

# Raptor

Ultra-Wide Band Ground Penetrating Radar Array System

User Manual



Document information

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# 1 About this manual

ImpulseRadar Raptor® antennas are state-of-the-art, self-contained Ultra-Wide Band (UWB) Ground Penetrating Radar (GPR) systems. The electronic and mechanical design combined with the flexible firmware makes Raptor® antennas configurable for several different applications. The most common of these is subsurface 3D mapping and this manual is written to primarily address the configuration of Raptor® antennas in a multi-channel 3D GPR array for this application.

For information on other applications and/or configurations, please contact your local ImpulseRadar representative, or contact our support team at: [support@impulseradar.se](mailto:support@impulseradar.se)

This manual is structured as follows:

<b>Section 1 - Hardware</b>	Hardware system components and configuration for standard carrier solutions
<b>Section 3 – Appendices</b>	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](mailto:info@impulseradar.se)

## **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 V1.2.1
- US: FCC, subpart 15.103c
- Canada: IC RSS-220 limits

*The Raptor®-45 Transmitter (Tx) meets the legislation requirements for each of these regulatory bodies.*

*The Raptor®-45 Receiver (Rx) and Raptor® Switch/Power box are passive digital devices and therefore require no certification under FCC (subpart 15.103c).*

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 47 U.S.C.301 and the operator may be subject to legal penalties.

Operation is subject to the following conditions:

- This device may not cause harmful interference and
- 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.

## 2 Hardware

### 2.1. Overview

ImpulseRadar Raptor® 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.

The Raptor® Receiver (Rx) antenna incorporates two trig inputs, making it suitable for several different configurations. Regardless of the configuration, Raptor® antennas operate at very high speed and way above that of any conventional GPR system. Configuration options include:

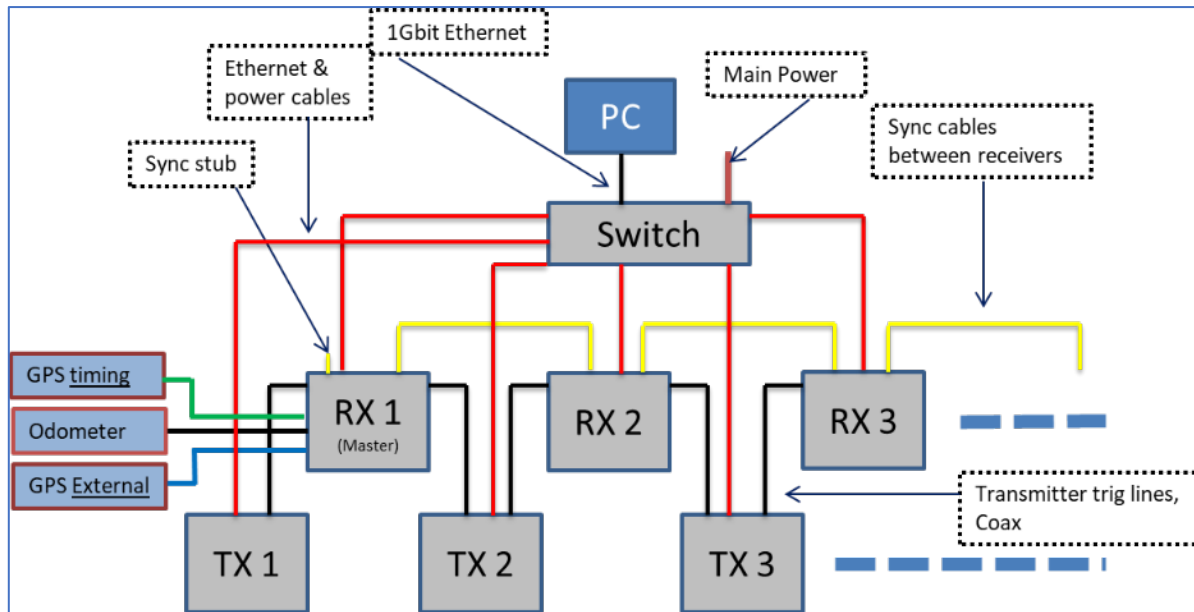
- Single channel
- Two channels with one receiver and two transmitters
- Multi-channel (ordinary) with each receiver controlling one transmitter
- Multi-channel (arbitrary) with each receiver sharing a transmitter with its neighbour/s

Of these configurations, the last one is the most popular and is commonly used for high-speed 3D mapping, which will be the focus for this manual.

For information on other applications and/or configurations, please contact your local ImpulseRadar representative, or contact our support team at: [support@impulseradar.se](mailto:support@impulseradar.se)

### 2.2. Configuration

Figure 1 below, illustrates the typical layout for an arbitrary multi-channel configuration for 3D mapping. A brief description of this layout follows, but a detailed description for each component can be found under the Components section below.



**Figure 1** Simplified system layout with multiple antennas configured for 3D mapping applications

From Figure 1 above, you can see one row of Receivers (RX) and one row of Transmitters (TX); each Receiver is connected to two Transmitters by means of coaxial cables and both sets are connected to the Switch (switch/power box). Each Receiver is also connected to its adjacent neighbours. If a Receiver sits at the end of the row, a 'sync-stub' replaces the cable connection to its missing neighbour. For every configuration, there must be a Master Receiver to which the odometer and GPS (for timing and positioning) are connected.

The GPS (for timing), which is supplied by ImpulseRadar and is also referred to as the internal GPS, is used for timing of individual data (to millisecond accuracy). An external RTK-based GPS system, or Total Station, should be connected and used for positioning. By using the internal GPS for timing only, any time-lag in the positioning is effectively removed, which results in higher quality data.

The Switch is connected via Ethernet cable to the control PC (typically a laptop), whose Ethernet port is set to 1Gbit to facilitate the transfer of the high volume of data.

The main power cable supplies all components, except the PC and the external GPS/Total Station. The cable itself is a 6mm<sup>2</sup> (AWG 9-10). It is important to note the importance of a good quality power supply, and this is described separately under the section **Power requirements – important!**

Figure 2 below, shows a typical 8-channel configuration including antennas, switch/power box, internal GPS and all associated cabling. This configuration fits perfectly into the Raptor® pushcart.



*Figure 2 Typical 8-channel Raptor® configuration*

The Talon® data acquisition and control software needs to run on a Windows PC (laptop) that has a 1Gb Ethernet port and meets the minimum specification requirements to cope with the Raptor® data stream. Refer to Appendix A for detailed specification requirements.

If you want to use real-time-map view during surveys, an internet connection is also necessary. This can be obtained by using a laptop that supports the integration of a SIM card and 4G LTE connectivity, or by configuring a suitable local hotspot to which the laptop can connect.

There are many cables in the system and the length requirement for each needs to be determined based on the configuration. For this reason, it's important to understand how you want to configure and mount the antennas and associated parts. Our technical services team can assist with configuration advice as needed.

## **2.3. Components**

### **2.3.1 Antennas**

#### ***Master Receiver***

For any given configuration, there must be at least one master receiver. A master receiver includes additional inputs to allow the connection of an odometer/wheel encoder and GPS (both internal and external) as shown in Figure 3 below. A master receiver controls the data acquisition by synchronizing the data acquisition with the odometer/wheel encoder or internal clock.

If an internal GPS unit is attached (green connector), the master receiver will automatically tag each trace with a GPS time stamp, expanded to millisecond precision with the help of internal clocks. The internal GPS may also be used to produce positioning coordinates during a survey; however, as an ordinary GPS unit it will not provide the level of accuracy required for 3D data collection.

