TcpGPS
for Android

ver. 2.9.0.0 – 15-10-2024

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1 Introduction

TcpGPS is an Android application (available both for mobile phones and tablets) that allows the user to carry out field work on measurements of farms, roads, crops, etc., in a simple way.

In addition, after carrying out the survey or importing a file of measured points, it is possible to proceed to the staking out of these points, offering tools for quick and easy location of these points on the ground.

Finally, the data obtained can be exported to a range of different formats (TXT, GML, KML, etc.) and shared with any other apps, including Google Drive, in order to be able to have it available in many platforms.

TcpGPS app is available for any Android device with a version 7.0 or above, for both smartphone and tablet. In this document the screenshots were taken in a smartphone in order to show functionality independently.

1.1 Installation

Installing TcpGPS Android application requires a device with Android OS and Internet connection. The recommended requirements are shown in the following table:

Feature	Recommended
Android OS	V7.0 to V14
RAM	Minimum 3GB
Performance Indicator	Minimum 12 and recommended 28 or more, according to the Android device comparison website https://www.androidbenchmark.net/g2dmark_chart.html
Display Size	Recommended 5” or more
Connectivity	Data connection Bluetooth Internal GPS
Sensors	Magnetometer, accelerometer and gyroscope

From Google Play Store you can find and install the application, named **TcpGPS**.

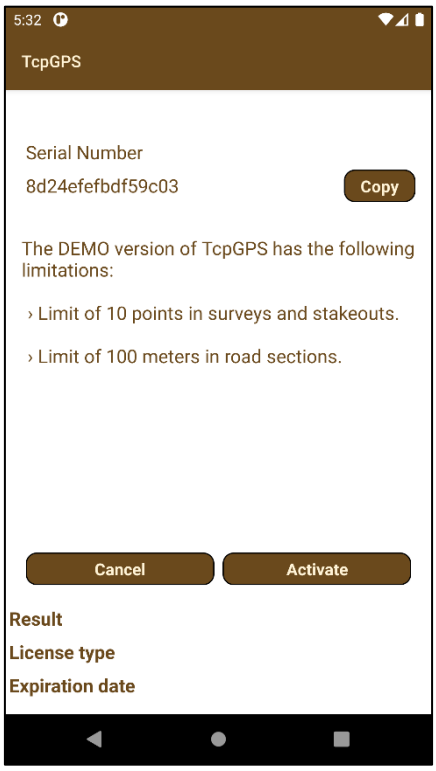


Figure 1. License request

The application requires a set of permissions:

- **Bluetooth** for connecting to external GNSS receivers.
- **Internet** for downloading ESRI maps, sharing exported files and using NTRIP and WMS services.
- **Location** for getting position from the internal GPS.
- **Camera** for making photos and use augmented reality.
- **Microphone** for recording voice notes.
- **Storage** for accessing files and storing results.

These permissions will be requested to accept after installing the application.

The first time the application is started, the user will be required to fill the data information fields for requesting a license. Two different license versions are available for TcpGPS Android.

1.2 Demo license

Once the application has been downloaded and installed, you can request a **demo license** with a limit of 10 points by entering your email and your country. If you have already purchased your permanent license, you can enter the activation code and start working in the unlimited mode.

1.3 Full license

At the application start, if you do not have a license, you may type an activation code (see **Figure 1. License request**) you can get sending an email to **sales@aplitop.com**.

If you already have a **demo** license you can also type the activation code to upgrade your license from **demo** to **full**.

For more details, you can find the technical note for licenses here:

https://aplitop.sharefile.com/d-s80b3616e52b343fc902dc68f4aab45d4

Please be mindful that the license must be released before uninstalling the application or it will be unable to be used in another device, or the same device after reinstalling the application.

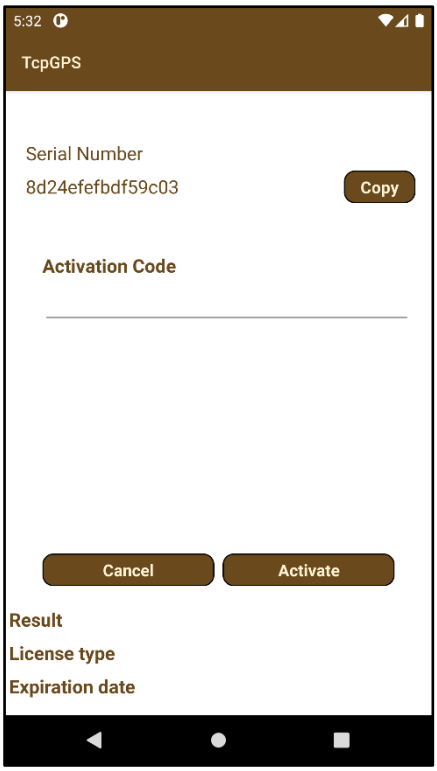


Figure 2. Permanent License Request

1.4 Application data

In section **Menu > Application > About us** is possible to find information about:

- **License agreement.**
- **User information** associated to license**.**
- **System and application information**: version and device, list of sensors, etcetera.

2 Session wizard

When the application start-ups, it displays a wizard for configuring the GNSS receiver and the project to be used in the working session.

Figure 3. GNSS receiver connection assistant

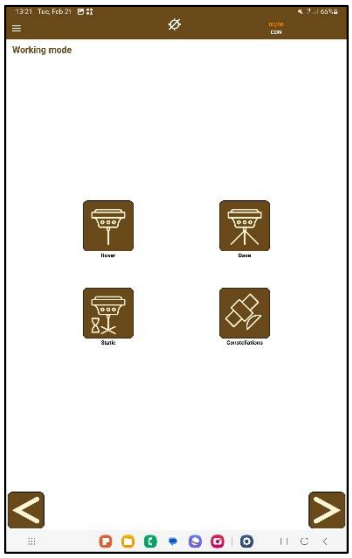


Figure 4. GNSS receiver working mode assistant

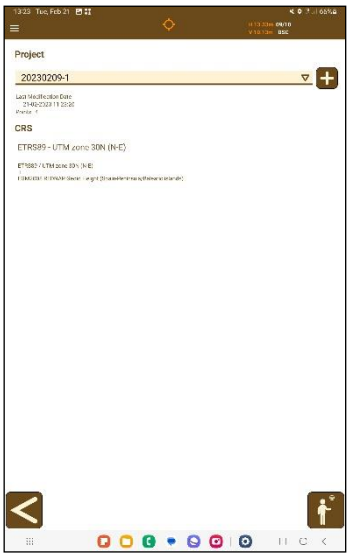


Figure 5. Project configuration assistant

2.1 GNSS receiver connection assistant screen

On this screen (Figure 3), the user can connect and configure the GNSS receiver he wants to use or both receivers if a base-rover configuration is needed. These are the options available:

- **Receiver**: The last receiver and model used in the last session are shown here. It allows to connect to a new receiver or model  , or connect/disconnect to the last one.
- **Console:** It is possible to access to a terminal for checking what is the app receiving from the receiver by clicking  .

You are also able to check the automatically connect checkbox and once you enter this screen be it from the menu or when starting the application, the application will attempt to connect to the receiver automatically. This will also attempt to connect to the NTRIP server automatically once you reach that screen.

Once the receiver is connected (or not), by clicking on **Next** the user continues to the next wizard screen:

2.2 GNSS working mode assistant screen

This screen (Figure 4) has available four options for configuring the working mode on our GNSS receiver:

- **Rover**. GNSS rover configuration for collecting data.
- **Base**. GNSS base configuration for sending corrections to all GPS connected as rover to that base.
- **Static**. It allows to configure the GNSS to start and stop a static measurement of the current point.
- **Constellations**. It allows to select the constellations you want to use in your measures.

Depending on the features and available resources of each GNSS model, these options will be enabled or disabled.

2.3 Project assistant screen

On this screen, the user can configure the project he wants to work on. He can create a new project or select one of his previous for continuing the job. The following is the list of options for setting up the project:

- **Project**: A list of the projects created by the application is presented, placing it in the last used project. You can choose another project from the list or create a new one on the button  .
- **Coordinate system**: The coordinate system of the current project is shown with all the information of it.

Once the settings have been established, you can start working by clicking on the button  .

3 Connection with GNSS receiver

TcpGPS allows one to use two data sources: the *device's internal GNSS receiver*, if it has one, or an *external GNSS receiver, connected via Bluetooth, Bluetooth LE* or TCP/IP (normally using WiFi network).

In **GNSS receiver connection assistant** screen or **Device > Connection** section are available the needed options for selecting and configuring the different types of receivers. Once the type of receiver is selected and the needed configuration is completed, the communication will be established by pressing **Connect**. With **Disconnect** button the application is disconnected from the current receiver.

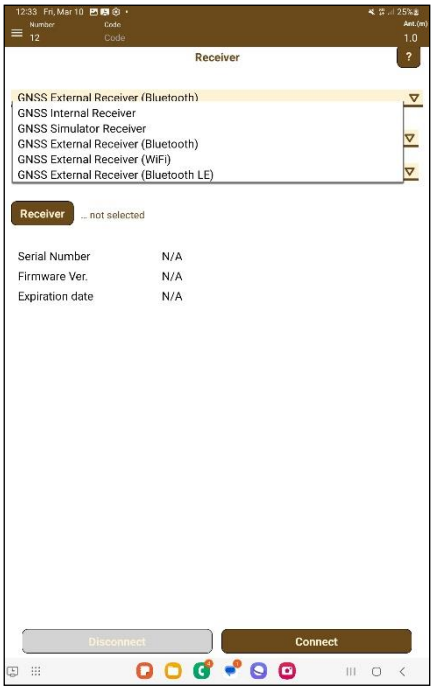


Figure 6. Selection of the GNSS receiver

- **GNSS Internal Receiver**: It allows to use the device's internal GNSS receiver, using the system parameters (**Generic / LOCAL** option) or NMEA output (**Generic / NMEA** option), if the operating system version allows it. Also, it's possible to connect with external receivers using mock locations through third-party apps. In this case, receiver's brand and model must be selected.

- **GNSS Simulator Receiver**: This mode uses a file of geographic coordinates, in WGS84 datum, to simulate the locations in the application. The file extension must be **TXT** and must contain one point per line with the following format:

  PointNumber,Wgs84LatitudeInDegrees,Wgs84LongitudInDegrees,AltitudeInMeters

  Ex.: **1,36.73191533,-4.46158488,138.994**

The latitude must be between **-90.0** and **90.0** degrees and longitude must be between **-180.0** and **180.0** degrees.

- **GNSS External Receiver (Bluetooth)**: It allows to connect with GNSS receivers through Bluetooth classic connection (no BLE).

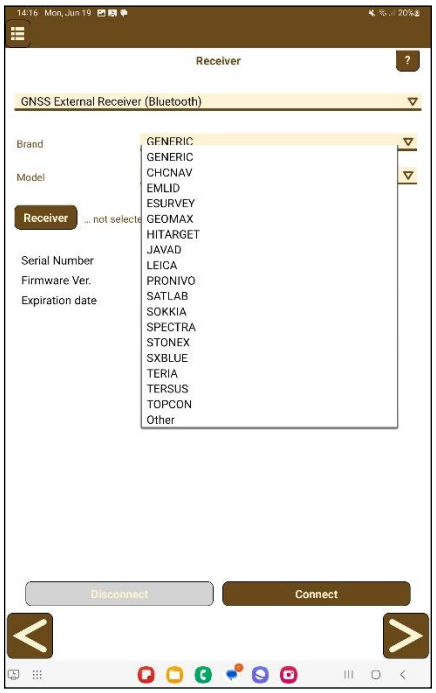


Figure 7. Brand and model selection

Figure 8. Search of a GNSS device

The application stores the information of the last GNSS connected, but if no one was used before, a GNSS can be found by pressing the button **Device**.

In this screen, **Search** button will start the searching of near Bluetooth devices. When the friendly name (or the MAC address, if the name is not available) is shown in the list, it can be selected.

In the upper right corner of the screen it is possible to perform a filter by the names of the receivers in the list, writing the name and then pressing the **"Search"** button.

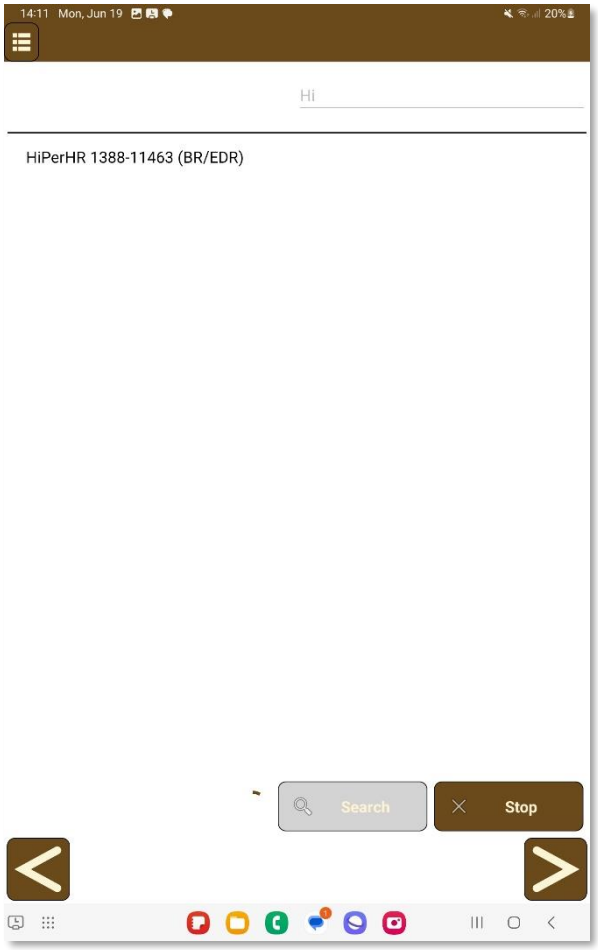


Figura 9. GNSS devices list filter

- **GNSS External Receiver (WiFi)**: It allows to connect with GNSS receivers through TCP/IP, normally, when connecting to the same WiFi network. After selecting the brand and model, it must be entered the IP address and the port used to send the receiver's data.

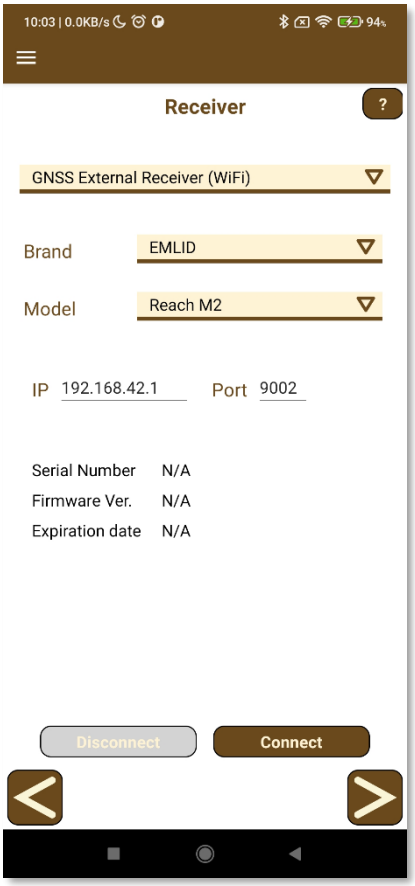


Figure 10. Selection of the GNSS receiver

- **GNSS External Receiver (Bluetooth LE)**: It allows to connect with GNSS receivers through the Bluetooth LE protocol, choosing a brand and model that are compatible with Bluetooth LE.

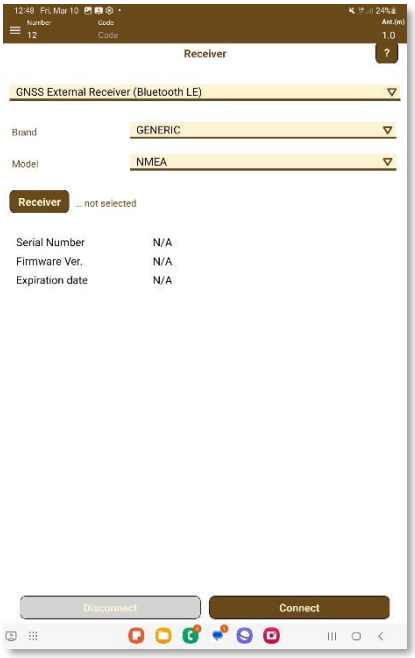


Figure 11. Selection of the External BLE GNSS receiver

3.1 Configuration of the external GNSS receiver

Once the app is connected to the receiver, it can be configured by setting its parameters in **Device > Set up receiver**.

Each supported brand and model have a set of specific forms where modifying these parameters and send the configuration to the receiver.

Usually, GNSS receivers can be configured in two modes: **base** or **rover**, and each one can establish different types of **data links**, depending on the capacities and hardware available.

3.1.1 Base configuration[1]

This option enables the user to configure the receiver in RTK mode, what allows the rover receivers to work with centimetric precision.

Firstly, the position where the base is located must be set. It can be introduced by two ways:

- **Getting the position for the receiver**, by using the **GPS** button. This location will be taken with the receiver in autonomous mode, what can be ideal when a local

[1] In this section are described the common options to configure the GNSS. However, these options can change, not to be available or to be needed additional parameters depending on the receiver.

system is going to be created, then the location of the base is not important, or it will be placed in a different location in each session.

- **Using a point from the current project**. This option is only available once a project is loaded.
- **Typing the location manually.** It allows to configure the base introducing the values manually. The distance between the current location and the location introduced must be less than 100 meters.

The user can use projected or geographic coordinates in all cases.

Next step is to choose the type of **data link**. When clicking **Next**, the screen for configuring the data link will be displayed. This screen depends on the brand and model of the receiver and the set of parameters will change. Check the technical notes available in our website (https://www.aplitop.com/documentation-technical-notes) for detailed information about the configuration of different GNSS brands and models.

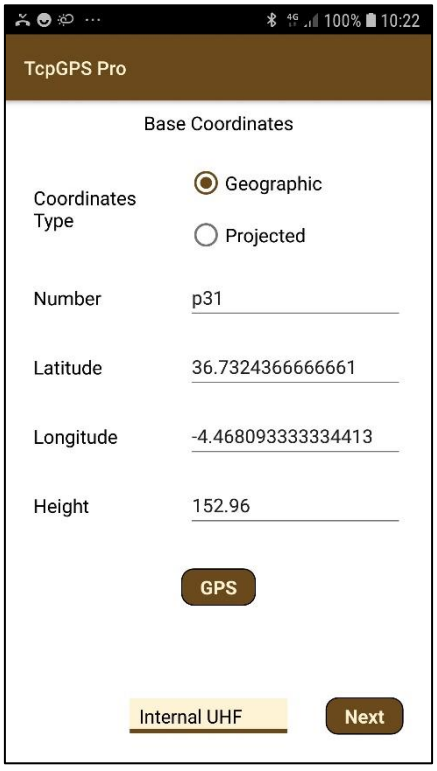


Figure 12. Base configuration

3.1.2 Rover configuration

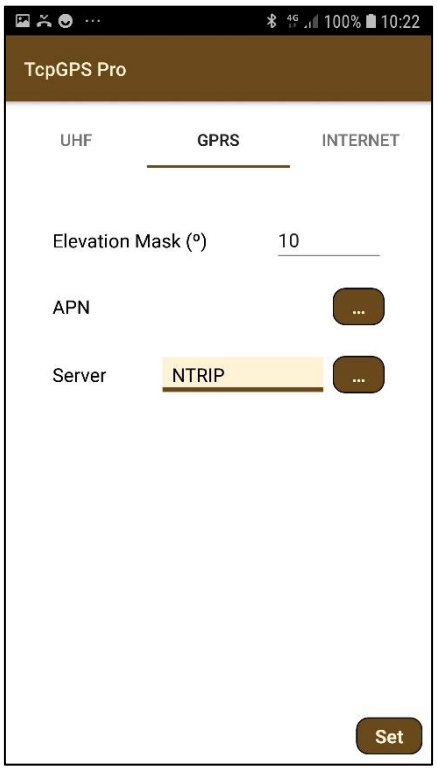


Figure 13. Rover configuration

This option configures the rover receiver for getting RTK corrections via radio, GSM or GSM, or DGPS corrections with SBAS u OMNISTAR (not all these configurations are available in every receiver, even some receivers could offer other types of configurations).

The configuration will be sent to the receiver by pressing **Send** button.

Check the technical notes available in our website for detailed information about the configuration of the different GNSS brands and models supported by the software (https://www.aplitop.com/documentation-technical-notes).

3.2 Static

Some devices allow the user to record data in static mode, for postprocessing. In this case, the option **Static** will be present in the menu.

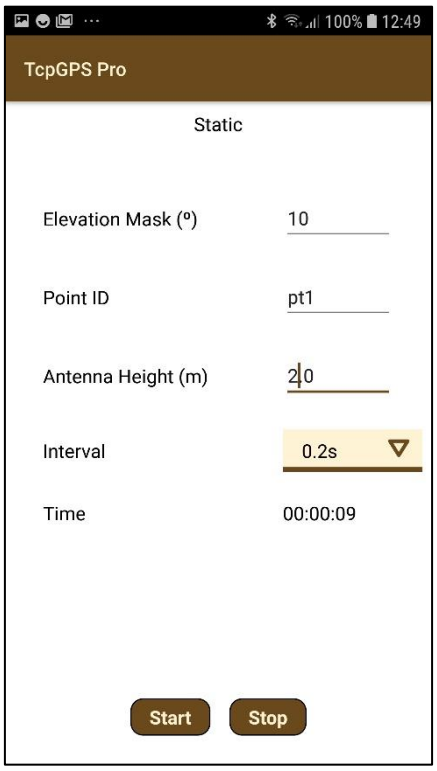


Figure 14. Static recording configuration

After setting the parameters, the recording will be initialized by pressing **Start** button and finished using **Stop** button.

3.3 Terminal

A terminal is available for advanced users who wants to know what the receiver is sending, where is shown the frames and messages received. This terminal is accessed from **Device > Terminal** or in the button  in the **GNSS receiver connection assistant screen**. This terminal has the following options for interacting:

- **Pause/Continue:** The user can pause and continue receiving data into the terminal. However, while the reception is paused, the messages received will be discarded by the terminal.
- **Record:** Store the messages to a log file.
- **Clean:** Remove all the frames shown in terminal.
- **Hex output:** The messages are shown with hexadecimal values.

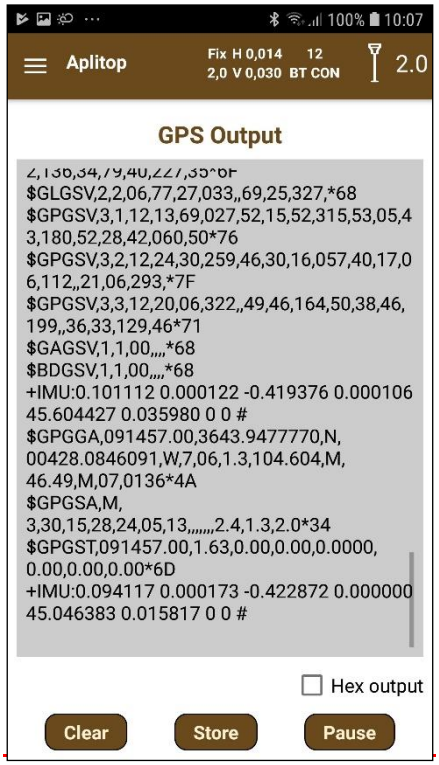


Figure 15. Monitor of the messages received from the GNSS

3.4 GPS status

It is possible to consult the GPS status by opening the **GPS status** section, pressing on the **communications toolbar**.

In this section, you can find information on both GPS (Figure 16) and available satellites (Figure 17). The arrows in the **options menu** can be used to navigate between one view and another.

In the following table are described the parameters shown in the numerical screen of this section:

UTC Time	Current UTC time.
Satellites	Number of satellites used in the measurements.
Position Type	Position type of the measurements.
Latitude/ Longitude/ Ellipsoidal Height	Coordinates of the current position in WGS84.
H. Prec/ V.Prec	Horizontal and vertical precisions of the current measures (meters).
HDOP (Horizontal Dilution of Precision)	Empirical and dimensionless indicator of the quality of the horizontal measure. The lower it is the higher is the quality.

VDOP (Vertical Dilution of Precision	Empirical and dimensionless indicator of the quality of the vertical measure. The lower it is the higher is the quality.
PDOP (Position Dilution of Precision)	Empirical and dimensionless indicator of the quality of the measure. The lower it is the higher is the quality.
Age	Real Time Age of the corrections received by the GNSS.
Easting/ Northing/ Orthometric Height	Coordinates in the coordinates system used in the project (shown above these parameters).

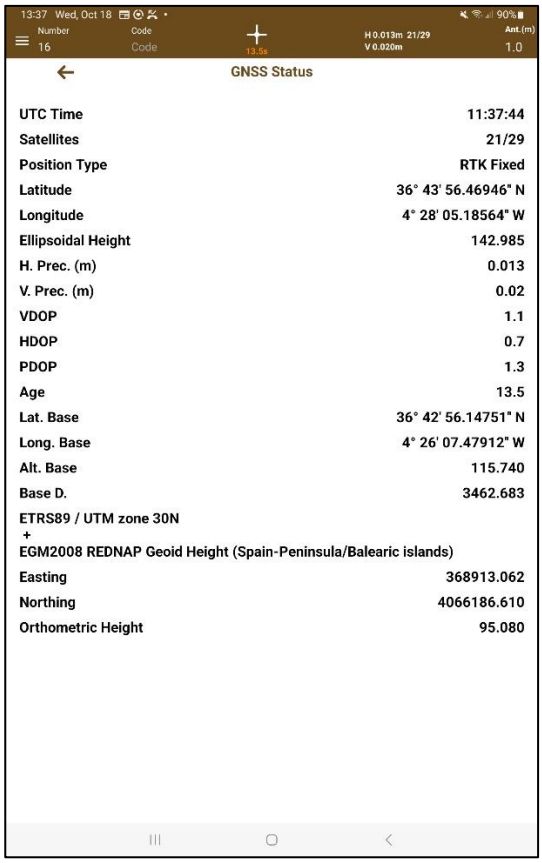


Figure 16. GPS status

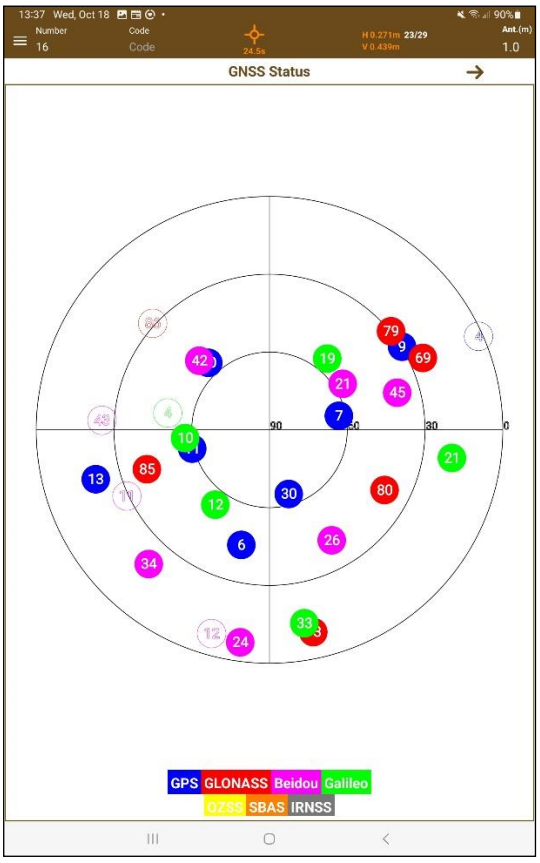


Figure 17. Satellites constellation

4 Preparation of the project

From the **Session** screen at the start of the application or the main menu in **Menu > Project**, the user can create a new project o select one of the previously created.

4.1 Project options

The **Project** submenu can be found on the menu, which allows you to choose one of the following options:

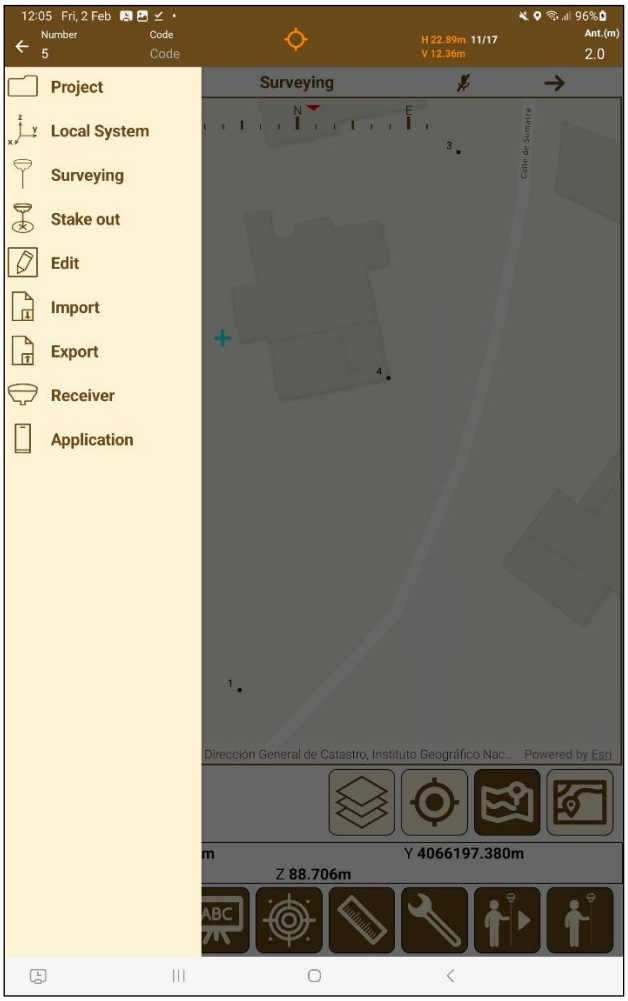


Figure 18. Main menu

- **Information**: On this screen you can consult the properties of the project (the name, author, coordinate system, etc.). As well as the local system, if any is applied. If the user wishes to swap between pre-existing local systems they can do so.
- **New project**: Allows a new project to be created, as it is described in section **Creation of a new** project**.**
- **Open**: Allows you to choose another project to work on.

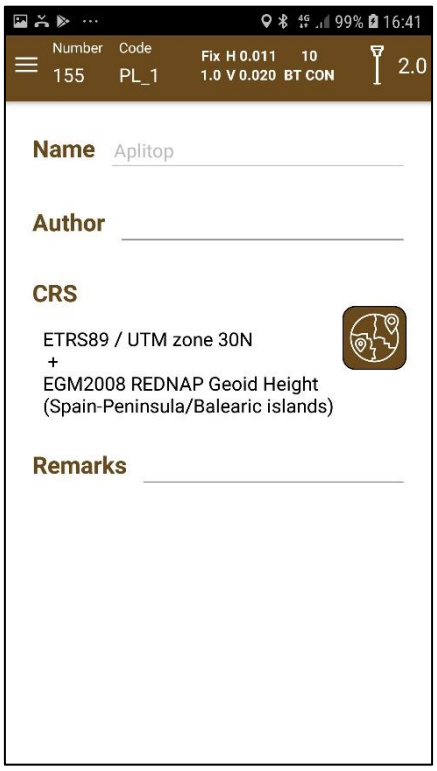


Figure 19. Project information screen

4.2 Creation of a new project

If the option to create a *new project* is selected, the application will display the screen shown in the Figure 20. It will request:

- The **Project Name**
- The **Author** of the job.
- **Project information** with the last update date and the number of points.
- Descriptive, informative **comments** or relevant project data.
- A **Coordinate system** that will be used for the job.

Once all the data has been entered, the project will be load and the application will be entered in **Survey** mode.

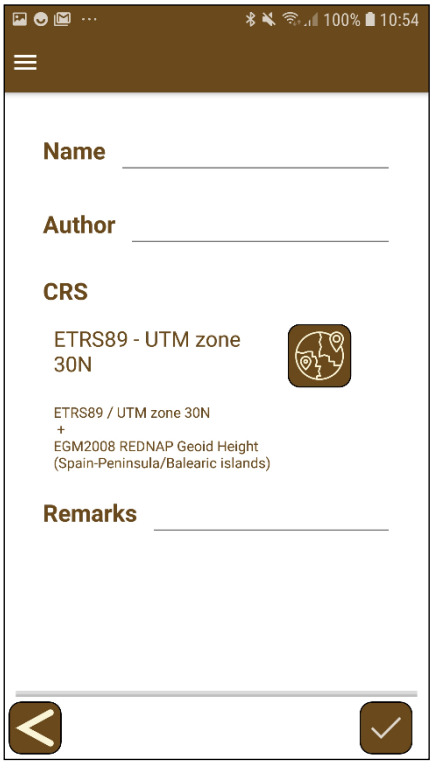


Figure 20. Project creation

4.3 Selection of coordinate system

ISO Standard 19111, **Geographic information - Spatial referencing by coordinates**, defines the conceptual scheme for the description of spatial referencing through coordinates. Describes the necessary data to define the reference systems of one, two- and three-dimensional coordinates as well as the information needed to convert coordinates from one system to another.

According to this Standard, a coordinate reference system is composed of a coordinate system and a datum. Of the different types of datums that distinguish the Standard, the **Geodetic Datums** and the **Vertical Datums** are the ones that will be used in this module. The former requires the description of an **Ellipsoid** and the latter do not.

