CrossOver User manual

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About this manual

ImpulseRadar CrossOver antennas are state-of-the-art, self-contained Ultra-Wide Band (UWB) Ground Penetrating Radar (GPR) systems. The dual frequencies and mechanical design combined with the various accessories, such as push-carts and pulling-kits, makes each antenna suitable for several different 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 in relation to this manual and its content. Please send your comments or suggestions to us at: info@impulseradar.se

Hardware

Overview

ImpulseRadar CrossOver antennas are self-contained Ultra-Wide Band (UWB) Ground Penetrating Radar (GPR) systems. The electronic design is based on a modern real-time sampling (RTS) technology platform, offering state-of-the-art data acquisition capabilities. Each CrossOver antenna incorporates two separate GPR-channels, operating at high speed as well as an in-built differential GPS. The following antennas are available at the time of writing:

Antenna	Abbreviation	Centre Frequency
• CrossOver 730	CO730	70 MHz and 300 MHz
• CrossOver 1760	CO1760	170 MHz and 600 MHz
• CrossOver 4080	CO4080	400 MHz and 800 MHz

The CrossOver antennas are supported with a range of accessories that includes push-carts (CO4080 and CO1760 only), pulling kits and external GPS mounts, as shown in **Figure 1** below.

Figure 1 *System overview*

Data collection is managed over an Ethernet link and a suitable Android device/PC running the CrossOver App (CO-App). With the CO-App, the operator may collect single line data, albeit with two frequencies, or a few different types of multi-line projects. Whether 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

Antennas

In Figure 2 below the whole CrossOver series is shown, side, by side.

Figure 2, The CrossOver GPR antennas, left-to-right; CO4080, CO1760 and CO730.

Apart from physical size, CrossOver antennas share a similar mechanical design and the same arrangement for the battery, connector panel and measuring wheel mount. A CO4080 antenna is used to highlight these features, as shown below in **Figure 3**.

Regardless of model, each Crossover antenna 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 3 *CO4080 antenna with battery attached*

Connector panel

Refer to the arrangement shown in **Figure 3**:

- **Yellow** – Kill switch. In certain countries, a GPR device used on walls should have a kill-switch. If required, this connector allows the connection of an external kill switch. Note that for those countries where kill-switch is required, the units will not work without it attached and the button on the handle depressed.

- **Red** – Power and Ethernet. A battery is the preferred way of powering the antenna; however, an optionable power cable is available upon request. This connector is also used for testing and factory upgrades via Ethernet.
- **Silver** – On/Off button. Press the button once for approx. 2s to switch the antenna on. When on, the button glows blue. A subsequent press will switch the antenna off.
- **Blue** – External GPS. Allows the connection of an external GPS antenna to provide higher precision positioning. Communication is based on RS232 and the NMEA 0183, V2, protocol.
- **Black** – Measuring wheel. Note, this connector is placed further back on the lower frequencies.

All cable-connectors are high-quality Yamaishi-type. Cable-connectors are inserted/removed by holding the connector sleeve then gently pushing or pulling straight without turning. The connectors are keyed so that it's not possible to damage the unit by attaching a cable to the wrong connector.

Battery

CrossOver antennas are powered via a removeable 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 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 4** below.

Figure 4 *Mounting the battery*

Cart

The CO4080 and CO1760 antennas can be used with optional Carts (foldable), as shown below in **Figure 5**. The push-cart allows the antenna to be manoeuvred easily over a range of surfaces.

Figure 5 *CrossOver Cart (foldable)*

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

When not in use, the handle mechanism can be folded by removing the M5 retaining screw, as shown in **Figure 5** 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 allows the antenna to be positioned on, or very close, to the ground surface. This arrangement, as shown in **Figure 6** below, allows the antenna to 'float' freely vertically and follow the contour of the ground, or move over bumps and other small obstacles.

