IceRadar 4.1 – Software User Manual

ver 1.0

1. Introduction and foreword

IceRadar was developed to assist glaciologists in performing radar surveys on icefields and glaciers using portable and cost-effective equipment. IceRadar was developed by Blue System Integration Ltd. (BSI) of Vancouver, B.C. Canada. www.bluesystem.ca - info@bluesystem.ca - 604.726.1817

IceRadar is a product developed with off-the-shelf hardware and customization in mind to maximize the value it brings to its end-users. It is distributed as a product, including radar transmitter, digitizer, computer platform, and software. As such, the system uses a pre-installed software key that binds digitizer hardware and computer used for acquiring data. Should one of these items be replaced, please contact BSI for obtaining a new key.

Feedback and additional specific requirements are welcome as this product remains customizable.

The hardware components have been selected to optimize portability, tolerance to shocks and vibrations, and costs. The embedded computing unit (EPU) was built to fulfil these requirements. It is a light industrial touch panel computer running on Windows XP Embedded. It has no moving part and is equipped with a solid state hard drive (SSD) with no moving part. All subsystems are mounted into a rugged case further protecting them from dust, rain, and shocks.

It is important to note that the capacity of the EPU' solid-state-drive is significantly smaller than the capacity found on today's desktop and laptop computers. This should be addressed by:

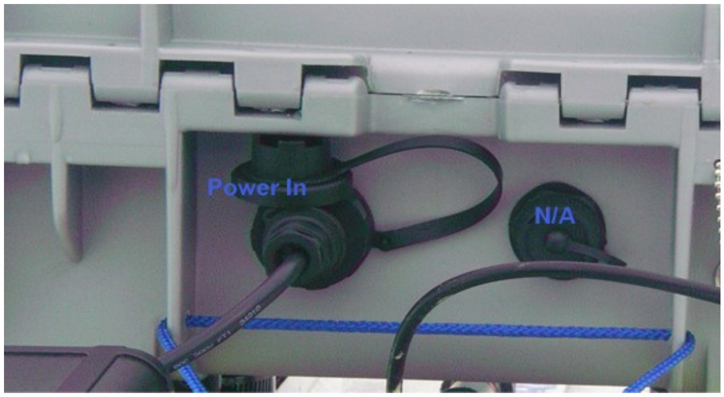
- not installing additional software on the C: drive
- keeping Microsoft Windows updates disabled.

The EPU must be considered as a field instrument, and as such no other application should run when IceRadar is operating. Additionally, the EPU's power settings were tuned to match fieldwork requirements. The computer will neither hibernate, nor go on standby, and the screen will turn off after about a minute to save power. All these settings can be changed by the user, and as such, one should be aware of the reasons behind them. Changing these settings is not recommended. Also, to save battery life the wireless adaptor was disabled and turned off.

If you change time zone, do not forget to adjust the EPUtime as this may result in time mismatch with the GPS.

2. Powering up the System

First make sure the power switch on the EPU front panel is OFF. Plug the power cord in the back of the system protecting the cap from snow.



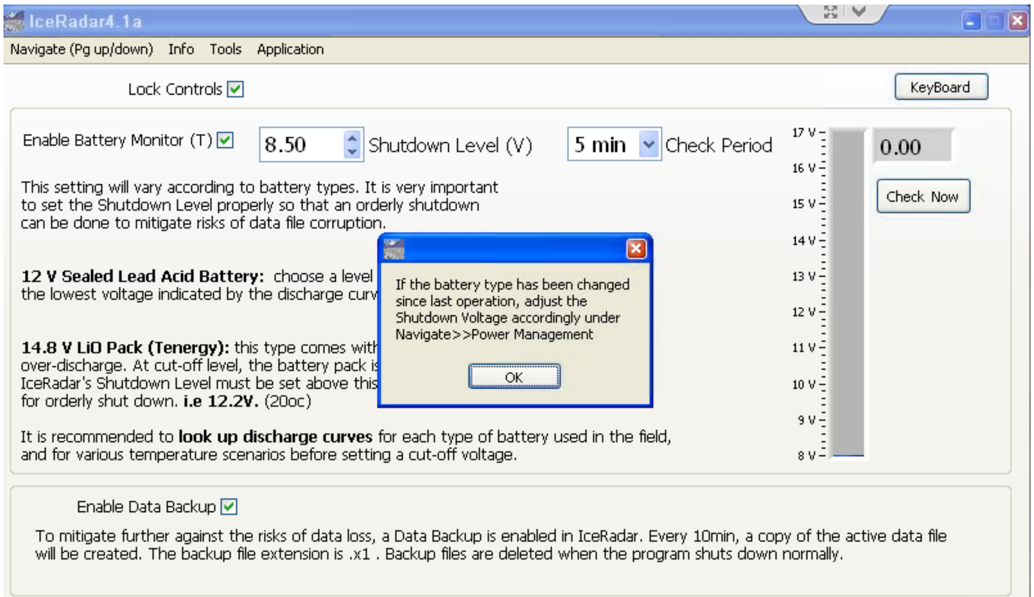
As soon as a power source is connected to the EPU, the voltage indicator should display a voltage reading. At this point turning the switch ON will boot the computer.

Important: To power down the system, **never** turn off the power switch before **first** shutting down the computer via software.

3. Launching the Data Acquisition Software

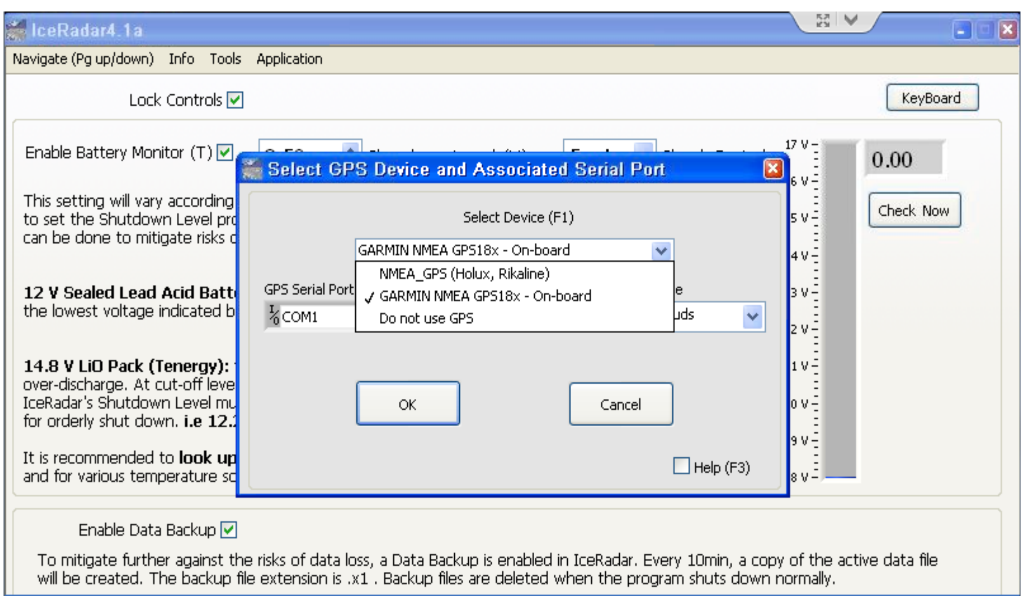
Starting the application

Start the application by clicking on the IceRadar icon on the desktop.

