



Halo Photonics Stream Line Scanning Doppler LiDAR system - Hardware and Software Guide.



Our modular, autonomous, turn-key, pulsed Doppler LiDAR systems were conceived to meet the need for remote sensing of motion and backscatter in the atmosphere. In this mode of operation, naturally occurring aerosols and clouds act as a distributed target and backscatter the transmitted pulses. The receiver detects the Doppler shift brought about by the motion of the distributed targets and therefore the line-of-sight component of their velocity. The novel optical technology employed and the design approach have led to a new class of eye-safe (Class 1M), high performance LiDAR exhibiting exceptional stability which is compatible with a continuous and unattended mode of operation. Typical applications include boundary layer wind profiling, plume dispersion, analysis of complex flows, cloud studies, cloud base measurements and gust and air quality monitoring.

While every effort has been made to provide accurate and calibrated data products, HALO Photonics does not currently guarantee the calibration of the data in absolute terms.

The system has been designed to be rugged and autonomous. Even so, the end user must respect the fact that the system is a precision optical instrument that must be treated with great care.

The laser emission from the antenna is in the **class 1M category**. The responsibility for ensuring suitable safety procedures and operating modes lies entirely with the end user. HALO Photonics does not accept any responsibility for issues relating to the field deployment of the equipment and propagation of the beam in the atmosphere.



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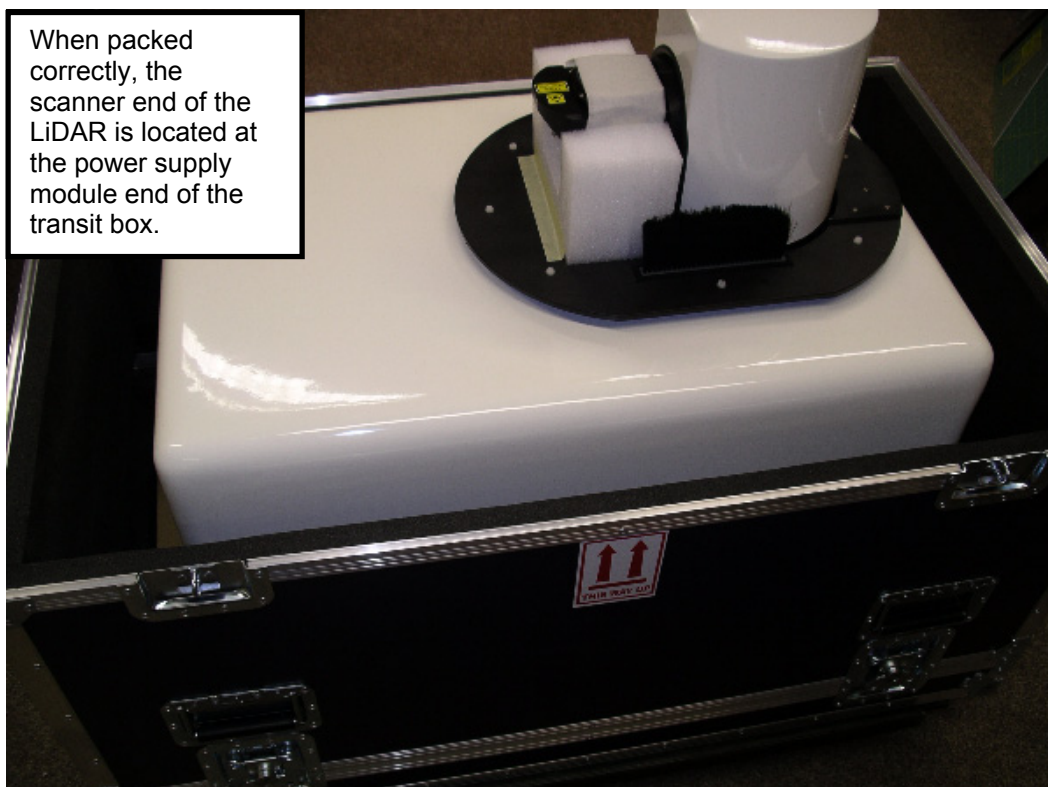
1 Unpacking.

The Stream Line 75 system from Halo Photonics comprises an autonomous self-contained LiDAR and scanning unit with integral data acquisition and processing housed in a temperature stabilised, environmental enclosure.

For transportation, the LiDAR and its power supply unit are housed in a transit case that has a removable wheeled base, with 2 of the wheels having integral brakes. The transit case with LiDAR weighs approximately 110Kg and will need to be moved according to the appropriate manual handling health and safety guidelines.

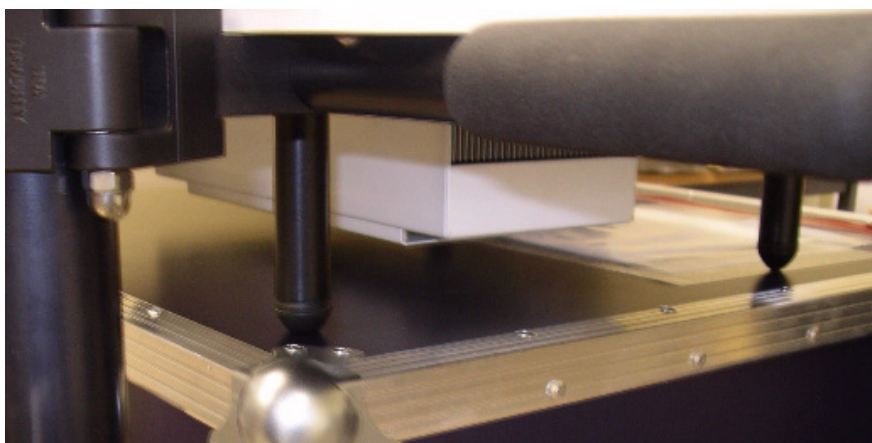
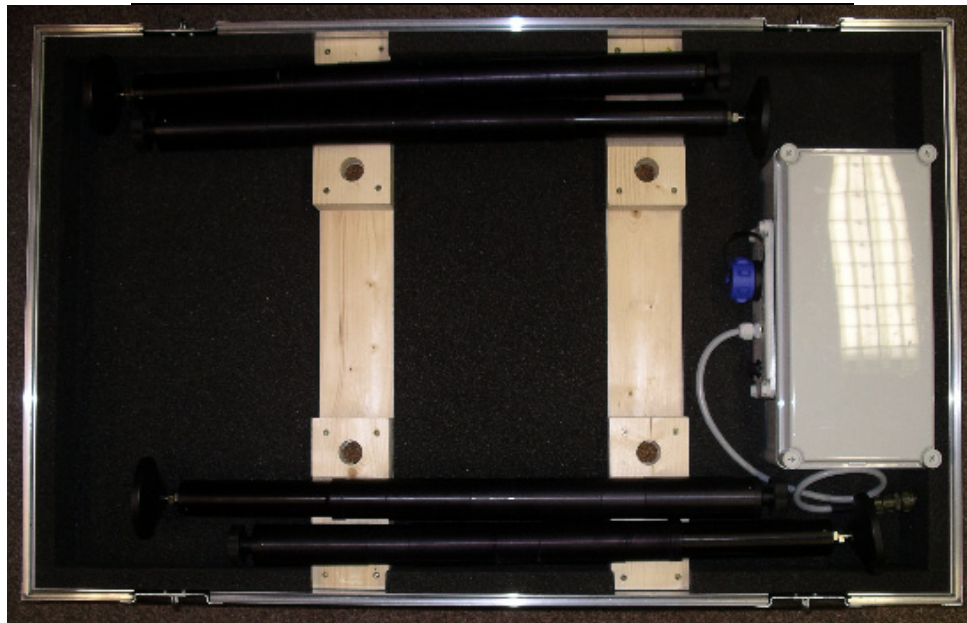


The transit case consists of 3 separate pieces. The top piece can be used as a base when attaching the support legs to the LiDAR.

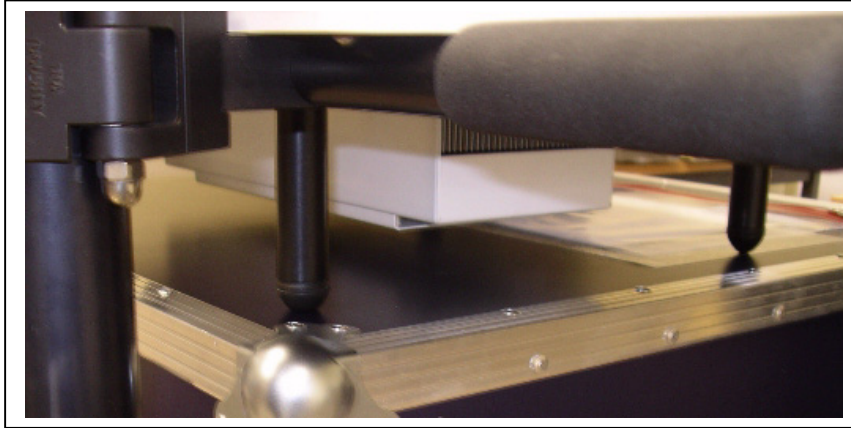


If the LiDAR has 2 of its lifting handles removed, then they must be **fully** screwed onto the appropriate captive threads located in the leg to base plate brackets **before** the unit can be lifted. Failure to screw them on tightly could result in damage. **The LiDAR must always be moved using the handles and never any other surface.**

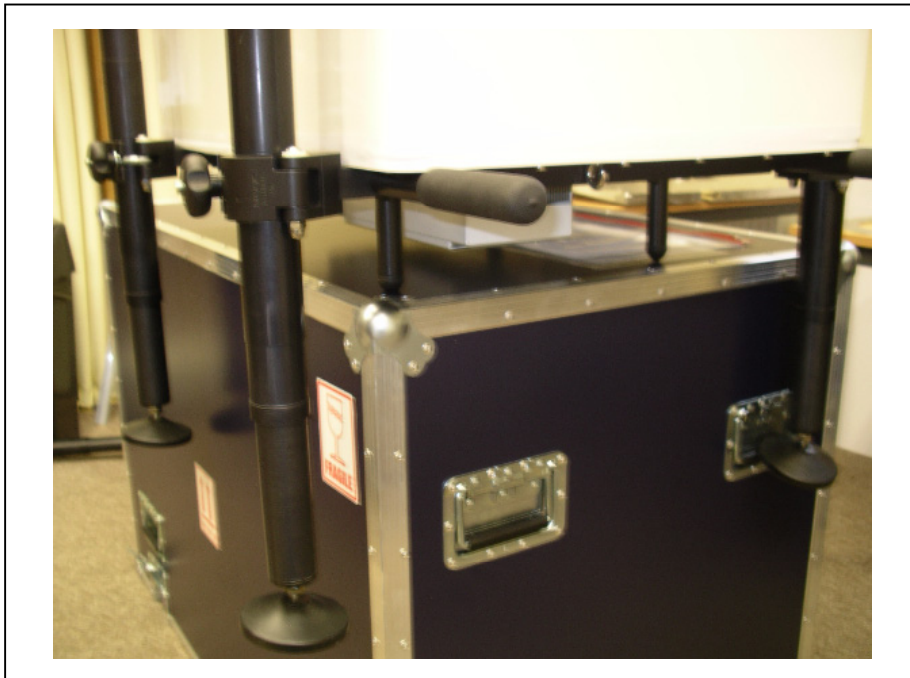
The LiDAR can now be lifted out and placed onto the lid of the transit case in such a way as to allow 3 out of the 4 legs to be attached.



The small pillars with rubber-coned ends act as support legs when the 4 main legs are not attached. They prevent the weight of the LiDAR being taken by the cooling aggregate mounted on the underside of the main base plate, which would cause damage. The correct positioning of the rubber feet can be seen in the picture – also make sure that the LiDAR sits parallel to the side of the surface. Another suitable surface, such as a sturdy table could also be used in place of the transit case lid if available.

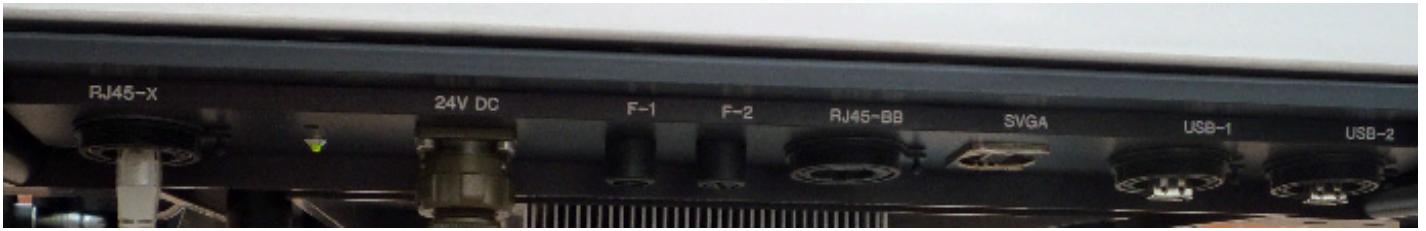


There are three locating areas machined into the legs. The middle position is recommended to give a good working height. Hold each leg in position, close the clamp and tighten it up to hand tightness. It is not necessary to over tighten the clamps, as the LiDAR will rest on the locating notches.



