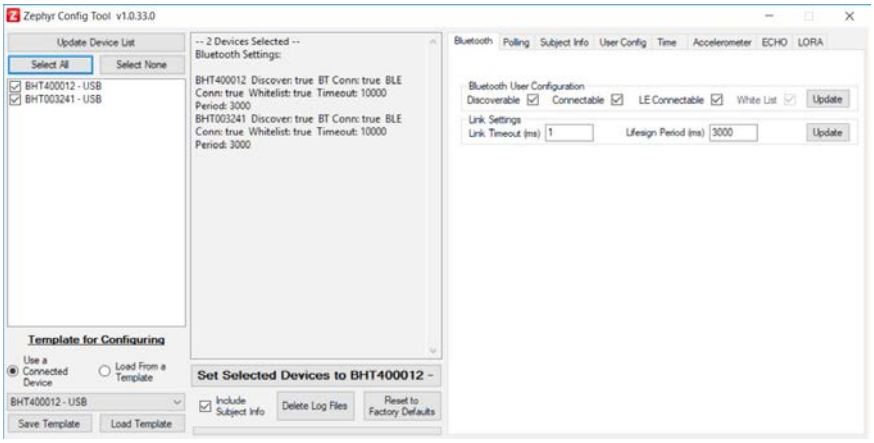
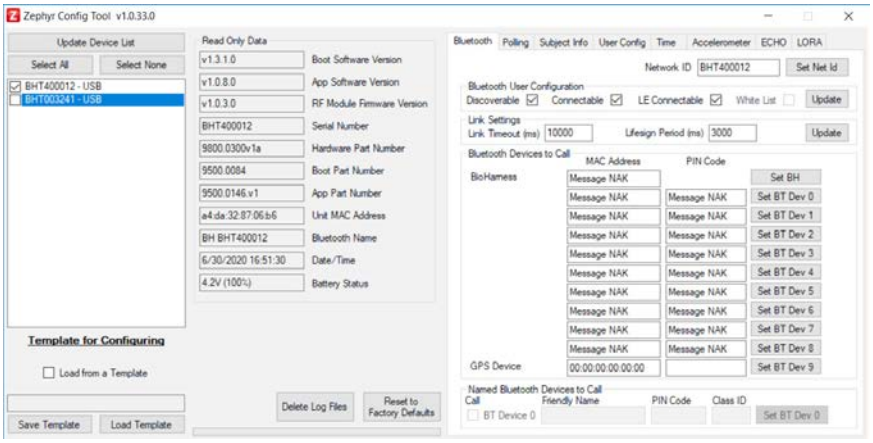
Zephyr™ Config Tool (2/9)

5. If multiple devices are selected, the left hand panel will show partial parameters.

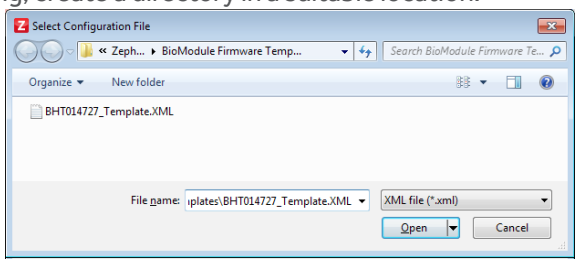


6. If a single device is selected, more detail will show.



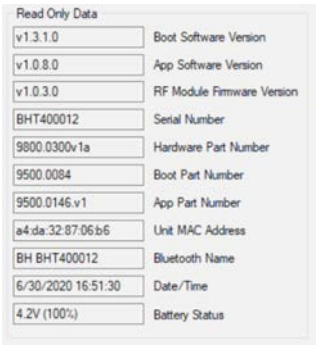
Configure From a Template

- BioModules can be configured from a Template. No default templates exist - a BioModule must first be configured manually, and then this configuration saved as an XML template file. Use the **Save Template**/**Load Template** buttons appropriately.
- When saving, create a directory in a suitable location.



Zephyr™ Config Tool (3/9)

Read-Only Data



These values cannot be changed using the Config Tool, except for **Date/Time**.

Item	Description
Boot Software Version	App software boot loader - not user updatable
App Software Version	Device Firmware Version - can be updated with update tool.
RF Module Firmware	May be updated by some firmware versions automatically.
Serial, Hardware & Boot & App Part Nos.	Zephyr™ internal part numbers
Unit MAC Address	Bluetooth™* Address
Bluetooth™* Name	Name when detected over Bluetooth™*
Date/Time	Internal device time. Update in **Time** tab.

Delete Log Files

Use this button to delete all log files. This operation can also be done from the Zephyr™ Downloader.

Note

Deletion of log files is not strictly necessary, except for housekeeping purposes. When new logs are being created, the oldest log will be deleted / over-written automatically to free up memory space.

Reset To Factory Defaults

Use this button to return the device to the configuration it was shipped with. You can also save the shipped configuration as a template prior to making any custom changes.

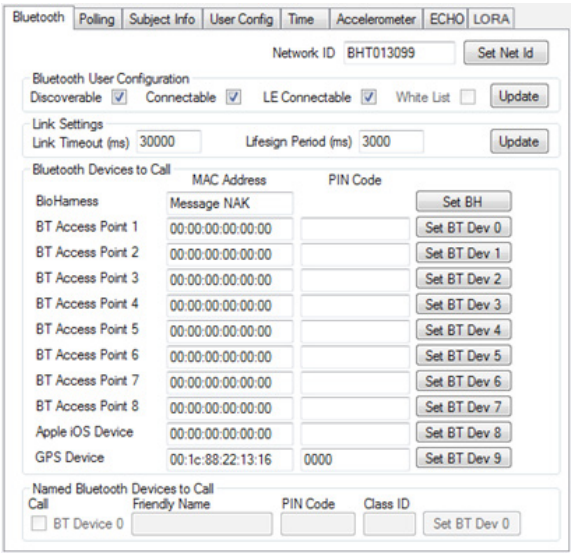
Caution

Manually change BioModule settings with care. Changing some settings may cause the device to stop working or give invalid data.

Zephyr™ Config Tool (4/9)

Configuration Tabs

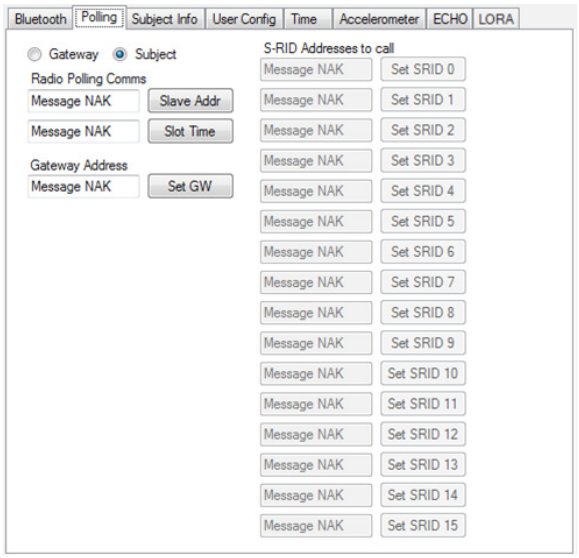
Bluetooth™*



Item	Description
Network ID	Device ID when detected over Bluetooth™*.
Discoverable	Make device discoverable or 'hide' from BT detection.
Connectable	Enable Bluetooth™* Connectivity.
LE Connectable	Enable Bluetooth™* Low Energy Connectivity, if device supports it.
Link Timeout, Lifesign Period	Default settings will ensure BioModule never terminates BT connection.
BioHarness™	Not used to configure BioModule.
BT Access Point #	Legacy Settings for older BT access Point systems (out of production).
Apple™* iOS™* Device	Not Implemented.
GPS Device	This is normally configured automatically over LoRa, but can be manually paired here if the MAC address of the supported GPS device is known.
Named Bluetooth™* Device To Call	Not used in PSM LoRa systems

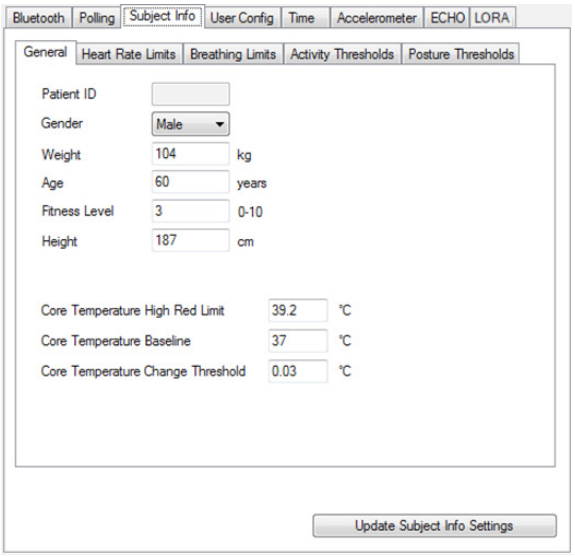
OMNISENSE™ TOOLS
Zephyr™ Config Tool (5/9)

Polling



The Polling tab is not used in PSM LoRa Systems.

Subject Info

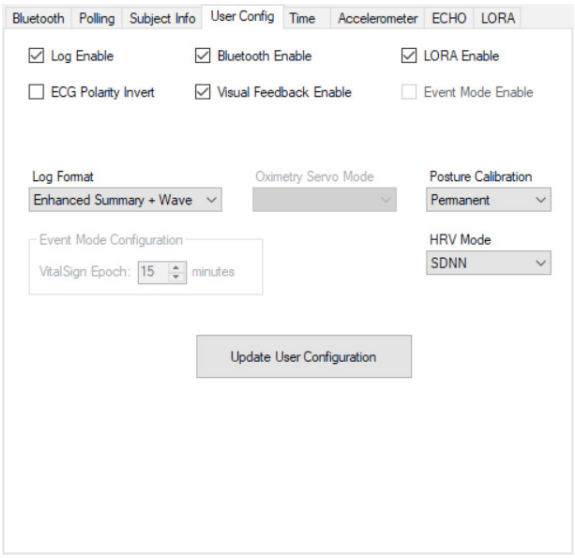


Caution

Subject Info Parameters are used to configure various parameters in the Subject Status algorithms. They are populated over-the-air by the LoRa system and should **not** be edited manually.