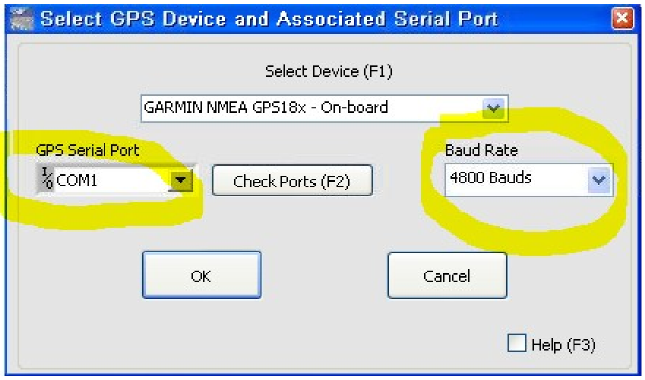


The first screen to appear is the Power Management Screen. Details about power management will be discussed further down in this section. Just OK the pop-up box.

The following pop-up asks the user to select which GPS to use. The standard, on-board GPS is **Garmin NMEA GPS18x** and there is no need to change this, unless no GPS is going to be used. The NMEA_GPS option is for legacy systems only.

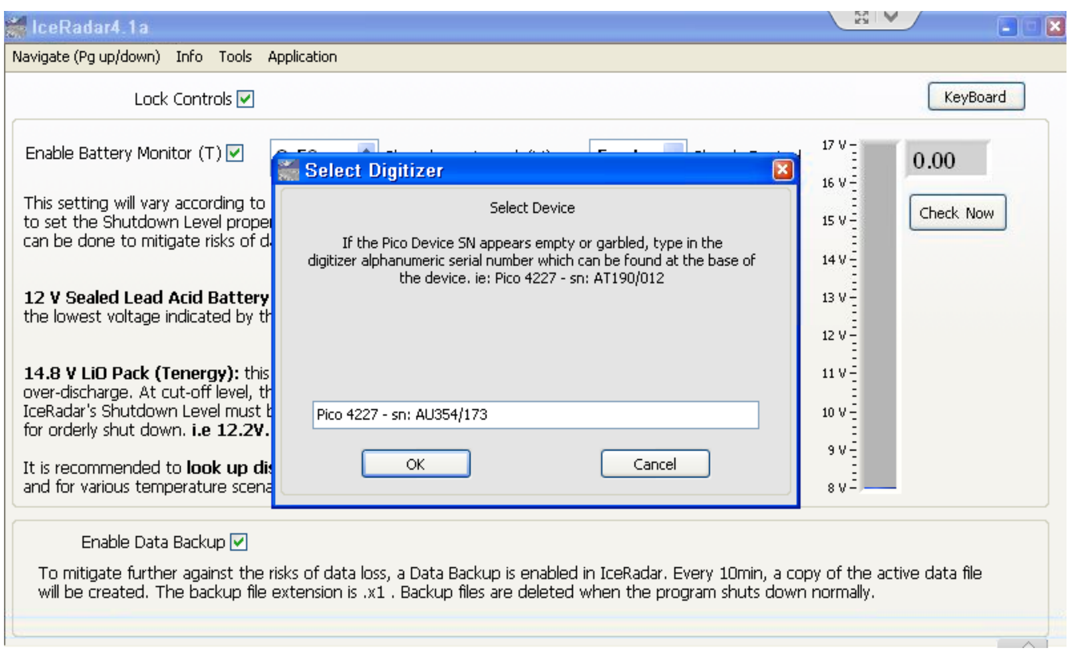


GPS communication Baud Rate sets how the computer communicates with the GPS unit. The GPS has been set to operate at 4800 bauds on COM1, and as a result the computer's COM 1must be set to also operate at the same speed. The only reason to change this setting is if the actual GPS hardware settings were altered (discussed later).



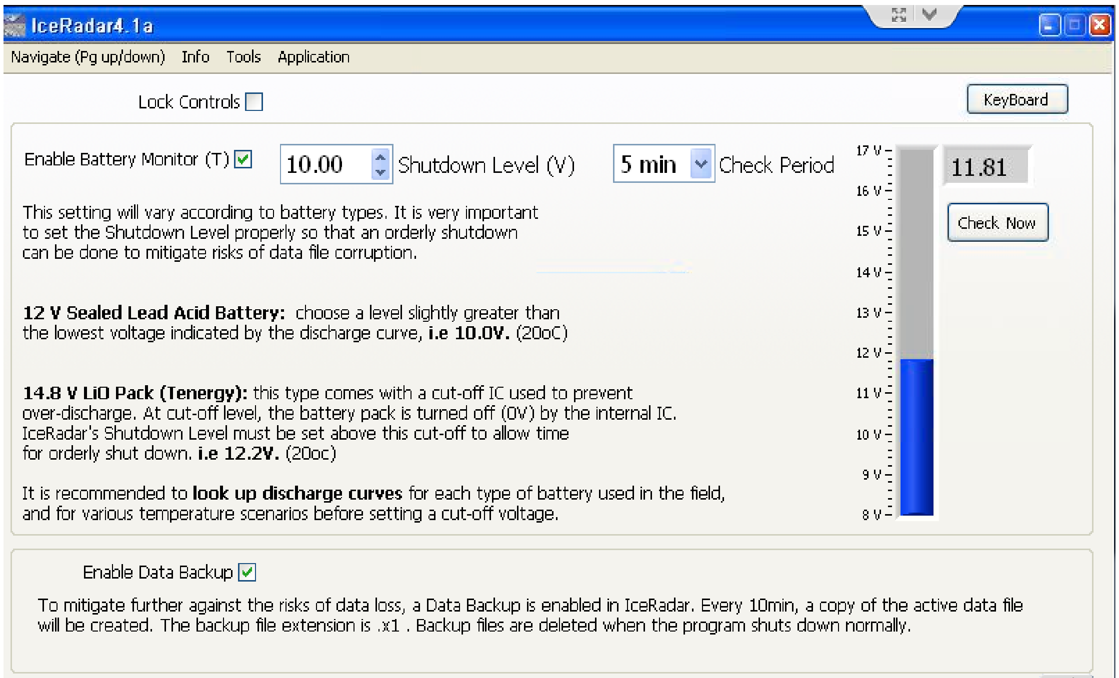
The Check Port button opens the Device Manager and is used for the Legacy NMEA_GPS option when such devices were connected to a USB port on the computer. These required to find which serial port was associated with the GPS. This is not required when using the on-board Garmin GPS.

Finally the last step is to OK the selected digitizer and indicates the user that the internal digitizer was found and recognized by the system. Once this is done, the Power Management and Backup screen is the first one accessible.



Power Management and Data Backup Screen

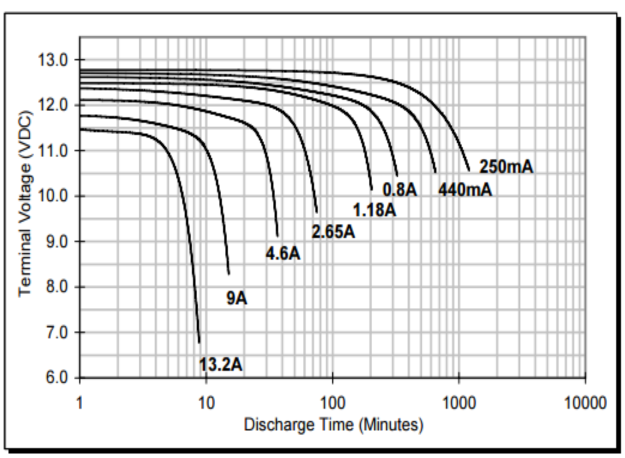
The **Power Management** and **Data Backup** options are mostly detailed on the panel itself.