The LiDAR can now be lifted off and gently placed onto the floor. It will be necessary to support the LiDAR while the last leg is attached.

2 Connections.



From left to right:

RJ45-X – This is for use with an RJ45 crossover, which will connect the internal PC to an attached PC.

Power **LED** and recessed internal PC power button.

24C DC – this is the 24V DC power inlet coming from the power supply module.

F-1 – 10A 5x20mm fuse for the LiDAR circuit.

F-2 – 10A 5x20mm fuse for the thermo-electric cooler circuit if fitted.

RJ 45-BB – this is a standard RJ45 connection that can be connected to a regular hub or switch – used to connect the LiDAR to the internet for use with the remote access software.

SVGA – a standard SVGA connector for use with a monitor. Note that the internal PC video resolution is set to be 1280 x 1024 pixels, so the attached monitor will need to be capable of supporting this resolution.

USB-1 and **USB-2** are both standard high-speed USB connections to the internal PC. They can be used for connecting a keyboard and mouse, storage devices or mobile broadband dongles.

3 Power supply module.

Operating characteristics.

The module contains 2 x 12V batteries and a UPS control system, which incorporates a battery charger for the attached batteries.

If the input power to the module is lost i.e. a power cut, then the UPS will provide power to the LiDAR for 30 minutes. If the input power comes back on during this time, then the UPS will switch back and run from the main 24V feed.

If the voltage reaching the LiDAR falls to 20.5V, then the LiDAR will shut itself down – **but only if the main control software is running and collecting data.**

The front panel of the power-cut protection unit is shown below.




I/P Active LED – illuminated when the unit has input power.

O/P Active LED – when lit, 24V is available at the output connector.

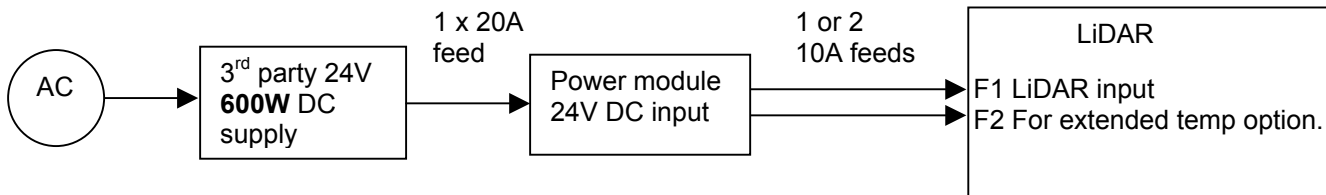
Aux – Battery voltage monitor.

The module will provide a 24V DC output for approximately 30 minutes after input power is lost. The LiDAR software will shut the system down gracefully to minimise the risk of damage to the internal hardware and software when the voltage from the module falls to 20.5V or below. **This auto shutdown is only active while the LiDAR main control software is running and the LiDAR is taking data.**

3.1 24V DC connection details.

<p>Bulgin Maxi Buccaneer 2 pin socket needed to connect to the power module input plug. A plug is supplied with the system, and has some wire connected for guidance.</p>	<p>PX0911/02/S</p> <p>+24V DC on the '1' terminal 0V on the '2' terminal</p> 
<p>Recommended PSU for connection to the 24V DC input power protection module.</p> <p>It is recommended that the no-load voltage of the PSU be turned up to 25.5V before connection to the LiDAR PSU.</p>	<p>TDK-Lambda HWS600-24</p>

Connecting to the power protection module.

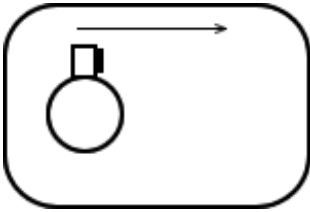


3.2 Power up timing sequence.

The LiDAR will power up approximately 18 minutes after power is applied. This delay will give the thermal control system time to heat or cool the inside of the enclosure prior to the rest of the electronics being powered.

<p>Time zero</p>	<p>The LiDAR is connected to the power supply module, and power is applied to the power supply module. A green LED on the power supply module labelled 'I/P Active' and another labelled 'O/P Active' will illuminate.</p>
<p>T0 + 8 sec (T1)</p>	<p>If the extended temperature option is fitted, the cooling aggregate fans will be powered.</p>
<p>T0 + ~18 mins (T2)</p>	<p>A green LED on the connector panel of the LiDAR will be illuminated, and the scanner will move to its home position.</p>
<p>T2 + 1 min (T3)</p>	<p>The PC will have booted, and connection should be possible using the remote access software. If a monitor, keyboard and mouse connection is made, but there is no picture displayed on the monitor, then the [CTRL][ALT] and [F1] keys will need to be pressed to enable the video output.</p>

4 Orientation and levelling.



A bearing will need to be entered into the control software shortly after start up. The bearing is taken along the direction of the arrow in the plan view shown. This is the LiDAR's home position, and is moved to when power is first applied.

For example, the bearing to enter for the orientation shown would be 90 degrees.

When the main control software is started, a pitch and roll value will be displayed, and there will be a delay before the system is started to allow the LiDAR to be levelled.

The table below shows each tilt situation, and the corresponding display. The system is shown in its homed position – i.e. when powered and before starting any software.

	-ve pitch value will be displayed.
	+ve pitch value will be displayed.
	-ve roll value will be displayed.
	+ve roll value will be displayed.

- An adjustment knob at the top of each leg will extend and retract a telescopic sub-leg to vary its length. Adjust the legs in pairs – one end or one side at a time.
- Turn the adjustment knobs clock wise (looking from above) to retract the leg, and counter-clock wise to extend.
- The pitch and roll sensor has a resolution of 0.1 degrees.

Site considerations:

It is highly recommended that the LiDAR be deployed on a surface that is not liable to get excessively hot, as the cooling aggregate (air-flowed heat exchanger) is located on the underside of the base unit. Steps should be taken to minimise the heat generated underneath the LiDAR from direct sunlight - a turfed area is ideal. For cold running, a wind break to protect the LiDAR from the prevailing wind will help.



It is recommended that the power supply module be located directly underneath the LiDAR, and raised off the ground to reduce exposure to the weather. The module's enclosure is rated to IP66, but minimising exposure to the weather will only help.

5 Software overview.

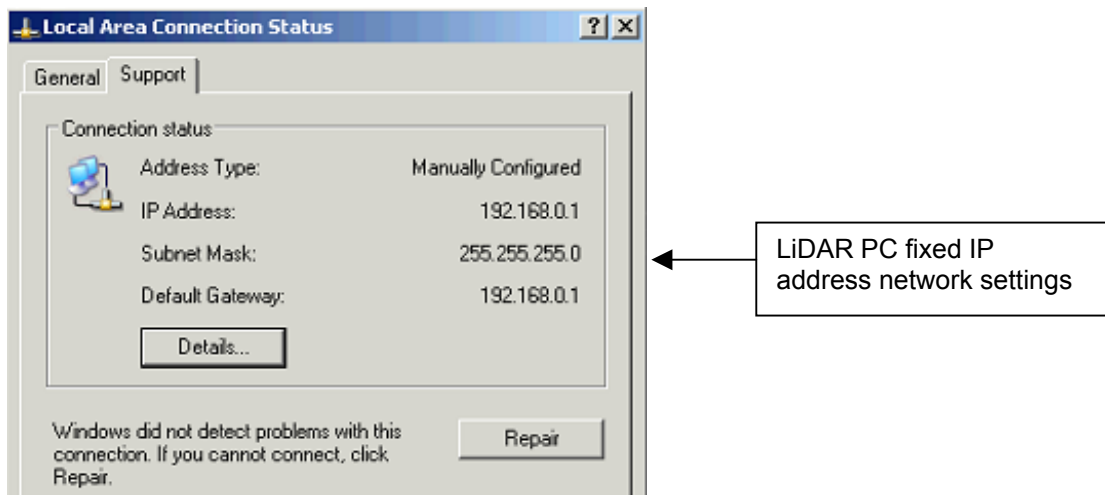
Throughout the entire suite of software, user configurable controls are coloured with an orange background and informational data a white background. Most of the software modules have a 'STOP', 'Finished' or 'Stop and shut down' button. These buttons should always be used to terminate the software correctly, and never the red button shown top left, or the windows style 'X' close button top right.

5.1 Remote access.

The LiDAR will power up as soon as the power supply module's initial 'delay on' time delay has elapsed. The green LED on the connector panel will come on with power, and a PC 'beep' approximately 8 seconds after power up may be heard. The scanner will move to its home position and will then be locked in position, and at this stage, nothing else will happen while the PC is booting. If the autostart version of the software is pasted into the Windows startup menu, then the software will begin, otherwise nothing else will happen after bootup.

Remote access software

The internal control PC has 2 ethernet connections. The RJ45-BB one is set to obtain its IP address automatically, and will need to be connected to a router. The RJ45-X has settings suitable for use with a crossover cable.



To connect to the crossover connection, use the following settings on **your crossover connected PC**:

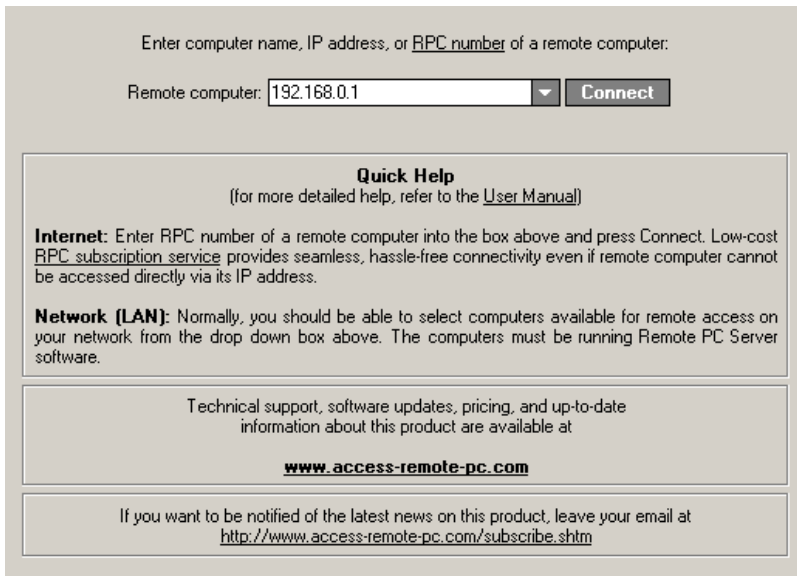
Network settings.

Network settings for an attached PC using the crossover ethernet cable	
IP Address	192.168.0.2
Subnet Mask	255.255.255.0
Default Gateway	192.168.0.1

Communication between the LiDAR and an attached, LAN connected (or Internet connected) PC is achieved by installing and running the client part of the remote access software found at this address:

<http://www.access-remote-pc.com/download.shtm>

After the LiDAR PC has been given time to boot up, the remote PC software can be started on the connected PC, and the following screen will be displayed.



