal memory of the *magicGNSS* User Terminal. If it is disable, no output files will be produced.
- **Enable RINEX Storage**: enables/disabled the recording of the navigation and observation inputs into RINEX files and SBAS messages into EMS files.

- **Enable the TCP/IP Server Output**: enables/disables the output of the NMEA messages through a TCP/IP server. Information to connect the clients to the server is provided below the section title.
- **Enable the TCP/IP Client Output**: enables/disables the output of the NMEA messages acting the tool as a TCP/IP client.
- **TCP Client Configuration**: If TCP client output is selected, this item allows the configuration of the IP address and port to which the client should establish the connection.

4.3.3. NOTIFICATIONS

This menu allows the configuration of the notifications raised by the tool.
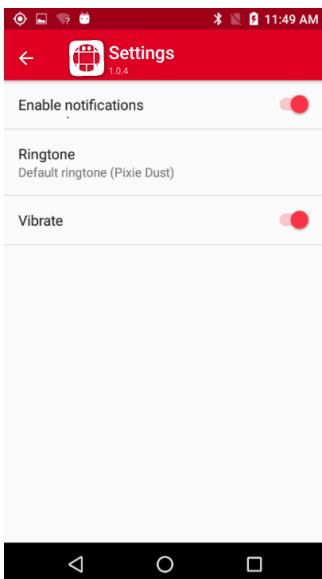
- **Enable notifications**: enables/disables the generation of notifications.
- **Ringtone**: allows the selection of a ringtone associated with the generation of *magicSBAS UM* notifications
- **Vibrate**: enables/disabled the vibration of the devices when *magicSBAS UM* notifications are produced

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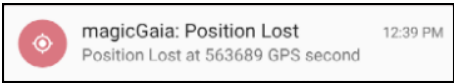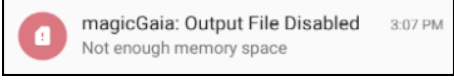
magicSBAS UM generates three types of notifications:

Notification type	Example	Description
Position Fix	magicGaia: Position Fix 3:01 PM Position Fix at 522360 GPS second	It is generated when position can be computed for the first time or when it is computed again after a period when it was not computed
Position Lost	magicGaia: Position Lost 12:39 PM Position Lost at 563689 GPS second	It is generated when position cannot be computed after an epoch at which it was computed.
Output Files Disabled	magicGaia: Output File Disabled 3:07 PM Not enough memory space	It is generated when output files were enabled but they shall be disabled due to free space shortage.

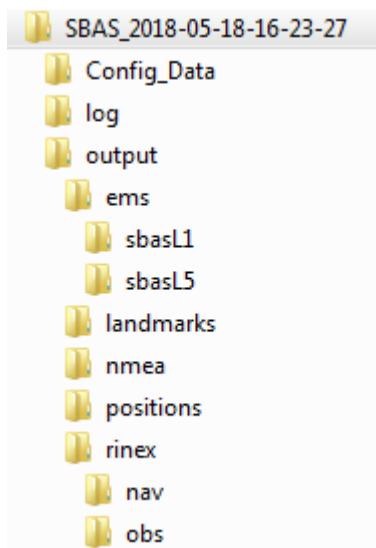## 4.4. THE MAGICSBAS UM OUTPUTS

magicSBAS UM stores its outputs in the internal memory. Each time the play button is touched, a session folder is created using the following nomenclature:

Internal Memory:/data/media/0/Android/data/gmv.magicgaia/files/magicGaia/SBAS_YYYY-MM-DD-hh-mm-ss

Where:

- *YYYY*: is the year corresponding to the phone local time in which the execution is started.
- *MM*: is the month corresponding to the phone local time in which the execution is started.
- *DD*: is the day of the month corresponding to the phone local time in which the execution is started.
- *hh*: is the hour corresponding to the phone local time in which the execution is started.
- *mm*: is the minute corresponding to the phone local time in which the execution is started.
- *ss*: is the second corresponding to the phone local time in which the execution is started.

Within this session folder the following folder structure is created:

```
SBAS_2018-05-18-16-23-27
    Config_Data
    log
    output
        ems
            sbasL1
            sbasL5
        landmarks
        nmea
        positions
        rinex
            nav
            obs
```

- **log**: contains the *magicSBAS UM* log for troubleshooting
- **outputs**: contains all outputs generated by *magicSBAS UM*:
    - **ems**: Contains the SBAS EMS files
    - **landmarks**: contains the landmark file
    - **positions**: contains the KML file
    - **nmea**: contains the NMEA file with all NMEA messages generated by the tool
    - **rinex**: contains the RINEX files recorded by the tool
- **Config_Data**: contains a *magicSBAS UM* configuration for the scenario that is compatible with magicGemini tool.