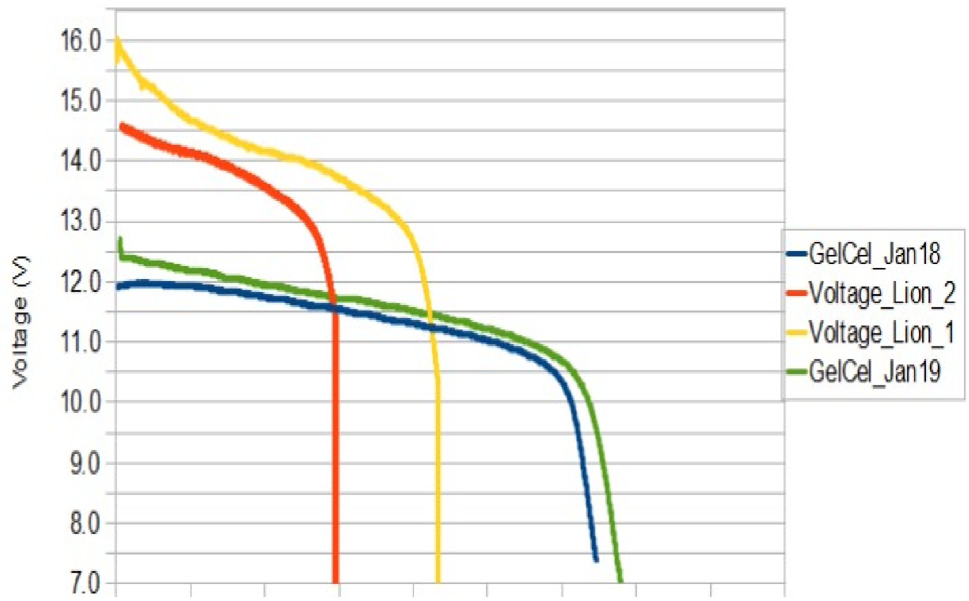
Shutdown Level specifies at which battery level the software will initiates and orderly shutdown. The battery level is checked at interval sets by the **Check Period**. **Enable Data Backup** insures there is always a second data file in the system updated at most 10 minute prior to the current data file. Check hard disk file available file space, as the backup procedure requires extra disk space.

Additional Information regarding battery and IceRadar Power Management

It is recommended to become familiar with battery discharge curves which are battery type's specific. They can be obtained from manufacturers. Discharge profiles are usually a function of current draw and temperature, as well as battery's history usage, and care of recharge procedure. Below are example of such characteristics for an Infinity SLA Battery IT5-12 : 12V 5Ah



Note that the voltage of LiO batteries, like the ones illustrated below on the red and yellow curves, drops much more quickly than lead acid batteries in green and blue when they reach the “knee” in their profiles. Lithium-based batteries are typically equipped with **cut-off circuitry shutting down the voltage output completely** once the cut-off voltage is reached.



As a result it is very important to set up IceRadar **Shutdown Level for the EPU well above the battery cut-off**.

Using SLA Gel Cell batteries which are not equipped with such IC can be a good alternative to avoid this problem. It is recommended though to not put the voltage cut off too low with a Gel Cell to avoid draining the battery too much, compromising its life span.

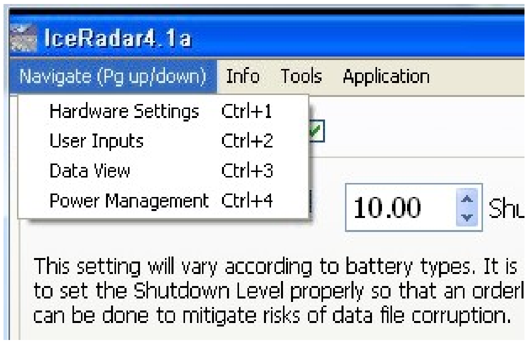
Finally, it should be reminded that all batteries must be recharged with temperature compensated smart charger, as charge current should be diminished below 10oC. Also, Lithium-based battery must not be charged when the battery temperature is below 0oC, which would lead to chemistry changes inside the cells which eventually will destroy the battery. This is not a well known fact, as Lithium battery are known for good **operating** performance in the cold, which is true, despite **charging**, must be performed > 0oC . Obviously no re-heating of battery should take place other than carrying it in one's pocket, or inside warm facilities when possible.

As a guideline, the EPU draws about 0.8A to 1A under 12V. A 12V 5A.h battery should be expected to last 3.5 to 5 hours at ambient temperature of about 20oC.

Future versions of the EPU will accommodate as much as feasible available battery management procedures which may be retrofitted into current EPUs.

4. Navigating the Screens

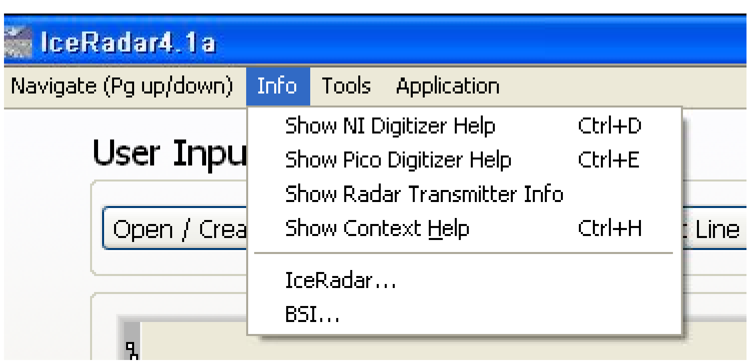
Use the Navigate drop down to toggle to any of the available screens.



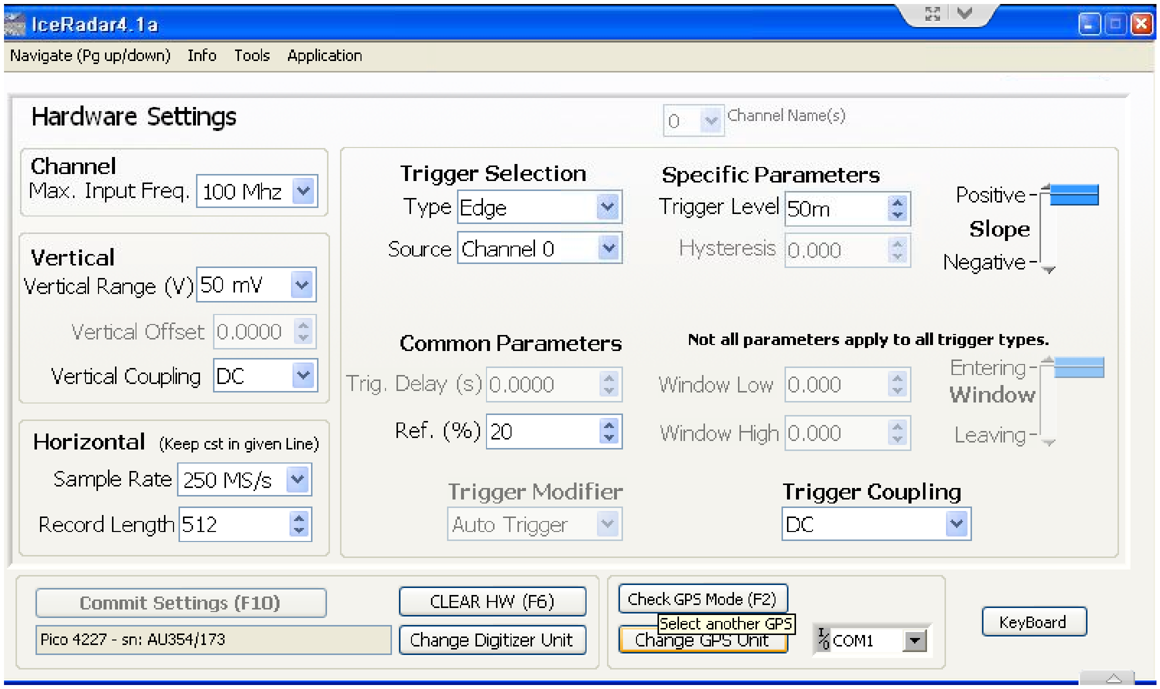
- **Hardware Settings** screen sets the acquisition hardware parameters such as trigger level and expected signal range.
- **User Inputs** screen is mainly used to set some parameters such as transmitter repeat rate, antennas spacing and data file management (open, create, line selection)
- **Data View** is the main acquisition panel
- **Power Management** sets the Shutdown level and data backup.

