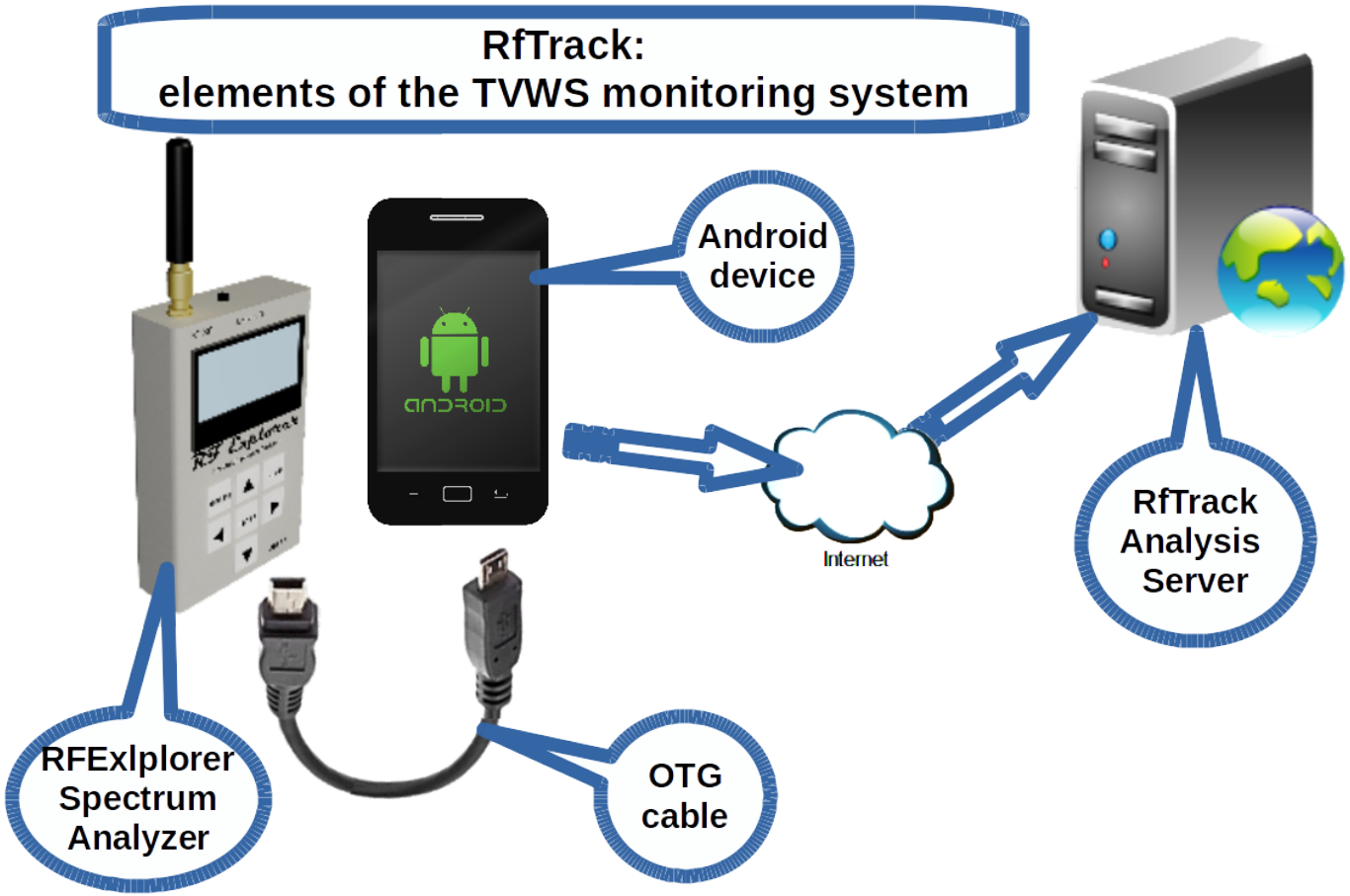
RfTrack, TVWS Monitoring System

User's manual

RTfTrack is a monitoring system for the TVWS frequencies, composed of these main elements:

- RFExplorer, a low cost spectrum analyzer.
- An Android device (tablet or smartphone) equipped with GPS running RfTrack, the app for logging management. Must be connected through an OTG cable to the RFExplorer.
- The Analysis Server, accessible via Web: receives data from measurement campaigns sent from the app, analyzes the data and generates spectrum measurements reports.



Monitoring system requirements

Before installing the RfTrack application on your Android device, you must verify that the Android unit meets certain requirements.

Features of the Android Unit

The Android USB Host Mode

USB On-The-Go (USB OTG or OTG) is a specification first used in late 2001 that allows USB devices (such as mobile phones) to act as a 'host':

1. The 'host', or master device, sets up communications with the slave device (the RFExplorer, in this case).
2. The software on the host enables the operations needed for data handling
3. The host is responsible for all data transfers on the USB bus

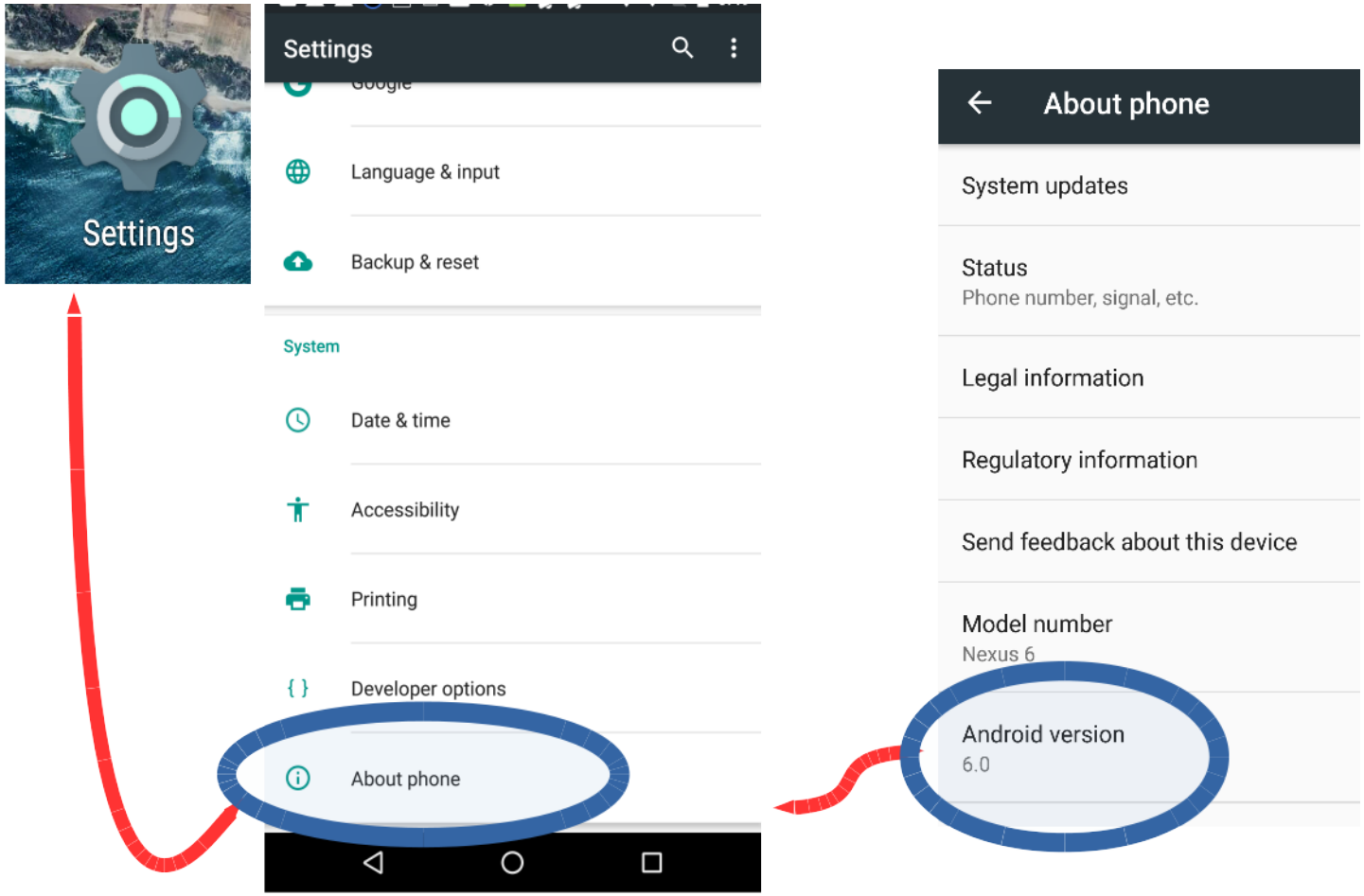
To connect the RFExplorer to your Android, these requirements must be satisfied:

1. **Use a USB OTG (USB On-The-Go) cable to connect the Android to the RFExplorer**. This cable costs a few Euros. It can be found in computer or phones stores, or on eBay, for example. It has a mini USB connector on one end, to connect to the RFExplorer and a micro USB type B connector to connect your Android device at the other end. You can also join two cables with the proper connectors to achieve the same goal.
2. **The unit must have built-in the hardware support for the "USB Host Mode"** The host mode might not be supported at the hardware level, for istance by constraints imposed by the hardware design.
3. **The Operating System must support the USB Host Mode.** USB Host Mode support was introduced in Android version 3.1 (Honeycomb), so if you have Android 3.1 or newer installed, you should have the necessary support for it in your OS.
4. **Software Drivers**: the system must have installed the USB Host Mode drivers and the drivers for the USB device that is plugged in.


Mini Usb Connector To RFExplorer
OTG CABLE
Micro Usb Connector Type B to the Android Unit

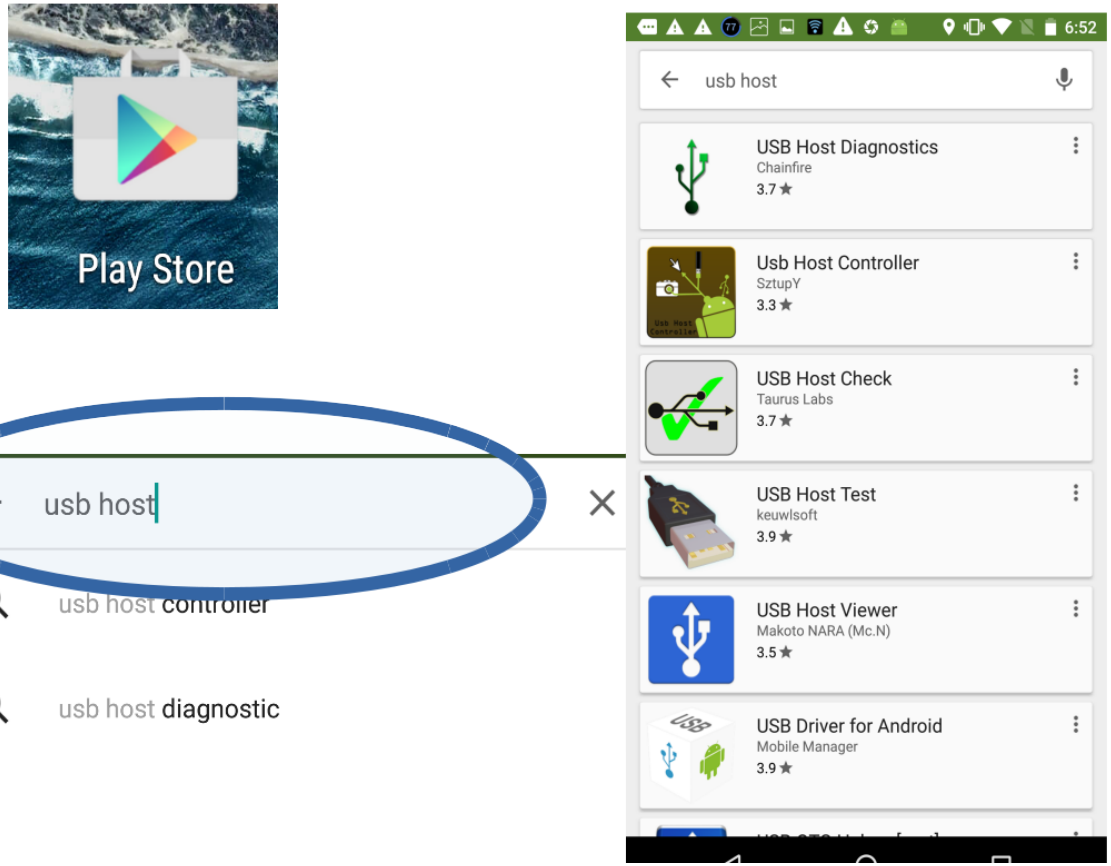
How to verify the Android version installed in your system

1. Select "**Settings**"
2. Choose the last menu item, "**About Phone**"
3. In the "**About phone**" entry, find the "**Android Version**" field. This example shows that Android 6 (Marshmallow) is installed.