Based on this classification, two groups of coordinate reference systems have been created: Geodetic **SRC and the Vertical SRC**.

The **Geodetic** SRCs are divided into different types. Based on the classification of **ISO 19111** and the classification made by the **EPSG (European Petroleum Survey Group, www.epsg.org,** http://www.epsg.org/now the **OGP**, **International Association of Oil & Gas Producers**) in its database, we will distinguish: the **SRC Geographical, the SRC Geocentric and** the **SRC Projected**.

To start working on a project, it is essential to define in which coordinate system the points and geographic data will be represented.

Clicking on the button  displays a list of coordinate systems that have previously been configured in the application.

If you want to add a new one, click on  .

Once the coordinate system is selected from the list, it will be assigned to the project by clicking on the button  .

The coordinate system could be also deleted using the button  .

If you use a coordinate system frequently, it can be set as your default coordinate system of your new projects by selecting it from the list and pressing the button  .

It is possible to edit the name of the coordinate system by selecting a coordinate system from the list and pressing the  button. This will change the name in all existing projects, as well.

4.3.1 Creating a coordinate system

After touching the  button, the CRS creation screen will appear.

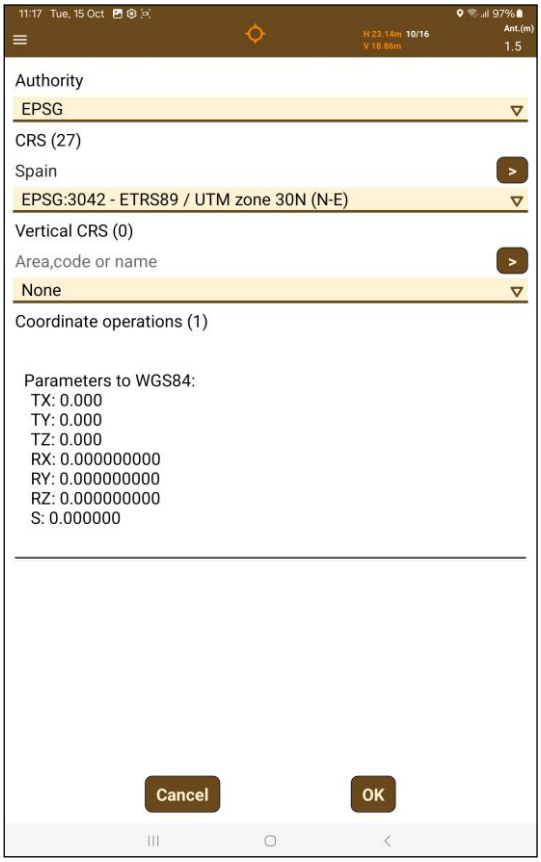


Figure 21. CRS Creation Screen

First, it's possible to choose the Authority between these:

- EPSG
- ESRI
- IGNF
- USER

EPSG is the default, as the one that has the most data. USER will contain special CRS as well as RTCM based CRS.

It's possible to filter through CRS and Vertical CRS by using the textboxes. It's possible to filter through name, code, or country, as show in the previous image.

4.3.1.1 Horizontal CRS

The CRS must have a horizontal CRS or just "CRS". It is not possible to have a CRS without this, and UTM zone 1N will be selected by default if nothing is chosen.

After typing in the code, name, or country, it is possible to choose whichever CRS is applicable regarding the physical location of the project and the desired projection.

Figure 22. Spain CRS list

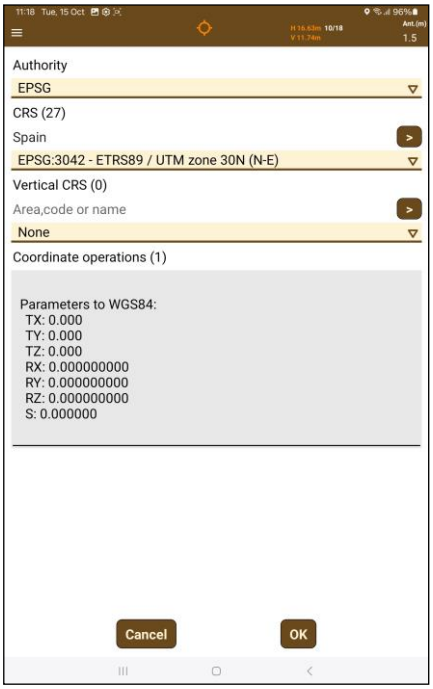


Figure 23. Chosen Coordinate Operation

Choosing the CRS will populate the Coordinate Operations list, which is able to be touched to select one to finish creating the CRS.

4.3.1.2 Vertical CRS

After searching for a country, code, or name of a vertical CRS, it'll be possible to change from "Nothing" to a vertical CRS. If the horizontal CRS is incompatible with the selected vertical CRS, nothing will appear in the Coordinate Operations list. If a Vertical CRS is chosen and there's a desire to remove it, you can go back to "Nothing".

If it is compatible, Coordinate Operations using Geoid files will appear on the list.

If the Geodesy file is not in the device, it will show the words "(Download available)". After the Coordinate Operation is touched in the list, a Download Files button 

will appear. If it is touched, a small message saying "Downloading files…" will appear. After the message "(1)" appears after, the file has been downloaded, it is then now possible to finalize creating the CRS.

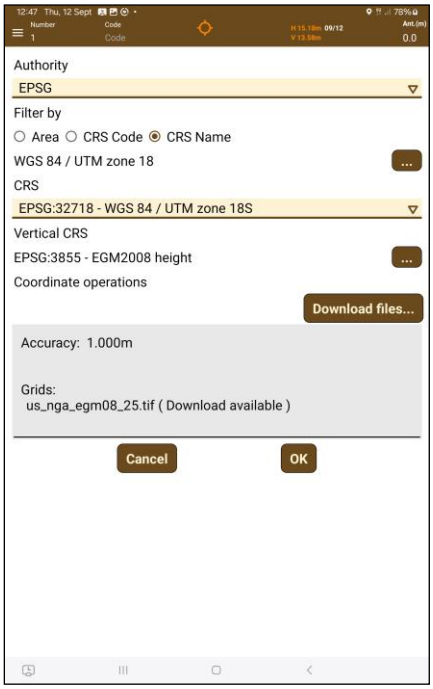


Figure 24. Vertical CRS Coordinate Operations

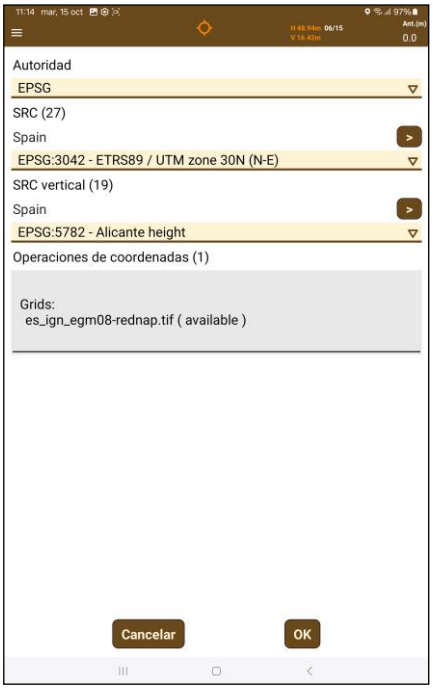


Figure 25. Vertical CRS Geoid File Downloaded

4.3.1.3 Finishing creating a CRS

Once a Coordinate Operation has been chosen (this is obligatory), the OK button can be pressed. 

A dialog for inserting the name of the coordinate system created will appear.

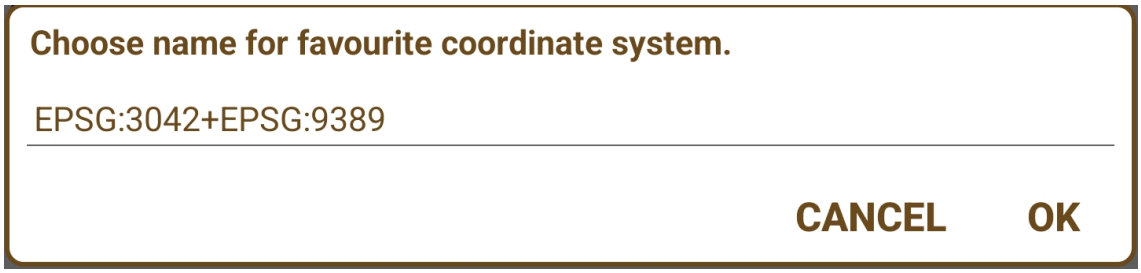


Figure 26. CRS Naming Dialog

A name including the codes of the selected CRS will be displayed by default, but it can be changed to anything.

There can't be two CRS with the same name in the application.

4.3.2 Creating a coordinate system from RTCM messages

For countries in which NTRIP servers send RTCM transformation messages alongside real-time corrections, it is possible to create a coordinate system with the info contained in said messages.

The supported messages are 1021, 1023, 1025, 1026, 1027. In case of message 1025, only the following projections are allowed:

- Transverse Mercator (EPSG:9807)
- Lambert Conic Conformal 1SP (EPSG:9801)
- Lambert Conic Conformal 2SP (EPSG:9802)
- Cassini-Soldner (EPSG:9806)
- Oblique Mercator (EPSG:9815)
- Oblique Stereographic (EPSG:9809)

4.3.2.1 Creating RTCM CRS

To access the creation of RTCM CRS, an external GNSS device must be connected and then accessing the receiver configuration. When configuring the receiver, after accessing the Rover option  , the NTRIP tab should be selected. After pressing the 

button, the NTRIP dialog box will appear.

At the bottom of it, there is a checkbox titled “Analyze CRS RTCM”. Once checked, that will give access to the “Create CRS RTCM” button”. Pressing it will reveal the RTCM screen.

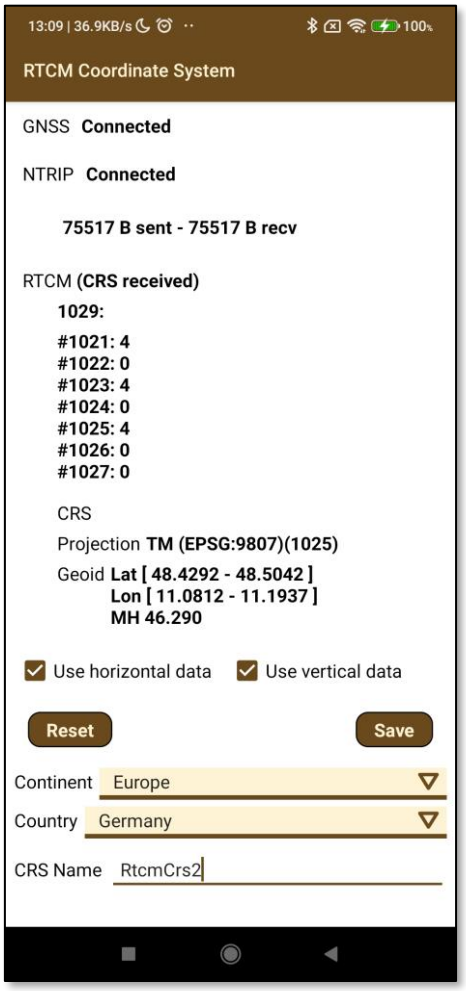


Figure 27. RTCM Coordinate System Creation

The data presented are:

Continent/Country: Shows the selected area where the coordinate system will be stored. It is important selecting the correct are so the new system will be shown in the list.

GNSS: Connection status with GNSS receptor.

NTRIP: Connection status with the NTRIP server.

RTCM: Coordinate system status, which can be **waiting for coordinate system** or **coordinate system received**. The following are shown: The content of the RTCM 1029 message and the number of received messages from 1021 to 1027.

CRS: Name of the system that the server sends.

Projection: Name of the used projection.

Geoid: Information of the area where the geoid is valid and the average geoidal separation.

Use horizontal data: Indicates whether the geodesic CRS should be created or not.

Usar vertical data: Indicates whether the geoid should be created or not.

Reset: Restarts the data capture to create the coordinate system.

Save: This button will be enabled when the system has been received and it allows it to be saved in the geodesic local database for later use, with a **name the user has selected**.

4.3.2.2 Using RTCM CRS

After creating the RTCM CRS with the preferred name, it can be selected by choosing the USER Authority. Afterwards, it will appear inside the dropdown selection menu for CRS.

There is no need to choose a Coordinate operations. It's possible to press OK directly, and this will save the RTCM CRS to be able to be selected for a project.

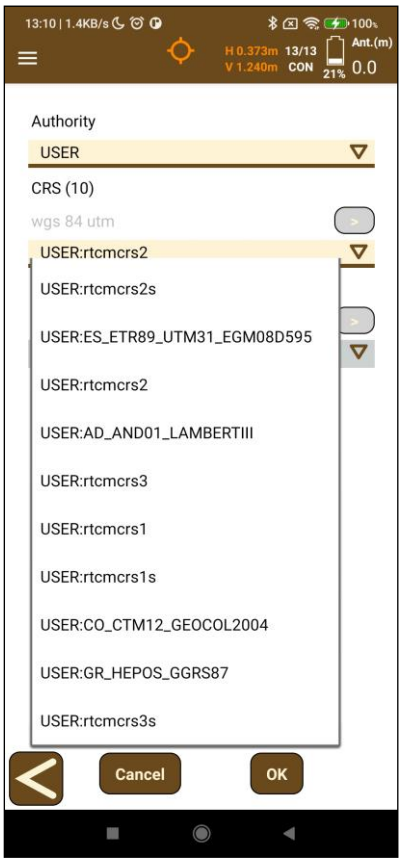


Figure 28. List of User CRS, including the created RTCM

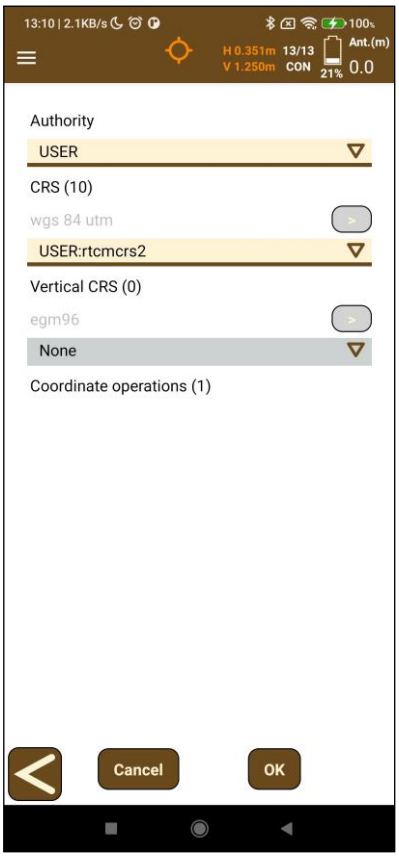


Figure 29. User CRS selected, ready to press OK to save

4.3.3 Importing Geodesy Files

TcpGPS allows for importing of new Geodesy files to be used with new Coordinate Systems, by accessing **Import > Geodesy** in the menu. The Android File Explorer, SAF, will open allowing you to choose *.dat*, *.gde*, *.gsb* and *.db* files. Please be mindful that usage of these imported Geodesy files is under the user's responsibility. They cannot be deleted later except by uninstalling the application.

4.4 Project Deletion

TcpGPS allows projects to be deleted one by one by simply selecting them from the list, pressing the delete button and confirming that the decision is correct. If the project is currently open, the application will not allow the project to be erased, so that there is no data loss. It is important to keep in mind that performing this operation is **completely irreversible**.

Figure 30. List of projects to delete

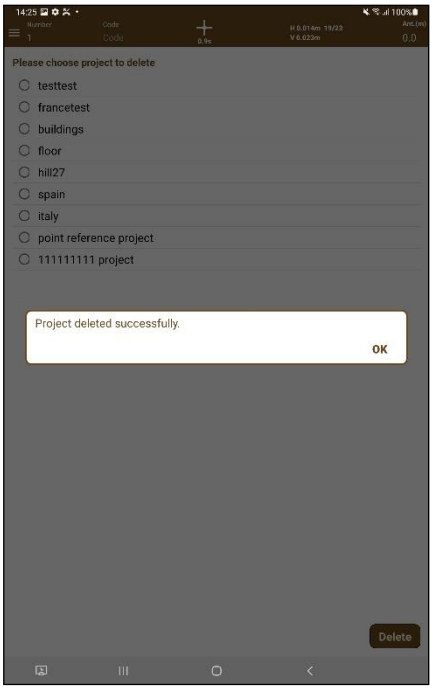


Figure 31. Project deleted successfully

4.5 Backup

TcpGPS allows backup files of all projects to be created, which are exported in .zip, and then restore them after, both by chosen projects or fully restored. These options can be accessed from the menu, under the **Application** section.

4.5.1 Create backup

To create a backup, the folder must be chosen using the  button to give the application permission to be allowed to write on the folder that has been chosen. Once

this is done, the button *Create Backup* will enable, and a **.zip** will be created in the chosen folder.

This **.zip** can be shared, (see **14.8 Share exported files**) but it is important to keep in mind that it is probable that the file is of a large size, and it is possible that some applications can't use it, but it can be exported to *Google Drive* without any issue.

4.5.2 Restore Backup

To restore a backup, the  button must be pressed to open the Android Explorer, choose the backup **.zip** file. It Will be read to obtain all the projects inside of the backup.

If the Restore All option is chosen, all the projects will be restored from the backup. If the Restore Projects is chosen instead, the projects to be restored from the backup may be individually picked from the list.

NOTE: If a project to be restored shares a name with a previously existing project, it will be replaced! Make sure that there will not be any data loss.

Once the backup restoration has been performed, the application will close to avoid errors and data loss.

Figure 32. Restore Backup

Figure 33. Create Backup

5 Workspace

Figure 34 shows an image of the workspace as presented at start-up. The following parts are distinguished:

1. **Map**: The map is the main working element since it is where the points and information about them are displayed.
2. **Map menu**: Various options for working with the map are displayed in the map menu, such as accessing the layers presented in the map, zoom extension, GPS tracking, and map mode.
3. **Working menu**: Options for carrying out work regarding surveying, staking out, points, etc. are displayed in this menu, depending on the section being accessed.
4. **Application menu**: Options to browse through the different sections of the application are displayed in this menu, such as surveying, staking out, or project.
5. **Status toolbar**: Information regarding the GPS and Bluetooth status. Additionally, fields for setting the number, code and antenna height of the receiver are available.
6. **Navigation controls**: This menu has buttons to change the working mode in those templates that are allowed, as well as additional options, also depending on the template.
7. **Data panel**: This space is used for showing information and data needed in the current working section.

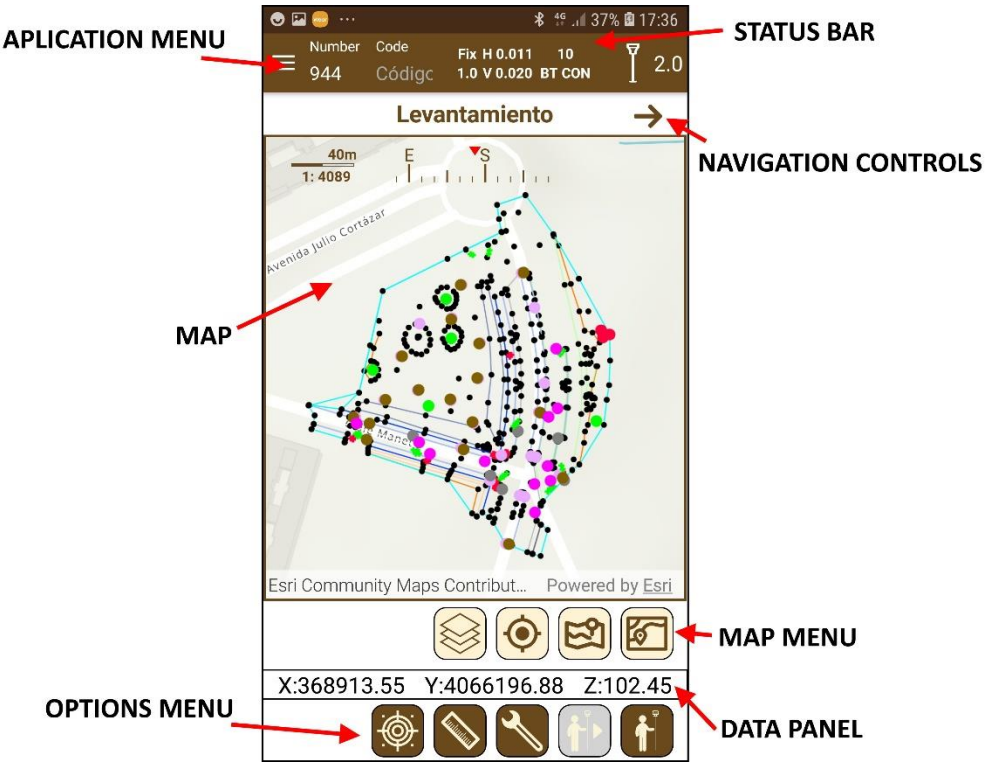


Figure 34. Workspace

Each of these parts will be described below, and the information and elements that are presented in will be shown in each section.

5.1 Map menu

In sections where the map is used, a floating menu appears inside the map window containing options for interacting with it. Some options are shown only in some sections. In the following table are described all the available options:

	Access to **Layer management** section.
	Zoom the map showing all the elements of the project. Zoom Extent.
	Enable/disable the GPS tracking.
	Change the base map type: **topographic**, **streets** or **satellite**.

5.2 Status toolbar

In the status bar you have access to the Application **Menu,** as well as to the information on the current status of the receiver that is being used. In Figure 35 you can see in detail the content of the menu bar.

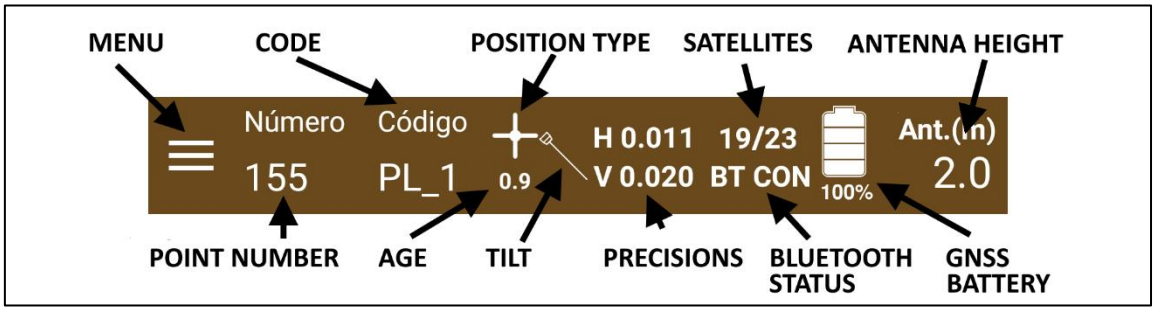


Figure 35. Status toolbar

- **Application menu**: Described above, it gives access to the different templates of the application.
- **Antenna height**: Set the antenna height in the project (meters).
- **Type of position**: Position that the GPS is currently capturing. It can be:

 **Fixed**

 **Floating**

 **Autonomous**

-
- **Age**: It refers to the age in real time, in seconds. The latency of the corrections that are received from the reference base.
- **Tilt**: Those receivers where tilt option is supported, this icon will show the status of it. The possible icons are:

 Tilt not connected or error.

 Need to calibrate. Please, follow the steps provided by the manufacturer.

 Keep the receiver vertically.

 Tilt limit exceeded.

 Ready for measurement.

- **Precisions:** The vertical and horizontal precisions in which the receiver is currently working in, in meters.
- **Battery:** Those receivers whose battery state is supported, it will be shown here together the remaining charge.
- **Satellites**: Number of satellites currently used to perform the measurements.
- **Bluetooth status**: Icon that shows the current status of the Bluetooth connection to the external receiver (if this receiver option is being used). The following messages are used for describing the status of the Bluetooth:
    - **BT ICX**: Initializing connection.
    - **BT CRC**: Creating connection.
    - **BT CTN**: Connecting with GNSS.
    - **BT CON**: Connected to GNSS.
    - **BT ND**: No data from receiver.
    - **BT EC1**: Connection error 1.
    - **BT EC2**: Connection error 2.

- **BT DSN**: Disconnecting from receiver.
- **BT CLC**: Closing connection.
- **BT DSC**: Disconnected from receiver.
- **BT EXC**: Connection exception.
- **BT EXD**: Disconnection exception.

6 Application Menu

It is possible to change between two menu types depending on the type of menu that the user wants to use.

These menu types can be swapped from the **Settings** section in the **Application** submenu.

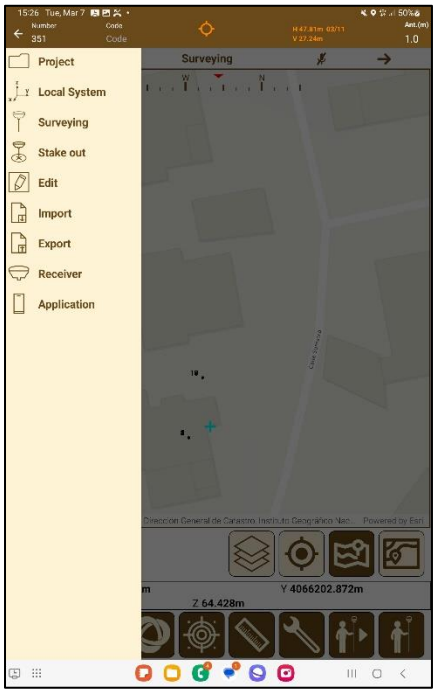


Figure 36. Side Menu

Figure 37. Button Menu

The **Side Menu** features a sidebar that opens into submenus. It is dynamic and fast.

The **Button Menu** features a full-screen menu with large buttons to press that open other full-screen submenus with their own set of buttons and icons. It is easy to use and to read.

6.1 Disable Menu Buttons

Under **Settings** section in the **Application** submenu, you are able to change the visibility of the buttons.

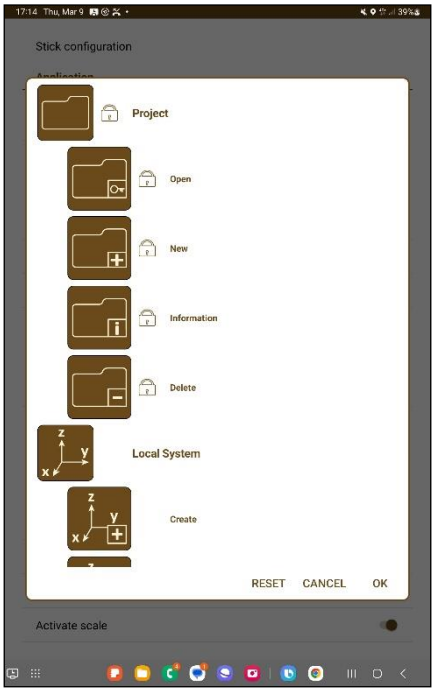


Figure 38. Disable Menu Buttons

By touching the menu items, the background of these will darken, signifying that the menu items will not appear when you open the menu, either menu type. Menu items that have a lock next to them are not able to be disabled, due to the fact that they're essential to the correct functioning of the application.

By pressing the "Reset" button, it is possible to reset the settings, removing all of the selected menu items, so all of them are visible quickly.

7 Configuring the workspace

The **Settings** option can be found in the **Application** submenu. This option leads to the **Settings** section, where a set of parameters for the workspace is available (Figure 39). These options are described in the table below:

Surveying and Staking Out	
Item categories	Item categories to be considered for GPS data. **Only affects current project.**
Minimum Number of Satellites	Minimum number of satellites for obtaining GPS data. **Only affects current project.**
Real Time Age	Maximum difference in time between corrections that will be considered to validate

	the position received. **Only affects current project.**
Horizontal and vertical precisions	Minimum precisions that will be considered to validate the position received from the GPS in meters. **Only affects current project.**
PDOP	Empirical and dimensionless indicator of the quality of the position received (Position Dilution of Precision). The lower the value, the higher the quality. **Only affects current project.**
Height of the Antenna	Default antenna height to be used during the Project (in meters)
Attributes after taking Point	After taking a point, if this is active, the point edit screen will be automatically opened, the GIS User Attributes tab being activated so they can be quickly updated.
Long press for precision points	In case this is active, the possibility of taking survey or stake out points via epochs with the chosen observation time only with a long button press. If it is deactivated, and observation time is greater than 0, with a short press, point via epochs will be taken.
Observation Time	Time interval in seconds when the epochs for defining the current point will be taken.
Codes separator	Character used as reference for codes separation in multicodes (see **Point code management**)
Code Suffixes	Allows you to change the suffixes of the codes for line/polygon start, line finish/end and polygon/area close. If you leave any field blank, it will default to your language's default for suffixes.
Enable Code Prefixes	Allows you to use code prefixes in the whole application. If you enable this and you have any codes that begin with numbers and are followed by a letter, you will be unable to enable this option, in order to keep the integrity of the data intact.

Not parsing of Codes	Allows you to write anything you wish in the code box, but codes will no longer be parsed, that is, they will have no graphical representation. This is useful for teams that write data in codes, but don't care about graphical representation. The code database will not be able to be accessed while this mode is active.
Replace Voice Recognition Codes letters for numbers	With this option active, when using voice recognition in the code selection screen, it will transform single numbers from letters to a numeric character. Example: "FOUR" > "4"
Codes file	Allow to choose a file with a list of predefined codes for points.
Default Coordinate System	Allows you to choose a default coordinate system that can't be changed even when creating a new project.
Voice measure keyword	In those working sections where the icon  is present, the measure by voice can be enabled. The word defined here will be the one interpreted as the keyword to measure.
Default Base Map	Change the base map by default. You can enable/disable ESRI Maps as well as choose the type of map you want between Topographic, Street or Satellite, and it will always be that type when you enter a map screen. You can also add a WMS/WMTS that the base map will always be when you create a new project. You can also add new WMS/WMTS, but you can't manage them from this screen.

Staking Out

Staking Out Mode	Staking out mode used (north, movement, or most recent point staked out)
Horizontal Tolerance	Horizontal tolerance to take the point as having been reached (in meters). **Only affects current project.**
Vertical Tolerance	Vertical tolerance to take the point as having been reached (in meters). **Only affects current project.**

Distance Target Mode	Distance at which to change to target mode (in meters). **Only affects current project.**
Next Point	Automatic stepping to the next point to be staked out according to the number of the point or by proximity to the current one.

Augmented Reality

Text Size in AR	Size of the text used for showing the id of the points.
Distance for displaying texts	This distance is used for displaying only the texts of the points that are at this distance as maximum.
Stick configuration	The user can configure the length and the color of the highlighted stick.

Application

Orientation	Allows to choose the screen orientation (portrait or landscape).
Sound Mode	Switch between sounds or voice indications.
Menu Type	Allows choosing the type of menu you want to use in the application.
Enable Menu Buttons	Allows the enabling and disabling visibility of menu items. (See **7.1 Disable Menu Buttons**)
Use Clustering	Enable the clustering of points when zooming.
Cluster Tolerance	Level of point clustering.
Minimum Observation Scale for Cluster	Scale level from which point clustering will be applied.
Minimum Observation Scale for Point Data	Scale level from which the point data will be displayed on the map.
Activate floating button	Allows to use a floating button that can be set at any place of the screen for measuring points.
Floating button size	Sets the size of the floating button.

Activate log	Allows the activation of the logger for generating log files of the current session.
Activate compass	Activation of the compass over the map.
Activate scale	Visualization of the map scale.

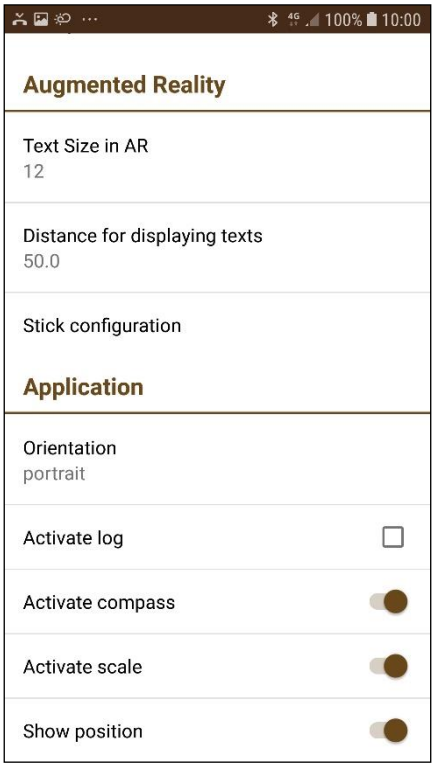


Figure 39. Configuration section

8 Local systems

There are two ways to create local systems, one using point pairs and visual aid of two maps, or by parameters.

It is not possible to create a Local System when one is already being used. It will be removed when the the attempt to create a new one is made.

8.1 Create a Local System with Point Pairs

this section the user can create, apply or remove a local transformation by adding or modifying control points. Available transformations are **2D/3D Displacement** and **2D/3D Helmert**. **Appendix A.** Transformations contains detailed information about these transformations.

It is recommended to create Local Systems with the device in a Landscape orientation, as it shows both maps at the same time, as shown in Figure 35.