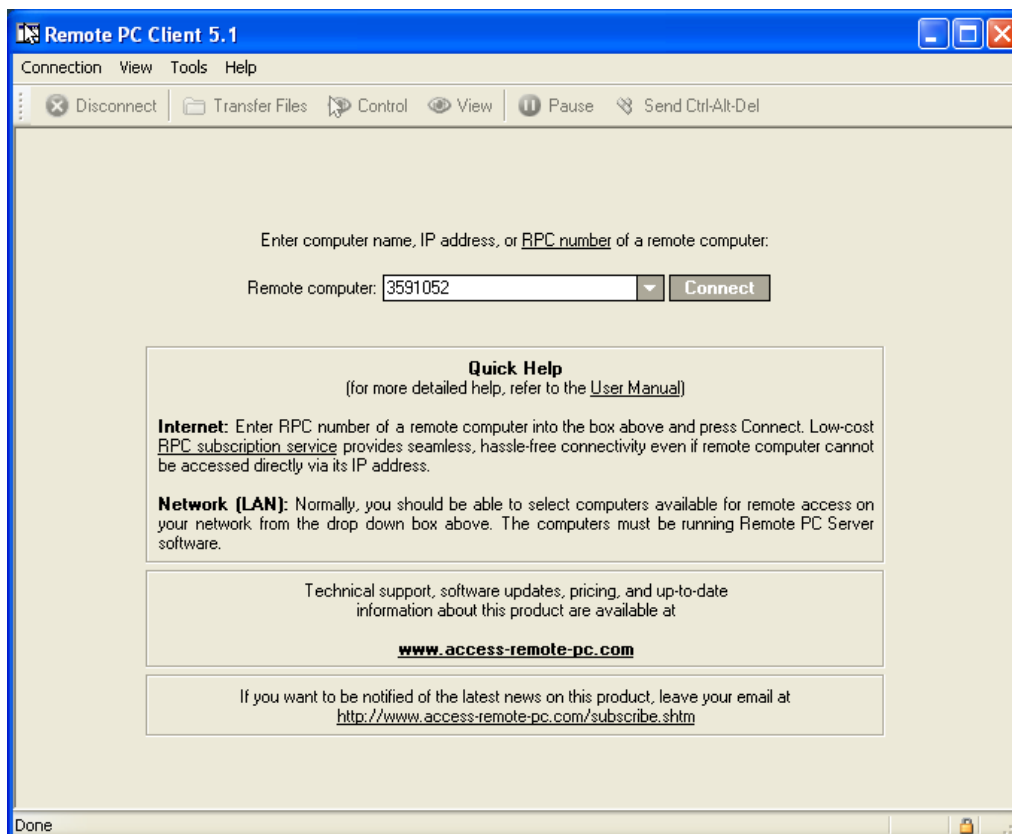
If the connection is made via a crossover cable connected directly to RJ45-X on the LiDAR, then the following Remote computer name is used: **192.168.0.1**

This will also apply if the viewing computer and the LiDAR (via its RJ45-BB) are connected to a shared LAN.

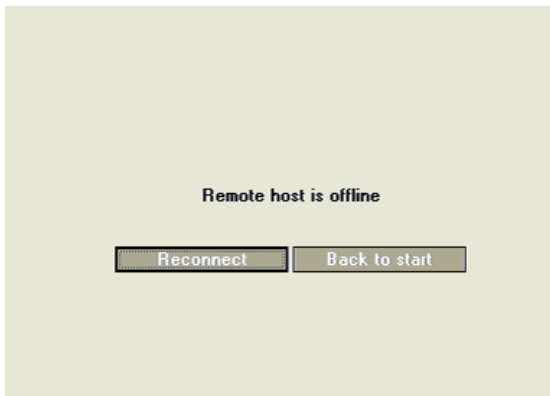
Once this has been selected and the connect button clicked, the username and password dialogue box will appear.

If the system is connected to the **Internet**, then access can be gained by entering a number in the 'Remote computer' pull down menu instead and the same login details will apply.

The RPC number and login details are detailed in section 8.

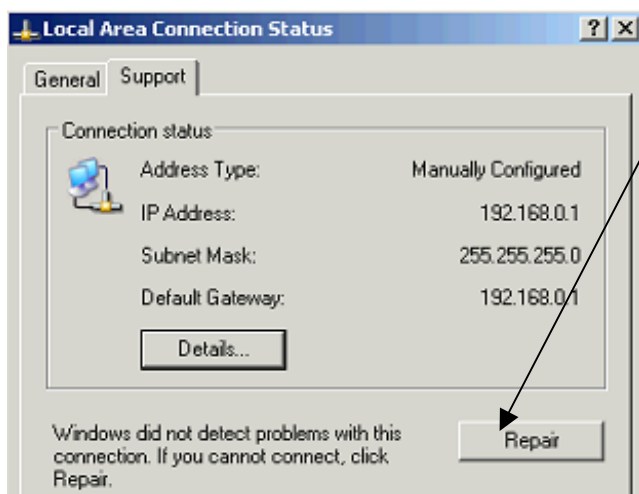


If the remote PC is physically switched off, or is having a problem connecting to the Internet or LAN, then the following message will be displayed after the 'Connect' button is pressed:



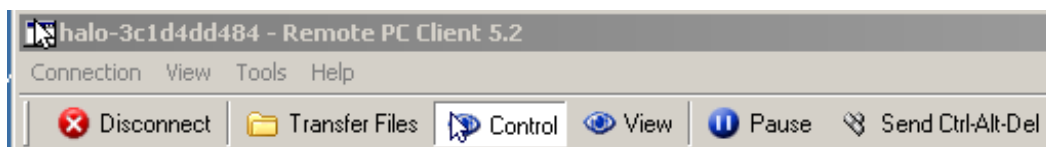
If connection is problematic, check that your attached PC is using the correct network settings and that the correct RJ connection and leads are being used. If the problem persists, follow this procedure:

Choose the network connections, choose the fixed IP connection number (double click), then choose the support tab. If it's stuck on acquiring address or is having problems, click the 'Repair' button. It should then assign the 192.168.0.2 IP address.



If the connection configuration and login details are all correct, then the desktop of the LiDAR PC will be displayed.

At the top of the window, there is a 'Disconnect' button, Transfer files, Control and View.



The **Transfer Files** button will launch a Windows style drag and drop screen with the remote files on the right, and the local PC on the left. Transfer via this method will be at the connection speed of the LAN. If the LiDAR PC is taking data, then the transfer will be slowed down. **Be careful not to transfer or access any data files that are currently being written to, or sharing violations will occur.**

Control allows full control over the PC in every way, while **View** just allows viewing with no interaction.

NB. When viewing a remote desktop, it is easy to get confused with respect to which desktop belongs to each PC. It is recommended to alter the desktop appearance of the attached PC so as to make it sufficiently different to that of the LiDAR PC to minimise the risk of closing down by mistake.

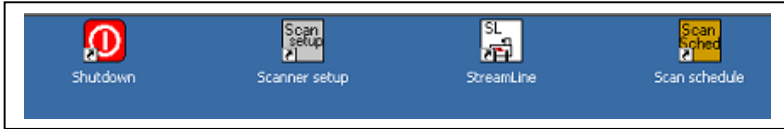
Terminate the software when finished using the **Disconnect** button.


5.2 The desktop.

There are 4 software modules related to running the LiDAR:

Scanner setup
Shutdown
Scan schedule
Lidar control

The corresponding icons are shown here:



The StreamLine main control software. Double click the icon to load it, then click the 'Run' arrow (top left)  to start it.

Another version of the Lidar control module is provided that will automatically start the LiDAR when opened.

The **Auto start** version can be copied into the **Windows Start up** directory, and will ensure that after a power cut, the LiDAR control software loads up and runs at start up with no other user intervention.



Both versions of the control software are identical in every other aspect and will both use settings from the previous run each time they start - including the previous scan schedule.



The **scan schedule** can be altered during normal control software operation (covered later) and is also accessible from the desktop at any time. Make sure that no more than one instance of the module is running at any given time.

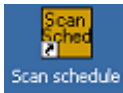


The Scanner setup software can only be used when no other software is running, and must be closed before other software is started. It is used to manually move the scanner, and to disable the motors.



The **Shutdown** module is used to power off the internal components when the LiDAR will be fully powered down prior to moving.

5.3 Scan Schedule.



This program is used to configure the built in scan pattern settings, the scan schedule and the repetition timing of all scans.

Select scan	Rays /pnt	No. Points	Repeat (min)	~Duration (min)	
Stare	1				90 (Az) 90 (El)
VAD	1	90	2	0	80 Elev. angle
RHI	1	8	2	0	80 Start AZ
DBS	6	3	2	0	75 Elev. angle
Scan file 1	2	15	2	0	
Scan file 2	1	15	2	0	
Scan file 3	1	1	2	0	
Scan file 4	1	1	2	0	
Scan file 5	1	1	2	0	
Approximate total duration (min)				0.00	Finished

On running the scan schedule software, the above screen is displayed. The buttons on the left are used to enable/disable the various scan types. If no scans are selected, the system will default to the staring mode. The previously used settings are displayed when this module is run.

The '**Rays/pnt**' number represents the number of complete rays that are averaged at each point (line of sight).

The '**No. Points**' figure is used to select the number of individual lines of sights making up the VAD and RHI scan.

The '**Repeat**' number represents the number of minutes between each start time of successive scan executions. The minimum repeat number available will be roughly equal to the total duration time for all scans + 2 minutes. The minimum repeat time is calculated each time a scan is selected or deselected, and it is not possible to select a repeat time below the minimum. If a scan is deselected, its effect on the minimum repeat time is removed.

The **Duration** gives a rough guide to the time take to execute each scan, with a total for all selected scans at the bottom of the column. The software will use **2.5 seconds per ray** to calculate all duration figures. This allows for the time taken to move the scanner from point to point to be taken into account.

The final column is used for inputting fixed angles of elevation or azimuth for the scan types.

5.3.1 Stare coordinates

The stare coordinates are used by default whenever the LiDAR software is started and whenever no other scanning patterns are being used. If no other scanning is set, the LiDAR will continue to use the stare coordinates for data collection. A suitable staring position can be entered into the Az and El fields. **It is recommended that an Azimuth position is used to minimise the scanner pod being placed directly over the wiping brush.**

If the **wiping brush** becomes very distorted, it can be reshaped while wet, and dried straight. It can be removed by unscrewing two grub screws that can be accessed while pushing the top heat shield plate down *slightly*.

5.3.2 VAD scans.

Select scan	Rays /pnt	No. Points	Repeat (min)	~Duration (min)	
Stare	1				90 (Az) 90 (El)
VAD	1	8	60	0.2	60 Elev. angle
RHI	1	8	6	0	80 Start AZ
DBS	6	3	6	0	75 Elev. angle
Scan file 1	2	30	6	0	
Scan file 2	1	15	4	0	
Scan file 3	1	1	4	0	
Scan file 4	1	1	4	0	
Scan file 5	1	1	4	0	

Approximate total duration (min) 0.20 **Finished**

To add a VAD scanning routine to the current schedule, the VAD is button is pressed. The various options for the VAD scan are selected by altering the editable (yellow) boxes.

If the Finished button were pressed in the example above, the scan schedule would be set as follows:

- On main system start up, (for example the time is 09:50) data would be collected with the beam set to the vertical position until 10:50.
- At 10:50, a VAD scan would be performed consisting of 8 rays at 60 degrees elevation from horizontal with 45 degrees in azimuth between them. The first ray would be at 0 degrees in azimuth, the next at 45 degrees and so on.
- After the VAD scan is finished, (the time is now approximately 10:51), the system goes back to staring vertically until ~ 11:50.
- The repetition time is counted from the beginning of a scan file to the next beginning, and not from when a scan finishes. E.g. 10-minute repeats with a scan duration of 2 minutes will produce a scan every 10 minutes – not every 12 minutes.

5.3.3 RHI scans.

Select scan	Rays /pnt	No. Points	Repeat (min)	~Duration (min)	
Stare	1				90 (Az) 90 (El)
VAD <input checked="" type="checkbox"/>	1	8	60	0.2	60 Elev. angle
RHI <input checked="" type="checkbox"/>	1	18	120	0.45	90 Start AZ
DBS <input type="checkbox"/>	6	3	6	0	75 Elev. angle
Scan file 1 <input type="checkbox"/>	2	30	6	0	
Scan file 2 <input type="checkbox"/>	1	15	4	0	
Scan file 3 <input type="checkbox"/>	1	1	4	0	
Scan file 4 <input type="checkbox"/>	1	1	4	0	
Scan file 5 <input type="checkbox"/>	1	1	4	0	
Approximate total duration (min)				0.65	Finished

The input parameters for an RHI scan are similar to those of the VAD type. The starting azimuth will be the bearing of the first point at 0 degrees elevation. For the example above, the scanner will move to 10 degrees elevation for the next point, then to 20 degrees etc. finishing at 180 degrees elevation (or 0 degrees at 270 degrees azimuth equivalent). The RHI always starts and finishes at the horizontal orientation.

The RHI example above will repeat every 2 hours. As the VAD is set to repeat every hour, they will coincide every 3rd hour. In that situation, the VAD scan will execute, immediately followed by the RHI scan. As usual, the system will be orientated in the stare mode when no other scan types are in progress.