How to verify that the Android device supports“USB host mode”

1. Launch the “Play Store” app
2. Search for “**usb host**”
3. Several applications will result that can determines if your device has USB host capabilities.
4. Install one of these applications to verify the usb host capability of your device.



Install the RfTrack application

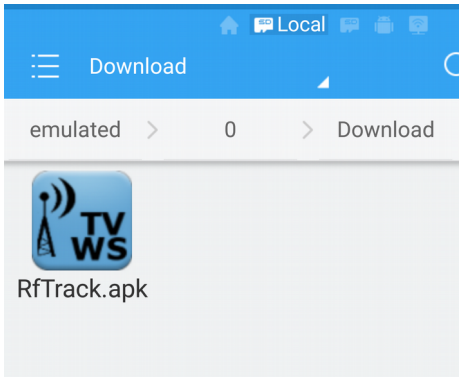
Just like any Android application, RTfTrack can be installed in several ways:

- The apk file can be obtained from Internet (received by email or downloaded from GitHub) and then executed.
- Search the Google Play Store for RFTrack, download and install.

Install RfTrack using the APK downloaded from Internet

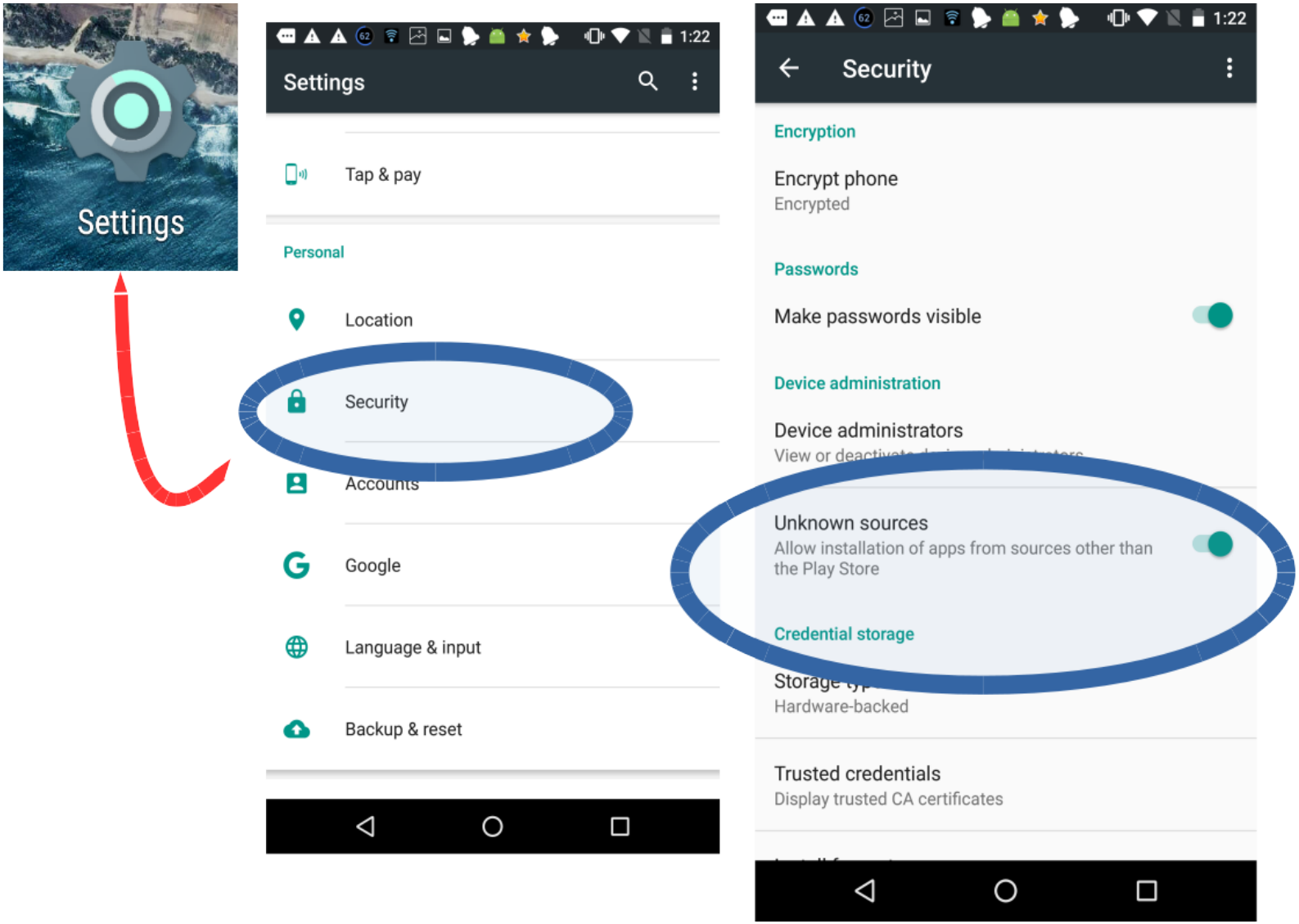
By default, Android saves the files downloaded in the Download folder.

To install the application, "tap" on the APK file.



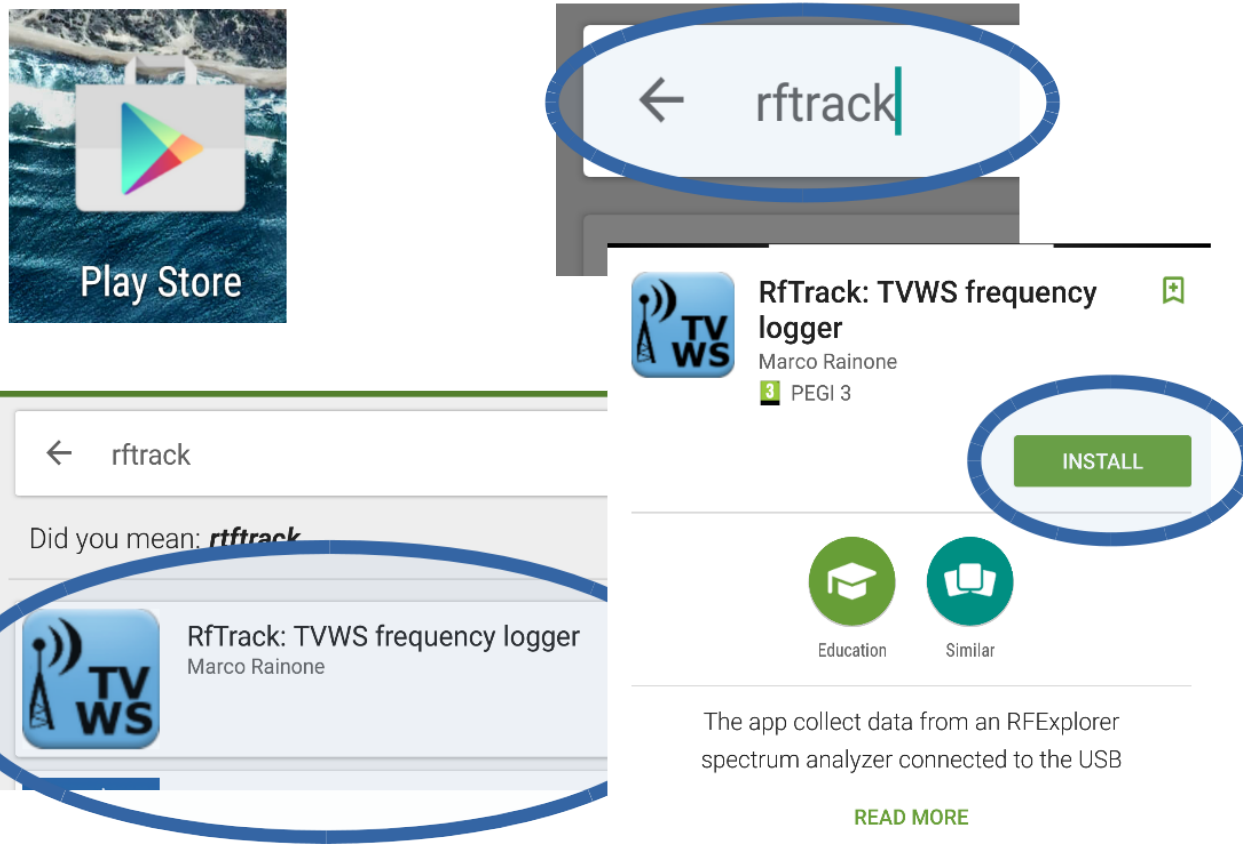
If Android warns that RfTrack cannot be installed for security reasons, you must go to Settings and enable **installation from unknown sources**.

1. Tap on **Settings**
2. Select **Security**
3. Switch ON the "**Unknown sources**" installation flag.


Settings
1:22
Settings
Tap & pay
Personal
Location
Security
Accounts
Google
Language & input
Backup & reset
1:22
Security
Encryption
Encrypt phone
Encrypted
Passwords
Make passwords visible
Device administration
Device administrators
Unknown sources
Allow installation of apps from sources other than the Play Store
Credential storage
Hardware-backed
Trusted credentials
Display trusted CA certificates

Install RfTrack from Google Play Store

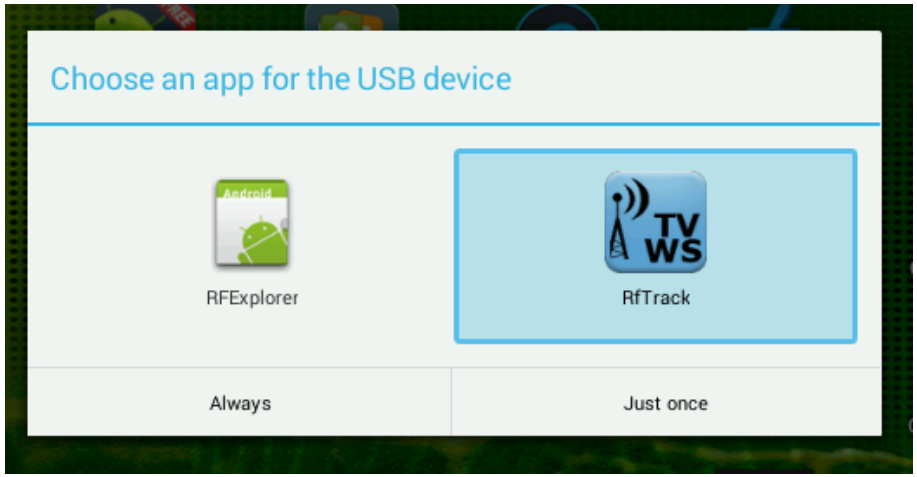
1. Tap on “**Play Store**”
2. Search the word “**rftrack**”
3. Select the application proposed: “**RfTrack: TVWS frequency logger**”
4. Tap on “**Install**”



