PinPointR

ImpulseRadar
PinPointR User Manual V1.4

Content

About this manual

ImpulseRadar PinPointR system uses an antenna that is a self-contained Ultra-Wide Band (UWB) Ground Penetrating Radar (GPR) system. The dual frequencies and mechanical design combined with the various accessories like the GPS mounting kit make the system suitable for different kind of locating and mapping applications.

For information on other applications and/ or configurations, please contact your local ImpulseRadar representative, or contact our sales team at sales@impulseradar.se

This manual is structured as follows:

- Section 1 – Hardware antennas and accessories
- Section 2 – Software data acquisition and control
- Section 3 – Appendices additional notes and technical information

We welcome your feedback concerning this manual and its content. Please send your comments or suggestions to us at info@impulseradar.se

Hardware overview

The PinPointR system and its dual-channel antenna's electronic design is based on a modern real-time sampling (RTS) technology platform, offering state-of-the-art data acquisition capabilities. The PinPointR antenna incorporates two separate GPR-channels, operating at high speed as well as an in-built GPS.

Antenna	Centre Frequency
• PinPointR	400 MHz and 800 MHz

The PinPointR system includes a push-cart and the PinPointR antenna with a range of accessories shown in **Figure 1** below.

Figure 1 *System overview*

Data collection is managed over an Ethernet WiFi link and a suitable Android device running the ImpulseRadar App (IPR App). With the IPR App, the operator may collect single line data, albeit with two frequencies, or a few different types of multi-line projects. Whether a single line of project-based data has been collected, data-sets may be directly imported into the CrossPoint Windows software for processing and evaluation.

For information on other applications and/ or configurations, please contact your local ImpulseRadar representative, or contact our sales team at sales@impulseradar.se

Antenna

The PinPointR antenna has a field-rugged design equipped with both a low and high-frequency channel, making it possible to detect shallow and deep utilities. Power supply via a removable and rechargeable li-ion battery easy to exchange on the top of the antenna. The connectors and On/off button, as shown below in **Figure 2**.

The PinPointR antenna also includes and a high-quality differential GPS receiver (Ublox/ Tallysman). There is no external connection to these components, although markings on the housing showing their approximate internal location.

Figure 2 *PinPointR antenna with a battery attached*

Connector panel

Refer to the arrangement shown in **Figure 2**:

- **Silver** – On/ Off button. Press the button once for approx. 2 seconds to switch on the antenna. When on, the button glows blue. A subsequent press will switch the antenna off.
- **Blue** – External GPS. It allows the connection of an external GPS antenna to provide higher precision positioning. Communication is via a serial RS232 connection using the NMEA 0183 protocol, and GGA data string.
- **Black** – Measuring wheel. It allows the connection of the push-cart wheel encoder cable.

All cable connectors are of high-quality from Yamaichi. To insert/ remove a cable connector, hold the connector sleeve then gently push or pull the connector straight without turning. Each connector has a key slot to prevent damage if incorrectly connected into the wrong socket.

Battery

The PinPointR antenna is powered via a removable and rechargeable Li-ion battery, which is a nominal 8.7Ah/96.57Wh, providing approximately 7-hours of continuous operation.

Note: *ImpulseRadar Li-ion batteries are approved according to UN38.3 and can, therefore, be safely hand-carried/ shipped by air.*

The battery fits securely to the top of the antenna. To insert, position it on the mounting plate and slide it gently into place until you hear the locking pin engage (click). To remove, pull the locking pin out, then gently slide the battery out and off from the mounting plate, Refer to the images in **Figure 3** below.

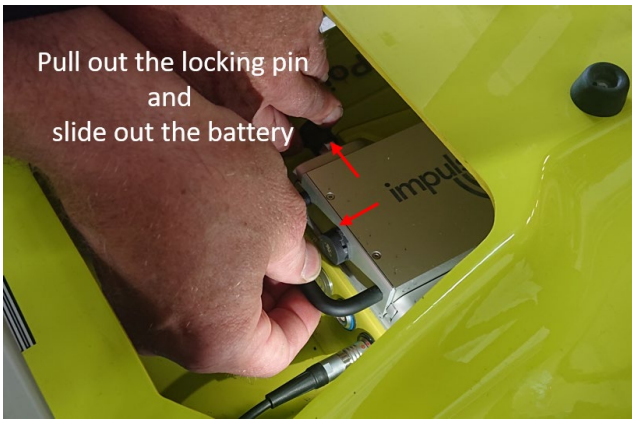

Figure 3 *Mounting the battery*

Cart

The PinPointR Cart has a foldable handle assembly, as shown below in **Figure 4**. The push-cart allows the antenna to be maneuvered easily over a range of surfaces.

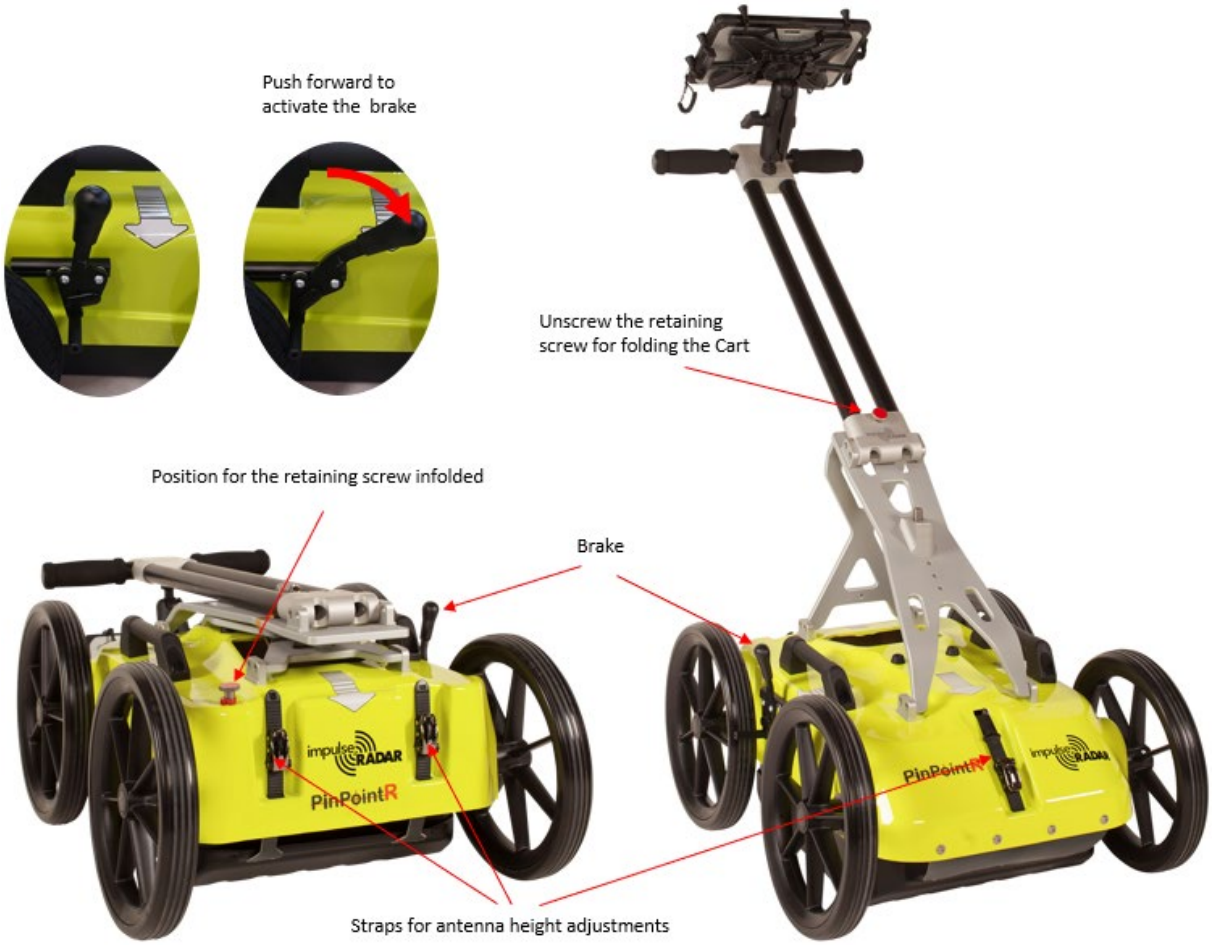

Figure 4 *PinPointR Cart (foldable)*

The Cart incorporates a break on the rear-right wheel, easily engaged by your foot.

Note: It is important to lock the brake every time the operator releases his hands from the handle. The cart can move very easily even on relatively flat ground unless the brake is in the locked position.

When not in use, the handle mechanism can be folded by removing the M6 retaining screw, as shown in **Figure 4** above. This reduces the overall physical size to facilitate transportation and/or storage.

The antenna is mounted into a tray that is connected to the cart-hood by adjustable support straps. This arrangement allows the antenna to be positioned on or very close to the ground surface. This arrangement, as shown in **Figure 5** below, allows the antenna to 'float' freely vertically and follow the contour of the ground, or move over bumps and other small obstacles.