OMNISENSE™ TOOLS
Zephyr™ Config Tool (6/9)

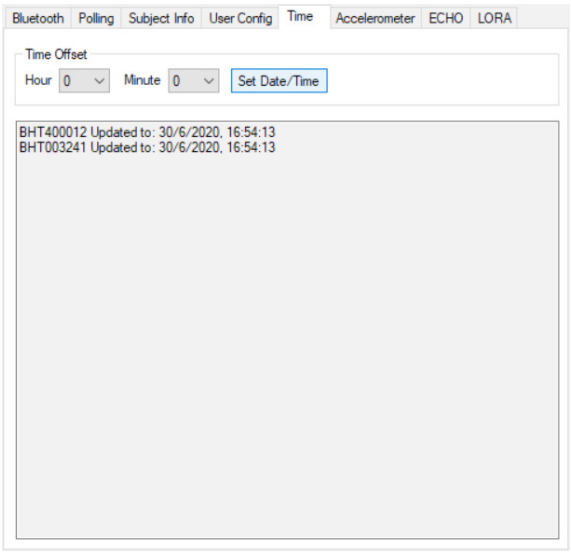
User Config



Item	Description
Log Enable	Enable Logging (checked by default).
Bluetooth™* Enable	Enable Bluetooth™* transmit.
LoRa Enable	Enable LoRa transmit.
ECG Polarity Invert	Invert the ECG waveform (intended to accommodate future garment orientations).
Visual Feedback Enable	If unchecked, all LEDs turn off after 30 seconds.
Event Mode Enable	For non-PSM systems.
Log Format	Set as needed. Must be Summary & Waveform or Enhanced Summary & Waveform for use with a GPS. Default is Summary.
Posture Calibration	Default is permanent - current calibration is maintained after power cycle. For manual calibration while wearing a garment, push the button three times before inserting into garment, then get into laying flat on back position, and remain stable for about 10 seconds. The BioModule LEDs will light in a rotating sequence while in calibration mode.
HRV Mode	SDNN - rolling 300-beat calculation. RMSSD - rolling 15-second calculation.
Update User Configuration	Save any changes.

Zephyr™ Config Tool (7/9)

Time



Item	Description
Time Offset	Add an offset if needed (e.g. PC time is not appropriate).
Set Date/Time	Use to set the device clock, with or without an offset.

Time Auto-set

BioModule clocks are automatically set to local PC time under two conditions:

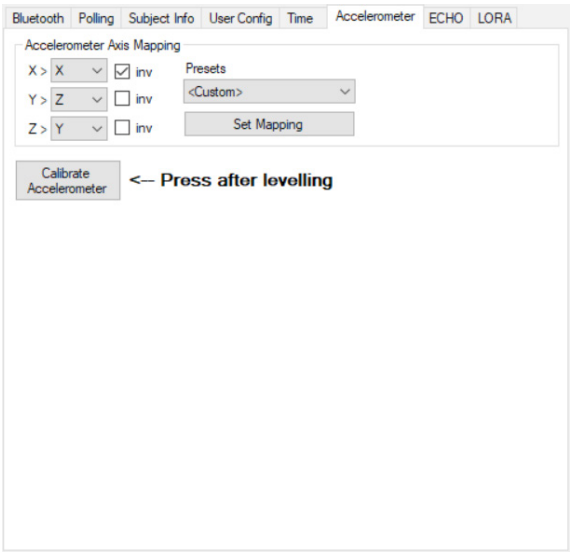
- On Startup of OmniSense™ Live in a PSM LoRa system, when initial radio connection with the device is made.
- When the device logs are read by the Zephyr™ Downloader in OmniSense™ Analysis (this can be turned off in the Downloader options menu).

Note

If a BioModule is used directly in logging mode after being powered off, re-synchronize the clock manually using the Config Tool,by using OmniSense™ Live in LoRa mode, or by reading the device using the Zephyr™ Downloader (no logs need to be downloaded). Otherwise, there may be an offset of a few seconds from real time.

Zephyr™ Config Tool (8/9)

Accelerometer



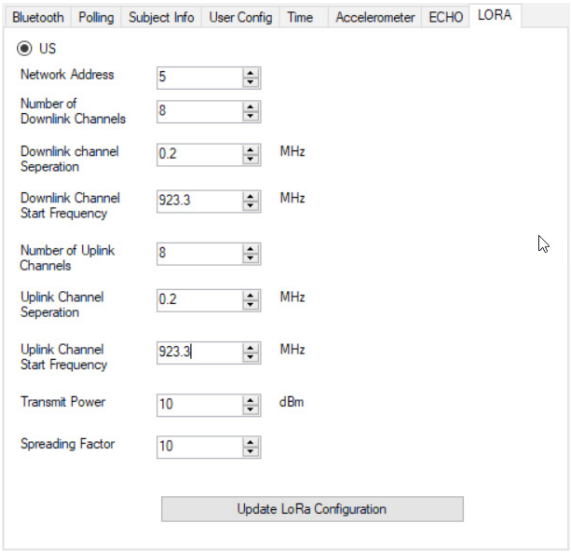
Item	Description
Presets	Set to required garment type.
Set Mapping	Use to commit a new setting.
Calibrate Accelerometer	Use to zero-reset accelerometer orientation. See Caution below. BioModules can now be set while worn, to eliminate individual offsets. See the **User Config** section of this tool for details.

Caution

Device accelerometers are factory calibrated and should never normally require recalibration. Recalibrating may create an offset in device orientation. It should only be attempted on a calibrated horizontal surface. **The BioModule should be located vertically in a cradle when this is done.** The BioModule should be reset to factory defaults on left panel of Config Tool first.

OMNISENSE™ TOOLS
Zephyr™ Config Tool (9/9)

LoRa



Item	Description
Network Address	Should be different for each BioModule in a PSM system, within the range appropriate for LoRa mode. See Setup section. Assigned on shipment.
Number of Downlink Channels	Set to 8. Do not change.
Downlink Channel Separation	Set to 0.2. Do not change.
Downlink Channel Start Frequency	Set to 924.6. Do not change. Must be the same as for the LoRa gateway and PC app.
Number of Uplink Channels	Set to 8. Do not change.
Uplink Channel Separation	Set to 0.2. Do not change.
Transmit Power	Set to 20. Do not change.
Spreading Factor	Set to 10. Do not change.

Caution

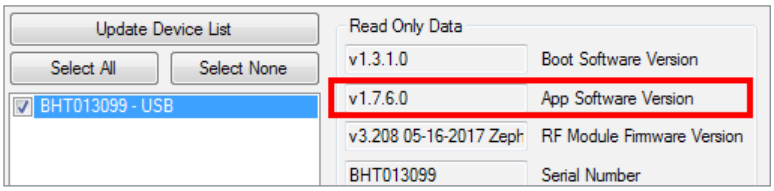
No two BioModules in a PSM system should have the same **Network Address**, otherwise a conflict may occur. No data, or the wrong data, may be received from either device.

Note

Two separate PSM LoRa systems operating on the same site should be set to different downlink channel start frequencies. Contact Zephyr™ support for details on reconfiguring a LoRa gateway.

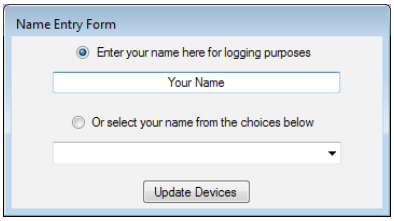
BioModule Firmware Updates

BioModule device internal Firmware - referred to as **'App Software'** version in the Zephyr™ Config Tool - is updated periodically, as new functionality is added to the system. Each new revision of OmniSense™ is accompanied with files for updating device firmware, and the ZUSBUpdater tool to update devices.

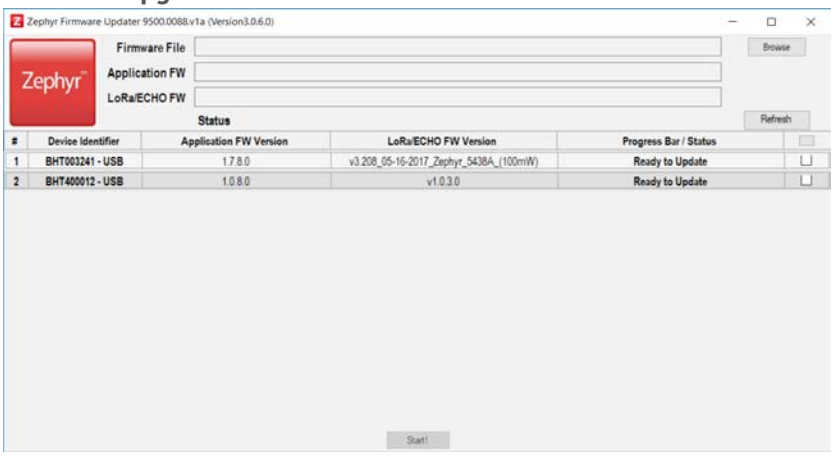


BioModule Firmware version in Zephyr™ Config Tool

- Double-click the ZUSBUpdater.exe file to start the tool, and enter a name in the Name Entry dialog to start the updater.



- Operation of the updater tool is described fully in **Appendix 1: BioModule Firmware Upgrade**



Caution

Care must be taken to load the appropriate version of the firmware update file, corresponding to the hardware type of the BioModule.:

- BioModule 3.0: Bluetooth™* + ECHO + Bluetooth™* Low Energy
- BioModule 4.0: Bluetooth™* + LoRa + Bluetooth™* Low Energy

BioModule 4.0 serial numbers always start with a "BHT4" prefix. See the BioModule Firmware Upgrade appendix for instructions for using the hardware part number to identify your device version number.

If in doubt contact Zephyr™ Support for assistance.

External Processing of R-R Files

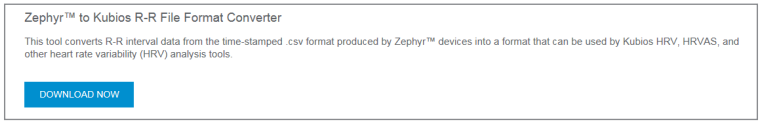
Kubios HRV is a third-party application for producing comprehensive analysis of RR data, producing graphical and metrical representations of Heart Rate Variability.

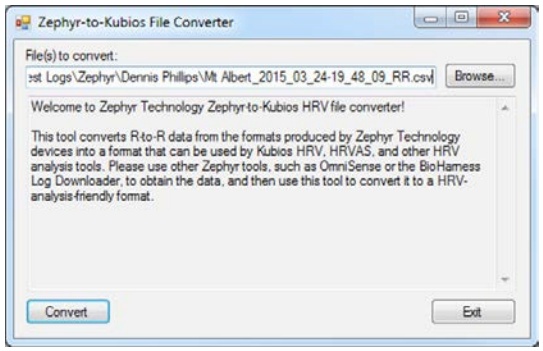
It is available from **https://www.kubios.com**. There is a free version for researchers.

The Zephyr™ Kubios Converter is a utility for processing RR files exported from BioModule log sessions. It converts them into a text file suitable for importing into Kubios HRV.

