USER HANDBOOK FOR GROUNDVUE 3_1 V4

V4 2018

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1 INTRODUCTION

Groundvue 3_1 is a single channel Ground Penetrating Radar (GPR) system capable of running antennas of any frequency from 250MHz up to 6GHz from the Groundvue range. This includes the Crack Detection Head.

This GPR has a very fast data collection capability, up to 1,600scans per second. It can be used attached to a vehicle, at traffic speeds or from a trolley or hand towed if the ground surface conditions require this. A variety of skids are available to support different modes of operation.

Location information can be derived either from an encoder wheel (odometer), string encoder or using GPS.

The system makes use of an easy to use operator interface which has been designed to run on Laptops, Tablets or PCs. It is fully compatible with Windows 8, 7 and XP. The system uses a WiFi connection between the computing device and the radar. For frequencies which are incompatible with WiFi (e.g. higher than 1GHz) a standard Ethernet cable option is available.

2 SYSTEM DESCRIPTION

2.1 Antennas

Groundvue 3_1 operates on a single channel which is compatible with antennas of the following 6 central frequencies: 6GHz, 4GHz, 1.5 GHz, 1 GHz, 400 MHz and 250MHz. It is also possible to use a single Crack Detection Head (CDH) although we recommend using this alongside a traditional antenna which would require a multi-channel Groundvue 3.

Only 1 transmitter and 1 receiver can be used at the same time. Figure 1 shows the system configuration for integrated antennas. The only external cables link the controller to the integrated antenna. The integrated antenna box contains a part of the control system, the RF Head, a transmitter (Tx) and a receiver (Rx) antenna of the same frequency. Any of the available frequencies can be used, with the timesweep (depth measurement in nanoseconds time) set to match the antenna frequency.

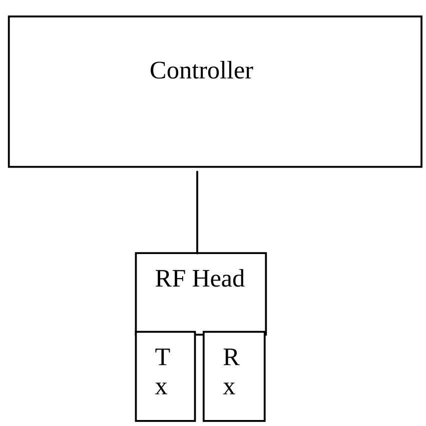

Figure 1 Groundvue 3_1 with integrated antennas.

2.2 Antenna Options

Groundvue 3_1 can use any integrated or non-integrated antennas in any frequency combination from the range available. Typically the frequency of antenna will be determined by the type of GPR investigation, the depth of survey and the target definition.

Normal operation with a single channel Groundvue 3 uses a single integrated antenna which incorporates a transmitter (Tx) and receiver (Rx) of the same frequency. This applies to the traditional antennas and also the adapted antennas used for crack detection and crack depth determination.

It is also possible to use non-integrated antennas if WARR calibration is to be used to determine transmission velocity through the soil or other survey medium.

Using integrated antennas or non-integrated antennas has no effect on the speed of data collection. The type of antenna used does not slow the system down.

2.3 Crack Depth Detection

Groundvue 3_1 is also fully compatible with the Groundvue Crack Detection Head (CDH). Both integrated and non-integrated antennas are available. For both versions, the transmitters and receivers are not separable as the CDH should not be used to determine transmission velocity through the ground or other survey medium.

We recommend, for most investigations, that the CDH is used in conjunction with at least one traditional antenna of the same frequency so that layer information is generated simultaneously with the crack depth data. This requires a multi-channel Groundvue 3. However the CDH can be used on a single channel Groundvue 3 provided that either the layer information is derived separately or that the layer information is not required for the survey. For further advice on this topic, contact Utsi Electronics Ltd.

2.4 Groundvue 3_1 Control system

Groundvue 3_1 is operated by laptop, tablet or PC. The current compatible Windows software is Windows 8, Windows 7 and Windows XP. The control system can be operated using a built in WiFi link. It is not advisable to use the WiFi link when deploying antennas of frequencies above 1GHz as there is a potential for interference from the 2.5GHz WiFi transmissions on to the GPR data. For antennas of 1GHz or above, an Ethernet cable is available to link the GPR controller to the laptop, tablet or PC.

Data is displayed in real time on the laptop or other computing device. It is possible to have a rolling Greyscale display, an A scan display or both.

There are inputs for external wheel encoder quadrature signals in order to determine location. Alternatively, the system is fully compatible with GPS. All data, including location information is stored in a specific folder within the laptop, tablet or PC.

3 SOFTWARE INSTALLATION

The Groundvue 3_1 operating software supplied with the GPR is compatible with Windows 8, 7 or XP. Insert the disk in the computing device to be used to control the radar and to store the data. If a tablet is to be used for control of the radar, insert the disk into a PC and use a USB stick to transfer the software from the PC to the tablet.

There should be 6 files on the disk. Create a folder on the desktop of the computing device to be used for surveying. Copy all of these files to this folder. The 6 files are:

GlassGraph.dll
GroundVue.exe
GroundVue.exe.config
GVCommon.dll
IPAddressControlLib.dll
MiscUtils.dll.

Once the files have been copied, remove the disk and store in a safe place for future use. This new folder will act as the centralised store for the operating software. Survey data will be saved in a designated folder specific to the survey.

The controller has options of a range of timesweeps:
10 to 160 ns, 20 to 320 ns, 40 to 640 ns or 80 to 1280 ns. The range is specified at the time of ordering and built into the controller at the point of manufacture. In the software supplied, this timebase multiplication factor (1,2,4 or 8) is stored in the GroundVue.exe.config file above.

3.1 Setting up the IP Address

The radar controller uses a static IP address which needs to be set up within the laptop (or other computing device) used to interface with the radar. The instructions in this section of the handbook are for devices using Windows 8 or 7. For XP, see the instructions in Appendix A.

Open the control panel & access ”Network and Internet” followed by “Network and Sharing Centre”. Select “change adapter settings” from the left hand side bar to display the choice of network adapters. If WiFi is to be used, select the Wireless Internet connection. If the Ethernet is to be used, select Local Area Connection It is not advisable to use WiFi if antennas of 1.5GHz or higher frequency are to be used since there is a risk of interference from the WiFi transmissions into the GPR data. For antennas of 1GHz or lower frequency, there is no interference implication and WiFi can be used.

Right click on the chosen connection and select Properties. Select Internet Protocol V4 (IPV4) and then click on Properties. On the IPV4 window, select “use the following IP address” and enter the static IP address for the controller. The static IP address is recorded on the lid of the radar controller. It is important to note this address in this handbook in case the wording wears out with use.

Static IP Address of Groundvue 3_1…………………………………………………………

Now enter the Subnet mask. This is 255 255 255 0. This completes the set up sequence. Press OK and then close the Wireless Network Connection Properties window.

4. SETTING UP THE RADAR

The radar hardware set up follows the system diagram in the System Description, Sections 2.1 and 2.2. The basic connections are

- from laptop/tablet/PC to controller;
- from controller to integrated antenna
  or
- from controller to RF Head and
- from RF Head to transmitter and
- from RF Head to receiver.

The controller also requires input from the encoder wheel in order to be able to set the required sampling interval.

The radar power source comes from a 12V battery. This GPR system draws very little current. It takes approximately 280mA maximum when WiFi is in use. GV3_1 has a built in lithium ion battery. There is also a connection available to run the system from external 12V batteries, using the leads provided, in order to extend the survey time available**. Do not use this lead to a battery connected to a charger, such as in a car, or the internal LiIon battery will be damaged.**

External batteries are placed:

- in the battery compartment at the foot of the trolley (if a trolley is used) ;
- on the auxiliary carrier plate (if hand towing is to be used); and
- in the vicinity of the controller if the system is to be mounted on a vehicle.

If the trolley is to be used with an external battery, it will be necessary to use the external power cables to connect the battery to the controller. To connect these, open the battery compartment casing and place the battery inside. Connect a power cable to the battery. At the battery end the connections should be red cable to red connector and black cable to black connector. Connect a power cable to the controller. The power cable from the controller can now be connected to the power cable from the battery using the small white connectors. Close the battery compartment before using the radar.

If the survey is to be carried out by hand towing the radar, both battery and controller should be placed in their allotted slots in the auxiliary carrier plate: see Figure 2. The small white connectors can be used to couple the power cable from the controller to that from the battery. At the battery end the connections should be red cable to red connector and black cable to black connector.