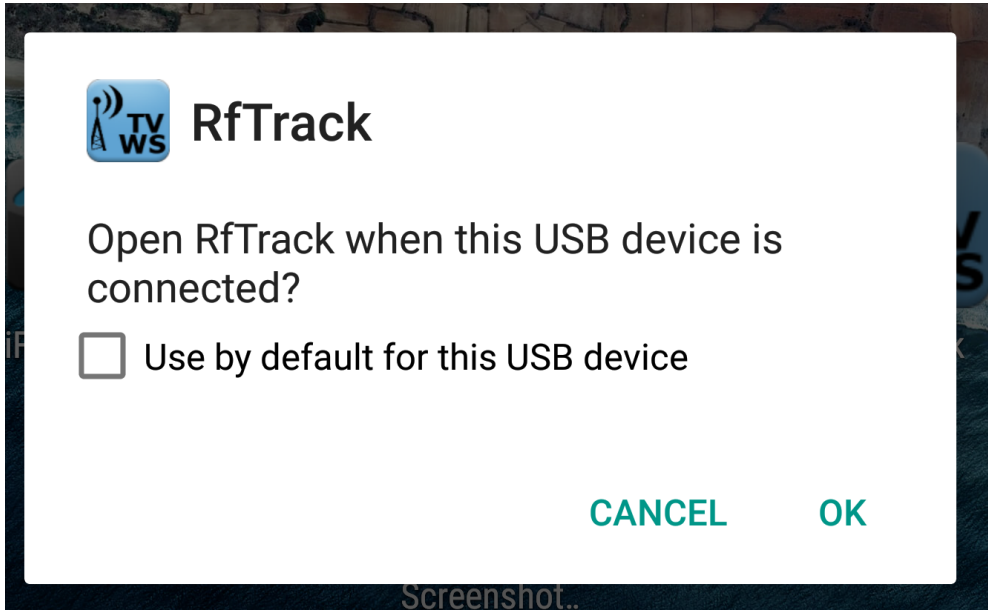
Run RfTrack

The execution of the RfTrack application takes advantage of a useful feature in Android, enabled if "**USB host mode**" is active:

as soon as you plug in a new device on USB port using an OTG cable, the operating system displays a dialog offering a list of applications that might be able to handle that unit.



In this example, Android shows the list of installed applications that can be chosen to handle communication with the RFExplorer.



In this example, connecting RFExplorer using the OTG cable, Android proposes the launch of RfTrack.

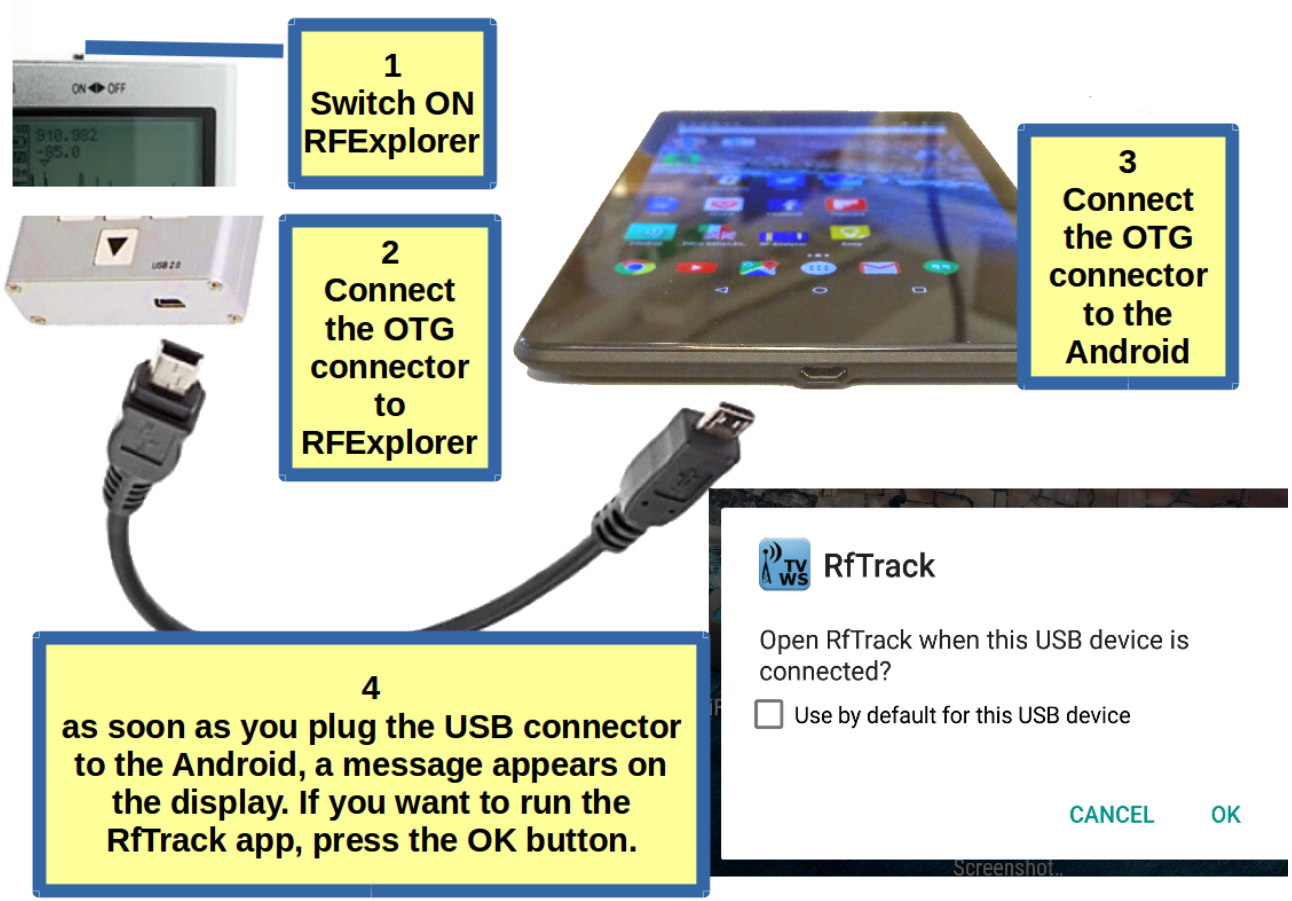
Press OK to execute the application.

Even if ithe spectrum analyzer is not connected, RfTrack can be launched in a classical way as any other Android application.

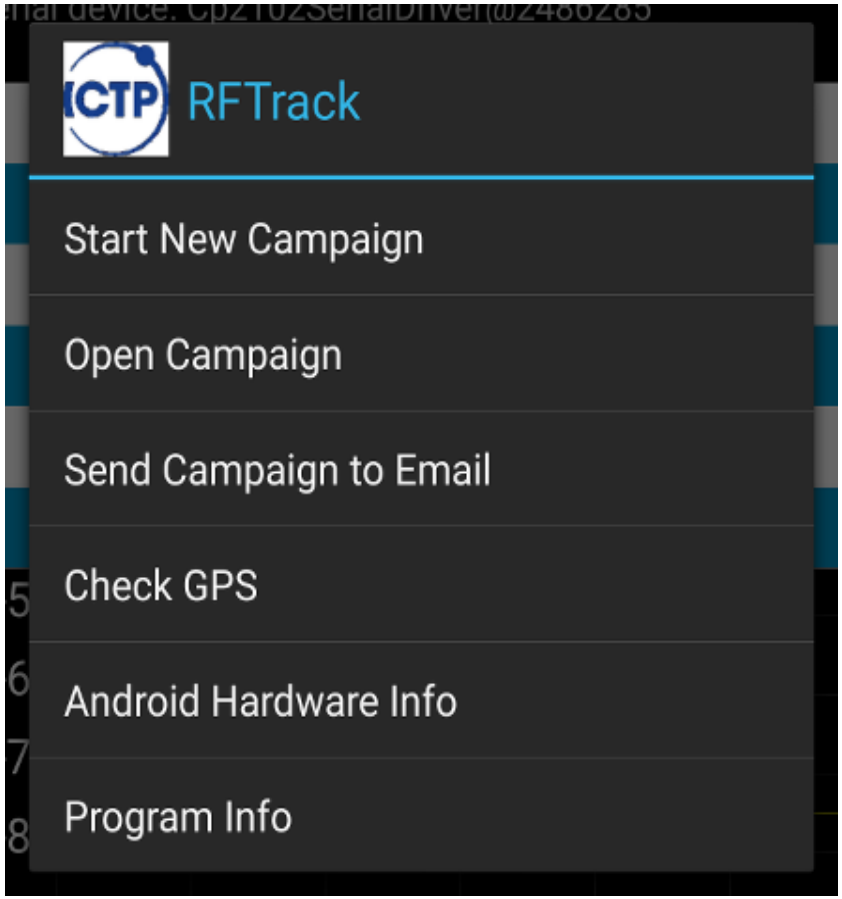
In this case, all the features associated with the real time data acquisition are automatically disabled (they require the presence of the RFExplorer), but you can still do data maintenance, for example send previously recorded measurement campaigns to the remote analysis server.

Steps to run RfTrack automatically

1. It is recommended to turn on the spectrum analyzer before connecting it to the Android, sliding the microswitch placed near the antenna jack to the ON position. This will avoid increased discharge of your smartphone's battery by additionally powering the RFExplorer.
2. Connect the mini USB connector of the OTG cable to the RFExplorer
3. Connect the micro USB type B connector of the OTG cable to the Android unit
4. If “**USB host mode support**” works in your Android System, the message: “**Open RfTrack when this USB device is connected ?**” will show. Press OK to accept.



RfTrack Main Menu



Begin choosing the option **Start New Campaign** or alternatively **Open Campaign**, if you wish to add data to an existing campaign.

- All the data collected in a campaign are saved in a specific SqLite database
- The name of the database created is the name of the campaign provided by the user
- The database is stored in the local memory of the Android device: either the internal user memory or the Secure Digital card if present.