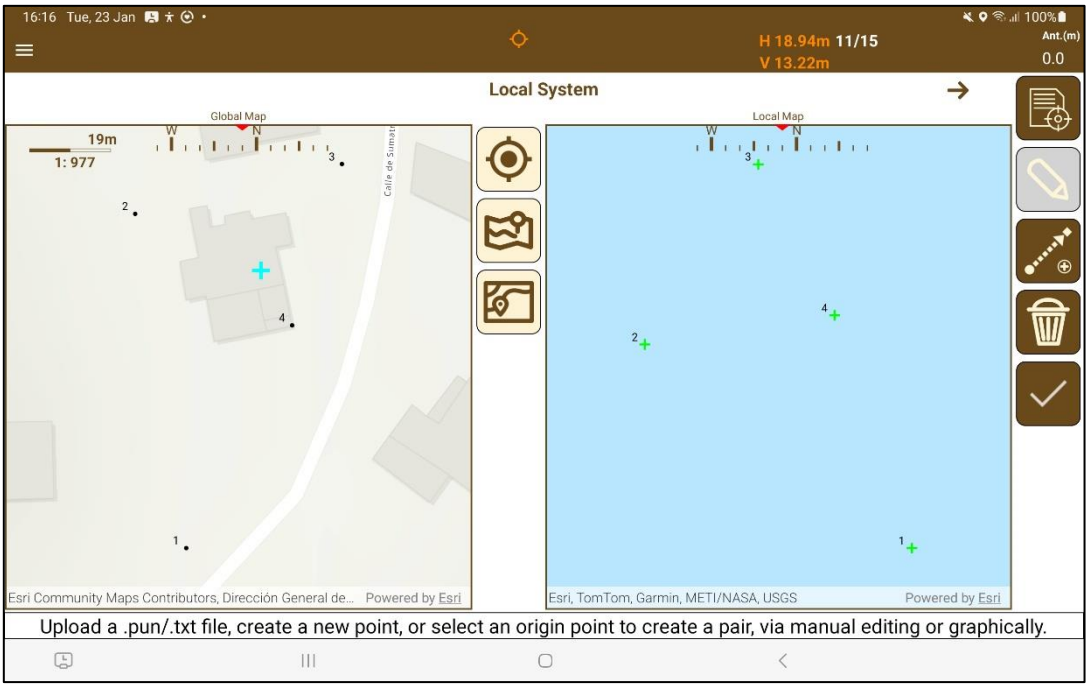


Figure 40. Creation of a local system with point pairs

It is also possible to create local systems with the device in the Portrait orientation, and the arrows can be used to swap between the Global Map and the Local Map, as well as the Data View, so maps can be used as if they were side by side.

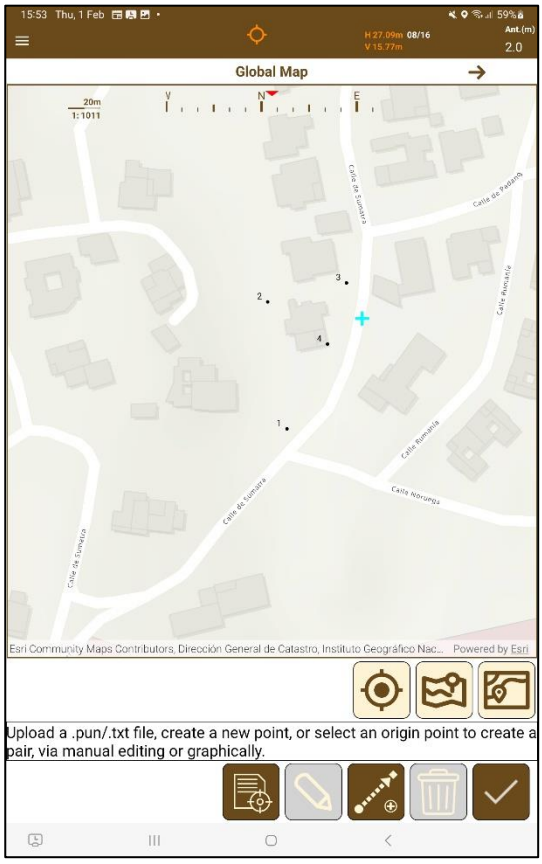


Figure 41. Portrait Global Map

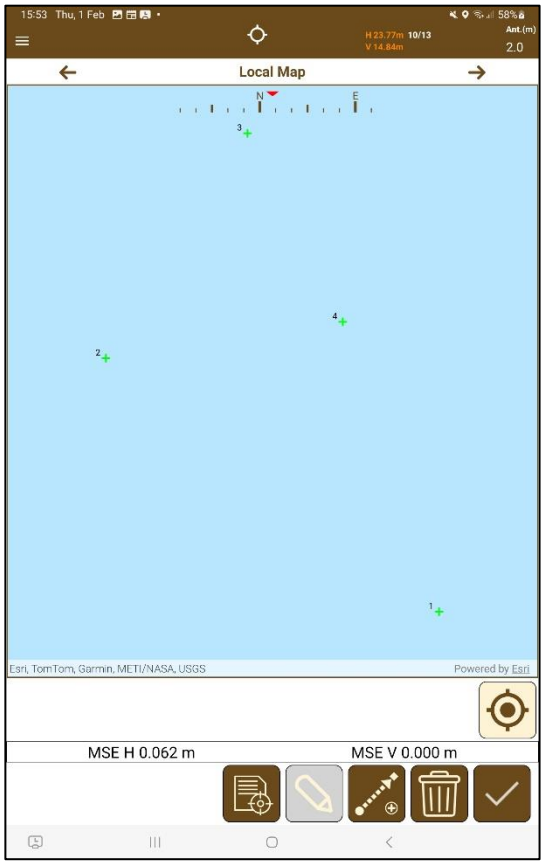


Figure 42. Portrait Local Map

On the menu of this template are the buttons for the different options that allow the insertion of points and creation of point pairs in addition to being able to select these directly on the map if there are points previously existing in the project database. These are outlined below:

	Manual insertion of the source and target of the point pair. Allows to create new origin points from GNSS.
	Add a target point to a selected source point or edit a selected exsiting point pair.
	Import a **.txt** or **.pun** file with points that are used as a source for target points. The format is: Number X Y Z Code.

	Erases all pairs between source and target points, resetting the transformation, but keeping all the points added.

After importing a target point file, if the point numbers of the target points match any of the source point numbers, point pairs will be created automatically. This is the reccomended way of creating local systems quickly if there are plans on using it beforehand.

When manually inserting, or editing the target point paired with a source point, a dialogue is displayed to allow the user to edit the information of the points. This dialogue has options for typing the source point coordinates, using the current GNSS receiver position, or selecting points from the database for source coordinates, or the imported file for target coordinates.

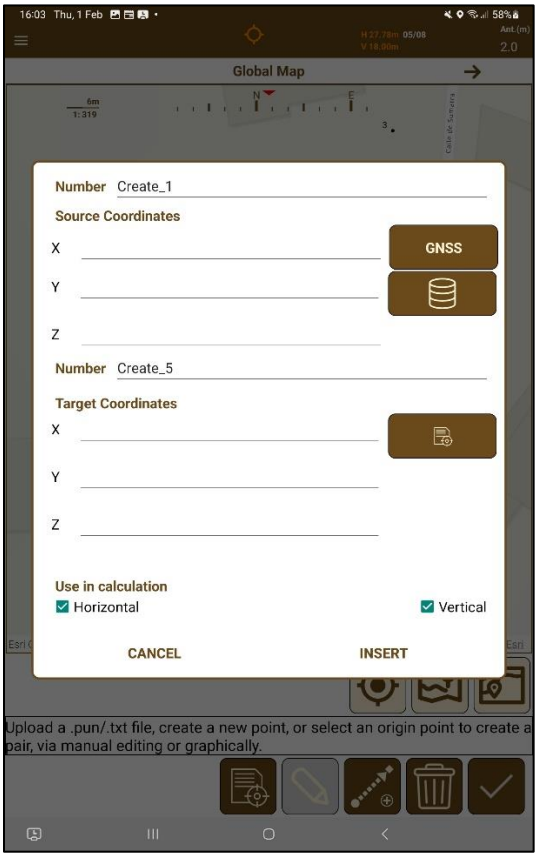
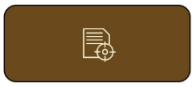
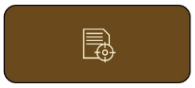


Figure 43. Point Pair Creation

Figure 44. Point Pair Editing

These dialogs have the following icons:

	Obtains the current geographical location (X,Y,Z) of the current GNSS receiver and adds it to the Source Coordinates.
	Obtains the number and Source Coordinates of a point existing in the project database.
	Obtains the number and Target Coordinates of a point existing in the already uploaded target points file.

It is important to remember that **each point can only be in a single pair**. To avoid duplicate pairs, the application automatically removes points already existing in pairs from the list of points that can be selected from both the source  and destination  point lists, as well as not letting you save the pair if either the source or target points already exist in a pair.

To keep data integrity intact, if the point number written in the source or target point textboxes is the point number of a point that already exists in either list, the coordinate textboxes will change to the X Y Z data of the point that has that point number, and it will not be able to be changed. This way the integrity of the pre-existing numbers is kept.

Once point pairs are created, the numeric screen shows detailed information about the transformation, the points used, leftovers and errors.

Using the dropdown different types of lists can be selected:

- **Source points list**: The coordinates of these points will be used as *origin coordinates*.
- **Target points list**: The coordinates of these points will be used as *target coordinates.*
- **Leftovers list**: Show the differences between each origin and target point. This is the list that has all of pairs already defined in the local system.

The number of control points will enable one or several transformations that can be selected in the spinner of the numeric screen.

Each transformation will be characterized by a set of parameters:

- **MSE 3D**: Medium Square Error in 3D.

- **MSE H/V**: Medium Square Error in horizontal and vertical.
- **Max**. **Res. X/Y/Z**: Maximum residue in X/Y/Z coordinates.

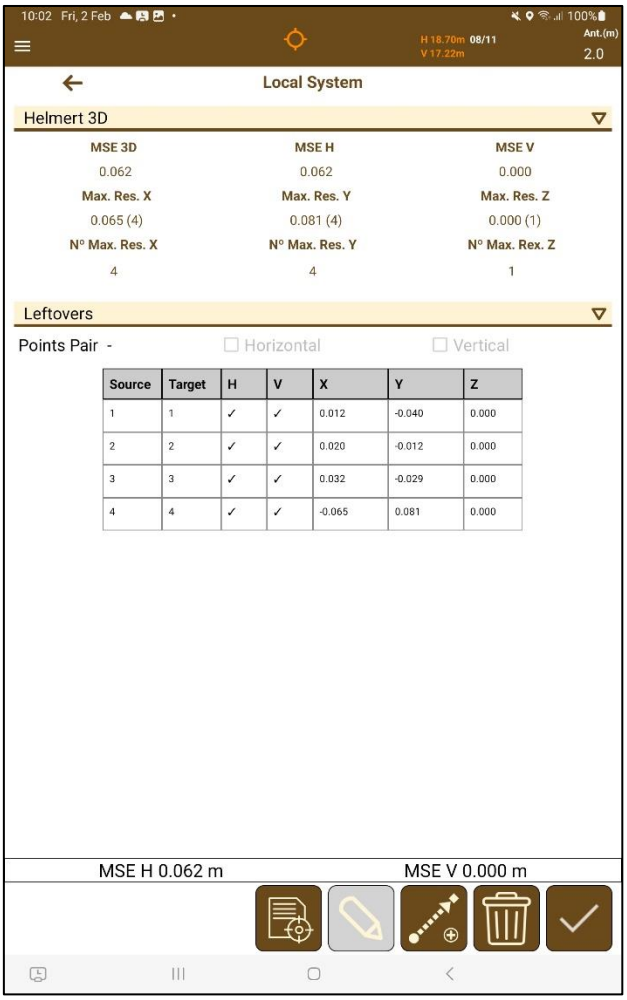


Figure 45. Transformation data

After selecting a point pair in the list, it is possible to toggle the horizontal or vertical transformation of each pair with the checkboxes that become enabled when you choose a source/target point that is part of a point pair, or an element from the leftovers list.

The transformation can be saved to the project by pressing the icon  . A name for the file will be requested and the transformation will be stored in a file with the **.ntr** extension into the project folder.

The application will ask whether to only transform points with raw data or transform all points. Points with raw data are the ones that have been manually taken in the survey screen. Points without raw data are the ones that have been imported.

8.2 Create a Local System with Parameters

In **Menu>Local System> Create By Parameters**, parameters can be inputted in order to create a new .ntr file that will be applied to the current project.

Depending on the type of transformation, chosen at the top of the screen, different data will be asked to be inputted.

- Translation 2D:
  - Translation X
  - Translation Y
- Translation 3D:
  - Translation X
  - Translation Y
  - Translation Z
- Helmert 2D:
  - Translation X
  - Translation Y
  - Rotation
  - Scale
- Helmert 3D:
  - Translation X
  - Translation Y
  - Translation Z
  - Rotation X
  - Rotation Y
  - Rotation Z
  - Scale

All of the data involving Rotation must be introduced in a Grade º Minute' Second " format, including the symbols.

8.3 Apply a local system

In **Menu > Local System > Apply**, the user can select a **.ntr** file in the device containing a transformation previously created and apply it to the current project.

The application will ask whether to only transform points with raw data or transform all points. Points with raw data are the ones that have been manually taken with the survey screen. Points without raw data are the ones that have been imported.

8.4 Remove a local system

The user can stop using a transformation at any moment by clicking on **Menu > Local System > Remove**. The transformation will stop being used and the points will be

converted to the original coordinates system of the project. The same points that were transformed, whether only the ones with raw data or all of them are transformed back. The transformation file is not deleted from the internal storage of the device.

8.5 Place a local system

This option is used to apply an offset to an existent local system, allowing to fix the differences between the current coordinates of the reference base and the coordinates of the project.

Figure 46. Place in local system map

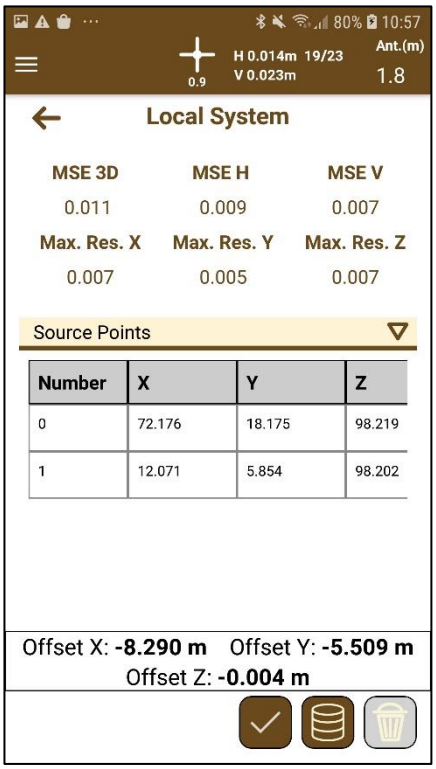


Figure 47. Numeric section of place in local system

By **Menu > Local System > Place** the user accesses to the screen for adding these offsets. Selecting a point from the map or using the list of the points contained in the project by clicking on  , the user can start configuring the new offset.

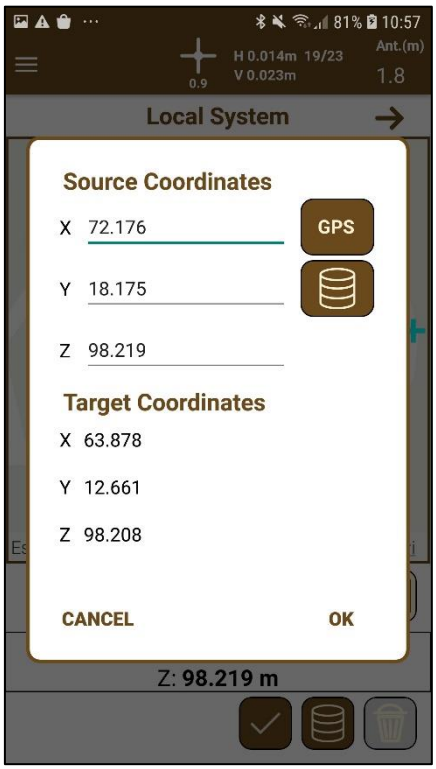


Figure 48. Dialog for pairing origin and target points

Then, a dialog appears to choose the origin point that will be used to calculate the offset, using the current position of the GPS (button **GPS)** or the list of points of the project  .

When the pair of points is accepted, a green cross will be shown in the map marking the position of the origin point. The user can add as many points as he wants, and the offset will be the average of all these points.

If the user wants to delete any of the pairs, he must only select it in the list of the numeric section and click the button  .

By clicking the button  , the offsets of X, Y and Z coordinates will be stored and applied to the next points the user will survey.

In the information panel at the bottom of the screen the user can check the current position and, if he slides his finger on it to the left, the panel with the calculated offsets will be shown.

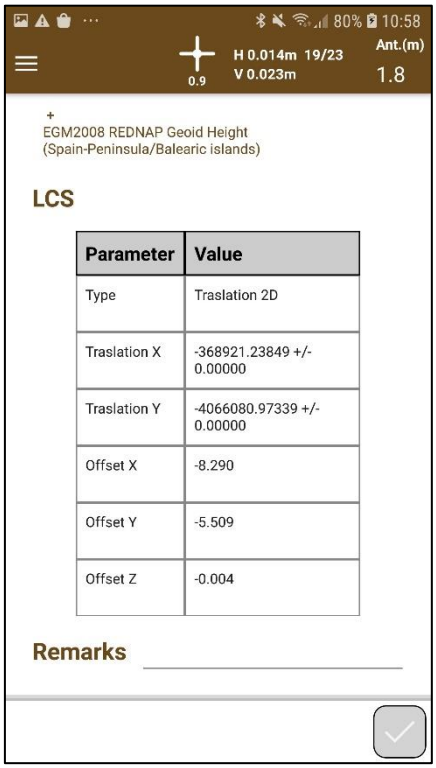


Figure 49. Current offsets to be applied to points

9 Layer management

In the TcpGPS maps (both when surveying and staking out) a division into layers is carried out that are organized according to their nature (Figure 50).

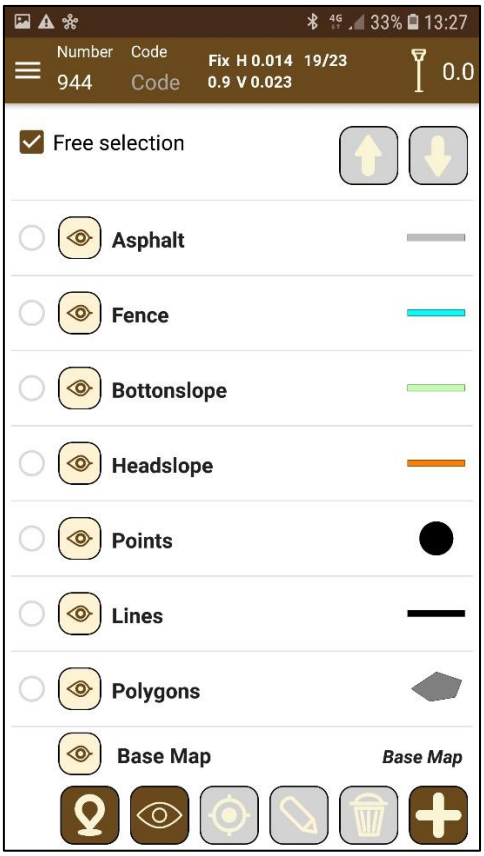


Figure 50. Layer manager

The following types of layer store points, lines and polygons created when working. These layers are associated to codes, and the same layer may be associated with different codes, but always of the same type:

- **Points Layers**: These layers divide the set of work points into different subsets separated by their code. When a new project is created, a layer of **points** is automatically created that will contain all the points that do not have a code, or the code has no layer associated.
- **Lines Layers**: These layers contain lines and polylines defined attending to the lineal code associated. When a new project is created, a layer of **lines** is created for those lines with no code or the code has no layer associated.
- **Polygons Layers**: These layers contain polygons defined attending to the polygonal code associated. When a new project is created, a layer of **polygons** is created for those polygons with no code or the code has no layer associated.

The types of layer below contain base maps or cartographies, which will be used as references, but also for other tasks as surface analysis:

- **Base Map layer**: This layer is created automatically when a new project is created and is unique.
- **DXF layer**: This layer contains a DXF map imported from a **.dxf** file.
- **DWG layer**: This layer contains maps imported from **.dwg** files.
- **Surface layer**: This layer contains a 3D Surface built by DXF 3D faces or LandXML. This layer is used in surface analysis (see **Surface Analysis**

This template is intended to check a 3D surface imported from a DXF file containing *3D faces* or a LandXML containing *surfaces* entities. To carry out this check, the dimension defined on the surface will be compared with the elevation measured by the GPS and the difference will be shown. In addition, the face on which the GPS is located at each moment is highlighted.

In the **Layer management** section is possible to change the active layer in case the project contains multiple surface layers. The active surface layer will be the one taken for making the analysis.

The information shown is:

- **Height**: Current height of the GNSS receiver.
- **Height diff.**: Difference of height between the GNSS height and the current selected surface.

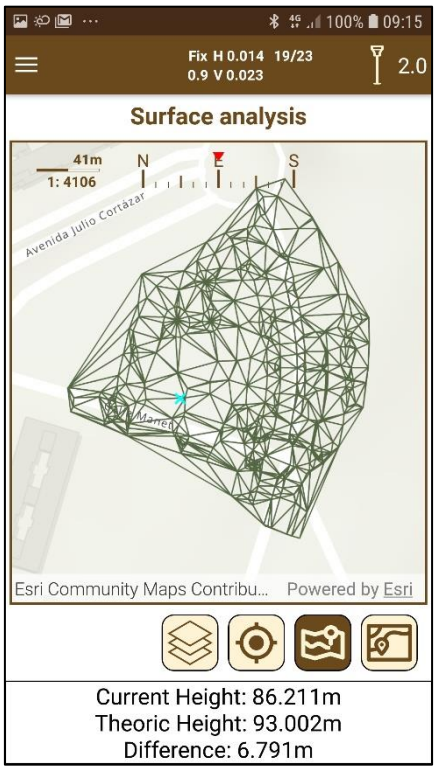


Figure 134. Surface analysis

- **KML/KMZ layer**: This layer contains a KML cartography. It also can be imported from compressed format with **.kmz** extension**.**
- **GML layer**: This layer contains a GML cartography.
- **Shape layer**: This layer contains a SHAPE map imported from a **.shp**[2] file.
- **WMS layer**: This layer allows a **WMS** service to be configured that will be displayed on the map.

The following commands can be executed on each of these layers:

- **Sort layers**: You can change the order of one layer with respect to another using the buttons to **raise** or **lower** the layer in the stack of layers.
- **Add layer** : Import a layer from a file.
- **Edit the layer** : The settings window of the selected layer type is displayed.

[2] As well as the **.shp** extension, the associated **.prj**, **.shx**, and **.dbf** files must be present.

- **Delete layer**  : Deletes the project layer.
- **Center in map**  : Center the map fitting the selected layer.
- **Display the layer**  : Enables or disables the display of the layer on the map.
- **Basic point configuration**  : Set the style and basic information to display of the points. The style will be applied only if the point has no code associated.

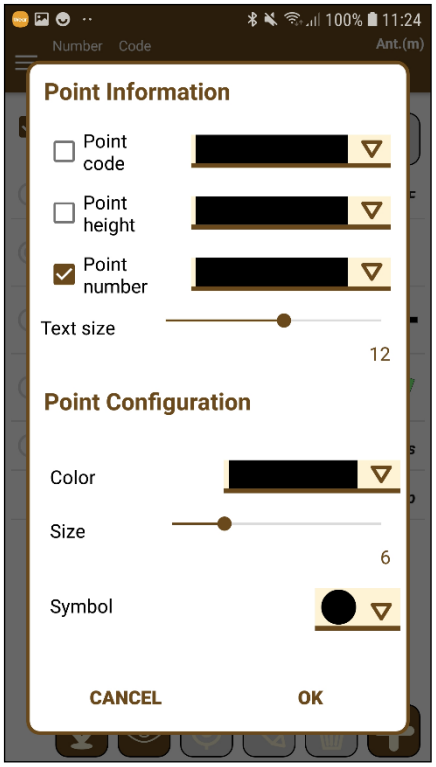


Figure 51. Point Information and Configuration

Additionally, each layer can be shown or hidden by clicking on  button.

Each layer has a selector at left side for setting the current active layer. This active layer will be the reference for searching when clicking on the map. If you do not want to establish a single active layer and you want to perform searches in general, the **Free Selection** box must be activated.

9.1 Editing the Base Map layer

This layer, like the **Points** layer, is a special layer that is created when a new project is created. Its purpose is to manage the base map that will be presented in the workspace. The properties that you can define here are (Figure 52):

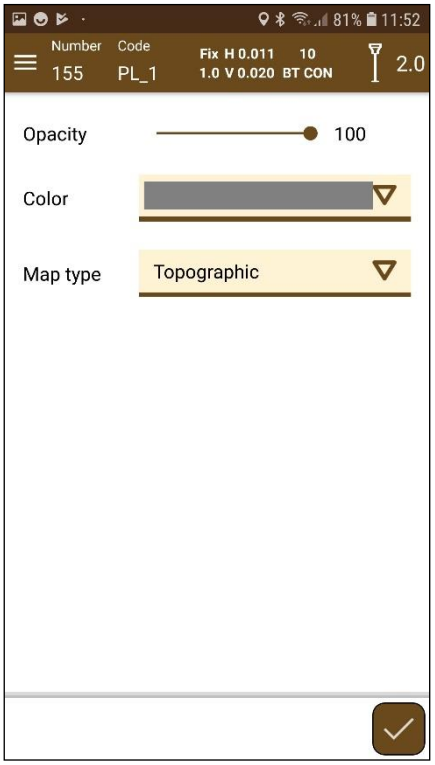


Figure 52. Editing the Base Map layer

- **Opacity**: Level of map transparency.
- **Color**: Background color when the map could not be loaded, or its visualization is disabled.

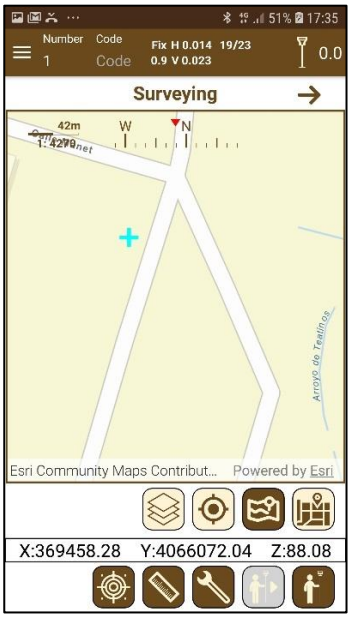


Figure 53. Street map

Figure 54. Satellite map

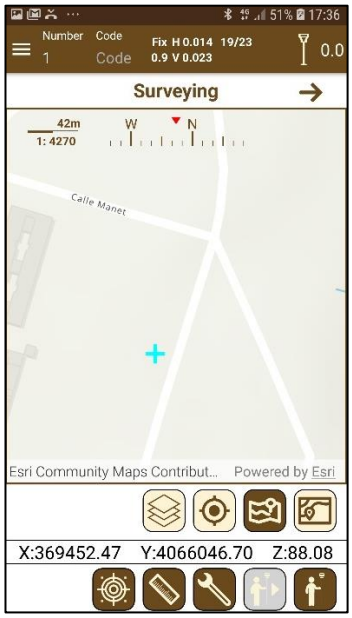


Figure 55. Topographic map

Apart from ESRI maps, the user can configure his own base maps using WMS/WMTS services. To do that the following options have been added:

- **Import WMS/WMTS service**: Allow to import a list of WMS/WMTS service from a file containing pairs **Name** and **Service URL**, and optionally **Username** and **Password** if the WMS/WMTS requires credentials.
- **Add WMS/WMTS service**: Allow to add a WMS/WMTS service manually.
- **Edit WMS/WMTS service**: Allow to modify the WMS/WMTS information.

Delete WMTS service: Remove a WMTS service from the list.

9.2 Editing the shape layer

A **shape** layer manages a file of this type to be displayed in the workspace (Figure 56). In order to be able to load these types of files, it is necessary to have four different file types in the same folder:

- **.shp**: This is the SHAPE file with the information to be displayed.
- **.shx**: This is the associated index file.
- **.prj**: Projection file indicating the system on which the map was made.
- **.dbf**: Database with information associated with the points and geometries of the map.

Shape files containing punctual, linear or polygonal geometries, both 2D and 3D, are supported.

These files can be loaded from the internal storage of the device or Google Drive, using Android's File Explorer (see Error! Reference source not found.). Clicking the button  you will access Android's file explorer, which can access the device's files as well as the Google Account's Google Drive.
The properties to be defined for this layer are:

- **Layer name**.
- **Opacity**: Level of transparency of the layer.
- **Color**: Color for lines and dots on the map.
- **File**: File to be displayed.

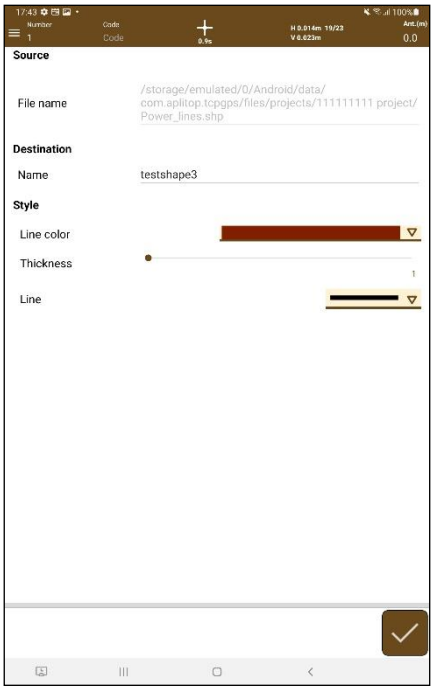


Figure 56. Editing the Shape layer

9.3 Edition of DXF, KML/KMZ, GML and DWG layers

The DXF, KML / KMZ and GML layers contain cartographies of these types, where all the information is inside those files. These layers share the form of editing since it will be their content that establishes the parameters of each one.

The properties that can be configured on this layer are:

- **Layer name**.
- **Opacity**: Level of transparency of the layer.
- **File**: File to be displayed.

As with shape layers, files can be loaded from the internal storage of the device or from a Google Drive account.

9.3.1 DXF

The entities supported in DXF are:

- **ARC**: Arcs (2D and 3D).
- **CIRCLE**: Circles (2D and 3D).
- **POLYLINE / LWPOLYLINE**: Polylines (2D and 3D).
- **LINE**: Lines (2D and 3D).
- **POINT**: Points (2D and 3D).
- **VERTEX**: Vertices of polylines (2D).
- **TEXT**: Texts.
- **BLOCK**: Blocks (discretized into polylines)

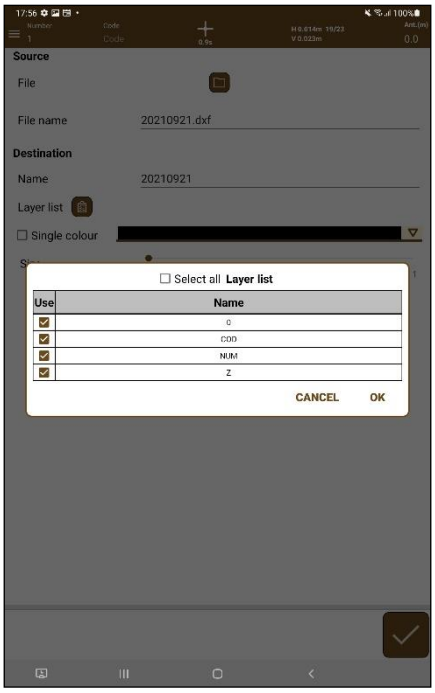


Figure 57. DXF Layers

9.3.2 DWG

In this case, the entities supported by TcpGPS are **points**, **lines**, **polylines 2D** and **3D**, **arcs**, **circles**, **ellipses**, **splines**, **helices** as well as **single line texts** and **blocks** which have been discretized into polyline entities.

9.3.3 KML/KMZ

The following entities are supported with the indicated structures:

- **Points**

```
<Placemark>
   <Point>
      <coordinates></coordinates>
```

```
      </Point>
   </Placemark>
```

- **Polylines**

```
   <Placemark>
      <MultiGeometry>
         <LineString>
            <coordinates></coordinates>
         </LineString>
      </MultiGeometry>
   </Placemark>
```

- **Polygons**

```
   <Placemark>
         <Polygon>
            <outerBoundaryIs>
                  <LinearRing>
                        <coordinates> </coordinates>
                  </LinearRing>
            </outerBoundaryIs>
      </Polygon>
   </Placemark>
```

9.3.4 GML

Geometry entities that contain the following structure are supported:

```
<cp:geometry>
      <gml:MultiSurface gml:id="" srsName="">
            <gml:surfaceMember>
                  <gml:Surface gml:id="" srsName="">
                        <gml:patches>
                              <gml:PolygonPatch>
                                    <gml:exterior>
                                          <gml:LinearRing>
                  <gml:posList srsDimension="" count=""></gml:posList>
                                          </gml:LinearRing>
                                    </gml:exterior>
                              </gml:PolygonPatch>
                        </gml:patches>
                  </gml:Surface>
            </gml:surfaceMember>
      </gml:MultiSurface>
 </cp:geometry>
```

9.3.5 GPX

Waypoint and track entities that contain the following structure are supported:

```
<wpt lat="" lon="">

  <ele></ele>
```

```
  <name></name>
  <desc></desc>
</wpt>
<trk>
  <name></name>
  <desc></desc>
  <trkseg>
    <trkpt lat="" lon">
      <ele></ele>
    </trkpt>
  </trkseg>
</trk>
```

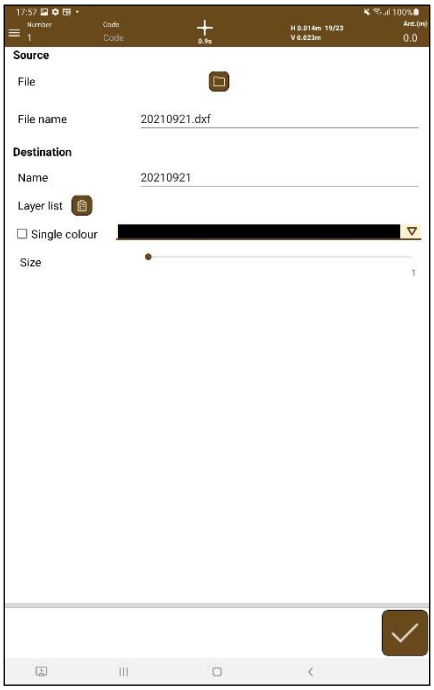


Figure 58. Editing the DXF, KML/KMZ or GML layers

9.4 Edition of surface layers

The surface layer manages a 3D surface imported (see Import a Surface) from a DXF file, that contains 3D face entities (**FACE3D**), from a LandXML file or from an IFC file version 4.3.