An external GPS (blue connector) is highly recommended for positioning purposes and should be a survey grade (RTK-GPS) with sub-centimetre accuracy.

A master receiver incorporates a blue LED that can be used to visually confirm what GPS is connected. A 1-time flash indicates the internal GPS unit is connected, whilst a 2-time flash indicates an external GPS is connected. If both internal and external GPS are connected, the LED will light continuously. Refer to

Appendix B for more details on LED colour codes and their meaning.

### **Slave Receiver**

Slave receivers have a combined power/ethernet connector, over which it communicates with the PC at 100 Mb/s. To control data acquisition, sync-connector cables are used to connect each receiver to its adjacent neighbours. When a receiver sits at the end of a row, a 'sync-stub' replaces the cable connection to its missing neighbour.



*Figure 3 Raptor@-45 Master Receiver (left) and Slave Receiver (right)*

### **Transmitters**

A transmitter antenna has two trig input connectors (coaxial) and one power connector. A green LED indicates power, and a flashing blue LED indicates incoming trig signals.

#### **2.3.2 Switch/Power-box**

The switch/power box, as shown in Figure 4 below, is the link between Raptor® antennas and the acquisition/control PC. This device incorporates a third-party 1Gb Ethernet switch and a power distribution board, which supplies power to each antenna.

The device is clearly labelled to show the purpose of each connector. Each numbered antenna connector is fuse protected at 1.5A for transmitters and 3.5A for receivers. The device and its internal circuitry include reverse polarity protection. However, to minimise the possibility of damage, you should only connect cables in the manner described.



*Figure 4 Switch/power box*

Whilst it is not generally necessary to open the switch/power box, there may be rare occasions where this is necessary for troubleshooting purposes. Refer to Appendix C for troubleshooting guidance.

Ethernet switch defaults:

- IP address: 192.168.1.60
- User: admin
- Password: no password set

These defaults should remain unchanged and allow you to login to the Ethernet switch to check its settings and monitor communications/data traffic. It is necessary to login to the switch to make some small changes to the factory settings.

Firstly, ensure that Talon® software has been installed on the acquisition/control PC, and this has been set-up correctly. Refer to the Talon manual available on our website.

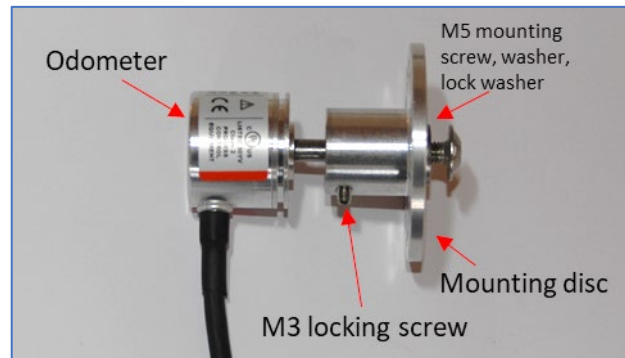
With the switch/power box connected to the acquisition/control PC, open a web browser and login to the switch using the credentials listed above. Check the port settings to ensure that all antennas are on a fixed 100Mb, full duplex link, while the data collection PC should be on an auto-negotiated line.

Modern Ethernet devices such as this, operate using something called green Ethernet, which is a standard for reducing the power needed for communication. However, this is not compatible with the requirements of the Raptor® technology, consequently all power saving features should be disabled under the factory settings.

### 2.3.3 Odometer/wheel encoder

Generally, GPR data collection is controlled by means of an odometer/wheel encoder to get data collected at regular intervals.

The Raptor® pushcart includes an integrated wheel encoder. For vehicle-based surveys, we provide a wheel encoder mounting kit (as shown in **Figure 5**), which you must use to attach the wheel encoder to one of the survey vehicle wheels. This requires some tools and a little preparation.



*Figure 5 Odometer/wheel encoder mounting kit*

On the survey vehicle, select one of the wheels to which the wheel encoder will be fitted and drill a  $\varnothing$  5 mm hole through the hub cap. Attach the mounting disc using the M5 mounting screw and washers as supplied. Attach the odometer to the other end of the disc (as shown in **Figure 5**) and secure its axis with the M3 locking screw. This method of mounting the odometer has proven to be sufficiently strong for normal operations. However, the mounting disc can be secured further by means of the additional holes surrounding its perimeter. We also provide extension cables for the odometer, should they be needed.

### 2.3.4 GPS – timing

To enable precise time-tagging of individual traces, we provide a simple GPS receiver as shown in Figure 6. This is referred to as the internal GPS and incorporates a GPS antenna and timing module. Magnets attached to the rear of the GPS housing allow it to be fitted to the bodywork of the survey vehicle or any suitable metallic mounting point.



*Figure 6 GPS for time-tagging of data*

**Note:** to avoid possible damage to the paintwork of the survey vehicle, we recommend using a thin piece of non-metallic material between the GPS and the vehicle bodywork.

### 2.3.5 GPS/Total Station – Positioning

To obtain accurate results when 3D-mapping, it is necessary to have a positioning system that can provide centimetre accuracy over the entire survey area. Ideally, a survey grade RTK-GPS system should be used; however, in areas where GPS coverage is poor, or non-existent, a total station can be used instead.

Using GPS greatly simplifies the survey process, but you should be confident of good and stable coverage during data collection to avoid losing coordinates or the RTK lock. Losing a few points may not be too problematic for the final data, if the survey lines are relatively straight, but it is critical to have precise GPS positions at the start and end points of each line.

The GPS needs to be configured to output positioning data using the NMEA 0183 protocol with any NMEA-string starting with “\$GPGGA” or “\$GNGGA”.

When using a total station, it is necessary to have line of sight between it and the Raptor® system. If this cannot be achieved with the total station fixed in one position, then you will need to create tie-in points for the other total station positions used during the survey. It is important to note that when using a total station, the positional data will be in a local coordinate system. This local coordinate system must be referenced to the one in which you want the final data presented. Consequently, at least one of the total station positions must be referenced to the final coordinate system used.

## 2.4. Carrier solutions

Since Raptor® antennas can be configured in different ways and for any number of channels from 1 to 30, our customers generally prefer to make their own carrier solutions to satisfy their application or project requirements. That said, our technical services team can offer design advice related to custom-made carrier solutions. For those who prefer an off-the-shelf solution, the Raptor® pushcart or vehicle mounted carrier solution allow the configuration of up to 8 or 18-channels respectively.

### 2.4.1 Cart

The Raptor® cart is a portable and light-weight carrier solution that can accommodate up to 8-channels and is ideally suited to survey pavements/sidewalks, smaller areas, or those where access may be limited. Figure 7 and Figure 8, below illustrate the cart, its various features, antenna configuration and fitting. The antennas are mounted on an adjustable undercarriage, which also acts as a replaceable skid/wear plate. The mounting straps allow for height adjustment as needed. The design allows the antennas to move up and down and to maintain close ground contact to enhance data quality. When folded, the cart will fit into the boot space of a European estate car.