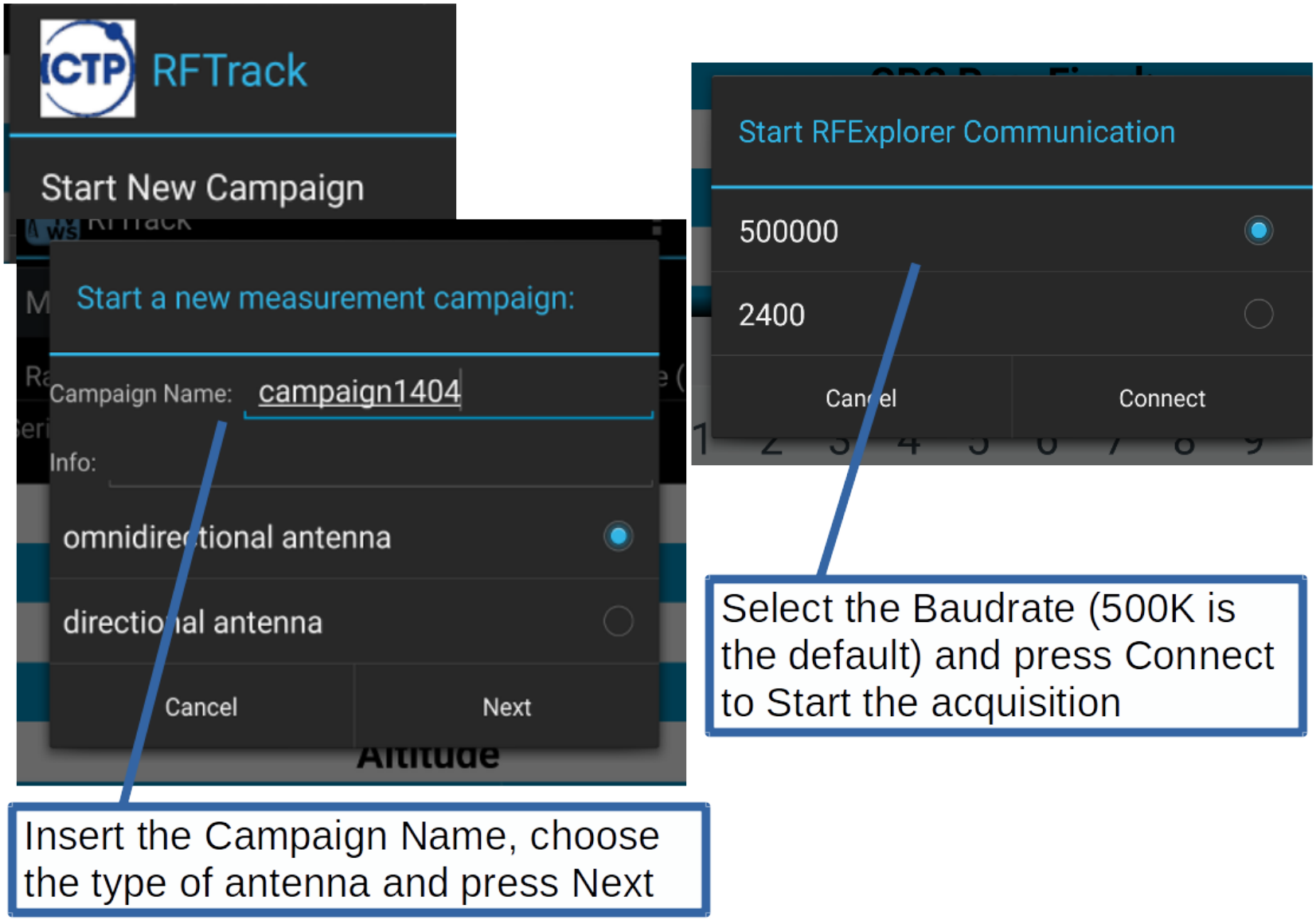
To permit the geolocation of the acquired measurements from the RFExplorer spectrum analyzer, RfTrack saves the data provided by the built in GPS in the database:

- Latitude and Longitude, Altitude (in meters above the sea level), speed (in meters / second), Accuracy (estimate of the GPS position reliability), time provided by the GPS, etc.

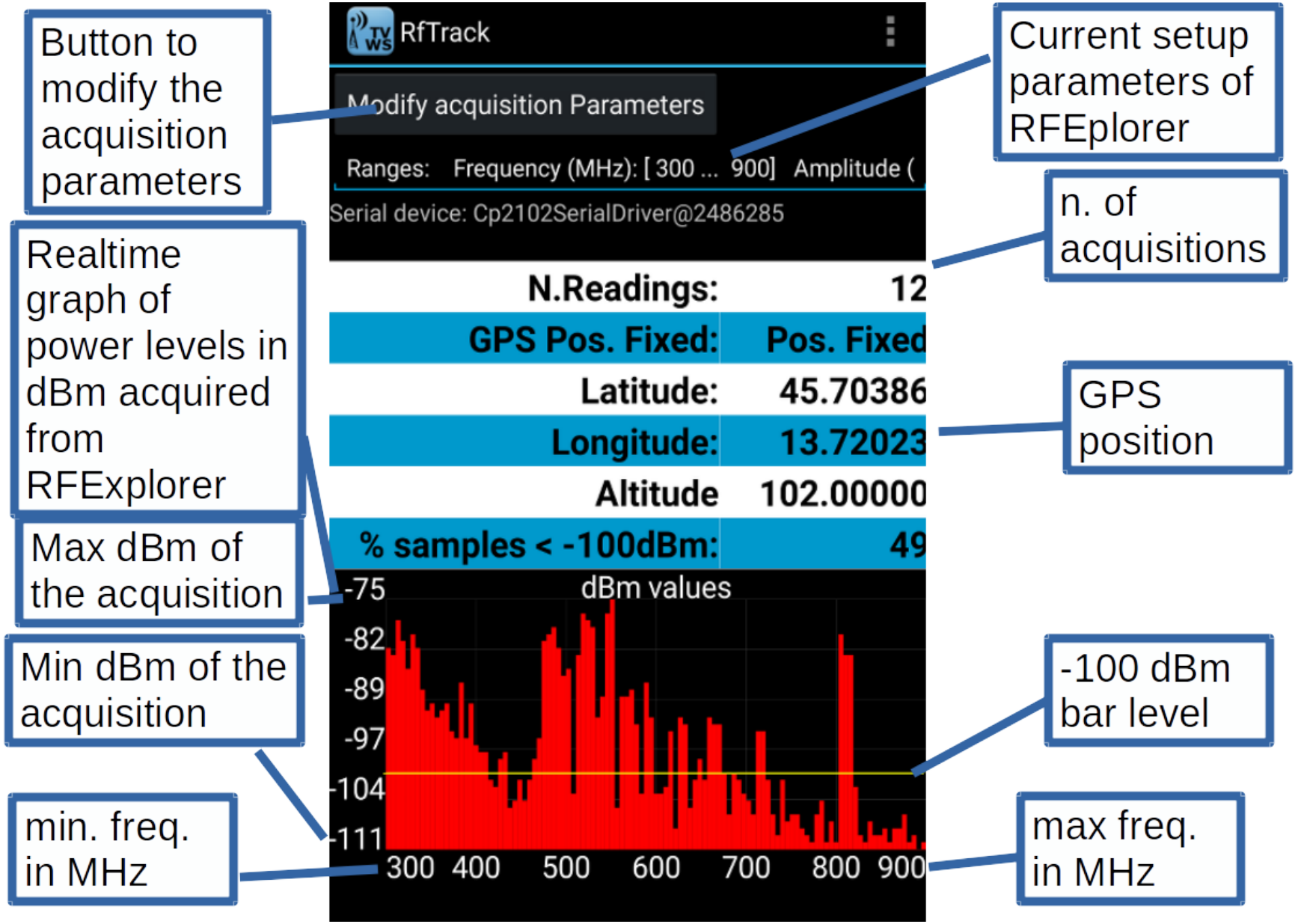
The Rftrack program can be used even if your device does not have a GPS.

In this case, the user can manually enter longitude, latitude and height above ground level before proceeding to the measurement campaign.

Start New Campaign

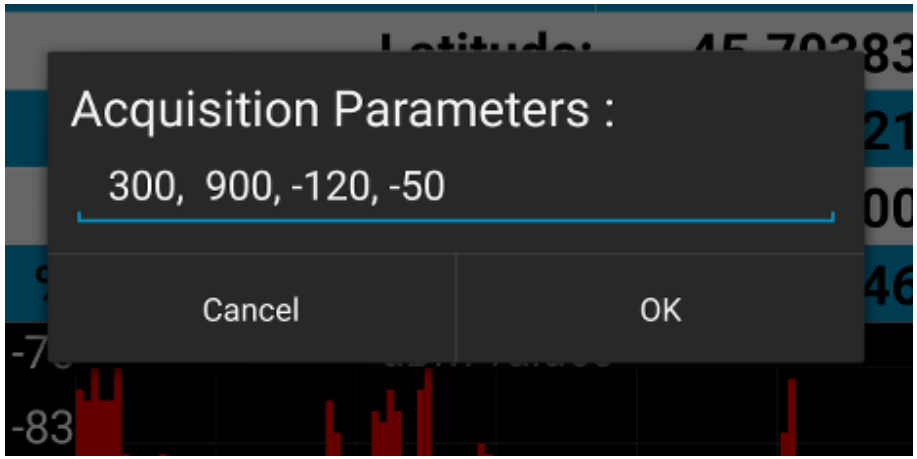


The data acquisition display



Modify the acquisition parameters

Pressing the “Modify acquisition Parameters” button, the user can modify the configuration parameters previously sent to RFExplorer and restart the measurement campaign.

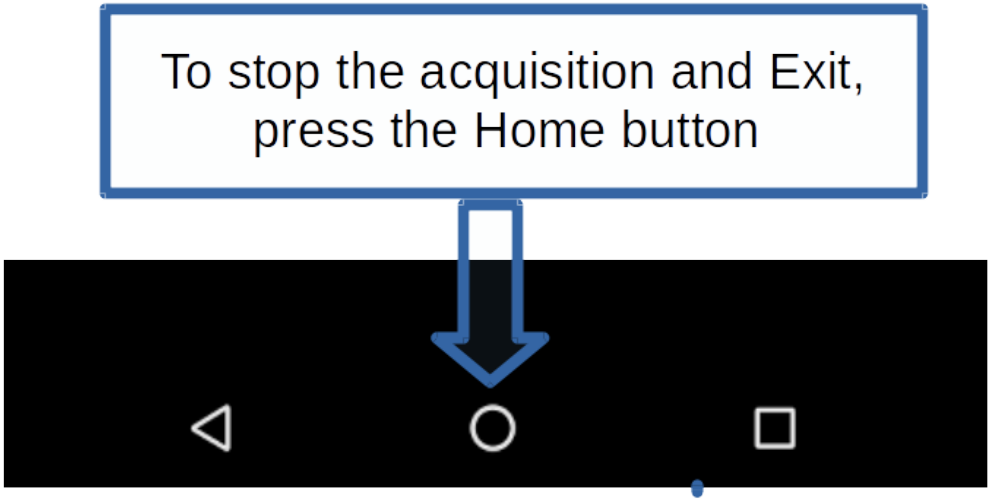


N.	Parameter	Example
1	RFExplorer Frequency Setting, lower limit in MHz	300
2	RFExplorer Frequency Setting, upper limit in MHz	900
3	RFExplorer dBm Setting, lower limit	-120
4	RFExplorer dBm Setting, upper limit	-50

These parameters have limits that depend on the RFExplorer model type.

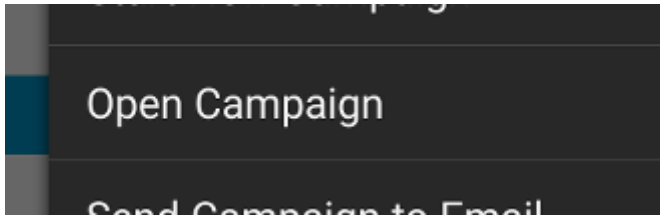
To find these limits, see the documentation provided with your spectrum analyzer.