5.3.4 Wind profile.

Select scan	Rays /pnt	No. Points	Repeat (min)	~Duration (min)	
Stare	1				90 (Az) 90 (El)
VAD <input checked="" type="checkbox"/>	1	8	60	0.2	60 Elev. angle
RHI <input checked="" type="checkbox"/>	1	18	120	0.45	90 Start AZ
DBS <input checked="" type="checkbox"/>	2	3	20	0.15	60 Elev. angle
Scan file 1 <input checked="" type="checkbox"/>	2	30	6	0	
Scan file 2 <input checked="" type="checkbox"/>	1	15	4	0	
Scan file 3 <input checked="" type="checkbox"/>	1	1	4	0	
Scan file 4 <input checked="" type="checkbox"/>	1	1	4	0	
Scan file 5 <input checked="" type="checkbox"/>	1	1	4	0	
Approximate total duration (min)				0.80	Finished

The wind profile pattern emulates the RADAR wind profiler method of scanning 3 beams, one vertically pointing, one at a set elevation angle, to the North and another towards the East – **providing that the current bearing is set correctly.**

The options available for the wind profile scan are to set the elevation angle (from horizontal) and the number of rays averaged for each position.

5.3.5 User supplied scan file.

Select scan	Rays /pnt	No. Points	Repeat (min)	~Duration (min)	
Stare	1				90 (Az) 90 (El)
VAD <input checked="" type="checkbox"/>	1	8	60	0.2	60 Elev. angle
RHI <input checked="" type="checkbox"/>	1	18	120	0.45	90 Start AZ
DBS <input checked="" type="checkbox"/>	2	3	20	0.15	60 Elev. angle
Scan file 1 <input checked="" type="checkbox"/>	2	12	6	0.6	C:\Lider\System\test1.txt
Scan file 2 <input type="checkbox"/>	1	15	4	0	
Scan file 3 <input type="checkbox"/>	1	1	4	0	
Scan file 4 <input type="checkbox"/>	1	1	4	0	
Scan file 5 <input type="checkbox"/>	1	1	4	0	

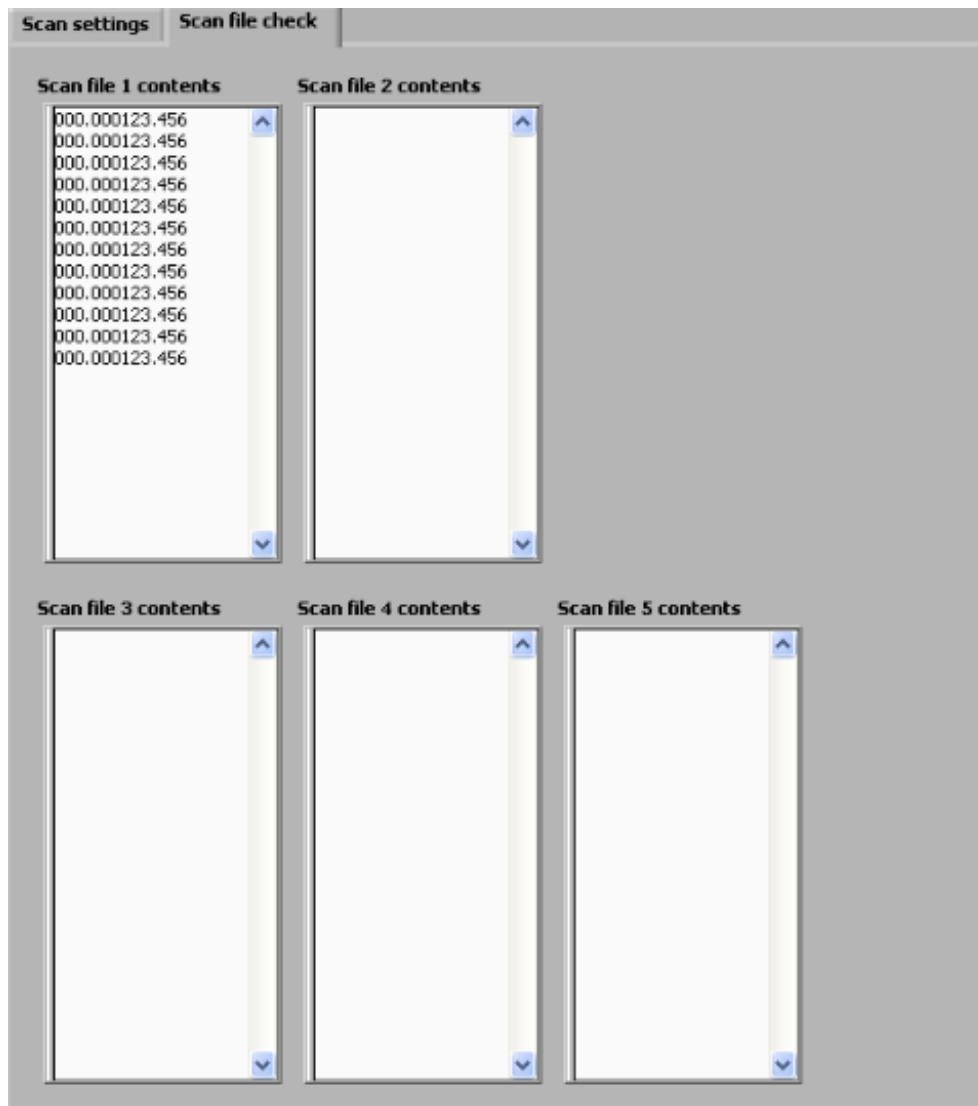
Approximate total duration (min) **1.40** **Finished**

The scan file option is used to input a user generated scan pattern, which can consist of any number of coordinate pairs within the 2π steradian field of regard.

After pressing any of the Scan file buttons, the filename to be used should be selected using the file browser pop-up. Once loaded, the approximate scan duration, number of points etc. will be displayed. The file that has been selected will not be over written by the schedule software, it merely creates a new file with appropriate headers for reading by the control software.

User supplied scan file (continued).

The file contents can be checked by selecting the 'Scan file check' tab at the top of the panel. If correct, it should resemble the format shown below.



5.3.6 Creating a custom scan file.

To create a custom scan file, the following format must be used:

1st pair (az, el) in the form 123.456123.456 – both must be **zero padded** f6.3 format.
2nd pair
.
.
last pair

Save the data to any directory as a .txt file – it can be named appropriately to describe the scan pattern that it represents. Many files can be produced and saved using this method.

During data collection, the system will move to and take data at each point in turn until the end of the file.

For example, to produce a file that stares continually in one position, the same coordinate pairs would be repeated many times.

Scan files can be loaded from any location, but are stored in the directory C:\Lidar\System\Scan parameters\ after they have had the correct header prefix added for use with the control software.

Example file: (3 pairs of coordinates)

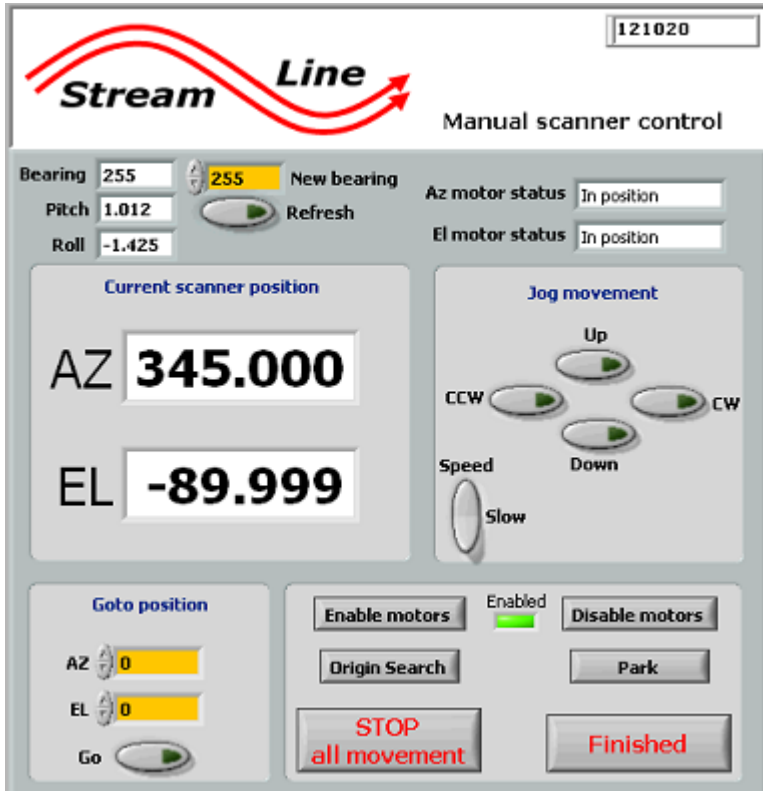
```
340.004090.000  
295.004040.000  
025.004040.000
```



5.4 Setting the scanner.

This module allows the scanner to be moved manually and can be useful in setting up scan co-ordinates for a user generated scan file. It cannot be used while the main LiDAR software is running.

This software is not to be used while the data collection software is running, as both will try to communicate with the scanner simultaneously, which will cause problems.



The **Bearing** display shows the bearing that the LiDAR is currently using for its orientation. If it is incorrect, enter the correct orientation bearing into the yellow 'Manual bearing' box.

If your system has a tilt sensor fitted, then it's **Pitch** and **Roll** will be displayed.

The **Current position** is read back from the scanner and displayed at a resolution of 1/100th of a degree. The readout is updated even when the scan motors are disabled.


The **Goto** feature is used to give precise positioning of both axes simultaneously – both values will be sent to the scanner each time the Go button is pressed. Angle resolutions of up to 1/100th of a degree can be entered.

The **Jog movement** allows coarse and fine adjustments. 'Up' relates to the scanner elevation increasing in angle from 0 degrees (horizontal). CW moves the scanner in increasing angle in a clockwise direction when viewed from above.

Both motors can be **Enabled** and **Disabled** – angle reading will continue while the motors are disabled. This can be useful when moving the scanner round by hand to determine a position manually. If the scanner motors are disabled due to tripping out for example, disabling and enabling should clear the fault.

An **Origin search** will place the motor in the home (0,0) position.

Parking the scanner places it in a looking down position over its heat shield.

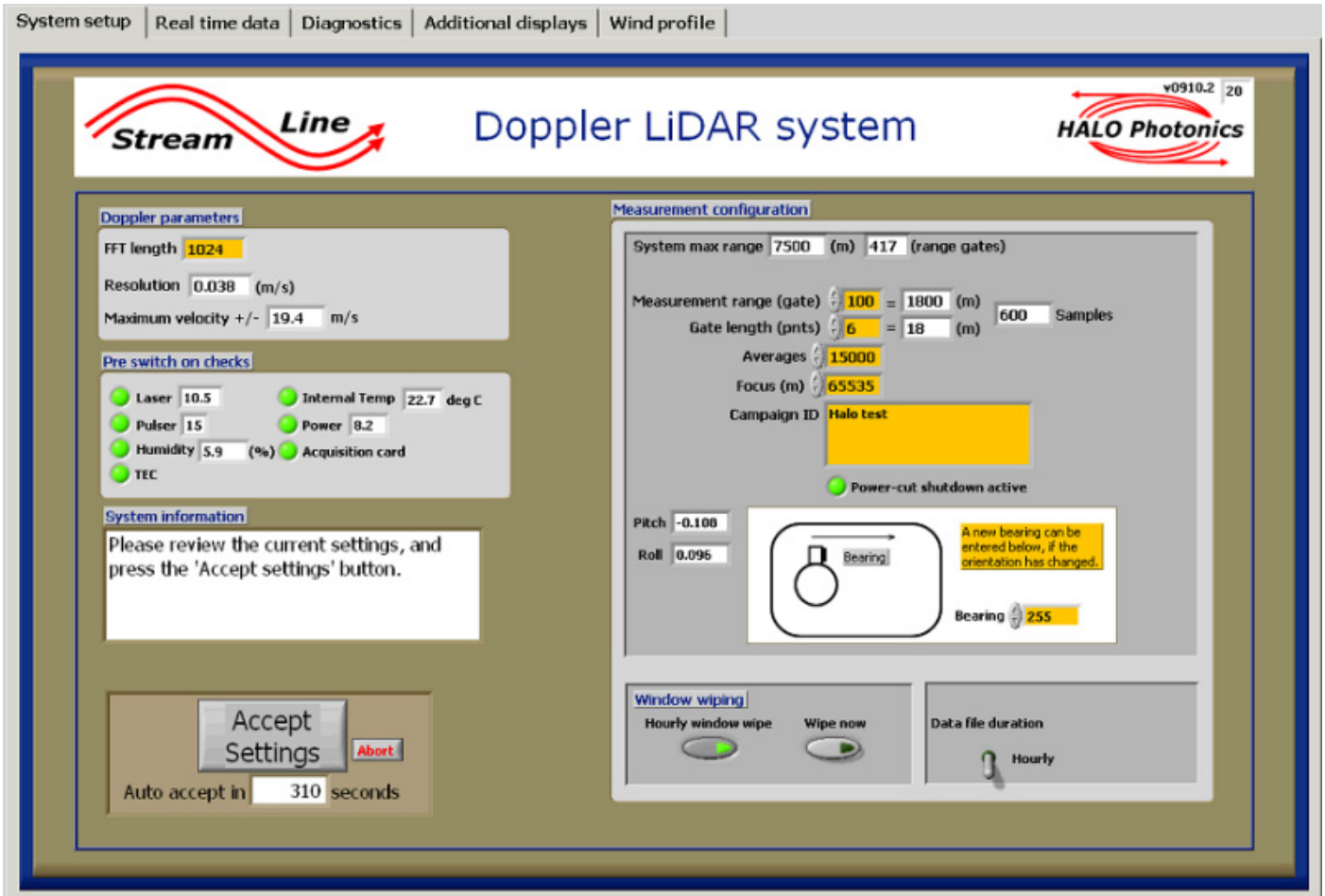
Press the  to stop the software, and the regular Windows close icon to close it.