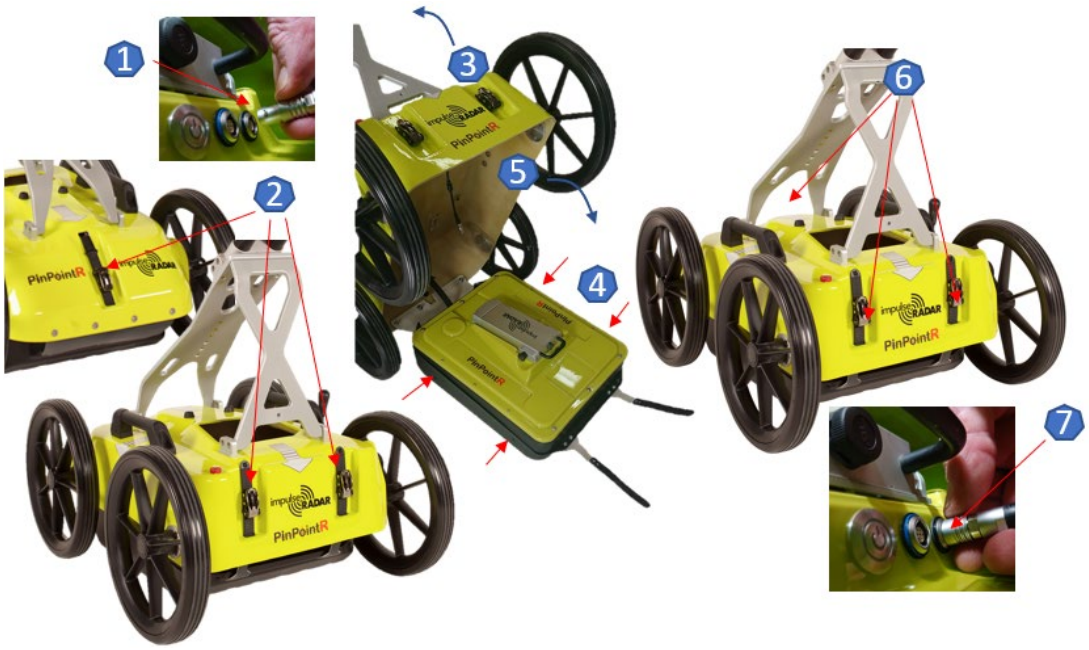

Figure 5 *Antenna fitting and height adjustments*

Antenna fitting procedure, as referenced in **Figure 5** above:

1. Disconnect the wheel connector attached to the antenna.
2. Remove the two rear and the front straps from the snap connectors
3. Lift the cart-hood and slide the antenna into the skid tray
4. Connect the antenna to the tray with M5 Screws on both sides
5. Close the cart-hood and refit the rear and front straps into the snap connectors
6. Adjust the front and rear straps to obtain the desired height
7. Connect the odometer cable (black connector)

Note: *when removing the antenna, remember to disconnect the odometer cable before lifting the cart-hood. It's important to make sure to remove the front strap to avoid tension on the strap connect point at the front of the skid tray.*

Odometer encoder

To measure survey distance, the push-cart has one of two types of odometer construction mounted on the right-rear wheel. The first and older type has the odometer located above the center of the wheel shaft were a belt (O-ring) is connected between the wheel and the odometer. The second and

most recent type has the odometer mounted in the center of the wheel axel, and no O-ring is needed. For the belt-driven type, the O-ring can easily be removed and replaced by first removing the wheel by unscrewing the M6 retaining screw (as shown in **Figure 6** below). A spare O-ring is placed on the encoder cable on the inside of the hood.

Note: *when refitting the wheel, use blue Loctite or equivalent to help secure the M6 retaining screw.*

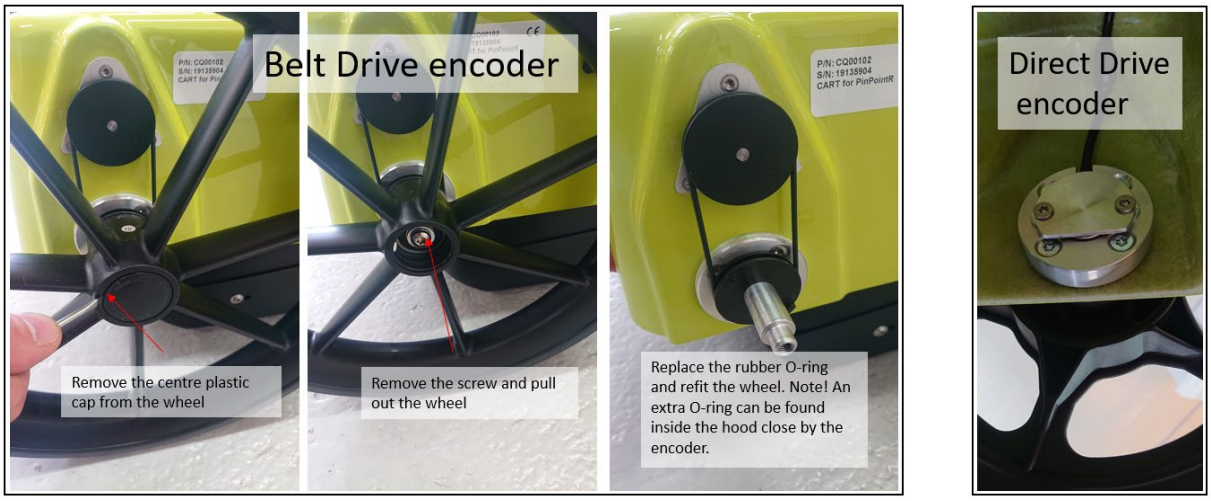

Figure 6 *Belt or Direct Drive encoder and wheel assembly*

GPS mounts

An optional GPS mounting accessory is available for the push-cart, as shown below in **Figure 7**.

Figure 7 *GPS-mounts on the Cart*

Software overview

The PinPointR is set-up and controlled wirelessly via the IPR App once installed on a suitable Android device. Refer to **Appendix A** for a list of specification requirements.

Android devices that meet or exceed the minimum specification requirements will generally offer better performance in terms of data recovery and on-screen functionality. That said, low-end Android-based smartphones can offer a quick and simple means of collecting radar profiles.

Since Android devices are not as standardized as PC's, there may be slight variations in the way software is installed and operated between different devices. The following section will detail various screenshots and menus as taken from a recommended device. However, this may be slightly different from your device.

How to avoid WiFi connection issues

The PinPointR antenna acts as a wireless access point (WAP) to which your Android device needs to connect. Once the device has been set-up and connected to the antenna once, it will then automatically connect again when within range (if the AP is not disabled (forgotten)).

Nowadays, you are more than likely to have more than one device, and you may, in fact, like to have more than one device set-up to collect PinPointR data. This raises an issue concerning which device will connect and stay connected if more than one is within range; since this could lead to interruptions in data acquisition. To manage this, once a PinPointR antenna is connected to a device, the antenna cannot be connected to other nearby devices (but these devices can force a connection if it is necessary to change a device).

For users with multiple PinPointR antennas, we recommend allocating one primary data acquisition device to each, to avoid the potential issues described above. Furthermore, once the device is connected, you should disable the AP for any other PinPointR antennas on that device.

IPR App installation

Security note

As part of the Android operating system, there is a security restriction that prevents the installation of applications from outside the Google Play Store. Since the IPR App is not yet available on the Google Play Store, you will need to make some adjustments to your device system settings to proceed with the installation, as follows:

1. Navigate to Settings > Personal > Lock screen and security
2. Check the option "Unknown sources"
3. At the message prompt, select "OK"

You may now proceed with the installation of the IPR App.

The IPR App software is supplied on a USB thumb drive and can either be installed directly from this device or by copying it to the internal memory of your Android device. Whichever method you chose, the installation process is as follows:

1. Locate the file <IPR-X.XXX.apk>[1] and start it to initiate the installation

2. The recommended file system for this App is "ES File Explorer"

3. When prompted, allow permission for the PinPointR App to access photos, media, and files on your device, so that radargrams can be saved and opened. Also, allow permission for the PinPointR App to access your device location. This permission allows the app to manage Wi-fi and Bluetooth communication, which is necessary for the app to be able to connect properly to the PinPointR antenna. The App will keep asking for the permissions until all the permissions asked for are granted. If you deny the permission and the same time checks “never ask again,” you will be directed to the Android Settings App and then the App will exit because the app will not work properly without the permissions.

[1] *X.XXX will be numerical according to the latest software release.*

WiFi pairing

Follow the process below to connect your Android device to a PinPointR antenna. Refer to **Figure** 8 for supporting screenshots.

1. Switch on the PinPointR antenna

2. On your Android device, navigate to Settings > Wi-Fi > and look for the PinPointR antenna ID, which will appear as ‘CO_XXXXXXXX’ (where XXXXXXXX is the serial number of the antenna)

3. Select this Access Point (AP), and you will be prompted to enter the password, which is ‘impulseradar’

4. Press ‘Connect’ to complete the process

Once connected, a ‘no-internet’ warning may appear, which can be disregarded. If the warning dialogue permits, authorize the network, and do not show the warning again.

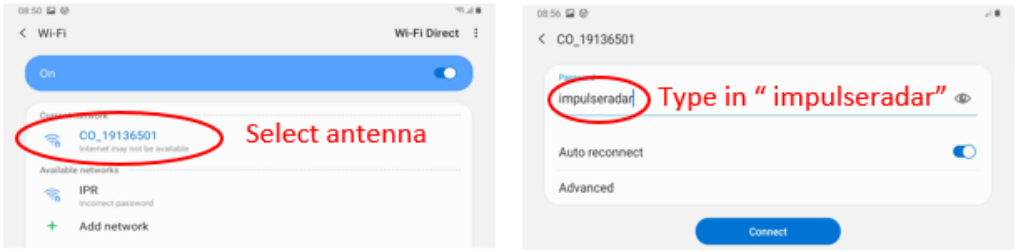

Figure 8 *Pairing a PinPointR antenna to an Android device*

Using the IPR App

From the home screen of your Android device, press the IPR App icon to enter the application’s start screen. The start screen, as shown below in **Figure** , provides access to the various functions of the IPR App.