Stop the data acquisition and Exit

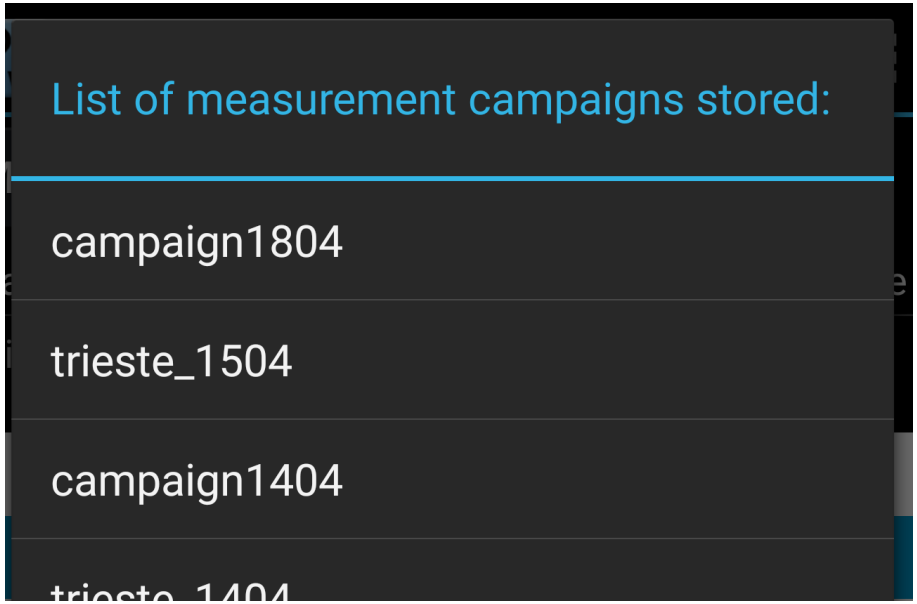


Open a previous campaign and continue the acquisition

In Main menu, press **Open Campaign**

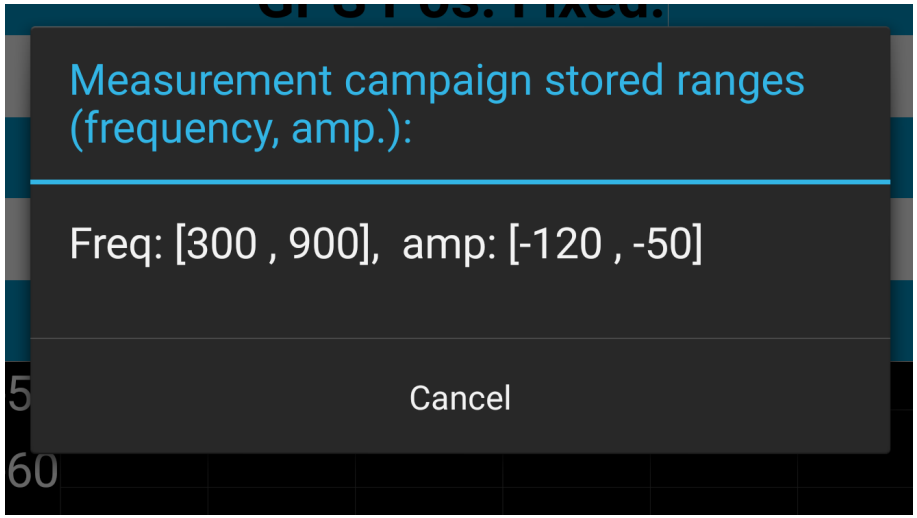


RFTrack shows a list with the names of the measurement campaigns currently stored.

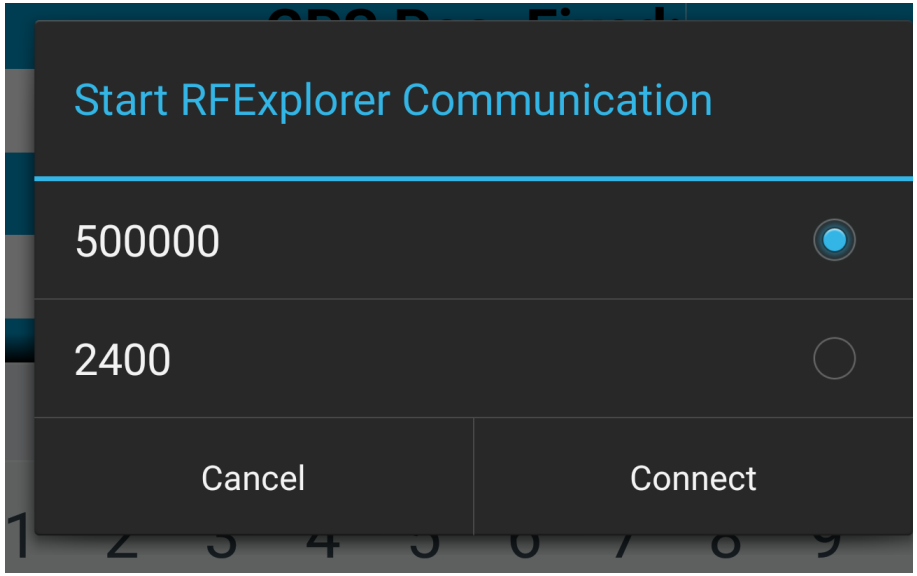


To select the campaign, click on its name.

During the previous measurements the instrument configuration parameters might have changed. A list of parameters that the user can choose before proceeding with new acquisitions is shown



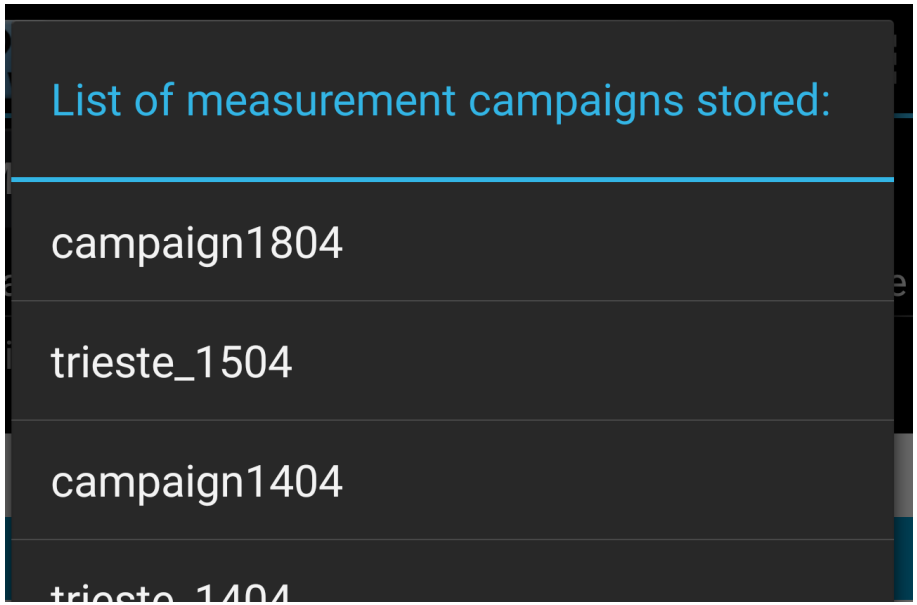
Select the Baud Rate and start the acquisition.



Sending data to the Analysis Server

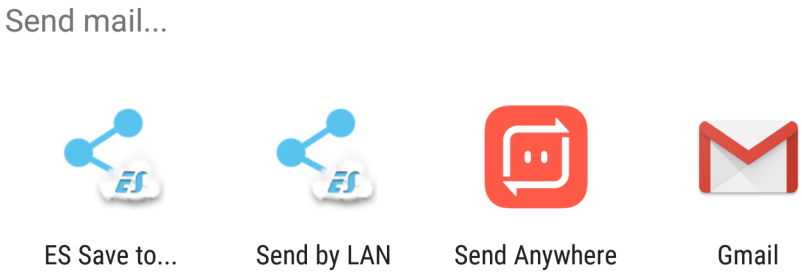
In main menu press Send Campaign to Email

RFTrack shows a list with the names of the measurement campaigns currently stored.



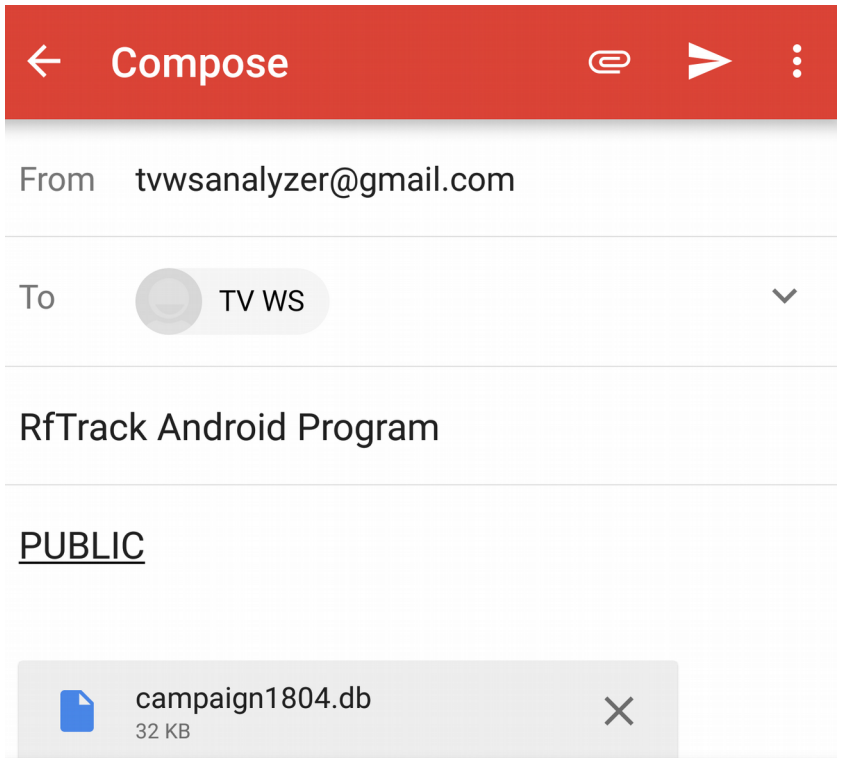
To select a campaign, click on its name.

A list of programs that can be used for sending data is presented

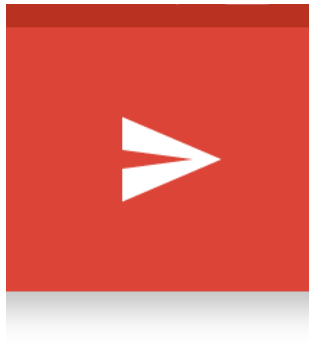


Pressing **Gmail**, the precompiled form for sending the mail is offered.

The database with the measurements will be sent as an attachment.

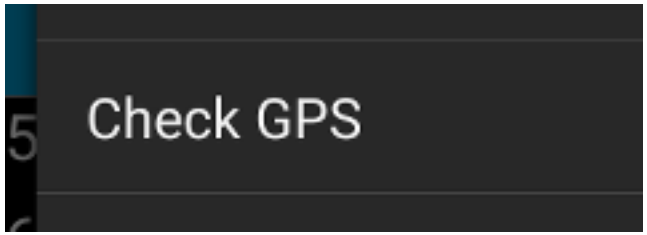


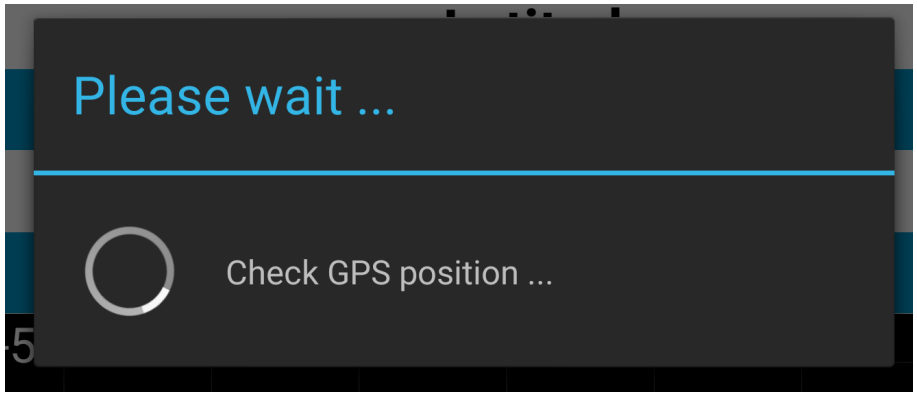
To send data, press the following icon (on top bar, upper right).