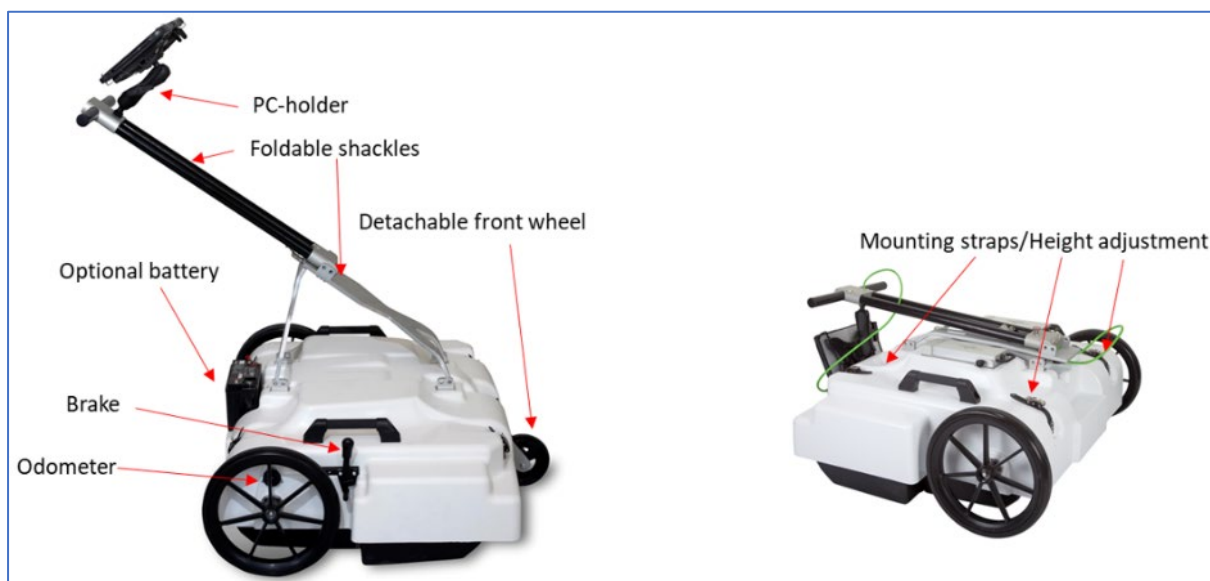


Figure 7 Raptor® cart fully assembled for use (left) and folded for transportation/storage (right)

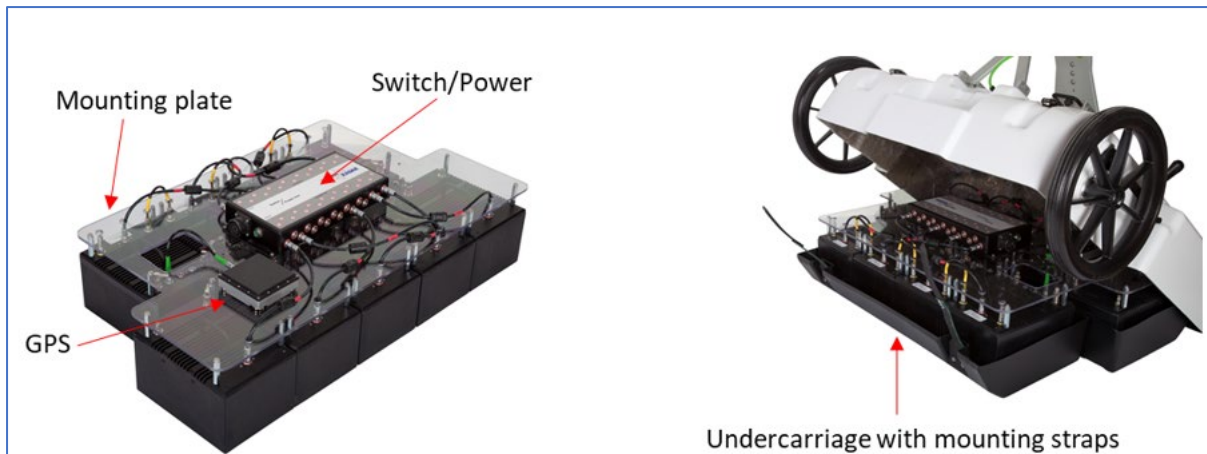


Figure 8 An 8-channel Raptor® configuration with mounting plate installed in the Raptor® cart

The Raptor® cart includes mounting plates for two standard ImpulseRadar rechargeable batteries, which will provide approximately four hours of operation. Additional batteries may be kept on standby and swapped out to extend operating time. Alternatively, an external motorcycle style battery may be used to offer extended operation. The cart hood includes a dedicated space at the rear with a moulded shelf where such a battery can be fitted. Moreover, Raptor® pushcart can be provided as a four-wheel solution as shown in Figure 9.

A mounting point on the handle assembly allows a GPS antenna or total station prism to be fitted centrally above the antenna assembly. Mounting accessories are also available to increase the height of the antenna/prism and to secure against unwanted sideways movement.

A survey-ready configuration with standard batteries and external GPS is shown in Figure 9.

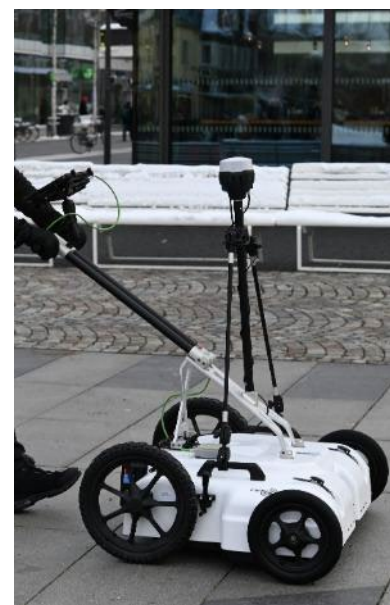


Figure 9 Survey ready 8-channel Raptor® push-cart configuration

## 2.4.2 Vehicle mount

The vehicle mounted carrier solution allows the configuration of up to 18-channels and is suited for surveying larger areas and roads. The carrier can be mounted on to the tow-ball of any vehicle that can safely support the total weight of 70 kg. For other types of tow bar/hitch, we provide the mechanical drawings for the carrier mounting plate, so that suitable adaptors can be constructed locally (refer to Appendix D). The design incorporates straps that allow the height of the carrier to be adjusted in relation to the ground surface. For optimum results during survey, a gap of 3-4 cm is recommended as shown in Figure 10.



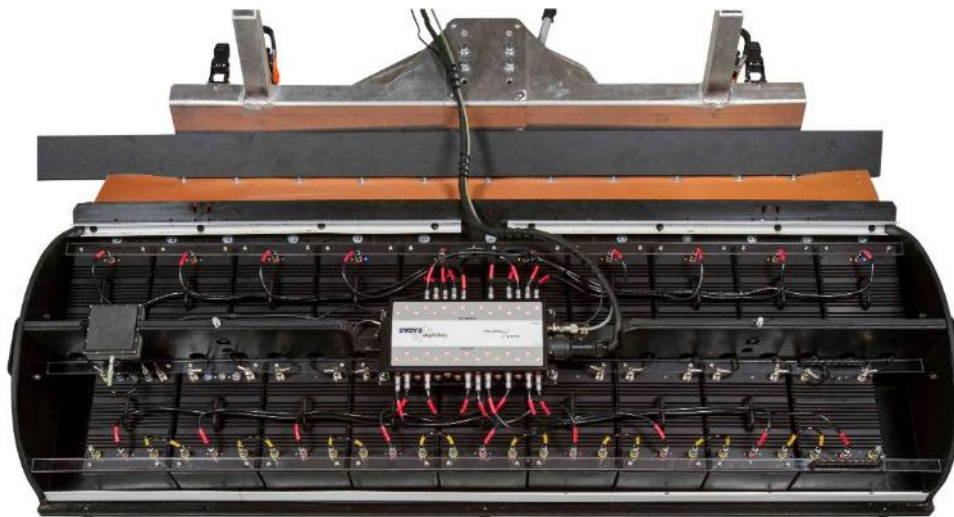
Figure 10 Side view of Raptor® vehicle mounted carrier solution

Once fitted to a vehicle, the carrier will remain stable and only move vertically in accordance with the vehicle's suspension system. The bottom of the carrier is fitted with replaceable skid/wear plates to protect it in the event of ground contact. Figure 11 shows a full survey setup fitted to a typical sports utility vehicle.