The properties to be configured for this layer are:

- **Layer name**.
- **Opacity**: Level of transparency of the layer.
- **Color**: Line color

Once the layer has been configured, by clicking  the loading of the surface file starts and once it is completed it will return to the list of layers, where the newly created layer will appear.

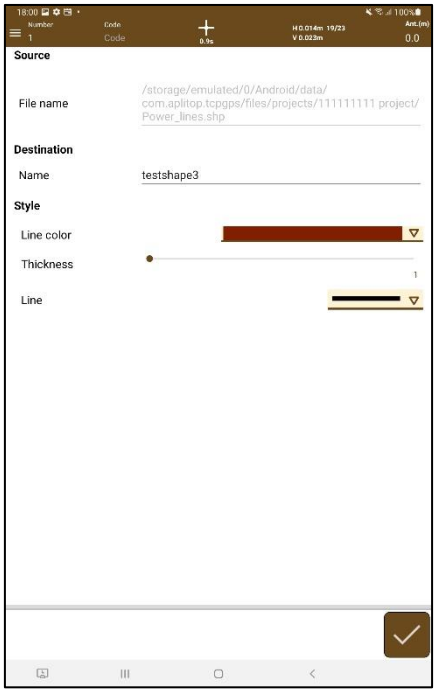


Figure 59. Editing the Surface layer

9.5 Edition of WMS/WMTS layers

A **WMS/WMTS** layer manages the connection with this kind of service for loading the information related to the current working area.

When you create a new WMS/WMTS layer, what you must do is create a new entry to connect to the desired service or use one of those that have been used previously. You can add as many services as you want, in addition to being able to edit existing ones (if there is a change in the URL that connects to it) or you can delete them if they are not going to be used or they are no longer available.

You are able to use username and password if the service you're using requires you to do so, but you can leave them blank if the service you're using has no requirement for credentials.

The functions available to edit layers of this type are:

	Allow to import a list of WMS/WMTS servers from a TXT file with the following format: **<Name> <URL> (optional: <Username> <Password>)**
	Defines a new WMS/WMTS service by entering the corresponding URL.
	It allows it to modify the URL of the WMS/WMTS service, in case of error or if it has been transferred to another address or server.
	It allows the deletion of a WMS/WMTS service from the list, if it is not used or it is no longer available.

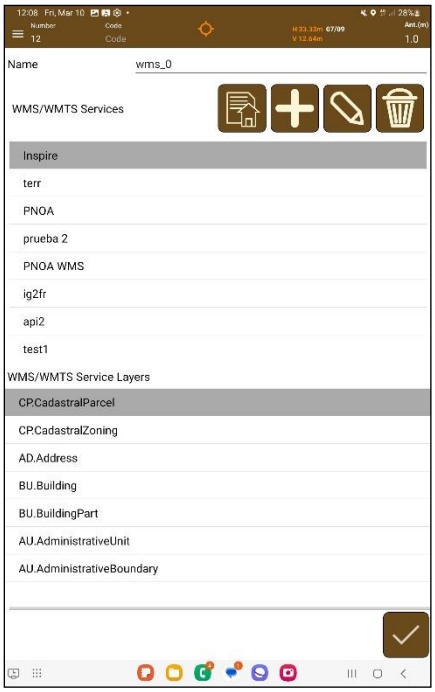


Figure 60. Editing the WMS/WMTS layer

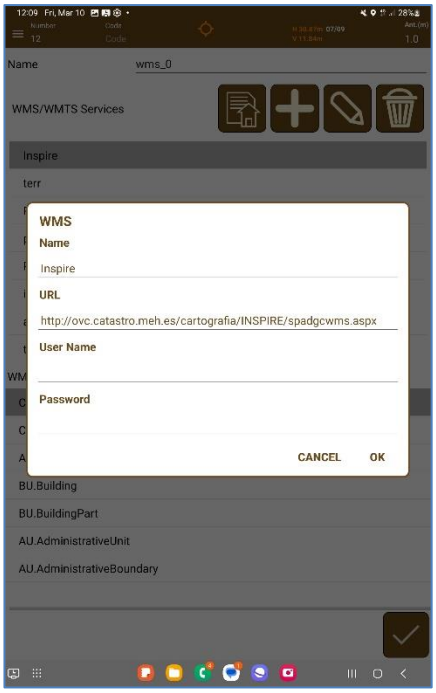


Figure 61. WMS/WMTS service example

10 Survey

This is the first screen that appears for the user when they enter the application. Two modes are available: **map mode** (**Map surveying screen**) and **numerical mode** (**Numerical surveying screen**). For switching between both modes, these buttons  can be used.

10.1 Map surveying screen

In the survey screen map mode are shown the points, cartographies and roads that compound the project.

Figure 62. Surveying map mode

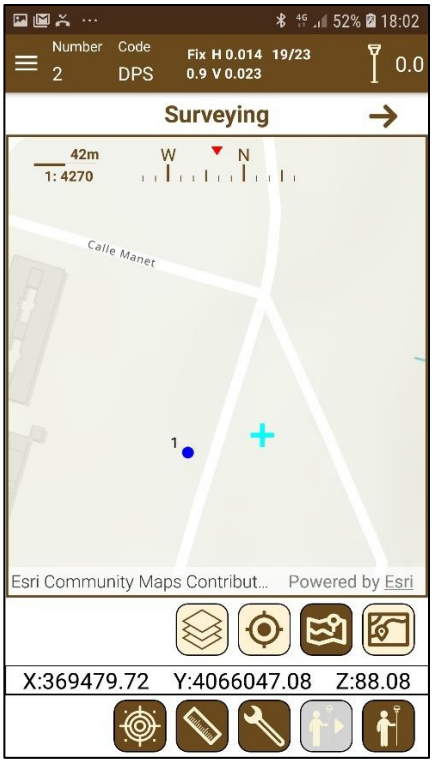


Figure 63. Example of point with its basic data

Figure 63 shows an example of a measured point with its basic information displayed around it:

- At top left of the point is shown the **number**.
- At right of the point is shown the **height**.
- At bottom right of the point is shown the **code**.

The floating menu below the map contains certain functions for interacting with the map. See **Map menu** section for detailed information about each option.

When you pick on a point, a dialog will be displayed showing his number. By clicking on the button  , it possible to access the detailed information of the point (see **Point Details**)

10.2 Numerical surveying screen

Several parameters associated with the points taken can be configured from the numerical surveying screen:

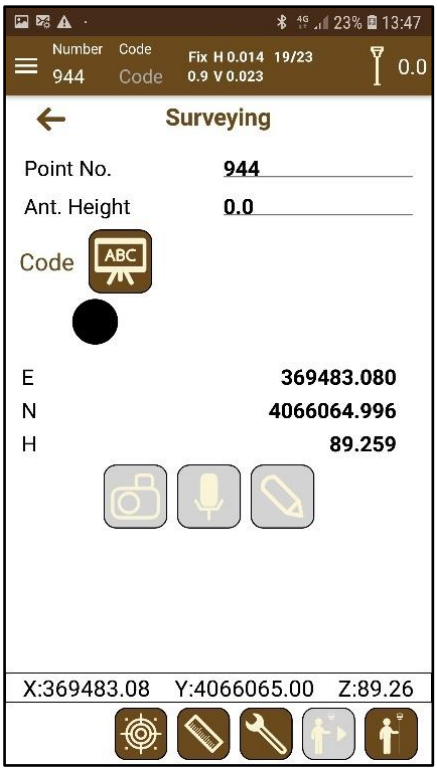


Figure 64. Surveying numerical mode

- **Point number**: Number of the next point that will be taken. This number will increase 1 in 1 as consecutive points are taken, from the given. The number of a point is an alphanumeric text that, in the case of numbering more than one point, it will add a suffix that will indicate the numbers taken with that same initial text. For example, if the number is decided to be **CRT**, the first point will be **CRT**, but the next one will be **CRT_1**, **CRT_2**, and so on.
- **Height of the antenna**: The height of the antenna at the moment the point was gathered. By default, the value defined in the **Settings** will appear, but if you

need to change this to a specific point or points, it is possible to define a new one here (this does not change the default value).

- **Code**: A code that will be associated to the point, which can be selected from a predefined list or a new code created (see **Point code management**).

The **numerical surveying** screen also displays the numerical information of the current GPS position.

10.3 Point survey

Using the button  of the menu bar you can take the current point where the GPS is located. If the point does not comply with any of the restrictions established in the settings regarding the type of position, the number of satellites or the accuracy, the user will be notified of this situation and he will decide whether he wants to take it. It will be disabled when you are using the **Replacing or** Averaging already existing point

When the point number in the status toolbar or in the numerical surveying screen is manually changed, if the point number already exists, it will be marked in red.

When a point is taken after doing so, a dialog will appear showing the XYZ of the previously existing point, the new point taken with the same point number, the averaging of both points, and the difference between the two.

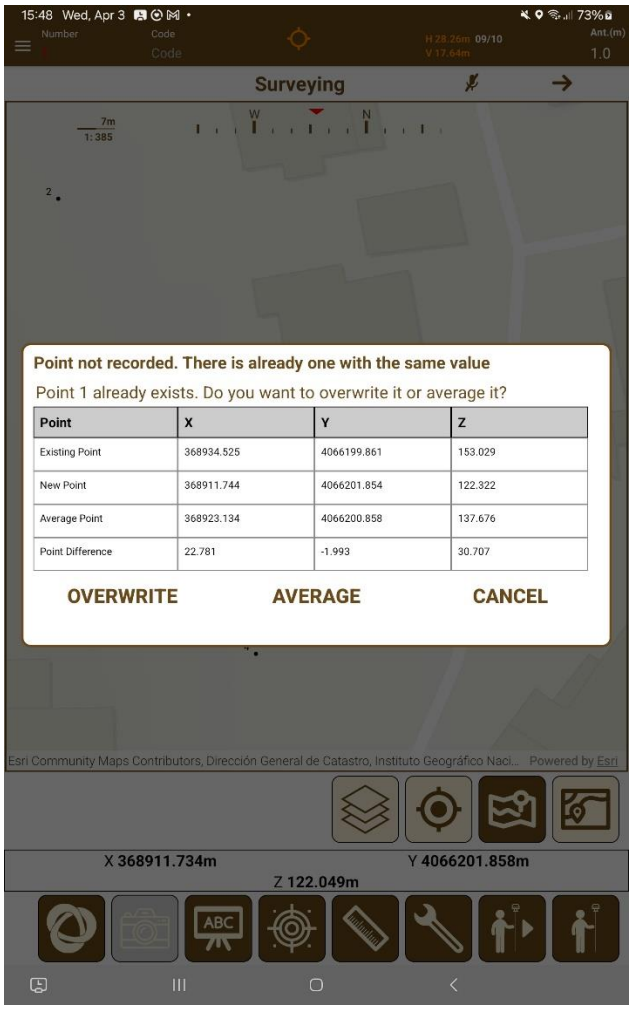


Figure 65. Dialog for replacing or averaging an already existing point

If a point is overwritten, they are completely replaced, both X/Y/Z and also the raw data.

If a point is averaged, the existing point and the new point X/Y/Z are averaged, the raw data from the new point is added, and then the raw data entries are averaged, the point will be considered an obvservation/**precision point,** as if it was taken via epochs.

Continuous survey**.**

In the **numerical mode** screen, it is possible to configure the point before taking it by assigning different parameters, as it is explained in **Numerical surveying screen**.

When taking a point, the user can directly associate an *image* and a *voice note* using the buttons that appear in the numerical template of the survey   . If detailed information about the point is required, it can be accessed by choosing the point on the map and clicking the **info** button). You may also access the camera after

taking the point in the bottom menu in vertical/portrait mode by touching the camera icon. 

When a point is taken, in addition, the base against which the corrections are being taken is associated if available (it will depend on the receiver and the source of corrections that is being used). This base is represented in the **Bases** layer that appears in the list of layers.

10.4 Replacing or Averaging already existing point

When the point number in the status toolbar or in the numerical surveying screen is manually changed, if the point number already exists, it will be marked in red.

When a point is taken after doing so, a dialog will appear showing the XYZ of the previously existing point, the new point taken with the same point number, the averaging of both points, and the difference between the two.

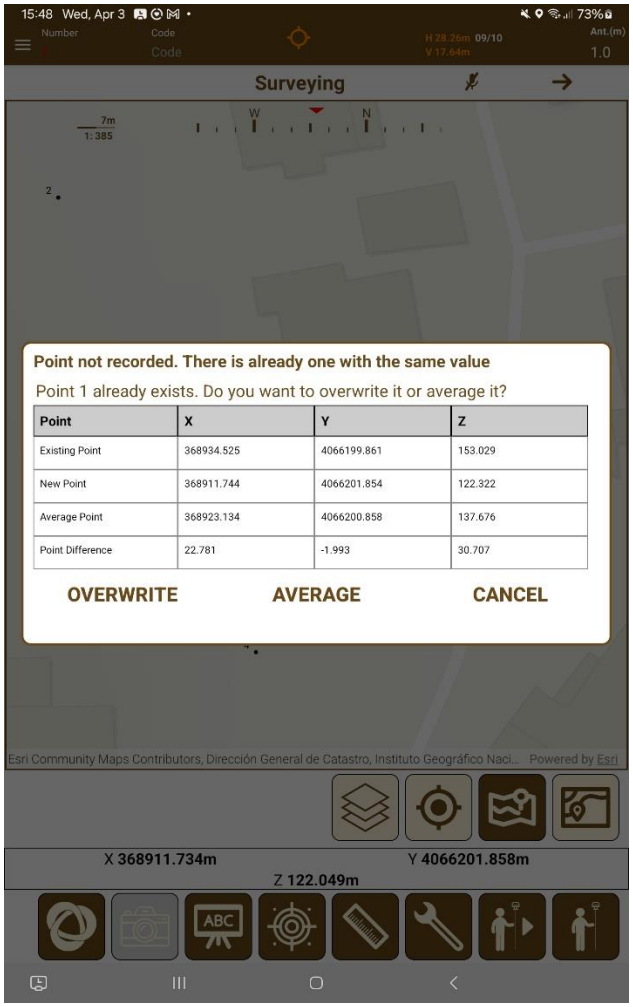


Figure 65. Dialog for replacing or averaging an already existing point

If a point is overwritten, they are completely replaced, both X/Y/Z and also the raw data.

If a point is averaged, the existing point and the new point X/Y/Z are averaged, the raw data from the new point is added, and then the raw data entries are averaged, the point will be considered an **obvservation/precision point**, as if it was taken via epochs.

10.5 Continuous survey

Using the button  begins the taking of a series of consecutive points according to three criteria:

- **Continuous measurement by time interval**: A time interval is defined for the next point to be taken.
- **Continuous measurement by distance**: A distance is defined after which the next point will be taken.
- **Continuous measurement by gradient interval**: A difference in level is defined after which the next point will be taken.

Before starting the taking of the points, a dialog will request which criteria will be used to decide when to take a point.

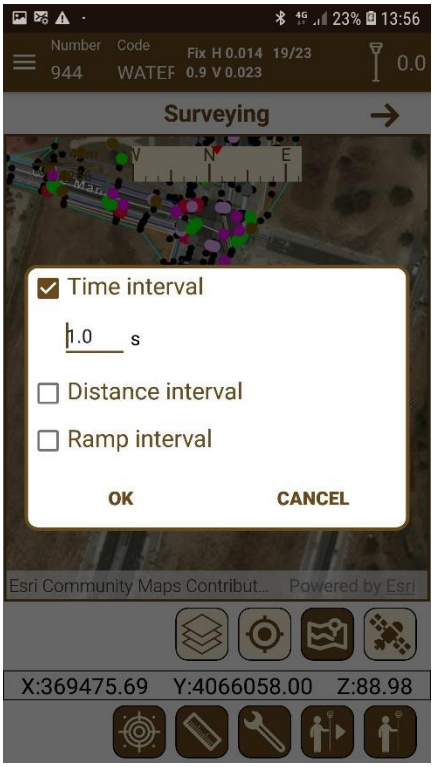


Figure 66. Dialog for setting up continuous surveying criteria

When points are taken continuously, the conditions to take them as valid will only be considered in the first one and for the rest of the points a voice will advise if the restrictions are satisfied or not and, in consequence, if the point is measured or not.

Once the taking starts, it can be stopped at any time by pressing the same button, that has changed its icon to  .

This mode is very useful when measuring lines or alignments, where the points must be measured at certain distance.

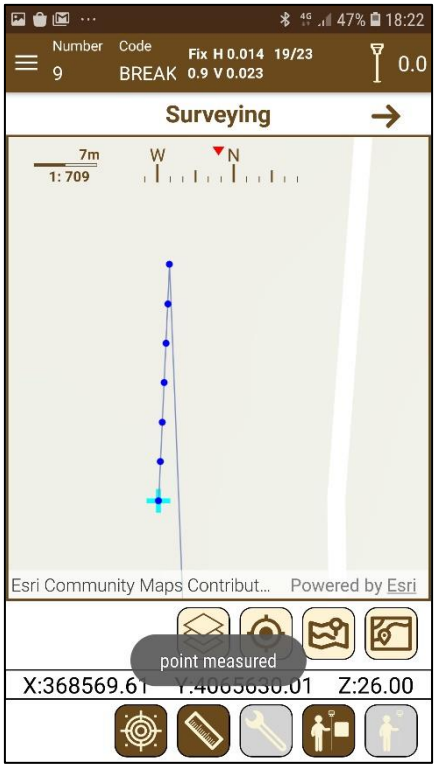


Figure 67. Continuous surveying

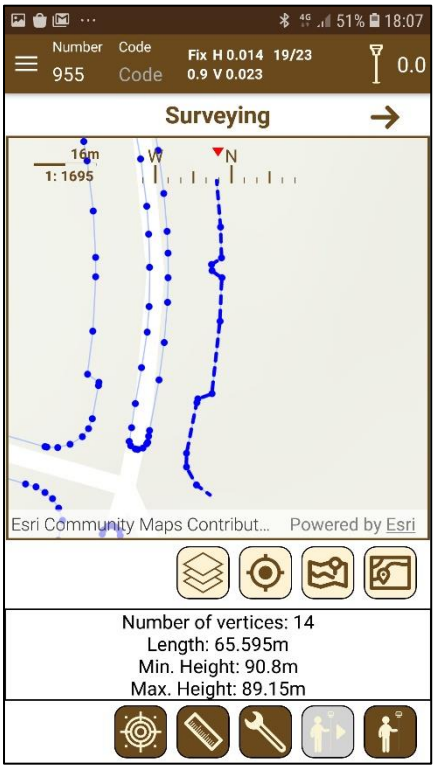


Figure 68. Line data

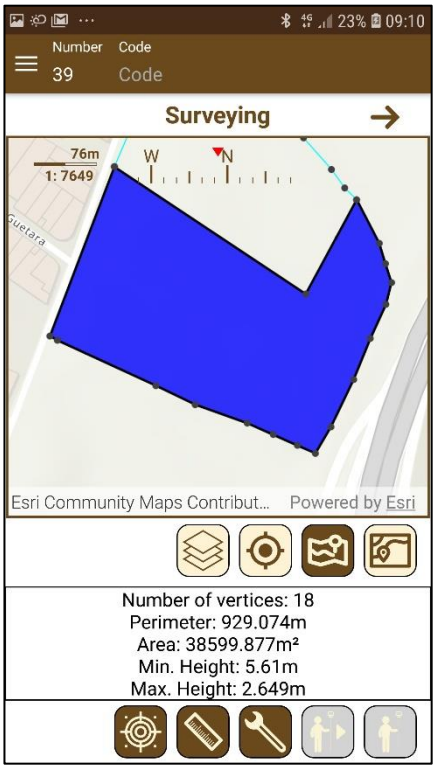


Figure 69. Area data

10.6 Point code management

To classify the points, it is possible to assign them a specific code that groups them and distinguishes them from the rest. This code may be composed by a set of codes of different type for identifying the point in a better way or to define different properties for the point. Some examples of codes are shown below:

TREE

SHOULDER,ASPHALT

MANHOLE,LP_1,PT_2

As you can see in the examples above, a **separator** character will be used for identifying each code of the multicode. To change this separator, see **Configuring the workspace**.

There are three types of codes in the application:

- **Punctual**: Used for defining singular points (TREE, MANHOLE, LAMPPOST…)
- **Lineal**: Define polylines. In this case, a sequence of points composes the polyline. The first point of the polyline will be attached the **s** suffix (start) and the last point the **e** suffix (end). Here you have an example:

ASPHALT S

ASPHALT

ASPHALT

ASPHALT E

- **Polygonal**: Define areas or parcels. As lineal codes, a suffix for the starting point (**s**) and another one for closing the polyline (**c**) are needed. For instance:

  PLOT S

  PLOT

  PLOT

  PLOT C,POST

In the numerical survey mode, the button 

displays the code management dialog. It is also possible to access the code management screen by a long click over the **Code** filed in the status bar.

In Figure 70 dialog is shown with the list of codes available in the database of the application. This database is modified as new codes are inserted and existing ones are modified or eliminated. By clicking on the desired code and accepting the choice, the code starts to be used in the following taken points. Using this list, you can build your code or multicode (if you want to assign more than one code to the point) only by checking the **Use** checkbox beside each code.

Previously, it was said that a **separator** is needed to compose a multicode and it can be selected in **Configuring the workspace**. If you want to add a new code to your multicode, you must click the button 

to introduce the **separator** or type it if you know which separator is selected.

If the code is lineal or polygonal, you can add the **start** or **end** suffix for the line or the **start** or **close** suffix for the polygon, only clicking the corresponding button or typing it. This is important because when the application builds the lines or polygons it uses these suffixes as references.

In Figure 71 it the options to edit or create a new code are displayed. The codes can be punctual or linear (depending on whether they will represent independent points or

points that will make up a line or a plot). In addition, a wide base of colors is available to assign to the points that contain this code.

Depending on the type of the code, you can configure the style of the elements that use this code. For points you can define the color, size and type of symbol. For lines you can set the color, width and style of line. For polygons, apart from the style of the contour line, you can define the fill color and the level of transparency.

It must be considered that if the code of the point is a multicode, the style for its representation over the map will be the style of the first code which associated layer is visible.

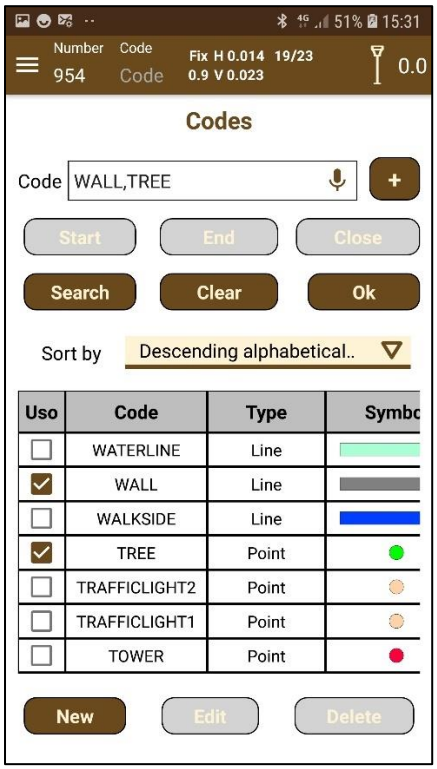


Figure 70. List of point codes

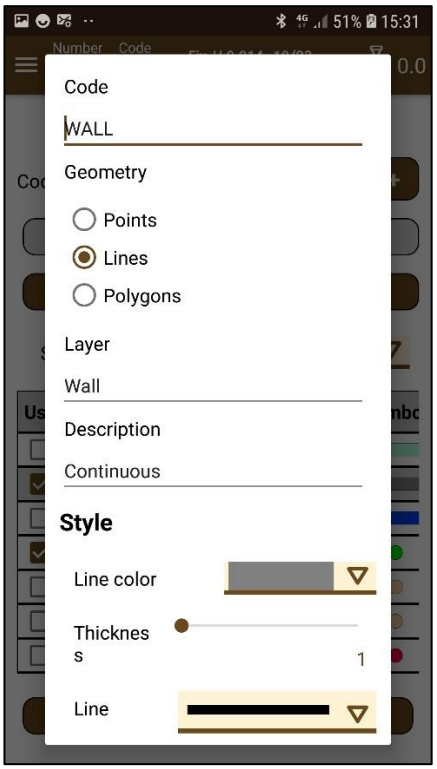


Figure 71. Edition and creation of codes

10.6.1 Export and Edit Simplified Code Database

By hitting Export and then Codes, it will be asked to choose a location to export the codes file. The data of these codes will be divided into the following categories:

Code Type Symbol Color Layer Description

The header line should **not** be modified, as the software uses it to recognize the file as valid.

Field	Description	Values	Remarks

Code	Point code		
Type	Geometry	P (point) L (line) A (polygon)	**Default**: P
Symbol	Symbology	**Points**: CIRCLE CROSS DIAMOND SQUARE TRIANGLE X **Lines & Polygons**: DASH DASH_DOT DASH_DOT_DOT DOT SOLID	Marker for point type codes **Default**: CIRCLE Line type for linear and polygonal type codes **Default**: SOLID
Colour	Color	0 - Black 1 - Red 2 - Yellow 3 - Green 4 - Cyan 5 - Blue 6 - Purple 7 - White	Other values up to 255 can be defined, according to the following table: https://gohtx.com/acadcolors.php
Layer	Layer name		The default names are: Points, Lines, and Polygons, but layers can be created with other names
Description	Code description		

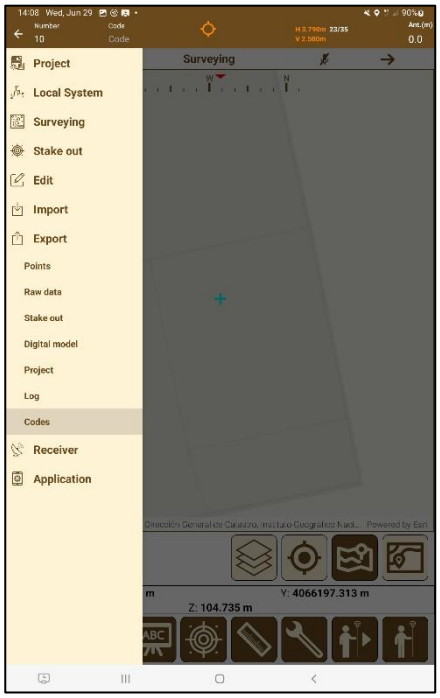
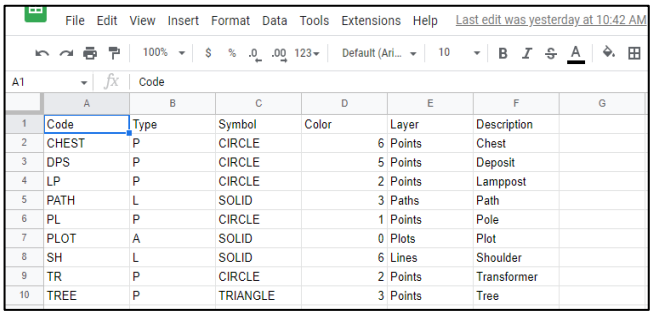


Figure 72. Export Menu



File Edit View Insert Format Data Tools Extensions Help Last edit was yesterday at 10:42 AM

A1 | Code

	A	B	C	D	E	F	G
1	Code	Type	Symbol	Color	Layer	Description	
2	CHEST	P	CIRCLE	6	Points	Chest	
3	DPS	P	CIRCLE	5	Points	Deposit	
4	LP	P	CIRCLE	2	Points	Lamppost	
5	PATH	L	SOLID	3	Paths	Path	
6	PL	P	CIRCLE	1	Points	Pole	
7	PLOT	A	SOLID	0	Plots	Plot	
8	SH	L	SOLID	6	Lines	Shoulder	
9	TR	P	CIRCLE	2	Points	Transformer	
10	TREE	P	TRIANGLE	3	Points	Tree	

Figure 73. Editing of codes with datasheet software

Once you have edited your file, you can save it as a **.txt** or **.csv** to import it into TcpGPS.

10.6.2 Import Simplified Code Database

Once you have a file containing the codes you want to use, you can open the menu and access Import and then Codes to open the Code Import Dialog box.

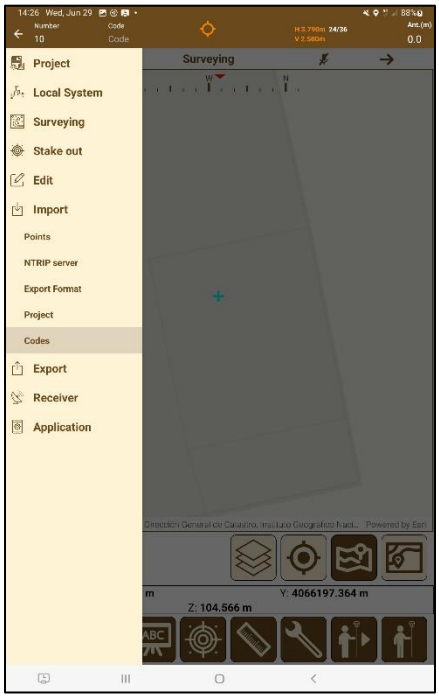


Figure 74. Import Menu

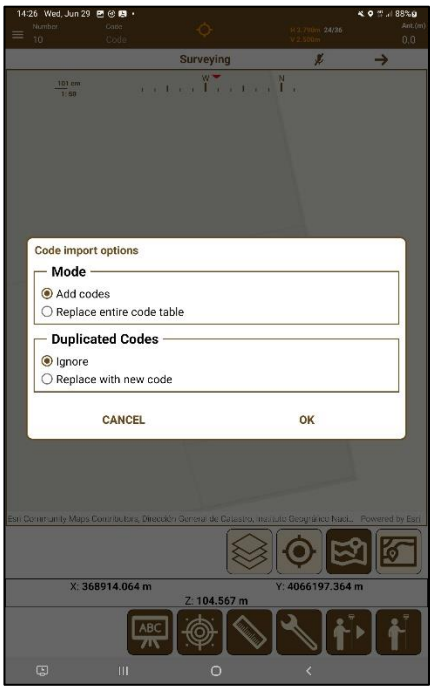


Figure 75. Code Import Dialog

This Dialog has the following options:

Mode: - **Add Codes**: Adds the codes to the bottom of the already existing database.

-**Replace entire code table**: Replaces the code database with the imported codes.

Duplicated Codes:

In case that the selected option above is **Add Codes**, you can choose how the application will behave regarding the imported codes with a code that already exists in the base code database

-**Ignore**: Duplicated codes will be ignored and will not be imported at all.

-**Replace with new code:** The imported code with the duplicated code that already exists in the base code database will replace the existing one.

10.6.3 Code Prefixes

You are able to enable to code prefix option in the Configuration screen, and once it is turned on, you can access the code list screen, select a code, and increase or decrease the prefix counter.

It is also possible to add a code separator to add two codes of the same code as long as they have different prefixes by adding the separator and increasing or decreasing the prefix counter.

You can also have multicode codes with or without prefixes by using the code separator button.

This allows the possibility of having multiple lines or polygons not finished/closed of the same code open at the same time, as long as they have different prefixes.