For survey operation from a vehicle, the battery can be placed anywhere safe within the vehicle (so that it does not impact on persons or equipment during the survey, including when the vehicle is slowing down or speeding up) and convenient to the location of the controller. The small white connectors can be used to couple the power cable from the controller to that from the battery. At the battery end the connections should be red cable to red connector and black cable to black connector.

On completion of a day’s or part day’s survey, all batteries, internal or external should be fully charged.

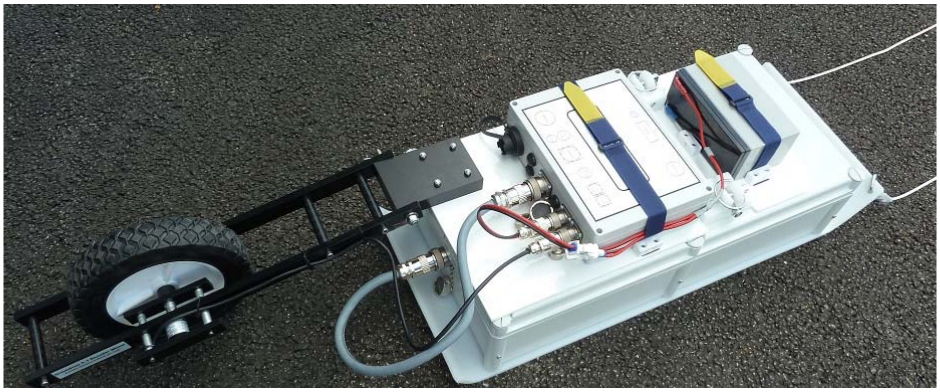

Figure 2: Auxiliary Carrier placed on Antenna with Controller & Battery in place for hand towing

The radar can be used in Wi-Fi mode in which case there is no need to connect the computing device used to the controller. For frequencies which are incompatible with WiFi (e.g. higher than 1GHz) a standard Ethernet cable option is available. This cable should be connected to the controller and to the Laptop/PC/Tablet where indicated.

If GPS is to be used to supply the position information, the GPS unit should be connected to the GPS connector (RS232, 9-pin) on the controller, next to this connector there is a PS/2 connector which is a 5V supply for the GPS. The data format of the GPS should be GPGGA / PseudoGPGGA and the baud rate should be set as described below in Section 5.1.5 GPS Control.

4.1 Using a Non-Standard Encoder Wheel or a String Encoder

Groundvue 3_1 is normally equipped with one of the standard Groundvue encoder wheels. However, it is possible to use the system with a non-standard Encoder Wheel or a string encoder (e.g. on very rough ground) or by bridging to a vehicle odometer. In order to use a non-standard external wheel, a string encoder or a vehicle odometer, a dedicated cable and a Groundvue compatible connector will be required.

The Groundvue 3_1 controller input is from an encoder with quadrature A/B outputs. The connector required for the encoder is a 4 pin, Souriau UTG series connector and the cable should be 4 core. String encoders and encoder wheels are usually provided with a suitable multi-core cable. The pin out is A: +5V (power input from the controller to the encoder), C: Ground, B and D: the quadrature outputs. Note that the direction of travel of the encoder will need to be matched to that of the radar. Since it is difficult to distinguish between pins B and D, it is possible for the direction of the encoder to be the opposite of that of the radar. There is no need to re-fit the encoder wheel. Use the “reverse direction” function on the encoder wheel setting: see the Reverse Direction instructions in Section 5.2.2.

5 USING THE RADAR TO SURVEY

Once the software has been loaded on to the computing device and the radar hardware has been set up, the radar can be used for survey.

Return to the Groundvue software folder on the desktop of the computing device being used for the survey. Open the executable file by double clicking on the GroundVue.exe file.

The operator is presented with four options:

Setup
Run
Record
Replay.

The Setup menu determines which type of radar system is used and establishes what the wireless data link is. The Run menu is used to set up survey parameters before the survey begins. It allows the operator to survey with the radar for exploration purposes but it does not record the data. The Record menu is used to record survey data. It shares the same set up features as the Run menu and can therefore be used without using the Run menu. The Record menu also has an additional window for survey notes. The Replay menu allows the operator to view previously recorded survey data.

5.1 The Setup Menu

For GroundVue 3 the settings are as illustrated in Figure 3.
For Model, select "GroundVue 3".
The only other setting for GroundVue3 is the GPS Baud Rate as specified by the GPS unit used attached to the Controller.
Press OK to finish the set up.

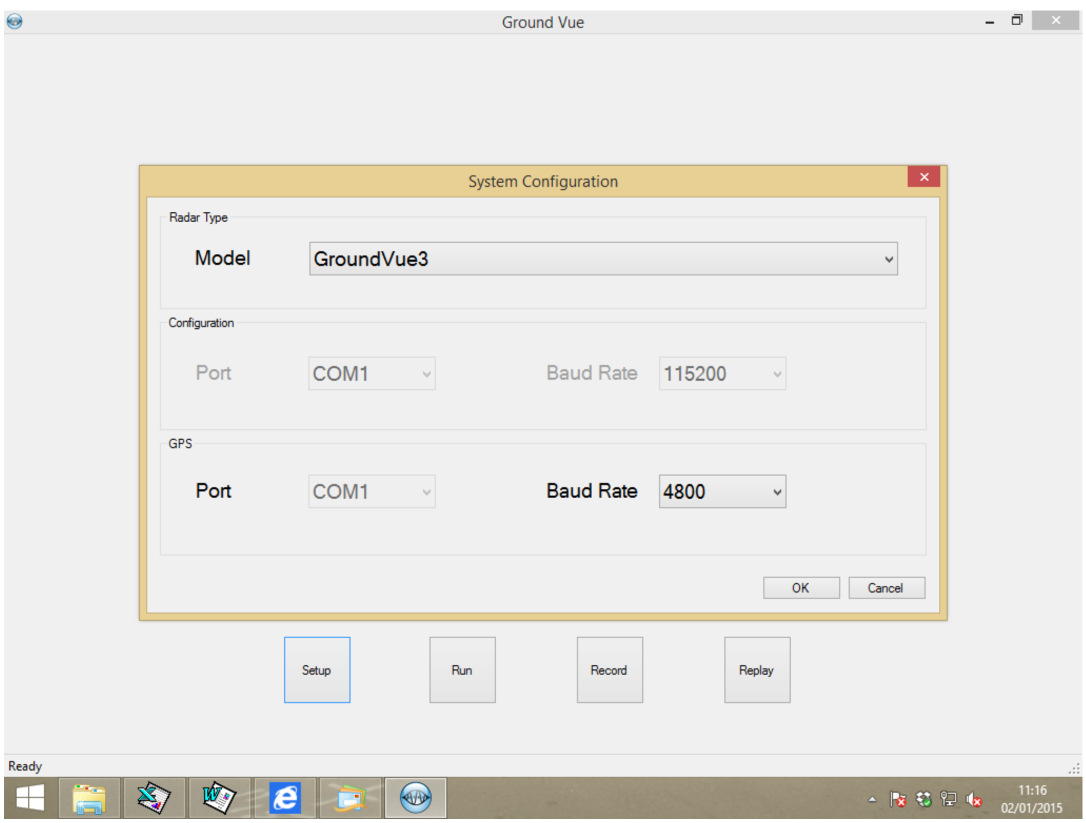

Figure 3: Setup configuration.

Click on the Run button to access the operating menu.

5.2 The Run Menu

The primary purpose of the Run menu is to set up the radar at the start of the survey. It allows the operator to select an appropriate scan frequency and to set survey depths appropriate to the survey. It also allows the operator to carry out a preliminary investigation of the site without recording the data. If all data is to be recorded, it is sufficient to proceed directly to the Record Menu (5.3). Figure 4 shows the Run or Set Up menu.

Note that Groundvue 3_1 uses the generic Groundvue 3 multi-channel software but without the capability of using multiple channels. Although the Run menu apparently offers multiple channels, these are not accessible on the single channel version of the system.