*Figure 11 Full survey setup fitted to an SUV*

Figure 12 below, shows the configuration and internal mounting of the antennas and other system components. As part of normal operation, the system will generate a certain amount of heat that usually gets dissipated into the surrounding air. However, in warmer climates or when running surveys in bright direct sunlight, the internal temperature of the carrier may rise above the specified maximum of 70°C. Therefore, we can supply an optional forced ventilation kit to help dissipate unwanted heat.



*Figure 12 An 18-channel configuration and internal mounting for vehicle mounted carrier*

## 2.5. Cables and connectors

The cables and connectors for linking Raptor® antennas to each other and between the switch/power box are colour coded and labelled to simplify assembly. It is impossible to harm the system in the event a wrong connection is made. Figure 13 shows a few of the different cables and connectors used to configure a system.

The length of these cables will limit the way in which antennas can be configured. If using a custom-made carrier solution, it is important that you have correctly specified how the antennas and other components will be configured. All cables are available in several pre-set lengths and can also generally be made to special order if required. However, for the power cables, the longest we recommend is 5 m.



*Figure 13 Trig cable, sync cable, power cable and sync stub (top to bottom)*

## 2.6. Power requirements – important!

A weak or noisy power supply can cause unpredictable system behaviour, even though the system includes built-in low-voltage protection. An 18-channel configuration typically draws approximately 9 A at 12 V, with substantially higher current possible during start-up. Therefore, the supplied power cables must not be modified or shortened, as this may lead to excessive voltage drop and instability.

For vehicle installations, it is strongly recommended to use a deep-cycle marine car battery as the sole power source. The battery must not be connected to any charger, power converter, or

### **WARNING: USE ONLY FACTORY-SUPPLIED BATTERY CHARGER**

To avoid the risk of fire, explosion, personal injury, or damage to the battery:

- Charge the Raptor pushcart battery only with the factory-supplied charger. It is specifically designed and calibrated for this battery's voltage, chemistry, and capacity.
- DO NOT use third-party, modified, or non-approved chargers. Incompatible charging devices may result in unsafe operating conditions and permanent battery damage.
- DO NOT attempt to charge the battery if it is damaged, swollen, or leaking. Contact a qualified technician or the manufacturer for assistance.
- Keep the charger and battery away from water, heat sources, flammable materials, and unsupervised areas during charging.

Failure to follow these instructions may void the warranty and cause serious safety hazards

vehicle alternator during operation. Such connections can introduce electrical noise or voltage transients, potentially causing abnormal or inconsistent data patterns thus de-grading data quality.

For push-cart configurations, the system should preferably be powered using the supplied battery to ensure optimal performance and stable operation.

## 3 Appendix A

### 3.1. Raptor® Specifications

<b>Raptor 45 &amp; 80 – Common Specifications</b>	
<b>Technology</b>	ImpulseRadar real-time sampling
<b>Antenna type</b>	Raptor®
<b>Signal to noise ratio (SNR)</b>	> 100 dB
<b>Significant/useful number of bits</b>	> 16 bits
<b>Scans/second</b>	> 800
<b>Data acquisition rate</b>	160 MHz
<b>Bandwidth</b>	> 120% (fractional, -10 dB)
<b>Acquisition mode</b>	Wheel, time or manual
<b>Positioning</b>	Wheel encoder, external GPS and Total-station
<b>GPS support</b>	Integrated support for GPS (int./ext.), NMEA 0183 protocol
<b>Data time-tagging</b>	To 1ms of \GPS-time
<b>Power supply</b>	12 V Li-Ion rechargeable battery, or ext. 12 V DC source
<b>Power consumption</b>	0.5 A per channel
<b>Operating temperature</b>	-20° to +50°C
<b>Environmental</b>	IP65
<b>Regulatory certification</b>	CE, FCC and IC
<b>USER INTERFACE</b>	Laptop PC (min. requirements)

<b>Display</b>	10" backlit, sun-readable
<b>Operating system</b>	Windows 10 or later
<b>Processor</b>	>1.8 GHz, 64-bit (x64)
<b>Memory</b>	>8 GB RAM (64-bit)
<b>Storage</b>	>20 GB (64-bit)
<b>Graphics</b>	DirectX 9 graphics device with > WDDM 1.0 driver
<b>Communications interface</b>	Ethernet 1 Gb
<b>Recommendation</b>	<i>Panasonic Tough Book FZ G2 (or equivalent)</i>
<b>SOFTWARE</b>	
<b>Talon-2 3D Data Acquisition Software</b>	<ul style="list-style-type: none"> <li>• Quick and easy configuration and start-up</li> <li>• Positioning configuration and device sync monitoring</li> <li>• Visualization of radargram for each channel</li> <li>• Data merge, storage and export</li> </ul>
<b>Condor 3D GPR Processing &amp; Interpretation Software</b>	<ul style="list-style-type: none"> <li>• Osprey View (method of visualizing 3D-GPR data)</li> <li>• Effective workflows</li> <li>• Efficient sub-surface imaging</li> </ul>

<b>Raptor 45 – Further Specifications</b>		
<b>Centre frequency</b>	450 MHz	
<b>Survey speed</b>	> 130 km/h @ 5 cm point interval	
<b>Time window</b>	166 ns (18-channels)	
<b>Operating time</b>	10 hours (8-channel with 50 Ah battery)	
<b>Dimensions</b>	230 x 165 x 160 mm (Antenna only)	
<b>Weight</b>	1.85 kg (Antenna only)	
<b>CARRIER SOLUTIONS</b>	Cart (up to 8-channels)	Vehicle (up to 18-channels)
<b>Dimensions (when in use)</b>		180 x 83 x 57 cm

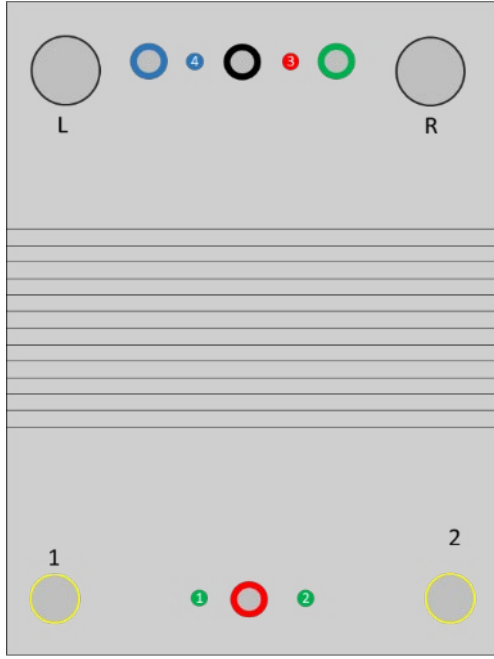
<b>Dimensions in-folded</b>		
4-wheel solution	92 x 102 x 45 cm	
3-wheel solution	92 x 90 x 45 cm	
<b>Scan width (swath)</b>	60 cm	140 cm
<b>Total weight with carrier</b>	56 kg	91 kg