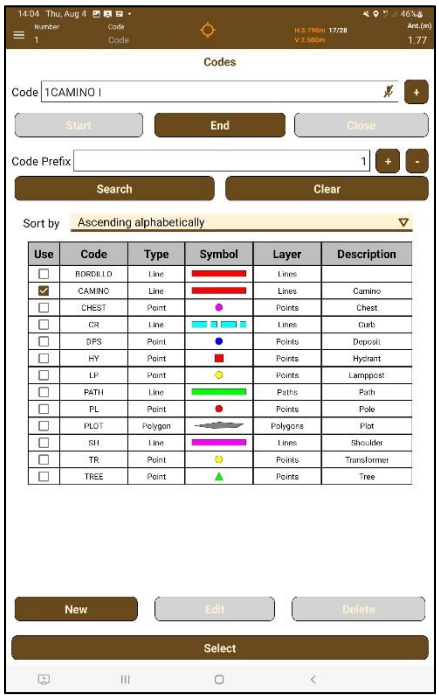


Figure 76. Code with prefixes

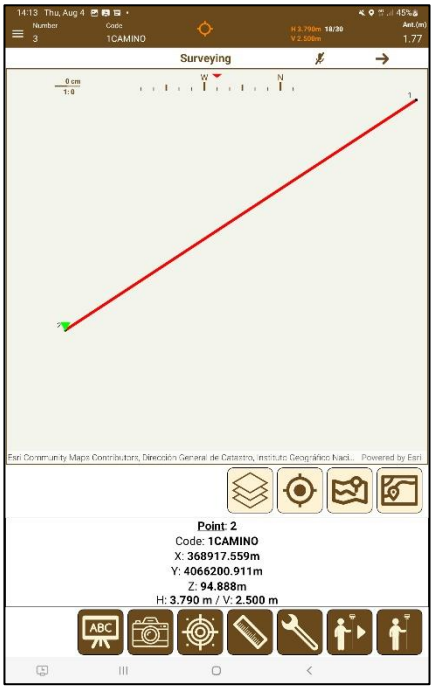


Figure 77. Line using a code with a prefix

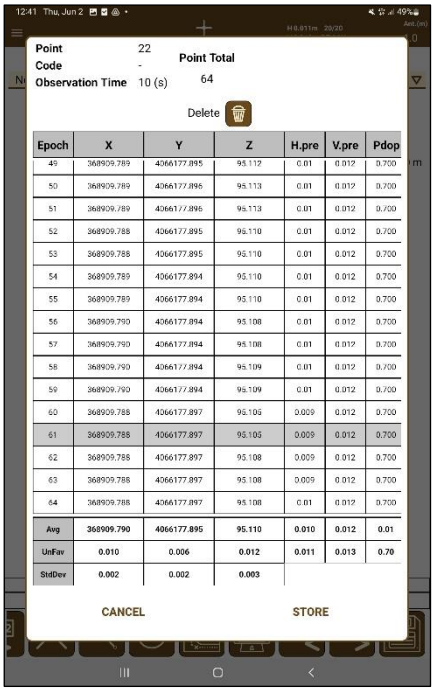
10.7 Taking points via epochs

As it was seen in the template of the **Configuring the workspace** it is possible to establish the **observation time** of a point. When the observation time is **greater than 0**, by taking a point in an individual capture, and touching the point taking button, or the option **Long press for precision points** is active and a long press is performed on the point taking button, epochs will then be taken during the interval. When the measurement is finished, the list of captures taken and the differences with the average are displayed. If the measurements taken are considered acceptable, the point can be recorded or discarded for a new measurement.

As shown in the section **Configuring the workspace**, it is possible to stablish the point observation time. When the stablished observation time is **more than 0**, and the stake out button is pressed, or the option **Long press for precision points** is activated, and a

long press is performed in the stake out button, its possible to perform a stake out of a point via epochs.

After performing the checks signaling the point validity, the point observation dialog is opened, where epochs from the GNSS Receiver are taken, and once it is finished, the average of all epochs are shown.



Epoch	X	Y	Z	H.pre	V.pre	Pdop
49	368909.789	4066177.895	95.112	0.01	0.012	0.700
50	368909.789	4066177.896	95.113	0.01	0.012	0.700
51	368909.789	4066177.896	95.113	0.01	0.012	0.700
52	368909.788	4066177.895	95.110	0.01	0.012	0.700
53	368909.788	4066177.895	95.110	0.01	0.012	0.700
54	368909.789	4066177.894	95.110	0.01	0.012	0.700
55	368909.789	4066177.894	95.110	0.01	0.012	0.700
56	368909.790	4066177.894	95.108	0.01	0.012	0.700
57	368909.790	4066177.894	95.108	0.01	0.012	0.700
58	368909.790	4066177.894	95.109	0.01	0.012	0.700
59	368909.790	4066177.894	95.109	0.01	0.012	0.700
60	368909.788	4066177.897	95.106	0.009	0.012	0.700
61	368909.788	4066177.897	95.105	0.009	0.012	0.700
62	368909.788	4066177.897	95.108	0.009	0.012	0.700
63	368909.788	4066177.897	95.108	0.009	0.012	0.700
64	368909.788	4066177.897	95.108	0.01	0.012	0.700
Avg	368909.790	4066177.895	95.110	0.010	0.012	0.01
UnFav	0.010	0.006	0.012	0.011	0.013	0.70
StdDev	0.002	0.002	0.003			

Figure 78. Point via epochs

In the case that one or more epochs are not in the specified tolerance measures specified in the configuration, the dialog will warn of this fact. If there is a need to remove unwanted epochs, it is possible to touch them to select them and then touch the delete button.

Figure 79. Point via epochs outside of allowed tolerances

10.8 Distances and areas

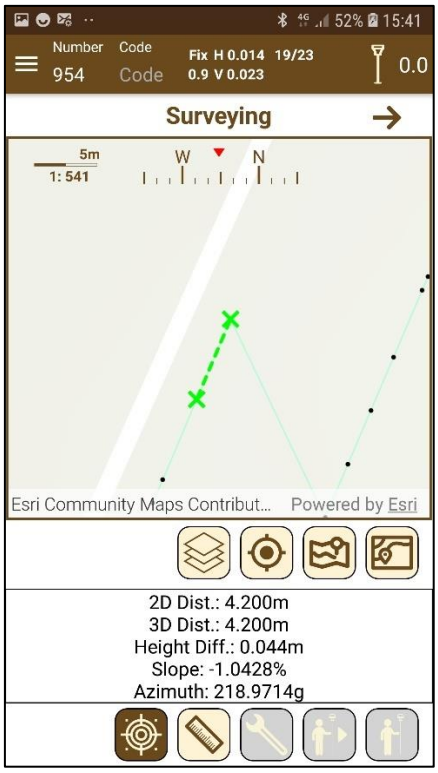


Figure 80. Measuring the distance between two points

In this mode, the map has an additional functionality: **distance and area measurement**.

When we press the button  the app asks the user for the kind of measure:

- If **distance measurement** is selected, we will be instructed to choose the first point; Once selected, the second point will be requested and then the information about the distance between the two will appear (Figure 80): *distance 2D* (without taking into account the dimension), *distance 3D*, the *height difference* and the *slope* between the two points.
- If **area measurement** is selected, you will select points over the map and the area will be built and updated each time a point is added. You must be careful because the order of the point will define the shape of the area. *Number of vertices*, *perimeter*, *area* and *maximum* and *minimum height* are the data shown.

10.9 Survey tools

Clicking the **tools** button  displays a dialog box where you can find a set of tools to work with the points gathered. These tools correspond to the calculation of new points using intersections or reference points. There are three types of intersection: **line-line intersection**, **line-circle intersection** and **circle-circle intersection**. Three options are available for creating new points from reference points: **distance and azimuth**, **2 points and distance** and **normal of second point**.

Figure 81. Surveying tools dialog box

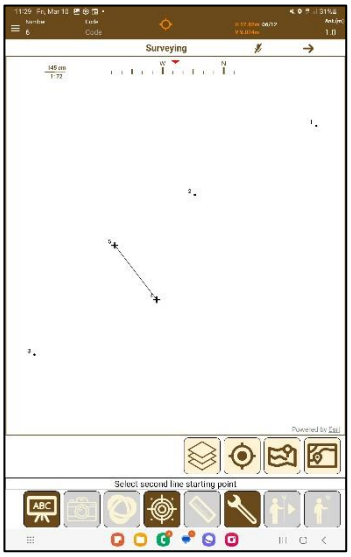


Figure 82. Selection of points for the intersection

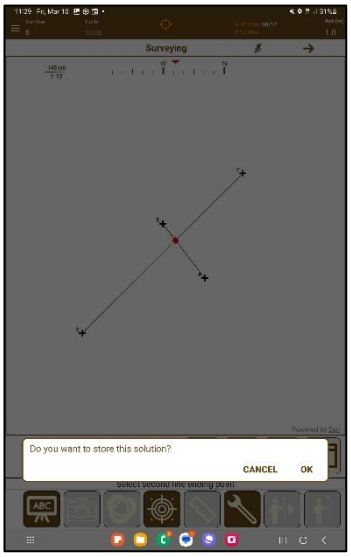


Figure 83. Confirmation of the intersection solution

10.9.1 Line-Line Intersection

In this case, the point where two lines are cut is calculated. The application will ask the user first to click on the two points that will form the first line and then select the two points that will form the second. It will show immediately the two lines and the intersection between them. If the lines are parallel, there will be no cut off point. Next, it will ask for confirmation, if you want to save this solution.

Figure 84. Intersection of two lines

10.9.2 Line-Circle Intersection

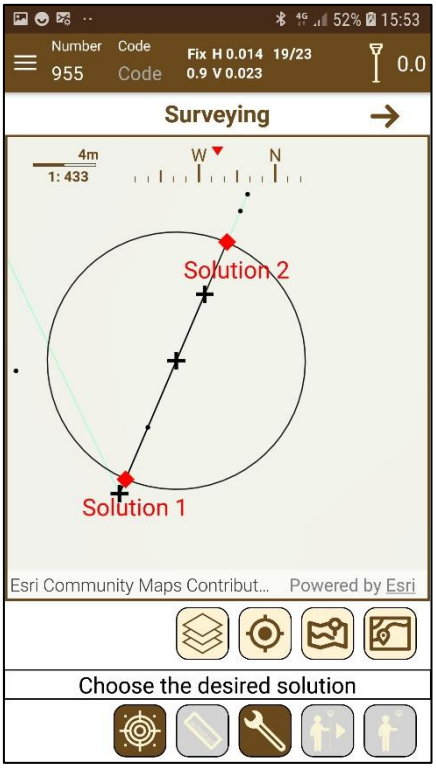


Figure 85. Line-circle intersection

The application will ask the user first to select the two points that form the line and, next, the point that will be the center of the circle, after which you must write the radius of it. In this case, it can happen that there is no solution if the line and the circle are separated; that there is only a solution if the line is a tangent to the circle, or that there are two solutions if the line cuts the circle. The application will show the line and the circle and the intersection between them and, if there is more than one, it will ask you to choose which of the two you want to record.

10.9.3 Circle-Circle Intersection

This case is like the previous one, and there may be none, one or two solutions. The application will request the user the center of the first circle and then the radius and perform the same operation for the second circle.

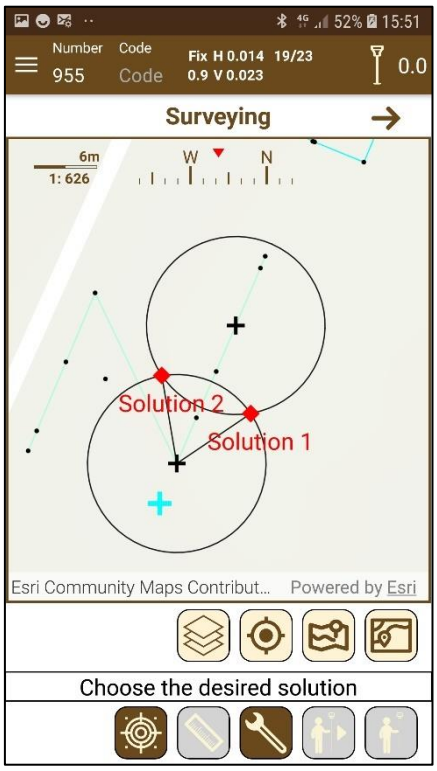


Figure 86. Circle-circle intersection

10.9.4 Distance and Azimuth

In addition to using intersection, points can also be calculated from others using the **Distance and azimuth** tool. The application will ask the user to choose a point from those present in the work and then enter the distance and the azimuth of the point that will be generated, taking as reference the selected point.

Figure 87. Point calculated by distance and azimuth

10.9.5 Two points and Distance

With this tool, the user can select two points a set a distance from the first point to calculate a new one, taking the azimuth between the selected points as the direction where apply the distance.

Figure 88. Two points and distance

10.9.6 Second Point Normal

With this tool, the user can select two points and then indicate a distance in meters, and then the application will began calculating a point to the normal vector of the second point chosen, or perpendicular.

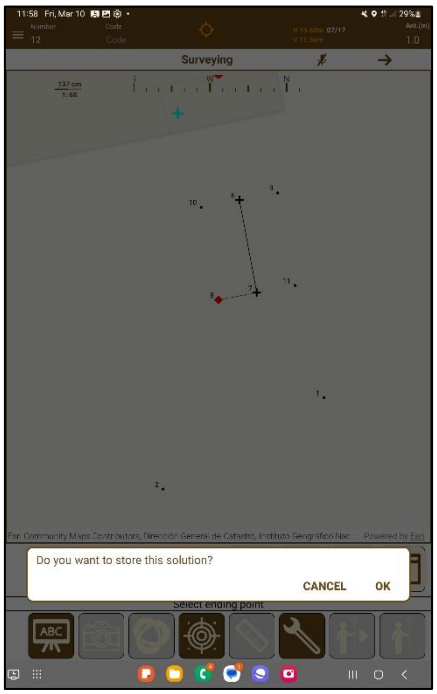


Figure 89. Second point normal

10.10 CAD tools

Pressing the CAD tools button  located in the Survey window button panel opens the dialog containing the different CAD options, which are described in the headers below:

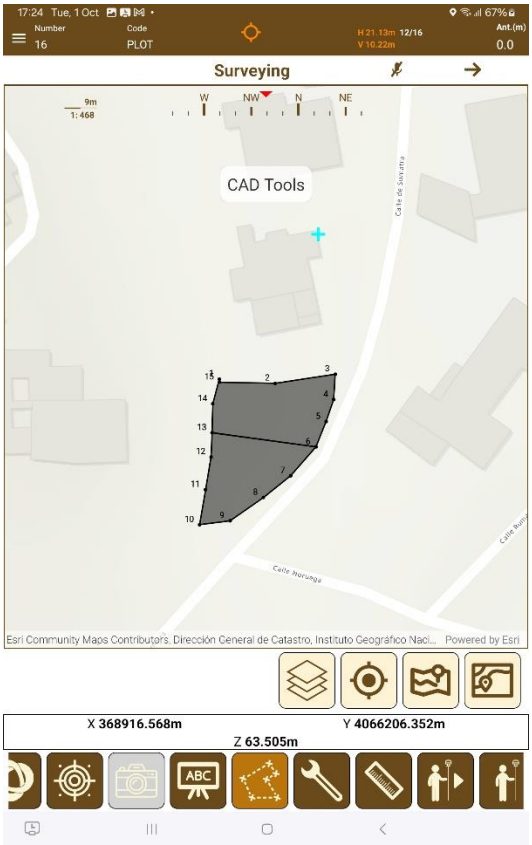


Figure 90. Launching CAD tools

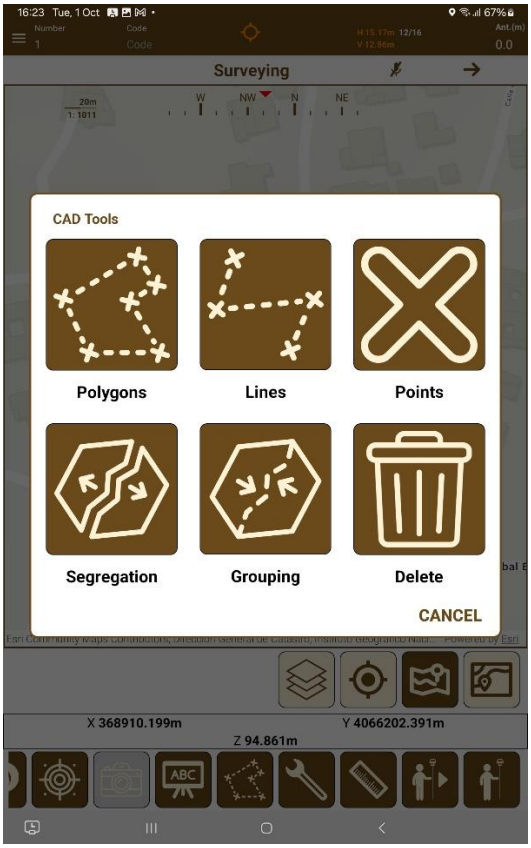


Figure 91. CAD tools dialog

10.10.1 Polygons

The  button allows the adding of polygons or parcels consecutively. The button to be added as vertices must be touched to create the entity.

To save the polygon, press its first vertex again or long press on the screen. After this confirmation, the edges of the plot will become continuous, and the interior area will appear colored. After this the tool proceeds to take the next polygon. A Polygonal type of code must be selected first.

To close this tool, press the button icon again, which now appears blank.

Figure 92. Creating plots with polygon tool

10.10.2 Lines

Pressing the  button allows adding lines by clicking on the points previously taken as vertices, if the current code is of a line type.

To confirm the line, long press anywhere on the screen, this will save the current line and prepare the tool to take the next one.

To close this tool, press the button icon again, which now appears in a lighter color.

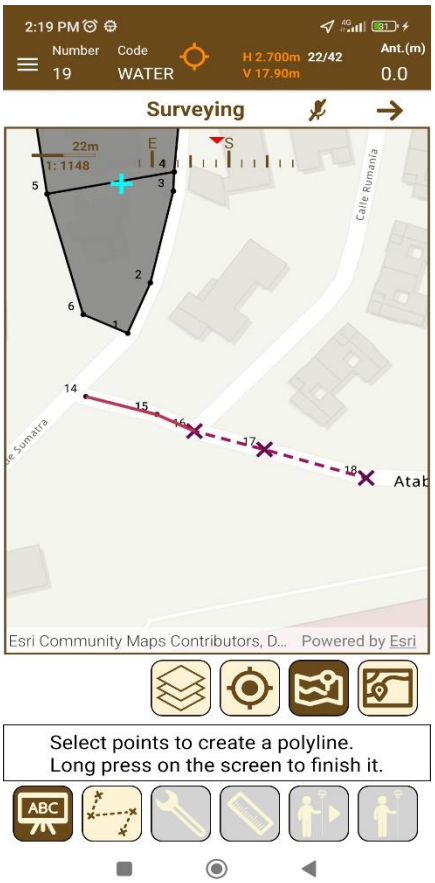


Figure 93. Creating lines with line tool

10.10.3 Points

Pressing the  button option allows taking a point by touching the screen as long as the current code is of the point type and the layer associated with this code exists. Keep in mind that these points taken with a manual screen tap lack the precision of those taken with a connected GNSS receiver.
Since they are not taken using geolocation, they lack associated raw data or height.

10.10.4 Segregation

After selecting the  button, it's possible to segregate a single parcel or polygon into two different ones. The two parcels created from the one being split will both share the same code as the one being split into two as well as GIS data.

To do so, first select the parcel or polygon to segregate, and then touch two vertices, the polygon will be split. To save the changes touch the button again, which has a light background now.

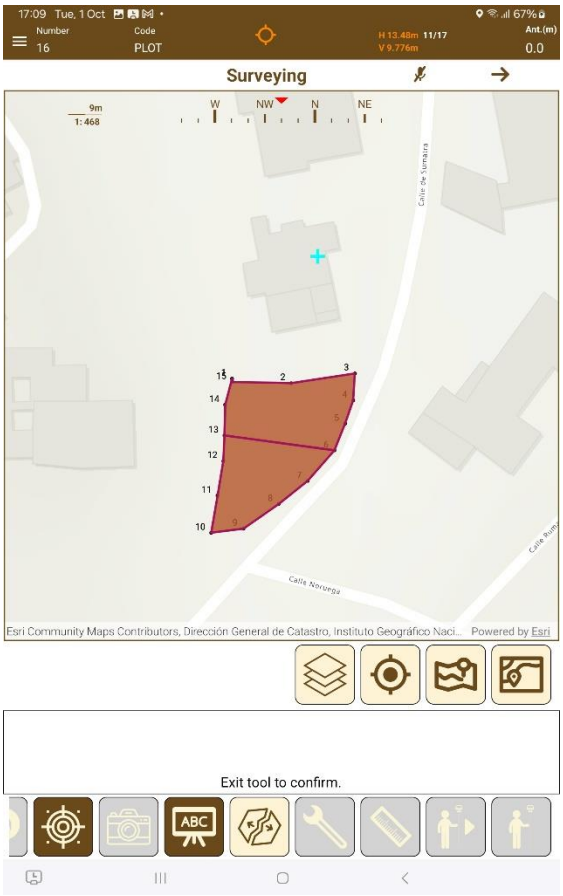


Figure 94. Split a plot into two different ones using vertices

10.10.5 Grouping

Pressing the  button allows merging two contiguous polygons or parcels into one.

The codes and GIS data from the polygon selected first will be used on the second polygon as they become one.

Figure 95. Creating a single polygon out of two

10.10.6 Delete

Pressing  Allows the deleting lines and polygons from the project.

Elements to delete are added one by one as they are tapped on the screen, the selected elements will be marked with a shade and by pressing the delete button again, these same elements will be deleted after prior confirmation.

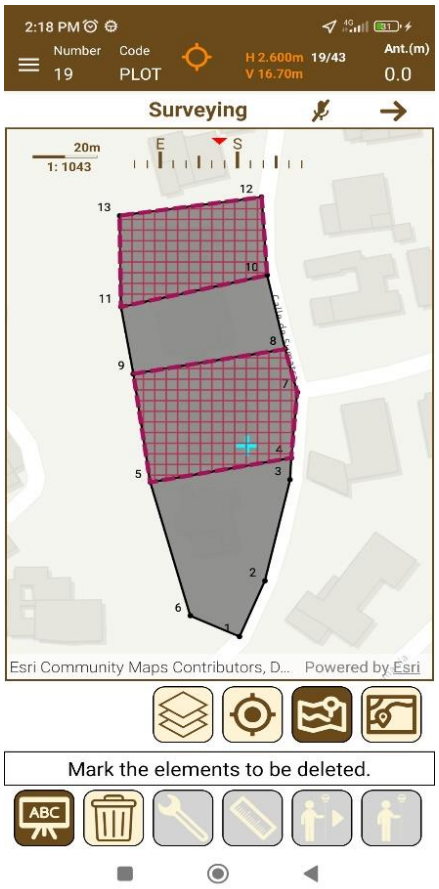


Figure 96. Deleting Tool

10.11 Save surveying data

When selecting a point, line, polygon/area, or when performing a measurement, the bar at the bottom of the screen will change from the receiver position to whatever Surveying information the application will want to show.

By pressing the  button, the data that is appearing in this section will be saved in a .txt file that can be saved to the device's storage, and once saved, it can be shared, just like any other export.

11 GIS

TcpGPS is prepared to collect and export data that can be used in GIS projects.

The working layers that make up the project can define a set of data that will be associated with the entities that are related to them (Points, polylines, or polygons).

This data can be edited and modified. When clicking in the edit button present in the layers menu, the GIS attributes menu will apear.

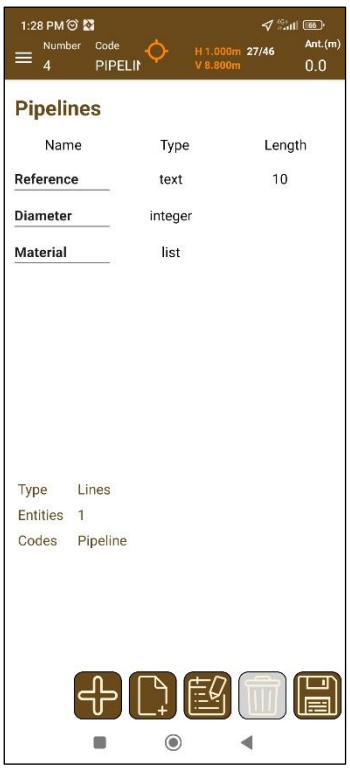


Figure 97. Attribute editing

New attributes can be added  and they will be linked to the elements of that layer.

It's possible  attributes selected one by one, or click in  to start again with an empty layer .

It's also possible to generate GIS attribute templates  wich allow the user to select quickly from a list the desired values. We'll talk more about this feature later.

There are a few different types:

- **Integer:** Allow the user to select an integer number.
- **Real:** Allow the user to select a decimal number.
- **Text:** Any kind of string.

- **Date:** Launches a calendar where user can pick up a date with the following format *dd/mm/yyyy*.
- **Image:** Allow the user to choose between the images associated to the entity points. This JPEG file will be linked to SHAPE.
- **List:** Deploys a list, previously configured, so the user can select quickly different options without having to write them down.

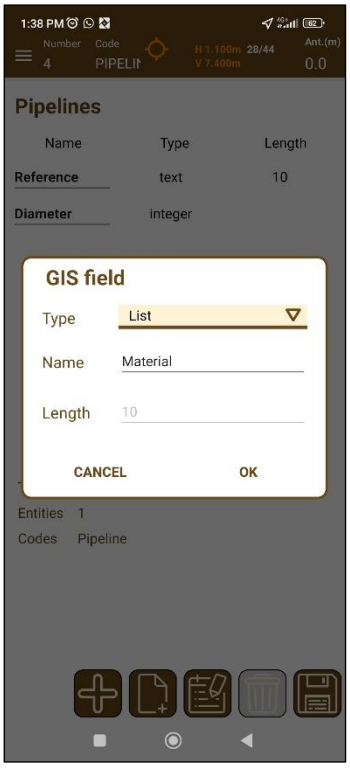


Figure 98. Creating GIS attributes

By pressing the button  you accept the changes made to the structure. Information that has been assigned to entities that are associated with this layer will have their structure modified in the same way that the data structure in this section has been edited.

Once these fields have been saved, the user can edit or consult them by entering the Point Editing screen in the case of specific entities, or by clicking on the information icon  that is displayed in the survey when selecting an entity.

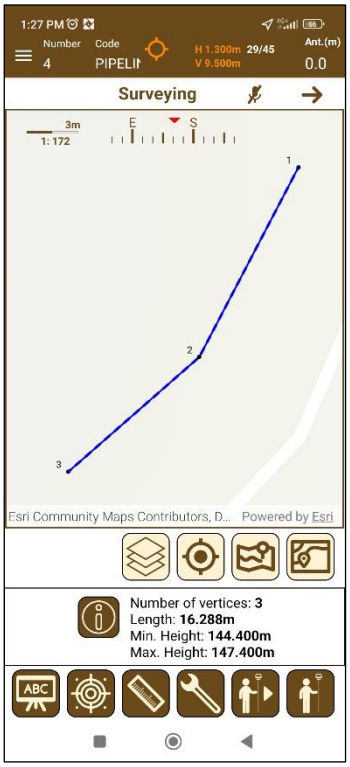


Figura 99. Selected entity in survey screen

En esta pantalla se podrá guardar y consultar los atributos GIS. Estos atributos tienen un formato **Clave:Valor**, donde la clave es el nombre del campo y el valor es introducido por el usuario.

When user clicks on the text fields, a keyboard will appear to enter values into them.

Figura 100. Adding attributes to a line

In the case of attribute templates, when you click on  a list will appear with the possible attributes to select, predefined by the user.

The predefined attributes are made up of a code and a description that will be shown to the user in a list format.

PVC(Code) : **Plastic**(Description)

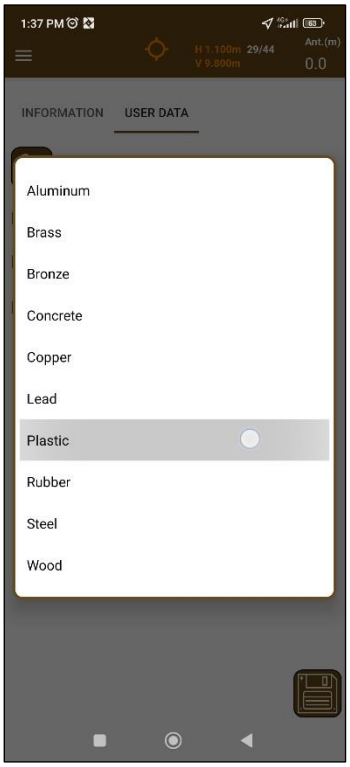


Figura 101. Selecting values on a GIS template

By clicking on the save button, these data will be saved in the project database.

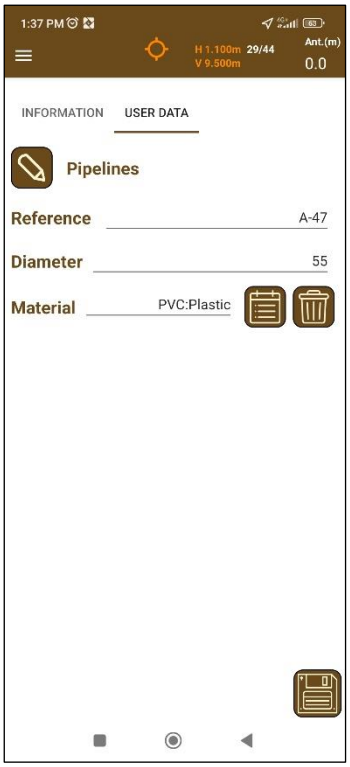


Figura 102. Consulting GIS attributes

Finally, this information can be exported along with the geographic data of the entity in Shape format, and can be consulted in any software that allows working with this type of format, for example, QGIS.

11.1 Creating GIS Templates

Templates are customizable and reusable elements that allow the user to select convenient attributes in a list. They are shared between all projects.

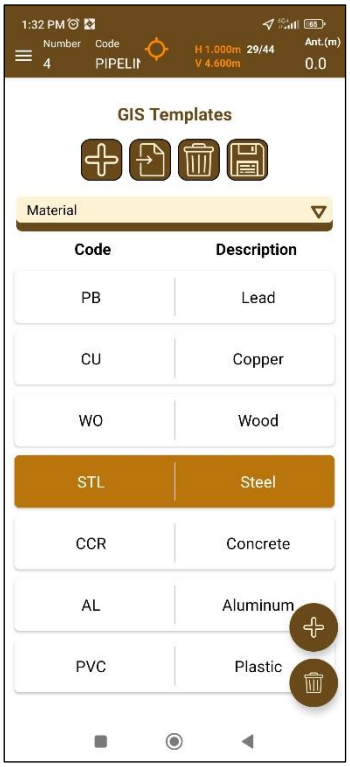


Figura 103. Editing GIS templates

Upper buttons control the existing templates and allow the user to import or create new ones.

 Creates a new template, it'll ask for a unique name for it.

 Deletes an existing template.

 To import files with the extension **CSV**.

Code;Description

WO;Wood

STL;Steel

…

Press the  save button to confirm the changes and save them permanently.

The floating buttons on the lower right allows adding or deleting entries to the selected template.

When clicking on the  add button, a dialog to enter the code and description values will appear.

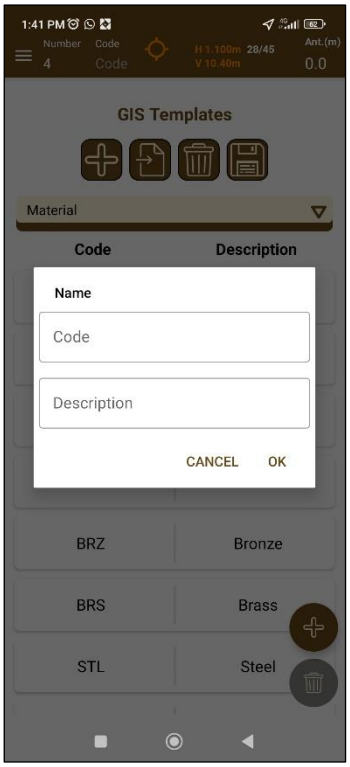


Figura 104. Adding a new entry to the current template

It is also possible add or remove values from templates imported as **CSV** documents.

12 Roads (Pro version)

When entering the road edition (**Menu> Edit> Roads**) a list of the roads that are currently in the project is presented.

Figure 105. List of roads

For the management of the list of roads, the following options are available:

	Adds a new road to the list. It can be imported from a **.eje** file (created from *TcpMDT*), a *LandXML* file or an IFC file version 4.3. In these two last cases, all roads included in the file will be imported, including their vertical alignments and all the cross-sections.
	Enter the road edition template where you can associate a vertical alignment and the cross templates to it.
	Remove the selected road and all the elements associated with it.

These roads are shown in the survey template of the application in blue and red which is currently the active road, selected on the list by clicking on the marker on the left.

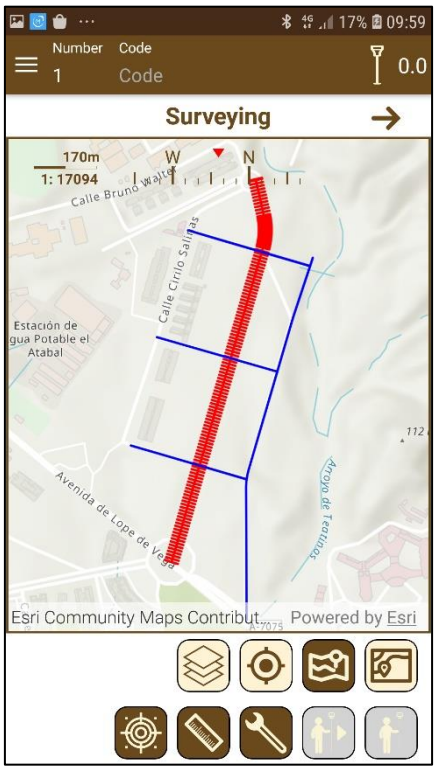


Figure 106. Roads in surveying

When the horizontal alignment of a new road has been loaded, you will go directly to the editing screen, where you can select a vertical alignment and make a list of files of templates that will be associated with that road.

The files that are supported are:

- **.eje files** that contain the horizontal alignment of the road.
- **.ras files** that contain the information of the vertical alignment.
- **.tra files** that contain the cross-section layers of the road.

These extensions correspond to the native files created by the TcpMDT **application**, although it is possible to use the **LandXML format**, of which the entities supported are:

- **Alignment**: It contains the points that form the horizontal alignment of the road.
- **Profile**: It contains the vertical alignment data.
- **CrossSects**: It contains the data of the templates of the road.

