



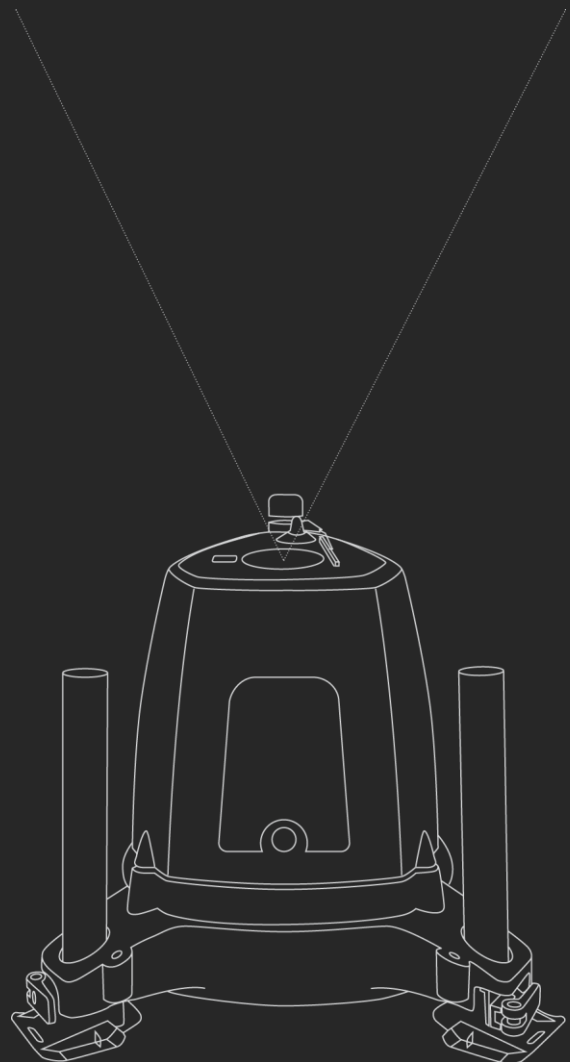
WALTZ

A USER'S GUIDE

21/06/2018

Version 2.2

Commercial In Confidence



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1 INTRODUCTION

This document provides guidance on the use of the Waltz software application for all variants of the ZephIR lidar:

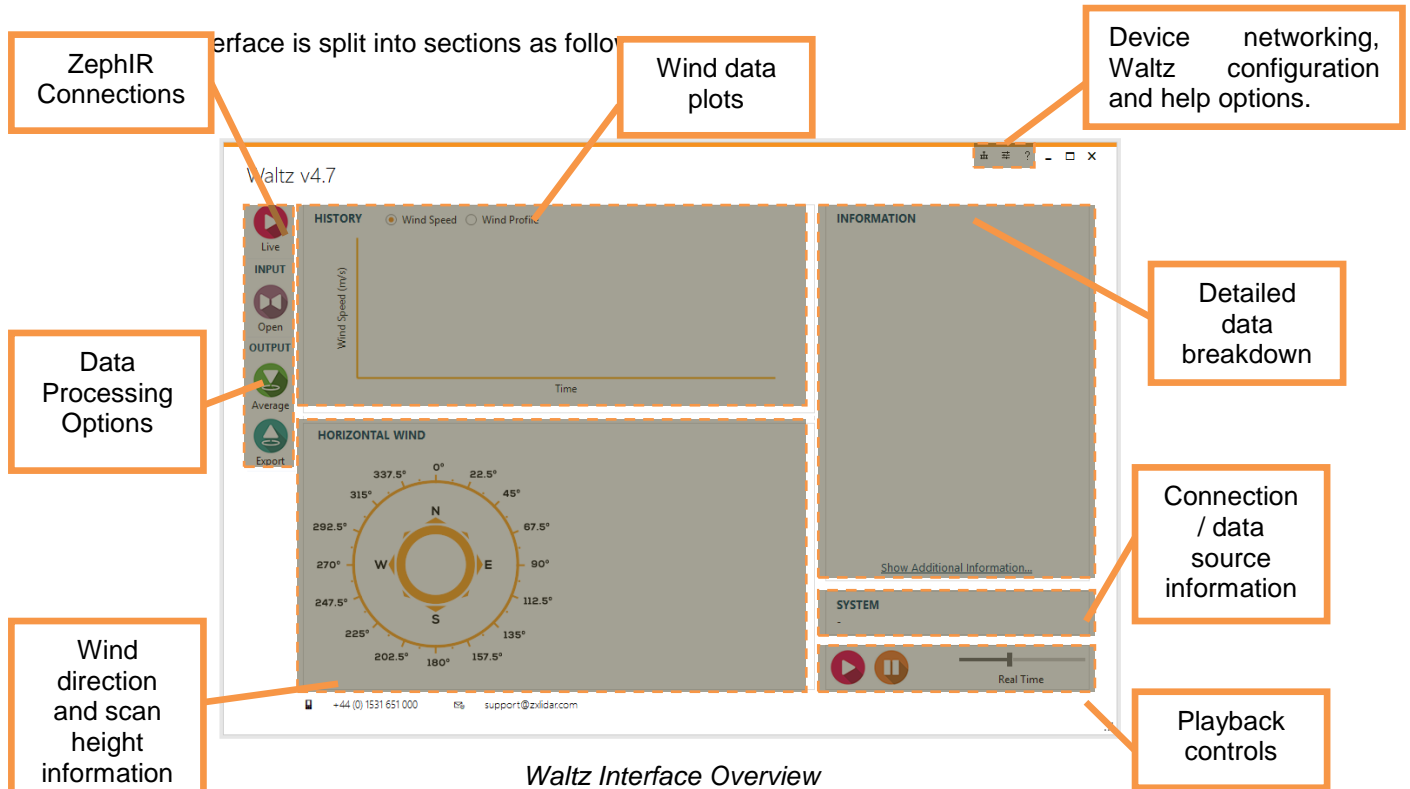
- ZephIR 150 (Z150).
- ZephIR 175 (Z175).
- ZephIR 300 (Z300).
- ZephIR 300M (Z300).
- ZX300 (Z300).
- ZephIR Turbine Mounted (ZTM).
- ZephIR Dual Mode (ZDM).

Note: Z150 and Z175 units are collectively referred to as 'Z150/175'. Z300 is a generic indicator for features common to 300M, ZX300 and ZephIR 300.


2 WALTZ OVERVIEW

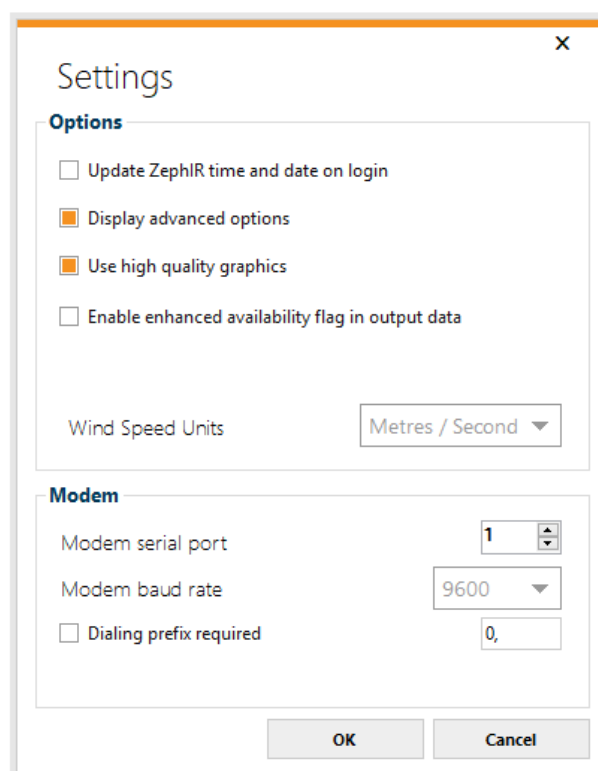
The Waltz software is the primary interface to a ZephIR unit and allows you to:

- Connect to a ZephIR.
- Retrieve system status information.
- View real-time spectral and wind data.
- Change the ZephIR's configurable options.
- Play back, average and export recorded data.



3 SETTING UP WALTZ FOR THE FIRST TIME

The first time Waltz is opened, it requires some configuration for full operation on the PC on which it is installed. To do this, select the settings icon  in the top right hand corner. The following screen should appear:



Waltz Settings Window

General options:

- **Update ZephIR time and date on Login** – if this option is selected, every time a ZephIR is accessed the time and date will be set to that of the current PC. If the PC is set to update its time over the internet, this allows the clock of the ZephIR to be maintained to a high accuracy. Note: This will only be accepted by the ZephIR if it is *not* currently configured to update its time and date from GPS.
- **Display advanced options** – Most users will only require the standard functionality provided by Waltz. Checking this box will enable extra options and settings which may be required by expert users.
- **Use high quality graphics** – If this is unchecked then Waltz will use simpler graphics and no animation.
- **Enable enhanced availability flag in output data**– By default, for ZX300 units, Waltz only indicates the data quality in the header, with this option ticked, the data quality for each data point is indicated. Check this box to enable relaxed filtering criteria with ZP300/300M units, if available, CSV outputs will indicate whether each data-point meets conventional ZephIR standards.
- **Wind Speed Units** – Identifies the units to display wind speeds in (knots or m/s).

Modem options:

- **Modem serial port** - To use a dial up connection, select the serial port on the PC to which the modem is attached.
- **Modem baud rate** - The default modem baud rate of 9600 should normally be left unchanged.
Dialling prefix required - If a prefix is required to dial an external number, check '**Dialling prefix required**' and enter the prefix in the box to the right.

Clicking 'OK' will clear the window and save the settings for future use.

4 CONNECTING TO A ZEPHIR



Live

To connect to a ZephiR click the '**Live**' button at the top left. Next select the method you wish to use to connect to the ZephiR from the '**Method**' box.

4.1 Modem

Use this option to connect to the built in ZephiR GSM modem (Z150/175 only) or optional Iridium modem.

Connect to ZephiR

Method

- ☒ Modem
- ☐ Ethernet
- ☐ GPRS

History

[Dropdown Menu]

Add Remove Clear

Modem Connection Options

Data phone number [Input Field]

Cancel Connect

Connection Window - Modem

Simply enter the phone number into the '**Modem**' box. This should be the data number for the SIM card and differs from the voice number. Click '**Connect**'.

4.2 Ethernet

Use this option to connect to the ZephIR over a network (wired or wifi), satellite internet connection, or Z300 GSM (i.e. cellular network) connection. Any ZephIRs* running on the local network which are visible to Waltz will appear in the list in the centre.

*Only ground based Z300's with at least firmware v1.3.

Connect to ZephIR

Method

☐ Modem
☒ Ethernet
☐ GPRS

History

Add Remove Clear

ZephIR Detection

Unit	Ethernet IP
463	10.10.6.193
523	10.10.6.153
651	10.10.7.31
780	10.10.7.160
781	10.10.7.161

Start scan Stop scan

Ethernet Connection Options

IP address 10.10.7.168

Cancel Connect

Connection Window - Ethernet

To select which ZephIR to connect to there are three options:

1. Click on an entry in the '**History**' list.
2. Click on one of the ZephIRs which was detected on the local network.
3. Manually enter the IP address of the ZephIR into the '**IP Address**' box.

Once a suitable Ethernet IP address has been entered, click '**Connect**'.

Note: If connecting to a Z300 or ZTM 'go-anywhere SIM' the VPN connection must be established first.

Note: If connecting to a ZephIR via the Ethernet port (LAN), the factory-set IP address of the unit is '10.10.X.Y', where:

X = 5 for units 301-369, 6 for 370-624 and 7 for 625 above.

Y = for units 301-369; 30 + last two digits of unit number.

for units 370-624; the unit number - 370.

for units 625 onwards; the unit number - 620.

For unit 312, the default IP address will be '10.10.5.42'.

For unit 427, the default IP address will be '10.10.6.57'.

For unit 750, the default IP address will be '10.10.7.130'.

Note: If connecting to a ZephiR via WiFi, You must establish a connection to the ad-hoc wifi network of the ZephiR to be able to connect to its IP address.

The WiFi address will always be 192.168.1.1 unless you're connecting to a system with a BGAN M2M terminal in which case it will be 192.168.1.2.

Note: The following TCP ports are used by the ZephiR: **10001** (general Waltz communications link; applies to all ZephiR models), **21** (used by Waltz when connected to a Z300 or ZTM for file transfer via the FTP) and **502** (not used by Waltz but should be opened for the Z300 and ZTM MODBUS interface).

4.3 GPRS (Z150/175 only)

This option can be used to connect to the ZephiR GSM modem via GPRS. It is only available when specifically requested from Zephir Ltd.

The screenshot shows a 'Connect to ZephiR' dialog box with a close button (X) in the top right corner. It contains three main sections: 'Method', 'History', and 'GPRS Connection Options'. In the 'Method' section, 'GPRS' is selected with a radio button. The 'History' section shows a dropdown menu with '788 (Network)' selected, and 'Add', 'Remove', and 'Clear' buttons below it. The 'GPRS Connection Options' section contains several input fields: 'Phone number' (empty), 'My IP address' (10.10.4.176), 'Access point' (internet), 'Username' (web), 'Password' (web), and 'Select preset' (empty dropdown). At the bottom are 'Cancel' and 'Connect' buttons.

Connection Window - GPRS

Please see 'GPRS Basics' in the main ZephiR user manual for more information on GPRS. There are a range of presets for different networks which will automatically fill in the GPRS settings when selected. It is possible that the networks will change these settings and you should check with the SIM card provider.

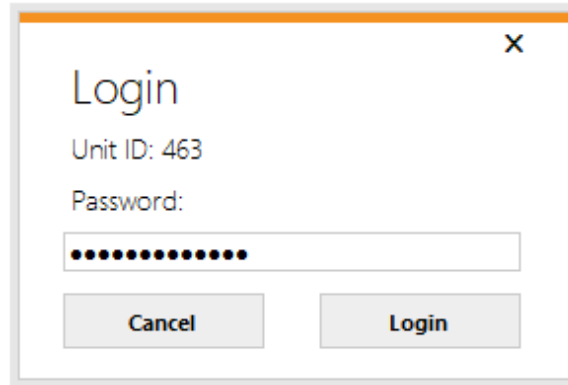
4.4 History

Whenever a connection to a ZephIR is successfully made, it is stored in the history list. This can be accessed by clicking on the drop down arrow in the '**History**' box. The connection options will then be filled in automatically.