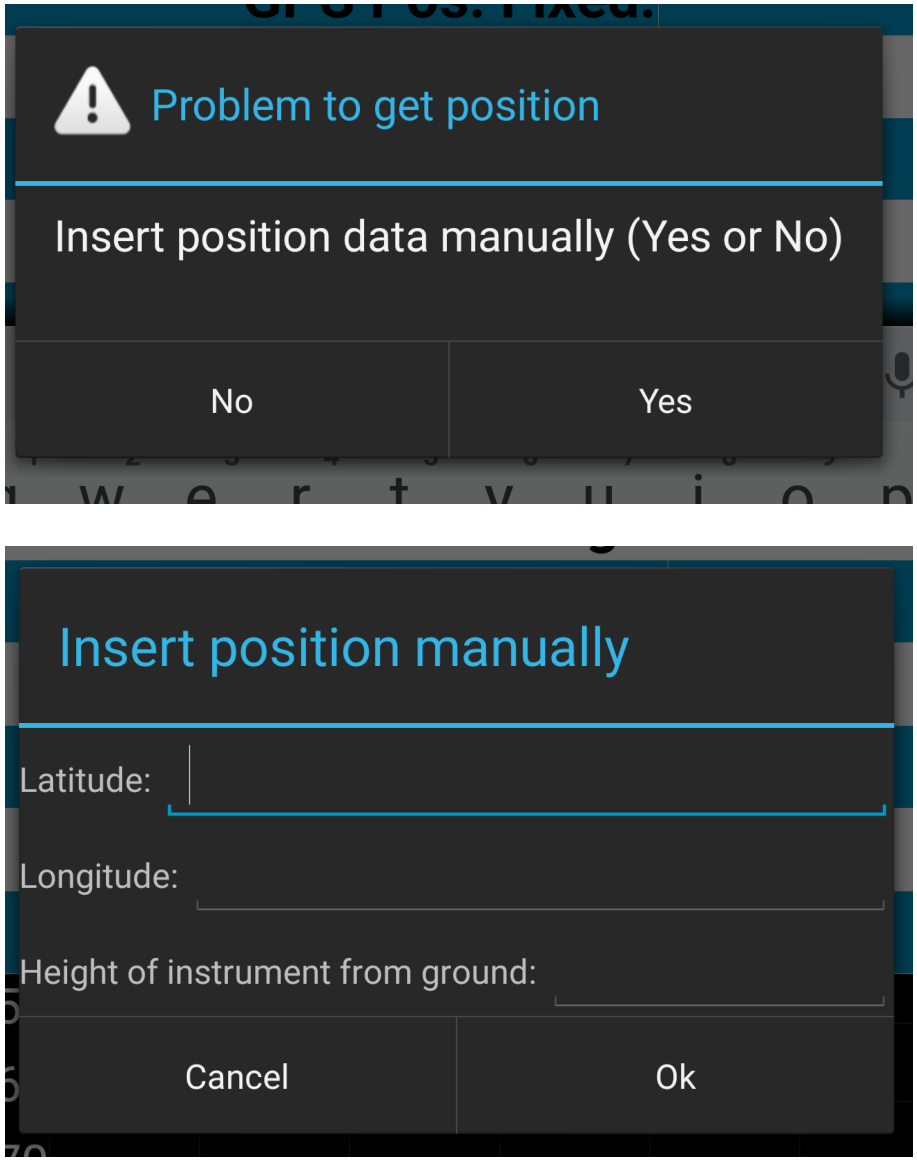
Check GPS

Pressing “Check GPS” on main menu, causes the program to check if the GPS is currently able to provide the correct position.



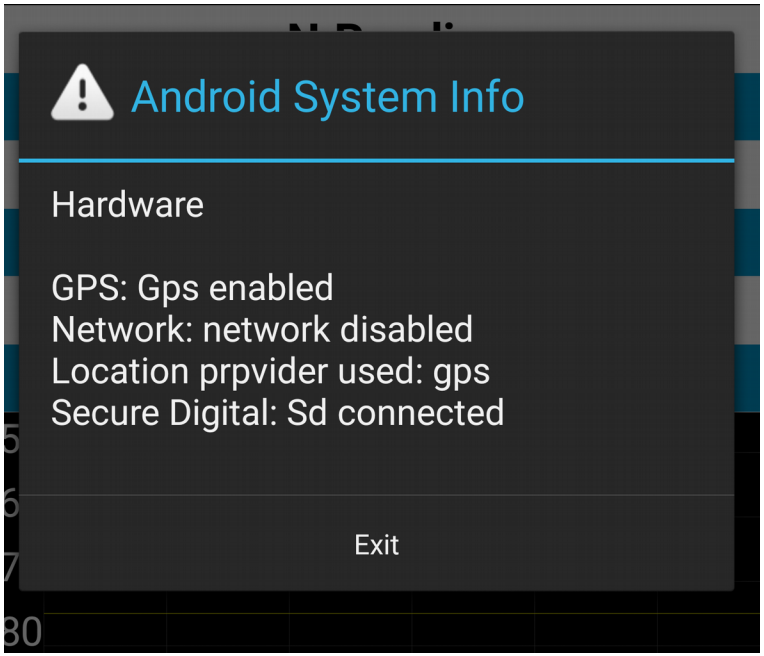


If the check fails (for example, the GPS is disabled), the program proposes the manual insertion of the position by the user.

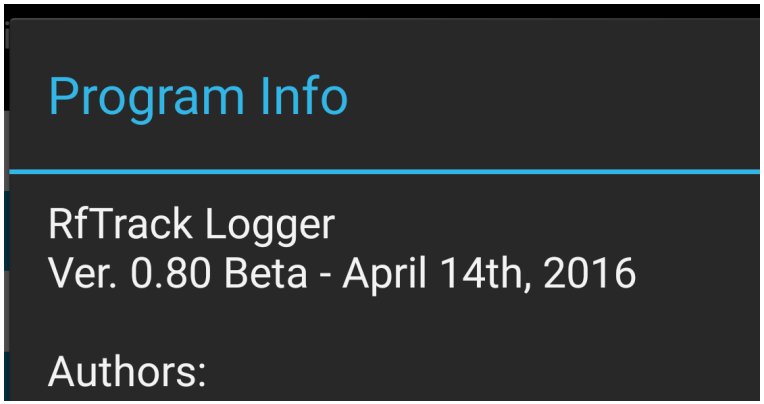


Android Device Info

The program checks the hardware and shows a report.



Program Info

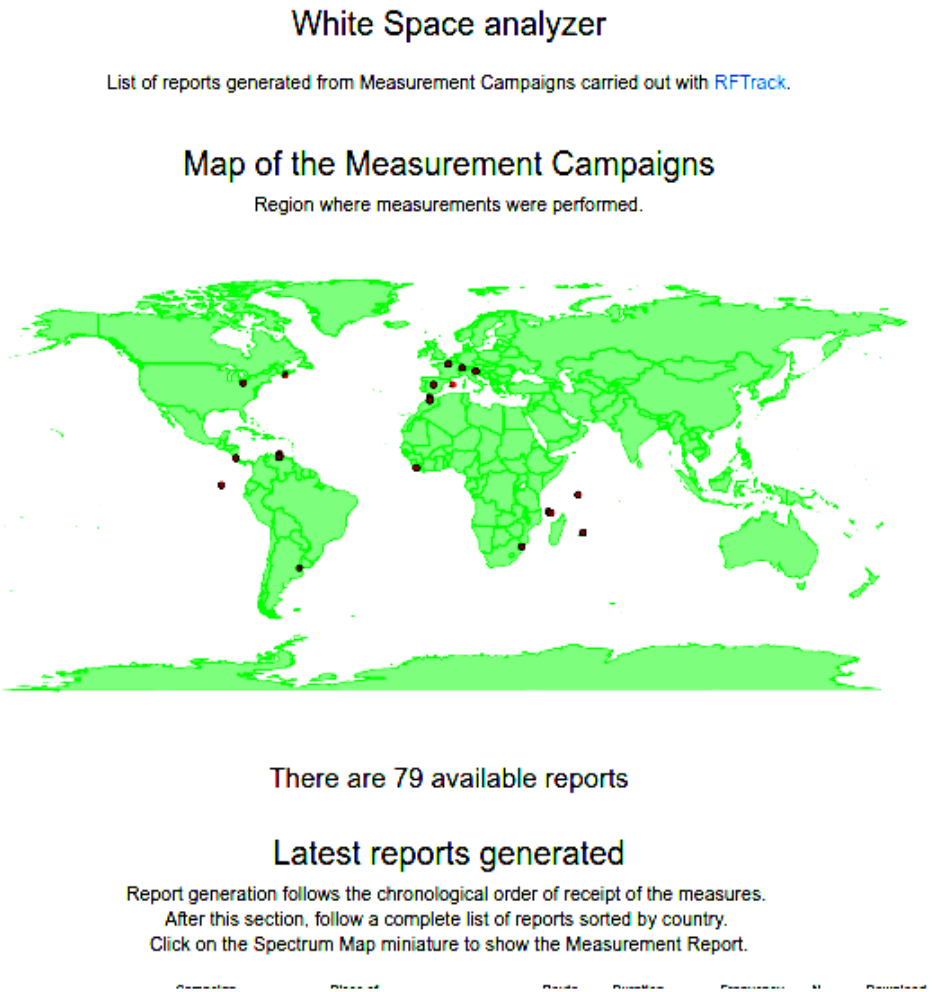


The Analysis Server

The remote server processes the info in the database and builds a report.

The reports is available at this web address:

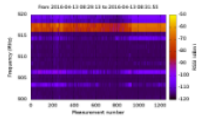
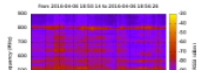
http://wireless.ictp.it/tvws/



Scrolling the page shows a list of latest reports generated.

Latest reports generated

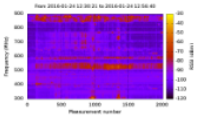
Report generation follows the chronological order of receipt of the measures.
After this section, follow a complete list of reports sorted by country.
Click on the Spectrum Map miniature to show the Measurement Report.

Report Html	Report Pdf	Campaign date	Country	Place of measurement	Region	Route length	Duration (hh:mm:ss)	Frequency range	N. points	Download Page
	PDF	2016-04-13	United States	Downtown	Ohio	0.2 Km	0:02:42	900..920 MHz	1256	
	PDF	2016-04-06	Italy	Gorizia	Friuli Venezia	3.3 Km	0:06:12	300..900	477	

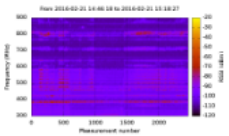
Then comes a section of reports sorted by countries in alphabetically order.

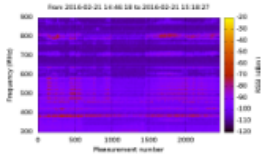
Reports sorted by country

Argentina

Report Html	Report Pdf	Campaign date	Place of measurement	Region	Route length	Duration (hh:mm:ss)	Frequency range	N. points	Download Page
	PDF	2016-01-24	Ezeiza	Buenos Aires	41.4 Km	0:26:19	300..900 MHz	2019	

Each line of the page shows the identification information of the report.