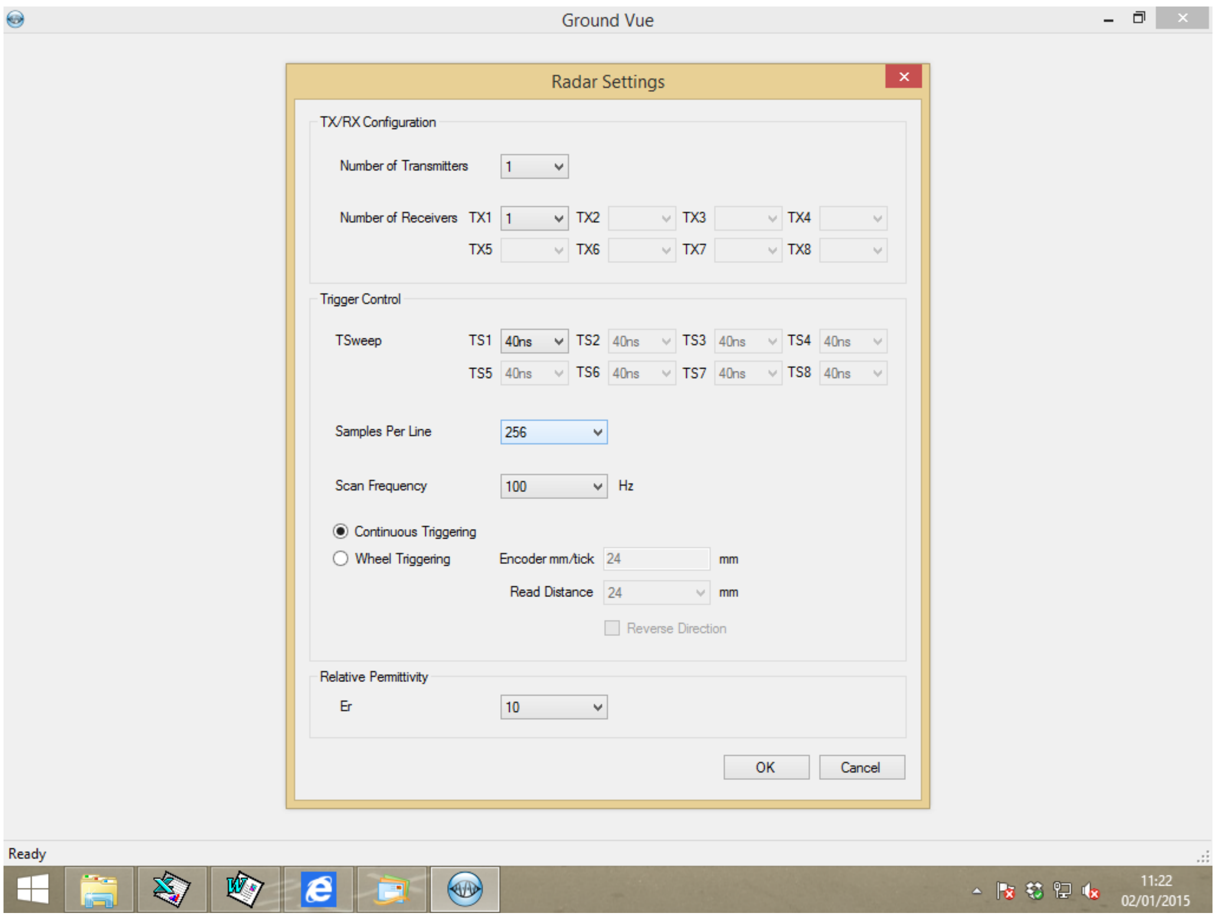

Figure 4: Groundvue Run Menu

5.2.1 Tx/Rx Configuration

There are no options over transmitter and receiver configurations since this is a single channel system. The user will always have to select one transmitter and one receiver. These should be of the same frequency. The range of frequencies available is listed in 2.1.

5.2.2 Tsweep

The timesweep is the two way travel time, measured in nanoseconds time, from the transmitter to the target and back to the receiver. The range of settings depends on the option selected at time of ordering. It is 10ns to 160ns, 20 to 320ns, 40 to 640ns or 80 to 1280ns. Guidance on selecting appropriate timesweeps can be found in Section 6.1.

5.2.3 Samples per line

The choice of the number of points per sweep depends on the ground conditions. For normal surveys, 256 points is ample as typical depths are only up to 20 wavelengths. However for low loss conditions like ice or clean water surveys, 512 can be selected. With 512 points, the scanrate is reduced by a factor of 2 relative to the 256 points scanrate.

5.2.4 Scan Frequency

The scan frequency determines the rate of data collection. The available settings of scan frequency range from 1600scans/second down to 1.6scans/sec.

Note that Groundvue radars do not use pre-set parameters because it is better to match the survey parameters to the site. We enable you to do this using the Run menu.

There are two further settings for data collection: either data can be continuously collected or it can be collected at intervals based on the distance measurement of the encoder wheel. As this GPR has a rapid data collection rate, continuous triggering should normally only be used for selecting survey parameters. This is because, to avoid distorting the data, the speed of data collection would have to match that of the operator &/or vehicle. Not only is this difficult to achieve in practice, it is potentially hazardous. Apart from initial site examination, one situation where it may be advantageous to use continuous triggering is in order to monitor movement below ground, for example, animal or water movement in the subsurface. For this, the trolley, antenna or vehicle is kept stationary. In this case, it is advisable to lower the scan rate to a minimum (1 to 10scans/sec). This avoids collecting too much data but without impairing the detection capability.

When using an encoder wheel (or odometer), select Wheel Triggering. The encoder mm/tick is the basic minimum interval determined by the size of the encoder wheel. This information is usually noted on the side of the encoder wheel. The Read distance can then be selected. The Read distance is the distance interval between successive readings and is a multiple of the encoder mm/tick.

When setting the sampling interval (along the line of travel of the radar) or “Read distance”, it is important to select a value which is low enough not to miss the targets. However, it is also important not to set the sampling interval too low for the wavelength of the radar. The full range of sampling intervals has to cover antenna frequencies from 6GHz to 250MHz and all settings are not suitable for all wavelengths. As a guide, the maximum setting should be the antenna size (which is frequency dependent) divided by 4. If the speed of data collection allows, this number can be decreased giving better (higher signal to noise ratio) radar data by allowing averaging (stacking).See also Section 6.2.

The Reverse Direction box might have to be ticked depending on the normal direction of the survey and the mounting of the encoder sensor. If the data does not scroll the first time the encoder wheel is used, change the Reverse Direction box setting.

5.2.5 Relative Permittivity

Radars measure in nanoseconds time. To turn this into depths measured in metres and centimetres or feet and inches, it is necessary to calibrate the transmission velocity through the ground. The relative permittivity (Er) is a direct measure of the ability of the soil (or other medium being surveyed) to hold charge and is inversely related to the transmission velocity. This value is therefore used to set the on-screen depth estimate.

It is not necessary to calibrate the transmission velocity in advance of survey. An approximate value can be used while surveying. For accurate depths, however, it is necessary to use a calibrated velocity but this can be done in post-processing. The table below shows suitable values of Relative Permittivity (Er) for different survey materials

Material	Air	Plastics	Plastics	Ice	Tarmac	Concrete
Er	1	2	3	4	6	8
Material	Dry Soil	Wet Soil	Wet Soil	Damp Organic Soil	Wet Organic Soil	Water
Er	10	15	20	30	50	80

Table 1: Relative Permittivity of Different Materials

5.3 The Record Menu

The first window to appear is the Run Details (Record Settings): see Figure 5. This window is used to define where the data will be saved and also to enter any Survey Notes.