In advanced mode, you also have the ability to manage the history entries manually. To add an entry by hand, proceed as before but instead of clicking '**Connect**', enter a name for the connection in the History box and click '**Add**'.

4.5 Password

If a successful connection to the ZephIR is established then the password box will be shown.



Login Window

The default password 'password' is entered automatically. If the unit has previously been accessed then the password will be updated automatically. Click '**Login**' to access the ZephIR.

Note: See Section 6 - Configuration for instructions on how to change the password.

5 STATUS

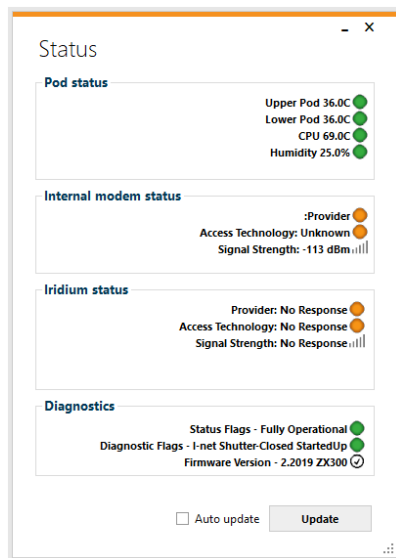
Several system functions are monitored within the ZephIR system, all of which can be reviewed within the application software. The system status should be checked whenever the ZephIR is powered on.



Status

Once a connection to the ZephIR has been established (See Section 4 - Connecting to a ZephIR), click on the '**Status**' button on the left hand side.

The status window will open:



Z300/ZTM Status Window

All the options should be either **green** or **amber**. If any are **amber** or **red** then hover over them to view more detailed information about the error. A ZephIR should not be left with **red** flags as it may not collect data correctly. If the errors are in the 'File System' box, please see the main ZephIR Operations Manual for troubleshooting.

Click on '**Update**' button to refresh the status flags.

Selecting '**Auto Update**' will provide a real time feed of the system status.

6 CONFIGURATION



Config

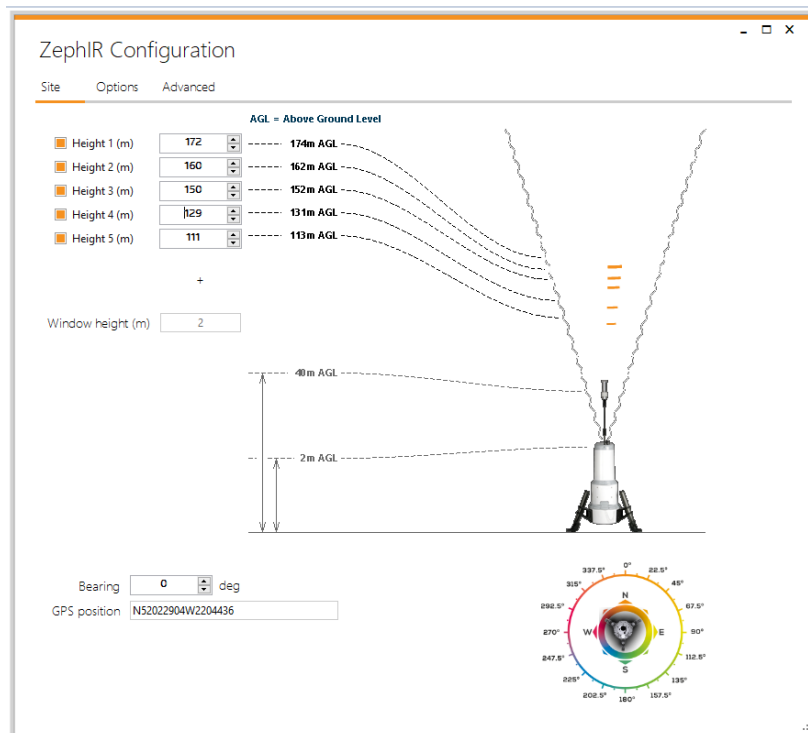
Once a connection to the ZephIR has been established, click on the 'Config' button on the left hand side.

6.1 Site Configuration

The ZephIR is capable of indexing through user-configurable height settings (1m steps) for the purpose of data acquisition. The minimum height available is 10m, whilst the maximum height available for data acquisition is 200m for a Z150/175 and 300m (validated up to 200m, see Section 6.1.2.1) for a Z300.

To configure the height settings required for a particular site, you must select The 'Site' tab on the ZephIR Configuration screen.

6.1.1 Z150/175 Site Configuration



Z150/175 Site Configuration Window

6.1.1.1 Heights

Enter the required heights for data collection into the appropriate locations. If fewer than five settings are required, de-select the check boxes next to the unwanted height boxes (the above figure shows 5 heights configured). The system will automatically re-order the heights for maximum efficiency when they are sent to the ZephIR.

6.1.1.2 Window Height

The '**Window height**' is provided as a reminder that the heights entered are relative to the window at the top of the unit. Since the Z150/175s are ~2m tall when deployed, if a measurement height of 150m is required, the height entered in the area above should be 148m. Z300 units are ~1m tall when deployed so if a measurement height of 80m is required, the height entered in the area above should be 79m.

6.1.1.3 GPS Position

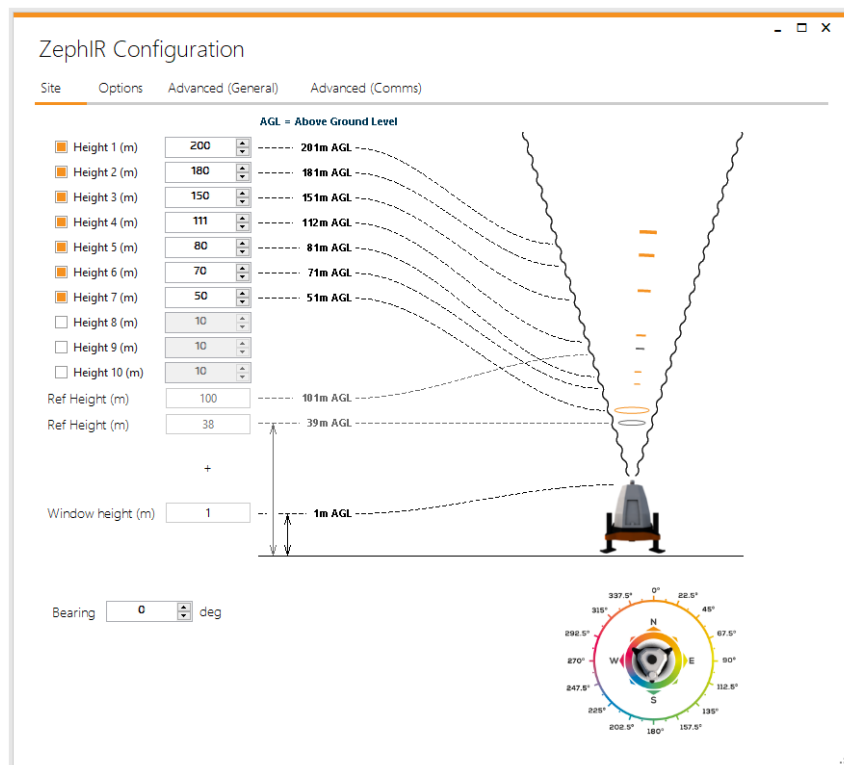
In the same configuration tab it is possible to set the location stamp '**GPS Position**' and bearing. The location stamp will be saved with each wind measurement and can be up to 17 characters in length. If a GPS input is available and the option to use it on the '**Advanced**' tab is ticked, this field will be overwritten with the value retrieved from the GPS sensor.

6.1.1.4 Bearing

The ZephIR '**Bearing (degrees)**' should be set to the orientation of the ZephIR with respect to North. If the ZephIR has been set up facing North then the bearing will be 0 or 360 degrees. If the ZephIR has been set up facing east then a bearing of 90 should be entered.

Note: The wind direction as measured by the ZephIR will be corrected by this bearing so it is important that this value accurately reflects the orientation of the ZephIR.

6.1.2 Z300 Site Configuration



ZX300 Site Configuration Window

6.1.2.1 Heights

Enter the required heights for data collection into the appropriate locations. If fewer than ten settings are required, de-select the check boxes next to the unwanted height boxes (the above figure shows 5 heights configured). The system will automatically re-order the heights for maximum efficiency when they are sent to the ZephIR.

IMPORTANT NOTE: Whilst it is possible to configure the heights up to 300m, Z300 units have only been validated up to 200m and therefore any measurements taken beyond this height have not been verified.

With ZX300 units, an additional 100m reference height will be included if no user defined height is made between 90m and 110m.

6.1.2.2 Window Height

The '**Window height**' is provided as a reminder that the heights entered are relative to the lens in the ZephIR (i.e. the window at the top of the unit). Since the Z300's are ~1m tall when deployed, if a measurement height of 150m is required, the height entered in the area above should be 149m.

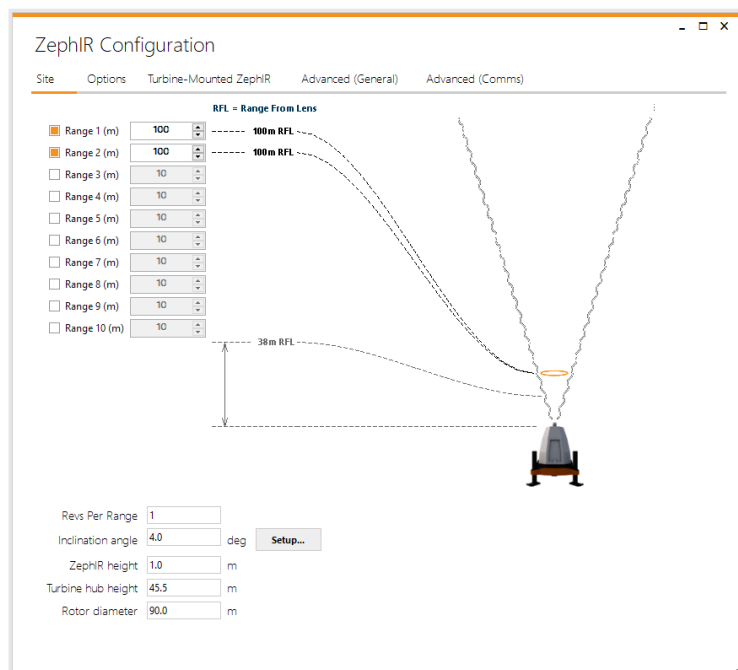
Note: For Z300 units (unlike Z150/175 units) it is possible to adjust the 'Lens Height' parameter. This tells the unit how high above the ground the ZephIR lens is. Typically it should be left at 1m, but may need to be adjusted if the unit is raised off the ground, for example in a trailer. This value is added to the heights set to create the 'Height Above Ground Level' entry in the data.

6.1.2.3 Bearing

The ZephIR '**Bearing (degrees)**' should be the orientation of the ZephIR with respect to North. If the ZephIR has been set up facing North then the bearing will be 0 or 360 degrees. If the ZephIR has been set up facing east then a bearing of 90 should be entered.

Note: The wind direction as measured by the ZephIR will be corrected by this bearing so it is important that this value accurately reflects the orientation of the ZephIR.

6.1.3 ZTM Site Configuration



ZTM Site Configuration Window

6.1.3.1 Ranges

Enter the required ranges for data collection into the appropriate locations. If fewer than ten settings are required, de-select the check boxes next to the unwanted range boxes (the above figure shows 2

ranges configured). The system will automatically re-order the ranges for maximum efficiency when they are sent to the ZephIR.

Note: When connected to a ZTM there is no 'Above Ground Level' indication as there is for ground-based ZephIR. Ranges are simply referenced to the lens position.

6.1.3.2 *Revs Per Range*

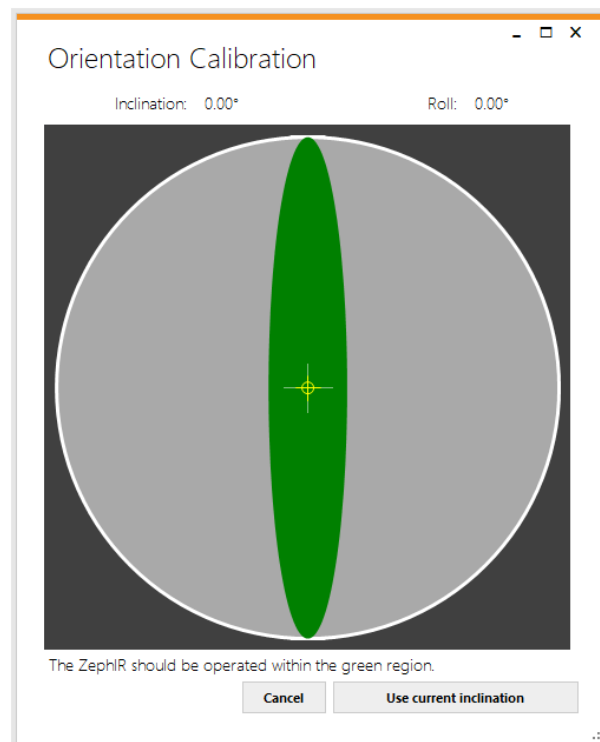
Indicates how many whole revolutions the ZephIR should spend continuously scanning (taking measurements) at each range. The minimum value is 1 revolution, each revolution takes 1 second and the number of revolutions can only be a whole number.

6.1.3.3 Inclination angle

Turbine mounted units should ideally be mounted perfectly horizontally. If this is not possible due to available mounting options, an inclination angle should be entered here to inform the ZephIR's algorithms that the unit is not level*. Positive values indicate that the unit is pointing above the horizon. Negative values indicate the unit is pointing down below the horizon.

Note: *This is only required for older ZTM units; For DM units equipped with motion sensors, the 'Setup..' button will provide a real time view and the sensors can enable real time feedback to the processing algorithms.

For DM units with motion sensors, click the '**Setup...**' button to view a live feed from the inclination and roll sensors to make levelling the ZephIR easier.



6.1.3.4 ZephIR Height

The height of the ZephIR above the ground (used for vertical wind shear calculations and determining which slice of the circular scan to use for pair-wise data outputs).