From **Figure** , the left image shows an example of when the antenna is properly connected, with all functions available. This includes the antenna battery status, which can be monitored from within the App as shown. The right image shows the limited functionality when there is no antenna connection.

Note: *the version number of the App is shown below the Impulseradar logo of the start screen and this may be requested in the event you need support services.*

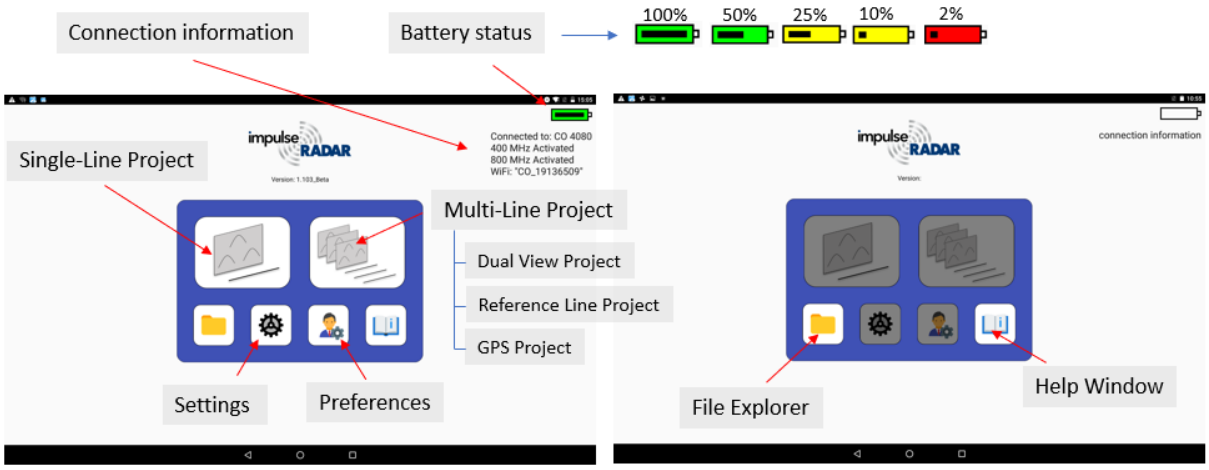

Figure 9 *PinPointR start screen. Right: not connected device.*

Switching between different antennas

The IPR App will detect if you are connecting to an antenna that is not the same as the previous Antenna that you were connected to and then prompt you and restart the app.

Projects, Settings, and Preference

Two different types of collecting data are possible with the app. Single Line projects for individual profiles or Multi-Line project if the user wants to record several profiles. In Multi-Line mode, the operator can select GPS Project, Reference Line Project or Dual View Project. Whatever project type the operator selects to run a project folder for the data needs to be created. **Figure 10** shows the three selections, New Project, Resume Latest Project, and Resume Old Project. Selections to handle

Figure 10 *Create new, resume latest or resume old projects*

Projects folders will be grouped in subfolders on the android device's internal storage. The created subfolders will always be found in the XOver Data folder that automatically gets created on the android device the first time the IPR app is installed. It is possible after a survey zip a project directly from the apps file explorer for a quick and easy way to upload the data to a cloud service. Do a long press on the project folder that you want to zip, and select “Zip Project”.

The settings and preference menu, as shown in **Figures 11 and 12,** below, contains the parameters needed to control the PinPointR system during data acquisition. Once set, these parameters remain

unchanged for all subsequent data acquisition. The menu for settings can be displayed in a basic version but also a more advanced mode. The app gets installed in Basic mode, activate advanced setting with the slide bar.

A detailed description of settings parameters:

- **Trig Source** – defines how data collection is controlled. Typically, this will be the Direct Drive Cart wheel selected from the wheel option menu, Time or Manual triggering can also be used. In Manual mode, the user must tap the trig button on the screen for every A-scan[1].
- **Distance Interval** – defines the distance between every A-scan[1], when Trig Source is set to Wheel, or Manual (sometimes also called point distance).
- **Time Interval** – defines the Time between every A-scan[1] when Trig source is set to Time.
- **Soil Velocity** – defines the velocity used to calculate the depth scale.
- **Number of Samples** – defines the time window or maximum penetration depth, and the adjacent Max Depth for the two channels is calculated based on the Soil Velocity.

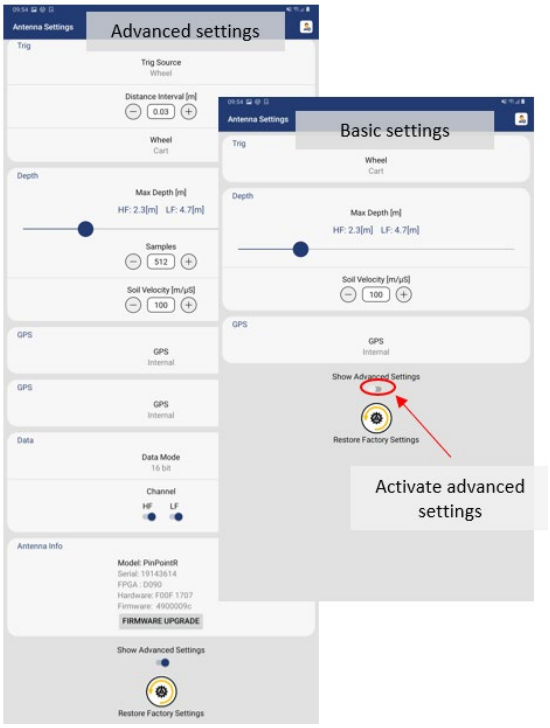

Figure 11 Settings menu, basic and advanced

- **Data Mode** – defines how many bits are used while storing the resulting radar data. PinPointR antennas, below 600 MHz, can provide more than 16-bits, so 32b can be selected. The precise number of useful bits depends on the point distance, survey speed, and antenna frequency. A lower antenna frequency combined with slower speed and larger point distance provides a higher number of useful bits. The limit today is approx. 19-20 useful bits. Note that using 32 bits during surveys requiring high speed only increases the risk of dropping data in Ethernet-link, use 16 bits and not unnecessary long time-windows to reduce the load on data transmission in these cases.
- **GPS** – defines whether to use the internal module or an externally connected system. If External is selected, you must adjust for the correct baud-rate, which can be obtained from the user manual for the GPS system used. EXT + TP is intended for use with an external while gathering precise time-stamping on each A-scan with help of the internal GPS. If no external GPS is present, when this option is selected, a time-sync file will still be created. See also later paragraph on GPS-symbols.
- **Wheels** – defines the type of wheel connected to the antenna for distance measurement. The standard wheel is the Direct Drive Cart. PinPointR users that have the older Belt Drive Cart need to select that type of wheel encoder manually.
- **Restore factory settings** – If internal settings have been corrupted or after a firmware upgrade, it's advisable to restore to factory settings, all essential system parameters will be reset to the

initial state. Note that the wheel type will be Direct Drive Cart as default. If a Belt Drive Cart is used this needs to be changed manually by the operator.

- **Firmware upgrade** - Menu trough which upgrade of firmware may be done, see later paragraph.

[1] *An A-scan is an envelope, or trace, formed by connecting all the samples collected at one specific point along the survey line.*

A detailed description of preferences:

- **Default Project Name (Single Line)** – By default, the name is the serial unit of the antenna. The operator can edit/delete and change the name according to his own wishes.
- **Measurement System** – Defines whether metric or Imperial values are used. When set to Imperial, the units will be in feet (ft.) and 10ths of ft.
- **Vertical scale** – Set time or Depth for the vertical scale.
- **Generate Field Report** – Off/On PDF report
- **Operator Name** – Info will be stored in the PDF report.
- **Company Name** – Info will be stored in the PDF report.

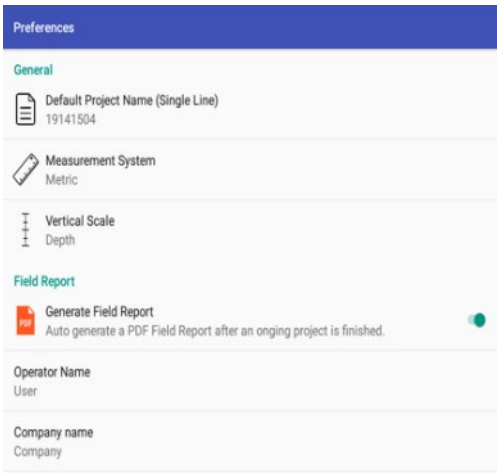

Figure 12 *Preferences*

In **Figure 13** below the general functions on the start screen and data collection screen is shown.