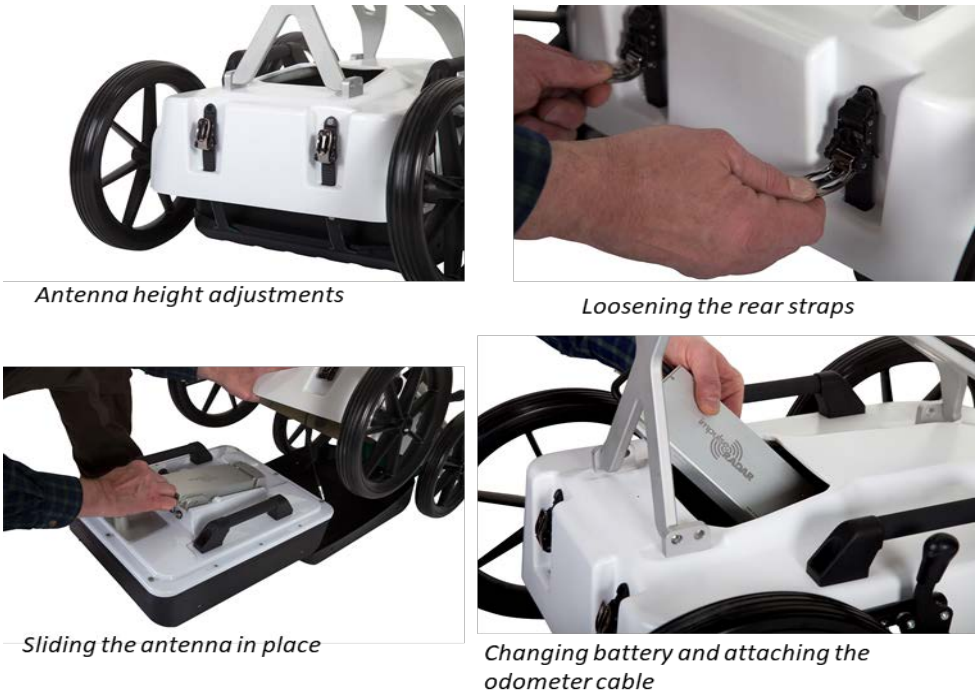

Figure 6 *Antenna fitting and height adjustments*

Antenna fitting procedure, as referenced in **Figure 6** above:

1. Remove the rear straps from the snap connectors
2. Lift the cart-hood and slide the antenna into the support tray
3. Connect the odometer cable (black connector)
4. Close the cart-hood and refit the rear straps into the snap connectors
5. Adjust the front and rear straps to obtain the desired height
6. When needed, the battery may be fitted/removed through the opening in the cart-hood

Note: *when removing the antenna, remember to disconnect the odometer cable prior to lifting the cart-hood.*

Odometer encoder

To measure distance, the push-cart incorporates an odometer encoder that links to the antenna via the odometer cable and connector. The encoder itself, is connected to the right-rear wheel by means of a rubber O-ring. If needed, this O-ring can easily be removed and replaced by first removing the wheel by unscrewing the M6 retaining screw (as shown in **Figure 7** below).

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

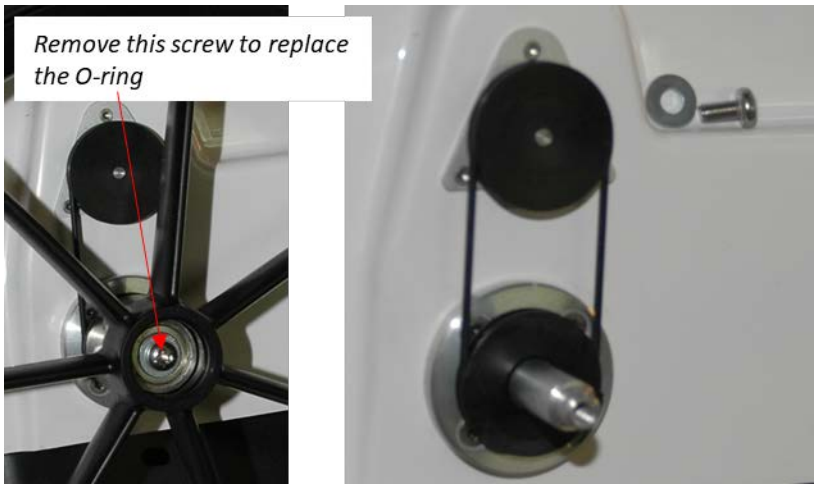

Figure 7 *Odometer encoder and wheel assembly*

GPS mounts

A range of optional GPS mounting accessories are available for both the push-cart and antenna itself, as shown below in **Figure 8**. The mounting poles are available in different lengths to vary the height of the GPS antenna, as/if needed.

Figure 8 *GPS-mounts for the Cart and antennas*

Measuring wheel

Referring to figure 8, below. The measuring wheel is made of printed plastics, the odometer and cable are housed inside, protected. Downward pressure is accomplished with rubber straps and the shape

Figure 9, Measuring wheel attached on antenna

is optimised for smooth operation, in all cases. Please note that there's a threaded hole in the mounting part, for keeping the locking bolt when the wheel is not in use (will help our clients keep track of the bolt).