Both the horizontal alignment and the vertical alignment and the construction of templates can be visualized in graphic mode and its data consulted on the button  .

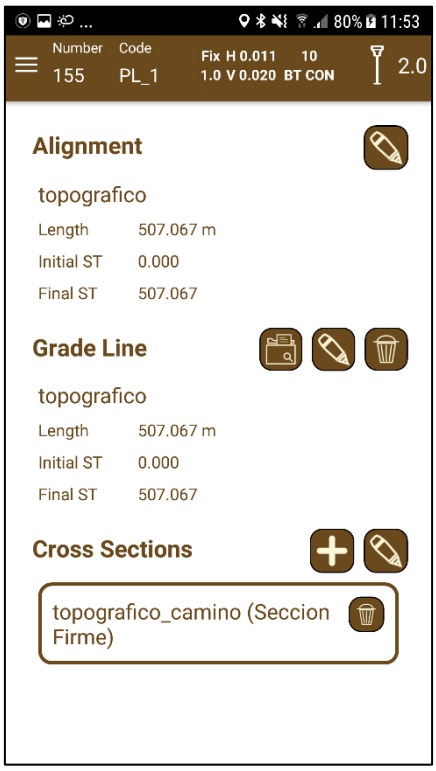


Figure 107. Editing a road

12.1 Horizontal alignment display

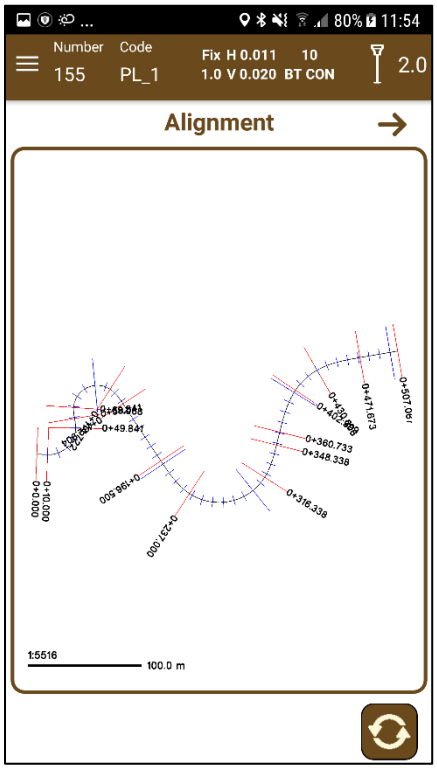
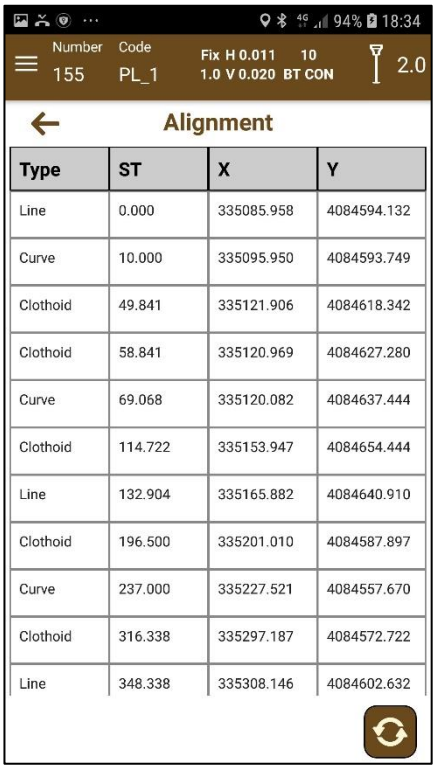


Figure 108. Top view of the alignment



Type	ST	X	Y
Line	0.000	335085.958	4084594.132
Curve	10.000	335095.950	4084593.749
Clothoid	49.841	335121.906	4084618.342
Clothoid	58.841	335120.969	4084627.280
Curve	69.068	335120.082	4084637.444
Clothoid	114.722	335153.947	4084654.444
Line	132.904	335165.882	4084640.910
Clothoid	196.500	335201.010	4084587.897
Curve	237.000	335227.521	4084557.670
Clothoid	316.338	335297.187	4084572.722
Line	348.338	335308.146	4084602.632

Figure 109. Numeric information of the alignment

The display of the horizontal alignment presents the vertical alignment and allows the rotation  of the presentation for a better observation, especially if a smartphone is used.

In smartphones you can alternate between the elevation view and a table with data of the horizontal alignment and in tablets both screens are presented at the same time for a better study of the information. The button  allows it to extend the plant of the horizontal alignment to full screen for a greater definition or to return to the two columns with the numerical information.

12.2 Vertical alignment display

The display of the vertical alignment presents it in elevation. As in the horizontal alignment, rotation of the presentation is allowed. In addition, in this case, a magnification factor can be applied to obtain a better definition of the vertical alignment in the button  . This magnification is in the **x1 - x20** range.

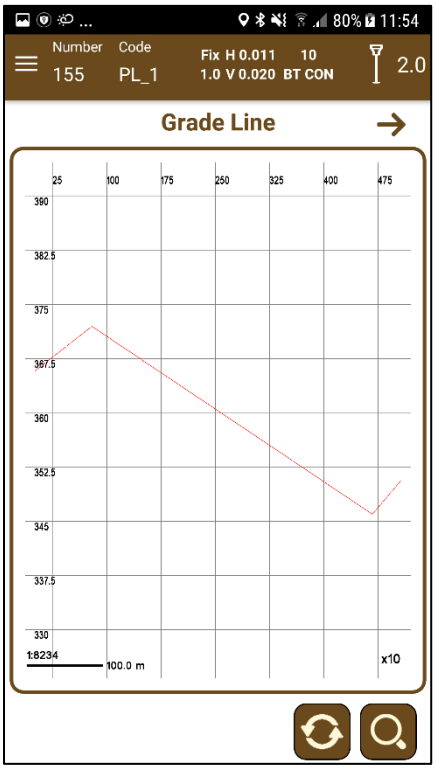


Figure 110. Vertical alignment view

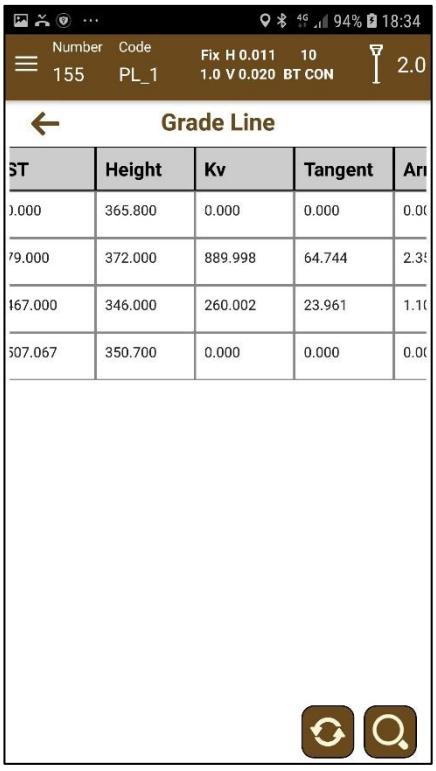
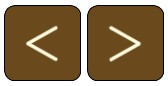


Figure 111. Vertical alignment numerical information

As in the horizontal alignment, on tablets the information of the vertical alignment and its elevation view is presented for a better analysis of it, as well as the possibility of hiding the column of data and extending the elevation of the vertical alignment.

12.3 Cross sections display

The display of the templates presents the template in the current station of each one of the transverse files contained in the list.

When you start the window, the application will immediately be placed in the template closest to the current position. With the buttons  you can switch from one station in the template to the previous one or the next one respectively. For templates, a magnification factor can also be applied to obtain a better definition.

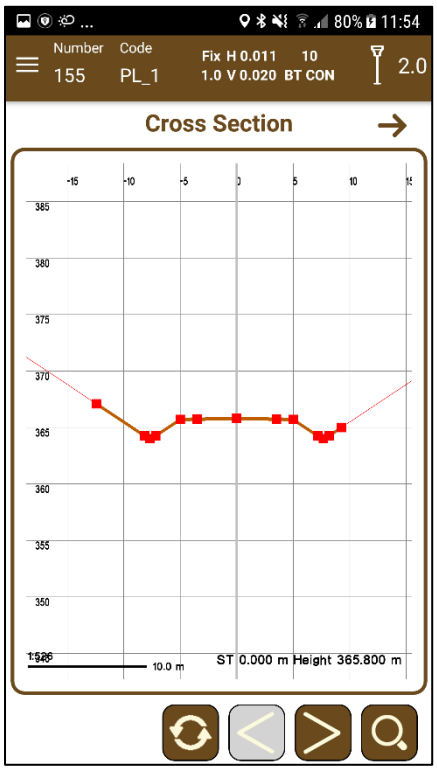


Figure 112. Cross section view

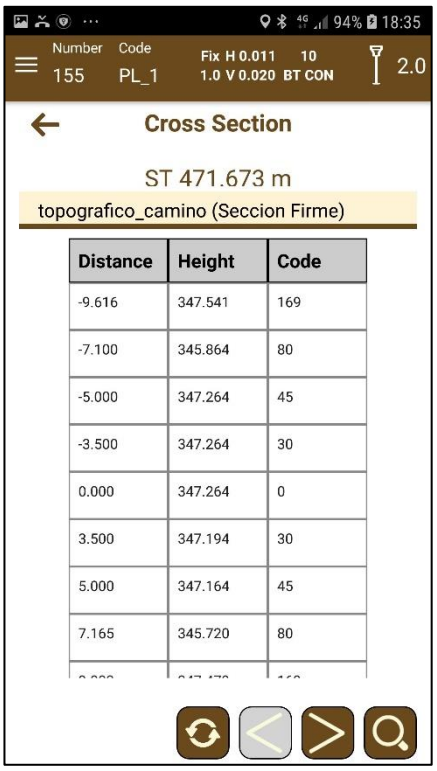


Figure 113. Cross section numerical information

In the numerical presentation of the data of the templates, the information of the points of the transverse file selected in the current station is shown. The template to be displayed can be chosen from the drop-down list, automatically updating the data, and, in the graphic view, the template with greater thickness of the line will be highlighted.

13 Surface Management (Professional version)

In TcpGPS digital models using the measured or imported points of the project can be created, as well as importing of surfaces or digital models. To access this option, click on the **Edit > Surfaces** submenu.

When the screen is entered, a list showing the uploaded surfaces will be displayed on the screen.

Four options are available in this screen, from left to right:

- **Import** of a surface.
- **Surface Tools** to measure, quick profile, and volume calculation, as well as creating triangulations.
- **Surface Analysis** of the selected surface. (See Surface Analysis.)
- **Deletion** of the selected surface.

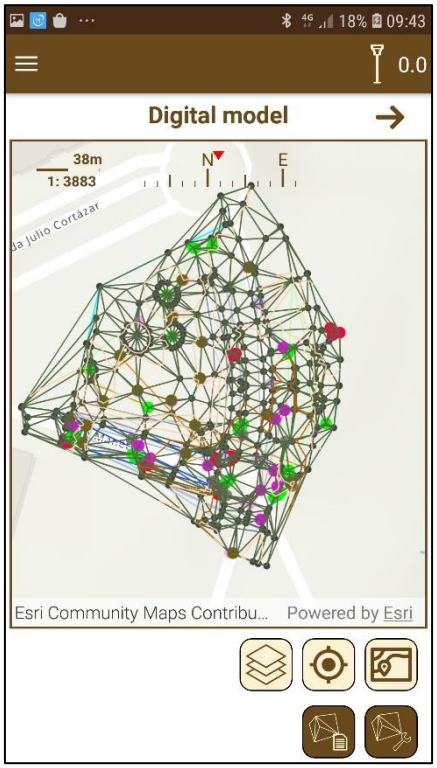


Figure 114. Digital model created

13.1 Import a Surface

The  button on the left option allows the user to import a surface from a **DXF,** a **LandXML** file or an **IFC 4.0** version file.

In case of a DXF file, the entities **3DFACE** will be taken to define the faces or triangles of the digital model.

For **LandXML** the entity used for creating digital models is **Surface**.

13.2 Surface Tools

Pressing the  button will open a map screen with further tools to be able to measure and interact with surfaces.

13.2.1 Measuring

Pressing the  button allows the selection of two points to get the distance between them to calculate the tasks to be done more easily.

13.2.2 Quick Profile

By pressing the button with the icon  located on the Digital Model screen it is possible to quickly make a section between the line that is drawn and the current model, thus showing the profile of this 3D model between said points.

After pressing the button, touch two points on the screen that will be the two ends of the line.

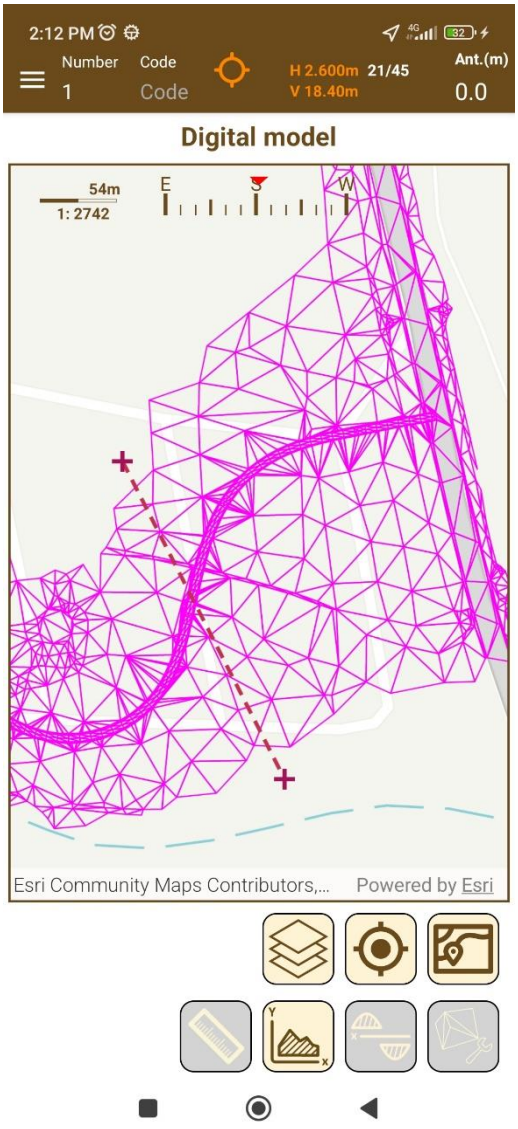


Figure 115. Drawing the profile line

If this line cuts the model, the graph with the level dimensions and its profile between the two points will be displayed on the screen.

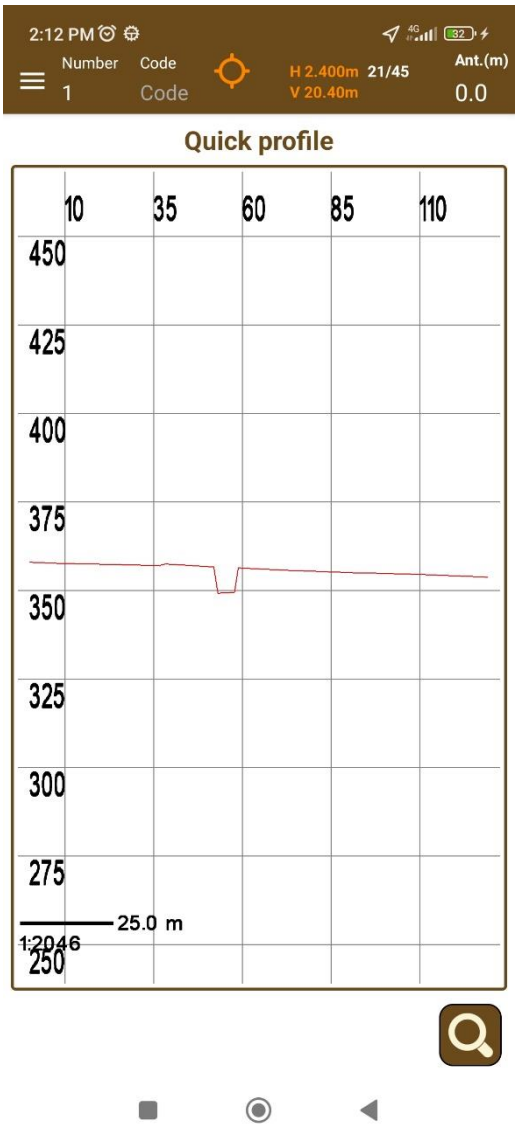


Figure 116. Terrain profile.

13.2.3 Volume Calculation

By pressing the button with the icon  located on the Digital Model screen you will enter the volume calculation mode.

The point measurement tool has also been included in this window. In this mode it is possible to determine the volumes of cutting and filling of a certain esplanade at the level indicated by the user.

To begin, it is necessary to select a polygon or parcel that is contained in or intersects with the selected model, by clicking on this polygon.

The selected polygon will be shown shaded with lines.

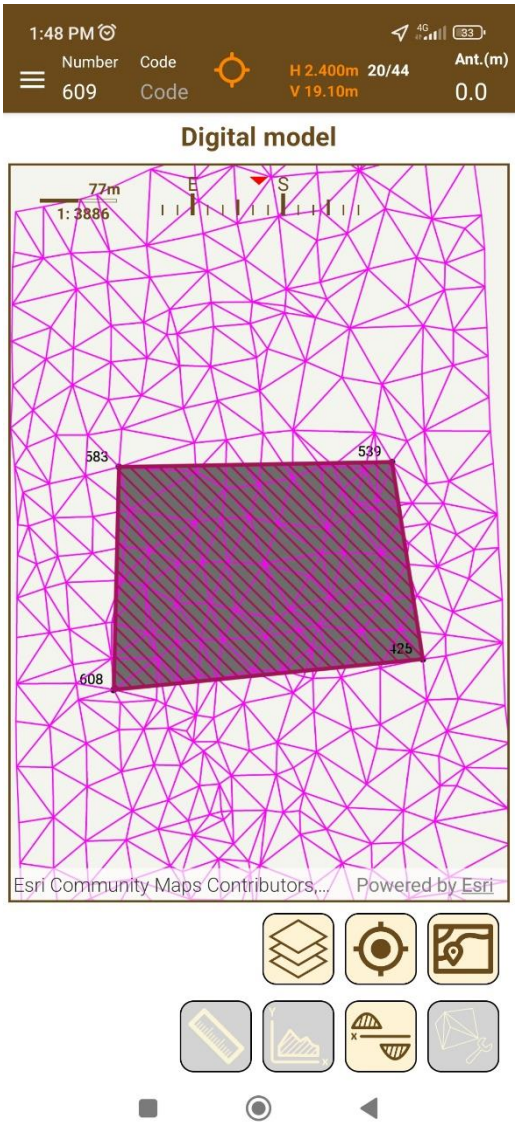


Figure 117. Polygon as esplanade.

After selecting the polygon, the program will perform some calculations to determine the maximum and minimum dimensions of the model in the selection area and will display them on the screen.

To calculate the volume, it is necessary to write the desired dimension and click accept.

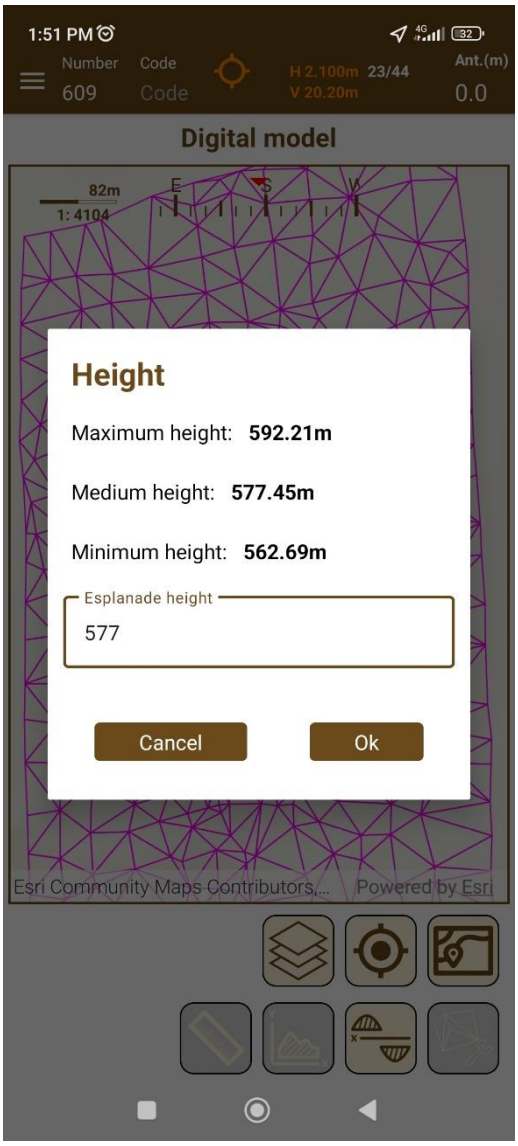


Figure 118. Area height

When the calculations are finished, a dialog will be displayed with the resulting values. Keep in mind that this is a completely vertical cut, perpendicular to the esplanade.

The export button allows you to save a file containing these values, with a ".txt" extension on the device, with the possibility of sharing it later.

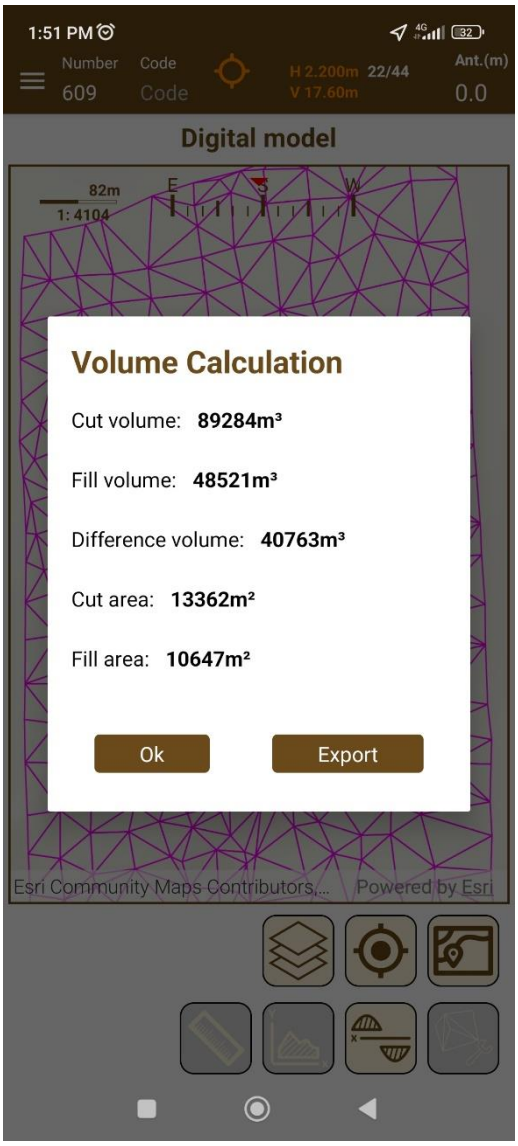


Figure 119. Volume calculation result

13.2.4 Triangulation to create a digital model

The  button accesses this mode. A digital model is created using a process called **triangulation** in which the points are turned into triangle vertices, generating an irregular mesh defining the terrain.

Figure 120. Creation of a digital model (1)

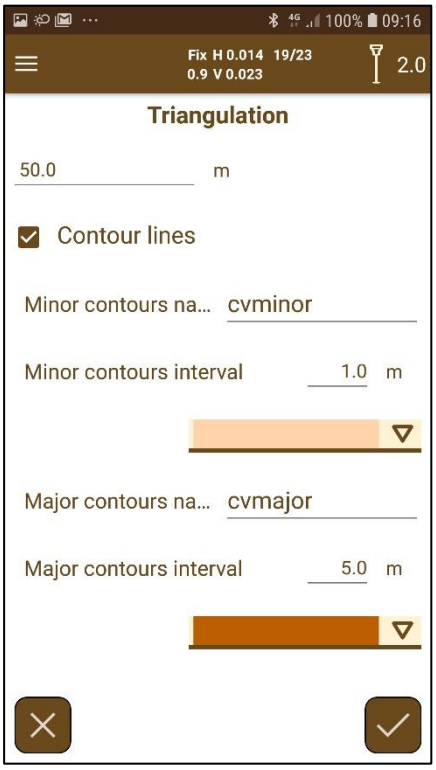


Figure 121. Creation of a digital model (2)

The following parameters will be required in the screen for configuring the digital model:

- **Name** of the digital model.
- **Color** for drawing the digital model.
- **Break lines**. If this option is enabled and the project contains lines or polylines, a list of them will be displayed for selecting those you want to use as break lines. These lines, either by the characteristics of the terrain or by the peculiar way of seeing it, will be obligatory lines (in advance) in the formation of the digital terrain model. It is not mandatory to define them, but it is highly advisable for the work to have validity and precision, since through these lines the relief is defined by following the existing slope changes.
- **Maximum distance**. It defines the maximum length for the edges of the triangles. If a triangle has an edge with a higher length than this value, it will not be created.
- **Contour lines**. By enabling this option, contour lines can be generated from the generated digital model. There are two types of contour lines:
    - **Minor contours**.
    - **Major contours**.

  Each type of contour is defined by its **name**, **color** and **height interval** between each of them.

By clicking on the accept button, the triangulation process will start. When it is finished, one or several layers will be added to the project:

- **Digital model layer**. This layer manages the visualization of the digital model, and it can be used in **surface analysis**.
- **Contour lines layer**. If the contour lines option was selected, two layers will be added, with the names typed, that manage each type of contour lines.

It's possible to generate as many models as desired, but if the names of the models or the contour lines match with any other present in the project, it will be replaced by the new one.

13.3 Surface Analysis

Pressing the  button will show a map screen where Surface Analysis can be performed to find information on the surfaces.

For more information, see **Surface Analysis**.

13.4 Surface Deletion

Touching the  button will allow a selected surface to be deleted.

Confirmation must be given to permanently delete a surface that has been loaded into TcpGPS beforehand.

14 Setting out

In the menu, the **Staking out** submenu can be found, which gives the option to choose one of the different modes, depending on the type of work that the user will perform:

- **Setting out of points**: Performs a setting out of the points contained on the project database.
- **Setting out of lines**: It allows to stake out lines formed by the union of two existing points in the database of the project.
- **Setting out of polylines**: The setting out is performed on polylines or polygons defined in a DXF, KML / KMZ, shape or GML cartography.
- **Surface analysis**: Analyze the difference in dimensions between the current position of the GPS and the 3D surface loaded.
- **Road Setting out**: It allows you to stake out a set of points configured on a road.

- **Slope control**: The current state of the land is analyzed according to the theoretical template that has been loaded into the project.

14.1 Setting out modes

When setting out, the reference to get the indications for reaching the points can be the **north**, the **movement**, the **last staked out point** or **sun/shadow**.

14.1.1 Setting out to the north

In this case the indications are referred to the **north** direction, so it is recommended to be oriented to the north when using this mode.

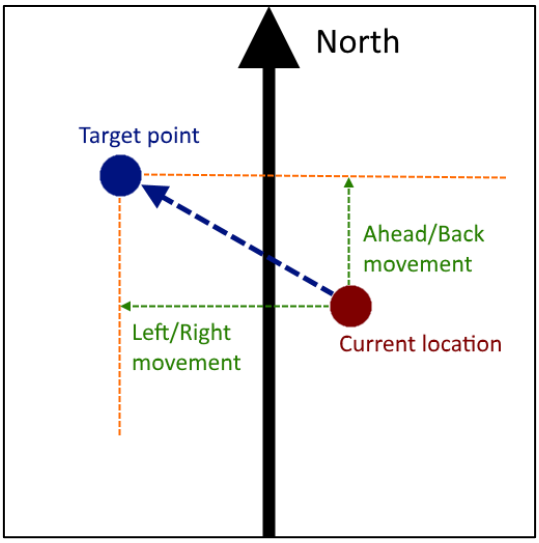


Figure 122. Example of setting out to the north

14.1.2 Setting out to the movement

In this case the last movement of the user is taken as reference for indicating the next movement he should do to reach the target point. In this mode, a new movement will be recognized when at least the location has change in 50 centimeters of distance.

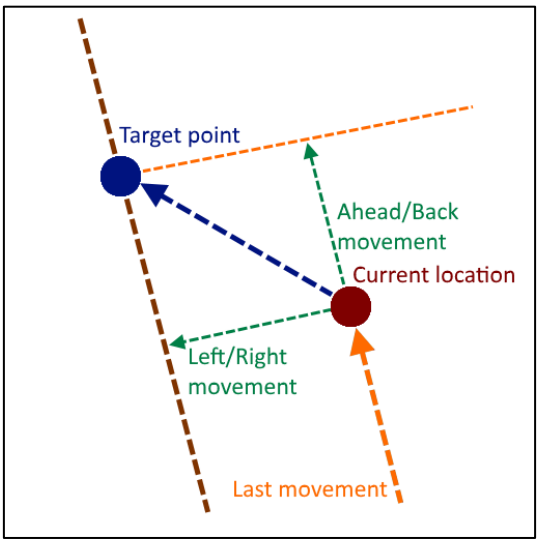


Figure 123. Example of setting out to the movement

When the position reaches the limit configured settings named **Target Mode Distance** (see **Configuring the workspace**) the last move the user did is taken as reference and it does not change anymore, in order to avoid continuous changes due to the small distance to the point.

14.1.3 Setting out to the last point

In this case, the line from the last set out point to the target point is taken as reference.

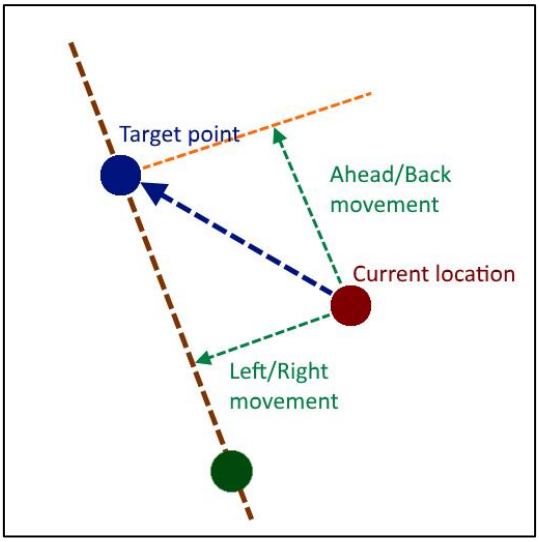


Figure 124. Example of setting out to the last point

14.1.4 Setting out to the sun or shadow

This mode is like setting out to north, but in the case the reference is the sun. The user must have the sun at his back and a good guide is his own shadow.

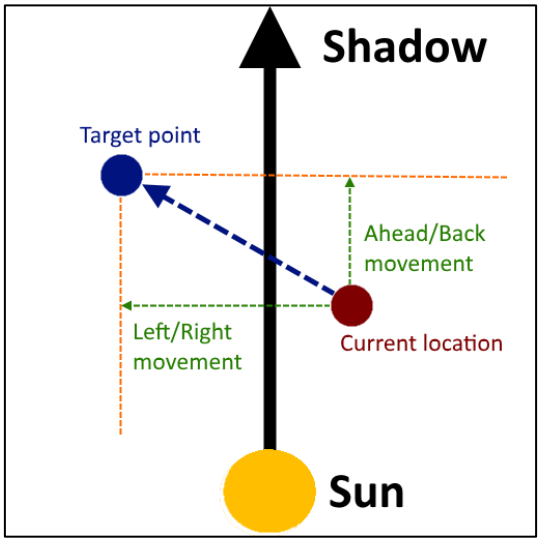


Figure 125. Setting out to the sun

It is very important to know that the reference will change depending on the hour and the day.

When using stake out to the shadow the direction is the inverse, i. e., the user must leave the sun behind him to obtain the reference. In this mode, the cast shadow can be a great help when it comes to orienting himself.

14.2 Set out points

In this section, individual points are staked out. To make the job easier, TcpGPS incorporates various modes for staking out.

14.2.1 Map Mode

In this mode, a map is displayed showing the available points for setting out and the current position of the GPS. You can select the point to set out simply by clicking on it. A signal indicating the point and a line between the current position and this one will serve to advance towards it in the correct direction. Over this line is shown the distance to the point.

14.2.2 Compass Mode

In this mode, the direction in which the point is relative to the north from the GPS position will be indicated. It is a mode that is recommended to locate points at a long

distance, since in the vicinity of the point the measurement of the angles can be erratic. To use it, the device must have a magnetometer.

In the compass, three lines are highlighted:

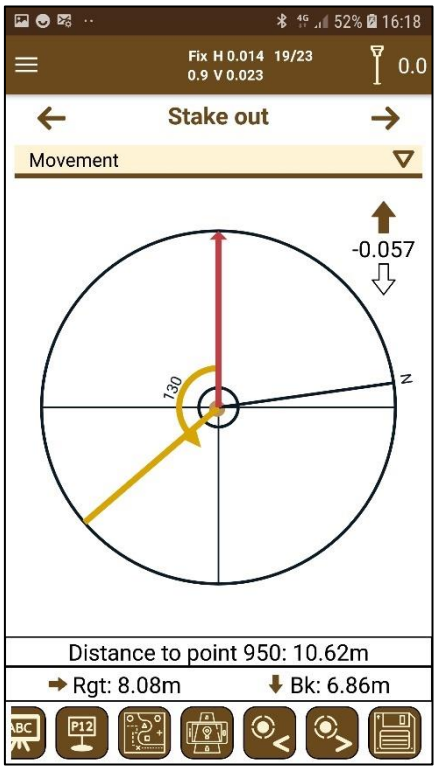


Figure 126. Compass staking out mode

- The **red line** is fixed and indicates the current direction the user device is pointing. This line changes its color to **green** when the line indicating the point to be set out matches with her.
- The **black line** indicates the direction of the north.
- The **orange line** indicates the direction to the point to be staked out.