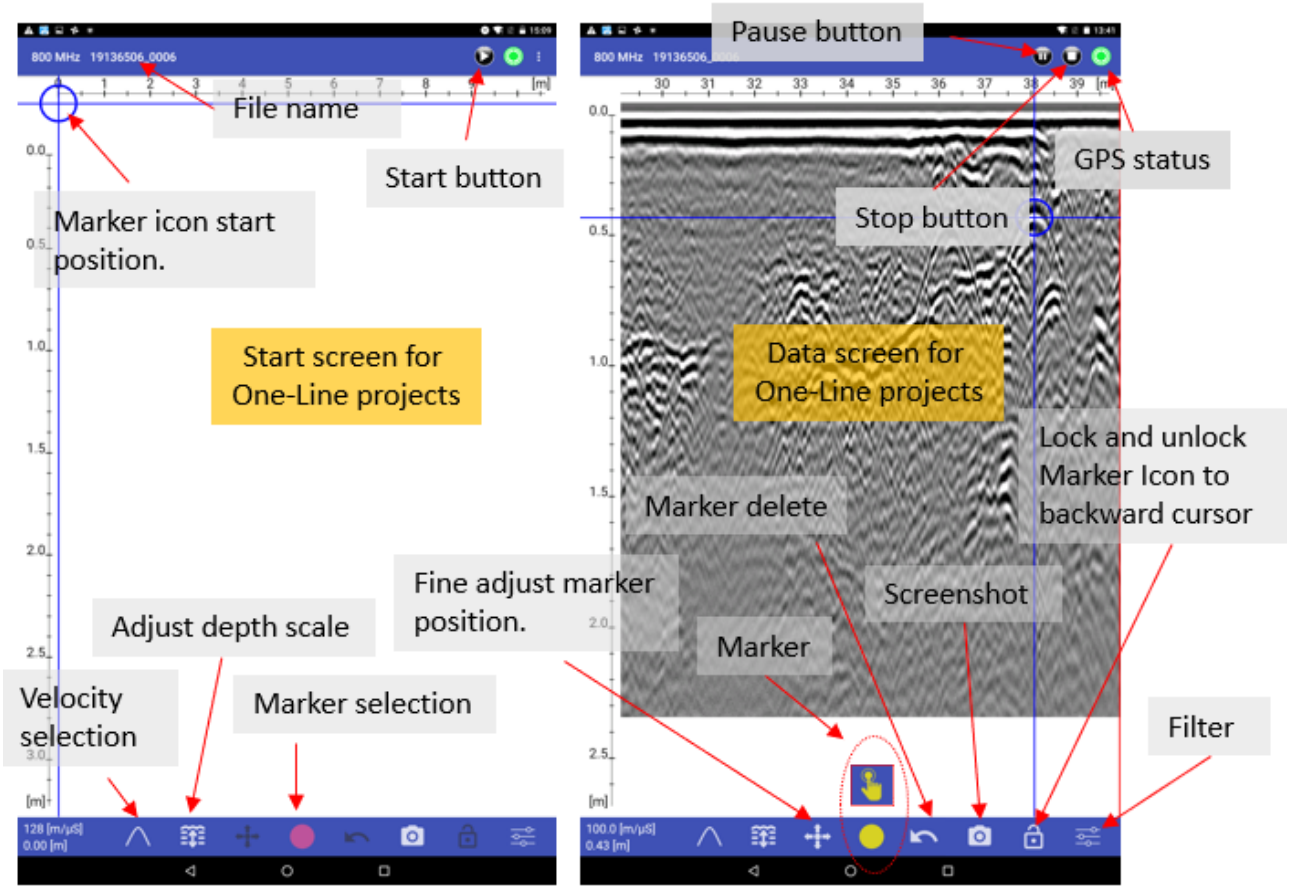

***Figure 13**, Menu bar during data collection*

GPS-symbols and function

By pressing the GPS-symbol a, static view on the present satellites and coordinates can be viewed, see **Figure** below.

The GPS symbol will change with the solutions at hand, symbols we use to show this is given in **Figure** .

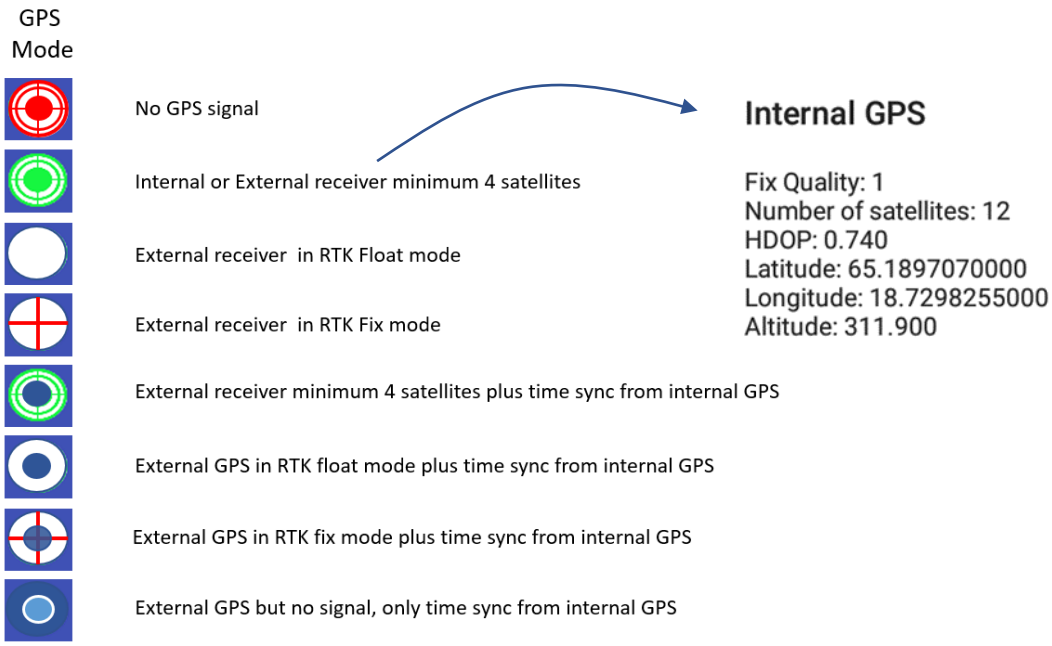

***Figure 14**, GPS-symbols and their meaning and GPS information showed when the symbol is pressed*

Note that when an RTK-GPS is used, hooked up to the system, the positing file generated is adjusted for the time lag in the RTK if the time sync is activated in the settings menu, so no further data manipulation is needed. The timing-file is provided for the rare occasion when the RTK is run separated from the system, for example, in a multi-sensor setup.

Wheels

The Cart wheel is the default selection for the PinPointR system. Any other use of the system will require a new wheel calibration.

Data viewing and adjustment

The screen and system functionality differ depending on the project type. It is possible to use the marker and velocity analyzing functionality for One-Line projects as well as a Reference line and GPS projects. During data acquisition independent of project type, the screen view can be set to show either the high-frequency channel only, low-frequency channel only, or both high and low-frequency channels together, as shown in **Figure 15** below. A 'double-tap' of the device screen will toggle between these views. Markers can only be set when one of the two channels are viewed on the screen. When both high and low frequencies are viewed the marker and velocity analyzing icons are not available on the lowermost part of the screen.

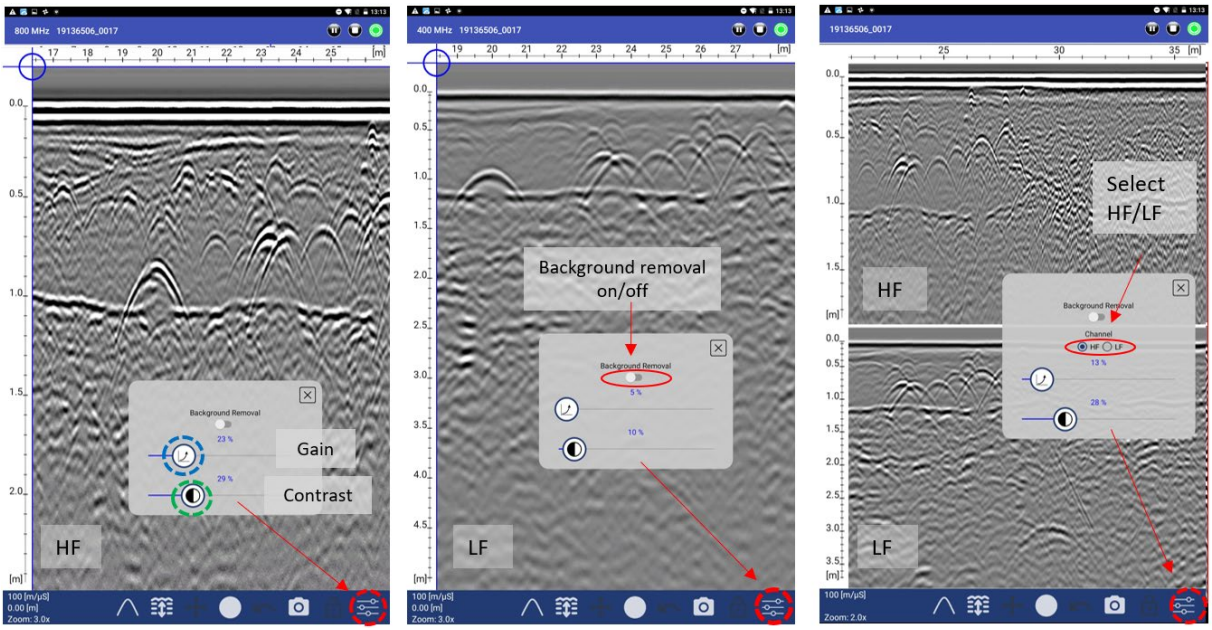

Figure 15 *Screen views during data acquisition,*

The filter window will pop up when the filter-icon is pressed (marked with red in **Figure 15**). The gain and contrast of the radargram can be adjusted when in single-channel mode but also in dual mode. In dual-mode the operator needs to select which of the channels to adjust. The contrast scrollbar is marked in green and the scrollbar for gain is marked in blue in **Figure 15**. To change gain and contrast, hold your finger on the icon and move the scrollbar to wanted position. Note, in most cases keep the gain and contrast to a low value. High gain and contrast values make most of the cases the radargram impossible to interpret. The filter window will close if you press the close button or somewhere outside the filter-window. It is also possible to move the filter-window, just press with a finger inside the window and move to the desired place.