Pulling kit

The pulling kit consists of pulling rods, chest-harness, waist belt

These accessories are primarily used in rough terrain, where carts are non-practical, and of course with the CO730-antenan for which no cart is available, see **Figure 10**, below.

Figure 10 *practical use of the waist belt, pulling rods, handle and pad-harness*

Software

Overview

CrossOver has been designed to work over an ethernet link with suitable Android devices running the CrossOver App. Refer to **Appendix A** for a list of specification requirements. Note that an adapter may be needed.

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 screen shots and menus as taken from a recommended device. However, this may be slightly different to your personal device.

CrossOver 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 CrossOver 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 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 CrossOver App.

The CrossOver 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 <CrossOver-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 CrossOver App to access photos, media and files on your device, so that radargrams can be saved and opened

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

Using the CrossOver App

From the home screen of your Android device, press the CrossOver App icon to enter the application's start screen. The start screen, as shown below in **Figure 11**, provides access to the various functions of the CrossOver App.

From **Figure 11**, the left image shows an example of when a CrossOver antenna is properly connected, with all functions are 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 at the bottom of the start screen and this may be requested in the event you need support services.*

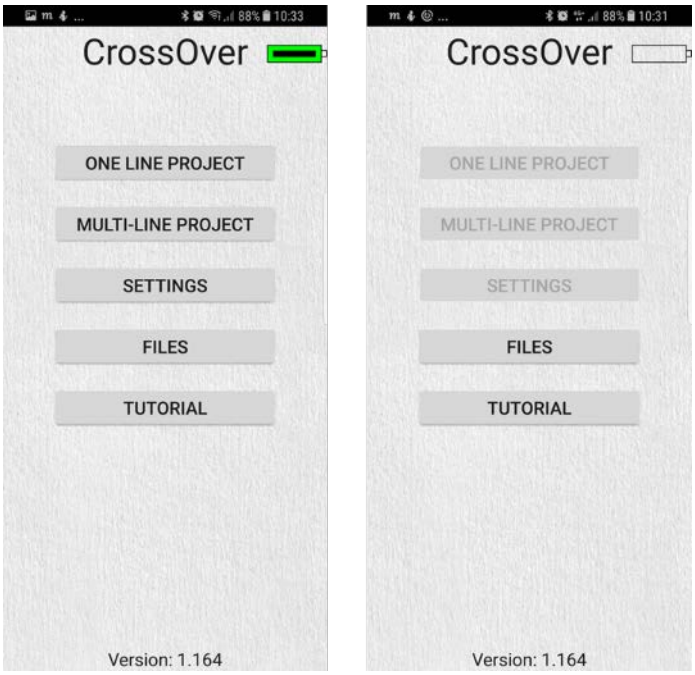

Figure 11 *CrossOver start screen. Right: not connected device.*

Settings

The settings menu, as shown in Figure 12, below, contains the parameters needed for controlling the CrossOver antenna during data acquisition. Once set, these parameters remain unchanged for all subsequent data acquisition.

A detailed description of each parameter follows:

- **Trig Source** – defines how data collection is controlled. Typically, this will be one of the CrossOver wheel options, but for certain applications, 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].
- **Measurement Units** – defines whether metric or Imperial values are used. When set to Imperial, the units will be in feet (ft.) and 10ths of ft.
- **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 is calculated based on the Soil Velocity.
- **Data Mode** – defines how many bits are used while storing the resulting radar data. CrossOver 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 increase the risk of dropping data in Ethernet-link, use 16 bits and not unnecessary long time-windows to reduce 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. Standard wheel options include Cart and Single, but you may create additional wheels and/or adjust wheel calibration settings as described in the 'wheels' section below.
- **Restore factory settings** – If internal settings has been corrupted or after a firmware upgrade, it's advisable to restore to factory settings, all essential system parameters will be reset to initial state.
- **Firmware upgrade** - Menu trough which upgrade of firmware may be done, see later paragraph.