<b>Raptor 80 – Further Specifications</b>		
<b>Centre frequency</b>	800 MHz	
<b>Survey speed</b>	> 70 km/h @ 5 cm point interval	
<b>Time window</b>	125 ns (24-channels)	
<b>Operating time</b>	7 hours (12-channel with 50 Ah battery)	
<b>Dimensions</b>	150 x 110 x 90 mm (Antenna only)	
<b>Weight</b>	0.87 kg (Antenna only)	
<b>CARRIER SOLUTIONS</b>	Cart (up to 12-channels)	Vehicle (up to 28-channels)
<b>Dimensions (when in use)</b>		180 x 83 x 57 cm
<b>Dimensions in-folded</b>		
4-wheel solution	92 x 102 x 45 cm	
3-wheel solution	92 x 90 x 45 cm	
<b>Scan width (swath)</b>	60 cm	140 cm
<b>Total weight with carrier</b>	50 kg	79 kg

## 4 Appendix B

### 4.1. LED colour codes

Table below, provides information on the colour of the LEDs on the Raptor® master receiver antenna and the meaning of each flash or flash sequence.

	No.	Color	Status Description
	1	Green	Slow Flash: Receiver, slave Constant ON: Not connected to s/w or Measuring Fast flash: Master
	2	Green	Flashes for a few milliseconds on Ethernet activity
	3	Red	OFF: Is OK Flash: ERROR code ON: Not connected to PC
	4	Blue	GPS: OFF or no GPS 1 Flash: Internal GPS 2 Flashes: External GPS ON: Both

## 5 Appendix C

### 5.1. Raptor® switch/power box

The switch/power box is the link between Raptor® antennas and the acquisition/control PC. This device incorporates a third-party 1Gb Ethernet switch and a power distribution board, which supplies power to each antenna.

Whilst it is not generally necessary to open the switch/power box, there may be rare occasions where this is necessary, and the following paragraphs offer some guidance for troubleshooting purposes.

Ethernet switch login defaults:

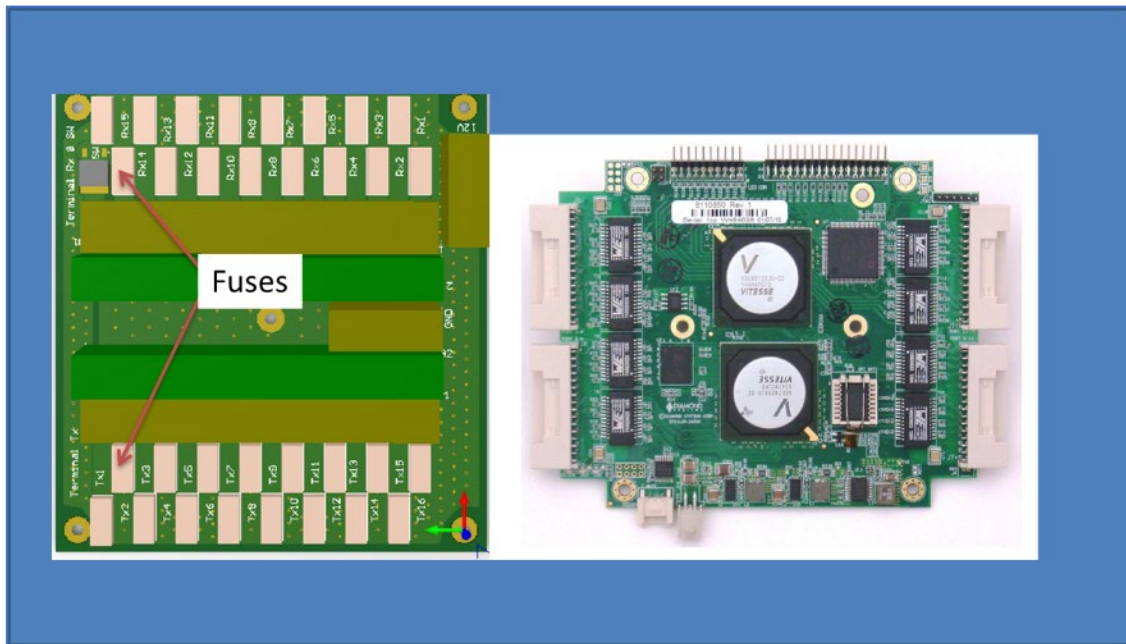
- **IP address:** 192.168.1.60
- **User:** admin
- **Password:** no password set

Use the credentials listed above to login to the Ethernet switch to check settings and monitor communications/data traffic as needed.

Problem	Possible Remedy
<b>No communication between PC and switch/power box</b>	<p>Check the integrity of the Ethernet cable – replace if necessary.</p> <p>Ensure Talon® is installed correctly, and the PC Ethernet interface is set to:</p> <p>Static IP: 10.10.255.252</p> <p>Netmask: 255.255.0.0</p>
<b>Communication between PC and switch/power box is intermittent/erratic</b>	<p>Check the integrity of the Ethernet cable – replace if necessary.</p> <p>Ensure the PC and Ethernet switch do not share the same IP address. Change the PC IP address if needed.</p>
<b>No power to antennas</b>	<p>Check the integrity of the power cable and connection – replace if necessary.</p> <p>Check fuses on power board – replace if necessary (refer to Figure 14).</p> <p>1.5A for transmitters</p> <p>3.5A for receivers</p> <p>Check power saving features for Ethernet switch – disable all.</p>
<b>Communication problems with antennas</b>	<p>Ensure antennas are on a fixed 100Mb, full duplex link, while the data collection PC is on an auto-negotiated line</p>

A dedicated user manual for the third-party Ethernet switch is available on request for further troubleshooting guidance. Should you require a copy, please email a request to our support team at: [support@impulseradar.se](mailto:support@impulseradar.se)

Figure 14 below, shows the internal circuit board for the power distribution board and the fuses installed for protection of the cables, 1.5A for the transmitters and 3.5A for the receivers.