Between the red line and the orange line is indicated the angle the user must turn to face the point.

On top of the compass is indicated the **distance** to reach point.

14.2.3 Target Mode

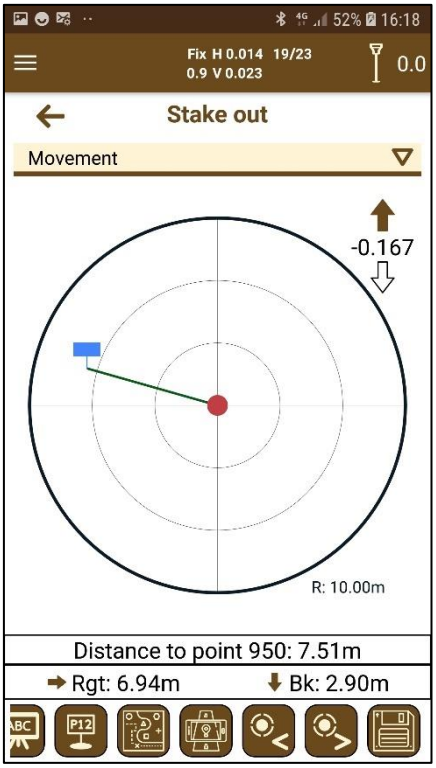


Figure 127. Target staking out mode

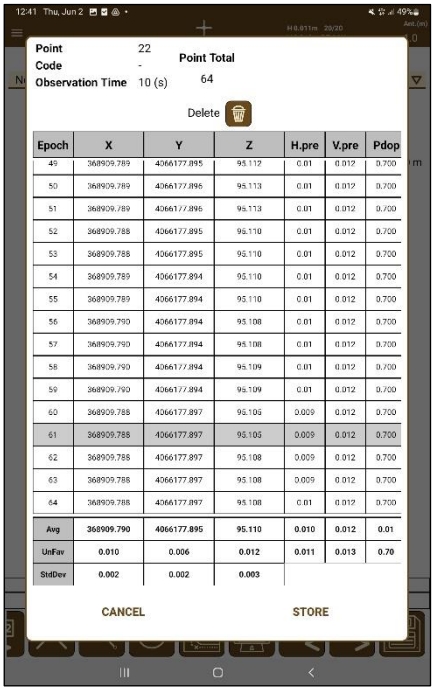
In this mode, the current position of the GPS (in **green**) is shown in relation to the center of a target that marks the point to be set out (in **red** at center of the dartboard). The position of the GPS within the target will be determined by the movements to be made depending on the selected setting out mode. In this mode, a greater precision is obtained when locating the point, so its use is recommended in the vicinity of the point to be set out.

On top of the dartboard are shown the movements the user should make to reach the point: left or right for lateral movements and forward or backward for advance movements.

14.2.4 Stake out via epochs

As shown in the section **Configuring the workspace**, it is possible to stablish the point observation time. When the stablished observation time is **more than 0**, and the stake out button is pressed, or the option **Long press for precision points** is activated, and a long press is performed in the stake out button, its possible to perform a stake out of a point via epochs.

After performing the checks signaling the point validity, the point observation dialog is opened, where epochs from the GNSS Receiver are taken, and once it is finished, the average of all epochs are shown.



Epoch	X	Y	Z	H.pre	V.pre	Pdop
49	368909.789	4066177.895	95.112	0.01	0.012	0.700
50	368909.789	4066177.896	95.113	0.01	0.012	0.700
51	368909.789	4066177.896	95.113	0.01	0.012	0.700
52	368909.788	4066177.895	95.110	0.01	0.012	0.700
53	368909.788	4066177.895	95.110	0.01	0.012	0.700
54	368909.789	4066177.894	95.110	0.01	0.012	0.700
55	368909.789	4066177.894	95.110	0.01	0.012	0.700
56	368909.790	4066177.894	95.108	0.01	0.012	0.700
57	368909.790	4066177.894	95.108	0.01	0.012	0.700
58	368909.790	4066177.894	95.109	0.01	0.012	0.700
59	368909.790	4066177.894	95.109	0.01	0.012	0.700
60	368909.788	4066177.897	95.106	0.009	0.012	0.700
61	368909.788	4066177.897	95.106	0.009	0.012	0.700
62	368909.788	4066177.897	95.108	0.009	0.012	0.700
63	368909.788	4066177.897	95.108	0.009	0.012	0.700
64	368909.788	4066177.897	95.108	0.01	0.012	0.700
Avg	368909.790	4066177.895	95.110	0.010	0.012	0.01
UnFav	0.010	0.006	0.012	0.011	0.013	0.70
StdDev	0.002	0.002	0.003			

Figure 128. Point via epochs

In the case that one or more epochs are not in the specified tolerance measures specified in the configuration, the dialog will warn of this fact. If there is a need to remove unwanted epochs, it is possible to touch them to select them and then touch the delete button.

Figure 129. Point via epochs outside of allowed tolerances

14.2.5 Changing the staking out mode

To change the mode, the controls will be used  will be used. In addition, when the minimum distance to the point configured in the application is met, the target mode is automatically passed to obtain more precision in setting out.

When the current location is at a distance lower than the set in **Menu > Settings > Stake out > Target Mode Distance**, the application will display the target mode automatically.

14.2.6 Staking out options

The following options are provided for working with **staking out of points**:

- **Staked out point**  : Saves the point staked out in the database by recording the current GPS data.
- **Next**  **/previous**  **point**: Allows selecting the point to be staked out by scrolling through the list of points according to their numerical order.
- **Select code**  : Allows selecting a specific set of points according to their code. Another option is associated with this one to allow you to return to the full list of points  .

- **Add Image to Last Point**  **:** Allows the adding of an image to the last point taken, either by updating it from the gallery or by using the device's camera.
- **Point selection**  : Allows selecting a point by entering its number.
- **Intersection stake out**  : Allows selecting a point pressing on the intersection of two lines or polygons, or a line that has an intersection with itself.
- **Vertex stake out**  : Allows selecting a point pressing on a line or polygon and the application will select the vertex closest to the point pressed onscreen.
- **Circle Center stake out**  : Allows selecting a point pressing on a circle, and the application will calculate the center of the circle for it to be staked out.

In each setting out mode, help is provided in the form of voice prompts to mark the movements to be made or the remaining distance to reach the point.

14.3 Stake Out Lines

In this template we will work on setting out a line (**Error! Reference source not found.**) t hat will be established between two selected points.

When you want to stake out a line, the application will ask for the first point (selectable in the map) and then for the second. Once the two points are selected, a line will join them on the map and the following information will be presented:

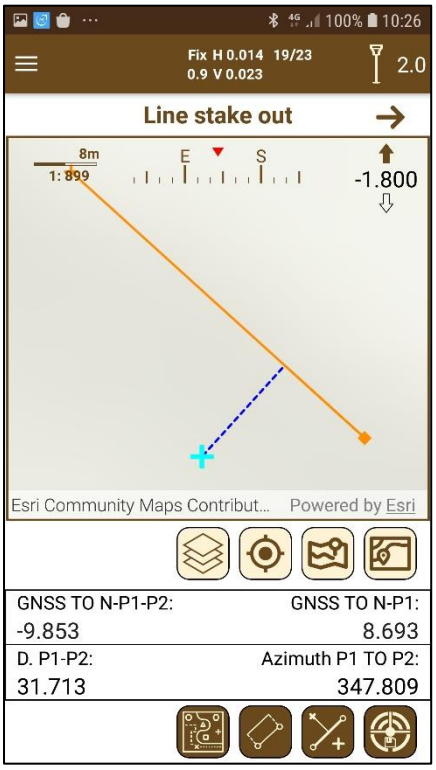


Figure 130. Line stake out

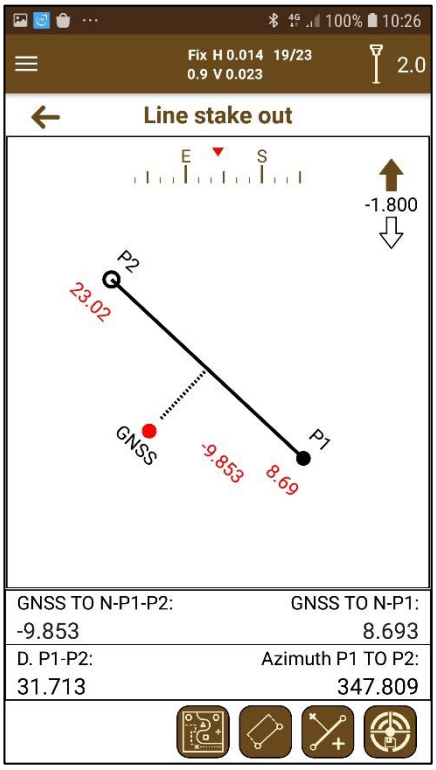


Figure 131. Schematic line stake out

- **GNSS TO N-P1-P2**: Distance from the current point to the line in perpendicular fashion. If the perpendicular falls outside the line, an extension of it will be drawn for its representation.
- **GNSS TO N-P1**: Understanding the origin as the first point chosen, this distance is the distance from the current point projected on the line, to the origin.
- **D P1-P2** is the length of the line.
- **Azimuth P1 TO P2** is the azimuth of the line following the direction P1 to P2.

Line stake out mode displays the line to stake out with the points at both sides and the current position of the user respect to the line.

If the user is out of line ahead (beyond the destination point) or behind (before reaching the point of origin) a dotted line will inform us of this situation.

All the stakeout data is presented on the representation.

If you want to set out another line, just press the button  .

Additionally, it is possible to stake out a parallel line to the defined in the map by clicking on the button <imagen>. A dialog will be displayed asking for the distance in meters where the parallel line will be set. If the distance is positive, the new line will be set to the right of the first one, and if it is negative to the left.

14.4 Set Out Polylines

In this case, we work on maps of type *DXF*, *KML / KMZ*, *GML* or *shape* that contain elements formed by an indeterminate number of points of the polylines or polygons (closed polylines) type and also the polylines and polygons measured in surveying.

When a polyline is selected, this is staked out by edge. The movements shown in the screen are the ones needed to reach the line.

If you want to stake out the vertices of the polyline, you can switch to vertex mode with the button  and back to edge mode with the button  .

In **vertex mode**, the vertices corresponding to the points that form it are automatically marked. It takes, by default, the vertex closest to the current one, being able to change the vertex with the buttons  .

When you want to store the information of one of the setting out points, press the button  . In this case, since the points of the polyline are not saved as project points, both the polyline vertex information and the setting out point information are stored in vertex mode, and the projected point in the polyline and the setting out point if it is in edge mode.

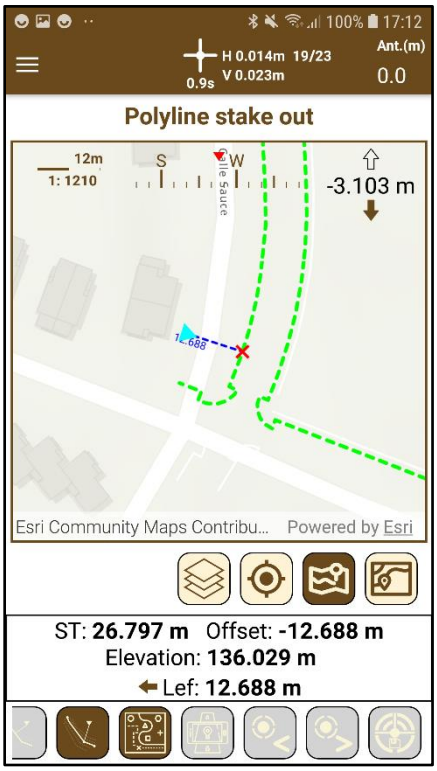


Figure 132. Polyline stake out using Edge

Figure 133. Polyline vertex stake out

14.5 Surface Analysis

This template is intended to check a 3D surface imported from a DXF file containing *3D faces* or a LandXML containing *surfaces* entities. To carry out this check, the dimension defined on the surface will be compared with the elevation measured by the GPS and the difference will be shown. In addition, the face on which the GPS is located at each moment is highlighted.

In the **Layer management** section is possible to change the active layer in case the project contains multiple surface layers. The active surface layer will be the one taken for making the analysis.

The information shown is:

- **Height**: Current height of the GNSS receiver.
- **Height diff.**: Difference of height between the GNSS height and the current selected surface.

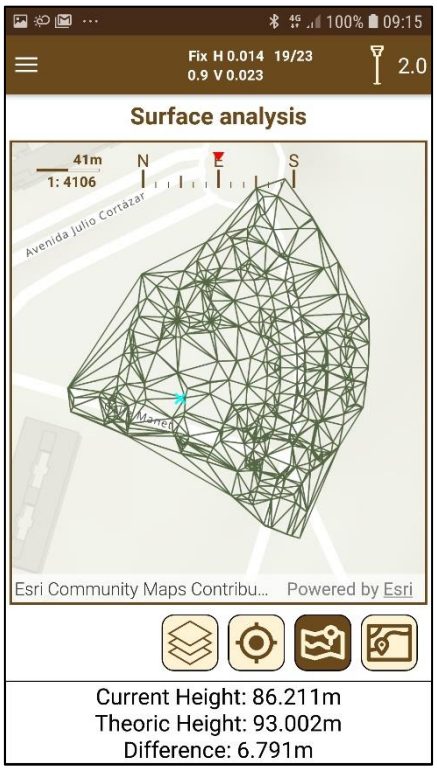


Figure 134. Surface analysis

14.6 Roads stake out (PRO version)

14.6.1 Stake out settings

In the setting out of roads, the points referred to the horizontal alignment of the road are set out. To do this, first you must configure the point or the set of points you want to set out.

If you want to set out a single point, just indicate it in the *Initial* Station.

If what is desired is to stake out a set of points along the horizontal alignment or parallel to it, the option *Interval* should be activated, and an *Initial Station* indicated from which the following points of the interval will be created. Then you can modify the interval between the points that will be taken. In addition, if this option has been selected, a drop-down list with the ordered set of interval points helps the user to choose the point to be set out.

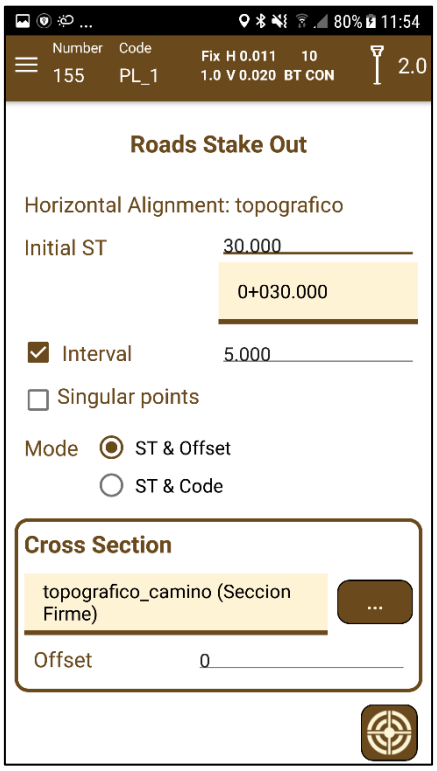


Figure 135. Road stake out settings

As an additional option, you can stake out, alone or next to the points defined in the interval, the singular points that form the horizontal alignment, marking the *Singular Points* option. These points are also added to the list of drop-down points and begin with an **[S]**.

If no other option is configured, all points will be located on the horizontal alignment. However, it is possible to set out points that are at a distance from the horizontal alignment, parallel to it. To do this, you can select if you want a list of points parallel to *the horizontal alignment at a certain distance (Setting out by Station and Displacement*) or to use a selected point of one of the vertices of the cross templates associated with the road, defined by a code (*Setting out by Station and Code*).

If there is no cross section selected, only the option of setting out by *Station and Displacement* will be available, indicating the displacement in meters that the points will have on the horizontal alignment. If the distance is positive, they will be placed to the right of the horizontal alignment and if it is negative to the left.

When a cross section is selected from the list associated with the horizontal alignment, the setting out option for Station *and Code* is activated, in this case you can enter a code manually or select it from the cross-template view on the button 

.

Once the list of points to be set out has been configured, the setting out of the button starts  .

14.6.2 Stake out display

The setting out screen has two modes: setting out *of a plant* and setting out *in elevation*. The latter will be shown if a cross section has been selected and if the road has a vertical alignment associated with it. To switch between both views, the navigation menu buttons are used  .

The information displayed on the elevation is the following:

- **The** Station and the current **displacement**.
- Move **forward / backward** from the current station to reach the point.
- Movement **in / out** of the horizontal alignment to reach the point.
- Current **elevation and movement up / down to reach the slope.**

In the plant, the information of the current position marked with a celestial cross is shown.

If you have selected a range of points to set out, with the buttons 

you can change the point to set out within the list.

Figure 136. Road stake out (top view)

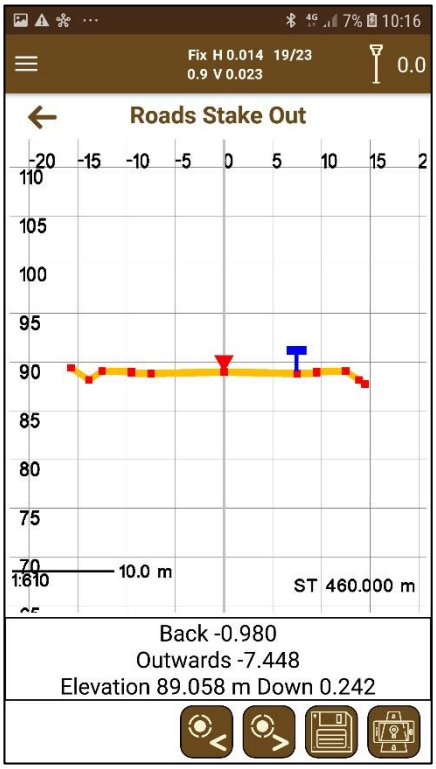


Figure 137. Road stake out (front view)

When the setting out point has been reached, it can be saved using the button  . In this case, two points will be saved in the project database: the original point calculated in the list of points to be set out and the point that has been marked as set out.

14.7 Slope control (PRO version)

14.7.1 Slope control configuration

In the control of slopes, the verification of the state of the terrain is made according to the road. In order to carry out slope control, the road must have a vertical alignment and at least one cross section.

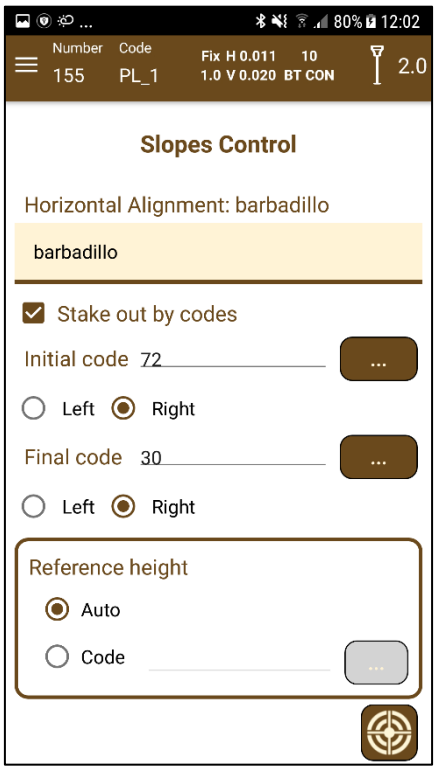


Figure 138. Slope control configuration

The first step to configure the slope control that you want to perform is to select the cross section to be used in the process. Once this is done, the following options will be activated:

- **Setting out through codes**: If you want to set out according to a certain segment template of the template, you can select the codes of the points in each end of a certain template. In this way, the control will be referred to the vector that defines the stretch and its extension in space. If this option is not selected, the control will be done according to the entire selected template.
- **Height dimension**: If the height dimension is taken automatically, the control will be referred to the current template dimension. If a point of the template is selected as the reference dimension, it will be determined by entering the code of that point or selecting it from the template itself.

To select the codes in each case from the selected template, press the button  . In this way, the template closest to the current position will be displayed or you can travel between the template to look up the required code directly on the models.

14.7.2 Slope control display

In the slope control display screen, the elevation of the template closest to the current position of the GPS and the information related to the movements to be made to reach the position in said slope is presented.

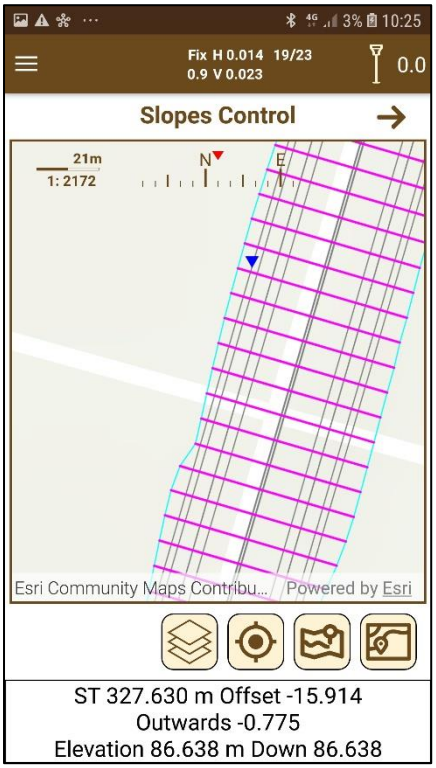


Figure 139. Slope control display (top view)

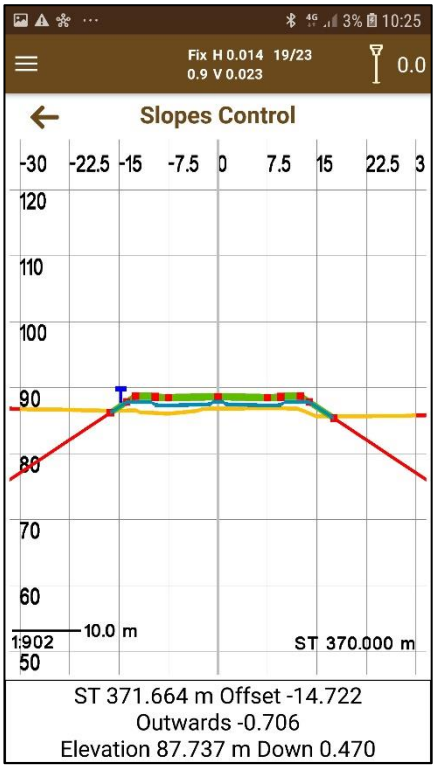


Figure 140. Slope control display (front view)

The information displayed is the following:

- **The Station** and the current **displacement**.
- Movement **in / out** of the horizontal alignment to reach the slope.
- Current **elevation and movement up / down to reach the slope.**

15 Issue Control (PRO version)

15.1 Add and Edit Issues

To add an BCF Issue, press the  at the Points Stake Out, Roads Stake Out and Surveying screens to open the BCF Issue creation Dialog. The following values can be added:

- **Title**: *Mandatory.* Issue title.
- **Type**: Indicate the Issue type, for information.
  - Issue
  - Request
  - Inquiry
  - Remark
  - Fault
- **State**: Indicates the Issue state type, for information.
  - Open
  - In Progress
  - Closed
  - Reopened
  - Active
- **Priority**: Indicates the Issue Priority to be able to prioritize tasks.
  - 1- Critical
  - 2- High
  - 3- Normal
  - 4- Low
- **Description**: *Optional*. Incidence Description.
- **Date**: Current date from the moment that the incidence is created.
- **Time**: Current time from the moment that the incidence is created.
- **Author**: License owner's user's e-mail address.
- **Image**: *Required*. Image related to the Issue. Can be obtained from the Gallery or straight from the device's Camera. If the image is touched, it will increase in size with *zoom*.

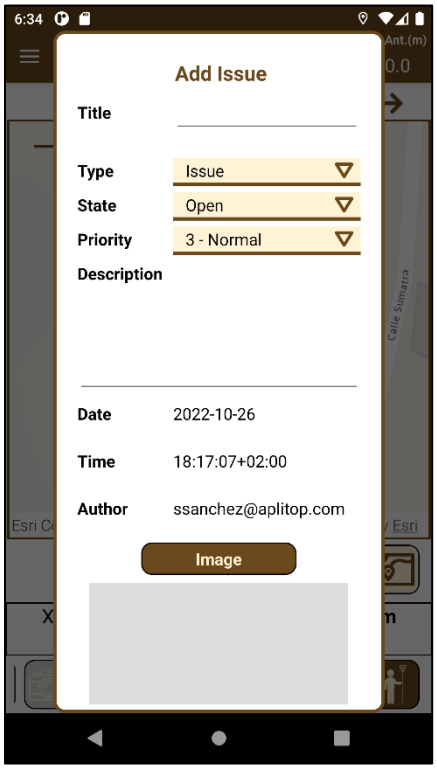


Figure 141. Issue Dialog

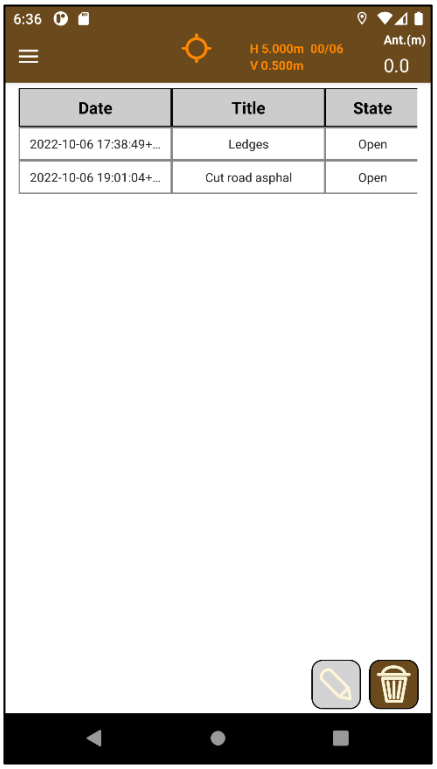


Figure 142. Issue List

It is able to access the Issues List at **Edit > Issues** in the menu, and in this screen, it is possible to select an Issue, open it to edit it, and as well as deleting one or more Incidences from this screen.

15.2 Import and Export Issues

Accessing to **Import > Issues** it is possible to import all incidences within a **.bcfzip** file, adding all of the Issues to the **project** database.

If the checkbox titled "*Overwriting Issues with pre-existing GUIs*" is checked, if the application detects Issue GUIs already existing in the project in the existing **.bcfzip** when importing, it will replace all of the project Issues with the Issues from the **.bcfzip**. If it is not checked, it will not import these Issues.

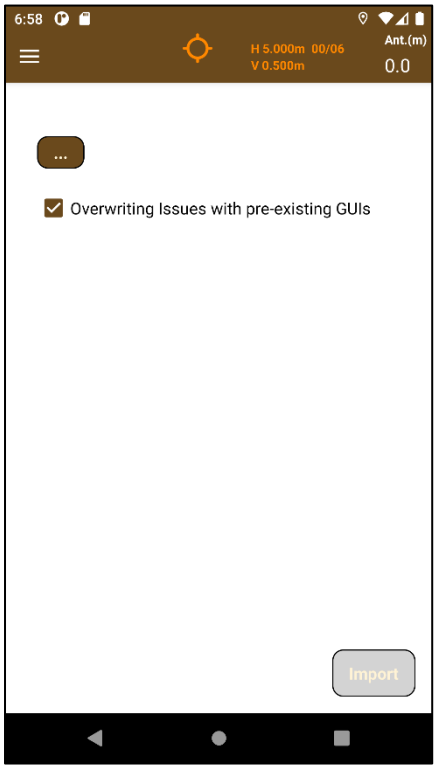


Figure 143. Issue Import

Figure 144. Issue Export

Files exported to project folder will be saved in the device folder of **Android/data/com.aplitop.tcpgps/files/projects/project-name/[export]**, which can only be accessed from a desktop or laptop device via USB cable.

If the option *User Folder* is chosen, it is possible to pick a folder pressing the 

button, which will open Android's file explorer (SAF) so the application can obtain permissions to write on the chosen folder. Once that has been done, the *Export* button will be enabled, and the application will create the file in the chosen folder.

Once exported, the files can be shared. (See section **Share Exported Files**)

16 Working with the data

Once the surveying data has been gathered and/or the staking out work performed on them, a range of tools are available to be able to work with the data. These tools can be accessed from the menu, under Export or Import.

The files can be exported both to *Project Folder* as well as at a *User Folder*. Files exported to project folder will be saved in the device folder of **Android/data/com.aplitop.tcpgps/files/projects/project-name/[export]**, which can only be accessed from a desktop or laptop device via USB cable.

If the option *User Folder* is chosen, it is possible to pick a folder pressing the 

button, which will open Android's file explorer (SAF) so the application can obtain permissions to write on the chosen folder. Once that has been done, the *Export* button will be enabled, and the application will create the file in the chosen folder.

Once exported, the files can be shared. (See **Share Exported Files**)

16.1 Importing points

It is possible to import points previously taken in other platforms or from other projects made with TcpGPS using files of the following types

- **TXT** or **PUN**: The format of the points in these files must be:

  <point id> <X> <Y> <Z> <point code>

  For example:

```
1 324177.421 4041653.935 0.85 SURV
2 324177.436 4041653.925 0.62 SURV
3 324177.422 4041653.937 0.63 SURV
4 324177.418 4041653.932 0.75 SURV
5 324177.432 4041653.942 0.55 SURV
6 324177.433 4041653.928 0.49 SURV
7 324177.414 4041653.939 0.65 SURV
8 324177.416 4041653.935 0.77 SURV
9 324177.427 4041653.919 0.76 SURV
10 324177.412 4041653.941 0.81 SURV
```

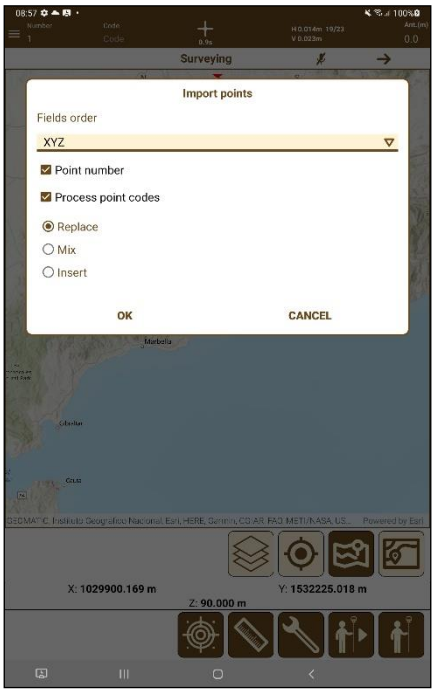


Figure 145. Import points

  - **Point Number**: Uses the indicated point in the folder instead of creating the number automatically.
  - **Process Point Codes**: Compare the point codes with the ones in the database to interpret it as open polylines, closed, or individual points, all of them with their codes.

- **DXF**: The **POINT** entities contained in the file will be taken.
- **KML / KMZ**: **Point** entities will be taken as valid points.
- **GSI**: The coordinates, point number, and code are obtained from elements **41, 42, 11, 81, 82** and **83**. The rest of elements are not considered.
- **CSV**: The coordinates, point number, and codes that are separated by commas or semicolons are obtained. As well as the files exported by TcpGPS

Selecting the file with the desired points will open a dialog with the following options to import these points:

The default option is **Replace**, that will erase all the points in the drawing and replace them with the imported points.

Insert adds the points at the end of the list of existing ones. The ordinal of the points of the file to be imported is ignored, and the new points will be imported from the initial number specified in the dialog.

Finally, the **Mix** option considers the point names, adding from the new file only those points whose number does not already exist in the point cloud.

16.2 Exporting points

Points gathered in TcpGPS can be exported to the following formats: **KML**, **KMZ** (Point Images), **PUN**, **CSV**, **TXT**, **DXF**, **Shape, GPX, TopStation** and **GML**. A special type of exportation is included, called, **MDT**, where a **.pun** and a **.gps** files are generated alongside associated images to use them into *TcpMDT*.

It is possible to use two different modifiers in exporting points:

- **Exporting points using a different Coordinate System:** This will use an already existing Coordinate System that has been previously defined in the app. They will be transformed and then exported. The two coordinate systems must be compatible with each other, or the exported data will be incorrect.
- **Exporting a point range:** This allows for the exporting of a range of points from the project database, from X to Y, defined by the user. The confirm button must be pressed once a range has been decided for it to save the range and obtain the points.