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

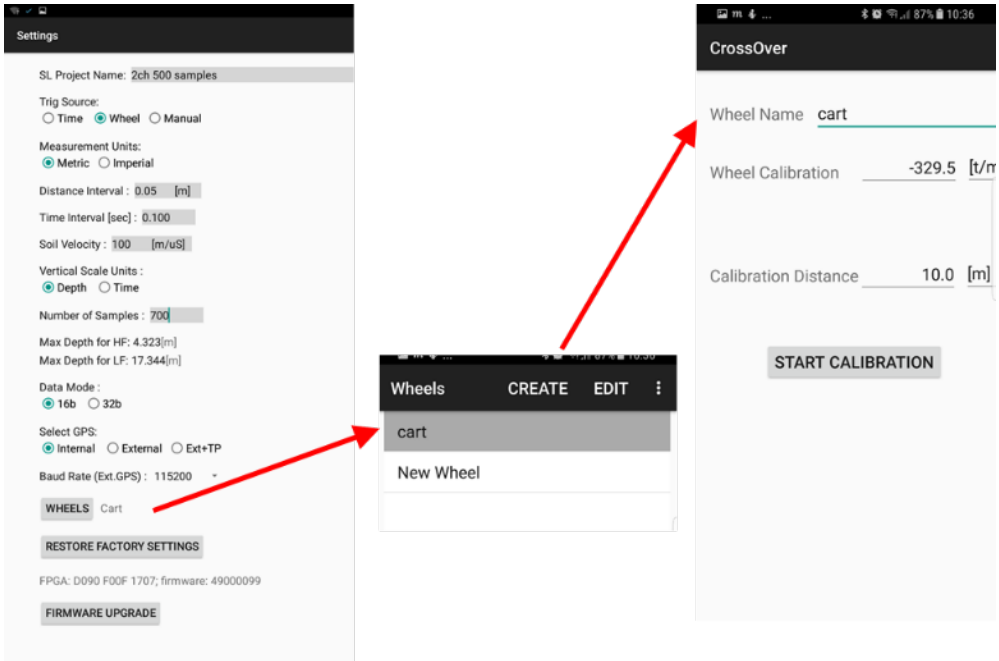

Figure 12, Settings menu and two of its child-menus, wheel selection and calibration

GPS-symbols and function

In Figure 13 below the menu bar during data collection is shown. The GPS is shown as a green circle with a blue centre, this symbol will change, dependent on what type of fix is available and from what source the GPS-coordinates are coming. Note that, for the GPS-coordinates to be saved on file, the GPS-symbol need to be shown, prior to starting the data collection.

Figure 13, Menu bar during data collection

By pressing the GPS-symbol a, static view on the present satellites and coordinates can be viewed, see Figure 14, below.

As mentioned the GPS symbol will change with the solutions at hand, the symbols we use to show this are given in Figure 14.

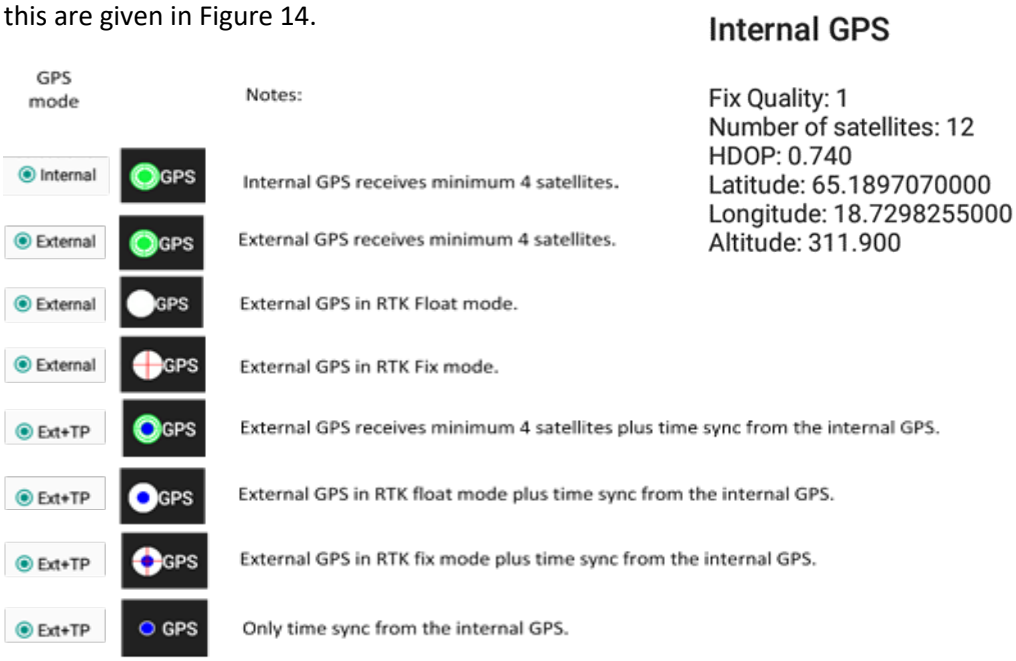

Figure 14, GPS-symbols and their meaning and GPS information shown when the symbol is pressed

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, 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

You may create additional wheels and/or adjust wheel calibration settings as required. The associated dialogue for these functions is shown above in Figure 12, above.