5. Hardware Settings

These settings are similar to an oscilloscope settings. They gives access to all the important digitizer hardware parameters. Once set, they should normally not change very often. Anytime a hardware setting is changed, committing the settings is required via the **Commit Setting** button. If no commit is done, the application will pop a message box indicating to do so.
Additional information can be found under the Info menu. The **NI Digitizers Help** refers to National Instruments Digitizers, and it contains an extensive backgrounder on how the hardware works. Further more information is also available under **Show Radar Transmitter Info**.



The Hardware Settings window gives access to all the important digitizer hardware parameters. Once these settings are done, they should normally not changed very often. Anytime a hardware setting is changed, committing the settings is required via the Commit Setting (F10) button. If not commit is done, the application will pop a message box.



Channel: Max Input Freq.
Specify the bandwidth of the channel expressed as the frequency at which the input circuitry attenuates the input signal by 3 dB.

Vertical:

Vertical Range: Vertical range is the peak-to-peak voltage span that a digitizer can measure at the input connector. For best vertical resolution it is better to use the smallest range that will fit the signal. If the range is smaller than the signal span, the signal will be clipped, which may be inconsequential if one is interested in detecting even smaller signal. For instance it may be ok to clip and air wave, to better detect smaller reflected pulses.

Vertical Coupling: On many digitizers, you can configure the input channels to be DC-coupled, AC-coupled. DC coupling allows DC and low-frequency components of a signal to pass through without attenuation. In contrast, AC coupling removes DC offsets and attenuates low frequency components of a signal. This feature can be exploited to zoom in on AC signals with large DC offsets, such as switching noise on a 12 V power supply.

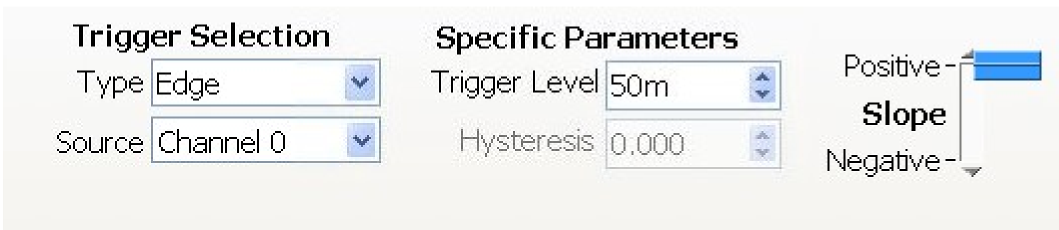
Horizontal:

Sample Rate: Sample rate, specified in samples per second (S/s), is the rate at which a signal is sampled and digitized by an analog-to-digital converter (ADC). According to the Nyquist theorem, a sample rate at least twice the highest frequency of the signal produces accurate measurements if the analog bandwidth is wide enough to let the signal pass through without attenuation.

Record Length: Record length refers to the amount of memory dedicated to storing digitized samples for postprocessing or display for a single acquisition. In a digitizer, record length limits the maximum duration of a single-shot acquisition. For example, with a 1,000-sample record and a sample rate of 20 MHz, the duration of acquisition is 50 µs (the number of points multiplied by the acquisition time per sample, or 1,000 x 50 ns. With a 100,000-sample record and a sample rate of 20 MHz, the duration of acquisition is 5 ms (100,000 x 50 ns).

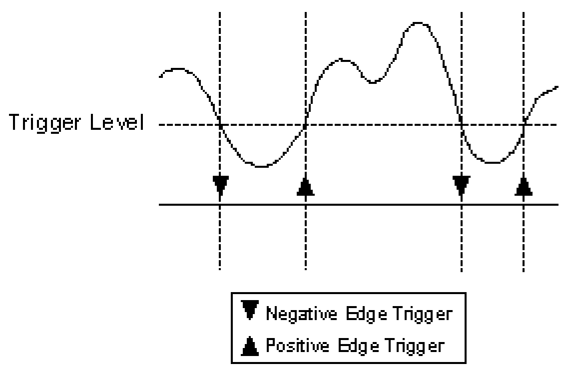
Wave speed (m/s)	Sampling rate S/s	Ice thickness (m)	Time for reflected wave (micro sec)	# samples in buffer
1.68E+008	2.50E+008	50	0.6	149
1.68E+008	2.50E+008	100	1.2	298
1.68E+008	2.50E+008	200	2.4	595
1.68E+008	2.50E+008	300	3.6	893
1.68E+008	2.50E+008	450	5.4	1339
1.68E+008	2.50E+008	500	6.0	1488
1.68E+008	2.50E+008	600	7.1	1786
1.68E+008	2.50E+008	850	10.1	2530
1.68E+008	2.50E+008	1000	11.9	2976
1.68E+008	2.50E+008	2000	23.8	5952

Trigger:

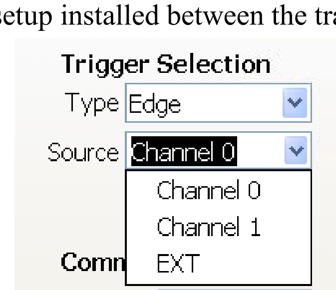


A trigger is an external stimulus that initiates one or more instrument functions. Generally speaking, Trigger stimuli include digital edges, software functions, and analog levels. The trigger can be derived from attributes of the signal to be acquired, such as the level and slope of the signal.

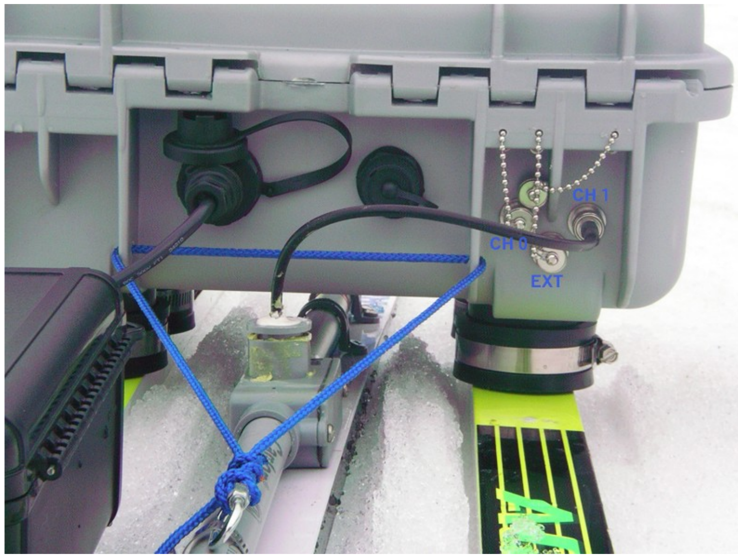
Trigger Selection.Type: In IceRadar the options are either Edge or Immediate (no trigger). An edge trigger occurs when a signal crosses a trigger threshold that you specify. You can specify the slope as either positive (on the rising edge) or negative (on the falling edge) to the trigger. The following figure shows edge triggering.



Trigger Selection.Source In IceRadar the Trigger typically uses the radar signal itself (air wave triggering), in this case use **channel 0** since the signal must be coming in on channel 0. Alternatively, some systems use a separate digital trigger with a fibre-optic setup installed between the transmitter and the receiver which would



use the **EXT** input that is the lowest TNC input in the back of the EPU.