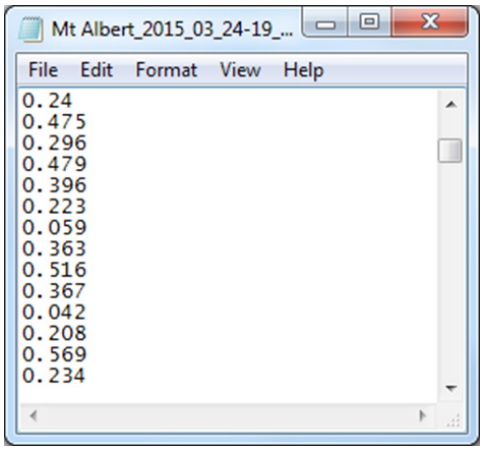
The Kubios Converter can be downloaded from

https://www.zephyranywhere.com/resources/developer-user-tools





1. Run the tool and browse for any _RR external csv file generated by the Zephyr™ Downloader from a BioModule log session.
2. Click the **Convert** button and a .txt file will be created in the same location.



3. This file can be imported into Kubios.

Zephyr™ Data Plotter

The Zephyr™ data plotter is a basic graphing tool for viewing larger data sets. It is for viewing only – no analysis or exporting of data can be performed.

It is useful for casual visual inspection of larger data sets - Microsoft™* Excel™* can only graph a maximum of 5 minutes of an ECG file due to a 32,000 data point limit.

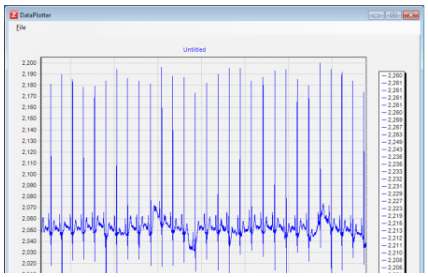
It can be downloaded from the Zephyr™ website at

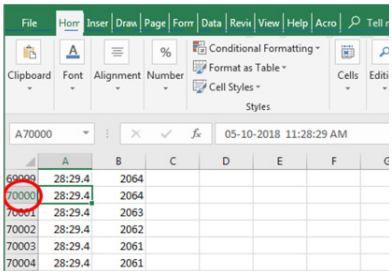
https://www.zephyranywhere.com/resources/developer-user-tools

Supported Files

Any parameter from a csv file can be plotted, by selecting the column (by number – 1st, 2nd etc) containing the data. However, the plotter cannot parse the date timestamp field which is in the first column of BioModule Log data files.

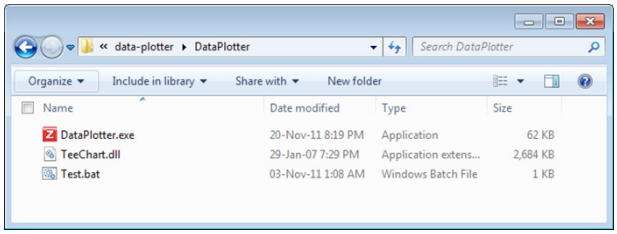
Thus, the X values (horizontal axis on the plot) must be set to **Autonumber** in the **Add Trace** dialog. The values will be numbered sequentially in the plot. To identify a specific feature on the plot within the original csv file, use the horizontal axis number and relate it to the row number in the corresponding Microsoft™* Excel™*/.csv file.



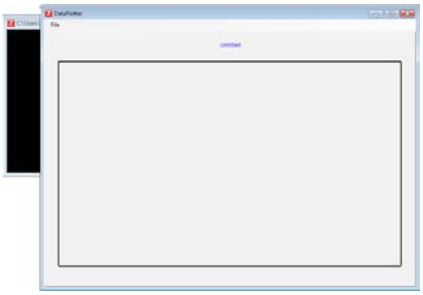


Using the Plotter

1. When downloaded from the Zephyr™ website , the directory should contain the following files:

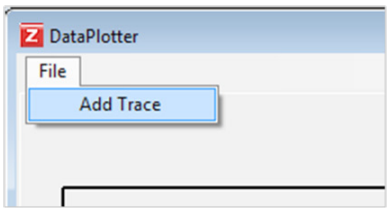


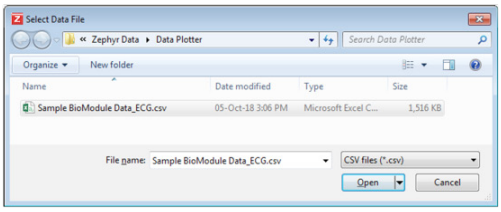
2. Double-click the **DataPlotter.exe** file to open the plotter. A black windows Command window will open at the same time.



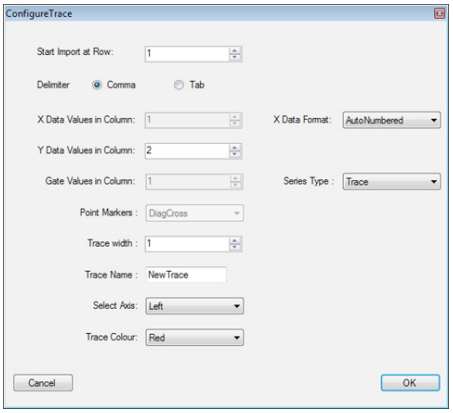
Zephyr™ Data Plotter (2/4)

3. Select the **File > Add Trace** menu option to open a dialog to browse to the desired csv file.





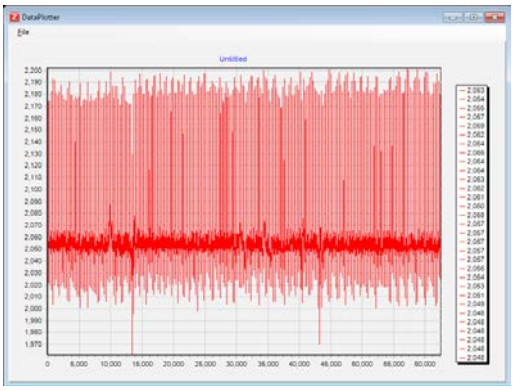
4. On file import, the Configure Trace dialog will display.



Item	Value	Description
Start Input at Row	1	Leave as 1 – column headings will be ignored.
Delimiter	Comma	Default.
X Data Values in Column	1	The timestamp column (Column A in Microsoft™* Excel™*).
X Data Format	Autonumbered	Horizontal axis will be numbered sequentially, ignoring the timestamp value.
Y Data Values in Column	2	Second column in the ECG file example (Column B in Microsoft™* Excel™*). Select column as desired.
Gate Values in Column	-	N/A
Trace width	1	1 pt
Trace Name	New Trace	Change as needed
Select Axis	L or R	Default left.
Trace Color	Select	Set as needed

Zephyr™ Data Plotter (3/4)

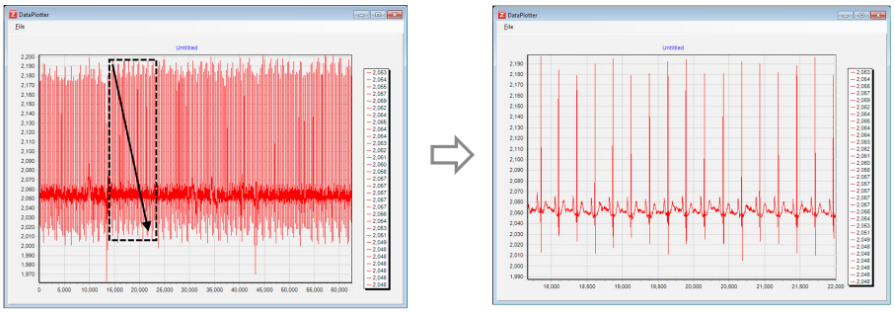
5. The trace will display



Plotter Functions

Zoom In

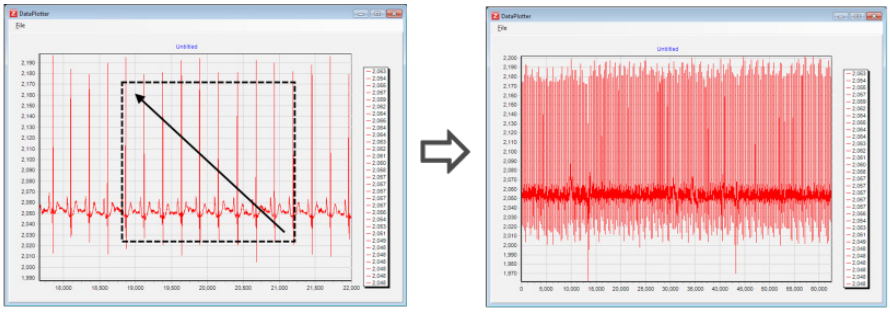
- To zoom in on a section of the plot, left-click drag a rectangle from top left to bottom right.



- Zoom in actions can be repeated continuously to isolate the desired part of the trace.

Zoom Out

- To zoom out, left-click drag a rectangle from bottom right, to top left in any location on the plot.

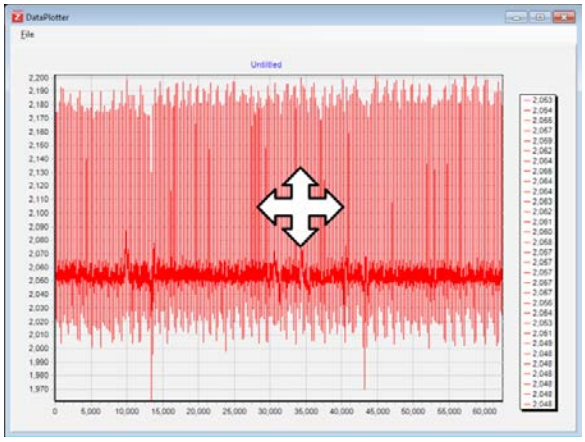


- When zooming out, the graph always returns to its original un-zoomed state – you cannot zoom back out in stages.

Zephyr™ Data Plotter (4/4)

Pan

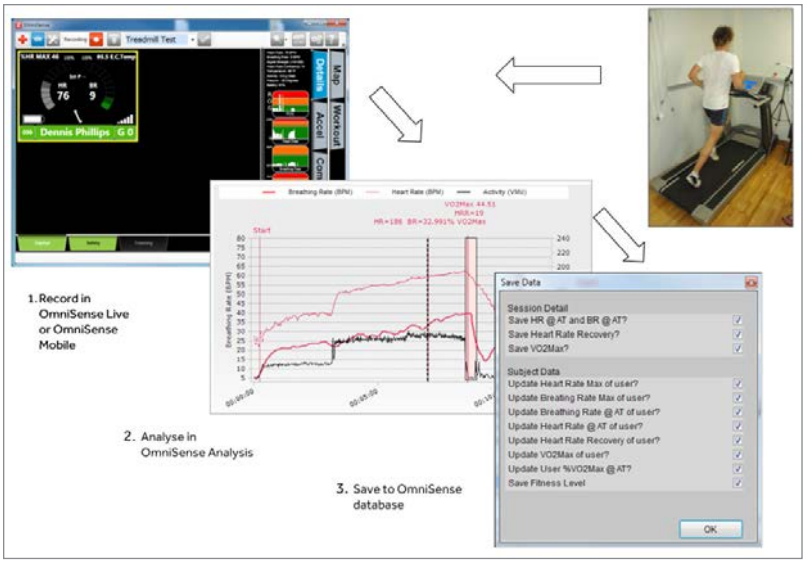
- To move the plot in any direction, **right**-click and drag with the mouse cursor in any direction. If the graph is zoomed in, the zoom will be maintained.