Report Html	Report Pdf	Campaign date	Place of measurement	Region	Route length	Duration (hh:mm:ss)	Frequency range	N. points	Download Page
		2016-02-21	Paris 12 Ancien - Quartier Saint-JacquesP	FR.11	5.2 Km	0:32:09	300..900 MHz	2463	

	Thumbnail for heatmap shown in the report. Click to open the report html page.
	Icon to open the report in PDF format
Campaign date / Place of measurement / Region / Route length / Duration (hh:mm:ss) / Frequency range / N. points 2016-02-21 / Paris 12 Ancien - Quartier Saint-JacquesP / FR.11 / 5.2 Km / 0:32:09 / 300..900 MHz / 2463	Identifying information regarding the measurement campaign.
	Icon to open the page containing additional material of the respective measurement campaign.

The html report

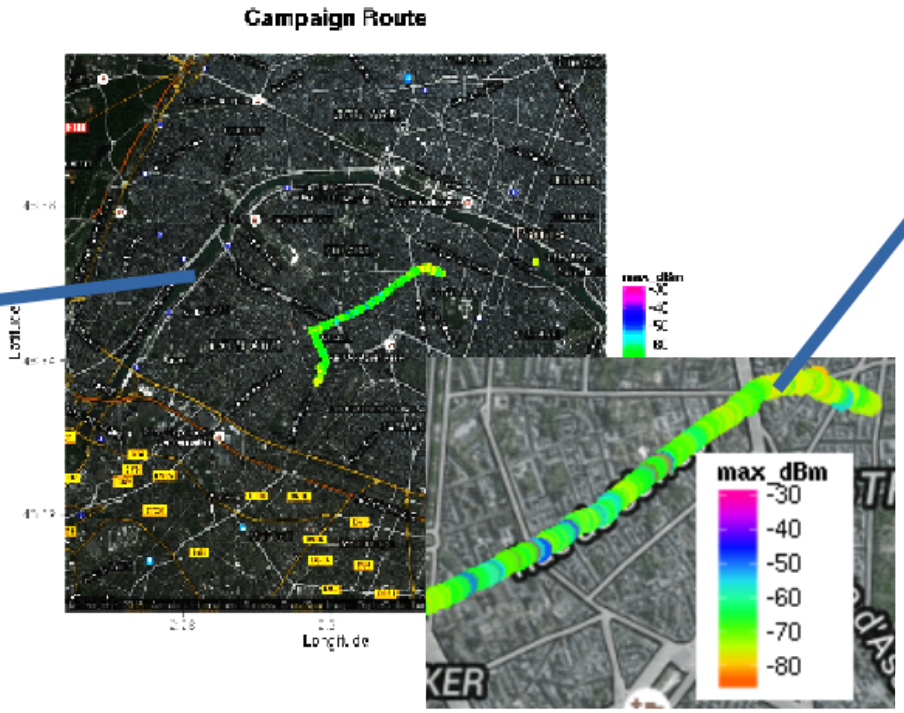
White Space analyzer

Measurements carried out with RFTrack over the specified frequency range and antenna.
Remember that most TV signals are vertically polarized.
The received signal level measured in dBm is dependent on the antenna gain and orientation.

In this report, click on charts to view the high-resolution versions, or other types of data representation.

Campaign measurements info

Campaign Route map. Click On the image to see the high resolution version



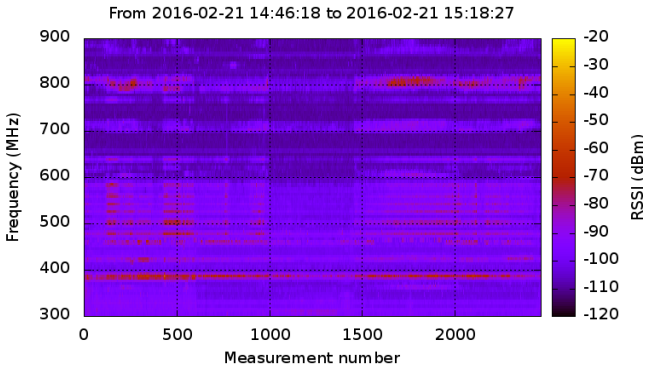
the color of each point on the route depends on the dBm max value detected in that position.

The following table contains info about the location where the measurements were taken

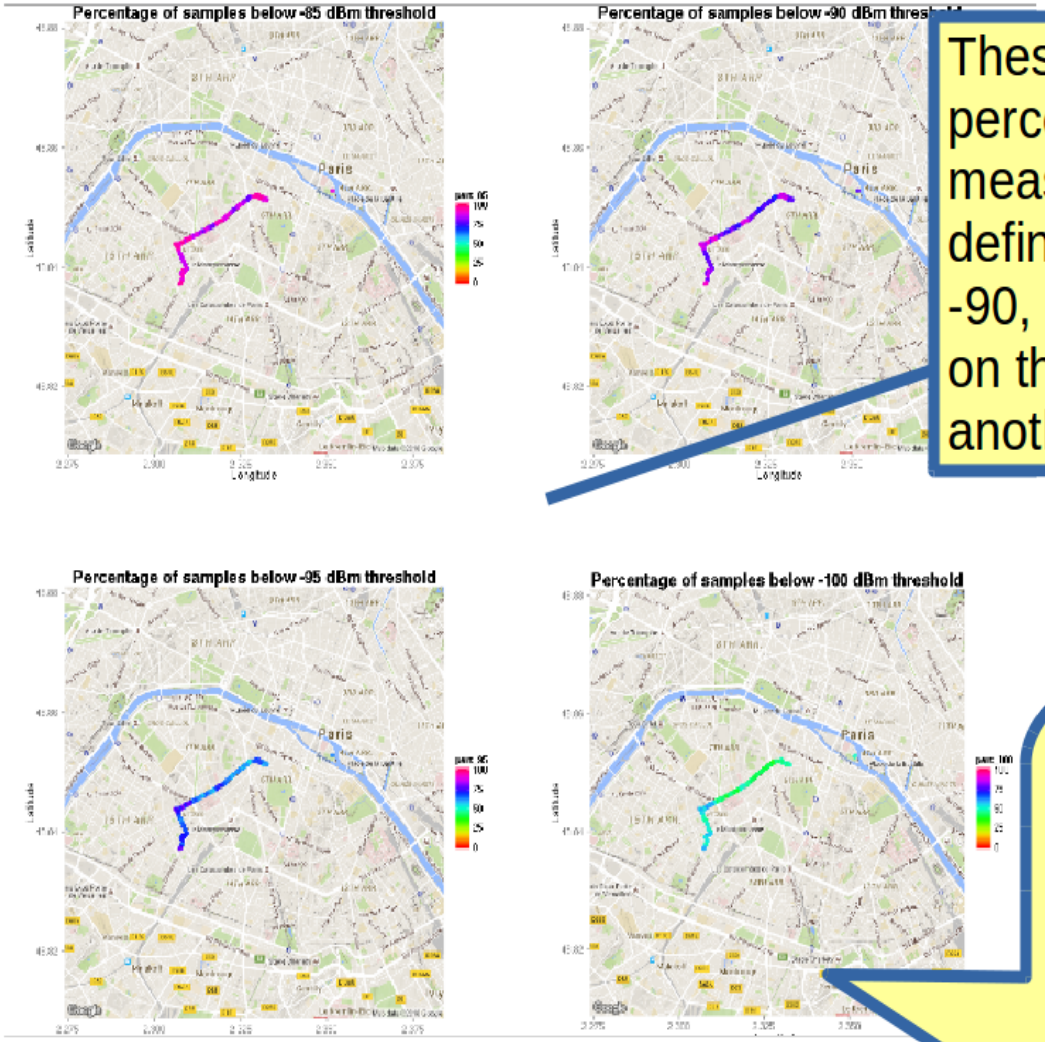
Info	Value
Campaign date:	2016-02-21
Campaign duration:	0:32:09 (hour:min:sec)
Route length:	5.2 Km
N. points:	2463
Country:	France
Country Code:	FR
Place of measurement:	Paris 12 Ancien - Quartier Saint-JacquesP
Region:	FR.11
Population:	no info

As in the Index page, this icon allows you to access to a page with additional material of the measurement campaign.

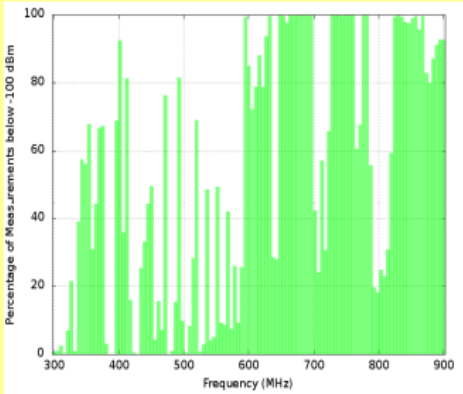
Other plots

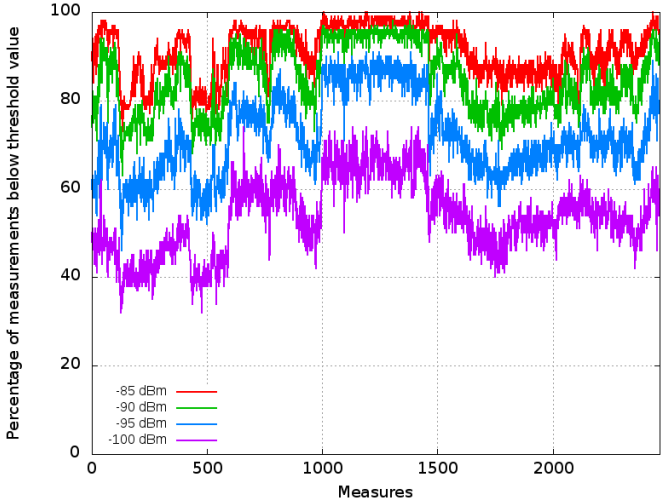


Heatmap generated by all the measures of the campaign.
Clicking on the image, you can view a high resolution version of the graph.

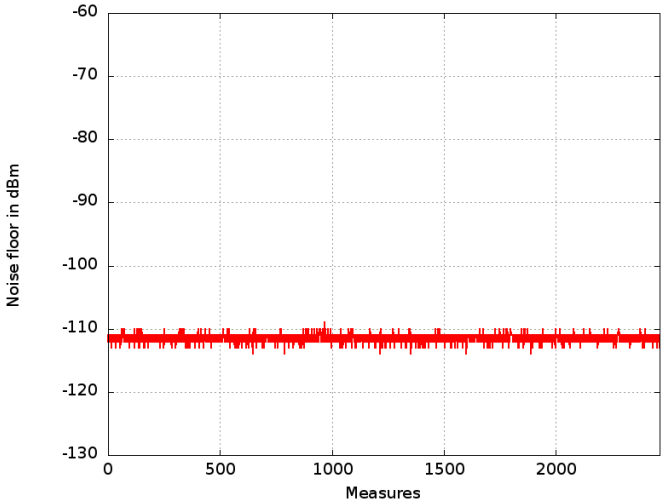


These routes show the percentage of measurements below a defined threshold (-85, -90, -95, -100). Clicking on the image offers another representation





Graph with the percentuage of dBm below a threshold value (-85,-90, -95, -100).
Clicking on the image, you can view a high resolution version of the same graph.



Noise floor graph.
Clicking on the image, you can view a high resolution version of the same graph.