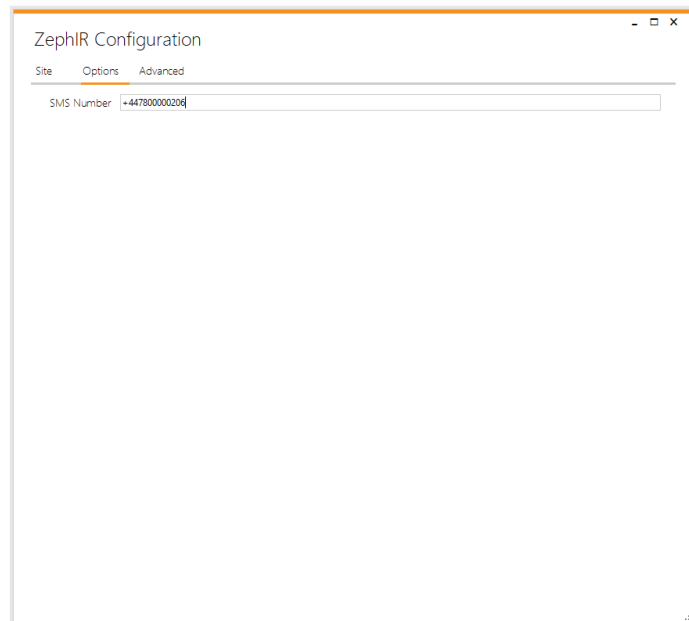
6.1.3.5 Turbine hub height

The height of the center of the turbine hub (used when determining which slice of the circular scan to use for pair-wise data outputs).

6.1.3.6 Rotor diameter

The rotor diameter of the turbine the ZephIR is mounted on should be entered here. This parameter is used to allow the ZephIR to make appropriate measurements for rotor equivalent wind speed quantities.

6.2 Options Z150/175



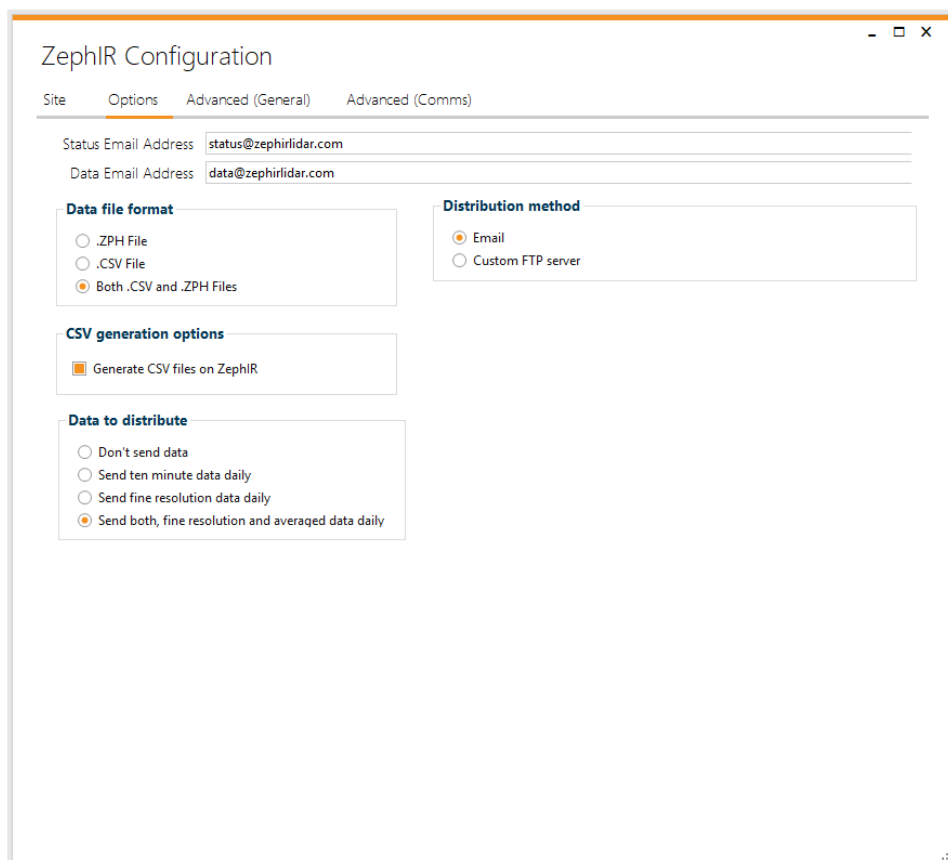
Z150/175 Configuration Window - Options

6.2.1 SMS Number

Z150/175 units can send SMS text messages if certain situations are detected. These include for example, external power failure resulting in imminent system shutdown or suspension of system operations. A complete list can be found at the end of the main ZephIR user manual.

The phone number should be entered in the 'SMS Number' box. If SMS text messages are not required, leave this box empty. It is recommended that SMS text messages are used wherever possible.

6.3 Options Z300



ZephIR Configuration

Site Options Advanced (General) Advanced (Comms)

Status Email Address

Data Email Address

Data file format

☐ .ZPH File

☐ .CSV File

☒ Both .CSV and .ZPH Files

Distribution method

☒ Email

☐ Custom FTP server

CSV generation options

☒ Generate CSV files on ZephIR

Data to distribute

☐ Don't send data

☐ Send ten minute data daily

☐ Send fine resolution data daily

☒ Send both, fine resolution and averaged data daily

Z300 Configuration Window - Options

6.3.1 Email Address, Status Email Address and Data Email Address

The ZephIR unit is able to transmit status and data files to chosen email addresses on a daily basis. Hence data is emailed at the end of each 24 hour period to the addresses listed here. ZephIR 300 units will email status messages if any there is a change in any operational conditions, such as external power failure, or the unit being switched on or off, or excessive temperatures detected etc. A complete list can be found at the end of the main ZephIR Operations Manual.

From Z300

Enter the email address to receive messages. Multiple recipients can be added by separating them with a comma.

Note: Z300 Firmware at v1.3215 and below have no limit on the number of email addresses but a character limit of 99 characters.

From firmware v1.3216 onwards, no more than 13 email addresses can be entered, but each may be up to 99 characters.

From firmware v2.2020 onwards, the set of email addresses for data and status have been separated, allowing data to be sent to a different set of email addresses than the email addresses

6.3.2 Data to distribute

ZephIR's produce wind measurements in two forms: unaveraged and 10-minute averaged. The '**Data to distribute**' settings control which form of data is sent from the ZephIR at midnight.

Note: From firmware v2.2020 onwards, the firmware supports sending both unaveraged and averaged data.

6.3.3 Data file format

ZephIR's are capable of producing Comma Separated Variable (.CSV) files on the unit as well as the standard ZephIR format (.ZPH) files. ZephIR recommends using .ZPH files for most applications as they are re-playable in the Waltz software and other processing tools on offer. Since all the ZephIR tools are windows only, if the ZephIR is to be integrated with a system running on another operating system, the CSV option can be used instead.

Note: From firmware v2.2020 onwards, the firmware supports sending both data formats.

6.3.4 CSV generation options

Tick this option to enable generation of .csv files on the unit itself. This allows users on non-windows operating systems to access the data in a convenient form for processing.

Note: This feature is only available in firmware 1.2 onwards

Note: You will have to connect to the ZephIR to download the .csv files as there is no option to email them automatically (doing so would not be a bandwidth-efficient way of transferring the data).

6.3.5 Distribution method

By default, the ZephIR will send its data via email. An additional option is to upload data via FTP (see Section 6.3.6 for specific configuration details). If using FTP connections and the ZephIR fails to complete an upload, it will resume the next time it attempts to send the data which enables required bandwidth reduction (particularly in locations where comms are less reliable).

Note: FTP distribution is only available from Z300 units running firmware v1.3 or later.

Note: If the modem profile is set to '**Iridium**' (see Section 6.7.3 - Modem Internet Connection) and the distribution method is set to 'Email', the ZephIR will upload it's data to an FTP server hosted by Wireless Innovation who will then email that data to whichever email address(es) are specified on the Iridium contract.

6.3.6 Custom FTP server details.

This section configures the specifics of uploading data via FTP.

- **Server address** – the domain name or IP address of the FTP server to upload to.
- **Port** – the port to connect to on the FTP server.
- **Username** – the username to supply to log into the FTP server.
- **Password** – the password to supply to log into the FTP server.

- **Remote path** – the path on the FTP server to upload files to.
- **Security** – whether to use standard or secure connections to the FTP server.

6.4 Options ZTM

The screenshot shows the 'ZephIR Configuration' window with the 'Options' tab selected. The 'Email Address' field is set to 'status@zephirlidar.com'. The 'Data to distribute' section has three radio buttons: 'Don't send data' (selected), 'Send ten minute data daily', and 'Send fine resolution data daily'. The 'Data Broadcasting' section has three checkboxes: 'Raw Data', 'Unaveraged Wind Data', and 'Averaged Wind Data'. The 'Data Filtering' section has a text box stating 'Data will be filtered out (marked as invalid) if:' followed by a series of conditions: '10m backscatter > 0.10' AND '10m to current range backscatter ratio > 5.00' OR 'Packets in average < 10' OR 'Normalised mean fit residual > 0.20'.

The data distribution and email settings are the same as the options detailed in section 6.3, with the exception of the CSV generation.

6.4.1 Data Broadcasting

Tick one or more of the options in this section to enable broadcasting of data via UDP on ports 10003-10005 to the local network. See the 'Z300 UDP Broadcast Interface.pdf' document for more information.

6.4.2 ZTM Data Filtering

The settings in this section will be stored in the .zph files created by the ZephIR and will also be applied to the data supplied via modbus. When data files are loaded into Waltz and output to CSV, the option to use the settings supplied here or override them will be presented. The three sections of the ZTM filtering deal with fog, poor wind speed estimation and packets in average respectively (See sections 6.4.2.1 to 6.4.2.3)

6.4.2.1 ZTM Fog Filtering

The fog filter uses aerosol backscatter levels to determine whether a measurement may have been contaminated by high scattering from fog. This could cause the ZephIR to measure the wind speed at

closer ranges than those specified in the range configuration. Even very dense fog is unlikely to affect measurements at ranges less than around 50 m, but fog may have an impact on readings at longer ranges.

There are two thresholds to enter here: “Min. 10m Backscatter” and “Min 10m to Xm Backscatter Ratio”, where Xm is the measurement range. The default settings of 0.1 and 5 have proved effective. One of the ZephIR ranges must be set to 10 m for the fog filter settings to be implemented.

6.4.2.2 ZTM Packets In Average Filtering

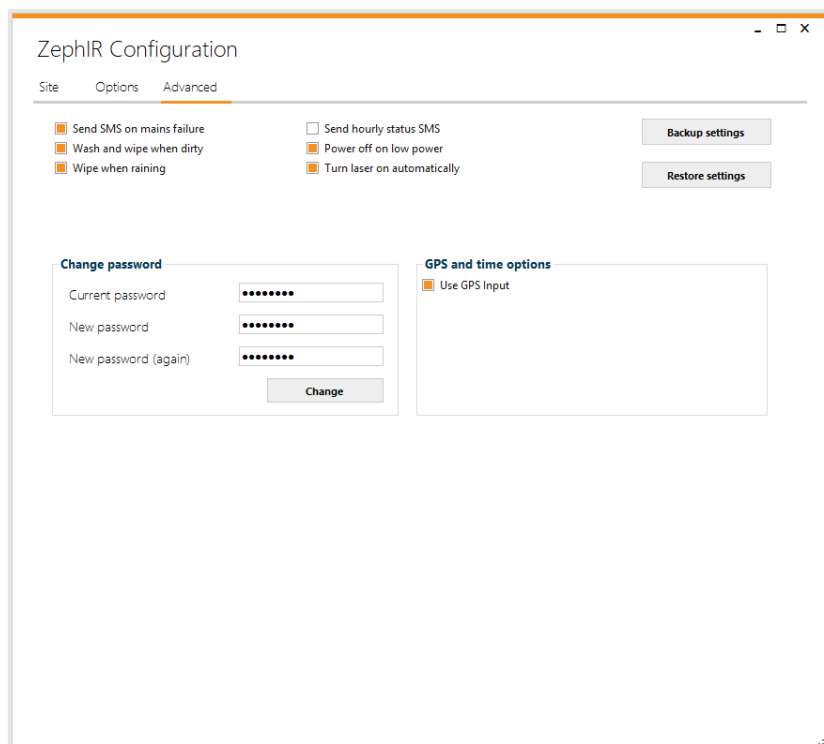
Packets in average (PIA) refers to the number of fit-derived high frequency measurements (typically 1 Hz) that have been used to produce the ZephIR ten-minute wind data. At periods of low data availability, generally caused by complex wind flows (poor-fit), low wind speeds etc., the PIA can become too low to produce reliable ten-minute statistics. In such cases these 10 minute periods are flagged as being unreliable. A default PIA value of 10 is recommended.

6.4.2.3 ZTM Poor Fit Filtering

As one part of the data processing chain, the ZephIR uses a least-squares-fit model to calculate the wind parameters from the measured LOS speeds. If the fit of the model to the actual data is poor, then it is likely that the model assumptions are not adequately fulfilled, the wind field is complex (e.g. including turbine wakes) and the measurement will suffer from higher uncertainty.

The poor fit filter setting enables these high uncertainty measurement to be removed from the tool's outputs. It is recommended that the default value of 0.2 is used for best results.

6.5 Advanced Options Z150/175



The screenshot shows the 'ZephIR Configuration' window with the 'Advanced' tab selected. The window contains several sections of settings:

- Site**: A tab at the top left.
- Options**: A tab at the top left.
- Advanced**: The active tab, showing various settings.
 - Send SMS on mains failure**: ☒
 - Wash and wipe when dirty**: ☒
 - Wipe when raining**: ☒
 - Send hourly status SMS**: ☐
 - Power off on low power**: ☒
 - Turn laser on automatically**: ☒
 - Backup settings**: A button.
 - Restore settings**: A button.
- Change password**: A section with three password input fields (Current password, New password, New password (again)) and a 'Change' button.
- GPS and time options**: A section with a 'Use GPS Input' checkbox, which is checked.

ZephIR 150/175 Configuration Window – Advanced Options

6.5.1 Send SMS on mains failure

When this option is ticked, the ZephIR will attempt to send an SMS to warn you when mains power to the unit fails.

6.5.2 Wipe When Raining

In the event of a problem with the wiper, it may be necessary to disable this to prevent damage to the ZephIR top window. To disable the wiper, uncheck the '**Wipe When Raining**' box.

Note: Disabling this function may result in reduced availability.

6.5.3 Wash and wipe when dirty

The ZephIR also has an automatic wash/wipe function. In order to fully disable the wiper, this must also be disabled. To do so, uncheck '**Wash and wipe when dirty**'. This should also be disabled if the washer fluid reservoir runs dry and it is impossible to fill it.

Note: Disabling this function may result in reduced availability.