The app remembers which channel you last viewed (HF, LF or both), and contrast and gain settings last used. Next time a new project or survey is started it will apply those settings. Note, if you restart the app those specific settings will be reset.

Note: *the images shown in* ***Figure*** *are screenshots from a Panasonic Toughpad FZ-A2 device. Icon sizes will change depending on the size of the Android device.*
Whilst also in the single-channel view, the time-zero position can be adjusted, by dragging the scale-up and down. Once set, the time-zero position is saved and will be used for subsequent profiles. Therefore, it makes sense to do this early on in a survey; this will also save time in managing data imported into the CrossPoint interpretation and visualization software.

Before starting data collection, or after stopping a line, you have access to the settings through the menu button, which is in the upper right-hand corner of the screen, as shown in **Figure** below.

Figure 16 *Acess setting menu*

Zooming is done, as on other Android-devices, with two-finger gestures, increasing or decreasing the distance between the fingers. Zooming is done step by step in five positions, 1.0x – 5.0x. The current zoom can be seen in the lower-left corner of the screen.

If the radargram does not fit on the screen when data is zoomed in, scrolling may be done by dragging one finger up and down on the screen.

Other buttons provide functionality for controlling the collection of data, including Start, Halt/Resume and Stop. Pressing the Halt button temporarily pauses the data collection, whilst pressing the same button again, allows data collection to be resumed.

Restoring missed traces

During data acquisition and the transfer of radar data from the antenna to the Android device, some of the radar traces may be missed. This is typically due to a weak or interrupted Ethernet link. For example, when working in areas with high levels of RF disturbance, or when the data acquisition device is moved too far from the antenna.

However, since all radar data is saved to the antenna's internal microSD card, any missed traces can easily be restored at the end of each profile when the stop button is pressed. Should this occur, a message will be displayed on-screen, as shown in **Figure 17** below.

Note: If you put the App in sleep-mode (minimize the App) during data acquisition (e.g. if you answer a phone call), the ongoing survey will stop and the data will be saved, but the missed traces may not be restored!

Note: *it is essential that the data acquisition unit and the antenna are near to each other during this process. Otherwise, the restoration process could take considerably longer.*

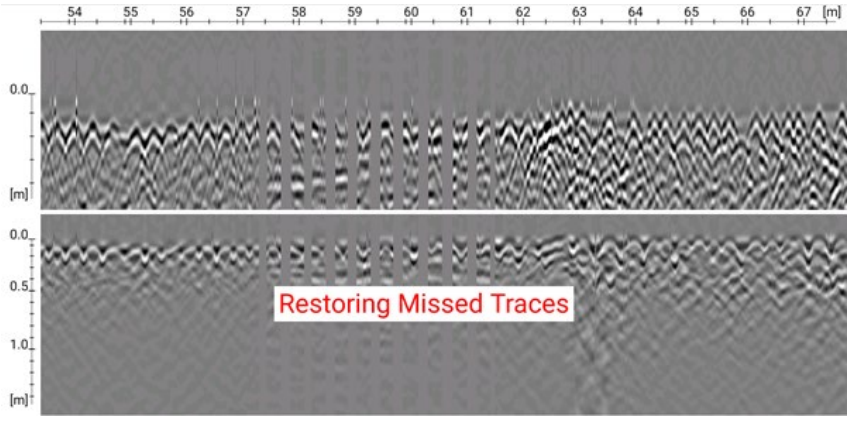

Figure 17 *Data recovery when the acquisition is stopped*

Projects

From the start screen, you may select either a 'One-Line Project' or 'Multi-Line Project.' As the names imply, this gives the option of collecting projects with either single or multi-line profiles. Regardless of project type, a *.cor file (GPS coordinates) will be saved alongside the GPR data if the internal GPS can lock onto suitable numbers of satellites.

One-line project

One-line projects include marker set function and velocity analyzing by the hyperbola fitting method. The function buttons are placed under the radar data screen when data is showed with either the low or high frequency, see **Figure 15**. Within the software, the operator can change in between the AS5488 and APWA standards for markers but also create customized maker types with text and color symbols. Note that the selection of a marker standard or custom must be done before a single project is started. Once a One-Line project is started the markers are locked to the previously used one.

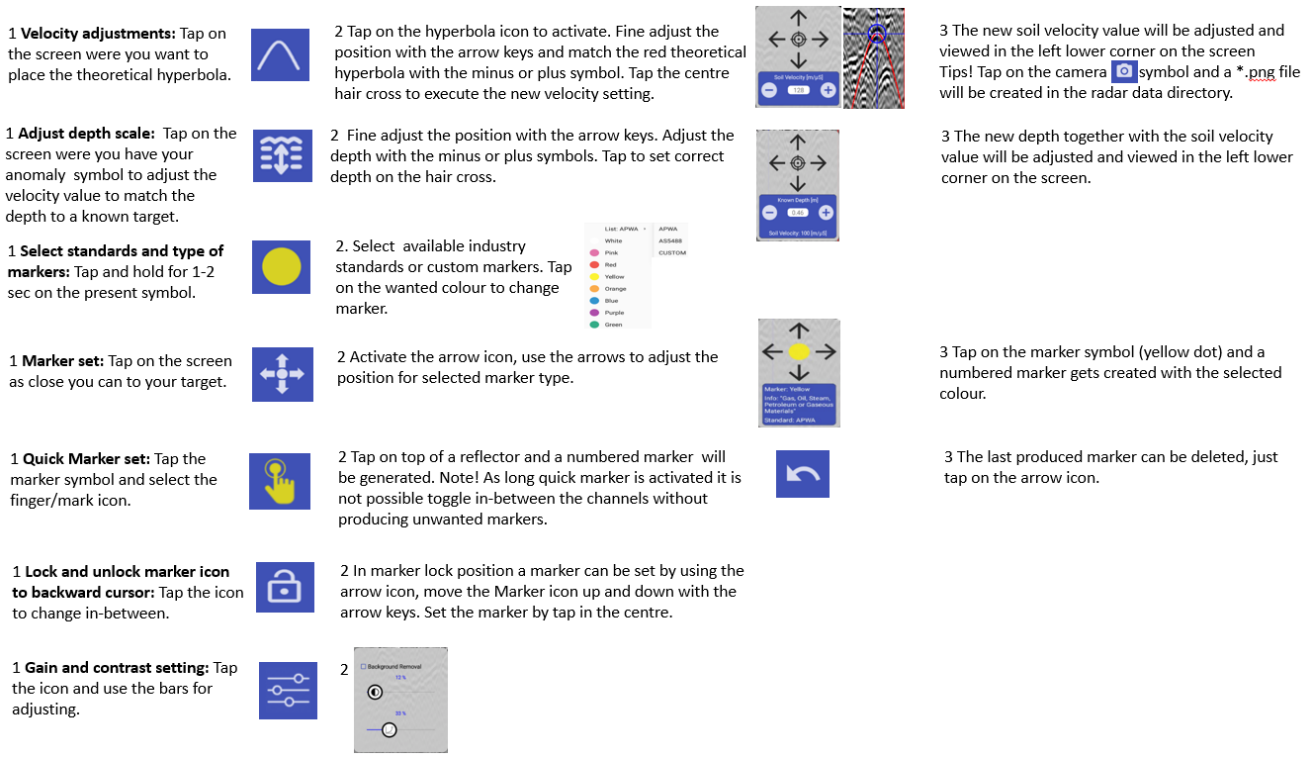

Figure 18 *Description of marker, filter and velocity analysing functions*

Multi-line project

Three types of multi-line projects are available as follows:

- Reference Line (RL)
- Dual View (DV)
- GPS

Markers can be set and managed just like in One-line projects for Reference line and GPS projects.

Reference Line (RL)

The RL project associates and orientates GPR profiles to a straight-line reference. This can be any type of physical line that can be referred to during and after data collection. Examples include boundary, curb or fence lines, or simply a metering-tape laid on the ground. Regardless, one end of the line needs to be defined as the starting point and then equidistant points marked along its length. Profiles are

then gathered in straight lines, perpendicular to the reference line, and a reference-marker is placed within the GPR data every time the reference line is crossed, as illustrated in **Figure** , below.