5.5 Main control software.


5.5.1 System setup.

After double clicking the icon (or if the software shortcut is added to the start up directory and the system is switched on from cold), the following screen will be displayed:



The **System information** box will display system messages and information.

The **Doppler parameters** are shown for information only, and it is suggested that the 1024 number be left by default.

The **Pre switch on checks** will commence once the software is started by pressing the run arrow  - top left (for the non Auto-starting version of the software). The **TEC** status will be displayed if your system has the extended temperature option fitted.

All the red lights in the switch on checks panel should turn green if the system is ok. If a failure occurs, then the software may stop and an appropriate message should appear in the **System information** box. Allow 30 seconds or so for the tests to complete.

Once the tests are complete, the previous settings will be loaded into all the parameter boxes and there is the option to change any of them before pressing the **Accept settings** button. The system will auto accept in 6 minutes if the accept button is not pressed. This is a system recovery feature and is to make sure that if the system comes on after power failure, then progress past this screen is achieved. The **Abort** button can be used to stop the software from progressing.

While the software is taking data, it is possible to navigate to any of the other tab displays. It is not possible however to alter any settings on the 'System setup' screen unless the 'Change LiDAR settings' button is pressed.

The **focus setting** dial should be left at 65535 (infinity) unless the focus has been changed to a known range. Changing the number in the focus box will not change the recorded data in any way – it is merely recorded in the data file header.

Measurement range:

The system's maximum measurement range is displayed in metres and range gates. The max desired measurement range in gate number is selected by entering it into the orange box. [Click outside the box, or press Enter to enter the number].

Lowering the maximum measurement range will reduce the data file size.

The **Gate length** shown in data points at a sample rate of 50MHz. The default is 10, but this can be increased in 2's. Increasing the gate length will increase the spectral resolution to the detriment of the range resolution.

Bearing:

The graphic shows the relevant LiDAR edge for which the bearing input applies. The previous bearing is shown and will be used if not updated.

The **hourly wipe** option will cause the window to be wiped every hour. This is a useful feature and it is recommended that it be selected. The system will perform a noise background every hour, which will take longer than this wiping routine, and they will occur simultaneously.

A window wipe can be initiated at any time by pressing the **Wipe now** button.

The **Power-cut shutdown** control system status is shown. The Stream Line LiDAR has a power supply module with the necessary circuitry to enable the shutdown feature, so this should always be displayed and have a green LED illuminated. If it is not shown, it may mean there is a fault with the power supply module.

The **Campaign ID** can be filled in with a short description of the current measurement campaign. Some system data is saved to the campaign log as shown below:

```

*****
Bearing: 0.0
Temperature: 17.65
Humidity: 27.10
PIN: 8.31
Roll: 0.00
Pitch: -0.01
Started: 08/01/11 16:45:21
*****
Bearing: 255.0
Temperature: 20.71
Humidity: 7.55
PIN: 8.26
Roll: 0.20
Pitch: -0.01
Started: 10/01/11 16:32:16
*****

```

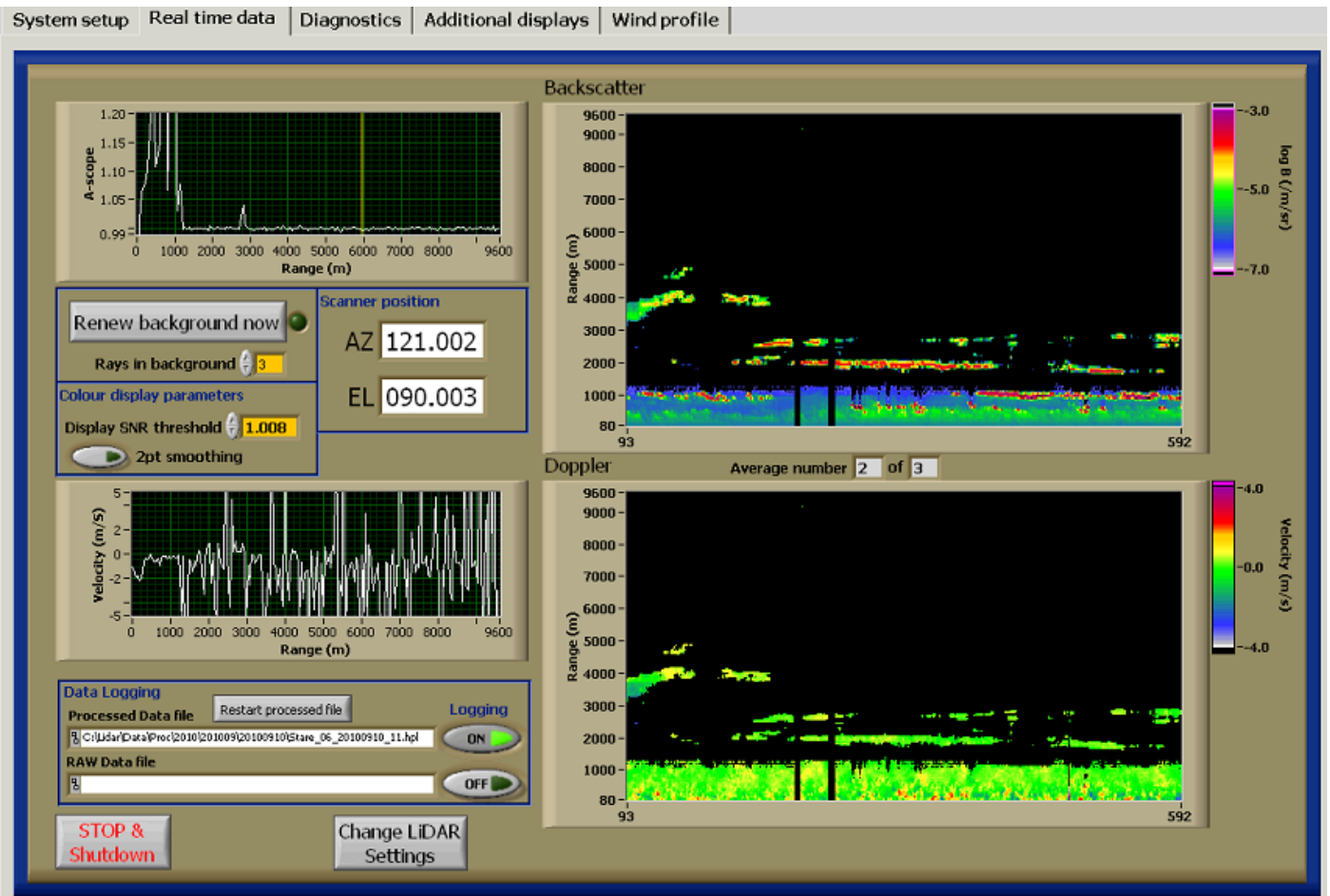
Each time the software is started, another set of parameters are saved to the campaign file. Roll & pitch are only saved if these sensors are fitted.

Toggle the **Data file duration** switch to choose either hourly or daily file saving.

The **De-pol** switch (if the optional depolarisation channel is fitted) will cause the de-polarisation toggle to activate when the system is staring vertically. Data from the cross-polarisation will be stored in separate files in the 'cross' directory within the 'proc' and 'raw' data directories.

After the required settings have been selected, and the **Accept settings** button has been pressed, the settings will be saved and become the new default values that the system will use for the next start up.

5.5.2 Real time data display.



On the left, the current scan position, the **A-scope** or power versus range and the **Doppler velocity** versus range are displayed. The backscatter and Doppler returns are shown on the right hand waterfall plots, with coloured Z-axes.

The **Data logging** file is shown in the file box and the processed logging button is on by default and the raw data logging button is off by default. Pressing the '**Restart file**' button will cause the current *processed* data file to be deleted and overwritten (but not the raw data file).

The **Colour display parameters** are purely for display and don't alter the logged data in any way.

The Background file:

This file is taken while the system is running normally, but with the atmospheric return blocked by way of the scanner directing the beam directly down. It is used to remove any (non white) features present in the noise floor. A new file is taken every hour, and if the LiDAR settings are altered.

The **background** button can be pressed if a bias in the Doppler display is evident.

Pressing the **Change LiDAR settings** button will cause the current data taking to pause, while new settings are chosen on the set up screen – in the same way that they were initially chosen on start up.

If more than 2 or more rays are being averaged, then this is displayed on the '**Average number**' display.

Scale settings.

Graph axis ranges can be altered by double clicking the graph x,y and z scale labels and entering new values.

5.5.2.1 Data logging.

Data are logged using the following directory structures:

C:\Lidar\Data\Proc\yyyy\yyyymm\yyyymmdd\ - for processed data

C:\Lidar\Data\Raw\yyyy\yyyymm\yyyymmdd\ - for raw data

And with the following naming convention:

Stare_ID_yyyymmdd.hpl – for daily stare files (.raw for raw data files) where ID is the LiDAR system ID

Stare_ID_yyyymmdd_hh.hpl – for hourly stare files (.raw for raw data files)



If the optional de-polarisation channel is fitted, then the directory structure will be as above with the additional 'cross' directory.

For other scan types, the naming convention is as shown:

VAD_ID_yyyymmdd_hhmmss.hpl (.raw for raw data files)

RHI_ID_yyyymmdd_hhmmss.hpl

Wind_Profile_ID_yyyymmdd_hhmmss.hpl

Usern_ID_yyyymmdd_hhmmss.hpl (n = user file number - 1 to 5)

All data files are appended to, therefore reducing the risk of loss of data due to power failure. **When copying data from the PC, copying of the file currently being saved to should be avoided as file sharing violations will occur.**

5.5.2.2 Typical staring data file header and data format:

```
Filename: C:\Lidar\Data\Proc\2010\201009\20100909\Stare_06_20100909_17.hpl
System ID: 06
Number of gates: 200
Range gate length (m): 48.0
Gate length (pts): 16
Pulses/ray: 36000
No. of rays in file: 1
Scan type: Stare
Focus range: 65535
Start time: 20100909 17:11:18.62
Resolution (m/s): 0.0380
Altitude of measurement (center of gate) = (range gate + 0.5) * Gate length
Data line 1: Decimal time (hours) Azimuth (degrees) Elevation (degrees)
f9.6,1x,f6.2,1x,f6.2
Data line 2: Range Gate Doppler (m/s) Intensity (SNR + 1) Beta (m-1 sr-1)
i3,1x,f6.4,1x,f8.6,1x,e12.6 - repeat for no. gates
****
17.188506 121.00 90.00
0 -0.9438 0.947137 -1.768121E-5
1 18.8837 0.989410 -1.770654E-5
2 0.0438 1.019421 3.449959E-7
3 0.0818 1.018930 3.379429E-7
4 -0.4120 1.021649 3.891171E-7
5 -0.2981 1.024979 4.527853E-7
6 -0.1081 1.026061 4.772335E-7
7 -0.1841 1.031567 5.849269E-7
8 -0.1081 1.035721 6.708409E-7
9 -0.0322 1.035326 6.733928E-7
10 -0.1081 1.044148 8.554822E-7
11 0.0438 1.043894 8.658305E-7
```