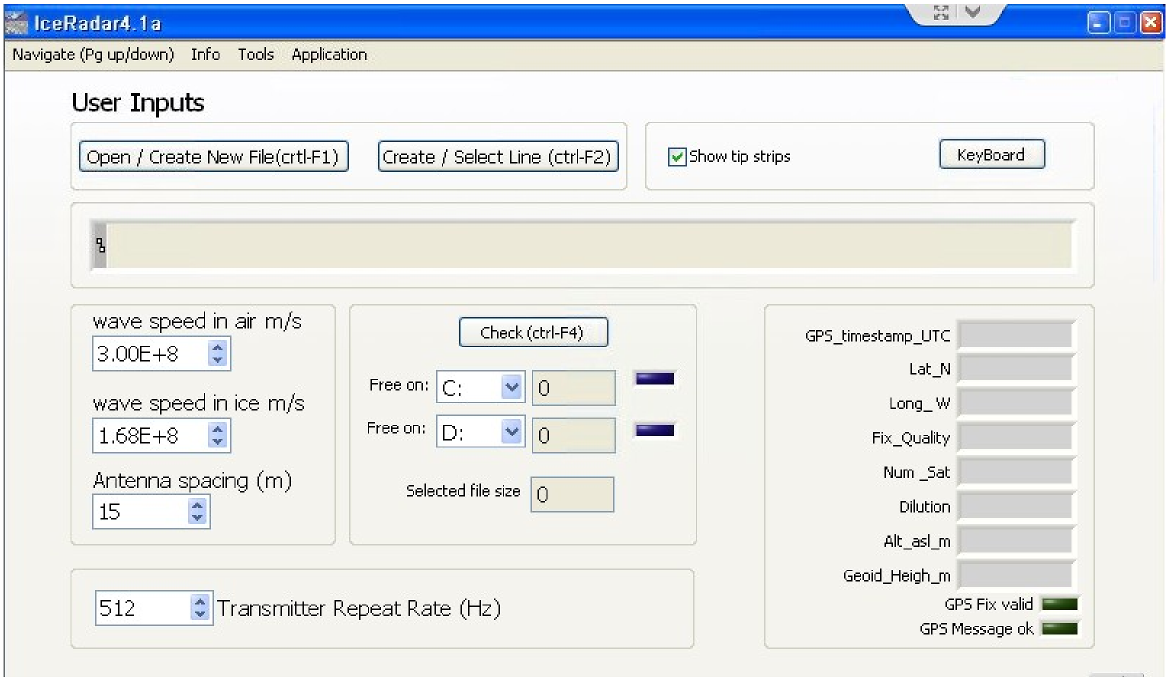


Trigger Level: The digitizer triggers when the trigger signal passes through the threshold you specify with this parameter and has the slope you specify with the **Trigger Slope parameter**

Trigger Reference: Ref (%)
This parameter sets where this reference is positioned in a record as a percentage of the total record. For instance, a value of 25.0 means 25% of the acquired data will be pre-trigger samples and 75% will be post-trigger samples.

The trigger settings are the most tricky aspect of the whole process. It is important to understand its principle, and also what to expect in terms of air wave signal. Typically an air wave should be in the 100mV range, less so above 50MHz. So the range should be set accordingly. The trigger level can be set below the range value. In this example. values of 20mV would work well. One wants to insure that the trigger level is properly set so pulses are not missed. Too high pulses would be missed, too low, other signals unrelated to radar (or other radars) could trigger the EPU. Once set though, the triggering is reliably repeatable and no more changes are required.

6. User Inputs



The User Inputs window allows the user to input the **Wave Parameters**, notably the **wave velocity in air**, the **wave velocity in ice**, and the **antenna spacing**.

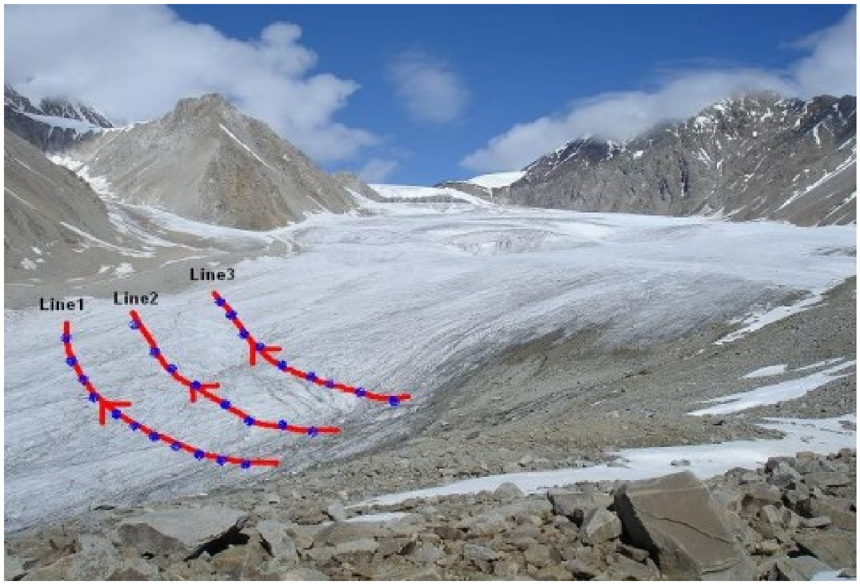
As a guideline here is the distance used between transmitter and receiver when used in-line (one behind each other)

- 5MHz: 30m apart
- 10MHz: 15m apart
- 35MHz: about 5 m apart
- 70-100Mhz: about 2m apart.

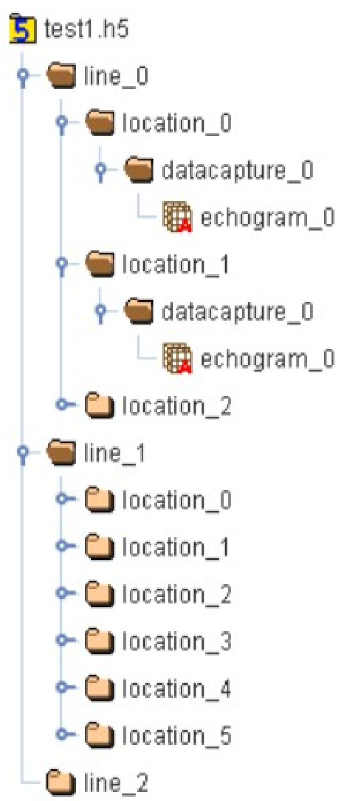
This screen is also used to set the file where data will be stored. Next, the user can select two volumes or hard drives present on the system to check their size comparatively to the data file. It is recommended to regularly check the solid state drive capacity. Finally, this window also provides the user with the full GPS reading parsed from the $GGA NMEA message.

IceRadar uses a hierarchical data format to store information (HDF5). The file format being self-describing, it allows an application to interpret the structure and contents of a file without any outside information. Data are first grouped into a top level object, called a **Line**, that represents a **given path on the glacier** where point measurements were taken. A Line represents a **logical grouping of Locations** where radargrams are acquired.

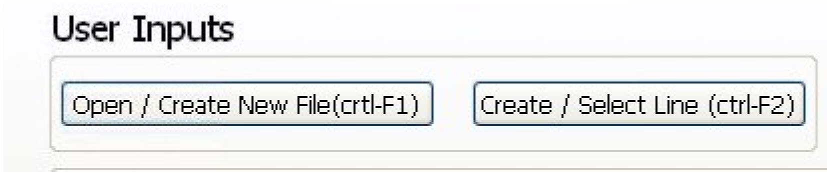
Each point measurement within a Line is linked to a subgroup object called a **Location**. This object is in turn linked to the radar data, the GPS data, later the calculated depth data. All these objects can have attributes (Meta data) associated to them. All the data is consolidated into the hierarchical file system, and can be accessed by the analysis routines. IceRadarAnalyzer is such a routine, however many development environment and languages such as Matlab, Python, etc... have HDF5 libraries available.