Baseline Fitness Testing

Use either a ramped maximal effort treadmill test or a ramped maximal effort beep test to establish baseline levels of fitness such as:

- Maximum Heart Rate (HR_{max})
- Heart Rate at Anaerobic Threshold (HR@AT)
- Heart Rate Recovery (HRR)
- VO_2max



Baseline fitness testing using OmniSense™ Local Live & Analysis

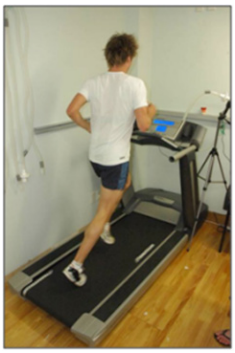
- If a fitness test is recorded in OmniSense™ Live, then the data can be retrieved in OmniSense™ Analysis, and analyzed automatically or manually.
- Fitness Assessments in the OmniSense™ Mobile application can be performed off site, and the data uploaded to the web portal.
- Fitness parameters can then be saved into the OmniSense™ database, and used as metrics in subsequent Fitness Reports for that subject.

Note

When a local PC session is connected to the cloud server, no session data is ever downloaded to the PC, but the athlete's fitness parameters **are** downloaded or uploaded, so they are synchronized in both locations. The most recent values always replace older versions.

BASELINE FITNESS TESTING
Overview/Test Protocols (2/5)

Treadmill Test Protocol



Use an ACSM ramp protocol, or a modified Conconi test.

1. 10 minute warm up, including stretches
2. Set the treadmill gradient at 5%
3. Set the start speed at 6 kph (3.7 mph)
4. Every 3 minutes, increase the treadmill speed by 2 kph (1.25 mph)
5. For maximum benefit, provide verbal encouragement to the athlete, especially during the latter part when effort is maximal.
6. The test finishes when the athlete can no longer continue.
7. The subject should remain stationary or reduce to walking for 30 seconds after they stop running, to allow a heart rate recovery measurement to be measured.

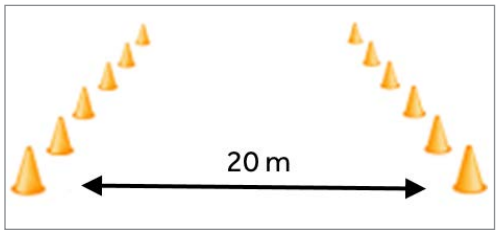
Caution

It is important that the above speed and timing criteria be observed, as the automatic VO_2max calculation is determined by the speed at which the subject stops running – specifically the duration they have been running for.

If different speed, gradient and timing criteria are used, the VO_2max calculation will be less accurate.

Beep Test Protocol

Also called a PACER (Progressive Aerobic Cardiovascular Endurance Run) test or a 20-meter shuttle run, athletes are prompted by an audio file (supplied with every OmniSense™ install) which announces beeps at steadily shortening intervals. This forces the athletes to run faster between the cones/markers, until they fail to reach a cone by the next beep.



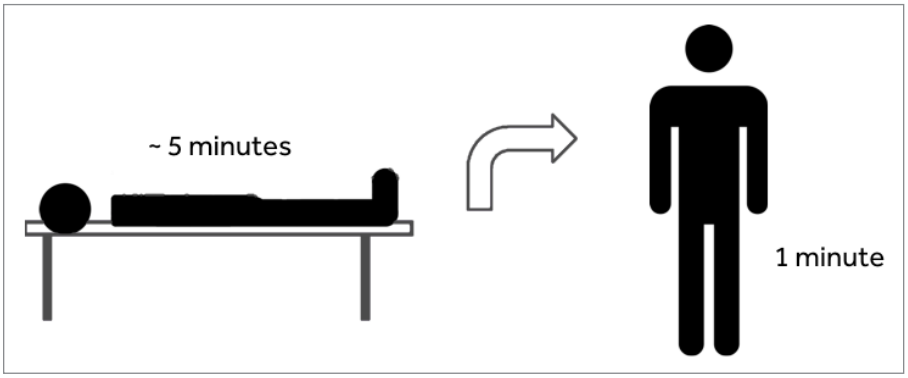
1. Place marks or cones 20 meters apart.
2. Athletes should warm up and stretch for 20 minutes.
3. Start the audio recording to initiate the test.

Cycle Iteration	# Shuttles at this level	Running Speed (kph)
1	7	8.0
2	8	9.0
3	8	9.5
4	9	10.0
5	9	10.5
6	10	11.0
7	10	11.5
8	11	12.0
9	11	12.5
10	11	13.0
11	12	13.5
12	12	14.0
13	13	14.5
14	13	15.0
15	14	15.5
16	14	16.0
17	15	16.5
18	15	17.0
19	15	17.5
20	16	18.0
21	16	18.5

Note

Beep test protocols vary internationally, with markers 20 meters or 20 yards apart. 20-meter spacing represents a 9.3% increase in distance over 20-yard spacing. Thus subjects using metric spacing must use 9.3% more effort for a given level in the test.. If different distance and timing criteria are used, the VO_2max value calculated during test analysis will be less accurate.

Orthostatic Hypotension Readiness Test Protocol



1. Lie down in a quiet, warm, comfortable setting for at least five minutes - the time taken to establish heart rate variability. If OmniSense™ Live is used, and HRV is one of the configured fields in the BioGauge, then HRV will display when a valid calculation has been made.
2. If conducted using the OmniSense™ Mobile application, and audio prompt will inform when the test is complete.
3. Stand up and remain stationary for one minute.

Note

The subject status should remain green throughout the test. If status shows grey for 5 sec at any point, indicating poor conductivity (dry skin or strap), then the HRV calculation may restart when status returns to green.

Note

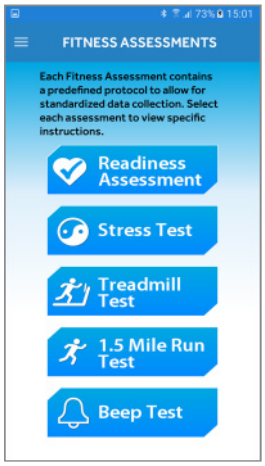
In the OmniSense™ Mobile application, this test is referred to in the Fitness Assessments screen as a **Readiness Assessment**.

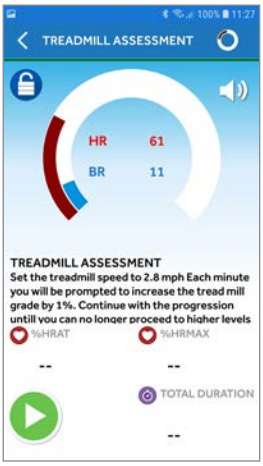
Overview/Test Protocols (5/5)

OmniSense™ Mobile

All baseline fitness tests can also be carried out using the OmniSense™ Mobile application. Test data, analysis and survey results are uploaded to the cloud database.

See the **OmniSense™ Mobile** section for details.





BASELINE FITNESS TESTING
Treadmill/Beep Test Analysis (1/5)

OmniSense™ Live

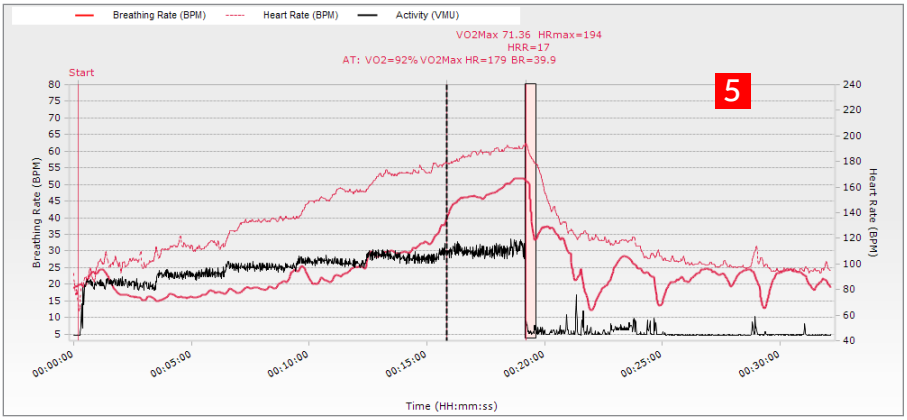
#	Description
1	Recording is ON by default; turn OFF if you do not want to record warm-up data, or exclude the warm up data later by creating a subsession in Analysis.
2	Create session names Treadmill Test/Beep Test in Live **Preferences** for current and future use; click the tick button to assign the session name.
3	Use markers to note any events you may want to refer to later in Analysis. The start and end of the test are easy to identify due to obvious changes in activity level.

- Perform the test according to the protocol.
- Make sure recording in ON.

BASELINE FITNESS TESTING
Treadmill/Beep Test Analysis (2/5)

Automatic Test Analysis

#	Description
1	Use the filter pull downs to locate the relevant treadmill or beep test session.
2	Double-click the session to move it to the Legend.
3	Select **Treadmill Test** or **Beep Test** from the Time Variables list as appropriate. Heart rate, breathing rate and activity level will be displayed on the graph. No other parameters can be selected.
4	Select the Detect button to implement automatic analysis of the test.
5	If successful, the anaerobic threshold will be detected, as well as HR max and heart rate recovery values. VO_2max will be calculated according to an ACSM formula. They are shown in red text and graphics on the graph.



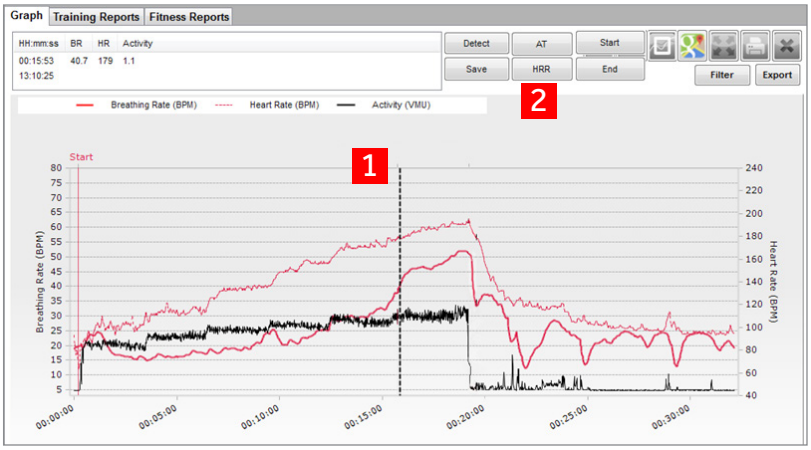
Note

If automatic analysis is not successful, or the AT threshold detected automatically appears to be wrong, a message will display, it must be made manually.