6.5.4 Send Hourly SMS

Enables a heartbeat SMS to be sent every hour.

6.5.5 Power Off on low power

The Z150/175 units automatically power down if the batteries run low. The unit must then be turned back on by pressing the power switch. This can be disabled by un-checking '**Power off on low power**'. However, doing so can lead to permanent battery damage and data corruption.

In a Z150/175 unit where this option has been de-selected, the unit will automatically turn back on when power is restored.

6.5.6 Turn Laser On Automatically

By default, ZephIR units will turn the laser on and begin collecting data as soon as they power on. Un-tick this option to wait for a user to manually enable the laser.

6.5.7 GPS and Time Options

In order for the wind data recorded by the ZephIR to be accurately time stamped, the internal clock must be set. This can be done by clicking on the '**Sync Now**' button. This will set the ZephIR internal clock to the time and date of the PC on which Waltz is running.

Note: Z175 units have a GPS unit built in from which is used (by default) to sync the unit to UTC time. In order to manually set the time using the '**Sync Now**' function, the GPS time input must be disabled.

6.5.8 Change Password

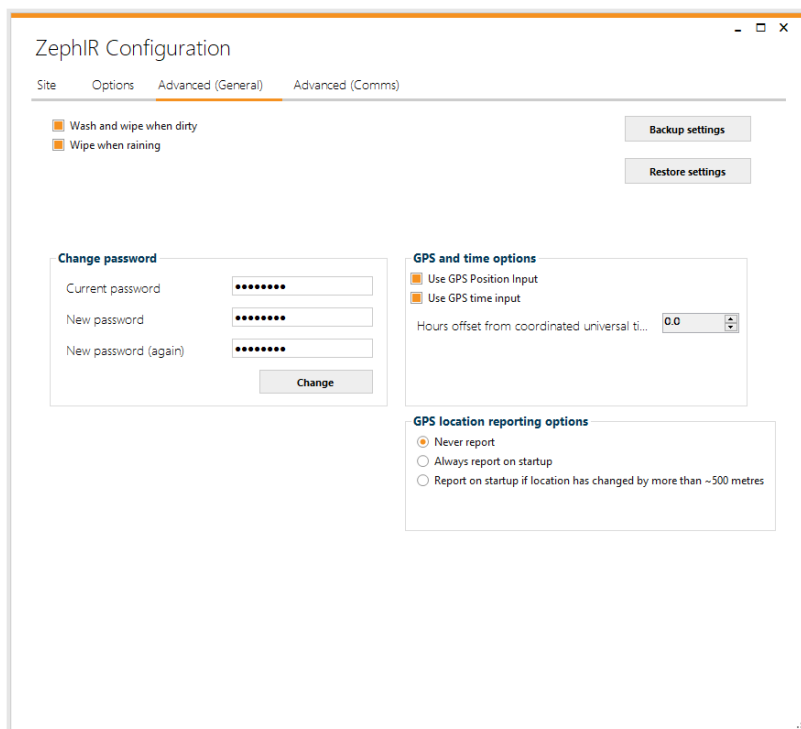
To change the password, enter the existing password and the new password twice then click '**Change**'. The new password will be required next time the ZephIR is accessed.

6.5.9 Backup / Restore Settings

It is possible to save the settings on a ZephIR for future reference. Click on the '**Backup Settings**' button to generate a configuration file. This will generate a '.txt' file which is human-readable as well as a file which can be used to restore a unit's configuration.

To restore previously backed up settings, simply click the '**Restore settings**' button and locate a previously saved .cfg file.

6.6 Advanced (General) Options Z300



ZephIR Z300 Configuration Window – Advanced Options

6.6.1 Wipe when raining

In the event of a problem with the wiper, it may be necessary to disable this to prevent damage to the ZephIR top window. To disable the wiper, uncheck the '**Wipe When Raining**' box.

Note: Disabling this function may result in reduced availability.

6.6.2 Wash and wipe when dirty

The ZephIR also has an automatic wash/wipe function. In order to fully disable the wiper, this must also be disabled. To do so, uncheck '**Wash and wipe when dirty**'. This should also be disabled if the washer fluid reservoir runs dry and it is impossible to fill it.

Note: Disabling this function may result in reduced availability.

6.6.3 Backup / Restore Settings

It is possible to save the settings on a ZephIR for future reference. Click on the '**Backup Settings**' button to generate a configuration file. This will generate a '.txt' file which is human readable as well as a file which can be used to restore a unit's configuration.

To restore previously backed up settings, simply click the '**Restore settings**' button and locate a previously saved .cfg file.

6.6.4 Change Password

To change the password, enter the existing password and the new password twice then click '**Change**'. The new password will be required next time the ZephIR is accessed.

Note: On Z300 units, the zipped data files stored on the unit will be also encrypted with this password. Since this is a 128-bit AES encryption, it is imperative that if a password is set that it is not lost as without it, any data zipped by the ZephIR will essentially be irretrievable.

6.6.5 Use GPS [position/time]

Z300 units are equipped with GPS sensors which allow the location and time to be automatically set using the GPS signal. Deselect these checkboxes to disable this behaviour and use manual settings.

If '**Use GPS time input**' is un-ticked, a '**Sync now**' button appears. Clicking this button will update the ZephIR using the time on the computer running Waltz.

Note: If the ZephIR is configured to ignore the GPS time input its clock may drift over time making comparisons against other devices inconclusive. In this case, the '**Update ZephIR time and date on login**' should be ticked in the settings and the unit should be connected to every hour.

6.6.6 Hours Offset From UTC

When using a GPS time input, this option allows you to enter a UTC time offset (if you require the timestamps in the wind data to correspond with a local time zone for example).

After changing the UTC time offset, the unit will reboot to ensure that all timestamps on the unit are correctly applied.

Note: This feature is only available on Z300 units running firmware version 1.2 onwards.

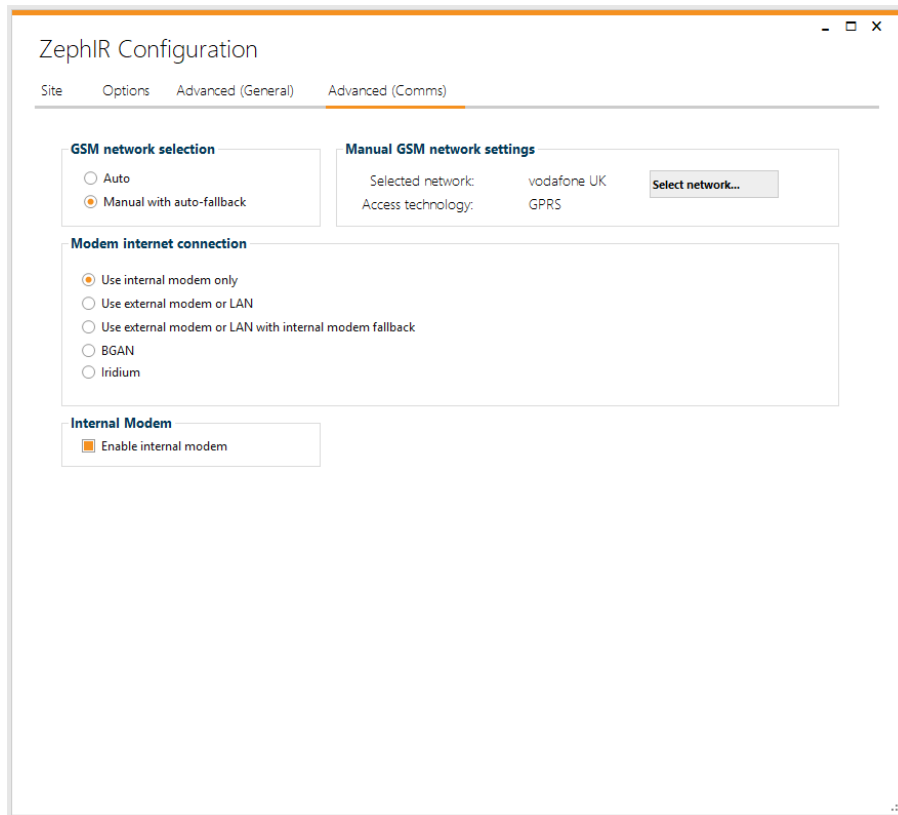
Note: The offset is only available when GPS time input is enabled. Without GPS time input enabled, you can synchronise the ZephIR's clock to the clock on their computer so there is no need for an offset.

6.6.7 GPS location reporting options

Selecting '**Always report on startup**' will enable the unit to send a GPS location email each time the unit starts up.

Selecting '**Report on startup if location has changed**' will cause the unit to send a GPS location email *only* if the location has changed since the last valid lock by more than 100m.

6.7 Advanced (Comms) Options Z300



Z300 Configuration Window – Advanced Options

6.7.1 GSM network selection

Z300 units with firmware v1.3 onwards allow control over the networks the internal modem will attempt to connect to.

Choose the **Auto** option to instruct the modem to use automatic network selection.

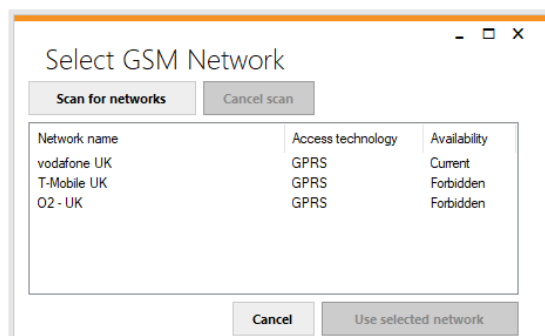
Choose the **Manual** option to instruct the modem to use a specific network (and fall back to auto if connection to that network fails). This option will reveal settings to allow selection of the required network (See 6.7.2 - Manual GSM network settings)

6.7.2 Manual GSM network settings

In manual GSM network mode, click '**Select network...**' to launch the network selection dialog:

GSM network selection

Click the '**Scan for networks**' button to identify what networks the internal modem detects. Click on the required network in the list and then click on '**Use selected network**'. Once the settings are applied to



the ZepHIR, the modem will try the selected network first (or resort to auto-mode if connection to that network fails).

6.7.3 Modem Internet Connection

A Z300, which is equipped with a go-anywhere SIM in its built in modem, external modem, BGAN or Iridium system, has the ability to connect to the internet for sending data and emails, and for login and configuration/monitoring of the unit. The connection dialog allows the modem behaviour to be altered.

Type of connection	Connection setting
<i>Use internal modem</i>	<i>This option should be selected if the user intends on using the internal modem for comms.</i>
<i>Use external modem or LAN</i>	<i>This option should be selected if the user intends on networking the unit by LAN or an external modem connected to the unit by the Ethernet connection.</i>
<i>Use external modem or LAN with internal modem fallback</i>	<i>This option should be selected if the user intends on networking the unit by LAN or an external modem connected to the unit by the Ethernet connection. However, wants to use the internal modem if the LAN/External modem connection fails.</i>
<i>BGAN</i>	The BGAN system would be connected like other external modems, via the Ethernet connection, This setting will only connect when sending data to reduce data costs.
<i>Iridium</i>	This setting will only connect over the Iridium system when sending data to reduce data costs.

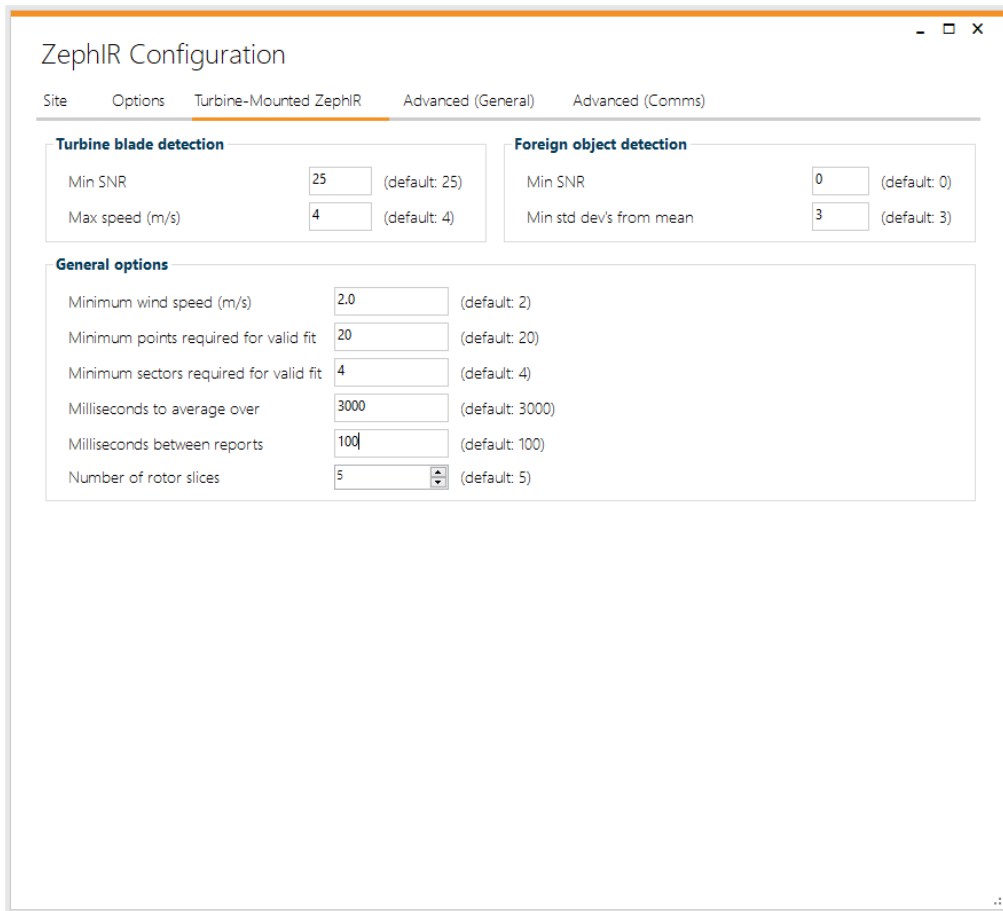
Users of other external modems should consult their airtime provider.

If a Go Anywhere SIM is set to any other option, the connection to the unit may be lost – requiring a site visit if no alternate method of communication is available.

6.7.4 Internal Modem

Z300 devices, with identifiers of 700 onwards, can be configured to disable the internal modem, so the unit won't attempt to communicate with the modem hardware.