(!) *magicSBAS UM* will only generate its output files if enough space is available on the *magicGNSS* User Terminal internal memory. If that is not the case, output data will only be generated through the real time interface (Wi-Fi, etc.).

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4.4.1. OUTPUT FILES

The following table shows the outputs that are generated by *magicSBAS UM*:

File type	File characteristics	Description	Relative Path
Rinex Files	Rinex Observation Format	Rinex version 3.03	\output\rinex\obs
	Rinex Navigation Format	Rinex version 3.03	\output\rinex\nav
Ems files	SBAS NOF L1 Format	EMS 2.0	\output\ems
	SBAS NOF L5 Format	EMS 2.0[3]	
NMEA Files	NMEA Version	NMEA-0183	\output\nmea
	NMEA Standard Messages	GPGGA, GPGST	
	NMEA Proprietary Messages	PGMVA, PGMVS	
	NMEA Files Name	YYYYMMDD_HHMMSS.dat (from device date)	
Landmarks files	Landmark File Name	landmarks.dat	\output\landmarks
KML file	KML File Name	positions.kml	\output\positions
	Content	KML file with the positions computed and landmark added.	
Configuration file	Configuration File Name	config.dat	\Config_Data
	Content	magicGemini configuration file	
Log files	Log File name	kernel_000	\log

4.4.2. REAL TIME OUTPUTS

magicSBAS UM is able to output the NMEA messages (GPGGA, PGMVA and PGMVS) in real time through a TCP interface (Wi-Fi, 3G).

4.4.3. OUTPUT FORMATS

Main *magicSBAS UM* output formats are well known standards as it can be check in the tables of the previous sections.

The landmark file is a simple ASCII file containing the time and position information of those epochs in which the landmark button (📍) was touched.

```
#GPS_week GPS_sec Lat(deg) Lon(deg) alt(m) Number Description
1163 523972 52.21848328  4.41929491  56.669 001 Test 1
1163 524452 52.21848574  4.41929781  57.315 002 End
```

magicSBAS UM also generates four types of NMEA messages, two standard message (GPGGA and GPGST) and two proprietary messages (PGMVA and PGMVS) that report some information not covered by the NMEA standard. The contents of these messages are described hereafter:

---

[3] EMS format is defined for SBAS L1. *magicSBAS UM* uses this format also for DFMC.

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Fields	NMEA Standard Message ($GPGGA)
UtcTime	UTC time of position fix
Latitude	Latitude (degrees)
LatInd	Direction of latitude (N: North, S: South)
Longitude	Longitude (degrees)
LonInd	Direction of longitude (E: East, W: West)
GPS_QI	GPS Quality indicator (Always 2)
usedSats	Number of satellites in use
HDOP	Horizontal dilution of precision
altitude	Orthometric Height (EGM2008)
M	M: Altitude measured in meters
Geoid_gap	Geoid separation (EGM2008)
M	M: Geoid separation measured in meters
StaId	Station ID (always 0000)
CRC	Cyclic Redundancy Check

Fields	NMEA Standard Message ($GPGST)
UtcTime	UTC time of position fix
N/A	N/A
error_ellipse_major	Semi-major axis of the estimated error ellipse (1 sigma, in meters)
error_ellipse_minor	Semi-minor axis of the estimated error ellipse (1 sigma, in meters)
error_ellipse_orientation	Error ellipse orientation from true north (degrees)
latitude_1sig	Latitude error estimation (1 sigma, in meters)
longitude_1sig	Longitude error estimation (1 sigma, in meters)
altitude_1sig	Altitude error estimation (1 sigma, in meters)
CRC	Cyclic Redundancy Check

NMEA proprietary message **PGMVA** contains the same parameters as $GPGGA, with the exception that GPS quality Indicator is set to 10 instead of 2, and there are two additional fields: HPL and VPL.

Fields	NMEA Proprietary Message ($PGMVA)
UtcTime	Time in UTC
UtcTime	UTC time of position fix
Latitude	Latitude (degrees)
LatInd	Direction of latitude (N: North, S: South)
longitude	Longitude (degrees)
lonInd	Direction of longitude (E: East, W: West)
GPS_QI	GPS Quality indicator (Always 10)
usedSats	Number of satellites in use
HDOP	Horizontal dilution of precision
altitude	Orthometric Height (EGM2008)
M	M: Altitude measured in meters
Geoid_gap	Geoid separation (EGM2008)
M	M: Geoid separation measured in meters