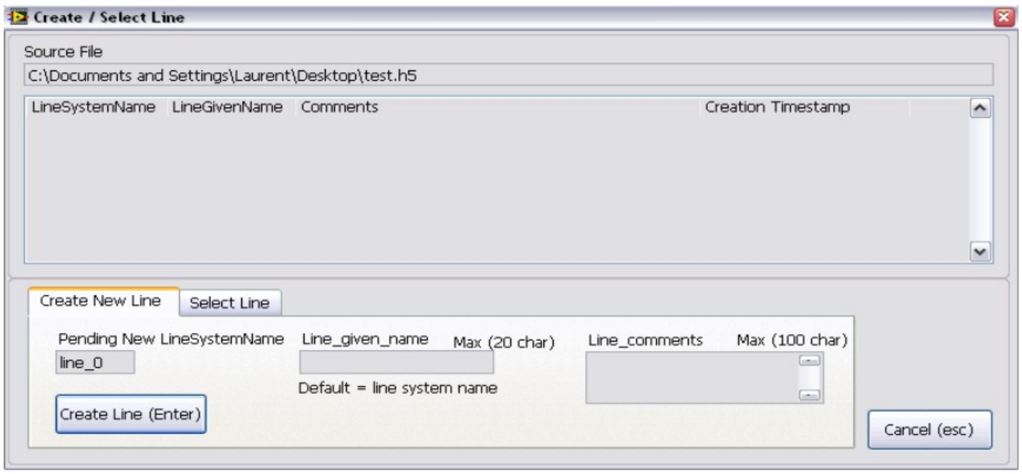


Typically, a given glacier survey would be associated with a data file. Each survey line would be a Line in the file system domain, and each points where data is gathered along the Line would be a Location containing Radargram and GPS data at first, and later picked data defining the depth. Additional survey lines would be associated to additional file system Lines. This data organization can be adapted to users' need. Each line could be a single file. However with this model, one would loose the benefit of not having to manage numerous files



The next step is to **create or select a file**, and create or select and already existing **line**.

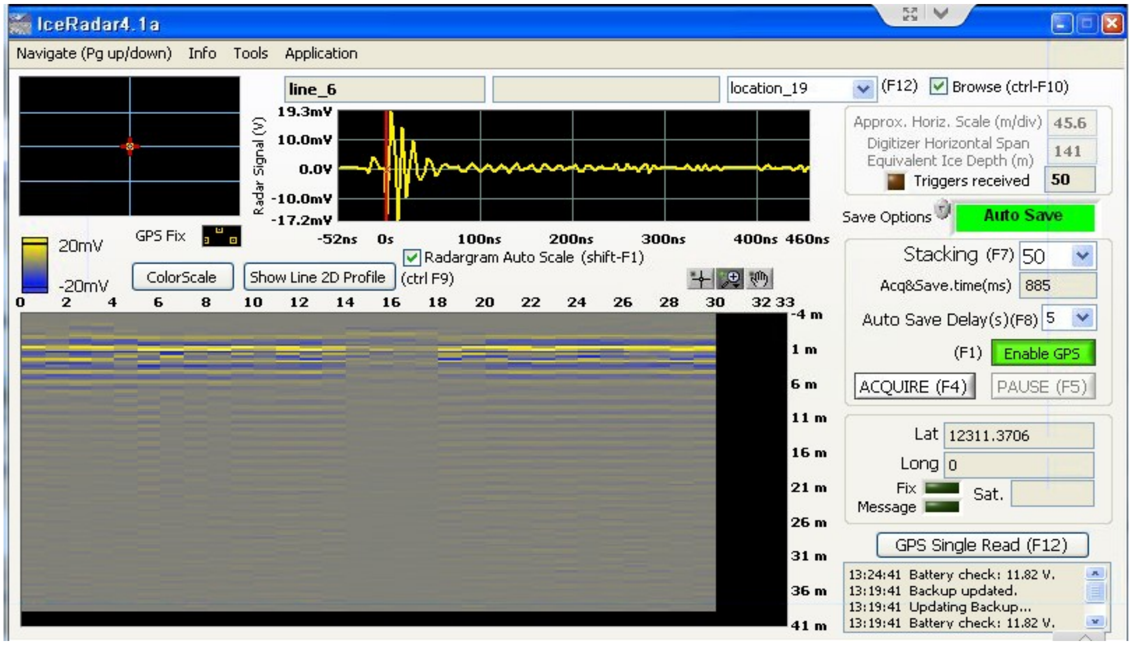




The above pop up will allow to create a first Line in a new file (line_0). Lines have a system name that cannot be changed, a given name that is user-defined, and a comments attribute. Hit Create Line to create a new line. The new active line can be seen at the top of the Data View window above the radargram graph object.

Each data file can contain as many Lines as necessary. The system is now ready to acquire data.

7. Data View



Select the **Save Options**, first to **No Data Save** to check the signal and fine tune the triggering. You can hit Acquire a few times to start building a 2D representation of the data. If **Single Point Save** is used, a **Create / Select Location pop-up** will appear to describe the given **Location**. Similarly to the Create / Select Line pop-up, a Location has a system name, given name, and description.

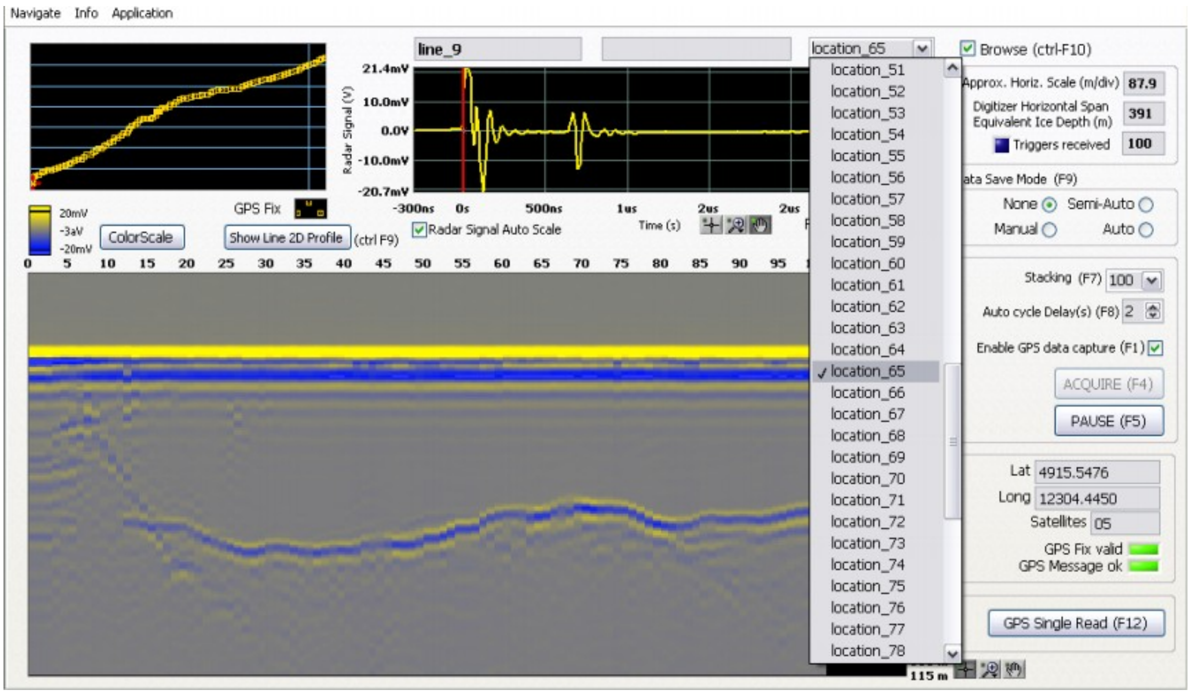
It is recommended to give a **Location** a **user name for any specific locations of interest** such as a survey pole, the beginning of a survey line, last point of a survey line etc... For more standards Location, running in **Auto Save** is best as it requires no user interaction.