Typical VAD data file header and data format:

```
Filename: C:\Lidar\Data\Proc\2010\201009\20100909\VAD_06_20100909_165213.hpl
System ID: 06
Number of gates: 320
Range gate length (m): 30.0
Gate length (pts): 10
Pulses/ray: 12000
No. of rays in file: 8
Scan type: VAD
Focus range: 65535
Start time: 20100909 16:52:20.54
Resolution (m/s): 0.0380
Altitude of measurement (center of gate) = (range gate + 0.5) * Gate length
Data line 1: Decimal time (hours) Azimuth (degrees) Elevation (degrees)
f9.6,1x,f6.2,1x,f6.2
Data line 2: Range Gate Doppler (m/s) Intensity (SNR + 1) Beta (m-1 sr-1)
i3,1x,f6.4,1x,f8.6,1x,e12.6 - repeat for no. gates
****
16.872372 360.00 75.00
0 -0.8678 0.992906 -1.767999E-5
1 13.3001 0.690805 -1.768839E-5
2 -2.2352 1.022761 4.030809E-7
3 -1.9314 1.025395 4.505609E-7
4 -2.1213 1.027799 4.944956E-7
5 -2.0833 1.029325 5.233433E-7
6 -1.7794 1.031933 5.721396E-7
7 -2.0833 1.027348 4.922573E-7
8 -1.5895 1.036381 6.583376E-7
9 -1.9314 1.038723 7.049130E-7
10 -1.5895 1.042201 7.733259E-7
11 -1.6275 1.044592 8.230941E-7
```

5.5.3 Additional displays.

The screenshot shows a software interface with a menu bar at the top: System setup | Real time data | Diagnostics | Additional displays | Wind profile. The main area is divided into several sections:

- System log file:** C:\lidar\System\Logs\system_log.txt
- Supply voltage:** 23.43
- Set point:** 2400
- Scan filename:** C:\lidar\System\Scan parameters\stare.txt
- Scanner position:** AZ 360.000, EL 090.003
- Scan Schedule Table:**

	Sched.	Current	Rpt (s)	Elapsed	C/C
VAD	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	500	41	<input type="checkbox"/>
RHI	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>			<input type="checkbox"/>
Wind prof.	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>			<input type="checkbox"/>
User file 1	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>			<input type="checkbox"/>
User file 2	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>			<input type="checkbox"/>
User file 3	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>			<input type="checkbox"/>
User file 4	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>			<input type="checkbox"/>
User file 5	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>			<input type="checkbox"/>
Stare	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>			<input type="checkbox"/>
- Buttons:** Edit scan schedule (circled), Reload schedule.

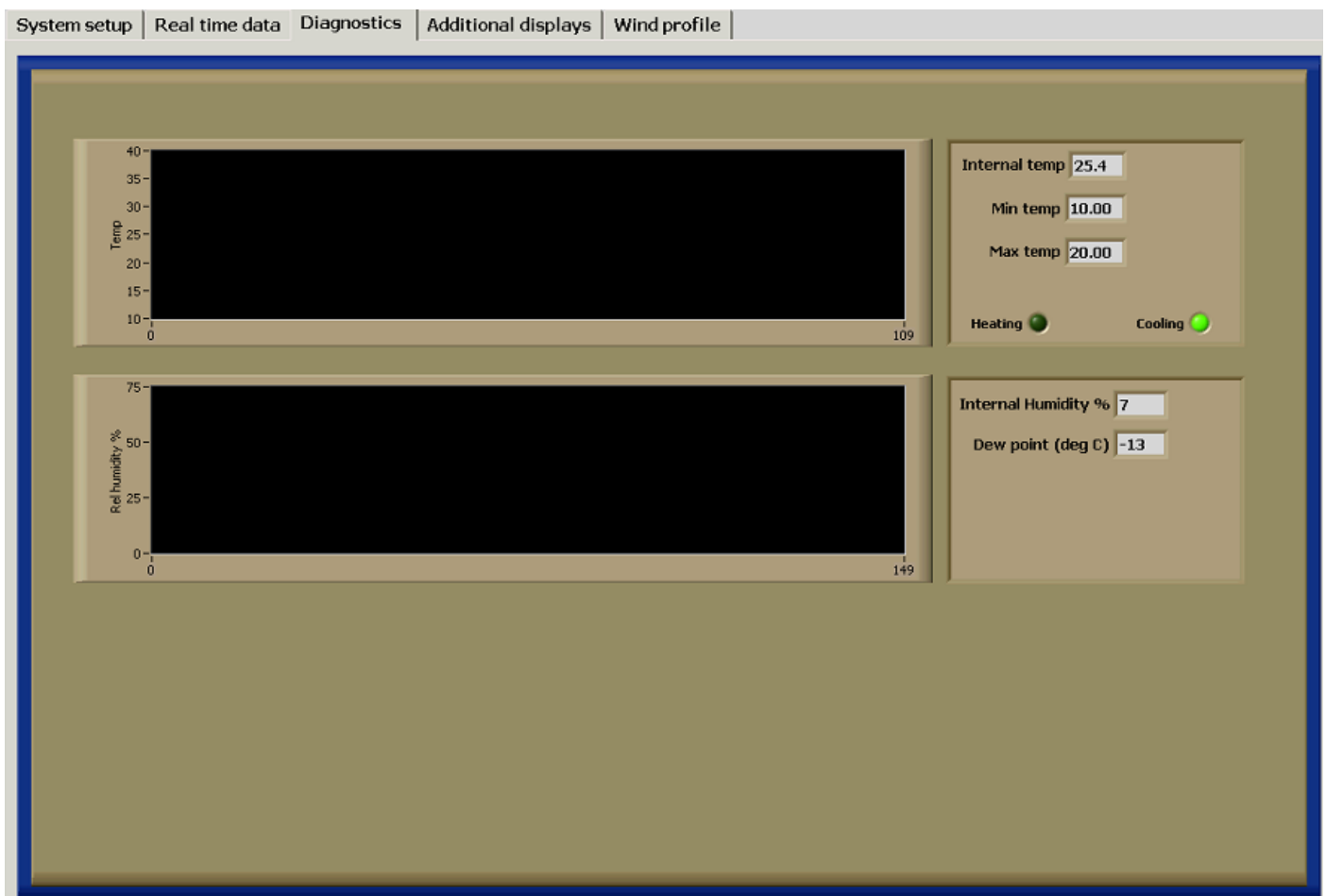
Annotations:

- A box on the left says: "Not available from v7 onwards. Use the edit schedule icon on the desktop." with an arrow pointing to the "Edit scan schedule" button.
- A box at the bottom explains the "C/C" button: "The 'C/C' button next to any currently displayed scan can be pressed to **continuously cycle** the chosen scan. If multiple C/C buttons are pressed, those scans will repeat, one after the other. During this mode, the 'Reload schedule' button will not be available. To edit the schedule, you must use the icon located on the desktop, and reload it once finished." It also notes: "If some scans are set to continuously cycle, any other scans not set to cycle will run at their selected repeat interval. The Wind profile scan does not have a C/C option."

After the schedule has been changed and the schedule 'Finished' button has been pressed, the schedule software will need to be closed. The **Reload schedule** button will then need to be pressed **before** the amended schedule is used.

The currently loaded schedule is displayed along with the scan pattern that is currently being performed along with their **repeat time** in seconds and the number of seconds until the next repeat.

5.5.4 Diagnostics.



The diagnostics page is used for checking the system humidity and temperature states. The displays are updated every 2 minutes.

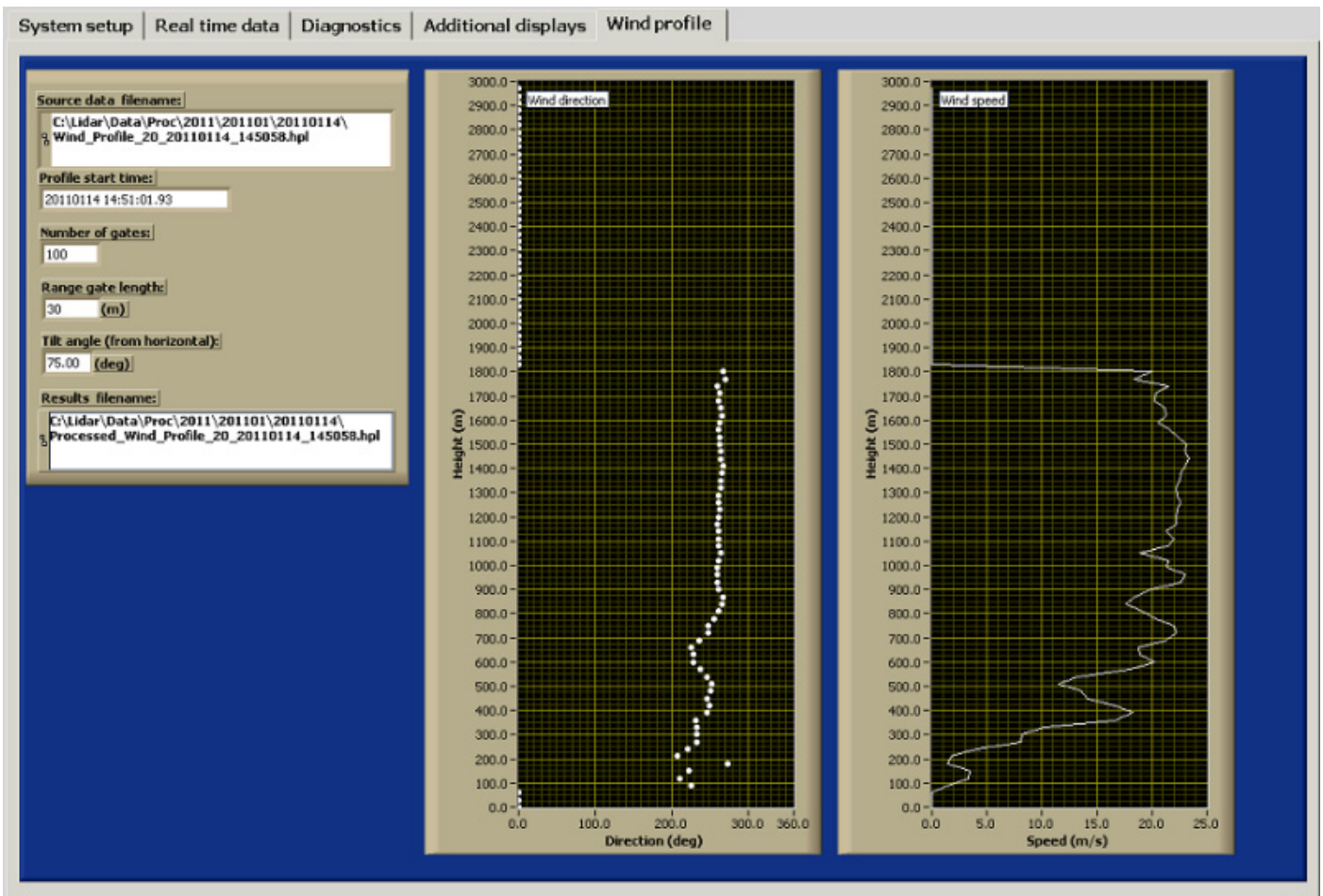
The temperature, humidity, supply voltage and thermal control status (on non-TEC units) data are logged to a file that is stored in the monthly directory in the processed data directory:

C:\Lidar\Data\Proc\yyyy\yyyymm\system_parameters_SystemID_yyyyymm.txt

An example file showing date/time, internal temperature (1 deg C resolution), internal relative humidity, thermal control status and supply voltage. If the system has a TEC unit fitted, then thermal control is autonomous to the TEC unit. For non-TEC systems, the last status will be 1 for cooling, 2 for heating and 0 for neither heating nor cooling.

```
10/09/2010 14:05:16 26.22 56.86 0 23.10
10/09/2010 14:07:16 25.20 55.23 0 23.14
```

5.5.5 Wind profile.



A few seconds after a wind profile measurement has been taken, the data are analysed to display a standard direction and speed profile as displayed above. The processed data are saved into the current processed data directory. File naming convention for processed wind profile data:


Processed_Wind_Profile_SystemID_yyyymmdd_hhmmss.hpl

Processed files are in the format shown below, with the number of heights first, then successive data points giving height (AGL), bearing and horizontal wind speed.

```
200
0 0.00 0.00
48 229.55 14.40
96 232.82 11.44
144 230.20 11.44
192 228.82 14.02
240 232.80 14.53
288 232.61 15.67
336 239.62 15.62
384 238.57 16.81
432 242.97 16.48
480 242.70 16.04
528 252.52 16.17
576 256.44 15.12
624 255.90 15.76
672 252.70 15.85
720 256.04 16.50
768 258.22 16.67
816 259.74 17.48
864 263.04 17.35
912 264.02 17.31
960 264.29 18.19
1008 264.68 18.04
1056 265.21 18.32
1104 265.14 18.19
1152 264.95 19.07
1200 267.08 18.58
1248 267.95 18.58
1296 268.80 18.14
```

5.6 Stopping the Software



Press the  button on the Real time data tab to stop the software and park the scanner.