BASELINE FITNESS TESTING
Treadmill/Beep Test Analysis (3/5)

Manual Test Analysis

Place the vertical graph cursor at the relevant points on the graph traces and use the manual detect buttons as indicated.



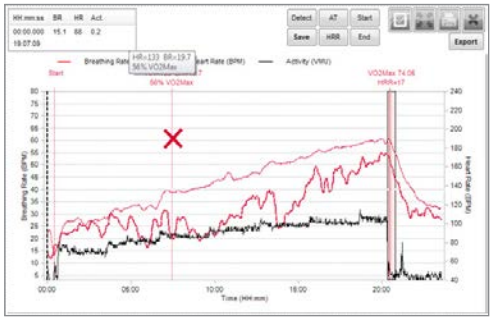
#	Description
1	Vertical Graph cursor
2	Automatic & manual detect buttons

- Use the buttons in the order below, placing the vertical graph cursor appropriately.
- The cursor can be relocated and any button re-used to correct errors.

Button	Description
Detect	Use for automatic detection. A message will display if the detection algorithm criteria are not satisfied.
Start	Set at the start of the active part of the test, for a valid VO_2 max estimate.
End	Set at the end of the active part of the test, for a valid VO_2 max estimate.
AT	Set at the **Anaerobic Threshold** (see next page)
HRR	Set at peak heart rate value at end of test, to establish heart rate recovery. A rectangle will show the 30-second HRR interval.
Save	Use to save the physiological parameters to the database after all parameters have been established. A dialog will display.

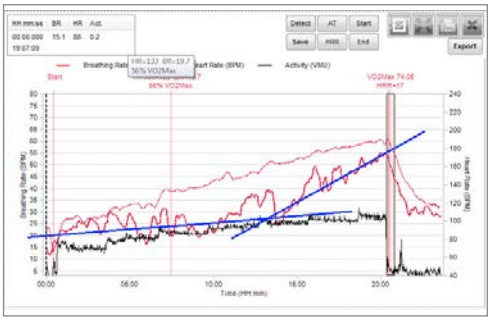
Manual AT Threshold Selection

In the example below, the automatic detection algorithm has failed, and set the AT Threshold at 56% of VO_2max, indicated by the red cross.



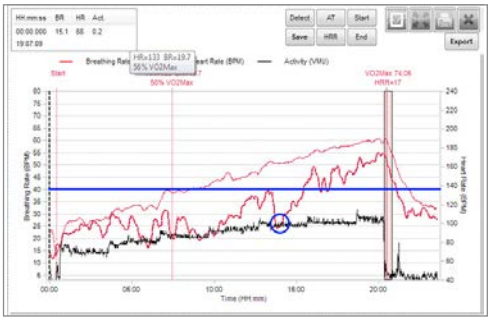
There are two alternative approaches to manual selection.

Method 1



- Look for a trend of more-rapidly-increasing breathing rate amongst the artefacts in the respiration rate. This is indicated where the blue lines intersect – a better estimation of AT than the automatically-determined value.

Method 2



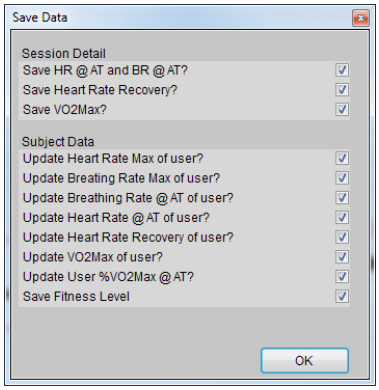
- Locate the last **major** inflection (upswing) in the respiration rate before the 40 breaths/min level (horizontal blue line) is passed. Minor inflections should be ignored. The blue circle indicates this location.

Using whichever method is best suited, relocate the graph cursor and click the **AT** button.

BASELINE FITNESS TESTING
Treadmill/Beep Test Analysis (5/5)

Save Fitness Test Parameters

Use the **Save** button once all fitness parameters have been satisfactorily established. A dialog will display.

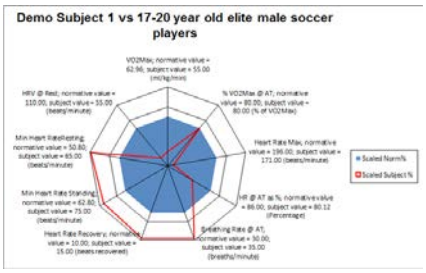


Session Detail

- If the Session detail parameters AT, HRmax , HRR and VO_2 are checked, then they will be saved with the session and will always re-display on the graph.

Subject Data

- Details will be saved into the OmniSense™ Database.
- Max values saved will be reflected in 100% deflection on subject BioGauge in Live.
- VO_2max will be displayed in Fitness Reports.



- Note that only three of these parameters are visible directly, in OmniSense™ **Live > Setup > Subject.**

HR max BPM	HR @ AT BPM	BR @ AT BPM
164	144	40
185	152	40

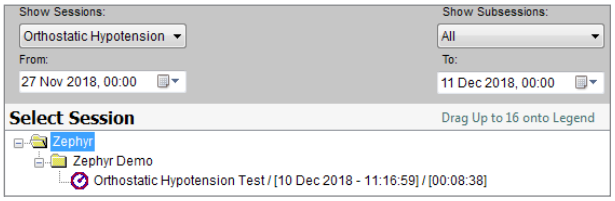
Note

Fitness test parameters saved to the database are synchronized between the local PC and the cloud database, when a PC session is connected to the cloud.

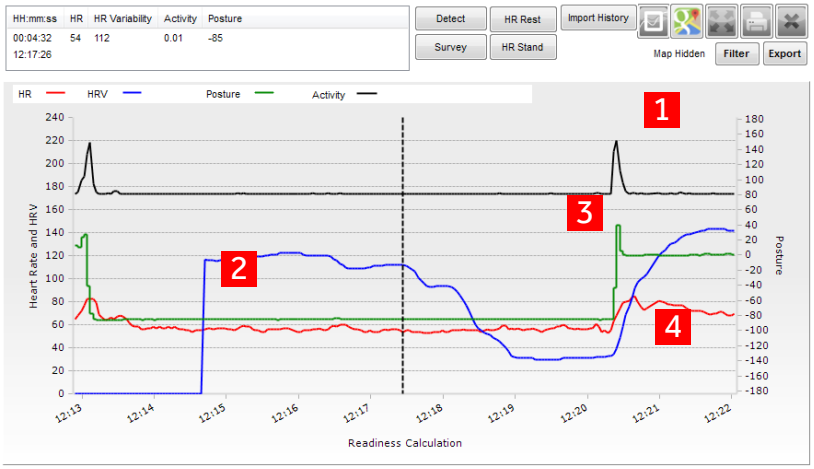
Orthostatic Hypotension Readiness Test Analysis

1. Conduct an orthostatic hypotension readiness test (called a Readiness Assessment in the OmniSense™ Mobile application) in OmniSense™ Live, ideally naming the session as such - though it can be renamed later in OmniSense™ Analysis.

2. In OmniSense™ Analysis, select the **Readiness** button from the toolbar, and populate the legend with the appropriate session.



3. The Readiness graph shows four parameters, and will display a number of features.



#	Description
1	Activity (black) is ~ zero and spikes when the subject stands.
2	HRV (blue) is zero until a valid value is determined.
3	Posture (green) is ~ -90° while lying, ~0° while standing.
4	Heart rate (red) stabilizes while lying, rises then falls as the subject stands.

Note

When **Readiness** is initially selected from the toolbar, the parameter panel automatically shows the **Readiness Calculation** parameter as selected.

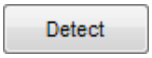
This selection is used when a Readiness analysis is intended. All other parameters are used when displaying historical results.

BASELINE FITNESS TESTING

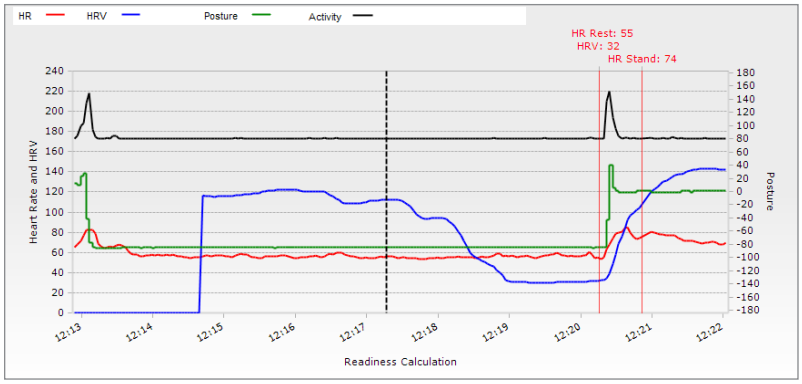
Orthostatic Hypotension Readiness Test Analysis (2/8)

Automated Test Analysis

1. With **Readiness** selected in the toolbar, and an orthostatic test loaded into the legend, select the **Detect** button.



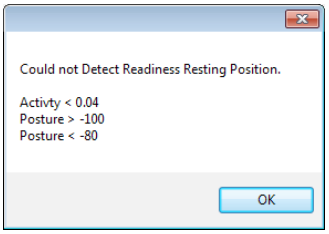
2. The detection algorithm will determine the point at which the subject went from lying to standing posture, and indicate **Resting Heart Rate** and **Resting Heart Rate Variability** approximately 10 seconds before the change, and **Standing Heart Rate** approximately 30 seconds after this point.



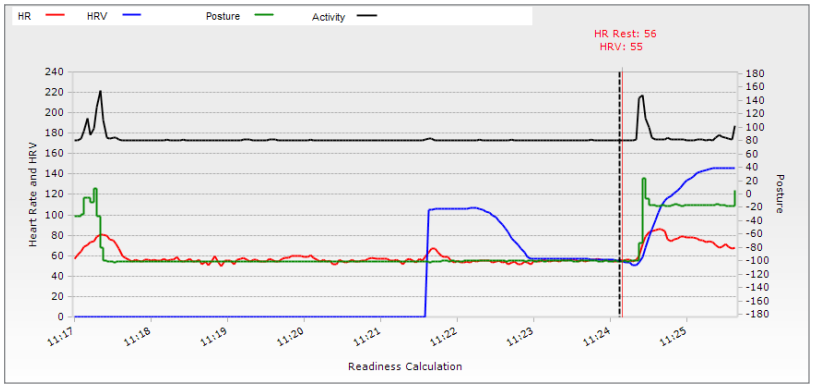
3. If the test criteria are met, then the parameters will indicate in red on the graph.

Manual Test Analysis

It may be that posture criteria are not met sufficiently. In this case, when the **Detect** button is selected, a dialog appears.



1. In this instance, manually set the vertical cursor approximately 10 seconds before the posture change/activity spike, and select the **HR Rest** button.