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Fields	NMEA Proprietary Message ($PGMVA)
StaId	Station ID (always 0000)
HPL	Horizontal Protection Level (meters)
VPL	Vertical Protection Level (meters)
CRC	Cyclic Redundancy Check

NMEA proprietary message **PGMVS** is a simplified message that contains the position and the Protection Levels:

Fields	NMEA Proprietary Message ($PGMVS)
gpsWeek	GPS Week Number
gpsSec	GPS Seconds
GnssComb	GNSS Combination: 0: GPS, 1: GLONASS, 2: Galileo, 3: GPS+GLONASS, 4: GPS+Galileo
solType	Navigation Solution Type: 0: Least Squares, 1: SBAS L1 augmented, 2: SBAS L5 augmented, 3: RAIM, 4: ARAIM, 5: DGPS, 6: Kalman Filter
Latitude	Latitude WGS84 (degrees)
Longitude	Longitude WGS84 (degrees)
Altitude	Height WGS84 (meters)
HPL	Horizontal Protection Level (meters)
VPL	Vertical Protection Level (meters)
CRC	Cyclic Redundancy Check

4.5. F.A.Q.

Q1: Which RINEX observables record *magicSBAS UM*?

magicSBAS UM records 3 types of observables: pseudorange measurements (C), carrier-phase measurements (L) and signal strength measurements (S).

In the case of GPS satellites, the tool is prepared to record the signals in L1, L2 and L5 bands. Thus, the GPS observables included in the recorded RINEX are: C1C, L1C, D1C, S1C, C2C, L2C, D2C, S2C, C2W, L2W, D2W, S2W, C5Q, L5Q, D5Q and S5Q.

In the case of Galileo satellites, the tool is prepared to record the signals in E1 and E5A bands. Thus, the Galileo observables included in the recorded RINEX are: C1C, L1C, D1C, S1C, C5Q, L5Q, D5Q and S5Q.

Q2: Does *magicSBAS UM* record RINEX and EMS of all signals or only of those being configured?

magicSBAS UM is prepared to track and record simultaneously the 3 GPS bands, the 2 Galileo bands and the 2 SBAS bands. It is noted that the availability of each signal will depend on the capability of the internal receiver to track them. Therefore, it is possible than some bands appear earlier in the RINEX than other.

Q3: What happens when *magicSBAS UM* runs out of battery?

magicSBAS UM stores its outputs each second. Therefore, it will continue computing and storing data until the device runs out of battery without losing data. However the tracking capabilities of the internal receiver can be affected when battery goes low (<10%). Then, it is recommended to keep the device connected to a power outlet or a power bank for long tests.

Q4: Does *magicSBAS UM* seem to track enough satellites but position is not being computed?

There are many reasons why this can happen. In SBAS navigation solutions you need to recover almost the full SBAS message sequence in order to apply them and this can take several minutes. Other parameter that may affect the availability of the position computing is the smoothing time. The receiver will need continuous measurements of a satellite for 3.6 times the configured smoothing time to use it

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in the position computation. Therefore, reducing this value will increase the number of usable satellites (notice in any case that the lower this value is, the noisier the measurements will be).

Q5: Does *magicSBAS UM* seem to track only one frequency of some constellation?

The antenna connected to *magicSBAS UM* is a key element in order to allow the tracking of the signals. Most of the GNSS antennas are designed to cover one or two frequency bands. Antenna specifications shall be verified in order to ensure that bands needed by the tool are covered.

Q6: *magicSBAS UM* TCP/IP outputs use 3G or Wi-Fi?

If Wi-Fi is available, *magicSBAS UM* will use this interface for the transmission of the NMEA outputs. If 3G is enabled and the device is not connected to a Wi-Fi network, then *magicSBAS UM* will use the 3G interface to send its data.

Q7: Can I use *magicSBAS UM* for Safety of Life applications?

⚠ **NO**. This device is a non-certified development, designed for conducting tests in research establishments, in the frame of the Satellite-Based Augmentation System (SBAS) Test-bed. Thus, it shall NOT be used for Safety of Life applications.

Q8: The magicSBAS application, after showing nominal behaviour for a long time period, starts providing non expected results.

It could be the case the device temperature exceeds some thresholds, above which the microprocessor is forced to slow down the processing velocity. Please check that the device is not running under direct sunlight or near some heat source.

Q9: Can I post-process the data recorded with magicGemini?

Yes. *magicSBAS UM* generates the needed configuration files to run the scenario recorded in post-processing with *magicGemini*. The session folder can be directly copied into *magicGemini* Scenario folder and the tool will automatically recognize the configuration.

magicSBAS UM application support

For *magicSBAS UM* application support, please contact magicgnss@gmv.com.

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