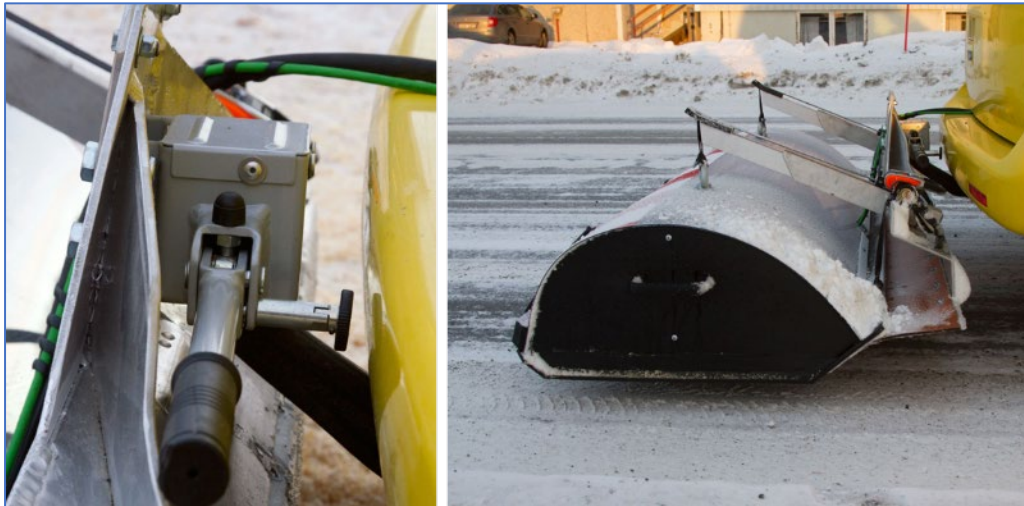


**Figure 14** Internal view of the switch/power box with power distribution board(left) and Ethernet switch (right).

## 6 Appendix D

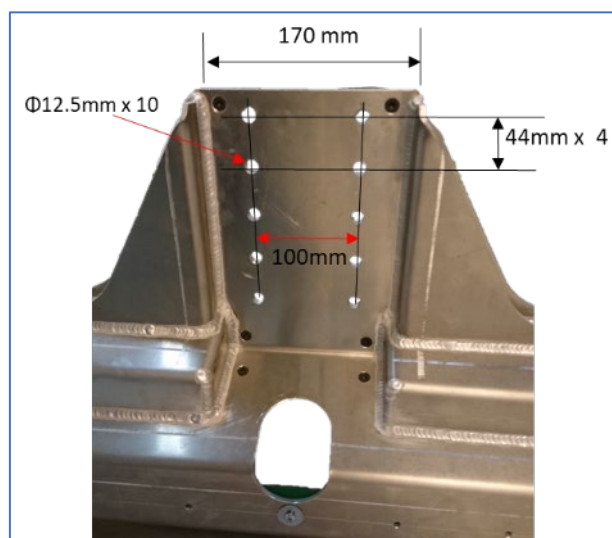
### 6.1. Attaching the Raptor® vehicle mount carrier

The standard kit for the vehicle carrier includes a mounting bracket which fits on a 50mm tow-ball. Close-up photos of the carrier mounted on a car is shown in Figure 15, below.



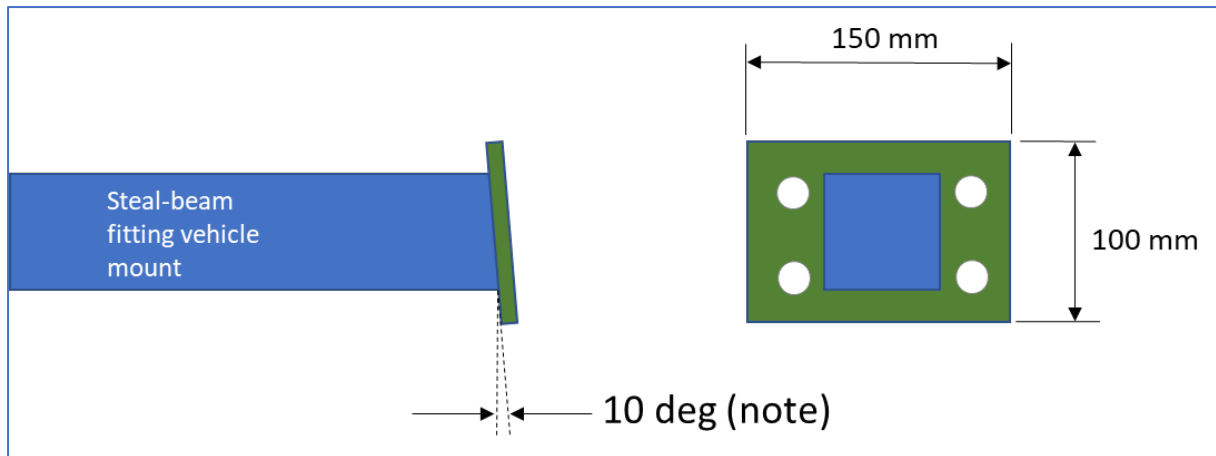
*Figure 15 Close-up of vehicle-carrier mounted on a car*

To enable mounting on different vehicles the bracket can be moved between different positions. Figure 16, below, illustrates the various fixing positions for the mounting bracket on the carrier solution. These fixing positions allow the bracket to be adjusted to four different heights.



*Figure 16 Mounting bracket for Raptor® vehicle mount carrier solution*

Figure 17 below, shows a diagram for an alternative towing attachment in the form of a box-style towing/trailer hitch. You will need to have this manufactured locally for proper fitting to your survey vehicle.



**Figure 17** Tow/trailer hitch design for mounting bracket of Raptor® vehicle mount carrier solution

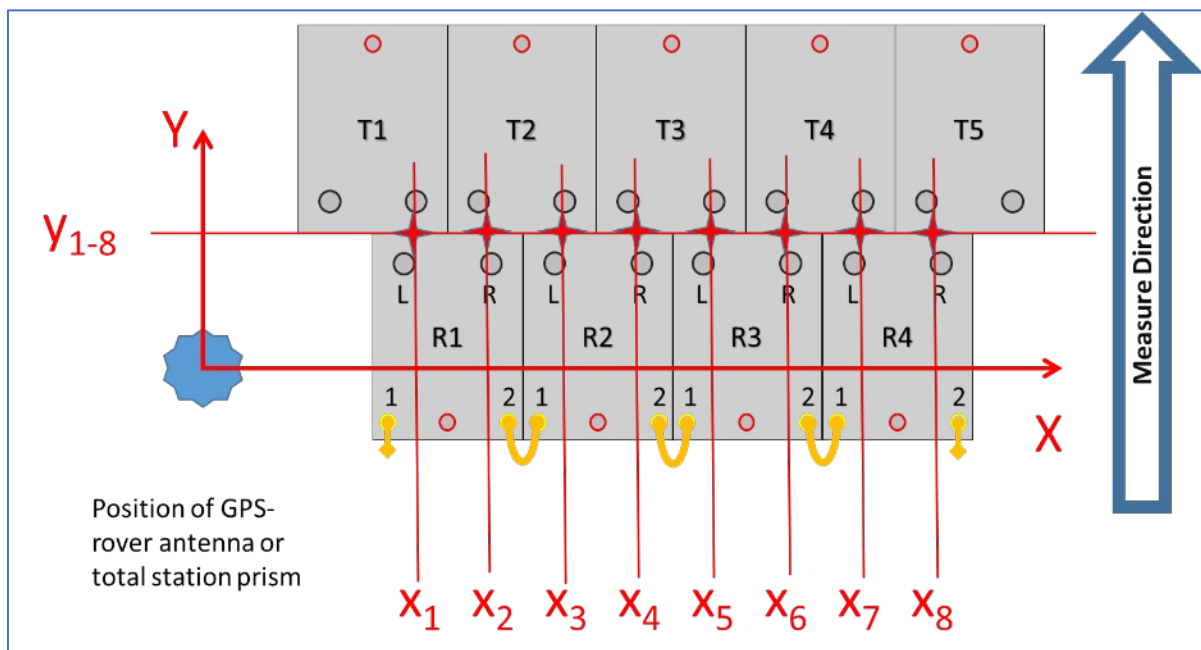
**Note:** The 10-degree sloping of the mounting plate is for this example only, it may have to be altered to meet the specific requirement of the survey vehicle used.

## 7 Appendix E

### 7.1. Coordinates for channel configuration

Each channel must have an individual position within the array configuration, in relation to the GPS antenna or total station prism (mounted on the carrier). Figure 18 below, illustrates how the standard configurations are positioned.