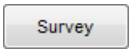


2. The **Resting HR** and **HRV** values will be shown.
3. Repeat for **Standing HR**, placing the cursor ~30 seconds after the subject is standing, using the **HR Stand** button.

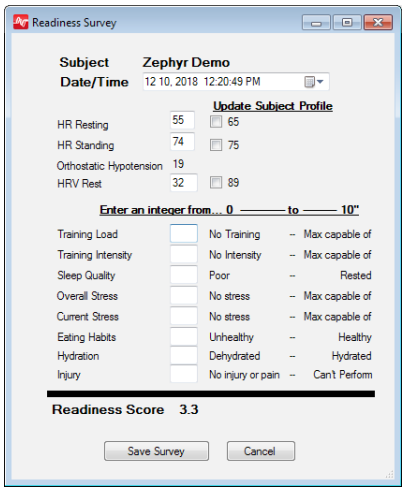
Orthostatic Hypotension Readiness Test Analysis (3/8)

Readiness Survey

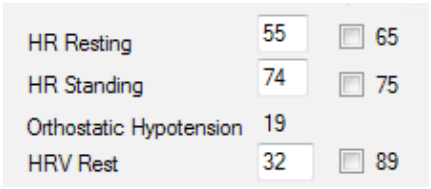
1. When the orthostatic readiness test analysis has been performed, select the **Survey** button.



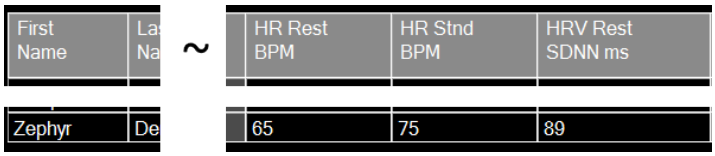
2. A survey dialog will display.



3. The dialog will contain the **Date/Time** of the currently analyzed test, and the parameters derived from it in editable fields.



4. The non-editable fields show the values for that subject currently stored in the OmniSense™ database. Check the appropriate boxes to update the subject's stored values when the survey is saved.



Orthostatic Hypotension is the difference in beats/minute between Resting and Standing heart rate.

These parameters comprise the objective components of the **Readiness Score** on a 1-10 scale. The subject must now complete a survey to allow the Readiness algorithm to factor in the subjective components.

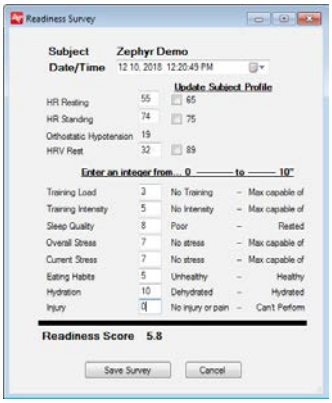
As seen above, the **Readiness Score** for the example currently stands at 3.3 with no survey responses added.

Orthostatic Hypotension Readiness Test Analysis (4/8)

5. The subject should now complete the survey. The answers are entirely subjective, and may only show value if trends are established after a number of tests and surveys have been recorded. The history of results can be retrieved in Analysis.

Item	Description
Training Load	Average in previous 10 days. 10 = maximum capability.
Training Intensity	Average in previous 10 days. 10 = maximum capability.
Sleep Quality	Subjective or scaled based on external 3rd party system. 0 = poor quality.
Overall Stress	0 = stress-free, 10 = very stressed.
Current Stress	0 = stress-free, 10 = very stressed.
Eating Habits	0 = poor, 10 = optimal, in consultation with coach/ nutritionist.
Hydration	0 = dehydrated, 10 = hydrated.
Injury	0 = unable to train/perform, 10 = no injury.

6. Once the survey is complete, use the **Save Survey** button to save the results into the OmniSense™ database. The **Readiness Score** is recalculated as each entry is made.



Note

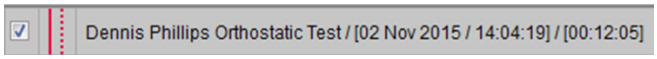
Subjective Readiness Survey responses are always on a scale 1-10, but each response can be given a weighting in Analysis **Preferences**, to increase or reduce its importance in the Readiness Score calculation.

Orthostatic Hypotension Readiness Test Analysis (5/8)

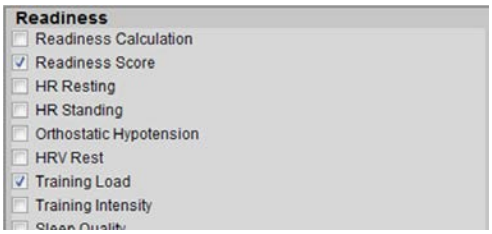
Display Readiness History

1. Select a date range in the **Filter Session List**. (This can be adjusted later).

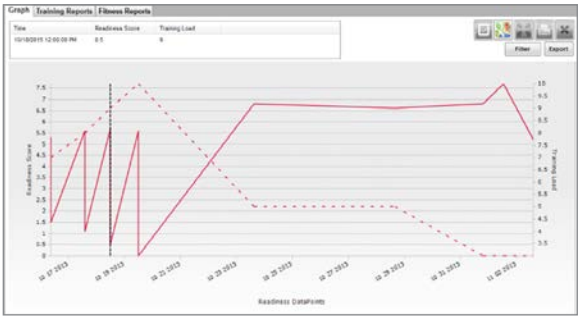
2. Populate the legend with a session from the desired subject - this can be any session, it is merely to establish the subject of interest. The details of this session will not be used.



3. Select the desired Readiness parameters.



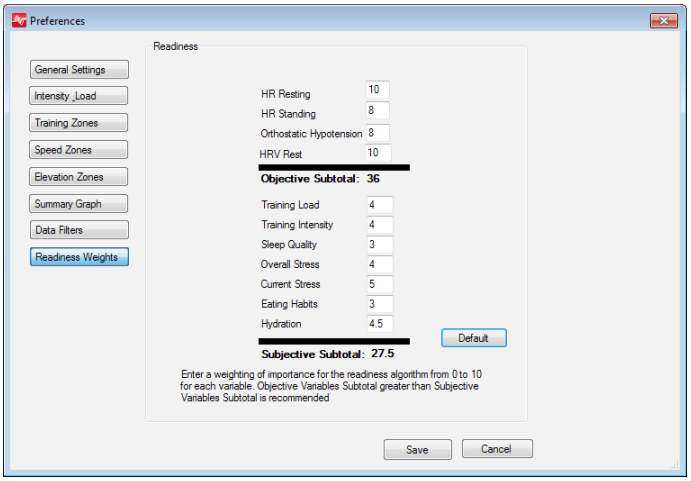
4. The Readiness history will display in the graph area.



Configure Readiness Survey Weightings

The components of the Readiness survey are each given a weighting which can be configured in **Analysis > Preferences**. This allows a coach to add more or less relevance to a particular survey response, as they see fit.

1. Select **Readiness Weights** from the **Preferences** dialog.



2. The default weightings are shown - reset to these using the **Default** button at any time.

3. Edit the weightings to suit. As the text below the fields indicates, it is recommended that the objective factors subtotal should always exceed that of the subjective factors.

4. Select **Save** to make the changes permanent.

Orthostatic Hypotension Readiness Test Analysis (7/8)

Import Readiness History

Recording the results of a Readiness survey taken remotely, and sent in a file to a coach or manager is largely now a legacy task.

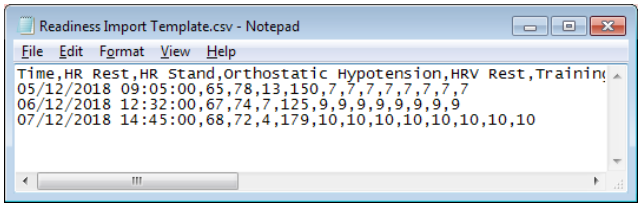
OmniSense™ Mobile now allows a registered user to perform the hypotension test remotely, and complete a survey.

The results uploaded automatically to the OmniSense™ cloud server, and submitting results in a file is no longer necessary.

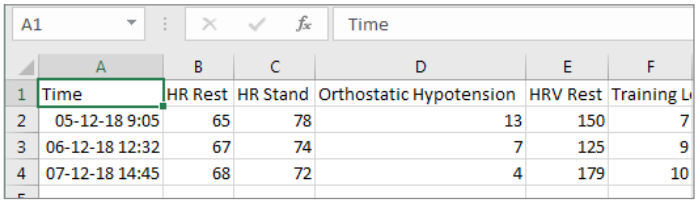
Create Readiness History File

The documentation folder accompanying each OmniSense™ installation should contain a file titled Readiness Import Template.csv.

1. Make a copy for any individual subject, Data must be entered in exactly the format contained in the file. When opened in Microsoft™* Notepad™*, the raw data and formatting can be seen.



2. By default, this file will open in Microsoft™* Excel™*. Note in particular the time entry format, and replicate this when completing. Delete any existing records.

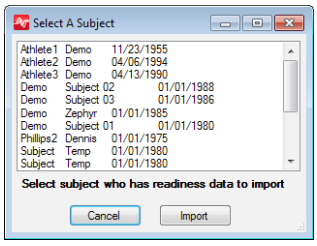


	A	B	C	D	E	F
1	Time	HR Rest	HR Stand	Orthostatic Hypotension	HRV Rest	Training L
2	05-12-18 9:05	65	78	13	150	7
3	06-12-18 12:32	67	74	7	125	9
4	07-12-18 14:45	68	72	4	179	10

3. The subject must enter their survey responses in the columns as shown.

Import Readiness History

1. In the **Readiness** pane, with **Readiness Calculation** as the checked parameter, select the **Import History** button. A list of all subjects will display. Select the subject for whom the history will apply.

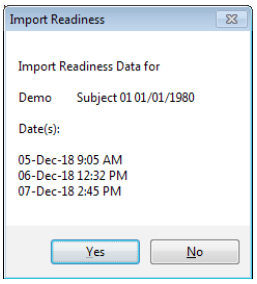


The format of the entries is Lastname | Firstname | Date of Birth.

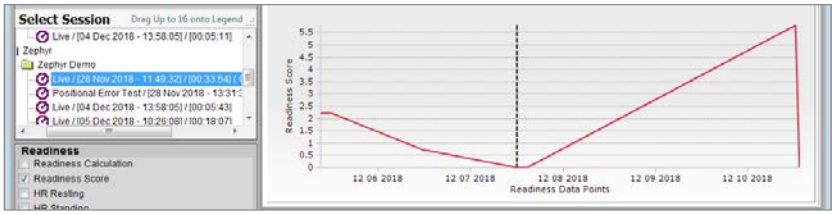
Orthostatic Hypotension Readiness Test Analysis (8/8)

2. Select the appropriate subject, and when prompted, browse to the location of the external history file.

3. When the file is selected, you will be prompted to confirm import of the results.



4. Once imported, these results will be displayed for the subject whenever any of the Readiness parameters are checked.



Caution

When external survey results are imported, they are permanently added to the OmniSense™ database against the selected subject. They cannot be deleted. Confirm the results are correct and assigned to the appropriate subject before importing.