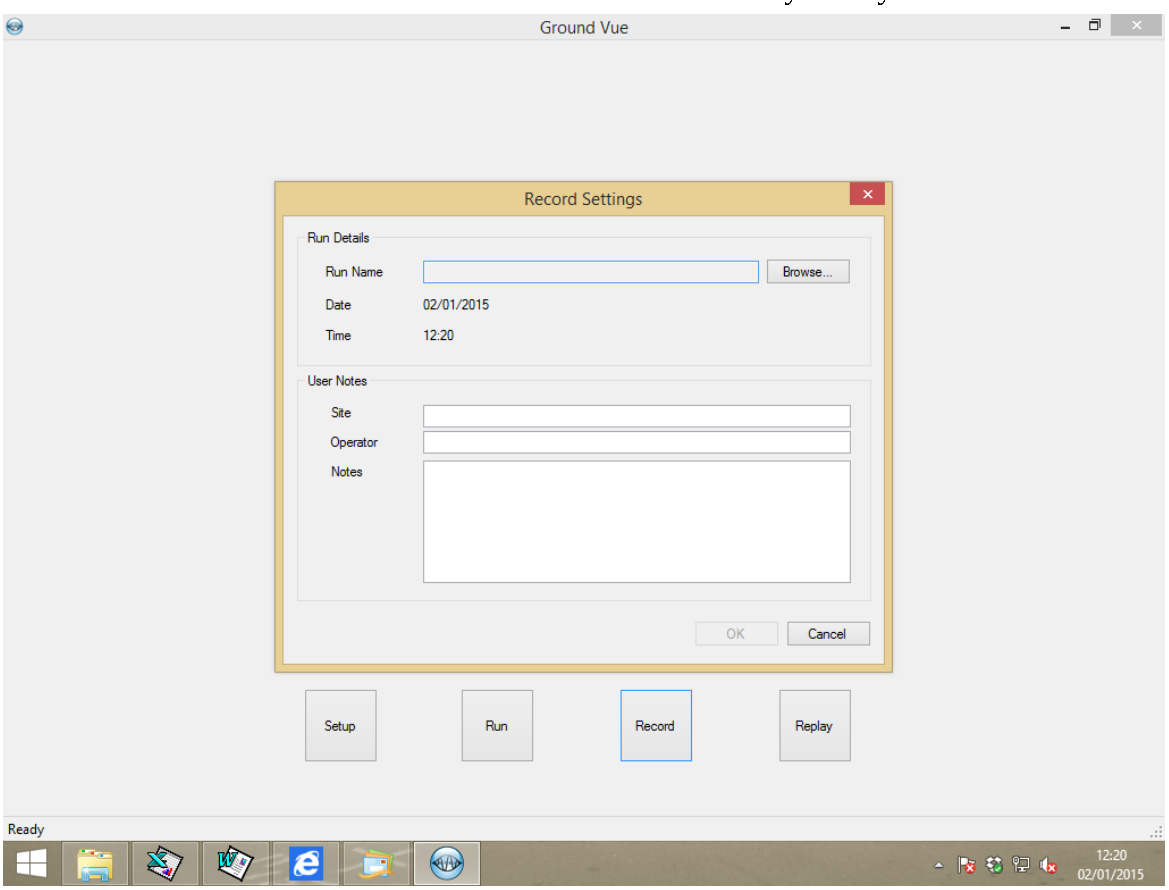

Figure 5: Run Details (Record Settings) Window

5.3.1 Run Details (Record Settings)

Use the Browse button to choose the folder in which the survey data is to be stored. This only needs to be done once at the beginning of the survey. Even after the laptop has been switched off, the data will continue to be saved in this folder until another folder has been designated in a similar manner. Select a name for the first survey run. As each survey run is completed, the software will automatically increase the number of the run by one digit from the previous one. Even if the tablet or laptop is switched off during the survey, once the Record menu has been activated, the software will offer the next number in sequence to the last recorded file. .

The lower half of the screen contains boxes for the name of the site, the name &/or initials of the operator(s) and for any notes that the operator wishes to accompany the data. This information is stored in the header file and can be accessed at will after recording.

Once the survey run details have been completed, press 'OK' to proceed to the next screen, the Radar Settings menu. Pressing 'Cancel' returns the operator to the initial Setup/Run/Record/Replay menu.

5.3.2 Radar Settings menu

This second window of the Record Menu is identical to that of the Run Menu (see 5.2 above). If the Run menu is used immediately before the Record menu, the parameters selected on the Run menu will re-appear on the Record menu. In this case, the operator can select 'OK' and being surveying.

If the Run menu has not been used to configure the radar, then the Radar Settings menu requires to be completed as outlined above.

Number of Transmitters	This has been pre-set to 1 from the system configuration. There is no other possible option for the single channel controller.
Number of Receivers	This has been pre-set to 1 from the system configuration. There is no other possible option for the single channel controller.
Trigger Control	This setting determines the Timesweep or the maximum depth in nanoseconds time. The timesweep is a 2-way travel time i.e. the time for the signal to transmit, reach the target and then return to the receive antenna. The controller will have a subset from 10 to 1280ns depending on the controller option. However not all timesweeps are suitable for all antennas and it is important to make the right selection for the frequency used.
Scan frequency	The scan frequency determines the rate of data collection. The top rate is 1600 scans/second. Depending on the survey condition, this may or may not be suitable. The value of scan frequency can be reduced if necessary. The available settings of scan frequency range from 1600scans/second down to 1.6scans/sec. If poor quality data is observed during survey, this may indicate that the antenna in use is not capable of

operating at as a high a speed as the controller in which case the scan frequency should be reduced to 100scans/sec. See also Section 5.1.3 for advice in the case of a stationary radar monitoring movement below ground.

Samples per line — For normal ground surveys, 256 points give good data. For low loss media where unusually deep penetration is expected, use 512 points.

Data Collection — Data collection can be continuous (normally suitable only for setting up the signal to match the site characteristics) or a standard distance sampling interval can be set using the wheel based triggering. It is not advisable to use continuous triggering while surveying since, unless the speed of the operator or the vehicle matches the speed of data collection of the radar, the data will be distorted.

Wheel Triggering — Wheel based triggering of the radar is always a function of the minimum encoder measurement (Encoder mm/tick). This is a function of the survey wheel used. Different survey wheels can be used with this system e.g. a vehicle's own odometer for survey from a vehicle, a trolley wheel for operation from a cart or an external wheel attached to the antenna for hand-towing. The Read distance is a multiple of the basic minimum encoder measurement. It is important to set the sampling interval (or Read distance) at a low enough level to detect the target but not so low as to impede data collection. See Section 6.2.

Reverse Direction — Once wheel triggering has been chosen, an option to reverse the direction of travel of the radar becomes available. This only comes into use when the encoder wheel setting is not aligned with the normal forward movement of the radar. This normally occurs when a non-standard Groundvue wheel is used. The radar automatically detects whether it is moving forwards or backwards. This function depends upon the fitting of the encoder wheel. It is possible to fit the encoder wheel so that it is fully functioning but in the reverse direction (cf Section 4.1). This can be checked by running the radar briefly in the Run or Set up menu. If the wheel detection is operating in the reverse direction to the radar, no data will appear on screen. Activating the reverse direction will produce radar data on screen. Note that using the reverse direction does not flip the data into the opposite direction. Post-processing software is necessary for this. It is not necessary to activate the reverse direction when moving back with the radar as this is detected automatically by the radar.

Relative Permittivity: — The relative permittivity setting is used to give a translation of the depth measured in nanoseconds into a depth in centimetres. The accuracy of this depth depends on the accuracy with which the transmission velocity of the electromagnetic waves has been estimated or measured. See Table 2 above for approximate relative permittivity values. The approximate depth-scale, based on the value of relative permittivity chosen, is shown on the data display during data recording.

5.3.3 Real Time Monitoring

When the “OK” button is pressed, a single monitoring screen will appear with a number of viewing options below (see Figure 6 below). The Transmitter Lock is for use in specialist UXO detection only and should be ignored.

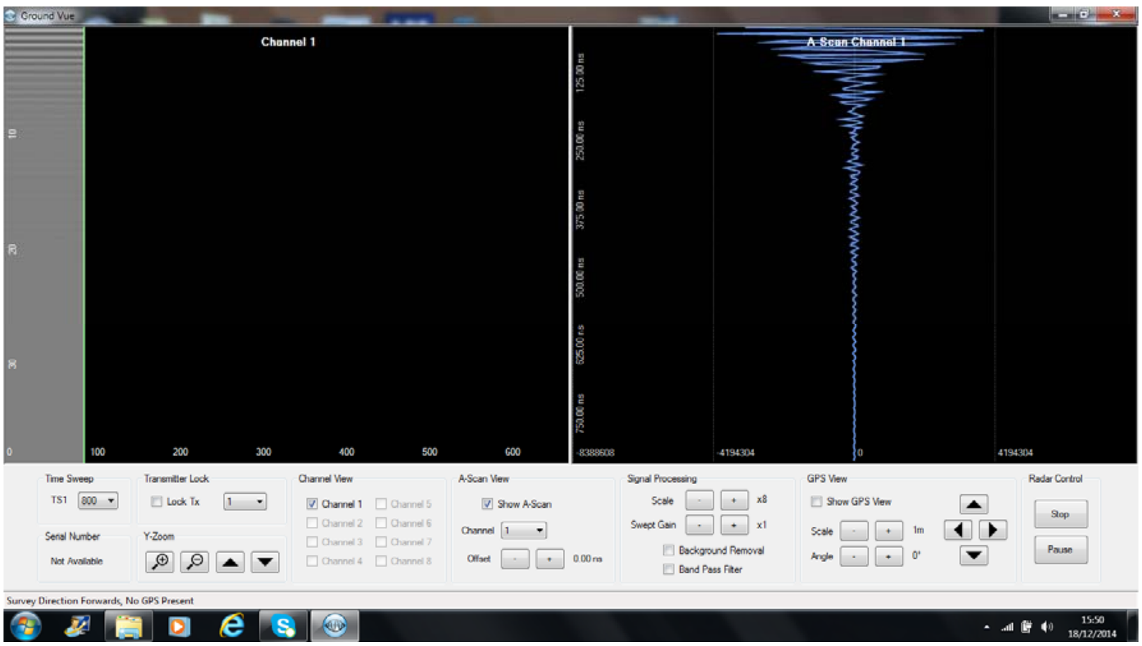

Figure 6. Groundvue monitoring window (with screens for 2d data and A-scan).