All channels have the same Y-position, while the X varies (in standard Raptor® configurations).



**Figure 18** Positioning convention for channel configuration

**Note:** It's important that correct channel configuration is correctly assigned within Talon®.

## 8 Appendix F

### 8.1. Files, file-formats and naming conventions

#### 8.1.1 Files stored in the project directory

Directory names:

- **<project name>**: current project name (project data directory has the same name)
- **<project name>\_Condor Export\_\*\*\***: combined files are saved in the subdirectory where \*\* is the number of dataset iterations which the user created such as 001 and 002.

Filenames formatting is shown in the table below. Some of the files are generated by the acquisition software Talon-2, while others are created by ViewR during the export process to a Condor-compatible format for further processing.

File Type	Description	Naming Convention	Explanation
<b>*.IPRH</b>	Profile Header File	<project name>_XXX_AYY.iprh	Where YY is profile (channel) running number (counting from 1) and XXX is a swath running number (counting from 1) <sup>1</sup>
<b>*.IPRB</b>	Profile Data File	<project name>_XXX_AYY.iprb	Same convention as above.
<b>*.COR</b>	Positions from RTK GPS	<project name>_XXX.cor	where XXX is a swath running number. <sup>1</sup>
<b>*.TIME</b>	GPS Time from internal GPS	<project name>_XXX.time	where XXX is a swath running number. <sup>1</sup>
<b>*.ORD</b>	Channel positions	<project name>_XXX.ord	where XXX is a swath running number. <sup>1</sup>
<b>*.TSP</b>	Total station positioning data	<project name>_XXX.tsp	where XXX is a swath running number. <sup>1</sup>
<b>Ref_G*.POS</b>	Total station position file	Ref_GXX.pos	where XX is running number for TS Position. <sup>1</sup>
<b>center.ccc</b>	Centre of the Local Coordinate system based	center.ccc	Created when user makes combined files in GPS Project. It is the centre of the local

	on GPS coordinates		coordinate system for all the swaths in this Project. <sup>2</sup>
<b>*.IPH</b>	Header of combined file	<project name>_XXX.rad	where XXX is a swath running number. <sup>1,2</sup>
<b>*.IPR</b>	Combined file (data)	<project name>_XXX.rd3	where XXX is a swath running number. <sup>1,2</sup>
<b>*.POS</b>	Combined file (positioning)	<project name>_XXX.pos	where XXX is a swath running number. <sup>1,2</sup>
<b>Tie_G*.POS</b>	Total station position file	Tie_GXX.pos	where XX is running number for TS Position. <sup>1,2</sup>
<b>*.IRP</b>	Project info file	<project name>.irp	Unique for each project
<b>*.TXT</b>	Created by ViewR	ProjectSettings.txt	Unique for each project
<b>*.LOG</b>	Temperature log	Temperature.log	Unique for each project
<b>*.LVL</b>	Battery level information	TraceAndBatteryLevel_XXX.lvl	where XXX is a swath running number
<b>*.GPS</b>	GPS log	<project name>_XXX.gps	where XXX is a swath running number
<b>*.INFO</b>	Combined file	utmzone.info	Project's UTM Zone information
<b>*.CNF</b>	Combined file	ObjectFeatureDefinitions.cnf	Contains information about surface features
<b>*.MRK</b>	Marker information	<project name>_XXX.mrk	where XXX is a swath running number

<sup>1</sup> File names are padded with zeros to replace 'X', e.g. <project name>\_001\_AYY.iprh

<sup>2</sup> Files created when combined files are made, saved in same directory as the combined files.

## 8.1.2 Files/information stored in system

### *Profile Header File*

Table below shows the information written in profile header text .

Header Field	Value	Explanation
HEADER VERSION	10	Version number for Raptor®
DATA VERSION	16	16b data format
DATE	2017-06-12	Measurement Date
START TIME	13:59:49	Measurement Start Time
STOP TIME	14:00:02	Measurement Stop Time
ANTENNA	400 MHz	Antenna Frequency
ANTENNA SEPARATION	0.250	Antenna separation in meters
SAMPLES	512	Number of samples in a trace
SIGNAL POSITION	13	Signal position
CLIPPED SAMPLES	0	Clipped samples (not in use now)
RUNS	32	Number of runs
MAX STACKS	512	Maximum number of stacks
AUTOSTACKS	1	Autostacks (1 = ON)
FREQUENCY	5120.000	Sampling Frequency
TIMEWINDOW	100.000	Time Window in nS
LAST TRACE	1259	Number of traces in the Profile
TRIG SOURCE	time	Trig Source – time or wheel
TIME INTERVAL	0.010000	Trig Interval if the trig source is time (sec)
DISTANCE INTERVAL	0.099544	Trig interval if the trig source is wheel (m)
USER DISTANCE INTERVAL	0.100000	Distance interval for interface
STOP POSITION	125.325588	Stop Position in meters
WHEEL NAME	mne_wheel_1	Wheel name (max 20 chars)
WHEEL CALIBRATION	300.51	Wheel calibration (ticks per meter)

<b>ZERO LEVEL</b>	40	Zero Level
<b>SOIL VELOCITY</b>	100.000000	Soil Velocity (m/uS)
<b>PREPROCESSING</b>	0	Not in use now
<b>OPERATOR COMMENT</b>	_	Not in use now
<b>ANTENNA F/W</b>	48001173	Receiver Firmware Version
<b>ANTENNA H/W</b>	0	Not in use now
<b>ANTENNA FPGA</b>	DA69	Receiver FPGA Version
<b>ANTENNA SERIAL</b>	1011	Receiver serial number
<b>SOFTWARE VERSION</b>	T 1.0.72	Software version (T means TALON)
<b>POSITIONING</b>	2	Positioning: (0-NO; 1-TS; 2-GPS)
<b>CHANNELS</b>	8	Number of channels in the array
<b>CHANNEL CONFIGURATION</b>	T4 - R3	This channel configuration
<b>CH_X_OFFSET</b>	777.000000	Channel X Position relative to GPS antenna or TS Prizma
<b>CH_Y_OFFSET</b>	77.000000	Channel Y Position relative to GPS antenna or TS Prizma

### ***Profile Data File***

Binary file. Talon® 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 RTK GPS***

It 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				

### ***GPS Time from internal GPS***

This is a text file. Every string contains 3 fields separated by tab:

Trace Number <tab> Date <tab> Time from the internal GPS (UTC Time)

Example:

1	2017-03-15	10:12:16:730
2	2017-03-15	10:12:19:673
3	2017-03-15	10:12:19:846
4	2017-03-15	10:12:19:938
5	2017-03-15	10:12:20:016
6	2017-03-15	10:12:20:082
7	2017-03-15	10:12:20:141
8	2017-03-15	10:12:20:195

### ***Channels Positions***

This is a text file. Every string contains 4 fields separated by space:

Channel Number <space> X <space> Y <space> 1 or 0 (if 1 then it is valid)

Note that in this file we number the channels starting from 0.

X-Shift and Y-Shift are antenna coordinates in meters in the special coordinate system, where the Total Station prism or GPS receiver is in the 0/0-point, the X-axis is parallel with the Array and the Y-axis is in the measurement direction.