The software will stop, and a message will be displayed stating that the power should be left on for a few minutes to allow the internal fans to remove residual hot air from the internal electronics.

After 5 minutes or so, the Shutdown software can be run.

5.7 Shutting down.



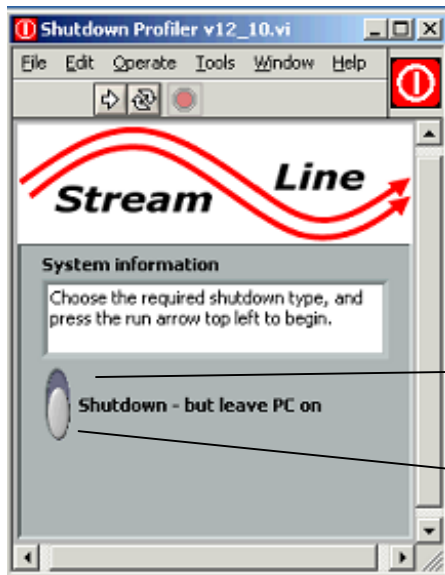
Double click the Shutdown icon to load up the software.

Description:

This module will shut down the internal systems of the LiDAR in a controlled manor, and will also shut down the PC if the option is selected.


When to use:

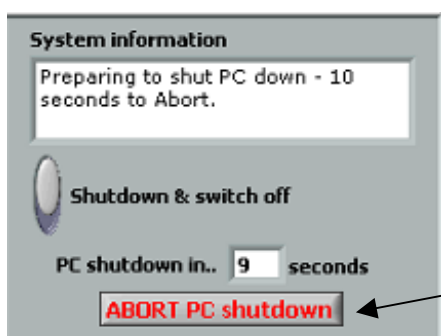
Use whenever the system is going to be powered off or not used for data collection i.e. for data transfer.



Both switch options are shown here. **Choose the required option prior to running the software.**



Press the run button  to start the chosen shutdown procedure.



The option to abort the PC switch off will be displayed for 10 seconds.

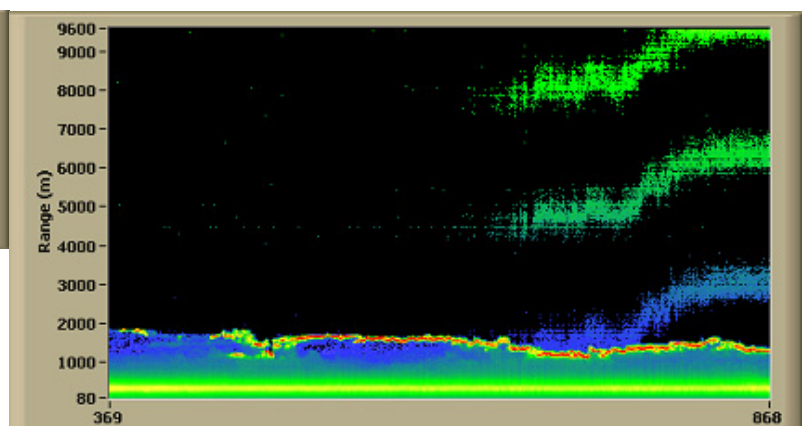
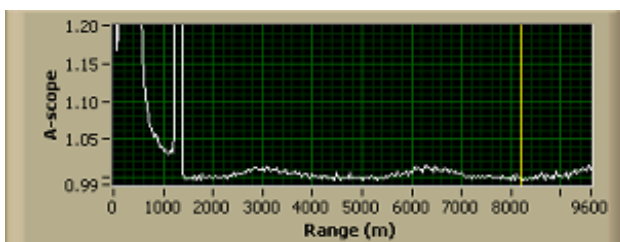
6. Troubleshooting.

Problem / observation	Possible cause / fix / check
<p>The LiDAR software is running, but the scanner isn't moving.</p>	<ol style="list-style-type: none"> 1. One or both of the motors may have been disabled. 2. Try to move the scanner by hand both in elevation and azimuth. If there is no resistance to movement for either azimuth or elevation then: <ul style="list-style-type: none"> • The scanner may not be powered. • Both motors have been disabled in the scanner setup software (Follow the process below) 3. If there is lack of resistance on either az or el to manual movement, then it is likely that the motor has encountered high resistance to movement and has disabled itself. The solution is to stop all currently running software and run the scanner setup software: <ul style="list-style-type: none"> • Press the Disable motors button • Press the Enable motors button • Press the origin search button <p>Make sure that both motors are functioning, and if they are, finish the scanner software and close it down. Normal operation should now be possible.</p> <ol style="list-style-type: none"> 4. If the above fixes don't work, please contact Halo. <ul style="list-style-type: none"> • The 24V 10A fuse (F-1) may have blown.
<p>The LiDAR won't power up – the green power LED in the LiDAR connector panel is not lit.</p>	<p>With all power cables disconnected, check the 10A fuse in the holder and replace if necessary.</p> <p>Check that the power supply module LEDs are coming on as normal – i.e. the 'I/P Active' one when mains power is applied, and the 'O/P Ready' one approximately 4 minutes after power was applied. There are 2 10A fuses inside the power supply module. Although there are no exposed mains connections inside, it is recommended that the unit be returned to Halo if the LEDs do not behave as described above.</p>
<p>The software has frozen.</p>	<ul style="list-style-type: none"> • Please make a note of the error message if any, and let Halo know. • Although there are no known issues with the software or hardware, there is always the chance of a system freeze due to mains spikes etc. If this happens:- • Try to close the software (using Ctrl-Alt-del) and try to shut the PC down using the shutdown module. If a remote connection is not possible, an svga monitor can be connected, along with a keyboard and mouse to the LiDAR connector panel. • Start the system up as normal
<p>There seems to be reduced or no signal.</p>	<ul style="list-style-type: none"> • Check the optical output window for dirt – clean if necessary. • The atmosphere could be exceptionally clean. • Check the focus setting

There's a large bias in the Doppler display	The background file needs to be renewed.
Some of the Pre switch-on check LEDs are red.	Please make a note of any error messages and contact Halo.
The humidity and/or temperature LEDs are red.	The software will be prevented from starting up in this situation. If there is reason to suspect that the readings are false, please contact Halo.
The Pulser LED is red.	The system should not start up in this situation. Please note the reading and contact Halo.
The Acquisition card LED is red.	<ul style="list-style-type: none"> The software will stop if this happens. The card may fail if the software was not shut down properly. The system will need to be completely re-booted. Restart the PC
The TEC LED is red	If this happens, then the software will stop. Try removing the F2 fuse for a few seconds before re-inserting. Try running the software again.
The Power LED is red.	Please make a note of the number (if any) in the power readout box and contact Halo. Try a complete shutdown and power off, and try again.
There's no picture displayed on the attached monitor.	<ul style="list-style-type: none"> Make sure that you have tried pressing [Ctrl][Alt] and [F1] – this will enable the video output. Make sure that your attached monitor can support a resolution of 1280 x 1024
Can't connect to the PC after powering everything up.	<ul style="list-style-type: none"> Make sure that the internal PC is powered up by connecting a monitor, keyboard and mouse to the SVGA connection. If there is no signal, press the PC button on the connector panel If there is a display, then check your network settings, and if correct, try a 'repair connection', or the LiDAR firewall might need to be turned off if the connecting PC is running Win7. If the RJ45-BB is also connected to a hub, and the PC is visible on the Internet, then it may not be possible to also connect using the crossover connection.
The Laser LED is red, and the power number is below 2, but the system does not abort startup.	<ul style="list-style-type: none"> Sometimes, the laser will take more time to come on than is given in software. The software Abort button can be pressed, followed by the run arrow being pressed, after which, the Laser LED should be green, and a value of 10.6 seen for the value. It is possible to continue the software even if the Laser LED is red. If there is a genuine problem with the laser, then the Power LED will also be red, and the software will stop.

Digitiser thermal drift at startup.

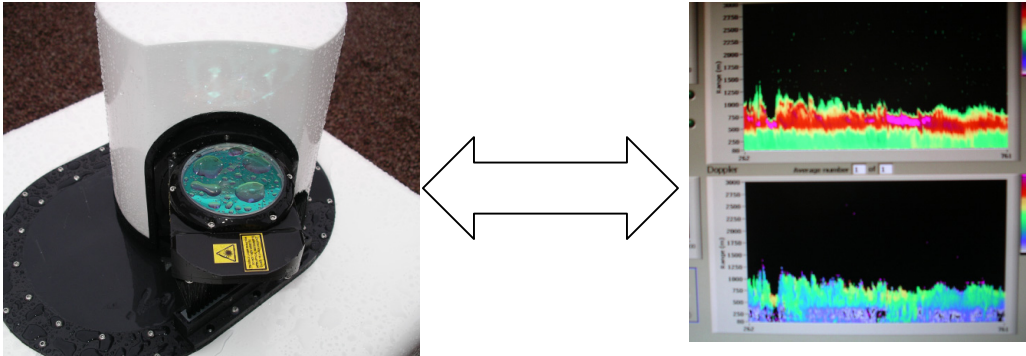
The effect shown below is sometimes evident soon after the system is powered up, and is due to the background file differing from the unthermalised digitiser return. The effect should gradually disappear, and is usually removed after a new background file is taken.



Optical output window

The default setting in the software is to wipe the window every hour. The purpose of the wipe is to remove water and dust. This setting can be deselected if required and there is also the option to wipe now. Depending upon the prevailing weather, the most appropriate option should be selected.

The optical performance will not be affected too badly from beaded standing water on the output window as illustrated below provided the fractional coverage of the clear aperture is not too high.



Manual cleaning.

The output window has a hard anti-reflection coating on the outer surface. The coating is reasonably robust but should it be deemed necessary to clean it, the procedure below should be adopted:

The surface of the window should be flooded with IPA or an equivalent optical cleaning solution and left to soak for a short period of time to loosen any debris which might have adhered to the surface. Wiping of the window should be done with a soft lens tissue. This cycle should be repeated until a satisfactory result is achieved.

Wiping brush.

If the wiping brush becomes very distorted, it can be reshaped while wet, and dried straight. It can be removed by unscrewing two grub screws that can be accessed after removing some of the nylon screws from the heat shield, allowing it to be moved out of the way *slightly*.

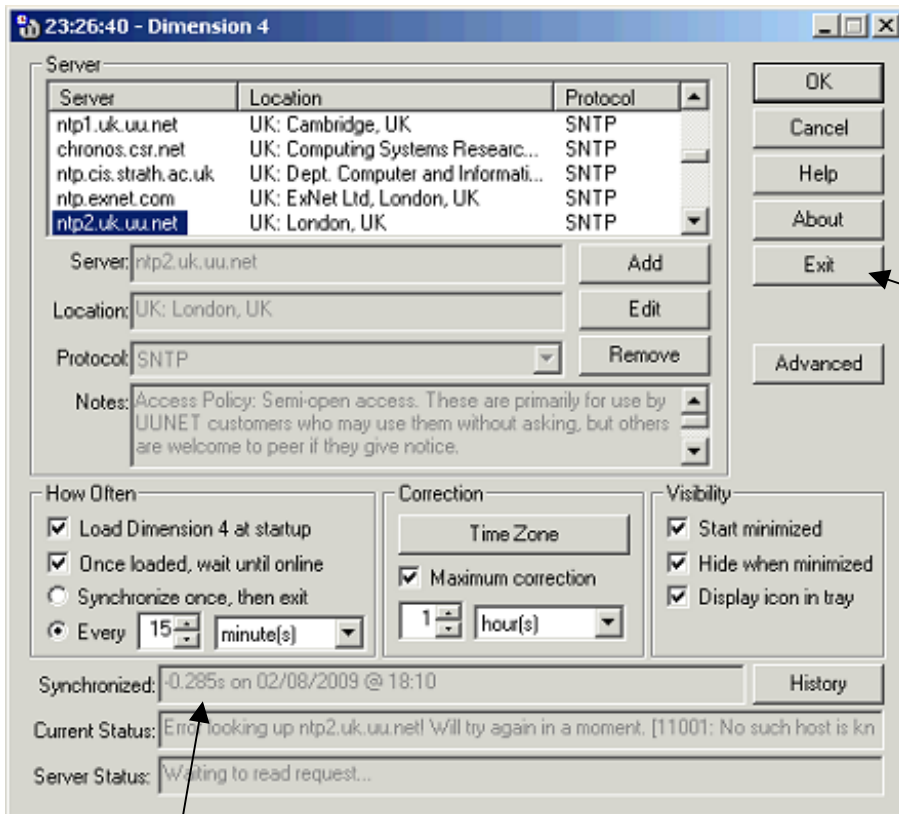
7. Time synchronisation software.