6.8 Turbine-Mounted ZephIR Options



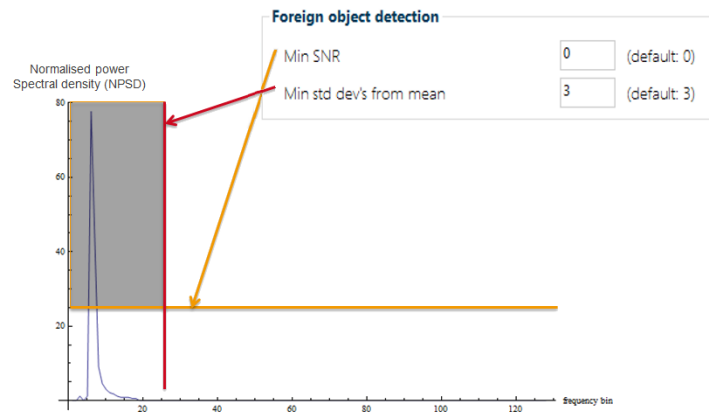
The screenshot shows the 'ZephIR Configuration' window with the 'Turbine-Mounted ZephIR' tab selected. The window has four tabs: 'Site', 'Options', 'Turbine-Mounted ZephIR', 'Advanced (General)', and 'Advanced (Comms)'. The 'Turbine-Mounted ZephIR' tab contains three sections of settings:

- Turbine blade detection:**
 - Min SNR: 25 (default: 25)
 - Max speed (m/s): 4 (default: 4)
- Foreign object detection:**
 - Min SNR: 0 (default: 0)
 - Min std dev's from mean: 3 (default: 3)
- General options:**
 - Minimum wind speed (m/s): 2.0 (default: 2)
 - Minimum points required for valid fit: 20 (default: 20)
 - Minimum sectors required for valid fit: 4 (default: 4)
 - Milliseconds to average over: 3000 (default: 3000)
 - Milliseconds between reports: 100 (default: 100)
 - Number of rotor slices: 5 (default: 5)

ZTM Configuration Window – Turbine-Mounted Options

6.8.1 Turbine Blade Detection

These options control how the ZephIR detects turbine blades that might be obscuring its view of the wind field. Any measurements which are detected as containing turbine blades will be filtered out to avoid biasing the ZephIR's wind measurement. In the example below all signals that fall within the shaded area will be considered as being due to the turbine blade.



Turbine Blade Detection Algorithm Illustration

6.8.1.1 Min SNR

Specifies the minimum signal-to-noise ratio (SNR) for a signal be identified as a turbine blade.

6.8.1.2 Max Speed

Specifies the maximum speed threshold up to which the signal will be identified as a turbine blade.

6.8.2 Foreign Object Detection

These options control how the ZephIR detects foreign objects (birds, trees, moving grassland etc.) that might be adversely influencing its view of the wind field. Any measurements which are detected as containing foreign objects will be filtered out to avoid biasing the ZephIR's wind measurement.

6.8.2.1 Min SNR

Specifies the minimum SNR for a signal to be identified as a foreign object.

6.8.2.2 Min Std Dev's From Mean

Specifies the minimum standard deviations a signal must be from the mean of all line of sight wind speeds in a measurement to be considered a foreign object.

6.8.3 General Options

These manage the more generic turbine-mounted ZephIR operations.

6.8.3.1 Minimum Wind Speed

Any points with a wind speed less than '**Minimum wind speed**' will not be used to calculate a wind speed measurement.

6.8.3.2 Minimum Points Required For Valid Fit

For the unit to output a valid wind speed it must have at least this many line of sight velocity measurements after the filters mentioned above are applied.

6.8.3.3 *Minimum Sectors Required For Valid Fit*

The ZephIR divides the 360 degree scan into four sectors. This setting controls how many of those sectors must contain at least one point before it will consider a measurement to be valid.

6.8.3.4 *Milliseconds to Average Over*

Indicates how much history to use to produce a fitted result. Bear in mind there is ~20ms per point so if 'Milliseconds to average' over was set to 1200, we'd expect to see roughly $1200/20=60$ points used to produce each wind measurement if no points are being filtered for turbine blades or foreign objects.

6.8.3.5 *Milliseconds Between Reports*

Indicates how frequently the unit should report the current wind speed. In the example above we're outputting the wind speed etc. once per second.

Note: Setting to values lower than 100ms are less reliable as it can start to exceed the processing limits of the ZephIR resulting in fewer points in fit and unreliable operation under certain conditions.

6.8.3.6 *Number of rotor slices*

Sets the number of slices to divide the rotor area into.

6.8.3.7 *Enable line of sight velocity motion compensation*

Enables line of sight velocity motion compensation to remove the effect of the nacelle fore-aft motion. Not normally required unless the ZephIR is being used in turbine control applications.

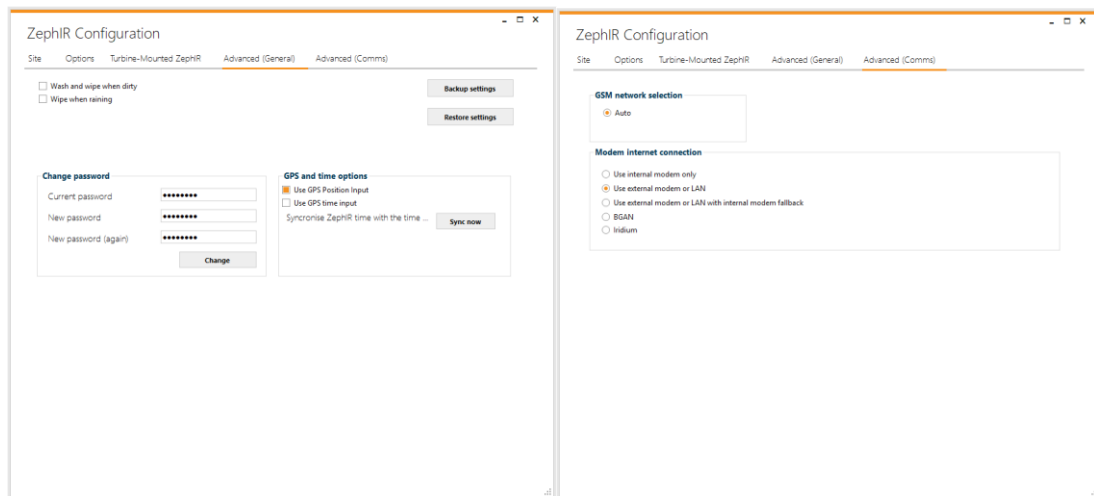
6.8.3.8 *Enable live inclination compensation*

Enables live inclination compensation to adjust the heights of the rotor equivalent height and rotor slice heights to counteract the changes in inclination in operation.

6.8.3.9 *Enable live roll compensation*

Enables live roll compensation for when the nacelle rolls in operation.

6.9 ZTM Advanced Options



ZTM Configuration Window – Advanced Options

The ZTM firmware allows exactly the same options as a ground based Z300 with v1.2 firmware (See Section 6.6 - Advanced (General) Options Z300 and Section 6.7 - Advanced (Comms) Options Z300) for advanced settings.

Note: The UTC time offset option isn't currently supported in the ZTM firmware.

6.10 Applying Settings

Once the ZephIR configuration has been changed, close the configuration window. You will then be prompted to send the updated configuration to the ZephIR. Clicking '**Yes**' will update the ZephIR, '**No**' will retain the existing configuration and '**Cancel**' will return to the configuration window. If '**Yes**' is selected, the new configuration will be sent to the ZephIR and saved to the internal storage.

7 ACTIONS



Actions

Several actions are available for remote triggering via the '**Actions**' button. Select one of the following options to instruction the ZepHIR to act on the option:

Wash And Wipe – Instructs the ZepHIR to spray water on its window and then wipe it clean.

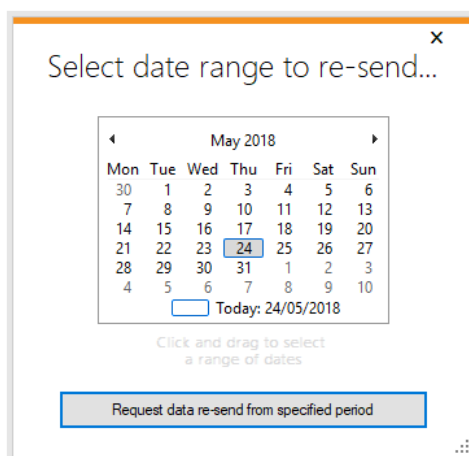
Send Test Message – Instructs the ZepHIR to attempt to send a test email to whichever email addresses are currently configured (see Section 6.3.1 - Email Address).

Enable Laser – Tells the ZepHIR to enable its laser. Under normal operations this isn't necessary as the ZepHIR will always enable its laser on startup but it can be useful if diagnostic work is required (on Z150/175 units for example after correcting a poorly seated cable).

Clear Wind Data – Tells the ZepHIR to clear all wind data from its internal storage.

Note: Clearing wind data should only be done once the data has been downloaded to a safe location, as this operation cannot be undone and there are no internal backups of the data once it's cleared.

Resend Data Files – Shows the re-send data dialog:



Re-queue data dialog.

Click on the dates to highlight one or more days then click '**Request data res-send from specified period**' to instruct the ZepHIR to re-send any data which was recorded from those period(s).

Enable Laser Alignment System – Enables the visible alignment laser on the front of ZDM ZepHIRs. Used when deploying a ZDM to help align the ZepHIR with the turbine axis.

Disable Laser Alignment System – Disables the visible alignment laser on the front of ZDM ZepHIRs.

8 DATA DOWNLOAD



Data

Whilst connected to a live ZephIR, click on the '**Data**' button on the left hand side to download data from the unit.

There are two types of data that can be downloaded:

- Wind [speed] data
- Ten minute averaged wind [speed] data

8.1 Z150/175

Download Data Window

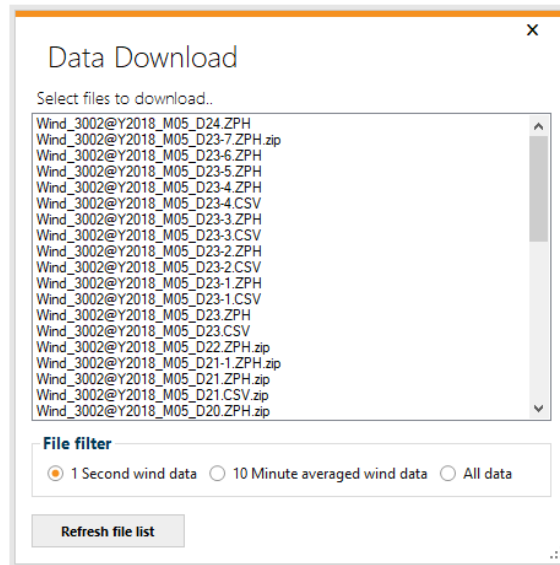
The option is given to only download data with a reference greater than a specified value. When a download is complete, you will be notified of the highest reference in the downloaded data. By specifying this as a starting point next time, only the more recent data will be downloaded.

When the data download window first opens, it will display the current (highest) reference on the ZephIR as well as the reference of the last data packet downloaded in the '**Data From Reference**' box. To automate downloads or download from multiple units, it is recommended that the Tempo scheduler download program be used instead.

Once the required data and any other options have been selected, click '**Download**'. You will be prompted for a location and filename to save the wind data to. Once this has been selected, download will begin. You will be notified once it is complete. Click '**Stop**' part way through the download will end the download prematurely but retain the data downloaded up to that point.

The '**Burst Mode**' option is designed for high latency links such as Iridium satellite modem connections and reduces the amount of handshaking that Waltz will perform. For standard links such as GPRS and Ethernet this mode is not required.

8.2 Z300/ZTM



Get Data Window

The Data Download dialogue allows download of the unaveraged and averaged wind data files. There are separate data files for each day of data recorded. Click the '**File filter**' options to filter the file list for specific types of data.

Averaged data will be prefixed with the filename *Wind10_n*, whereas high resolution wind data will be prefixed with *Wind_n*, where n is the unit ID.

Both types of file have a suffix with the data in the format Yyyy_Mmm_Ddd, where 'yyy', 'mm' and 'dd' is the year, month and day respectively in which the data was recorded.

At end of each day, the files are compressed to ZIP files and encrypted with the unit's password. If the ZephIR is using the default password then the .zip files will not be encrypted. To download files, simply select the desired files and click '**Download**'.

9 VIEWING DATA

Waltz has the ability to stream live data and play back saved data downloaded from the ZephIR. This data can be in the form of wind field parameters (unaveraged and averaged) or raw spectral measurements. The raw spectral measurements are unfiltered.

9.1 Live Data Streaming

To stream live data from a ZephIR, a connection must first be established (see Section 4 - Connecting to a ZephIR). Once connected, you'll be presented with the option to select the type of data to be streamed as shown below.



Stream Data Type Selection



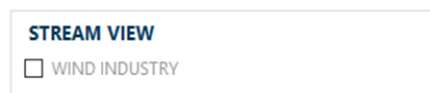
Select the requested data type either '**Wind Data**' or '**Raw Data**' then click on the play button to begin playing live data from the unit.



Click on the stop button to terminate the live data stream.

Note: Raw data streaming is only available if advanced options have been selected (see Section 3 - Setting up Waltz for the first time) and Waltz has subsequently been closed and re-opened. Due to the bandwidth required to stream live data, this should only be done over a local Ethernet or Wifi link and not a remote modem connection.

9.1.1 ZX300 Live Data Streaming



Stream View Selection

ZX300 units have unaveraged filtering, with different levels of filtering, included as a feature. This allows the user to select whether the stream view, either from live units or from a loaded ZPH file, displays the "Wind industry" level data or non "wind industry" level data.

9.2 Recorded Data Playback

In playback mode, a data file must be opened before playback can begin. The files must be stored somewhere that is accessible to the PC running Waltz. ZephIR data files have the extension '.ZPH' or '.WND'. Both types are supported by Waltz v4 onwards.

INPUT



Open

To open a file, click on the 'Open' button on the left or the play (triangular) button at the bottom right of the screen. This will open a standard windows dialogue box to allow you to select a data file.

Note: Multiple files of the same type can be opened at once in Waltz for playback and processing. Hold down the CTRL key and click on the additional files or the SHIFT key to select a range of files.

Alternatively, drag and drop one or more files on top of Waltz to open them.

Once a file has been opened, a unit number should be displayed in the 'System' box at the bottom right of the screen.

Set the playback speed to the desired value by dragging the slider at the bottom right of the screen.