A common situation involving the creation of a new wheel, is when using a CrossOver antenna in conjunction with a vehicle. This typically requires a wheel encoder to be attached to a wheel on the survey vehicle itself, for trig and distance measuring purposes.

Calibration of a wheel is done by entering the calibration distance, hitting the <START CALIBRATION> button and then moving over that distance. Press the <Stop button> once the calibration distance has been reached. This measures the number of tics/m that the wheel produces and saves this as a calibration value. However, if you already know the number of tics/m the wheel will produce, you may enter this value directly and then leave the dialogue.

Standard wheel options:

- CrossOver Single wheel:-382.0

- CrossOver Cart: 306.6

Data viewing and adjustment

The screen and system functionality are much the same, regardless of project type. During data acquisition, 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.

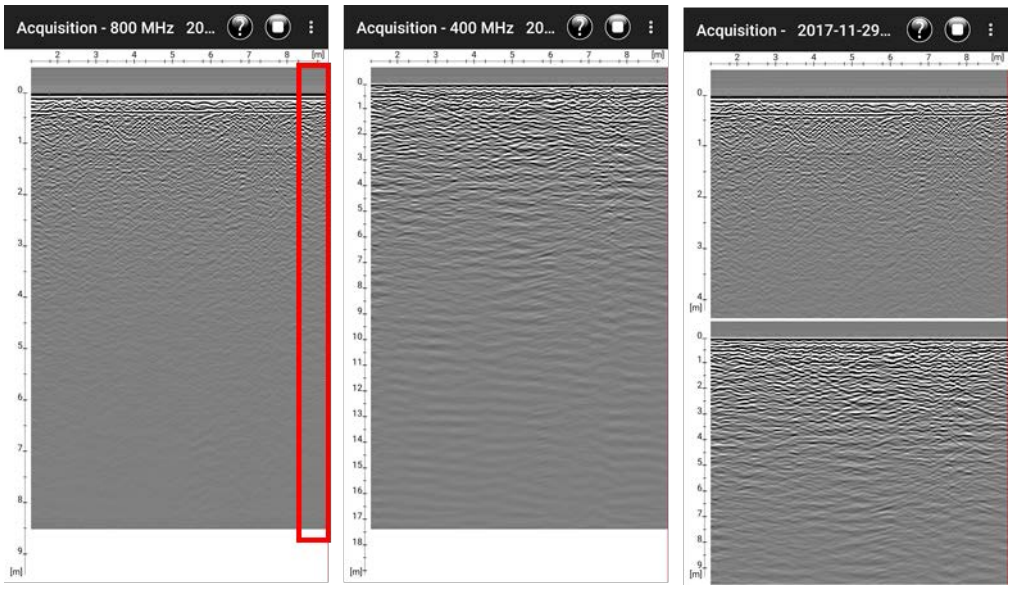

Figure 15 *Screen views during data acquisition, marked area shows where to adjust gain and contrast*

In the single-channel view, the gain and contrast of the radargram image can be adjusted at the right-hand side of the screen (red highlighted area), as shown in **Figure 15** above. A single-finger vertical swipe, up or down in this area, will increase or decrease the gain/contrast respectively.

Note: *the images shown in* ***Figure 15*** *are screen shots form an Android mobile 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 15** above.

Zooming is done, as on other Android-devices, with two-finger gestures, increasing or decreasing the distance between the fingers.

If the radargram does not fit on the screen, scrolling may be done with a 3-finger gesture, dragging the fingers up and down on the screen, will scroll the radargram.

Other buttons provide functionality for controlling the collection of data, including Start, Halt/Resume and Stop. Pressing the Halt button temporarily pauses 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. 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 14 below.