Example:

0	-0.710000	-0.950000	1
1	-0.630000	-0.950000	1
2	-0.550000	-0.950000	1
3	-0.460000	-0.950000	1
4	-0.380000	-0.950000	1
5	-0.290000	-0.950000	1

```

6 -0.210000 -0.950000 1
7 -0.120000 -0.950000 1
8 -0.040000 -0.950000 1
9 0.040000 -0.950000 1
10 0.120000 -0.950000 1
11 0.210000 -0.950000 1
12 0.290000 -0.950000 1
13 0.380000 -0.950000 1
14 0.460000 -0.950000 1
15 0.550000 -0.950000 1
16 0.630000 -0.950000 1
17 0.710000 -0.950000 1
18 71.000000 71.000000 0
19 71.000000 71.000000 0

```

### ***Total Station Positioning File***

It is a text file. Every string contains 6 fields separated by tab:

Trace Number <tab> X <tab> Y <tab> Z <tab> Time: HH:MM:SS:mmm <tab> Status (not in use now)

### ***Header of the Combined File***

This is a text file.

<b>Header Field</b>	<b>Explanation</b>
<b>SAMPLES: 711</b>	Number of samples
<b>FREQUENCY: 5120.000000</b>	Sampling frequency
<b>FREQUENCY STEPS: 1</b>	Not used: always 1
<b>SIGNAL POSITION: 12</b>	Signal position
<b>RAW SIGNAL POSITION: 65000</b>	Not used: always 65000
<b>DISTANCE FLAG: 1</b>	Triggering flag
<b>TIME FLAG: 0</b>	Triggering flag
<b>PROGRAM FLAG: 0</b>	Triggering flag
<b>EXTERNAL FLAG: 0</b>	Triggering flag
<b>TIME INTERVAL: 0.100000</b>	Trigger interval in seconds

<b>DISTANCE INTERVAL: 0.042729</b>	Trigger interval in meters
<b>OPERATOR: _</b>	Not used
<b>CUSTOMER: _</b>	Not used
<b>SITE: _</b>	Not used
<b>ANTENNAS: 500 MHz</b>	Antenna frequency
<b>ANTENNA ORIENTATION: NOT VALID FIELD</b>	Not used
<b>ANTENNA SEPARATION: 0.250</b>	Antenna separation in meters
<b>COMMENT: _</b>	Not used
<b>TIMEWINDOW: 138.867</b>	Time window in nanoseconds
<b>STACKS: 512</b>	Maximum number of stacks
<b>STACK EXPONENT: 0</b>	Not used
<b>STACKING TIME: 100.000</b>	Not used
<b>LAST TRACE: 3978</b>	Number of all traces in all channels
<b>STOP POSITION: 9.443</b>	Stop position in meters
<b>SYSTEM CALIBRATION: 0.000195</b>	Time between 2 samples in microseconds
<b>START POSITION: 0.000000</b>	Start position (always 0)
<b>SHORT FLAG: 0</b>	Not used
<b>INTERMEDIATE FLAG: 1</b>	Not used
<b>LONG FLAG: 0</b>	Not used
<b>PREPROCESSING: 0</b>	Not used
<b>HIGH: 0</b>	Not used
<b>LOW: 0</b>	Not used
<b>FIXED INCREMENT: 0.300000</b>	Not used
<b>FIXED MOVES UP: 0</b>	Not used

<b>FIXED MOVES DOWN: 1</b>	Not used
<b>FIXED POSITION: 0.000000</b>	Not used
<b>WHEEL CALIBRATION: 400.0000000000</b>	Wheel calibration in ticks per meter
<b>POSITIVE DIRECTION: 1</b>	Not used (always 1)
<b>NUMBER_OF_CH: 18</b>	Number of channels
<b>CH_X_OFFSETS: -0.710 -0.630 -0.550 - 0.460 -0.380 -0.290 -0.210 -0.120 -0.040 0.040 0.120 0.210 0.290 0.380 0.460 0.550 0.630 0.710</b>	Channel coordinates (X values)
<b>CH_Y_OFFSETS: -0.950 -0.950 -0.950 - 0.950 -0.950 -0.950 -0.950 -0.950 -0.950 -0.950 -0.950 -0.950 -0.950 -0.950 - 0.950 -0.950 -0.950 -0.950</b>	Channel coordinates (Y values)
<b>UNITS: m</b>	Units (always "m")
<b>DATE: 2017-04-04</b>	Combined file creation date
<b>TIME: 15:56</b>	Combined file creation time

### ***Combined Files Data File***

This is a binary file. It contains all channels for 1 swath. Data is stored as signed 16-bit integers. The traces are stored sequentially. First comes the first trace from all channels sequentially then second trace from all channels and so on.

### ***Total Station Position File (Ref\_GXX.pos and Tie\_GXX.pos)***

They are text files. They have the same structure. Name Tie\_GXX.pos is used for combined files.

Example (Ref\_G01.pos):

UNITS:m

1 7.450000 15.183333 -0.280000

2 1.980000 25.540000 -0.360000

3 -6.870000 22.880000 -0.510000

First goes reference point ID, followed by X,Y and Z in meters.

In this example you can see coordinates of 3 reference points which define TS position. If you want to connect this TS position with the next TS position you have to use the same points and get their coordinates from the new TS position, and it will be next (Ref\_G02.pos) file.

### ***Combined Files Positioning File (<project name>\_XXX.pos)***

This file contains TS Prisma or GPS Antenna positions for one swath in some local coordinate system. Distance between points in this file is defined by the parameter "Minimum Positioning Step" in the Positioning Parameters Dialog. Refer to Talon-2 manual for further details.

Example:

UNITS:m

```
1 17.980000 -11.820000 0.110000
22 17.600000 -11.090000 0.130000
38 17.320000 -10.550000 0.130000
54 17.020000 -10.000000 0.140000
70 16.710000 -9.460000 0.150000
93 16.250000 -8.670000 0.120000
111 15.900000 -8.070000 0.110000
129 15.560000 -7.490000 0.080000
```

First goes trace number, followed by X, Y and Z in meters.

## 9 Appendix G – Warranty Statement

### *Defects and limited warranty*

ImpulseRadar (the “Manufacturer”) warrants that for a period of twenty-four (24) months from delivery, the Manufacturer’s products will be free from defects in material and workmanship. The exception to this is consumable parts such as batteries, battery chargers, external interconnecting cables and skid/wear plates, which will carry a twelve (12) month warranty against defects in material and workmanship.

The Manufacturer’s obligations are limited to repairing or replacing parts or equipment (transportation and insurance pre-paid) which are returned to the Manufacturer without alteration or further damage and which, in the Manufacturer’s judgment, were defective or became defective during regular use.

Except for the foregoing limited warranty, the Manufacturer disclaims all warranties, express or implied, including any warranty of merchantability or fitness for a particular purpose. The Manufacturer assumes no liability for any direct, indirect, special, incidental or consequential damages or injuries caused by proper or improper operation of its equipment, whether or not defective. Concerning third-party products, the warranty and licensing terms for such third-party products shall apply instead of this warranty statement.

The Manufacturer offers the above warranty subject to the following conditions:

1. The Manufacturer shall be under no liability in respect of any defect arising from fair wear and tear, willful damage, negligence, abnormal working conditions, failure to follow the Manufacturer’s instructions (whether oral or in writing), misuse or alteration or repair of the Products without the Manufacturer’s approval.
2. The Manufacturer shall be under no liability under the above warranty (or any other warranty, condition or guarantee) if the total price for the Products has not been paid by the due date for payment.

An updated version of this Warranty Statement is available on our website at [www.impulseradargpr.com](http://www.impulseradargpr.com).