On the bottom line of the display is the status of the GPS. If no GPS is connected, the **No GPS Present** message is displayed. If the GPS is connected but is not generating valid data, the Easting and Northing numbers **0000,0000** are displayed. Once the GPS is working, the actual **GPS co-ordinates** are displayed on this line.

The **Channel View** allows the operator to select the number of channels for monitoring, independent of the number of channels that are collecting data. Since Groundvue 3_1 is a single channel system, one channel can be displayed. Alongside this one channel of 2-dimensional data, it is possible to monitor the quality of the signals through the changing A-scan.

The **A-Scan View** allows the operator to open an additional window on which the wiggle trace or A-Scan can be viewed for quality control. Only one channel can be viewed in A-Scan at any one time, even on the multi-channel version of the system. Select ‘Show A-Scan’ and then Channel 1. This setting can also be changed during the survey without affecting data collection and recording. We recommend that this option is only used at the beginning of the survey. Once the operator has satisfied himself or herself of the signal quality, it is not necessary to continue monitoring the signal unless an incident occurs during the survey which might have impacted on the operation of the radar. Leaving the A-Scan view off, allows the operator more space on-screen to monitor the actual GPR data.

The A-Scan view is also used to determine T-zero, the initial portion of the signal which relates to internal radar transmission prior to the signal entry into the surface. T-zero requires to be removed in order for an accurate depth estimation to be made. Groundvue 3_1 allows the user to adjust for T-zero on screen during survey using the Offset function.

The **Offset** allows the operator to eliminate T-zero from the trace. Activate the A-Scan view. The wiggle trace crosses a central vertical axis. While viewing the A-scan or wiggle trace, use the "+" and "-" buttons to move the signal in the A-Scan view to the point where the first zero crossing of the axis is placed at the top of the A-Scan view.   Once the top of the trace is the first zero crossing, T-zero has been eliminated.

Once this correction has been carried out the value of T-zero is recorded in the file header. For users of the ReflexW post-processing software, this means that the T-zero correction will be automatically read when the data is imported for post-processing. The T-zero correction will therefore be automatic.

5.3.4 On-Screen Signal Processing

The processing which is applied on-screen only affects the data being monitored. It enables the operator to view the data in the clearest manner possible. The processing is not stored. Only the raw data is recorded. The processes chosen to display the data will not therefore distort the post-processed data. Also, if the operator makes incorrect assessments on the processes, there is no need to repeat the survey as the data will not retain the selected processing.

There are two types of gain available to add to the data. The first of these is **Scale**. Scale applies the same amount of gain to the full radar trace. It is therefore a means of increasing or decreasing the contrast in the signals. Unless the site is very lossy or the very high frequency antennas (4GHz, 6GHz) are being used, it is often not necessary to increase the Scale beyond 1. However it is important in every survey to use an appropriate amount of gain for the actual conditions of the site. If a higher setting of Scale makes the data clearer, then it can safely be applied without prejudicing the final processed data since the value of Scale is not included in the recorded data.

The second type of gain is the **Swept Gain**.   This is time based gain, applied linearly, in order to compensate for signal losses which increase with depth as portions of the signal are returned and others dissipated in the ground.   Whatever the value of Swept Gain used, it enhances the signals lower down in preference to those closer to the surface in order to compensate for the level of losses which typically increase with depth. It will always be necessary to use some Swept Gain even for low frequency antennas. The value of Swept Gain is not recorded on the data.

Once a survey is underway, it may be necessary to adjust the Gains to further improve the displayed data. Changing the gain factors during the survey does not affect data collection or data recording which continue independently of the operator monitoring.

The **Background Removal** is a basic background removal which highlights anomalous material at the expense of the general survey environment. Depending on the nature of the target(s) of the survey and its (their) context, this can be a useful method of distinguishing objects from their surrounding material. On the other hand, if the purpose of the survey is to distinguish layer information, this function is not always helpful since, if the layer is reasonably constant, it may be removed as effectively being a part of the background. As with the gain settings, the Background Removal filter is also for the benefit of the radar operator and the process is not recorded.

The Band Pass Filter setting is not active for GroundVue3.

All three processing variables (Scale, Swept Gain and High Pass Filter) affect the monitored data and not the stored data. They are intended solely to enhance real time viewing. However, if the operator wishes to view the data after survey and change any or all of these parameters, this option is included in the Replay menu.

5.3.5 GPS map

There is an option to show the GPS radar track on the screen if the **Show GPS View** is ticked. The plot is centred on the first GPS position received by the system and there is a dot for every GPS sentence received. The scale and rotation can be adjusted with the control buttons and the plot can be panned with the cursor style buttons.

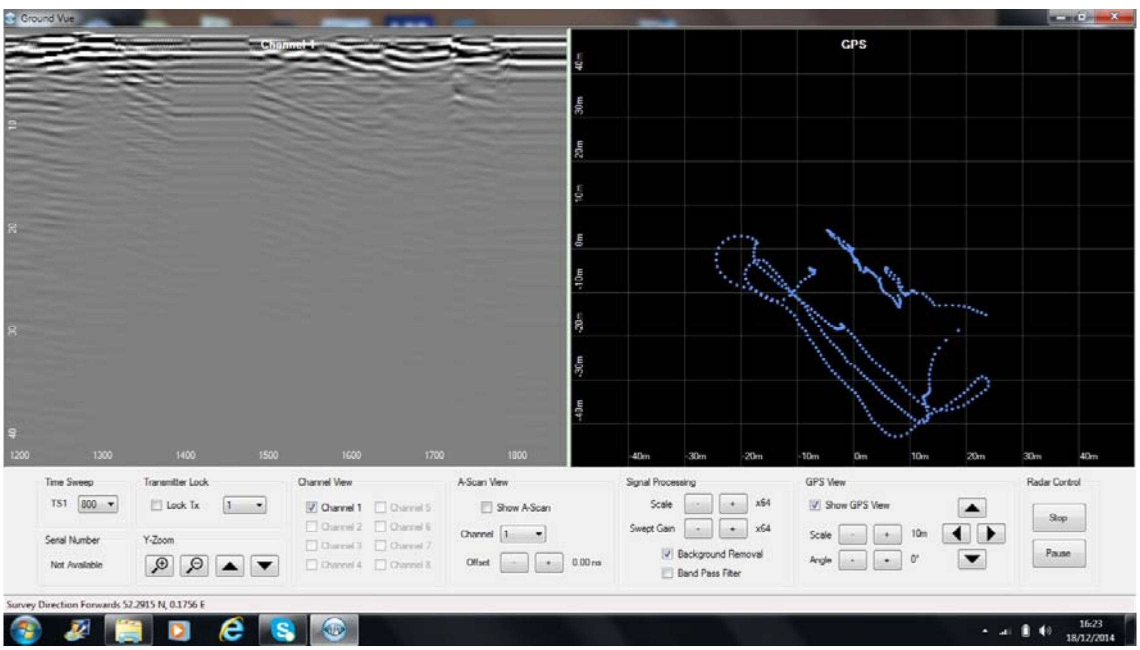

Figure 7: GroundVue monitoring window (with screens for 2d data and GPS map).

If a survey line is stopped and a new one started, the old survey lines still remain on the GPS window. This gives a real time check of the survey coverage. The GPS plots are only cleared when the GroundVue program is restarted.