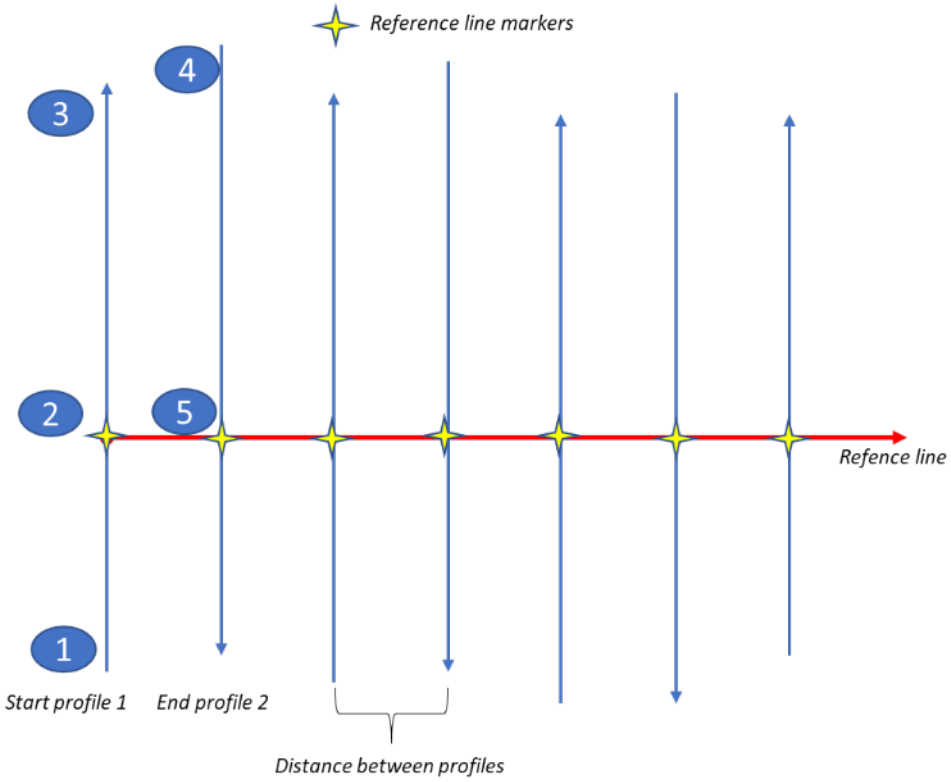

***Figure 19**, Layout of a reference-line project*

From the project start screen, **Figure** below, you will be prompted to enter a project name and the distance between each profile. Once entered, press the 'Start the Project' button to continue.

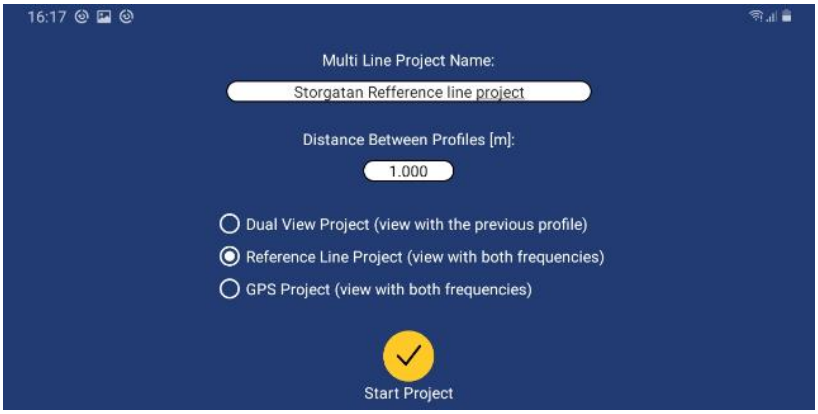

***Figure 20** Multi-Line Project start screen*

Once the project has started, the data collection screen will appear with directional control buttons, as shown in **Figure 21** below.

***Note:** during data collection, you can still view either the single-channel (low or high frequency) or dual-channel (low and high frequency) data, just as in the 'one line project' mode.*

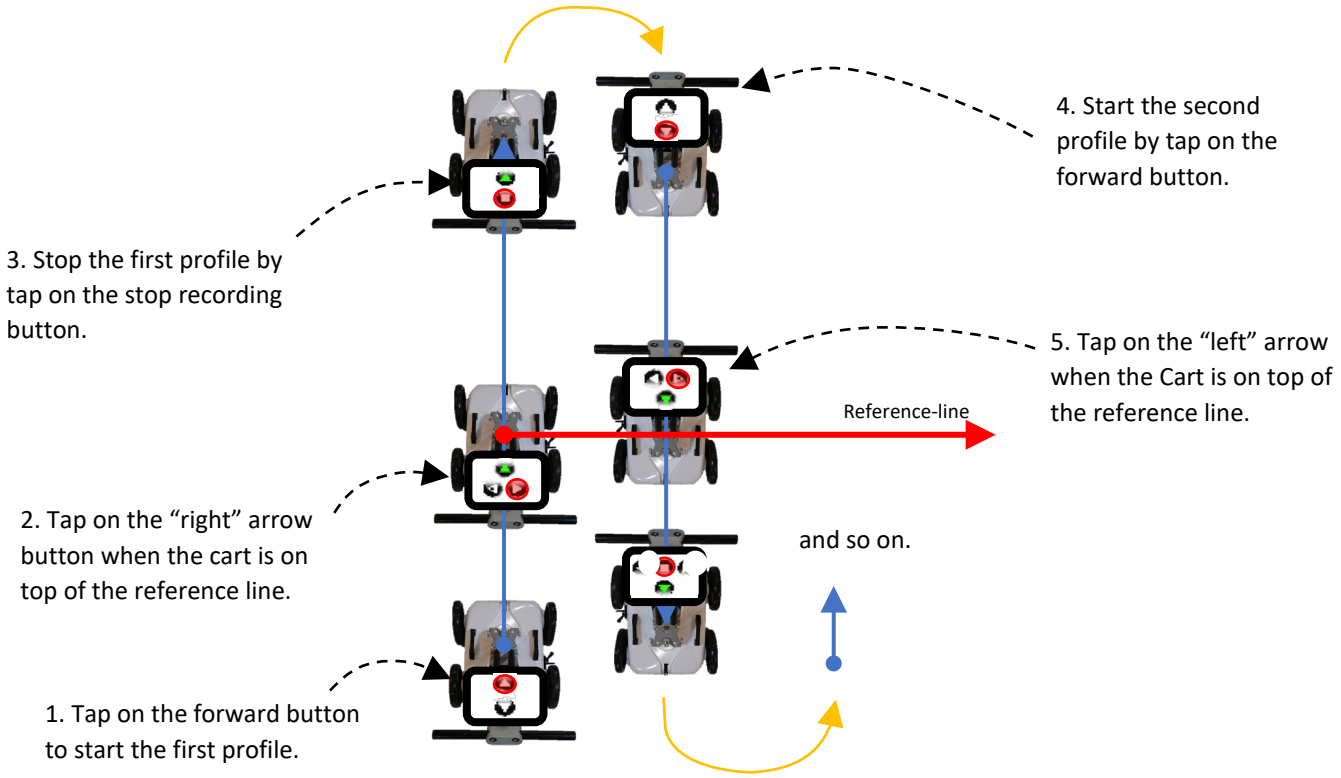

Figure 21 *Controls during reference-line projects, forward survey, and profiles to the right of the first profile*

Select the direction of the collection (forward/backward) and press the appropriate button to start the profile. Note that the example in **Figure 21** illustrates a forward motion of the cart for all profiles in the Reference Line project and requires a 180° turn at the end of each profile. Note, instead of turning the Cart 180° at the end of every profile the operator can also reverse the Cart, just activate the recording with the reverse arrow on the screen. The selected button will be highlighted in green to indicate the selected direction and additional buttons (left/right) will become available. These buttons are used for the placement of the reference marker, by indicating the position of the start point in relation to the direction of travel, when crossing the reference-line.

Referring to, the first profile is collected by moving away from position **1.** Upon reaching the reference-line at point **2**, a reference marker is placed in the data by pressing the ‘right‘ or “left” arrow button. If the decision is to move to the “right” with the upcoming profiles as illustrated in **Figure 21**, from now on all profiles in the project must be moved to the “right” of the first profile. Make sure that the Cart is stopped on top of the Reference line, arrows on the Cart hood must match the Reference line. The profile continues to be collected until reaching point **3**, at which the stop button is pressed.

The system is then moved to the start point of the second profile (point **4**). Important to keep the distance in-between the profiles as decided in **Figure 20**. Press the forward button to start the measurement when the Cart is in position for the second profile. Upon reaching point **5**, a reference marker is again placed into the data. This time the left marker button is selected because the next profile will be to the left of the present one.

After the last profile has been stopped just sweep from the bottom of the screen on the standard Android way, tap on the arrow pointing to the left and answer yes that this Reference line project will be finished.

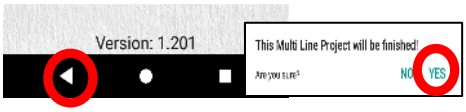

***Figure 22**, Close an RL-project*

If data is correctly gathered, all profiles will be correctly aligned and orientated with the reference-line and each other when opening the project in the CrossPoint software.

Dual View (DV)

This project type is intended to aid in on-site interpretation, rather than in post-processing. It is particularly useful for identifying features/objects that are relatively linear across a survey area, e.g. foundation walls, tree roots or utility lines.

When collecting and viewing a single GPR profile, it is difficult to judge whether a reflector is a genuine point of interest, or simply from random debris like a stone or piece of broken rock. Consequently, it is useful to view one, or more, parallel profiles to assist in their interpretation. This is the basis for the DV-project, which allows the current profile being collected to be viewed alongside the previous one, thereby making it easier to see if reflectors line up in similar positions across them. For this to work, the start position of each profile must be aligned with the stop position of the previous profile, as shown below in **Figure 23**, below.