For wind data the options are:

- 0.01x – one reading every 5 minutes
- 0.1x – one reading every 30 seconds.
- Real Time – one reading every 3 seconds.
- 10x – around three readings per second.
- 100x – around thirty readings per second.
- Fastest – playback as fast as the computer is capable, limited to 1000 readings per second.

For raw spectral data the options are:

- 0.01x – 5 readings every per second.
- 0.1x – around sixteen readings per second.
- Real Time – around fifty readings per second.
- 10x – around five hundred readings per second.
- 100x – playback as fast as the computer is capable, limited to 1000 readings per second.
- Fastest – the same as 100x above.

Note that, depending on the computer, playback speeds above Real Time are not guaranteed.



Click on the play button to begin playback.

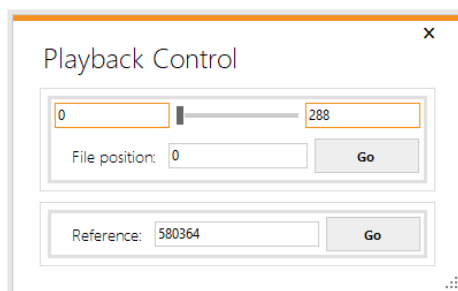


The pause (double lines) button will stop playback and allow it to continue from the same place by clicking play. Alternatively, clicking pause while playback is stopped will single-step through the data, one reading at a time.



The stop (square) button will stop playback and reset the reference to zero so that playback will next resume from the start of the file.

Playback is indexed by reference number or file position. To start at a particular reference, stop playback and click on the '**reference**' hyperlink. This will display a text box where the desired reference or file position can be entered:



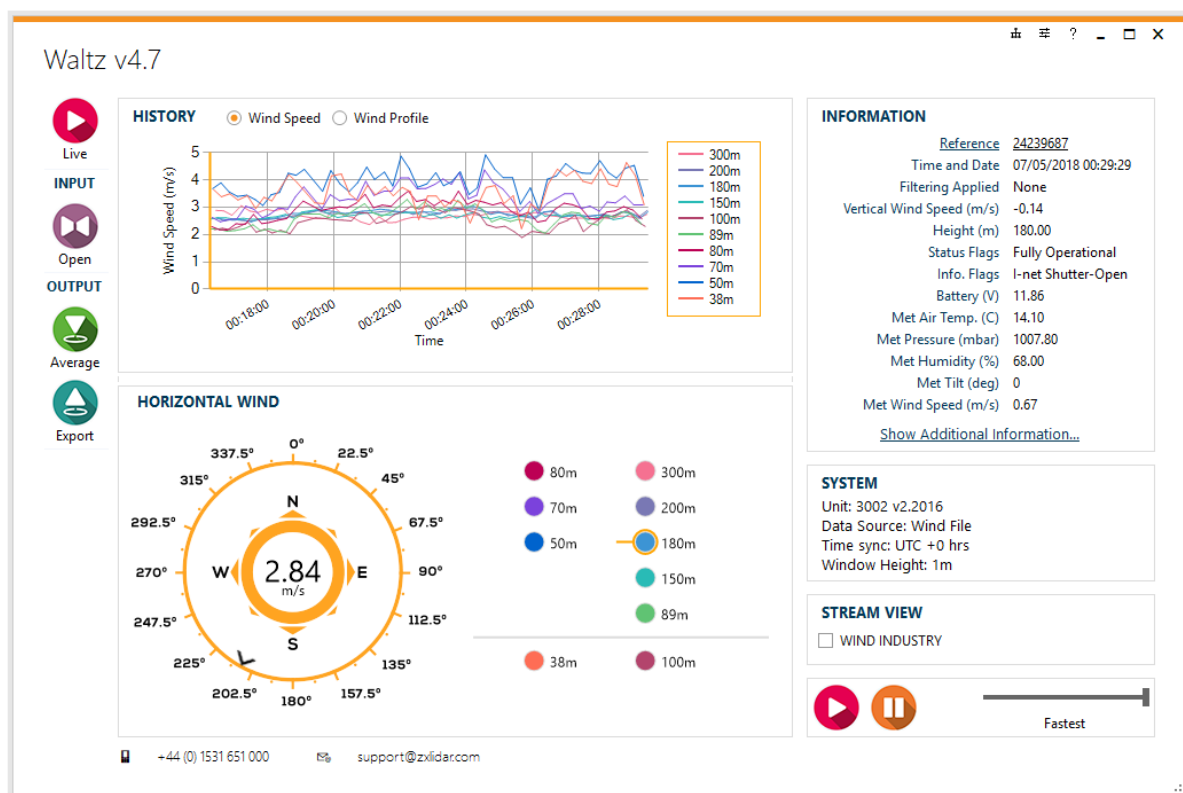
Playback control

Select a file position with the slider or enter a file position or reference number and then click on the appropriate 'Go' button to jump to that record. If searching for a specific reference, playback will resume at the first entry with a reference equal to or greater than the value specified.

Searching to a specific reference, opening new files or significant jumps in time will reset both the wind history and shear profile charts to give the clearest possible picture of the data.

9.3 Viewing Wind Data

The data is displayed in numerical form in the 'Information' box on the right and graphically in the left 'History' and 'Horizontal Wind' sections.

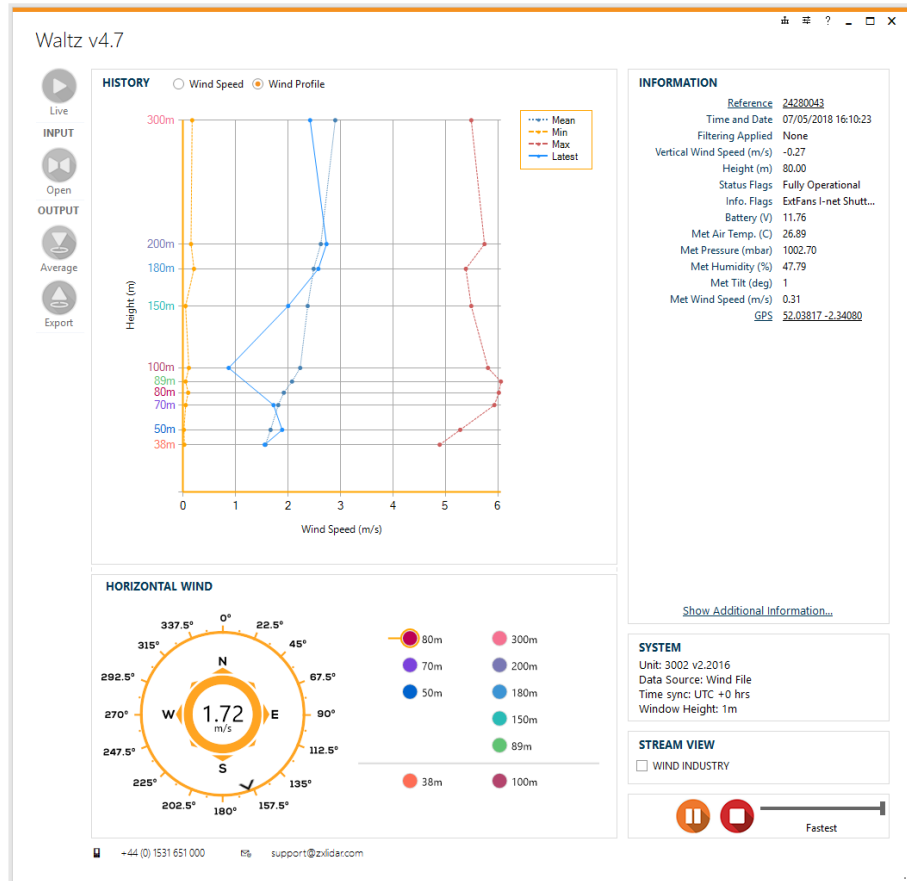


Time Series Window

Note: ZTM wind data drawn in the 'History' view uses the fit-derived algorithm (see the training materials for more information on wind reconstruction algorithms).

The '**Horizontal Wind**' section displays the horizontal wind speed in the centre of the compass. The dot around the outside shows the wind direction. All the measurement heights are shown in the coloured list on the right hand side. The current measurement height is shown by the orange circle outline.

The '**History**' section contains either a time series of the wind speeds at each height or a shear profile (wind profile). They are drawn in the colour shown in the '**Horizontal Wind**' section.



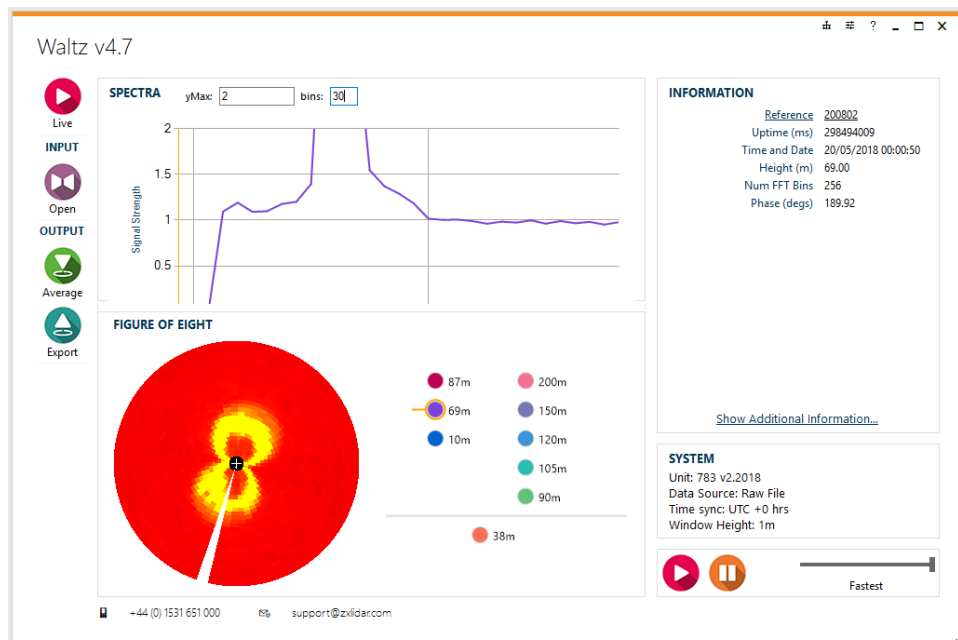
Shear Profile Window

The min, max and mean values in the shear profile plot are calculated from all values played back so far.

The '**Information**' section shows detailed information from the other sensors within the ZephIR, GPS location etc.

9.4 Viewing Raw Spectral Data

Raw spectral data is primarily displayed as a spectrograph (Power Spectral Density (PSD) against bin number) for a particular phase angle in the scan as shown below in the top-left '**Spectra**' box.



Raw Spectral Data Display

All the spectra in a whole scan can be viewed in the '**Figure of Eight**' plot which is effectively a spectrogram in the form of a polar plot. This shows the SNR value as a colour coded value (yellow is higher SNR in the screenshot above) for each bin (along the radius of the plot) and for a phase angle around the scan. The plot will be cleared when the ZepHIR moves to the next measurement height.

The scales of the spectrograph and colour code of the '**Figure of Eight**' plot can be adjusted using the '**yMax**' and '**bins**' fields. The '**yMax**' value specifies the maximum SNR that can be plotted and similarly the '**bins**' value specifies the maximum number of bins (from bin 0) to be displayed. Adjusting these two fields allows you to effectively zoom in or out of the plots. Setting '**yMax**' to '0' (default setting) means that each spectrum will be auto-scaled to its peak value. Note that this will produce a non-uniform colour coding across the spectra in the '**Figure of Eight**' plot as each segment will have its own scale. Manually setting '**yMax**' to a non-zero value will apply a consistent colour scaling to all the spectra (as shown in the screenshot above) which may improve data visualisation.

Associated data to the individual spectrum is also shown numerically in the '**Information**' box to the right of the screen.

10 WIND DATA PROCESSING

Waltz can be used to process wind data files.

10.1 Export to CSV



ZephIR wind files (.WND or .ZPH) files can be converted to CSV format to enable analysis in other programs, such as Excel or Windographer. To achieve this, open a data file in Waltz (See section 37 - Recorded Data Playback) and click on the **'Export'** button. A prompt will appear for the CSV filename.

10.1.1 General Overview

Waltz will then prompt to either export all references from the file or a specific range:

Export to CSV Dialog Window

Waltz will then generate a .csv file. Please see the ZephIR_CSV_Files document for more information on output format.

Note: If part way through the file, the height configuration was changed (See section 6.1 - Site Configuration), Waltz will detect this and automatically start a new file. If the original filename was called 'MyZephIRData.csv', an additional file will appear in the same folder with a name of 'MyZephIRData-1.csv' containing the data from when the heights were changed. If there were multiple height changes then several corresponding files will be generated ending in '-2.csv', '-3.csv' etc.

10.1.2 ZX300 specific options

ZX300 units have unaveraged filtering, with different levels of filtering, included as a feature. This allows the user to select whether the –unaveraged wind data recorded conforms to either the “Wind industry” level data or non “wind industry” level data.

The output CSV file will indicate which level of filtering was applied in the CSV file header, with either Wind-industry filtering: Disabled” or “Wind-industry filtering: Enabled”.

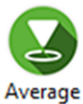
10.1.3 ZTM-specific options

Export to CSV (for averaged ZTM data) Dialog Window

For data generated with ZTM firmware v1.1172 onwards, there are options to quality filter the averaged wind data under certain conditions. By default, Waltz will use the settings that were configured on the ZephIR itself.

Tick the 'Override settings from input file(s)' option to override the filter thresholds applied to the data.

10.2 Averaging




Waltz contains the same averaging routines as the ZephIR. This means that high resolution wind data downloaded from the ZephIR, or copied directly from the compact flash card (Z150/175 only) can be converted into ten minute data files quickly and easily. To perform this, open a high resolution data file in Waltz. Click on the '**Average**' button. A prompt will appear for the averaged ZPH filename.