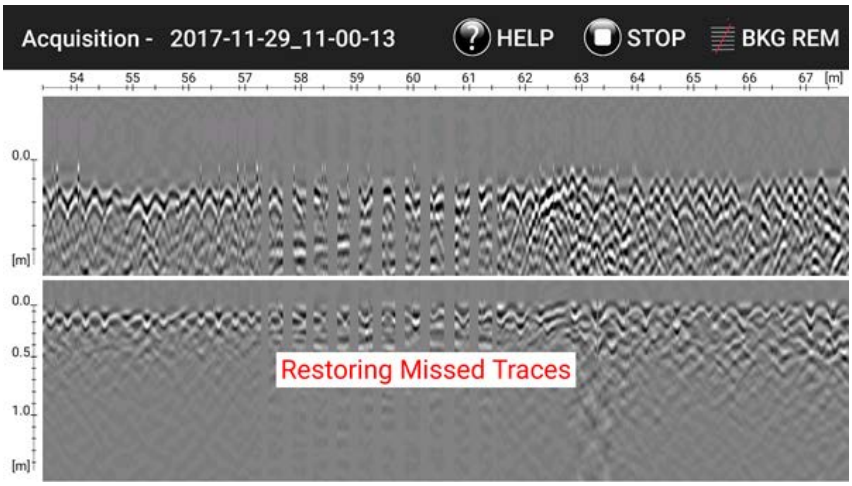

Figure 16 *Data recovery when the acquisition is stopped*

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 satellites.

Multi-line project

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

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

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 17, below.

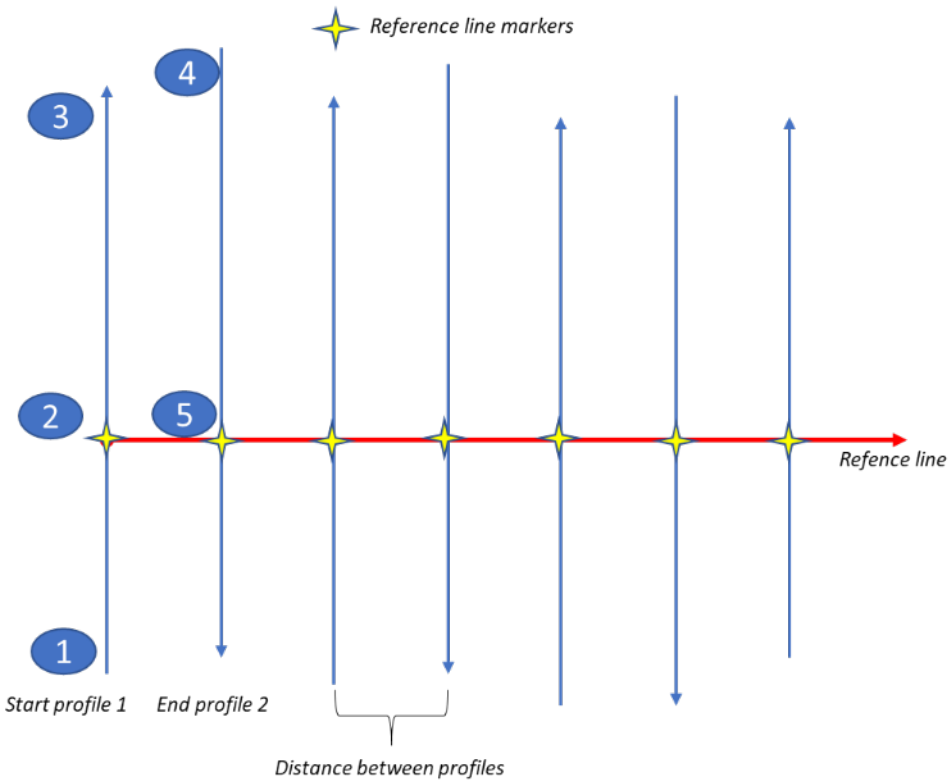

Figure 17, Layout of a reference-line project

From the project start screen (**Figure 18** 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 18 *Multi-Line Project start screen*

Once the project has started, the data collection screen will appear with directional control buttons, as shown in **Figure 19** 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.*