5.3.6 Radar Control

If an encoder wheel is being used, the data will begin to be recorded and to appear on the viewing screen(s) as soon as the radar and wheel move the sampling or Read distance. Although the data is recorded simultaneously with the progress of the survey, the data files are not closed until the operator presses 'Stop' on the Radar Control panel. It is important to close each recorded file in order to ensure that the data file remains uncorrupted.

If it is necessary to pause the survey for reasons such as obstructions which have to be removed from the path of the radar, there is no necessity to pause the radar provided that an encoder wheel or other distance measurement device is being used. When the radar becomes stationary no further readings are taken until the radar next moves a distance equivalent to the Read distance or sampling interval. The Pause button is therefore not used when surveying using a form of distance measurement.

If, however, the radar is being used in continuous mode, physically pausing the radar will not pause the data. The radar will continue to transmit and receive even though it is not physically moving. The **Pause button** should be used in order to suspend data collection. Once the radar is ready to continue, the operator selects "Run" to continue surveying. The "Run" button does not appear until after the Pause button has been pressed.

It is not normally recommended to carry out surveys with the radar operating in continuous mode but see Section 5.2.3 for the common exceptions to this rule.

Once the first survey run has been recorded, the next and subsequent runs are carried out in the same manner by activating "Record", "OK" on the Run details, and "OK" on the Radar settings. The Run details will offer the next survey line number (with an increment of 1) after the one which has just been recorded. Notes can be amended or added to on the Run details if this is required.

The basic Radar settings such as number of transmitters and receivers, Timesweep and Read distance should not be changed so that a coherent data set is recorded. Although the processing parameters on the monitoring window can be changed at will, there is no need to change these unless the operator requires this for viewing purposes. At the end of each survey line, the operator presses "Stop" to ensure that the data file is properly closed and accessible thereafter.

5.4 The Replay Menu

Once the data has been recorded, it is possible to replay any or all recorded survey data files from the Replay Menu. Pressing "Replay" takes the operator directly to the file in which the data has been recorded.

The format of the files is NameNo_Channel No. So, for example, Bridge111_1 would be the 111th survey line and the header file for the 1st channel along that survey line. This is a legacy feature from the GV3_8 controller where Bridge111_8 would be the 111th survey line and the header file for the 8th channel.

Select the file that you wish to replay. This opens the Run Details window for that file. This is for information only and the file cannot be altered. Close the Run Details file by pressing "OK". The monitoring screen now appears and the data will begin scrolling on all of the channels used in the survey.

The **Pause button** now serves a different function from that in the Record Menu. It can be used to stop the data scrolling so that the operator can take the time to change any or all of the processing parameters.

Once the Pause button has been activated, the Run button appears. The Run button is used to start the data scrolling again.

In this way the recorded data can be re-examined and interrogated using different survey parameters from those used during the survey. At no point is the raw recorded data affected by either replaying or by altering the processing steps applied for viewing purposes.

6 DETERMINING VALUES FOR DEPTH, SAMPLING INTERVALS AND GAIN

This section provides a guide to selecting suitable survey parameters. In practice these will be determined by the nature of the site under investigation and the following should be used as a guideline only.

6.1 Depth and Timesweep (Tsweep)

The Timesweep (or Tsweep) is the two way travel time for the signal to pass from the transmitter to the target and reflect back to the receiver. Except at shallow depths, Tsweep is therefore equivalent to twice the depth, measured in nanoseconds. At shallow depths the geometry of the transmitter and receiver make the two travel time somewhat larger than twice the real depth but this is normally accounted for in post-processing.

Translating a depth into a nanoseconds setting on the radar depends on a reasonably accurate measurement of the transmission velocity. The transmission velocity, in turn, depends upon the electromagnetic properties of the soil and, in particular, its moisture content, if any. This is because moisture present in the soil (or other survey medium) slows down the transmission significantly. In practice, in order to set up the radar appropriately, it is sufficient to know the depth to which we wish to probe and to have some idea of the likely transmission properties. An accurate velocity calibration will be required during the survey in order to ensure that correct depths are reported but this is not required in order to set up the radar in advance.

Starting from Speed = Distance/Time, the calculation required to determine Tsweep is Time = (Depth x 2)/Speed. Both depth and speed can be estimated. In the case of the depth, this is usually supplied by the client requiring a survey, for example, clearance to a certain depth. It is good practice to allow a margin in excess of the depth in order to allow for the slowing effect of any moisture present unless there is information to suggest that this is not necessary.

The transmission speed depends directly on the electromagnetic properties of the soil, specifically the relative permittivity (see Table 2). The equivalent approximate speeds of transmission for the materials in Table 2 are shown in Table 3.

Material	Air	Plastics	Plastics	Ice	Tarmac	Concrete
Velocity	0.3	0.2	0.17	0.15	0.12	0.1
Material	Dry Soil	Wet Soil	Wet Soil	Damp Organic Soil	Wet Organic Soil	Water
Velocity	0.095	0.077	0.067	0.055	0.04	0.033

Table 3: Approximate Transmission Velocities (in metres/nanosecond) for a Range of Materials

For dry soils or concrete over 3 months old, Table 4 shows appropriate depth settings in nanoseconds. These settings are not appropriate for all frequencies of antenna since the actual depth achieved depends both on the wavelength and also the soil properties.

Tsweep	20ns	30ns	40ns	80ns	120ns	160ns
Approx. Depth	1m	1.5m	2m	4m	6m	8m

Table 4: Depth Settings in Nanoseconds for Dry Soil/Mature Concrete

Typical Tsweep ranges, by frequency are shown in Table 5.

250MHz antennas	40 to 160ns
400MHZ antennas	20 to 80ns
1GHz antennas	10 to 40ns
1.5GHz antennas	10 to 30ns
4GHz antennas	10ns
6GHz antennas	10ns

Table 5: Tsweep Ranges by Frequency

Since the principal determining factor in the actual (as opposed to theoretical) depth range of a radar is the electromagnetic properties of the soil, the depth extent should be checked on-site. The Run or Set Up menu is intended for this purpose.

Note that the Tsweep cannot be changed during or after the survey and should not be changed between successive files. If a change is made to Tsweep, the operator must consider whether the earlier files should be repeated at a deeper setting. Unlike the processing parameters, the Tsweep is part of the recorded data.

6.2 Sampling Intervals and Read Distances

The sampling interval along the line of travel of the radar is known as the Read distance in the Groundvue operating software. This value is important because it is one of the survey parameters which cannot be changed after survey. In setting the Read distance, the operator has to balance two requirements:

1. the need to be sure of the signal hitting the target at least once and
2. the need to set the sampling interval within an appropriate range for the frequency of the radar.

It is possible, on any radar, to set the sampling interval too low for the wavelength emitted. This will result in missing data which, in turn, introduces uncertainty into the position of targets.

A good rule of thumb for a suitable sampling interval for any antenna is that the smallest viable sampling interval should allow 8 readings per wavelength. Table 6 below shows suggested sampling intervals for different frequencies of antenna.

Frequency	6GHz	4GHz	1.5GHz	1GHz	400MHz	250MHz
Read value	0.2cm	0.31cm	0.83cm	1.25cm	3.125cm	5cm

Table 6: Suggested minimum sampling intervals for different antenna frequencies used on dry soil

Many of the values of minimum Read distance are lower than the minimum sampling encoder wheel distance. It is therefore acceptable to use the minimum encoder setting as the Read parameter when using these antennas.

The values calculated above assume wavelength in dry soil. In wet conditions the wavelength will decrease and the sampling interval can therefore be shorter

Do not enter the **Read** parameter until all the other parameters have been defined. This is because, once the sampling interval has been selected, it is necessary to move the radar in order to view data on screen. If the radar is kept running continuously the selection of parameters can be made from the set up screen without moving the radar itself. Ensure that the correct encoder separation distance has been entered before selecting the Read parameter. The encoder separation distance is determined by the survey wheel being used.

6.3 Setting the Gain Parameters

Unlike the Tsweep and the Read distance (or sampling interval), the gain settings are not critical and can be changed both during the survey and after survey since the data is always recorded raw. The “Run” or Set up menu can be used to determine suitable gain parameters before the survey data is recorded. In this way it is possible to match the gain parameters to the electromagnetic properties of the site to be surveyed.

There are two types of gain – Scale and Swept Gain. Scale provides an overall contrast for the full depth of survey. Swept Gain is a time based gain which enhances the deeper returns relative to the surface and near surface. Swept Gain has a linear base.