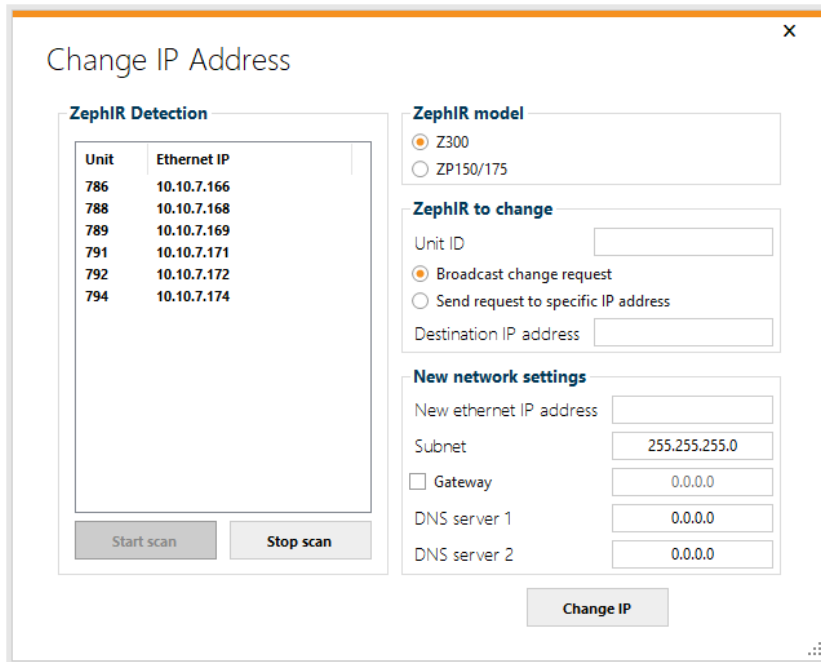
10.2.1 ZX300 specific options

ZX300 units have unaveraged filtering, with different levels of filtering, included as a feature. This allows the user to select whether the data, included in the average, conforms to either the "Wind industry" level data or non "wind industry" level data.

11 CHANGE IP ADDRESS

To change the IP address of a ZephiR, the computer running Waltz needs to be connected to a network on which the ZephiR is also connected.

Select the 'Change Unit IP' icon  from the top right hand corner of the main Waltz window.



Unit	Ethernet IP
786	10.10.7.166
788	10.10.7.168
789	10.10.7.169
791	10.10.7.171
792	10.10.7.172
794	10.10.7.174

Change IP Address Window

Z150/175 users should make use of the included Lantronix Device Installer. Instructions can be found in the main manual.

Z300 users can change the unit's IP address in Waltz.

The latest Z300 firmware supports auto-detection of ZephiRs on the local network. Clicking on a unit will fill in its current details in the right hand panel.

11.1 ZephiR detection

If the unit whose IP address needs changing is connected to the computer running Waltz and the network settings are set correctly on that computer then the ZephiR should appear in the list on the left. Clicking on an item in that list will populate the rest of the settings with the ZephiR's current network configuration.

Note: Auto-detection of ZephiRs is only supported Z300 units running firmware v1.3 onwards.

11.2 ZephiR to change

To change a Z300 unit's IP address, Waltz must either send a message directly to the ZephiR or broadcast it network-wide.

Whichever method is chosen, the '**Unit ID**' must match the unit that you're attempting to connect to. A ZephIR will only respond to IP change requests which are addressed to it.

Broadcast change request - If Waltz is running on a computer directly connected to a ZephIR or with only simple networking hardware then broadcasting is the simplest option to change a ZephIR's IP address. Selecting this option will broadcast the change request as a UDP message on port 10002

Send request to specific IP address – If the ZephIR is running on a remote connection or there is more sophisticated networking hardware between Waltz and the ZephIR, IP change request broadcasts will be blocked. Selecting the direct option will send the IP change request direct to the specified IP address.

The new IP address information should be set in 'New Network Settings'. Note that if a Gateway/DNS server is not provided then the ZephIR may resort to the configured modem device for sending emails and daily data.

Note: If a gateway is specified in these settings, the ZephIR will always try and use this route as long as an ethernet cable is connected (i.e. it will no-longer use its internal modem or iridium connection to attempt to send data so enabling the gateway will effectively disable other means of communication).

12 HELP AND SUPPORT

The Waltz software has been developed to make working with your ZephIR as simple as possible but if you have additional questions which this document doesn't address, don't hesitate to get in contact with ZephIR:

CONTACT	ZephIR Support Desk
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TEL.	+44 1531 650 757
EMAIL	zephirhelpdesk@zephirlidar.com



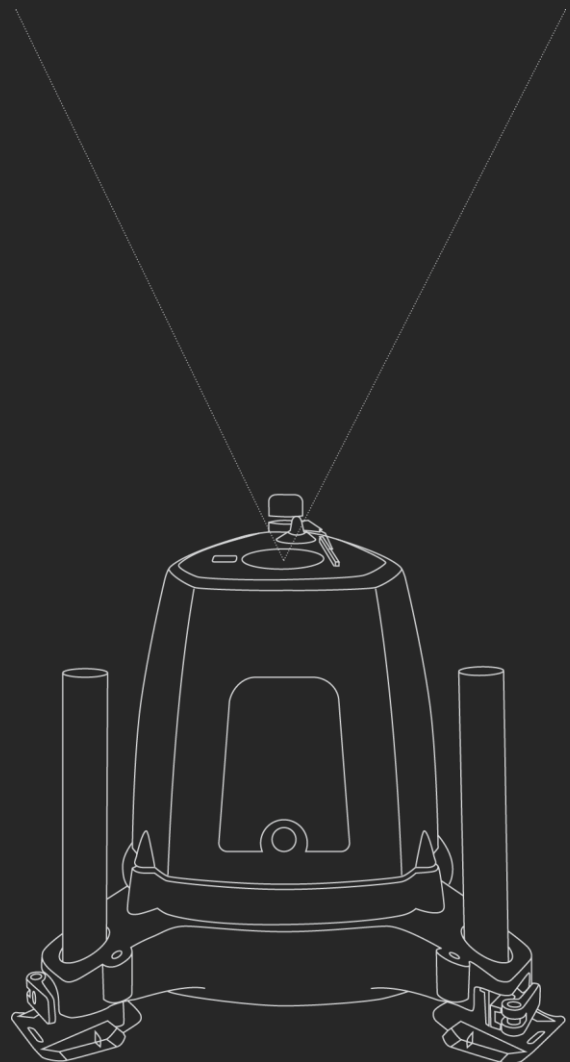
ZEPHIR CSV FILES

A USER'S GUIDE

5th July 2018

Version 2.6

Commercial In Confidence



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1 GENERAL CSV FORMAT NOTES

The ZephIR-branded PC software, Waltz, Tempo and Zph2Csv can convert ZPH files (bespoke ZephIR file system) to CSV files (comma separated files).

CSV files tabulate records in plain-text form, where each column entry is separated by a comma and each row is separated by a carriage return. There are no spaces after the separating commas. Many different programs should be able to read the CSV files, including Microsoft Excel and Windographer.

2 GROUND-BASED ZEPHIR

2.1 CSV Format Overview

The ZephIR software, Waltz and Zph2Csv, extracts data from the ZephIR-generated ZPH file and populates a human-readable CSV file.

Measurement-height-independent fields (e.g. 'Time and Date' and 'GPS') are listed first, each in their own column. These are then followed by the measurement-height-dependent fields (e.g. 'Horizontal Wind Speed' and 'Wind Direction') which will appear in height-descending order.

The final 'checksum' column is for internal diagnostic use.

If the measurement heights have been changed mid-file, Waltz/Tempo will generate a new CSV file (named 'filename-1.ZPH.csv' for example), containing the new height settings.

2.2 Header Description

The first line of the CSV file contains general information about the generated file. Some of these fields contain self-explanatory informative text while others contain data that is specific to the generated CSV file. These file-specific fields are described below:

- **CSV Converter** – The CSV Converter library version that generated the file.
- **Filter** – The version of the filter library that is incorporated into the CSV converter library.
- **Averager** - The version of the averaging library that was used (for averaged data only).
- **File system version** – The ZephIR file system version of the source file.
- **Unit** – The unit number of the ZephIR that made the measurements.
- **Time Zone** – The number of hours offset from UTC of the timestamps (Z300 firmware v1.2 onwards).
- **Notice** – "Time stamp indicate beginning of the averaging period".
- **Notice** – "38m is a fixed reference measurement".
- **Notice** – "100m is a fixed reference measurement", if the unit is a ZX300.
- **Notice** – "The GPS field contains latitude and longitude coordinates in decimal degrees (positive sign indicates North or East)"
- **Window height above ground** – The window height above ground.
- **Wind-industry filtering** – A flag indicating which set of filtering is being used when outputted to CSV.
- **Measurement heights** – The list of measurement heights in descending height order.

2.3 Column Header Descriptions

The exact list of fields found in the file is ZephIR model dependent. Fields found only in Z150s and Z175s are listed in BLUE. Fields found only in Z300s and ZX300s are listed in ORANGE. ZX300 specific is listed in teal. Fields common to all units are un-shaded.

Note that the measurement-height-dependent field column headings are appended with 'at H_m ', where ' H ' is the measurement height, to show the measurement height that the field relates to.

Header	Units	Description	
		Un-Averaged Data	10-min Averaged Data
Reference	-	Each un-averaged (1sec or 3sec) record has an associated reference. The reference starts at zero and increments with each record. If the ZephIR's internal storage is cleared, the reference resets to zero.	Reference of the last sample included in 10-min average.
Time and Date	-	Time and date in text format to nearest second. (Excel will reformat this as a real time and date).	Time and date of the first sample in 10-min average, but aligned with the averaging boundary. For example, a 10-min averaged record would start at 01:10:00 (hh:mm:ss) even if the first packet in the set came from 01:10:03.
Timestamp (s)	Seconds (s)	The time and date of the reading as a numerical value in seconds ¹ .	Timestamp of the first sample in 10-min average.
Info. Flags	-	General information relating to the operational mode of the ZephIR.	Combined list of all flags that were present during the 10-min averaging period.
Status Flags	-	Internal ZephIR status, relating to the operational state of the ZephIR. For Z150/175: Red/Amber/Green.	Combined list of all flags that were present during the 10-min averaging period..
Battery (V)	Volts (V)	Internal battery voltage.	Mean.

Header		Units	Description	
			Un-Averaged Data	10-min Averaged Data
Generator (V)		Volts (V)	External supply voltage, if present.	Value from first sample.
Upper Temp. (C)		Degrees Celsius (C)	Internal pod temperature as measured by internal sensor located near the window.	Mean.
Lower Temp. (C)		Degrees Celsius (C)	Internal pod temperature as measured by internal sensor located near the external heat sink.	Mean.
Optics Temp. (C)		Degrees Celsius (C)	Internal ZephIR optics pod temperature.	Value from first sample.
Electronics Temp. (C)		Degrees Celsius (C)	Internal ZephIR electronics pod temperature.	Value from first sample.
Battery Temp. (C)		Degrees Celsius (C)	Internal ZephIR battery pod temperature.	Value from first sample.
Pod Humidity (%)		Percent (%)	Internal ZephIR relative humidity.	Value from first sample.
Mutually exclusive	GPS	Decimal Degrees	GPS location (latitude and longitude) as measured by the Met station. North and East are positive.	Value from first sample.
	GPS data	Degrees, Decimal Minutes	GPS location data as measured by the Met station (or as set in the configuration).	Value from first sample.
Met Compass Bearing (deg)		Degrees	Bearing of the physical ZephIR with respect to True North, measured by the Met station. I.e. 5 degrees would be 5 degrees East of True North.	Unit-vector average.

Header		Units	Description	
			Un-Averaged Data	10-min Averaged Data
Met Tilt (deg)		Degrees	Maximum magnitude of pitch or roll away from horizontal as measured by the Met station.	Maximum.
Met Air Temp. (C)		Degrees Celsius (C)	Ambient temperature measured by the Met station.	Mean.
Met Pressure (mbar)		Millibar (mbar)	Ambient pressure measured by the Met station.	Maximum.
Met Humidity (%)		%	Ambient relative humidity measured by the Met station.	Value from first sample.
Met Wind Speed (m/s)		Metres per second (m/s)	Horizontal wind speed as measured by the Met station.	Mean.
Met Wind Direction (deg)		Degrees	Wind direction bearing as read by the Met station, relative to the ZephIR.	Unit-vector average.
Mutually exclusive	Raining	-	Flag indicating if the rain sensor detected rain (0 – Off, 1 – On).	N/A
	Rain Sensor	-	Flag indicating if the rain sensor detected rain (0 – Off, 1 – On).	N/A
	Proportion Of Packets With Rain (%)	Percentage (%)	N/A	Proportion of wind data samples which were collected while rainfall was detected.
Mutually exclusive	Fog	-	Flag indicating if fog has been detected (0 – Off, 1 – On).	N/A
	Proportion Of Packets with Fog (%)	Percentage (%)	N/A	Proportion of wind data samples which were collected while fog was detected.

Header	Units	Description	
		Un-Averaged Data	10-min Averaged Data
Packets in Average at Hm	-	N/A	Number of samples included in the 10-min average.
Wind Direction (deg) at Hm	Degrees	Wind direction as measured by the ZephIR at the given height.	Wind vector average.
Horizontal Wind Speed (m/s) at Hm	Metres per second (m/s)	Horizontal wind speed as measured by the ZephIR at the given height.	Mean.
Vertical Wind Speed (m/s) at Hm	Metres per second (m/s)	Vertical wind speed as measured by the ZephIR at the given height. By convention, a positive wind speed corresponds to an upward wind.	Mean.
Horizontal Std.Dev. (m/s) at Hm	Metres per second (m/s)	N/A	Standard deviation of un-averaged horizontal wind speeds included in 10-min average.
Horizontal Variance (m/s) ² at Hm	(Metres per second) ² (m/s) ²	N/A	Variance of un-averaged horizontal wind speeds included in the 10-min average.
Horizontal Min (m/s) at Hm	Metres per second (m/s)	N/A	Minimum horizontal wind speed measured by the ZephIR in the ten minute average.
Horizontal Max (m/s) at Hm	Metres per second (m/s)	N/A	Maximum horizontal wind speed measured by the ZephIR included the ten minute average.
TI at Hm	Dimensionless	N/A	Turbulence Intensity, defined: $TI = \left(\frac{\sigma_u}{\bar{u}}\right) / C$ where σ_u is the sample standard deviation and \bar{u} is the mean of the horizontal wind speed for a 10-min period. ²

¹ This is roughly the time, in seconds since 00:00:00 1/1/00. The exact formula is:

$$\text{time} = (((((((((\text{year} * 12) + \text{month}) * 31) + \text{day}) * 24) + \text{hours}) * 60) + \text{minutes}) * 60) + \text{seconds}$$
 Note that the year should be the two digit form, e.g. 05 for 2005.

². C is a correction factor needed to convert the scan-averaged lidar measurement to the point-measurements of a cup anemometer.