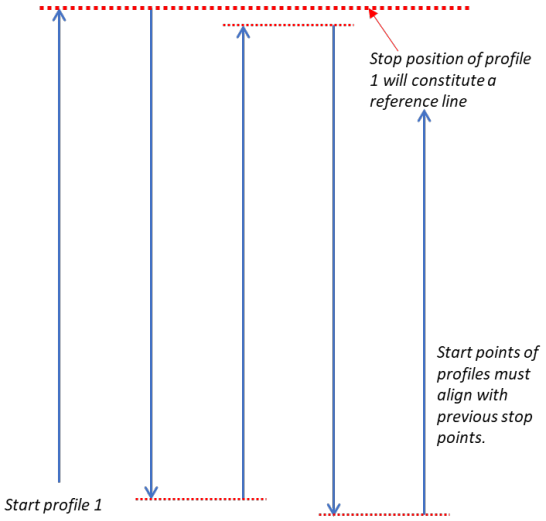

***Figure 23** Layout of Dual View-project*

When the stop button is pressed at the end of a profile, the radargram is automatically reversed, so that the next profile start point is aligned correctly. As the new profile is collected, it's data can be compared with the previous line. Furthermore, the back-up cursor (red line) covers both profiles making it even easier to see how closely reflectors align, as shown in **Figure 24** below.

It is possible to import a DV-project into Crosspoint. Doing so, there should be equidistant spacing between all profiles and profiles should be parallel as required for an RL-project. On import, the end of profile 1 constitutes an artificial reference line. If this is thought of prior to the survey, a DV-project may be used for post-processing/interpretation just as an RL-project.

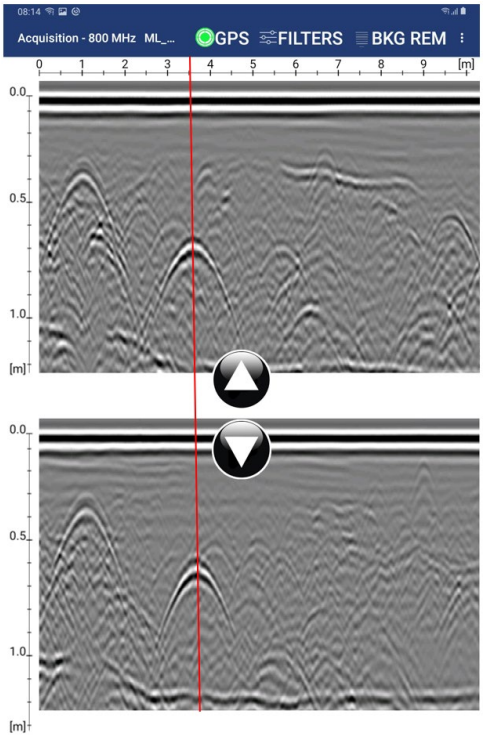

Figure 24 *Dual-View project showing two parallel profiles with a back-up cursor*

GPS-projects

As the name suggests, this project type requires GPS for positioning. However, to be of any use for accurate mapping a survey-grade RTK-GPS is required. That said, it is possible to run a GPS-project using the PinPointR antenna's internal GPS, but this will lack the precision required for accurate interpretation.

When using GPS, everything is arranged according to the accuracy of the GPS, so no special survey procedures are required. Simply start and stop profiles as required or take a single long profile whilst zig-zagging across the survey area. However, the former makes for much easier data interpretation when using CrossPoint since several profiles can be viewed simultaneously. Regardless, CrossPoint will correctly load maps and data.

Viewing files

The IPR App is not intended for data analysis; however, saved files may be viewed to assist in making decisions on-site, including QA/QC of collected data. There is no special view for project-based data, but individual profiles are accessible. When viewing saved files, you may zoom and adjust gain/contrast just as you would during data collection. However, an additional function is provided to scroll along with profiles, which is controlled using one finger-swipe horizontally.

Note on survey speed and settings

The PinPointR system can produce very large amounts of data. The bottleneck in survey speed is mostly related to the Ethernet-link.

At high survey speeds and short distance intervals, the system will rarely be able to go beyond 16-bits, therefore the load on the data link may be reduced by choosing to collect 16-bit data, instead of 32.

Choosing unnecessary long time-windows (number of samples) also increases the data transfers, so choosing a fitting time-window is a recommendation.

Finally, all GPR-systems loose lateral-resolution at depth. This decreases the demand on the distance interval, point spacing, no need to collect denser data than necessary, with respect to what you want to resolve. So, increasing the point distance also takes the load off the data-link. We have set the minimum point distance to 1[cm], so short distance interval is only suitable for concrete scanning with the 800MHz.

Note on Wi-Fi communication disturbances

If Bluetooth is enabled in your measuring device (phone or tablet), it will cause disturbances of the Wi-Fi communication between your device and the antenna. Therefore, the IPR App will prompt you and then automatically disable Bluetooth if it is enabled.

When the IPR App is connected to the antenna, the app will block your device from connecting to other local Wi-fi networks, to prevent your device from automatically switch to another Wi-fi during an ongoing survey.

Note: If you have several devices nearby that are connected or have been connected to the IPR antenna it is very important to disable the Wi-fi in all those devices (except your measuring device). Our recommendation is to turn those devices in flight mode! If you don't do this, the communication between your measuring device and the antenna may be disturbed and cause many missed traces.

Appendix A, Specifications

ImpulseRadar products are under continuous development and we reserve the right to change specifications at any time and without prior notice. You may verify product specifications at any time by contacting our headquarters at support@impulseradar.se

PinPointR

ANTENNA	
Technology	ImpulseRadar real-time sampling
Antenna type	PinPointR dual-channel
Centre frequency	CH-1: 400 MHz / CH-2: 800 MHz
Signal to noise ratio (SNR)	>100 dB
Significant/useful number of bits	>16 bit
Scans/second	>800
Survey speed	> 130 km/h @ 5 cm point interval
Time window	400 ns
Bandwidth	>120%, fractional, -10 dB
Acquisition mode	Wheel, time or manual
Positioning	Wheel encoder, internal DGPS, external GPS (NMEA 0183 protocol)
Power supply	12 V Li-Ion rechargeable battery, or ext. 12 V DC source
Power consumption	1.26 A
Operating time	7 hours
Dimensions	444 x 355 x 194 mm
Weight	6.35 kg (including battery)
Operating temperature	-20° to +50°C
Environmental	IP65
Regulatory certification	Pending (FCC & CE)
CART	
Dimensions (folded for transport)	870 x 540 x 370 mm
Dimensions (when in use)	1010 x 540 x 1030 mm
Wheels	4 x Ø315 mm
Weight	12.8 kg (Cart only)[1], 20 kg (Cart, Antenna & display)[2]
USER INTERFACE	
Display	720 x 1280 pixel or better
Operating system	Android™ (>ver. 6.0) or later
Memory	2.7 GB SDRAM or better
Processor	Intel Atom x5-Z8550, Quad-core 2.3 GHz Krait 400 or better
Recommendation	*Panasonic Toughpad FZ-A2 (or equivalent)*

Files stored in the project directory

<project name> - current project name (project data directory has the same name)

<project name>_Combined - combined files are saved in the subdirectory

File Type	Description	Naming Convention	Explanation
***.IPRB**	Profile Data File	<project name>_XXX_AYY.iprb	Where YY is profile (channel) running number (counting from 1) and XXX is a profile running number (counting from 1) [1]
***.COR**	Positions from GPS	<project name>_XXX.cor	where XXX is a profile running number. [1]
***.mlproj**	Multi Line Project Data File	<project name>_XXX.mlproj	Where YY is profile (channel) running number (counting from 1) and XXX is a profile running number (counting from 1) [1]

Table 1 *ImpulseRadar file types and descriptions*

[1] *file names are padded with zeros to replace 'X', e.g. <project name>_001_AYY.iprb*

Files/information stored in the system

Profile Header File (text file)

Example of the Header File	Explanations
HEADER VERSION: 20	Version number
DATA VERSION: 16	16b data format
DATE: 2017-06-12	Measurement date
START TIME: 14:48:13	Measurement start time
STOP TIME: 14:48:38	Measurement stop time
ANTENNA: 800 MHz	Antenna frequency
ANTENNA SEPARATION: 0.090	Antenna separation in meters
SAMPLES: 500	Number of samples in a trace
SIGNAL POSITION: 6	Signal position
CLIPPED SAMPLES: 0	Clipped samples (not in use now)
RUNS: 64	Number of runs
MAX STACKS: 512	Maximum number of stacks
AUTOSTACKS: 1	Autostacks (1 = ON)
FREQUENCY: 10240	Sampling Frequency
TIMEWINDOW: 48.828	Time Window in nS
LAST TRACE: 1741	Number of traces in the Profile
TRIG SOURCE: wheel	Trig Source – time or wheel
TIME INTERVAL: 0.010	Trig Interval if the trig source is time (sec)
DISTANCE INTERVAL: 0.009778	Trig interval if the trig source is wheel (m)
USER DISTANCE INTERVAL: 0.010000	Distance interval for interface
STOP POSITION: 17.024	Stop Position in meters
WHEEL NAME: cart	Wheel name (max 20 chars)

WHEEL CALIBRATION: 306.799877930	Wheel calibration (ticks per meter)
ZERO LEVEL: 58	Zero Level
SOIL VELOCITY: 100	Soil Velocity (m/uS)
PREPROCESSING: Unknown Preprocessing	Pre-processing information
OPERATOR COMMENT: Android SDK: 28 (9) Device: Sony H8324	Android Version and Device Name
ANTENNA F/W: 49000072	Receiver Firmware Version
ANTENNA H/W: F1702	Not in use now
ANTENNA FPGA: D085	Receiver FPGA Version
ANTENNA SERIAL: CO_117755	Receiver serial number
SOFTWARE VERSION: CO 1.163	Software version
POSITIONING: 0	Positioning: (0-NO; 1-TS; 2-GPS)
CHANNELS: 2	Number of channels used
CHANNEL CONFIGURATION: 1	This channel configuration
CH_X_OFFSET: 0.000	Channel Position relative to ext. positioning
CH_Y_OFFSET: 0.000	Channel Position relative to ext. positioning
MEASUREMENT DIRECTION: -1	Forward or backward
RELATIVE DIRECTION: 90	Direction to RL start (clockwise 360°)
RELATIVE DISTANCE: 1.000	Distance from RL start to cross-section
RELATIVE START: 0.000	Distance from profile start to cross-section

Table 2 *Profile header file information*

Profile Data File

This is a binary file. PinPointR can create data files with a 16-bit or 32-bit data format (see the field "DATA VERSION" in the header file). Samples are stored as signed 16-bit or 32-bit integers. The traces are stored sequentially.