Stacking allows to average the indicated number of traces before saving. Discrete values are : 1, 25, 50, 100, 256, 512, 1024. Note that stacking slows down the acquisition time and saving since more radargrams have to be acquired in order to compute the average.

AutoSave Delay sets the elapsed time between two consecutive radargrams' acquisition and saving. Be aware to not save set the delay at unnecessary fast rate, especially when travelling at low speed,in order to conserve disk space. A delay greater or equal to 5 seconds is usually plenty at walking or skiing speed.

Quick Data Browsing
To quickly check data that were previously acquired, it is possible to select a Line that was already logged and display its data with the **Show Line 2D Profile** button. Then, as shown on the image below, selecting the **Browse option** will select a specific location and browse amongst its associated radargrams. The location number also corresponds to the x-axis of the 2D graph.

Note that the 2D graph scale can be changed by clicking on the first and last number of the scale and typing the new scale limit value.



8. Known Caveats – Software

This section describes the known caveats of the IceRadar system. It should be considered as a recipe for better sleep once in the field, knowing that the few potential pitfalls are documented as opposed to be kept hidden away from the user until they creep up.

First are described the software caveats, followed by a focus on hardware potential pitfalls both in terms of electronics, and general mechanical parts.

Bluetooth Radio must remain OFF

The EPU is equipped with a Bluetooth (BT) adapter. All Bluetooth adapters have been **deactivated and must remain so** for proper operation of the radar acquisition system. If Windows re-enable BT (unlikely), the typical blue icon shows up on the right side of the Taskbar. To deactivate it, simply open the Device Manager and turn it off by right-clicking on the Generic Bluetooth Radio icon. **Do not uninstall the device though, just disable it**.

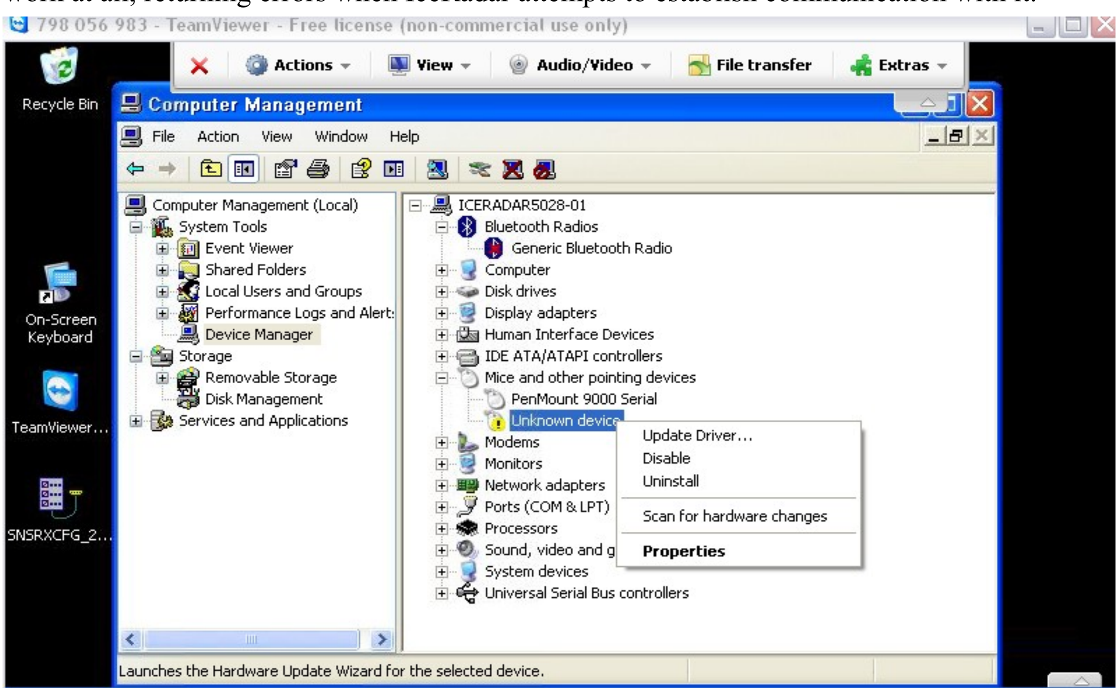
Disabling BallMouse to prevent GPS to be recognized as a mouse

This operation is usually only required once and is performed before shipping. However in some instance, the annoyance described below creeps back up, especially if the system is not properly shutdown and constrains Windows to recover its previous known state.

If the computer performs a fresh boot with :

- Garmin GPS connected to the serial port
- Garmin GPS in NMEA mode (default),

The OS may recognize the GPS as a ball mouse. It may or may not find the driver for it, but under the **Device Manager >>*Mice and Pointing Device*, the Ball Mouse, or an U*nknown Device*** will appear. In this case the GPS will not work at all, returning errors when IceRadar attempts to establish communication with it.



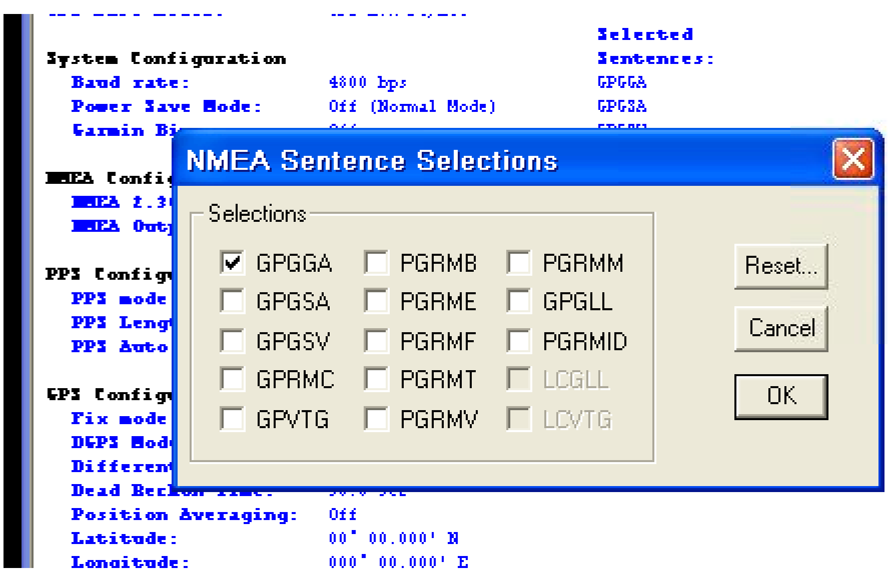
Disable the Unknown Device (or Ball Mouse) to solve the issue.

Note: Do not Disable PenMount, this is the touch screen driver.

On next reboot, the system should not recognize the GPS as a ball mouse, and the unknown device should be gone. This issue is also detailed in the Garmin GPS documentation

GPS 18x PC/LVC settings must not be changed

The GPS has been set to only broadcast the $GGA sentence, and so in NMEA mode, at 4800bps, and on COM1. These settings can be accessed with the Garmin software utility *SNSRXCFG_270.exe*. **They should not be changed.** Other GPS settings such as average mode should also not be changed.