FITNESS PARAMETERS
Intensity & Load (1/3)

Overview

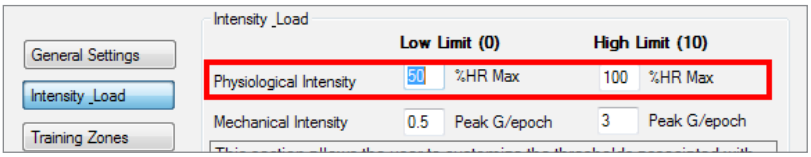
The following sections describe in more detail some of the physiological parameters and how they are calculated.

Category	Intensity	Load
Physiological	An index of cardiovascular output.	Cumulative effort of the cardiovascular system.
Mechanical	An index of musculoskeletal output.	Cumulative effort of the musculoskeletal system.
Training	Average of Physiological + Mechanical Intensities. An index of combined output .	Average of Physiological + Mechanical Loads. Total cumulative effort of the body.

- Aerobic, plyometric and similar training activities will have a high physiological intensity.
- Weight and other relatively static training methods will have a lower mechanical intensity, as measured by the BioModule, whose accelerometer is measuring whole body movement.

Physiological Load & Intensity

These are heart rate-related metrics. Intensity/effort is divided into 10 zones. The thresholds are configured in Live & Analysis Preferences.



Physiological Intensity Threshold default settings

- 50-54.9% of maximum heart rate is an intensity of 1
- 100% or greater of maximum heart rate is an intensity of 10
- Less than 50% of HRmax has no value ('null' - a zero would affect calculations)

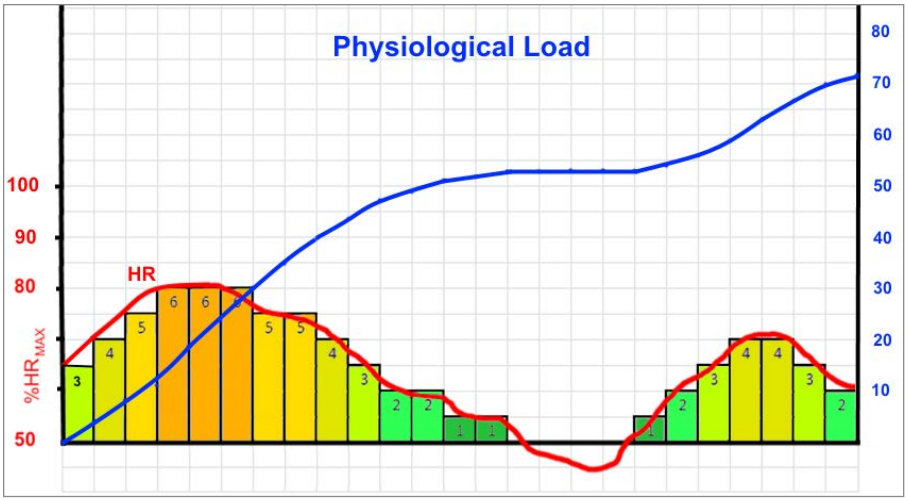
FITNESS PARAMETERS
Intensity & Load (2/3)

Physiological Intensity

Intensity Level	Heart Rate Range % HR maximum
Null	Less than 50
1	50.0 - 54.9
10	95.0 - 100.0

- Calculated once per second, over 1 second epoch.
- Scaled linearly within zone (e.g. 52.5% HRmax = Physiological Intensity Level 0.5)

Physiological Load



- Physiological Load = (Sum of physiological intensities)/60
  [Divide by 60 as intensity is measured in 1/60 minute epochs]
- Average Physiological Intensity per session
  = Physiological Load/Session Time in minutes.

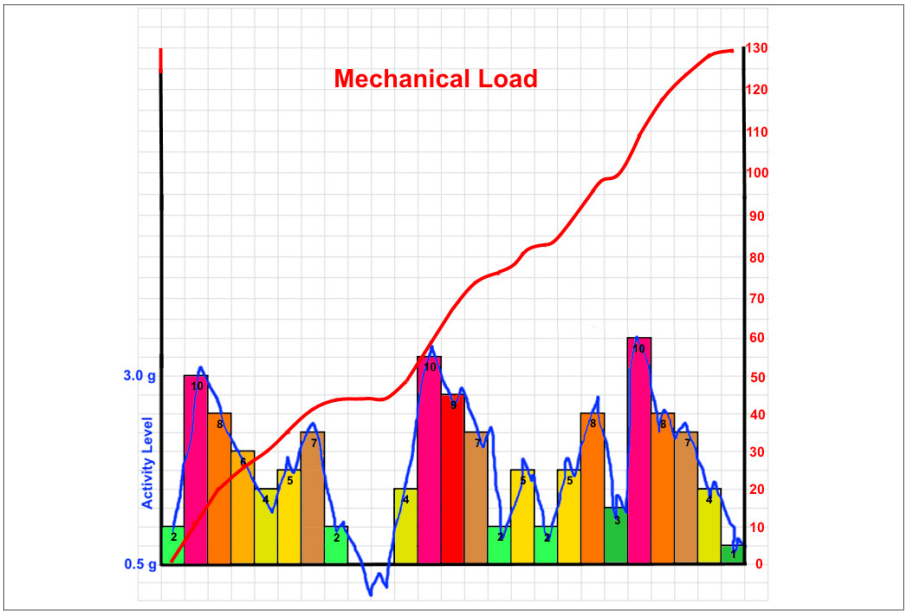
FITNESS PARAMETERS
Intensity & Load (3/3)

Mechanical Intensity

Intensity Level	Activity Level (g)
Null	Less than 0.5
1	0.5 - 0.75
10	3.0 or greater

- Calculated once per second, over 1 second epoch.
- Scaled linearly within Zone (e.g. 0.6g = Mechanical Intensity Level 0.4)

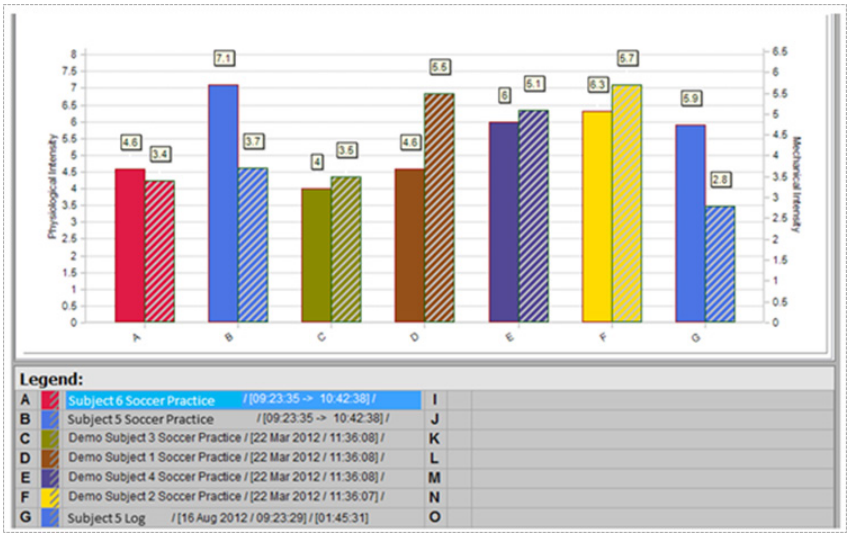
Mechanical Load



- Mechanical Load = (Sum of mechanical intensities)/60
  [Divide by 60 as intensity is measured in 1/60 minute epochs]
- Average Mechanical Intensity per session
  = Mechanical Load/Session Time in minutes.

FITNESS PARAMETERS
Interpreting Graphs (1/9)

Average Physiological vs. Average Mechanical Intensity

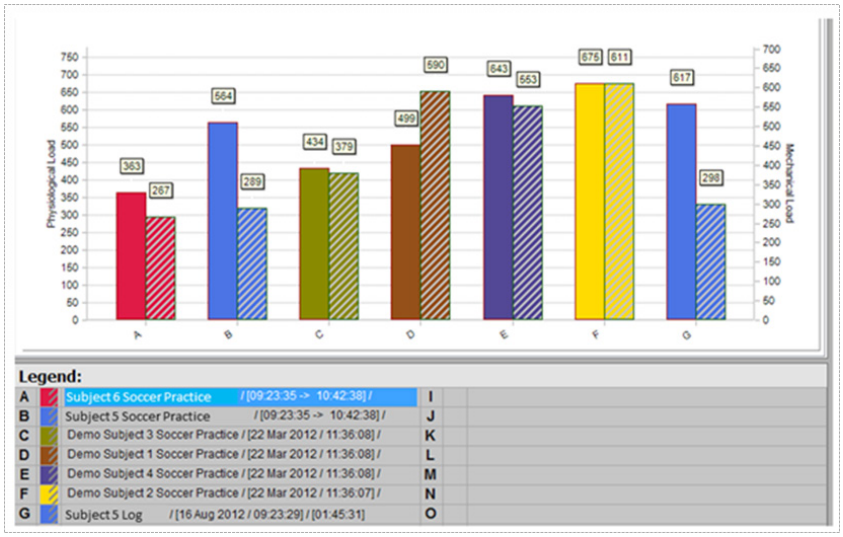


Left Axis	Right Axis
Average Physiological Intensity	Average Mechanical Intensity

- Average summary values (as opposed to Maximum or Minimum) give some indication of whole-session performance.
- High Average Mechanical Intensity with low Average Physiological Intensity is a good indicator of efficiency and useful when comparing multiple people doing similar activities.
- For example, Subject D (brown) has Average Physiological Intensity 4.6 and Average Mechanical Intensity 5.5 for the session. This subject is more efficient than subject B (blue, left) whose Average Physiological Intensity is 7.1 and Average Mechanical Intensity of 3.7.
- Subject D's heart is working less hard, for more mechanical results, than subject B's (or A or G) is.