Positions from GPS

This is a text file. The file format is simply a parsed version of the NMEA string written with tab separators as follows:

Trace number <tab> date <tab> time <tab> latitude <tab> ”N” <tab> longitude <tab> “E” <tab> height above MSL <tab> “M” <tab> Fix quality (4 – RTK)*

Trace number is counted from 1 (not from 0). Trace number is connected to positions exactly using time from internal GPS.

Example:

1	2017-03-15	10:12:19:601	65.18991723150	N	18.72870853800	E	317.289	M	4
2	2017-03-15	10:12:19:796	65.18991695317	N	18.72870772433	E	317.527	M	4
5	2017-03-15	10:12:20:000	65.18991630983	N	18.72870888283	E	317.528	M	4
8	2017-03-15	10:12:20:203	65.18991530700	N	18.72871088067	E	317.525	M	4
12	2017-03-15	10:12:20:398	65.18991406333	N	18.72871390350	E	317.562	M	4
17	2017-03-15	10:12:20:601	65.18991227283	N	18.72871711767	E	317.588	M	4
23	2017-03-15	10:12:20:796	65.18991046267	N	18.72872101300	E	317.557	M	4
33	2017-03-15	10:12:21:000	65.18990848683	N	18.72872542550	E	317.557	M	4

* Fix quality field:
0 = invalid
1 = GPS fix (SPS)

```
2 = DGPS fix
3 = PPS fix
4 = Real Time Kinematic
5 = Float RTK
6 = estimated (dead reckoning) (2.3 feature)
7 = Manual input mode
8 = Simulation mode
```

Multi-Line Project Header (.mlproj), text file

Dual-view proj type 1

ML_PROJECT_TYPE: REF_LINE
<profiles>
2ch dual nr2_001_0
2ch dual nr2_001_1
2ch dual nr2_002_0
2ch dual nr2_002_1
2ch dual nr2_003_0
2ch dual nr2_003_1
</profiles>
TYPE: 1
SEPARATION: 0.25

Ref line proj type 2

ML_PROJECT_TYPE: REF_LINE
<profiles>
2ch refline nr2_001_0
2ch refline nr2_001_1
2ch refline nr2_002_0
2ch refline nr2_002_1
</profiles>
TYPE: 2
SEPARATION: 0.25

ML proj GPS 3

ML_PROJECT_TYPE: GPS
<profiles>
1.201 extern gps ml outside_001_0
1.201 extern gps ml outside_001_1
1.201 extern gps ml outside_002_0
1.201 extern gps ml outside_002_1
1.201 extern gps ml outside_003_0
1.201 extern gps ml outside_003_1
</profiles>
TYPE: 3
SEPARATION: 0.25

Appendix C, GPS

How RTK Works

RTK involves a stationary base station and one or more mobile GPS receivers, also known as rovers. Provided that the base station has continuous line-of-sight to each rover, it transmits GPS corrections to each in real-time using radio waves. If a sufficient number of satellites are visible, RTK can provide a fixed position within a fraction of an inch. If insufficient satellites are visible, RTK can provide only a float solution, with a precision of a few inches.

Fixed RTK

RTK uses a complicated mathematical formula or algorithm to calculate the exact number of radio wavelengths between the satellites and the base station antenna -- a process known as ambiguity resolution -- and yield either a fixed or float solution. In a fixed solution, the number of wavelengths is a whole number or integer, and the algorithm is constrained to yield a whole number. A low number of visible satellites, poor satellite constellation geometry, and a poor radio link between the base station and the rover may prevent a fixed solution.

Float RTK

In a float solution, the algorithm does not yield an acceptable fixed solution, so the ambiguity is allowed to be a decimal or floating-point number. According to Tripod Data Systems, a float solution typically generates precise coordinates to between 4 and 18 inches over a known distance between two points of just over half a mile. If a float solution is the only solution available, it may be possible to reinitialize an RTK system, or wait, for a more precise fixed solution. However, if poor satellite visibility is to blame, a fixed solution may be unavailable.

Considerations

The precision of RTK data collection depends on the distance between the base station and the rovers, so it's desirable to keep the distance between them to less than 6 miles. RTK systems are available in single and dual-frequency versions; dual-frequency versions are typically faster, more precise and operate over longer distances than single frequency versions, but they are correspondingly more expensive.

Appendix D, Regulatory notices

The operation of GPR instruments is governed by various regulatory bodies and legislation depending on geographic location as follows:

- Europe ETSI EN 302 066-1&2 Vl.2.1
- US FCC, Part 15.F
- Canada IC RSS-220 limits

The CrossOver-antennas meets the legislation requirements for each of these regulatory bodies.

A common requirement of these regulations is that GPR equipment should only be used by professionals and those who adhere to the following rules of operation:

- UWB-transmitters should always be used near the ground or the material under investigation
- When not in use, the data collection should be stopped, and the unit/s switched off
- The transmitters should not be directed upwards, only towards the investigation body

Additional notes for users in Canada and the US

The operation of this device is restricted to law enforcement, fire and rescue officials, scientific research institutes, commercial mining companies, and construction companies. Operation by any other party is a violation of 47U.S.C.301 and the operator may be subject to legal penalties.

Operation is subject to the following conditions: (1) this device may not cause harmful interference and (2) this device must accept any interference received, including interference that may cause undesired operation of the device.

The operation of this device shall only occur when in contact with or within 1 m of the ground.

RSS 220:

Ce dispositif radar à pénétration du sol ne doit être utilisé qu'en contact avec le sol ou à au plus 1 m du sol.

Ce dispositif radar à pénétration du sol ne doit être utilisé que par des organismes d'application de la loi, des établissements de recherche scientifique, des sociétés minières commerciales, des entreprises de construction, et des organismes d'intervention d'urgence ou de lutte contre les incendies.

RSS GEN :

This device contains license-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada’s licence-exempt RSS(s). Operation is subject to the following two conditions:

(1) This device may not cause interference.

(2) This device must accept any interference, including interference that may cause undesired operation of the device.

L'émetteur/récepteur exempt de licence contenu dans le présent appareil est conforme aux CNR d'Innovation, Sciences et Développement économique Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes:

1. L'appareil ne doit pas produire de brouillage;

2. L'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

GPR Use Coordination (USA)

FCC regulation requires users of GPR equipment to coordinate the use of their GPR equipment as described below:

§15.525 Coordination requirements.

(a) UWB imaging systems require coordination through the FCC before the equipment may be used. The operator shall comply with any constraints on equipment usage resulting from this coordination.

(b) The users of UWB imaging devices shall supply operational areas to the FCC Office of Engineering and Technology, which shall coordinate this information with the Federal Government through the National Telecommunications and Information Administration. The information provided by the UWB operator shall include the name, address and other pertinent contact information of the user, the desired geographical area(s) of operation, and the FCC ID number and other nomenclature of the UWB device. If the imaging device is intended to be used for mobile applications, the geographical area(s) of operation may be the state(s) or county(ies) in which the equipment will be operated. The operator of an imaging system used for fixed operation shall supply a specific geographical location or the address at which the equipment will be operated. This material shall be submitted to Frequency Coordination Branch, OET, Federal Communications Commission, 445 12th Street, SW, Washington, D.C. 20554, Attn: UWB Coordination.

(c) The manufacturers, or their authorized sales agents, must inform purchasers and users of their systems of the requirement to undertake detailed coordination of operational areas with the FCC prior to the equipment being operated.

For your convenience, the information required by the FCC is indicated on the next page, please print and fill in the information and put the letter in the mail. FCC will respond with confirmation of coordination.

Date: _____

To:
Frequency Coordination Branch., OET
Federal Communications Commission
445 12th Street, SW
Washington, D.C. 20554
ATTN: UWB Coordination
Fax: 202-418-1944

RE: FCC GROUND PENETRATING RADAR COORDINATION NOTICE

COMPANY NAME:

_____
_____
_____

PRIMARY ADDRESS:

_____
_____
_____
_____

CONTACT INFORMATION [CONTACT NAME AND PHONE NUMBER]:

_____
_____
_____

AREA OF OPERATION [COUNTIES, STATES OR LARGER AREAS]:

_____
_____
_____
_____

FCC ID (tic the box)

CrossOver 4080: 2ALZQ-CO4080 ☐