9. Known Caveats – Hardware

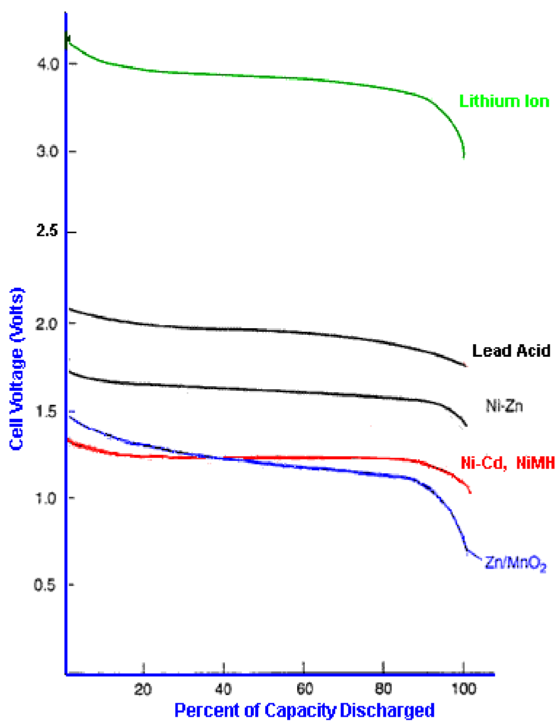
Preventing sudden power loss
This is the most important aspect to pay attention to.

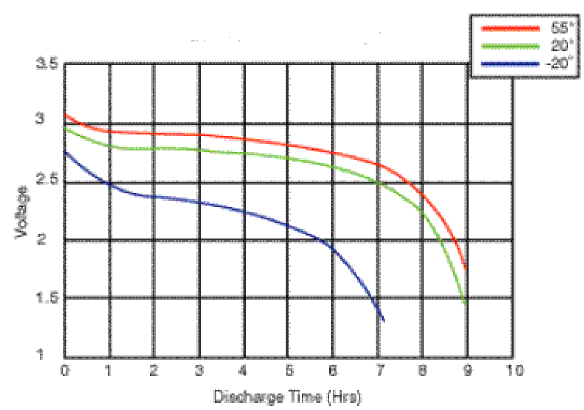
The receiving system is powered by external battery. It is critical to prevent any power interruption while the computer is operating. Potential consequences are (1) data file corruption if the power interruption occurs *at the exact time* of a *file write* or *file read* operation, and (2) OS' file system inconsistency.

(1) is mitigated as follows:

- applying care when establishing connections and setting up the rig, making sure **all strain-relief protections are in place and are secure.**
- Monitoring the battery state regularly on the system's digital display
- Keeping the software battery monitoring option active
- Keeping the backup file option active
- Becoming familiar with battery discharge curve which are battery type's specific, and can be obtained from the manufacturer.

Discharge profiles are usually a function of current draw and temperature, as well as battery's history usage. Below are example of such characteristics. Note that the LiO battery curves drop more quickly than lead acid when they reach their end zone. These battery types are typically equipped with cut-off circuitry shutting down the voltage output completely once the cut-off voltage is reached.





Hardware Caveats

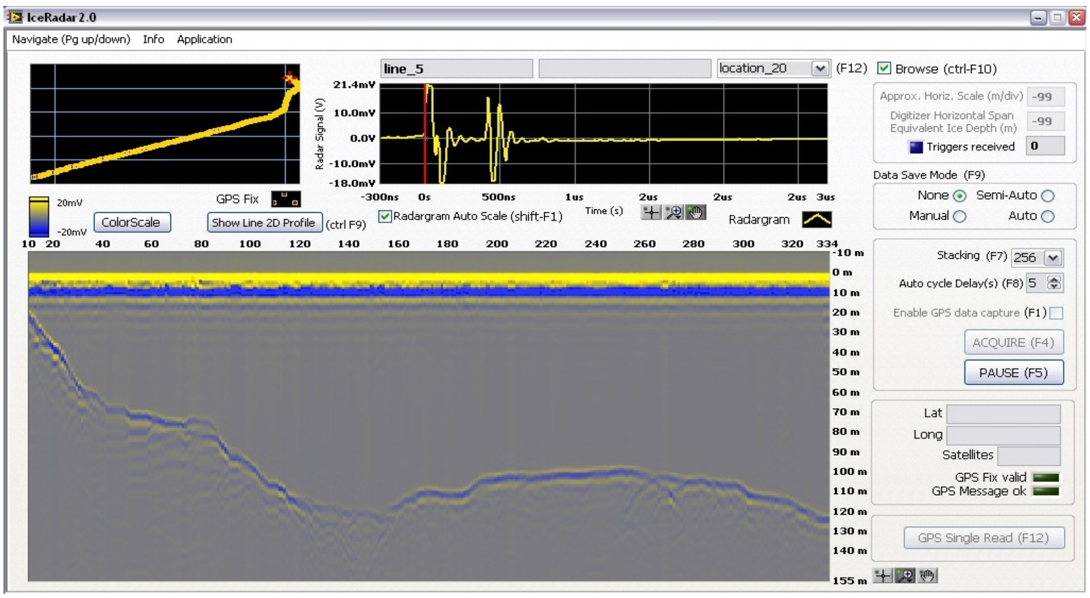
Setup, monitor, and maintain good strain reliefs throughout the survey

The transmitter and receiver cases are used to strain-relief the antenna pex tubing on both side of the case(s). This is essential to prevent potential pull-off of the pex tube' section end parts. Also, it prevents the connection from the antennas to the system to accidentally pull on both transmitter and receiver.

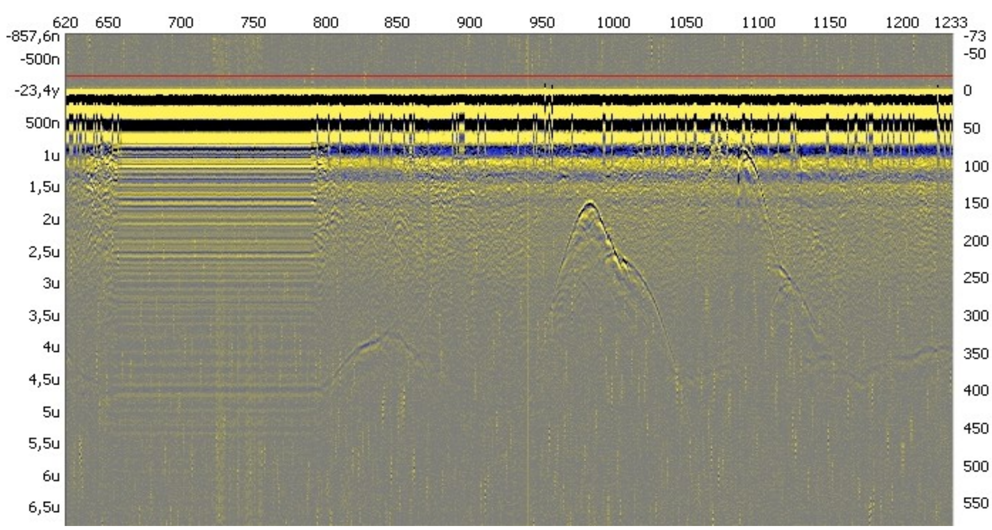
Making sure any pulling force is applied **solely on the case handles** will also insure the pex tubing is kept in good conditions.

10. Raw Data and Data Analysis

Raw Data produced by the system are very dependant on environmental conditions such as snow water content, ice temperature, and frequency used. In a typical 10 Mhz system radargram can be very clear and visible to the naked eye without any extra processing.



In other cases it may be more difficult to spot deeper bed reflections, in particular when one looks at a single radargram before the 2D data starts building up a profile.



In some case, very little in terms of bed or internal reflections can be spotted, and only further filtering and data analysis will be able to provide a clear rendering of the data.

The IceRadar software running on the EPU is meant to be a data acquisition application. It is not meant to analyze data even though it is possible to look-up data files with it. Instead, an application called IceRadarAnalyzer is provided and allows browsing of the radar data per line and location as well as picking. In the latest version of the analyzer (4.0), picking has been streamlined making the process much faster. The analyzer is just one of the many ways data can be analyzed. The HDF5 file format is open and a short-list of resources to program one's own routines (i.e Matlab, Python) is given at http://radar.bluesystem.ca/Iceradar_download.htm .

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