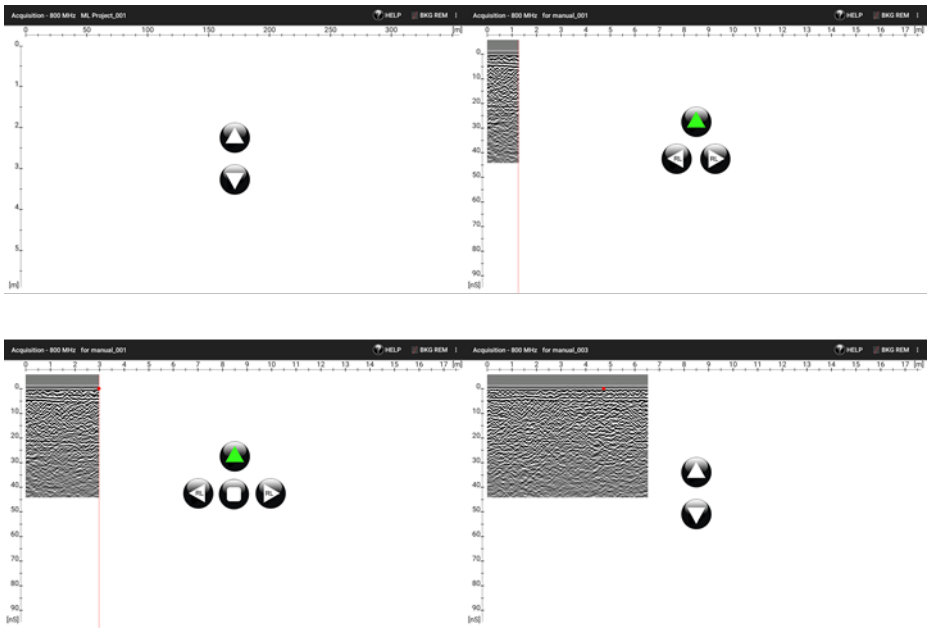

Figure 19 *Screen views and controls during reference-line projects*

Select the direction of data collection (forward/backward) and press the appropriate button to start the profile. 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' button. The right button is selected, because the next profile will be to the right. 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) and the forward/backward button is pressed to start the measurement. Upon reaching point 5, a reference marker is again placed into the data. This time the left marker button is selected (if the cart was turned and data collection done in the forward direction), because now the next profile will be to the left.

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.

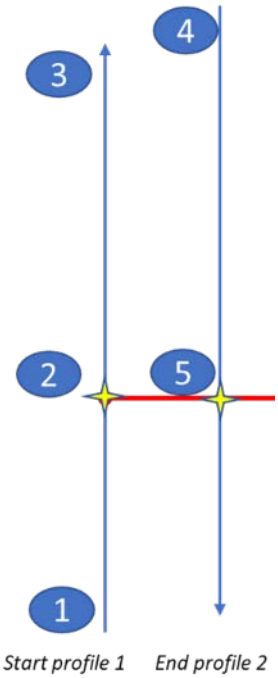

Figure 20, RL-project profile collection

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 21, below.

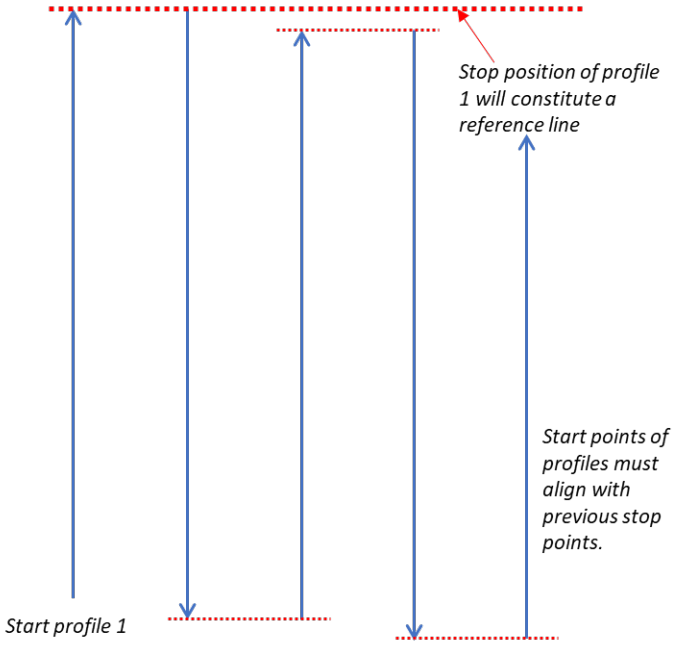

Figure 21, Layout of Dual View-project

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 22** 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 though of prior to the survey, an DV-project may be used for post-processing/interpretation just as an RL-project.