In order to match the gain parameters to the site, begin with a Scale of 1 and examine the A-scan or Wiggle trace of the signal. The aim is to create an A-scan profile in which the widest part of the trace fills half to two thirds of the available space and the part of the signal reflecting the depth at which the survey targets are expected is also enhanced. Increase the value of Swept Gain to see if this can be achieved. It is not unusual to have a value for Swept Gain of 8 or more.

If it proves impossible to enhance the signal to a point where the target area is visible then the Scale setting should be increased. If the largest signal appears to be clipped i.e. it extends beyond the range of the screen, there is no need to change the gain settings as the enhancement is only for the benefit of the viewer and does not affect the recorded data.

In the example shown in Figure 8 below, the largest signal already fills half to two thirds of the screen, indicating that it is not necessary to increase the Scale value from 1. The target area, however, could be enhanced and this is done by adding Swept Gain.

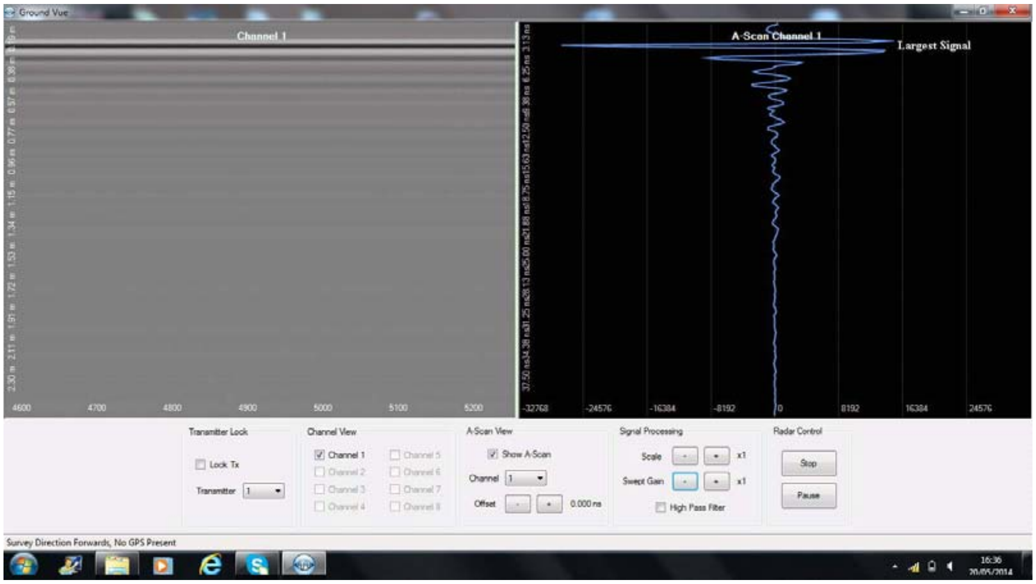

Figure 8: A-Scan with Scale & Swept Gain of 1

Figure 9 shows a signal with Swept Gain added to enhance the potential target area. The aim of adding Swept Gain is to increase the size of the signal in the Target Area without exaggerating the lowest signals to the point where the data becomes noisy and therefore difficult to see. In the example in Figure 8, the area marked "lowest signals" is, in fact, also part of the target area so the enhancement to the signal is acceptable. If too much Swept Gain is added, the distortion in the signal will be obvious and the greyscale view of the data will be heavily striped in black and white. This does not affect the recorded data but makes it difficult for the operator to monitor the data as it is recorded. If this should happen, the Swept Gain can be reduced at any time during or after the survey.

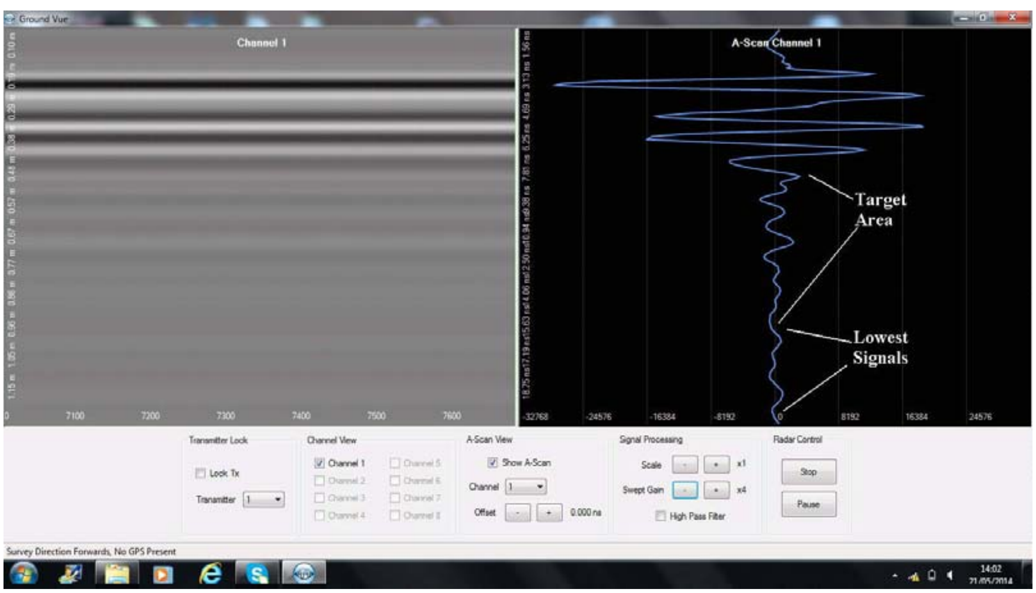

Figure 9: A-Scan with Swept Gain added.

If the operator prefers to set the gain while the system is recording, the Run or Set up menu can be bypassed and the Record window accessed directly. Since the gain settings do not affect the recorded data, changing the gain values during survey has no effect on the data.

7 MARKERS

Distance information, based on either the sampling interval (or Read distance) set by the encoder wheel or on GPS data, is recorded automatically on the GPR data. It is also possible to use the full range of laptop/tablet/PC keys (letter or number) to place additional markers on the data. The marker will carry a character determined by the key used. The usual reasons for using markers on the data are, for example, to indicate the position of survey reference lines, to indicate areas of particular interest in the survey or to indicate the position of surface obstacles.

8 RUN NUMBERING OF SURVEY LINES

Each time a survey run is completed, the menu will offer the next number in the sequence e.g. run 12 will be offered after run 11. If the operator enters a file name and number which already exists in the recorded data, the message "This file already exists" is displayed. It is only possible to overwrite previously recorded files if the operator explicitly selects this option.

9 DATA FORMAT

Data is stored in 16 bits as raw data. The only parameters that affect the recorded data directly are Tsweep and Read. The other parameters affect the display and may be varied during or after completion of the survey (see sections 5.3 and 6.3).

The data is stored under the run name as RUNNAME.dat. The run details are stored in the file RUNNAME.hdr. The stored data format is 2 bytes per point with LSB byte followed by MSB byte. There are 256 or 512 points (512 or 1024 bytes) followed by 1 byte of marker (ASCII).

In addition to the data and header files, GPS files (.gps) and gps number files (.gpt) are generated, irrespective of whether or not a GPS is used. If a GPS is not used, the .gps and .gpt files will be 0kB in size.

10 DATA PROCESSING

The GroundVue data format is compatible with the following interpretative packages:

- REFLEXW
- RoadDoctor
- GPR-Slice and
- Geosoft.

The ReflexW package can be either hired or purchased from Utsi Electronics Ltd.

If an interpretative package is to be used which is not included on the above list, the GroundVue data format can be supplied to the software manufacturer, on request.

It is generally only necessary to select the data files when importing GroundVue data into an interpretative package. The header information is automatically imported without the header files being selected.

11 UTILITY DETECTION

It is possible to use Groundvue 3_1 to locate accurately the position of a pipe or cable (or any other target) by using the marker function in conjunction with the reverse direction function. The pipe or cable or other target is generally recognised by the appearance of a hyperbola in the data. The position of the target is determined by the apex of the hyperbola and it is therefore not possible to identify this with any certainty until after the radar has passed over the object(s).

In order to determine the position relative to the ground surface, survey across the area covering the targets. Once the hyperbola from the target is clearly and fully available on-screen, begin to pull the radar backwards along the same track. This places a marker on the data. When the marker aligns with the apex of the hyperbola, the mid-point of the antennas lies directly above the pipe/cable/other target.