Wind Data Quality Processing

Wind measurements obtained with ANY method of anemometry (including lidar, sodar, and cups) are prone to increased levels of uncertainty in certain conditions. ZephIR's internal processing within the system's firmware and operator software identifies such conditions and rejects the corresponding 10-minute wind measurements from the output data file, marking them with relevant Quality Codes. The resulting processed ZephIR 10-minute wind data can therefore be used with high confidence and does not require any additional post-processing or filtering.

Two types of Quality Codes are used in the output file:

9999 – High quality wind speed measurement is not possible. This is often caused by very low wind speed, or due to partial obscuration of the ZephIR window, or significant interference with the laser beam at the specified height.

9998 – The ZephIR automatically detects atmospheric conditions which adversely affect lidar wind-speed measurements. For example, in thick fog the beam from a lidar device may not be able to reach the measurement height. Also when affected by significant precipitation, the ZephIR will reject the vertical component of the wind speed (the horizontal component is unaffected by precipitation).

NOTE: ZP300/Z300M un-averaged data is not fully quality controlled, whereas ZX300 unaveraged data is. Contact the ZephIR office if your project requires the use of un-averaged data.

2.3.1 “Wind industry” Filters

ZX300 units use filtering at the unaveraged wind data level. If the “Wind industry” filtering option is enabled, the filtering criteria will be set to filters that have undergone DNV-GL classification.

2.3.1.1. Enable “Wind-industry” or “Non Wind-industry” flag in output data

With this option enabled, an additional column will also appear at the end of the wind fields as “Data Meets Conventional ZephIR Standards at Hm”. Where this field reads TRUE, the wind data meets conventional ZephIR standards. Where this field reads FALSE, the wind data would normally be filtered out by standard ZephIR filters. With this disabled, the default output will be with wind-industry filters.

3 TURBINE-MOUNTED ZEPHIR

3.1 CSV Format Overview

The general CSV format for a turbine-mounted ZephIR is much the same as for ground-based ZephIRs. The fields found in turbine-mounted ZephIR data are described below.

Due to the potential for extended dwell period, unaveraged turbine-mounted ZephIR data appears as a single line per wind measurement.

Averaged data uses the same format as for ground-based ZephIRs; Measurement-range-independent fields are listed first, each in their own column. These are then followed by the measurement-range-dependent fields which will appear in range-descending order.

The final 'checksum' column is for internal diagnostic use.

3.2 Header Description

The first line of the CSV file contains general information about the generated file. Some of these fields contain self-explanatory informative text while others contain data that is specific to the generated CSV file. These file-specific fields are described below:

- **CSV Converter** – The CSV Converter library version that generated the file.
- **Filter** – The version of the filter library that is incorporated into the CSV converter library.
- **Averager** - The version of the averaging library that was used (for averaged data only).
- **File system version** – The ZephIR file system version of the source file.
- **Unit** – The unit number of the ZephIR that made the measurements.
- **Time Sync** – The time synchronisation used for the measurements.
- **ZephIR Inclination (from config)** – The inclination of the ZephIR's optical axis above the horizontal as setup in the ZephIR's config.
- **ZephIR height equivalent**– The height of the ZephIR unit above the ground as setup in the ZephIR's config (used to calculate wind shear).
- **Turbine hub height**– The height of the turbine the ZephIR is running on (used to calculate hub-height wind speeds).
- **LOS velocity motion compensation** – Indicates whether horizontal wind speeds are compensated for lidar motion.
- **Live inclination compensation** – Indicates whether motion sensor inclination input is used to correct the wind velocity measurements. While enabled, the ZephIR's config inclination setting is over-ridden.
- **Live roll compensation** – Indicates whether motion sensor roll input is used to correct the wind velocity measurements.
- **Rotor Diameter** - The diameter of the turbine rotor that was set in the ZephIR's configuration when the measurements were taken.
- **Rotor Slices** - The number of conceptual rotor slices that was set in the ZephIR's configuration.
- **Measurement ranges** – The list of measurement ranges in descending range order.

3.3 Column Header Descriptions

Note that the range-height-dependent field column headings are appended with 'at R_m ', where ' R ' is the measurement range, to show the measurement range that the field relates to.

The fields related to the rotor segments are appended with 'at Rotor Segment Height H_m at R_m ', where ' H ' is the height of the rotor slice segment above ground level and ' R ' is the measurement range, to show the measurement height and range that the field relates to.

Header		Units	Description	
			Un-Averaged Data	10-min Averaged Data
Reference		-	Each un-averaged record has an associated reference. The reference starts at zero and increments with each record. If the ZephIR's internal storage is cleared, the reference resets to zero.	Reference of the last sample included in 10-min average.
Time and Date		-	Time and date in text format to nearest second. (Excel will reformat this as a real time and date).	Time and date of the first sample in 10-min average, but aligned with the averaging boundary. For example, a 10-min averaged record would start at 01:10:00 (hh:mm:ss) even if the first packet in the set came from 01:10:03.
Timestamp (s)		Seconds (s)	The time and date of the reading as a numerical value in seconds ¹ .	Timestamp of the first sample in 10-min average.
Status Flags		-	Internal ZephIR status, relating to the operational state of the ZephIR.	Combined list of all flags that were present during the 10-min averaging period.
Mutually exclusive	GPS	Decimal Degrees	GPS location (latitude and longitude) as measured by the Met station. North and East are positive.	Value from first sample.

Header		Units	Description	
			Un-Averaged Data	10-min Averaged Data
	GPS data	Degrees, Decimal Minutes	GPS location data as measured by the Met station (or as set in the configuration). Superseded by 'GPS' field.	Value from first sample.
	Met Compass Bearing (deg)	Degrees	Bearing of Met station with respect to True North, measured by the Met station. I.e. 5 degrees would be 5 degrees East of True North.	Unit-vector average.
	Met Tilt (deg)	Degrees	Maximum magnitude of pitch or roll away from horizontal as measured by the Met station.	Maximum.
	Met Air Temp. (C)	Degrees Celsius (C)	Ambient temperature measured by the Met station.	Mean.
	Met Pressure (mbar)	Millibar (mbar)	Ambient pressure measured by the Met station.	Maximum.
	Met Humidity (%)	%	Ambient relative humidity measured by the Met station.	Value from first sample.
	Met Wind Speed (m/s)	Metres per second (m/s)	Horizontal wind speed as measured by the Met station.	Mean.
	Met Wind Direction (deg)	Degrees	Wind direction bearing read by the Met station, relative to the ZephIR optical axis	Unit-vector average.
	Inclination Angle Mean (deg)	Degrees	Mean inclination angle detected by the motion sensors.	Mean.

Header	Units	Description	
		Un-Averaged Data	10-min Averaged Data
Inclination Angle Std. Dev. (deg)	Degrees	Standard deviation of inclination angle detected by the motion sensors.	Standard deviation of mean inclination angle.
Roll Angle Mean (deg)	Degrees	Mean roll angle detected by the motion sensors.	Mean.
Roll Angle Std. Dev. (deg)	Degrees	Standard deviation of roll angle detected by the motion sensors.	Standard deviation of mean roll angle.
Fore-Aft Velocity Mean (m/s)	Metres per second (m/s)	Mean fore-aft velocity detected by the motion sensors.	Mean.
Fore-Aft Velocity Std. Dev. (m/s)	Metres per second (m/s)	Standard deviation of fore-aft velocity detected by the motion sensors.	Standard deviation of mean fore-aft velocity.
Proportion Of Packets With Rain (%)	Percentage (%)	N/A	Proportion of wind data samples which were collected while rainfall was detected.
Raining	-	Flag indicating if the rain sensor detected rain (0 – Off, 1 – On).	N/A
FD Packets in Average at <i>Rm</i>	-	N/A	Number of wind data samples included in the 10-min average.
FD Horizontal Wind Speed (m/s) at Scan Centre at <i>Rm</i>	Metres per second (m/s)	Horizontal wind speed as measured by the ZephIR at the given range, at the centre of the circular scan, as determined by the fit-derived algorithm.	Mean.

Header		Units	Description	
			Un-Averaged Data	10-min Averaged Data
Mutually exclusive	Vertical Wind Shear (m/s per m) at Rm	Metres per second per metre (m/s per m)	Vertical gradient of wind speeds (assumed linear) as measured by the ZephIR around the centre of the scan. Positive values indicate that the wind speed is higher above the optical axis than below. Superseded by 'FD Vertical Wind Shear Exponent' field.	Mean.
	FD Vertical Wind Shear Exponent at Rm	Dimension-less	Power law vertical wind shear exponent (alpha). Positive values indicate that the wind speed is higher above the optical axis than below.	Mean.
FD Wind Yaw Misalignment (deg) at Rm		Degrees	Angle of the horizontal wind direction vector to the ZephIR optical axis (i.e. yaw) as measured by the ZephIR. Positive values indicate that the wind direction is crossing from right to left (when looking from behind the ZephIR into the wind).	Wind vector average.
FD Horizontal Wind Speed Std. Dev. (m/s) at Scan Centre at Rm		Metres per second (m/s)	N/A	Standard deviation of the un-averaged fit-derived horizontal wind speeds at scan centre included in 10-min average.
FD Wind Yaw Misalignment Std. Dev. (deg) at Rm		Degrees	N/A	Standard deviation of the un-averaged fit-derived wind yaw angles included in the 10-min average.

Header	Units	Description	
		Un-Averaged Data	10-min Averaged Data
FD Horizontal Wind Speed Min (m/s) at Scan Centre at Rm	Metres per second (m/s)	N/A	Minimum fit-derived horizontal wind speed measured by the ZephIR at scan centre in the 10-min average.
FD Horizontal Wind Speed Max (m/s) at Scan Centre at Rm	Metres per second (m/s)	N/A	Maximum fit-derived horizontal wind speed measured by the ZephIR at scan centre in the 10-min average.
FD Backscatter (/1.3e-6/m/sr) at Rm	A scaling factor per metre per steradian. (/1.3e-6 /m/sr)	A measure of the strength of the return laser signal.	Mean.
FD Fit Flags at Rm	-	<p>A bit field representing the result of fitting process. Flag values are (hexadecimal):</p> <pre> VALID FIT 0x01 NOT ENOUGH POINTS 0x02 NOT ENOUGH SECTORS 0x04 IMPOSSIBLE FIT 0x08 CONTAINS ROTOR BLADE 0x10 CONTAINS FOREIGN OBJECT 0x20 LOW DOPPLER CONTAMINAT'N 0x40 </pre>	Combined list of all flags that were present during the 10-min averaging period.
FD Mean Fit Residual (m/s) at Rm	Metres per second (m/s)	The average fit residual of all the measurement points included in the fitting of the wind model.	Mean.
FD Shear Interpolated Horizontal Wind Speed (m/s) at Hub Height at Rm	Metres per second (m/s)	The wind speed at the configured hub height calculated by interpolation of the fit-derived wind speed at the scan centre using the shear.	Mean.

Header	Units	Description	
		Un-Averaged Data	10-min Averaged Data
Range (m)	Metres (m)	Range along the scanning axis at which the ZephIR is currently probing, as measured from the unit window to the scanning plane.	N/A
Left LOS Speed (m/s) at Rotor Segment Height H_m at R_m	Metres per second (m/s)	The line of sight wind speed of the left (as seen from behind the ZephIR) measurement point of the rotor slice.	N/A
Right LOS Speed (m/s) at Rotor Segment Height H_m at R_m	Metres per second (m/s)	The line of sight wind speed of the right (as seen from behind the ZephIR) measurement point of the rotor slice.	N/A
PDAC Horizontal Wind Speed (m/s) at Rotor Segment Height H_m at R_m	Metres per second (m/s)	N/A	The pair-derived wind speed of the rotor slice as calculated using the 10 minute averaged line of sight wind speeds of the left and right measurement points.
PDAC Wind Yaw Misalignment (deg) at Rotor Segment Height H_m at R_m	Degrees	N/A	The pair-derived wind yaw of the rotor slice as calculated using the average line of sight wind speeds of the left and right measurement points.
PDAC TI at Rotor Segment Height H_m at R_m	Dimensionless	N/A	The turbulence intensity of the rotor slice.
PDAC Horizontal Wind Speed Std. Dev. (m/s) at Rotor Segment Height H_m at R_m	Metres per second (m/s)	N/A	The standard deviation in the pair-derived wind speed of the rotor slice.

Header	Units	Description	
		Un-Averaged Data	10-min Averaged Data
PDAC Packets in Average at Rotor Segment Height Hm at Rm	-	N/A	The number of left and right measurement point pairs in the 10-min average.
PDAC Rotor Equivalent Horizontal Wind Speed (m/s) at Rm	Metres per second (m/s)	N/A	The wind speed for which a uniform wind profile (i.e. without vertical shear) would give the same kinetic energy flux across the rotor swept area as the actual wind profile. In addition to vertical wind shear, its calculation includes the effects of veer (variation of wind direction with height) across the rotor swept area.
PDAC Rotor Equivalent Wind Speed IEC Compliance at Rm	-	N/A	A formal procedure for the measurement and definition of the rotor equivalent wind speed is provided in Annex Q of the IEC draft standard IEC 61400-12-1 CD. If the ZephIR's measurements comply with the strict interpretation of the standard, this is indicated here. FALSE = Non-compliant TRUE = Compliant

¹ This is roughly the time, in seconds since 00:00:00 1/1/00. The exact formula is:
time = (((((((((year * 12) + month) * 31) + day) * 24) + hours) * 60) + minutes) * 60) + seconds

Note that the year should be the two digit form, e.g. 05 for 2005.

3.4 Wind Data quality processing

For turbine-mounted ZephIRs the following Quality Code is used in the output file:

9999 – It has not been possible to fit the measured wind data to the model. This may occur if the turbine is parked with a rotor blade obscuring the ZephIR, if the wind speed is very low, or if the wind turbine is yawed well away from the prevailing wind. Further information is provided by the contents of the 'Fit Flags' field, which will contain one of the following flags:

'NOT_ENOUGH_POINTS',
'NOT_ENOUGH_SECTORS' or
'IMPOSSIBLE_FIT_RESULT'.

APPENDIX A - ACRONYMS

Acronym	Meaning
FD	Fit-Derived. Refers to a parameter that has been calculated by fitting the measured wind parameters to a wind model.
PD	Pair-Derived. Refers to a parameter that has been calculated using a pair of (horizontally aligned) measurement points.
PDAC	Pair-Derived, Averaged then Calculated. Refers to a parameter that has been calculated using a pair of (horizontally aligned) measurement points that have been averaged over a 10-min period.
LOS	Line of Sight. Refers to the measured wind speed along the line of sight of the laser beam.