Additional material of the measurement campaign

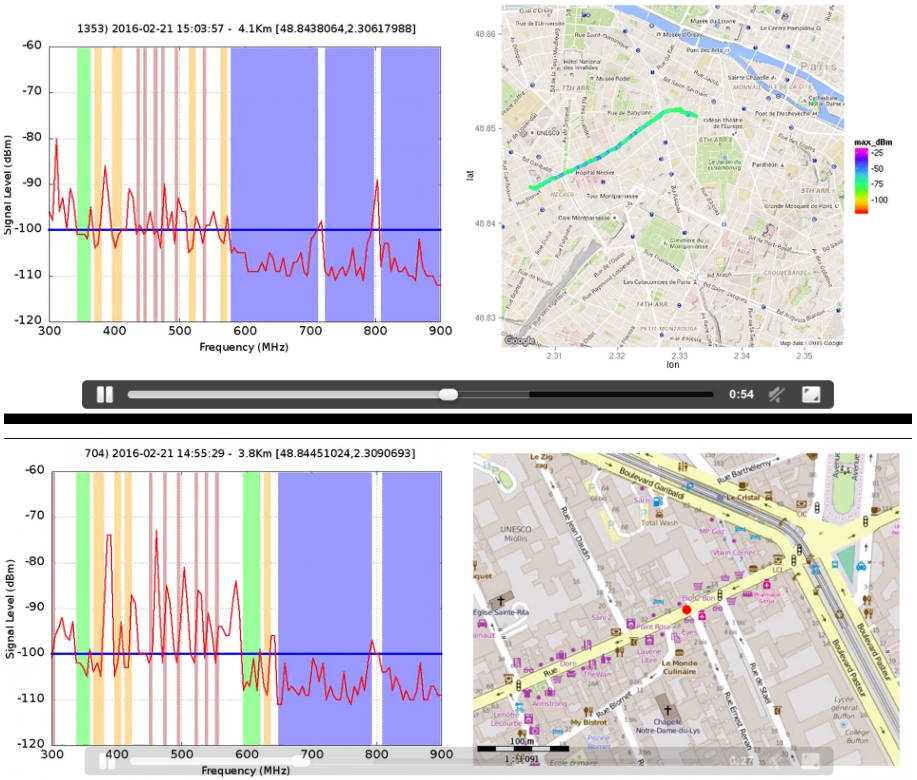
After data analysis, an additional page containing other material regarding the measurement campaign is also generated.

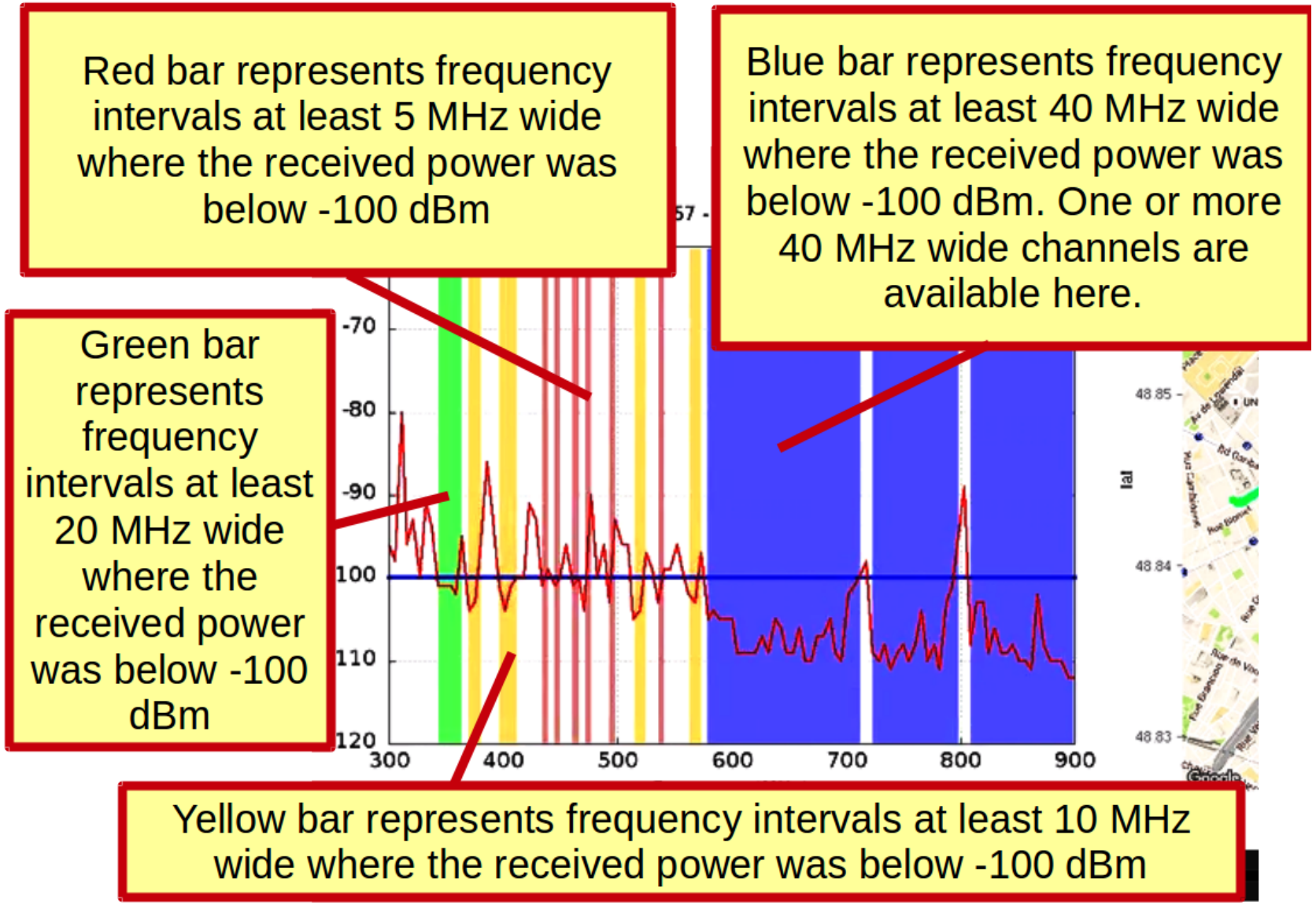
Two videos

You may view two mp4 videos that display graphs of dBm versus frequency at the GPS position on the map.

Data analysis video, first version.

Data analysis video, second version.




Red bar represents frequency intervals at least 5 MHz wide where the received power was below -100 dBm
Blue bar represents frequency intervals at least 40 MHz wide where the received power was below -100 dBm. One or more 40 MHz wide channels are available here.
Green bar represents frequency intervals at least 20 MHz wide where the received power was below -100 dBm
Yellow bar represents frequency intervals at least 10 MHz wide where the received power was below -100 dBm
-70
-80
-90
100
110
120
300
400
500
600
700
800
900
48.85
48.84
48.83

Other files that can be downloaded

Analysis Report in Pdf format.

Report images stored in Zip archive.

SQlite database, containing measurement data.

Technical information about the database used by RtfTrack

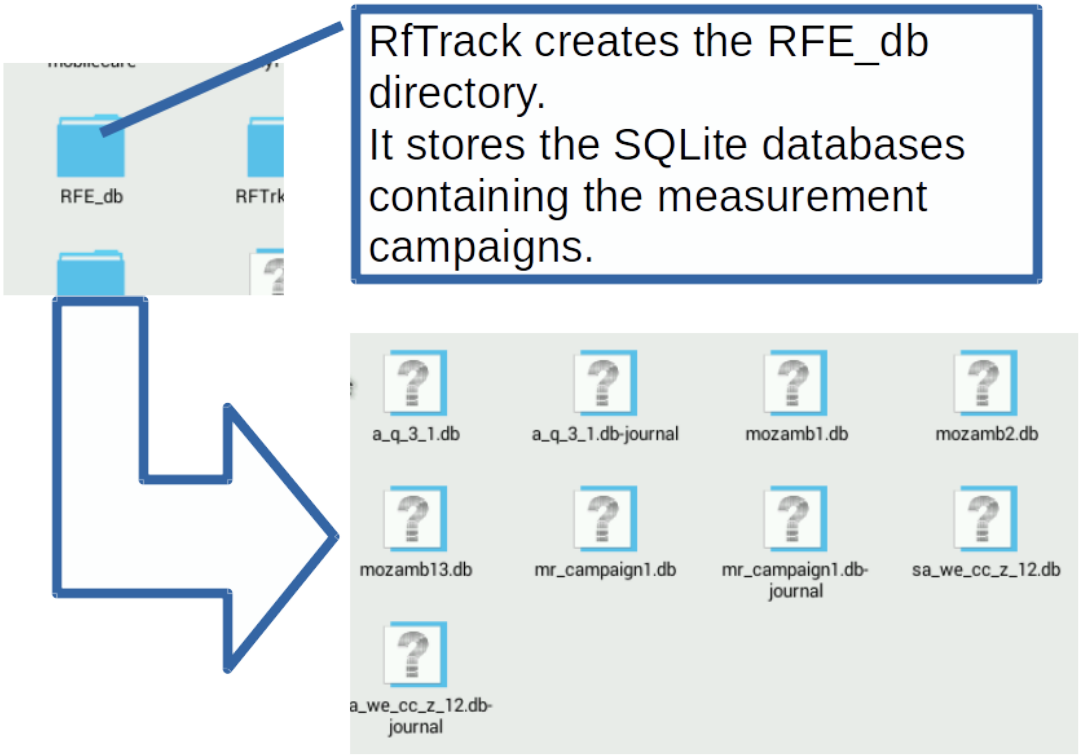
The RfTrack application saves all data in SQLite databases.

- SQLite is a lightweight relational database, used in Android for data storage purposes,
- This database requires no administration.
- Each complete database with multiple tables, indices, triggers, and views, is contained in a single disk file.
- SQLite is a compact library written in C: with all features enabled, the library size can be less than 500KB

For example, SQLite databases can be found in software running in Embedded devices and the internet of things

https://www.sqlite.org/whentouse.html

… **“SQLite is a good fit for use in cellphones, televisions, game consoles, cameras, thermostats, automobiles, machine tools, airplanes, remote sensors, drones, medical devices, and robots: the "internet of things".**



Some tools to manage SQlite databases

Below is the list of some freeware or open source tools that can be used to manage SQlite databases.
The list is provided for informational purposes only.
At any rate, the info provided may reflect preferences in the use of software.

Tool	Address	Info
	https://addons.mozilla.org/en-US/firefox/addon/sqlite-manager/	'Sqlite Manager': Firefox browser extension.
	https://github.com/lazierthanthou/sqlite-manager	'Sqlite Manager', project page on GitHub.
	https://chrome.google.com/webstore/detail/sqlite-database-browser-b/jlpbdkmaomigeneadlamehkfchdmojgg?hl=en	'SQLite Database Browser': Chrome browser extension.
	http://www.sqlitemanager.org/	Sqlite Manager: Web-based SQLite administration.
	http://www.phpliteadmin.org/	Phpliteadmin: Web-based database management tool for SQLite.
	http://sqlitebrowser.org/	DB Browser for SQLite: Open source tool to create, design, and edit SQLite databases. For Mac OS X, Windows, Linux
	http://sqlitestudio.pl/	SqliteStudio: SQLite database manager. For Mac OS X, Windows, Linux, BSD

Tool	Address	Info
	https://play.google.com/store/apps/details?id=com.xuecs.sqlitemanager&hl=en	'SQLite Manager', **Android app.**
	https://itunes.apple.com/en/app/sqlite-manager/id800058050?mt=8	'SQLite Manager', IPhone application.
	https://play.google.com/store/apps/details?id=com.kokufu.android.apps.sqliteviewer.free&hl=en	**Android SQLite Viewer.**

Project on github

The RTfTrack project has been released on GitHub and can be downloaded from this address:

https://github.com/tvwsanalyzer

Three repositories are available:

1. **rftrack-android-app:** it contains the RfTrack Android app sources.
2. **rftrack-server-scripts:** it stores the scripts of remote server, for data analysis and report generation of measuring campaigns
3. **rftrack-documentation:** RfTrack project documentation