Note that marking out pipes and cables on the ground, although very useful, is no substitute for post processing the data since this may identify additional targets which were not apparent in the 2-dimensional data alone.

12 LICENSING

12.1 Product Compliance-Europe

In all member states of the European Union (EU), GPR must demonstrate compliance with the provisions of the R&TTE directive 1999/05/EC.

Compliance with this directive has been demonstrated for GroundVue 3 antennas, by the application of harmonised standards, whose reference is published in the Official Journal (OJ) of the European Commission.

The standards used are as follows:

EN60950, covers product safety as set out article 3.1a of the directive

EN301 489-32, contains the specific conditions for GPR in respect of Electromagnetic Compatibility as set out in article 3.1b of the directive.
This standard is used together with EN301 489-1, which contains the emission and immunity test methods and limits.

EN302 066-2, covers the essential requirements for the effective use of the Radio Spectrum as set out in article 3.2 of the directive. This standard was used together with EN302 066-1, which contains the Technical characteristics and test methods.

The radar system is “CE” marked to indicate compliance with European Product Standards as outlined above. The “CE” labels should not be removed.

12.2 Product Compliance - USA

Notice (for U.S. Customers):
This FCC device complies with part 15, class F of the FCC Rules:
Operation is subject to the following conditions:
1. This device many not cause harmful interference, and

2. This device must accept any interference received, Including interference that may cause undesired operation

Warning: Changes or modifications to this unit not expressly approved by the party responsible for compliance could void the user’s authority to operate the equipment.

Parties operating this equipment must be eligible for licensing under the provisions of part 90 of 47 CFR.

Operation of this device is restricted to law enforcement, fire and rescue officials, scientific research institutes, commercial mining companies, construction companies and private parties operating on behalf of these groups. Operation by any other party is a violation of 47 U.S.C. § 301 and could subject the operator to serious legal penalties.

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 operator of an imaging system used for fixed operation shall supply a specific geographical location or address at which the equipment will be operated. This material shall be submitted to the Federal Communications Commission, 445 12th Street, SW Washington D.C. 20554. Attention UWB Coordination.

(c) Users of authorized, coordinated UWB systems may transfer them to other qualified users and to different locations upon coordination of change of ownership or location to the FCC and coordination with existing authorized operations.

(d) The NTIA/FCC coordination report shall include any needed constraints that apply to day-to-day operations. Such constraints could specify prohibited areas of operations or areas located near authorized radio stations for which additional coordination is required before operation of the UWB equipment. If additional local coordination is required, a local coordination contact will be provided.

Notice: Use of this device as a wall imaging system is prohibited by FCC regulations.

Caution: Exposure to Radiofrequency Radiation: The device shall be used in such a manner that the potential for human contact normal operation is minimized. This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with a minimum distance of 5cm between the radiator and your body

For U.S. Customers

Ground Penetrating Radar Coordination Notice and Equipment Registration

Note: This form is only for Domestic United States users. The Federal Communications Commission (FCC) requires that all users of GPR who purchased antennas after July 15th, 2002 register their equipment and areas of operation. If you have purchased any antennas after July 15th, 2002, you must fill out this form and fax or mail to the FCC.

1. Date:

2. Company name:

3. Address:

4. Contact Information [contact name and phone number]:

5. Area of Operation [state(s)]:

6. Equipment Identification: Brand Name: Utsi Electronics Ltd GV3-1 400 MHz
FCC ID (XXXX followed by GV3-1 400)

7. Receipt Date of Equipment:

Fax this form to the FCC at: 202-418-1944

Or

Mail to: Frequency Coordination Branch, OET Federal Communications Commission 445 12th Street, SW Washington, D.C. 20554

ATTN: UWB Coordination

12.3 Operator Use

Anyone using a GPR should be aware that, as transmitting devices, the equipment must be used responsibly. International licensing regulations require the operator to use GPR either in contact with the surface under investigation or within 1m of this surface. Using the GPR ground coupled ensures the best signal transmission into the ground/wall. Operators should comply with the requirements of the European Code of Practice, European Telecommunications Standards Institute (ETSI) Guidance, for which the document reference is ETSI EG 202 730. A link to this document is available from the European GPR Association's website at http://www.eurogpr.org – Home – Introduction to GPR – Code of Practice.

Certain countries, including the UK require the operator to hold a licence. UK licence application forms (OfW349) are available from http://licensing.ofcom.org.uk/.

Utsi Electronics Ltd recommends membership of the European GPR Association (EuroGPR) for regular users of GPR technology. EuroGPR not only keeps its members informed on licensing and guidance matters but also provides an on-line library of reference material. Application forms are available on-line on the "Contact Us" section of the website www.eurogpr.org.

13 TROUBLESHOOTING

Problem	Solutions
No data appears on the screen.	Check that the controller light is on, indicating that the radar is transmitting. If there is no light showing, turn the controller on. If turning the radar on does not solve the problem, change the battery before turning the radar on again. Check that the static IP address is set on the laptop – See Section 3.1 Setting up the IP address. If an ethernet cable is being used, check that this is connected to both the radar controller and the laptop. There should be a light showing at the ethernet input on the laptop. If no light is showing, check that both connections are secure. If necessary, change the ethernet cable. Check that the encoder wheel is set to recognise the same primary direction as the radar. No data will appear on the screen if the wheel is set to record in the opposite direction. When the radar moves in the reverse direction the screen will typically roll back. If the direction has been wrongly defined, there will be no data on screen to scroll back and the screen will remain blank. On the Radar Settings window, activate "Reverse Direction" in order to align the radar and the encoder wheel along the same primary direction. See also "Reverse Direction" in Section 5.2.2. If this cures the problem, all subsequent survey lines should be completed in reverse direction also.
The radar is emitting a warning beep.	Either the radar is moving too fast for the survey parameters selected **or** The battery is running low on power. For the former, check that the Read distance is not too small for the frequency and wavelength of the radar – see Section 6.2. If the sampling interval (or Read distance) is too small, increase the sampling interval. Note that, because this affects the whole survey and, in particular, the recorded data, it will be necessary to repeat any earlier survey runs at the same sampling interval in order to maintain a coherent data set but also to correct any positional inaccuracies arising from using too small a sampling interval. If it is not possible or desirable to increase the sampling interval then the scan frequency can be increased.

	If the scan frequency cannot be increased, then the operator should slow down. This usually only applies to rough surfaces. If the battery is low, a warning will appear on the screen.
Low battery warning on the display	If the radar is working on its internal battery, connect to an external battery (see Figure 3). If the radar is already running on an external battery, change the battery.
“You’re going too fast” warning appears on the display	Apply the solutions listed under “The radar is emitting a warning beep”.

14 CARE OF EQUIPMENT AFTER USE

A visual check for mechanical damage should be carried out at the end of each day or part day's surveying. Batteries require to be re-charged regularly. Any mud or other debris should be removed by wiping down the component boxes with a clean damp cloth. All cables should be disconnected & the exterior wiped clean before coiling loosely for storage.

Internal Batteries

The controller have a built in Li Ion battery (3S2P). These give at least 10 hours' operation time with one antenna. This battery must be kept fully charged or survey work will be interrupted.

At low temperatures, the capacity of the LiIon batteries drop and at –20 degrees C, the capacity might be halved.

LiIon batteries must not be charged if they are below 0 degrees C. So before charging in freezing climates, they have to be heated before charging.

Battery charger is supplied with Controller. For safety reasons, it is important that no other battery charger is used for this purpose. When the charger light goes green, the battery is charged.

We recommend an annual maintenance check be carried out on the system. Contact Utsi Electronics Ltd to arrange this.

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Appendix A. Setting up the IP Address for Computing Devices using Windows XP

Open the control panel and select Network and Internet Connections. On the Network & Internet connections window select Network Connections. Depending on the presentation it may be possible to go directly from the control panel to Network Connections.

From the new window select Local Area Connections and right click to select the Properties.

In the Properties window select Internet Protocol TCP/IP and then select Properties. Select "Use the following IP address" and enter the static IP address for the controller.

The static IP address is recorded on the lid of the radar controller. It is important to note this address in this handbook in case the wording wears out with use.

Static IP Address of Groundvue 3_8……………………………………………………

Now enter the Subnet mask. This is 255 255 255 0. This completes the set up sequence. Press OK. The various windows opened can now be closed.