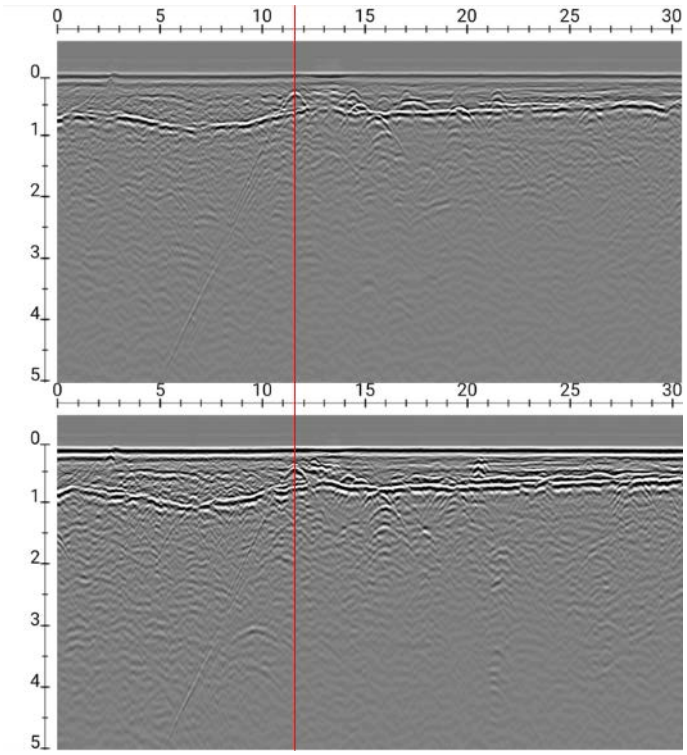

Figure 22 *Dual-View project showing two parallel profiles with back-up cursor*

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 CrossOver 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 CrossOver 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 profiles, which is controlled using one finger-swipe horizontally.

Note on survey speed and settings

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

At high survey speeds the systems will rarely be able to go beyond 16-bits, therefore the load on the data link may be reduces by choosing to collect 16-bit data, instead of 32.

Choosing unnecessary long time-windows (number of samples) also increase 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 then necessary, with respect to what you want to resolve. So, increasing the point distance also take 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.

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

CrossOver CO730

ANTENNA	
Technology	ImpulseRadar real-time sampling
Antenna type	CrossOver dual-channel
Centre frequency	CH-1: 70 MHz / CH-2: 300 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	1200 ns, standard
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	1.3 A
Operating time	7 hours
Dimensions	972 x 762 x 270 mm
Weight	19 kg (including battery)
Operating temperature	-20° to +50°C
Environmental	IP65
Regulatory certification	Pending (FCC & CE)
USER INTERFACE	
Display	720 x 1280 pixel or better
Operating system	Android™ (>ver. 5 Lollipop) 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)*

CrossOver CO1760

ANTENNA	
Technology	ImpulseRadar real-time sampling
Antenna type	CrossOver dual-channel
Centre frequency	CH-1: 170 MHz / CH-2: 600 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	900 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	1.2 A
Operating time	7 hours
Dimensions	695 x 445 x 205 mm
Weight	9.5 kg (including battery)
Operating temperature	-20° to +50°C
Environmental	IP65
Regulatory certification	Pending (FCC & CE)
CART	
Dimensions (folded for transport)	920 x 640 x 390 mm
Dimensions (when in use)	1100 x 640 x 1030
Wheels	4 x Ø315 mm
Weight	15.3 kg (Cart only)[1], 25.7 kg (Cart, Antenna & Display)[2]
USER INTERFACE	
Display	720 x 1280 pixel or better
Operating system	Android™ (>ver. 5 Lollipop) 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)*

CrossOver CO4080

ANTENNA	
Technology	ImpulseRadar real-time sampling
Antenna type	CrossOver 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. 5 Lollipop) 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 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	Not in use now
OPERATOR COMMENT: _	Not in use now
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. CrossOver can create data files with 16-bit or 32-bit data format (see the field "DATA VERSION" in 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

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 simply 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

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.

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 licence-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.

Licensing requirements (USA)

§15.50(b)(1) states

Parties operating this equipment must be eligible for lincencig under the provision of part 90 of this chapter.

Caution about modifications

Changes or modifications to this device, not expressly approved by ImpulseRadar Sweden could void the user´s authority to operate the equipment.

Use of a kill-switch (USA)

FCC regulations requires the CO730 to be operated together with a kill-switch, which causes the unit to stop transmitting when the switch is released. For this reason, all units shipped to the US will contain such a device, and the unit will not function without it.

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 appropriate box/boxes)

CrossOver 4080: 2ALZQ-CO4080 ☐

CrossOver 1760: 2ALZQ-CO1760 ☐

CrossOver 730: 2ALZQ-CO730 ☐