The PC internal clock has been set to ignore daylight saving time adjustment, and will be set to GMT.



The LiDAR has a time synchronisation program installed that will keep the computer clock synchronised to a network time server. The PC needs to have Internet access for this feature to work.

To open the software, right click the icon and choose open.



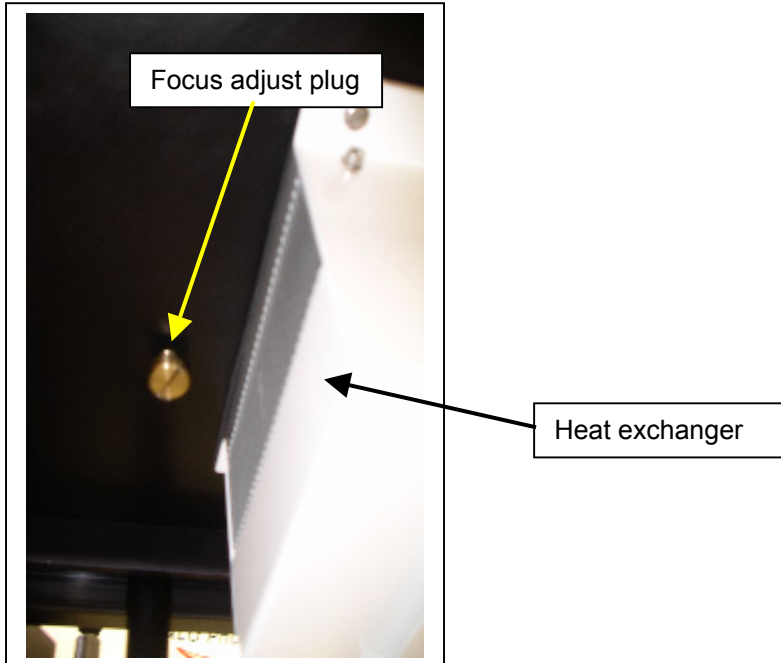
Use Exit to minimise this display.

This field shows the last synchronisation time.

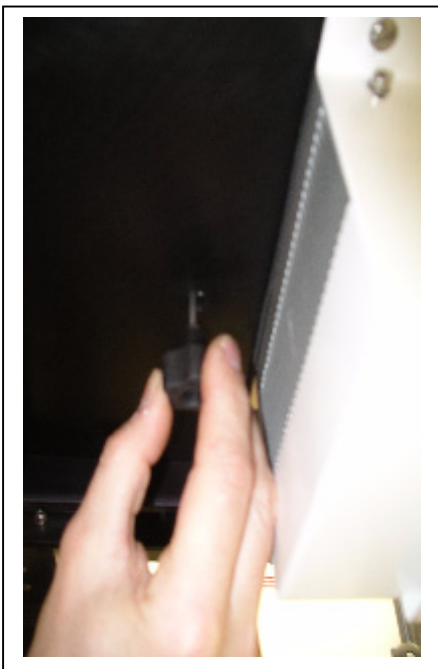
9. Manual Focus

The lidar is delivered with the focus set at infinity. This is the condition for the class 1M certification. Any adjustment of the focus by the user is done completely at the user's risk. If the focus setting is changed by the user, the user takes full responsibility for the modified operational characteristics of the lidar.

Adjust the focus by acting on the external focus control. This is done using the small tool provided made from an M4 bolt and a plastic knob. Carefully remove the brass plug in the base plate taking care not to loose the black o-ring mounted on the inside of the head of the brass plug.



Carefully engage the hexagonal tool with the hexagonal end of the internal drive shaft and turn slowly. Looking from underneath, turn CW to extend the focus, and CCW to pull it in. This should only be done while looking in real-time at the A-scope display so that the effect that the adjustment is having can be immediately seen.



It should only be necessary to make small changes of the order 1-2 turns of the knob. Pulling in the focus to ranges of the order a few hundred meters increases the signal at shorter ranges to the detriment of the long-range signal. After adjustment, ensure the brass plug is re-fitted with the o-ring correctly seated.

9.1 Electronic Focus

System max range (m) (range gates)

Measurement range (gate) = (m) Samples

Gate length (pnts) = (m)

Averages

Focus

Campaign ID

Pitch

Roll

Simulation mode

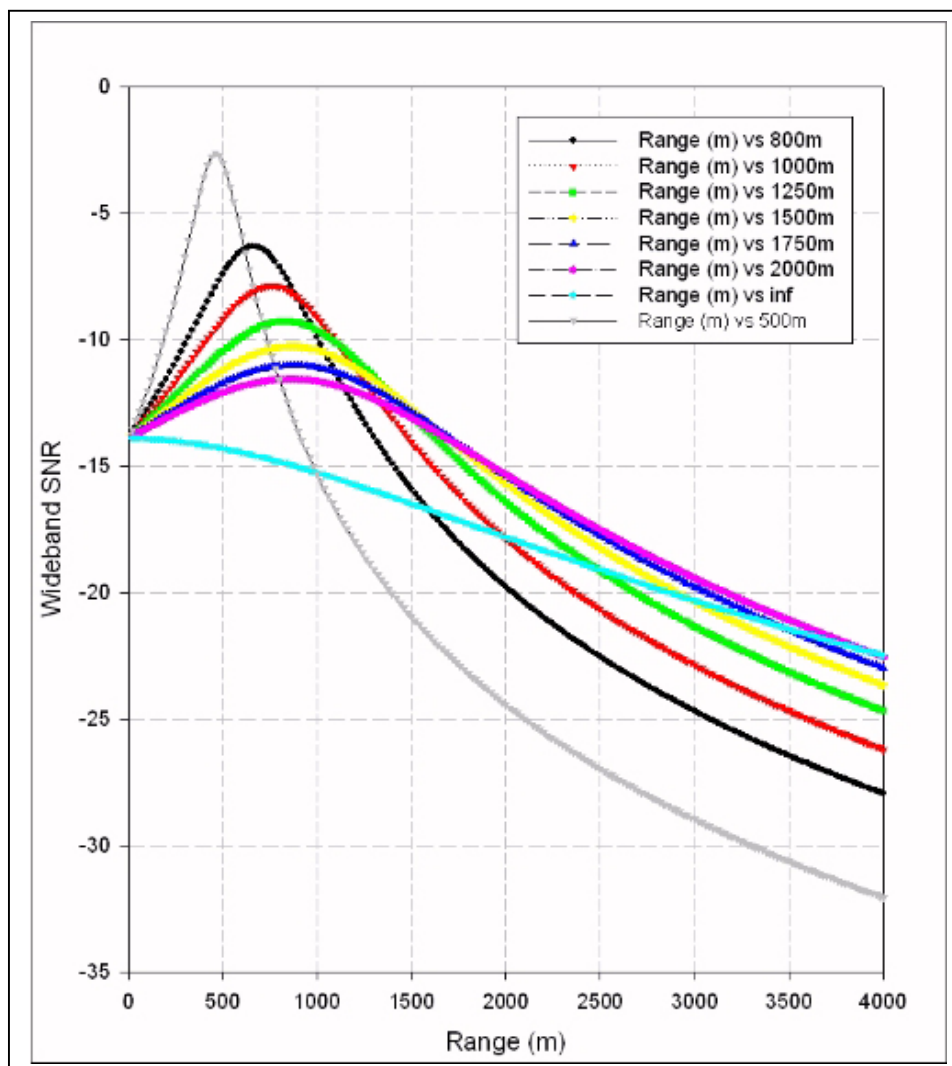
Bearing

A new bearing can be entered below, if the orientation has changed.

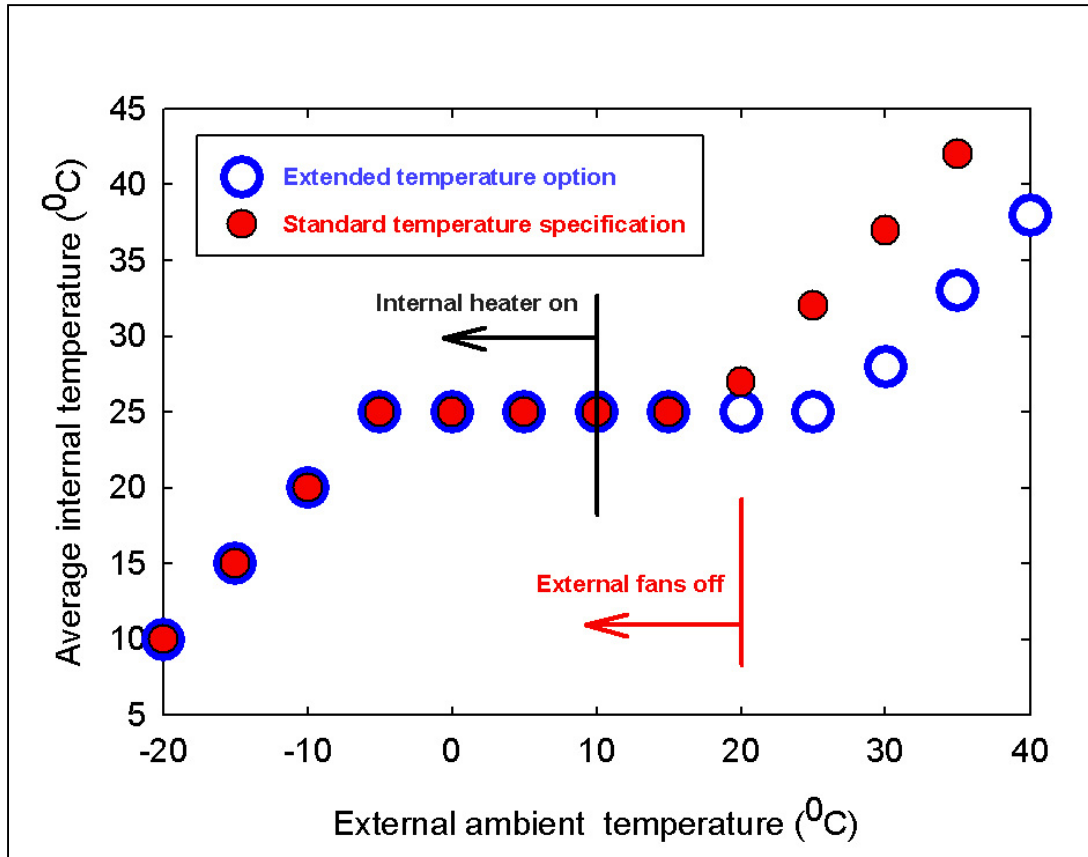
If your LiDAR is fitted with a focus unit that is controlled electronically, then you will see the control shown here at startup.

- ✓ 500m
- 800m
- 1000m
- 1250m
- 1500m
- 1750m
- 2000m
- Inf

The focus range selections correspond to the effective focus enhancements shown in the graph below. The focus can be changed at start up, or when the 'Change LiDAR settings' button is pressed during normal operation. Please note that if your LiDAR has an electronic system, then it won't be possible to adjust the focus manually as in section 9.



10. Typical thermal characteristics



The graph above illustrates the expected averaged internal temperature versus the external ambient temperature for the two different temperature specifications. The external ambient temperature is defined here as the temperature of the air being drawn into the heat exchanger on the underside of the lidar. Depending upon the characteristics of the ground, this may be hotter than the temperature as measured in the conventional way for meteorological reporting.

Systems fitted with the extended temperature option.

The heat exchanger fans will be on all of the time, and as soon as power is applied to the LiDAR, as the cooling system is not covered by the power cut protection circuit.

Standard temperature option.

The heat exchanger fans will be on when the internal ambient temperature goes above a set point, and off again when cooled to 2°C below this point. Thermal control is only operative while the main LiDAR control software is running – so in warm ambient conditions (> 25°C), make sure that the LiDAR is not sat in a powered but dormant state for more than a few tens of minutes.

If either system experiences an internal temperature of below 10°C, then an internal heater will come on. This is also software controlled and will only switch in and out if the main control software is running.

The internal fans (standard temperature option), and heater can be switched off by running the shutdown module.

Thermal shutdown.

In the event of a cooling system failure, or high ambient temperatures (> 40°C), the software will shut some parts of the LiDAR down. Data collection will be paused while the system is in this thermal shutdown mode. A notice will be displayed on the system information window, 'Thermal shutdown – waiting for the internal temperature to reduce', and an event will be written to the system error log.

When the temperature is back to an acceptable level (normally 5°C lower than shutdown temperature set point), then the system will resume taking data as normal.