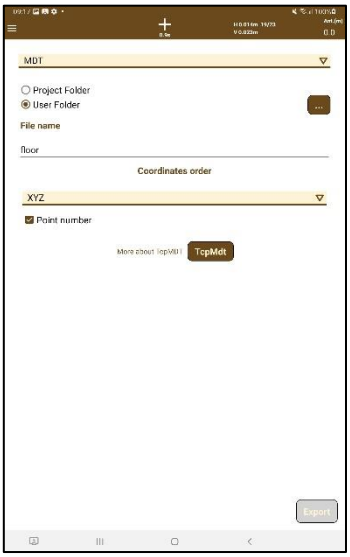


Figure 146. Point export menu

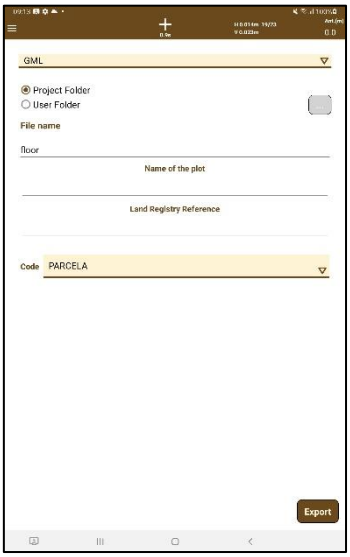


Figure 147. Export to GML format dialog box

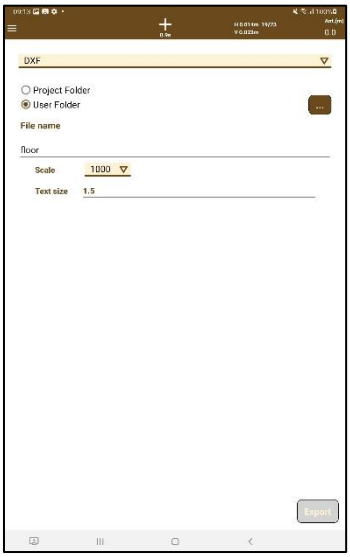


Figure 148. Export to TXT, DXF and KML formats dialog box

16.2.1 Exporting DXF y DWG

In this case, options for setting the size of the texts represented in the file are available:

- **Scale**: scale for adjusting the size of the text to the map.
- **Size**: size of the text for the scale defined previously.

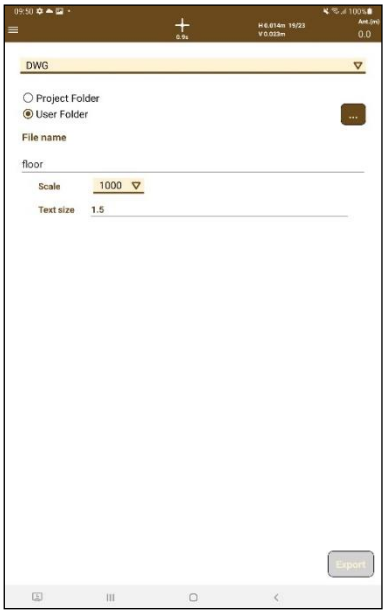


Figure 149. DWG export screen

16.2.2 Exporting to TXT

When exporting to TXT, it is possible to choose the desired separator that the point file will have. The options are *Blank Space*, *Comma*, *Semicolon* and *Tabulation*.

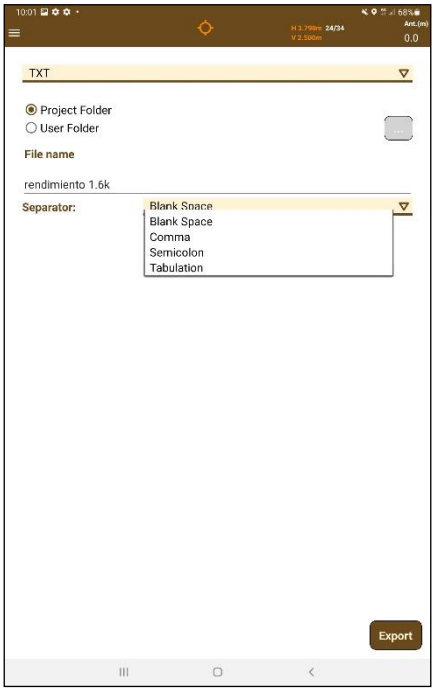


Figure 150. TXT Export screen

16.2.3 Exporting to Shape

When export to Shape is selected, the user can select the layers he wants to export. A shape file is generated for each layer depending on the type of entities the layer contains, as well as a .prj file containing the projection and coordinate system of the current project.

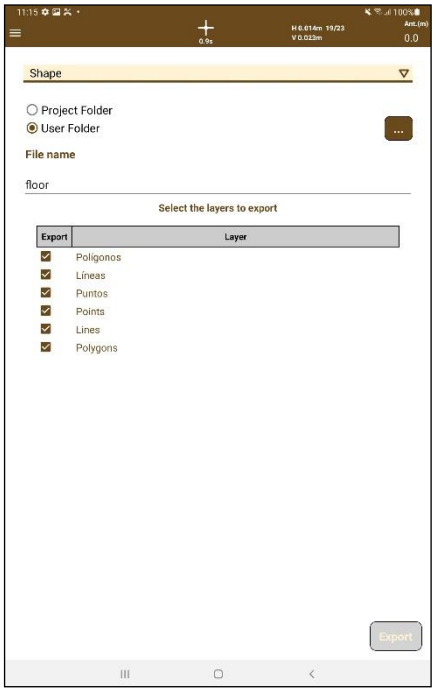


Figure 151. TXT Shape Export Screen

16.2.4 Exporting to CSV

When exporting to CSV format it is possible to choose which separator for the CSV files, between Semicolon separator and a Comma separator.

Figure 152. CSV Export Screen

16.2.5 Exporting to Custom Format

Additionally, the option to design custom formats has been implemented by selecting the **Custom** option, which we can be used to customize the attributes and types of data that the file will contain, adding to the name the extension with which we want to save the file.

By default, the app shows a profile named "Default", but we will have the possibility of creating our own custom formats with the supported attributes, in order to export the points with those characteristics added to those profiles.

The exported files will be saved in the local application file in the folder **tcpgps/project /custom**.

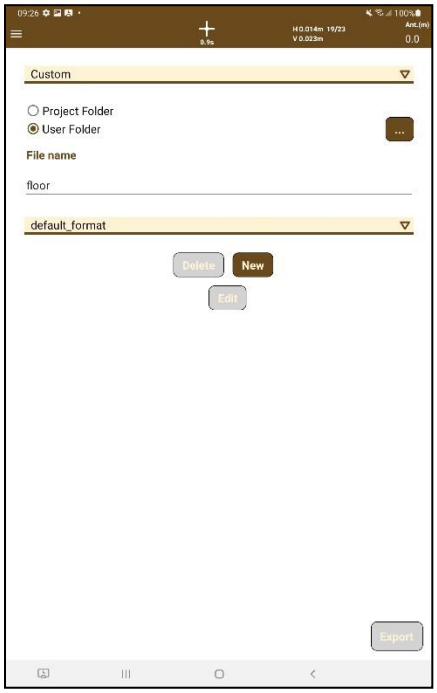


Figure 153. Custom format export

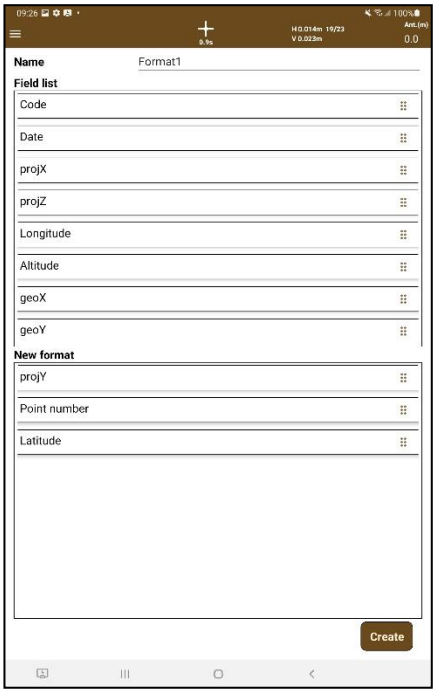


Figure 154. Custom format attributes edition

16.3 Exporting raw data

The raw data contained in the application associated with points taken during a survey can be exported to **.gps** format, which looks like this:

Type	Source	Date	Time	-	Point	Lat	Lon	Alt	Antenna Hei	Pdop	UsedSats	Position Typ	Horizontal Pi	Vertical Prec	Code	-	Position Typ	Age	Observation	Base Distance
P	Surveying	14/06/2020	11:20:50	-	1	3.635.948.858	-433.648.465	205.379	0.000	3.1	16	8	0.022	0.040	BANCO	-	RTK Fixed	1.0	0	0
P	Surveying	14/06/2020	11:22:19	-	2	3.635.947.568	-433.650.197	205.379	0.000	3.1	16	8	0.022	0.040	-	-	RTK Fixed	1.0	0	0
P	Surveying	14/06/2020	11:22:56	-	3	3.635.945.200	-433.649.831	203.102	2.000	3.0	17	8	0.036	0.050	ARBOL	-	RTK Fixed	1.0	0	0
P	Surveying	14/06/2020	11:23:12	-	4	3.635.946.500	-433.641.541	203.341	2.000	3.0	15	8	0.050	0.090	ARBOL	-	RTK Fixed	1.0	0	0
P	Surveying	14/06/2020	11:23:44	-	5	3.635.947.793	-433.646.731	203.350	2.000	3.0	17	8	0.058	0.100	CAMINO	-	RTK Fixed	1.0	0	0
P	Surveying	14/06/2020	11:23:53	-	6	3.635.948.819	-433.647.196	203.310	2.000	3.0	16	8	0.036	0.060	CAMINO	-	RTK Fixed	1.0	0	0
P	Surveying	14/06/2020	11:24:03	-	7	3.635.951.294	-433.647.773	203.315	2.000	3.0	15	8	0.036	0.070	CAMINO	-	RTK Fixed	1.0	0	0
P	Surveying	14/06/2020	11:24:10	-	8	3.635.952.949	-433.648.413	203.333	2.000	3.0	15	8	0.036	0.070	CAMINO	-	RTK Fixed	1.0	0	0
P	Surveying	14/06/2020	11:25:45	-	9	3.635.947.987	-433.647.475	203.306	2.000	3.0	17	8	0.036	0.070	PISCINA	-	RTK Fixed	1.0	0	0
P	Surveying	14/06/2020	11:25:48	-	10	3.635.947.923	-433.648.352	203.355	2.000	3.0	16	8	0.036	0.060	PISCINA	-	RTK Fixed	1.0	0	0
P	Surveying	14/06/2020	11:25:50	-	11	3.635.947.593	-433.648.991	203.351	2.000	3.0	17	8	0.036	0.060	PISCINA	-	RTK Fixed	1.0	0	0
P	Surveying	14/06/2020	11:25:51	-	12	3.635.947.008	-433.649.307	203.328	2.000	3.0	17	8	0.036	0.060	PISCINA	-	RTK Fixed	1.0	0	0
P	Surveying	14/06/2020	11:25:53	-	13	3.635.946.354	-433.649.155	203.301	2.000	3.0	16	8	0.036	0.060	PISCINA	-	RTK Fixed	1.0	0	0
P	Surveying	14/06/2020	11:25:54	-	14	3.635.945.803	-433.648.661	203.344	2.000	3.0	16	8	0.036	0.060	PISCINA	-	RTK Fixed	1.0	0	0
P	Surveying	14/06/2020	11:25:56	-	15	3.635.945.541	-433.647.866	203.297	2.000	3.0	17	8	0.036	0.060	PISCINA	-	RTK Fixed	1.0	0	0
P	Surveying	14/06/2020	11:25:57	-	16	3.635.945.450	-433.647.180	203.307	2.000	3.0	16	8	0.028	0.050	PISCINA	-	RTK Fixed	1.0	0	0
P	Surveying	14/06/2020	11:25:59	-	17	3.635.945.515	-433.646.502	203.322	2.000	3.0	16	8	0.028	0.050	PISCINA	-	RTK Fixed	1.0	0	0
P	Surveying	14/06/2020	11:26:00	-	18	3.635.945.527	-433.645.801	203.334	2.000	3.0	15	8	0.028	0.050	PISCINA	-	RTK Fixed	1.0	0	0
P	Surveying	14/06/2020	11:26:02	-	19	3.635.945.528	-433.645.017	203.315	2.000	3.0	15	8	0.028	0.050	PISCINA	-	RTK Fixed	1.0	0	0
P	Surveying	14/06/2020	11:26:03	-	20	3.635.945.766	-433.644.331	203.339	2.000	3.0	15	8	0.028	0.050	PISCINA	-	RTK Fixed	1.0	0	0
P	Surveying	14/06/2020	11:26:05	-	21	3.635.946.326	-433.643.896	203.325	2.000	3.0	15	8	0.028	0.050	PISCINA	-	RTK Fixed	1.0	0	0
P	Surveying	14/06/2020	11:26:06	-	22	3.635.946.933	-433.643.826	203.337	2.000	3.0	14	8	0.036	0.060	PISCINA	-	RTK Fixed	1.0	0	0
P	Surveying	14/06/2020	11:26:08	-	23	3.635.947.463	-433.644.140	203.313	2.000	3.0	15	8	0.036	0.060	PISCINA	-	RTK Fixed	1.0	0	0
P	Surveying	14/06/2020	11:26:10	-	24	3.635.947.818	-433.644.862	203.307	2.000	4.0	15	8	0.036	0.060	PISCINA	-	RTK Fixed	1.0	0	0
P	Surveying	14/06/2020	11:26:11	-	25	3.635.947.758	-433.645.542	203.308	2.000	3.0	16	8	0.036	0.060	PISCINA	-	RTK Fixed	1.0	0	0
P	Surveying	14/06/2020	11:26:13	-	26	3.635.947.641	-433.646.220	203.303	2.000	3.0	16	8	0.036	0.060	PISCINA	-	RTK Fixed	1.0	0	0
P	Surveying	14/06/2020	11:26:44	-	28	3.635.948.256	-433.649.435	203.310	2.000	3.0	17	8	0.028	0.050	XXX	-	RTK Fixed	1.0	0	0
P	Surveying	14/06/2020	11:30:15	-	29	3.635.951.311	-433.649.229	205.661	2.000	2.8	16	8	0.022	0.040	EPOCAS	-	RTK Fixed	1.0	10	0

Figure 155. GPS file example

Two files will be generated when exporting raw data, both with **.gps** extension:

- The first one with observation basic data (or the average of the observations if the point was taken using more than one epoch), for instance *"Example.gps"*.
- The other one is a detailed file with all observations of each point, for instance *"Example_Details.gps*".

Two types of lines exist in this format. Lines starting with **#** contains project information:

- **Projected SRC**: Projected reference coordinates system.
- **Geodesic T. Datums**: Transformation of geodesic datums.
- **Vertica SRC**: Vertical reference coordinates system.
- **Vertical T. Datums**: Transformation of vertical datums.
- **Local system**.
- **dX, dY, dZ**: Additional offsets applied to local system.

Lines starting with **P** or **B** contains information about the measured points:

- Base (**B**) or Point (**P**).
- Source.
- System date.
- System time.
- Name of the reference base. If "-" is shown, the base was configured in other working session. When working using NTRIP server, the name of the node is added.
- Point name.
- WGS84 Latitude.
- WGS84 Longitude.
- WGS84 Altitude.
- Antenna height. Offset is not included.
- PDOP.
- Number of used satellites.
- Position type identifier.
- Horizontal precision.
- Vertical precision.

- Point code.
- File where the point is stored.
- Position type description (Fixed, Floating, Autonomous, etcetera).
- HDOP.
- VDOP.

This format is compatible with **Aplitop**'s **TcpMDT** office **software**, so that the points are drawn automatically in CAD, being able to also consult all the raw data, as well as the linked images and voice notes. It also has numerous tools to create digital terrain models, generate contour lines, draw profiles, calculate volumes, etc. See https://www.aplitop.com/applications-topographic.

16.4 Stake out data export

When exporting stake out data, it is possible to choose the separator that the point file will have. The options are *Blank Space*, *Comma*, *Semicolon* and *Tabulation*.

Additionally, it is possible to add a prefix to point numbers, and as well, there is an option to export all the stake-out data, or only simple data, which only contain: Point number, X, Y, Z and Point Code.

It is also possible to export the stake-out data in the GSI format. If this format is chosen, you will not be able to choose a separator, or whether to export the full or simplified versions of the data.

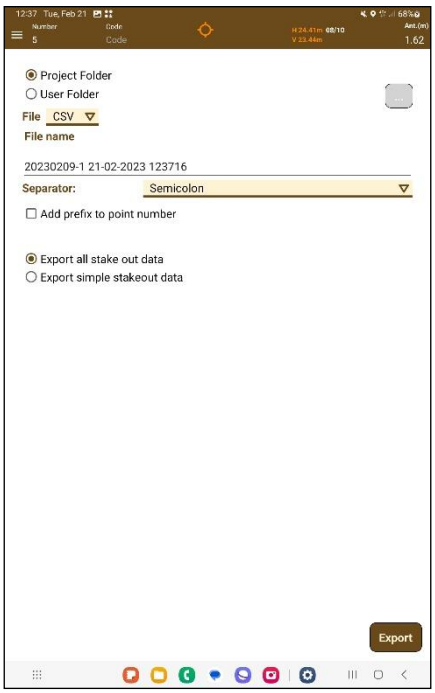


Figure 156. Stake out data export screen

16.5 Digital Model Export

If digital models have been generated in the project, they can be exported to a DXF format with 3D faces.

When choosing this option, a dialog will be shown which will ask for the name of the file that the export will create and the digital model to be exported, chosen from the list.

16.6 Log Export

This option exports the log files cyphered and compressed in a **.zip** file, so they can be sent or shared with Customer Support.

16.7 Working with Project Data

The file structure of the application projects is the following:

```
+ Device Internal Memory
     + Android
          + Data
               + com.aplitop.tcpgps
                    + projects
                         + Project_1
                              +img
                                   - index.txt
                              + snd
                                   - index.txt
```

The files *index.txt* found in folders **img** and **snd** containing images associated to points and voice notes respectively, they contain the relations between said images and voice notes and the points they are associated to, in such a way that each line appears the point number first and afterwards the name of the associated image or voice note.

It is important to keep in mind that the project files are only accessible from a laptop or desktop computer via USB cable, they are hidden from file explorer apps in Android devices.

16.7.1 Project Export

Once this option is pressed, the Android File Explorer (SAF) will open, and it will allow a **.zip** file containing the whole project folder, all its data, and layers. This **.zip** can be saved in the device's storage, as well as in Google Drive using the Android File Explorer.

16.7.2 Project Import

Once this option is pressed, the Android File Explorer (SAF) will open, and it will allow a **.zip** file that contains a project folder, all its data and layers. This **.zip** can be loaded from the device's storage as well as from Google Drive using the Android File Explorer.

To avoid data loss from the currently open project, it is not possible to import a project that it is open at the moment of importing.

If you try to import a pre-existing project, it is necessary to confirm that the projects want to be rewritten in the application.

16.8 Ntrip Server import

Once this option has been pressed, the Android File Explorer, SAF will open, and it is possible to select an .xml file that contains all of the information of multiple Ntrip servers. Useful if there's a need to import Ntrip servers to another device.

16.9 Export Format import

Once this option has been pressed, the Android File Explorer, SAF, will open, and it is possible to select an .xml file that contains all of the information of different export formats to use in the option to custom export formats. Useful if there's a need to import the custom formats to another device.

16.10 Share exported files

Every time an export task is made, the user will be notified that it has been done correctly, with a message, in which there is an option to share the item in this moment. The moment the share button is pressed, the Android Share screen will appear, so the files may be shared with Google Drive, and other apps, including mail managers, messaging, etc.

Figure 157. Export Confirm

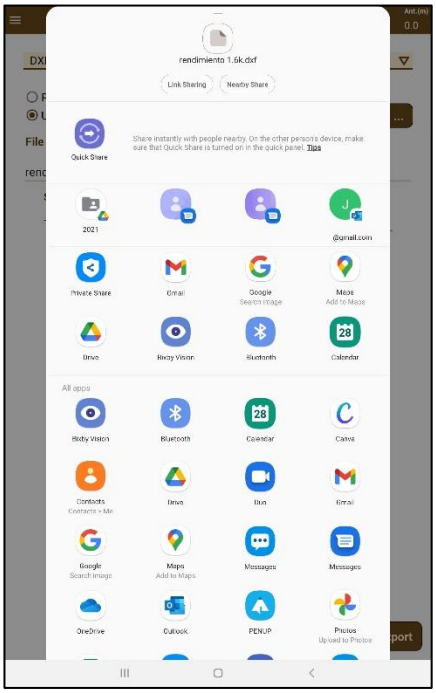


Figure 158. Share Window

16.11 Editing points list

Points gathered using TcpGPS are stored in the database associated with the project. The stored data can be viewed in the **List of points** in the **Edit** section (Figure 159).

16.11.1 Basic data

General information of the point as it was gathered, also considering the coordinate system used. Other information like whether the point has attached an image or a voice note is shown in that list in the form of icons.

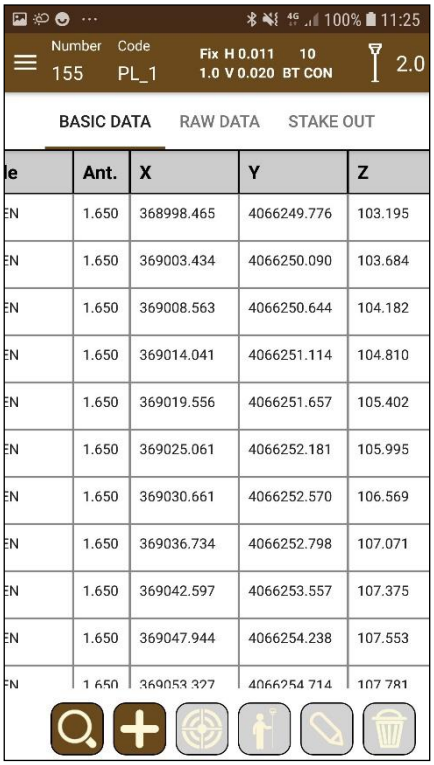


Figure 159. Basic data list

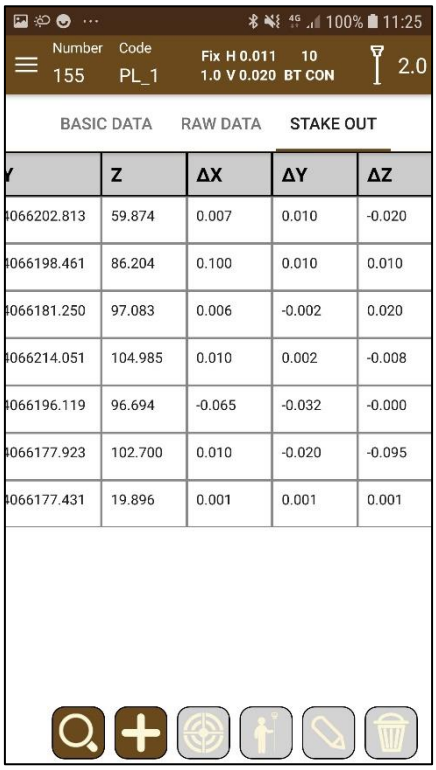
16.11.2 Raw data

Complete information of the point for later processing. Stored raw data fields are *date* and *time*, *source* from where the point was stored, *antenna height*, *latitude* and *longitude*, *height*, *position type*, *horizontal* and *vertical precisions, pdop, hdop, vdop* and *number of satellites*.

	Lon.	Alt.	Position Type
95729"	-4° 27' 45.52082"	133.558	RTK Fixed
85070"	-4° 27' 45.06762"	132.310	RTK Fixed
73700"	-4° 27' 44.58420"	133.260	RTK Fixed
63041"	-4° 27' 44.13099"	133.885	RTK Fixed
62382"	-4° 27' 43.67779"	128.384	RTK Fixed
55196"	-4° 27' 43.40255"	132.450	RTK Fixed
59980"	-4° 27' 43.40442"	128.837	RTK Fixed
64763"	-4° 27' 43.40629"	132.058	RTK Fixed
4128"	-4° 27' 43.40845"	133.003	RTK Fixed
79652"	-4° 27' 43.62504"	132.687	RTK Fixed
85088"	-4° 27' 43.85643"	131.087	RTK Fixed

Figure 160. Raw data list

16.11.3 Staking out data



Y	Z	ΔX	ΔY	ΔZ
4066202.813	59.874	0.007	0.010	-0.020
4066198.461	86.204	0.100	0.010	0.010
4066181.250	97.083	0.006	-0.002	0.020
4066214.051	104.985	0.010	0.002	-0.008
4066196.119	96.694	-0.065	-0.032	-0.000
4066177.923	102.700	0.010	-0.020	-0.095
4066177.431	19.896	0.001	0.001	0.001

Figure 161. Stake out data list

Information for points that have been staked out. In this list are shown the differences between the point measured originally and the point got in the staking out process. The last staking-out performed on a point is only shown if it has been done several times.

16.11.4 Options

On these lists, you can search for specific points by their number or by their code, options are available in the button  .

It is also possible to select a point from any list and select from a range actions to perform on it:

	This takes the user to the surveying section by centering the view on the selected point.
	This takes the user to the staking out section with the selected point ready to start the operation.
	This takes the user to the **Details of the point** section, from where information about the point can be viewed.
	Allow the user to add a point by typing its geographic or projected coordinates.
	Allow to remove the selected point.

16.11.5 Point Details

This provides detailed information about the point, not only with respect to its numerical data, but also making it possible to associated multimedia information such as photos and voice notes with it. Said photos will save the raw data of Latitude and Logitud from the point in the image's Exif header. Additionally, it is also possible to edit the user data defined by the layer associated to the code of the point (see Error! R eference source not found.).

TCPGps allows multiple images to be associated with a point.

Figure 162. Basic point information

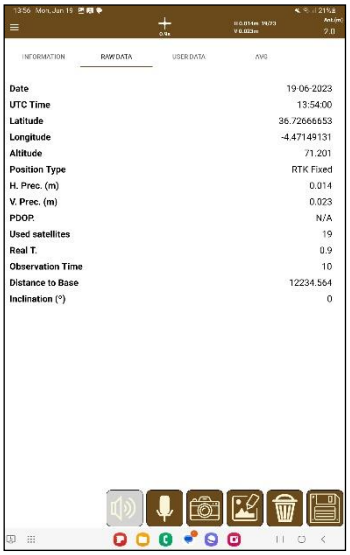


Figure 163. Raw point data

Figure 164. Information and multimedia data associated with the point

16.11.6 Point Image Editing

Pressing the  button or performing a long press on the image will open the point image edit screen. The image will be shown alongside several controls to perform the point image editing:

- **Annotations**  **:** Opens a dialog to be able to add point information to the image. The information is:
  - **Date & Time**
  - **Coordinates X, Y**
  - **Coordinate Z**
  - **Code**
  - **Comment**
  - **User Attributes 1, 2, 3 & 4**

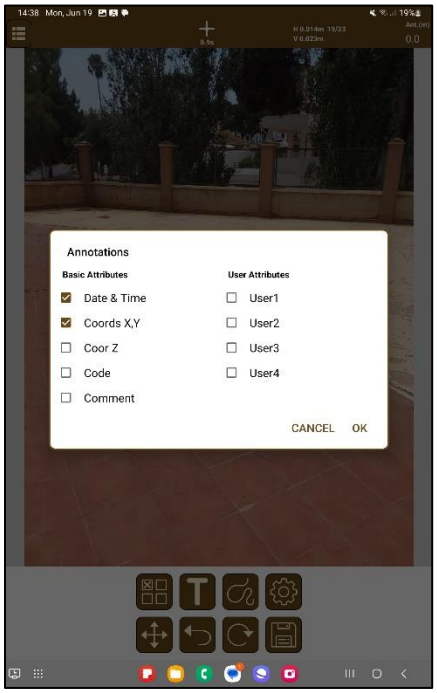


Figure 165. Annotation Selection

Figure 166. Annotations in Image

- **Text**  **:** After pressing the button, a new dialog will open where it's possible to write the text to add to the image. Once the text has been written, once the image is pressed, the text will be located where the image had been touched, aligned left to right.

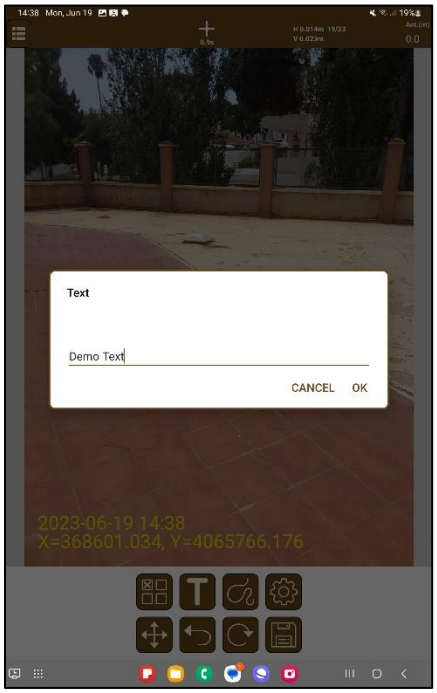


Figure 167. Text to add in image

Figure 168. Text added in image

- **Brush**  **:** Alows to freely draw in the image using the touchscreen.

Figure 169. Drawing on the image

- **Configuration**  **:** Allows modifying of the color and size, of both the text and the brush tool. In the next figure is shown the default configuration.

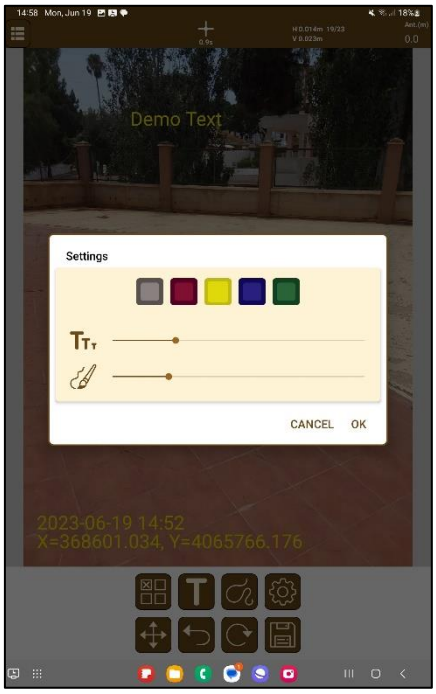


Figure 170. Drawing Configuration

- **Move**  **:** Moves the last element drawn in the image.
- **Undo**  **:** Undoes the last element drawn in the image.
- **Restart**  **:** Erases all the graphical element in the image.
- **Save**  **:** Saves all graphical changes done upon the image.

16.11.7 Details of the polylines

Like point features, polylines and polygons created in the survey may also have user data associated with it depending on the layer their code is associated with.

Appendix A. Transformations

In local systems you can define four types of transformations: **2D / 3D translations and 2D / 3D Helmert**. Below is the mathematical development of each of these transformations.

2D Displacements

Calculate the displacements x and y through the Arithmetic average of the differences between the origin and the destination. Only a couple of points are necessary.

Formulas:

$$x' = x + T_x$$

$$y' = y + T_y$$

where:

x ', y' = x, y transformed coordinates.

x, y = Original x, y coordinates.

Tx = Translation x.

Ty = Translation y.

Helmert 2D

It is also known as ***a 4-parameter similarity transformation***. The transformation process includes 3 steps: scaling, rotation and translations.

The first two are defined by a parameter each and the translations include 2. At least two pairs of points are necessary.

Formulas:

$$x' = (S \cdot \cos\theta) \cdot x + (S \cdot \sin\theta) \cdot y + T_x$$

$$y' = -(S \cdot \sin\theta) \cdot x + (S \cdot \cos\theta) \cdot y + T_y$$

where:

x ', y' = x, y transformed coordinates.

x, y = Original x, y coordinates.

S = Scale.

Θ = Angle of rotation.

Tx = Translation x.

Ty = Translation y.

3D Displacements

This type of transformation calculates the displacements x, y, z through the Arithmetic mean of the differences between the origin and the destination. Only a couple of points are necessary.

Formulas:

$$x' = x + T_x$$

$$y' = y + T_y$$

$$z' = z + T_z$$

where:

x ', y', z ' = x, y, z transformed coordinates.

x, y, z = Original x, y, z coordinates.

Tx = Translation x.

Ty = Translation y.

Tz = Translation z.

Helmert 3D

It is also known as ***the 7-parameter transformation***. The parameters involved are: three rotations, three translations and a scale factor. The rotation matrix is constructed by three consecutive turns around the x, y, z horizontal alignment. It is necessary to have at least 3 pairs of points.

Formulas:

$$x' = S \cdot (m_{11} \cdot x + m_{12} \cdot y + m_{13} \cdot z) + T_x$$

$$y' = S \cdot (m_{21} \cdot x + m_{22} \cdot y + m_{23} \cdot z) + T_y$$

$$z' = S \cdot (m_{31} \cdot x + m_{32} \cdot y + m_{33} \cdot z) + T_z$$

where:

x ', y', z ' = x, y, z transformed coordinates.

x, y, z = Original x, y, z coordinates.

S = Scale.

Tx = Translation x.

Ty = Translation y.

Tz = Translation z.

m11 ... m33= Coefficients of the rotation matrix.

Glossary

Datum Concept that describes the relations of position, orientation and scale of the ellipsoid reference with the Earth.

DGPS. Differential GPS code.

Ellipsoid Three-dimensional object generated by the rotation of an ellipse around the polar horizontal alignment of the Earth.

Epoch. Time at which a measurement is made by the receiver.

Geoid. Surface with a constant gravitational force.

GNSS Global Navigation Satellite System.

NMEA. Standard protocol for transmitting data from the GPS receiver to a computer (National Marine Electronics Associations).

NTRIP Networked Transport of RTCM via Internet Protocol.

RTK. Real-time kinematics.

SRC. Coordinates' reference system

URL Uniform Resource Locator.

WMS Web Map Service (Web Map Service).

WMTS Web Map Tile Service (Web Map Service).