FITNESS PARAMETERS
Interpreting Graphs (2/9)

Physiological vs. Mechanical Load

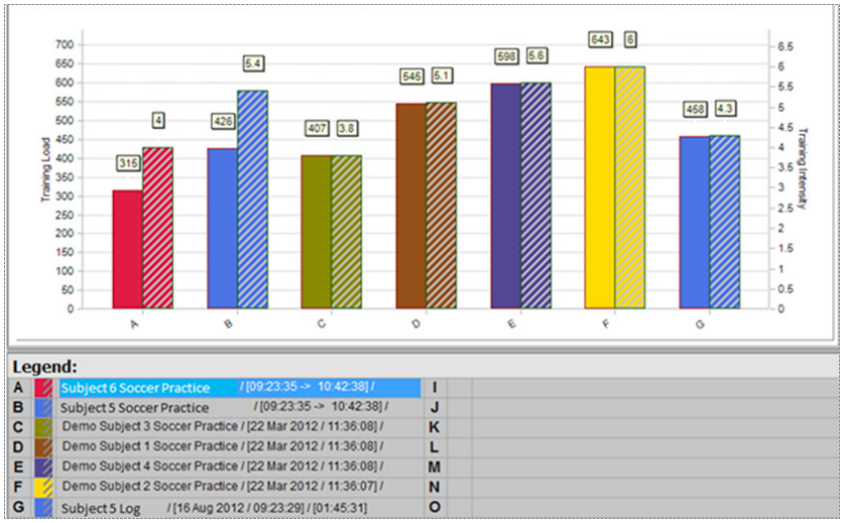


Left Axis	Right Axis
Physiological Load	Mechanical Load

- Load is the summation (or area under the curve) of the corresponding intensity value plotted over time.
- It provides a measure of the overall conditioning value or impact of the session.
- High physiological load with low mechanical load can be an indicator of anxiety or inefficiency – assuming the session involves running or movement. Subjects B and G (both blue) show this possible indication.

FITNESS PARAMETERS
Interpreting Graphs (3/9)

Training Load & Intensity

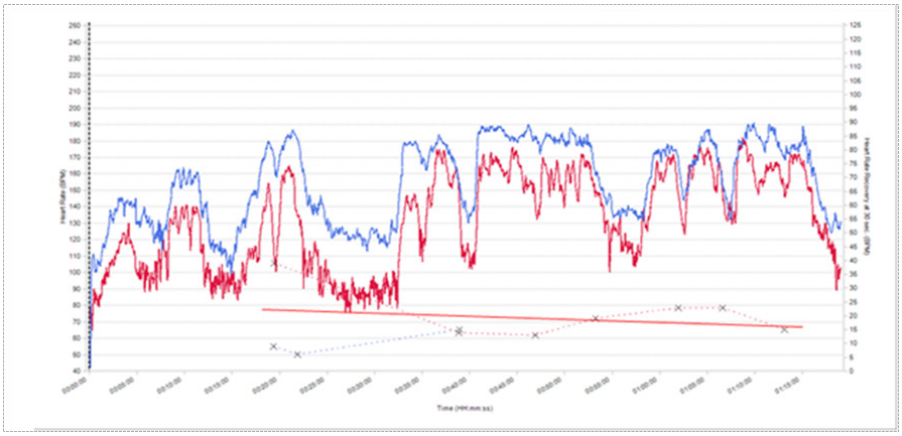


Left Axis	Right Axis
Training Load	Training Intensity

- Training Load & Intensity provide a metric that is a combination of the physiological and mechanical components for the most simplified summary of overall training value & impact of the workout session.

FITNESS PARAMETERS
Interpreting Graphs (4/9)

Recovery & Fatigue

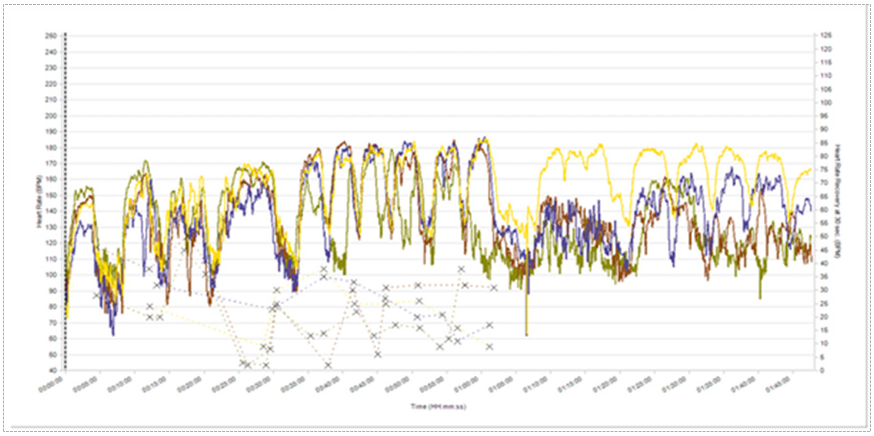


Left Axis	Right Axis
Heart Rate	Heart Rate Recovery @ 30 sec

- HRR 30 recordings are triggered when an athlete has exceeded an activity threshold and HR threshold for a set period of time, and then become inactive for 30 seconds to take a recovery measurement.

- Blue Subject 5 rarely stopped long enough for an HRR 30 recovery measurement to be taken.

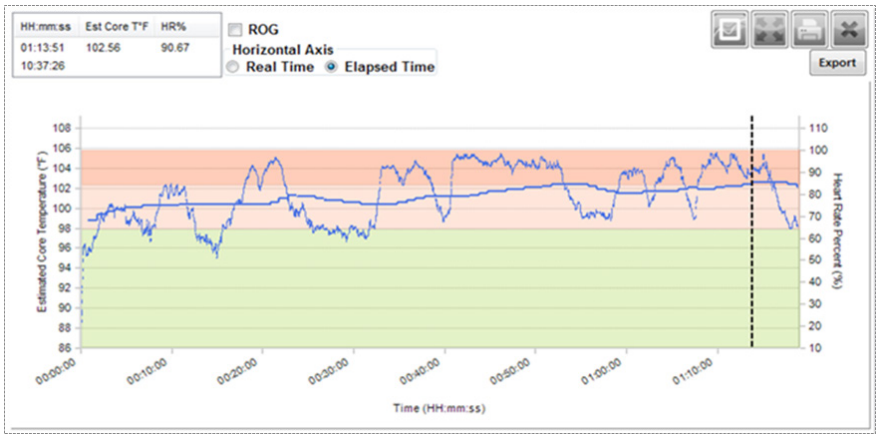
- Red subject 6 HRR30 trend line(red) shows only a very slight fatigue slope (recovery becomes slightly less as the session proceeds), which indicates that the subject is well conditioned and not pushed to fatigue. A steeper downward trend line may indicate the onset of fatigue.



- In the second half of this session, less recovery time was allowed, so automatic HRR 30 calculations are less frequent.

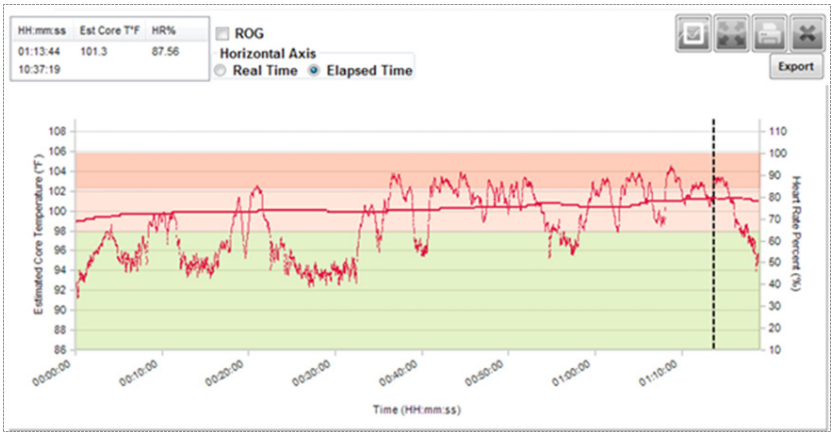
FITNESS PARAMETERS
Interpreting Graphs (5/9)

Safety & Core Temperature



Left Axis	Right Axis
Estimated Core Temperature	Heart Rate Percent

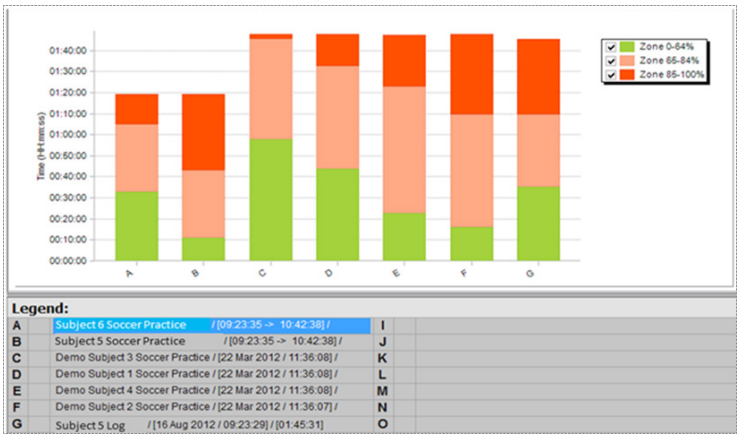
- This plot shows the subject Heart Rate % (% of Maximum Heart Rate) and Estimated Core Temperature over time.
- At the end of the session the vertical cursor location shows his core temperature reached a max of 102.56° F which is at the low end of potential heat stress.
- Beyond 103° to 104° F, there would be safety concerns.



- In the graph above the subject's temperature never reached an Alarm level (Max 101.3°F) because he was able to recover periodically.

FITNESS PARAMETERS
Interpreting Graphs (6/9)

Time in HR Zones



Left Axis	Right Axis
Time	N/A - only one summary parameter can display if the graph is a stacked bar chart

- This summary variable shows the time spent from 0 – 64.9% HRmax (green), 65 – 84.9% (orange) and 85 – 100% (red). These zones are fixed, and do not correspond to heart rate Training Zones.
- Maximum heart rate should be measured along with other fitness parameters and calibrated in the software by running through a fitness test as described in the **Baseline Fitness Testing** section.
- Subject 5 is included twice (bar B and bar G). Bar G is the log data imported later from his BioModule, with post session recovery data removed. You can do this by creating a subsession, described in the **Analysis Operations** section.

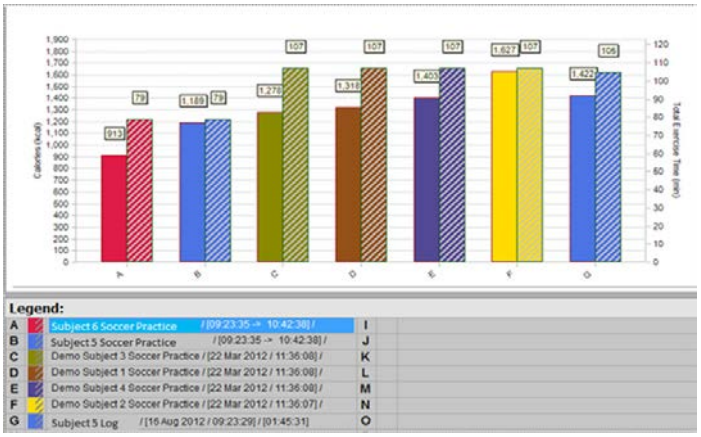
Note

The HR zones here are defined by the fixed thresholds 65% and 85% of subject maximum heart rate.

These should not be confused with the five Training zones, which are also heart rate zones, used in conjunction with workouts. Training Zone thresholds are configurable in Live **Preferences.**

FITNESS PARAMETERS
Interpreting Graphs (7/9)

Caloric Expenditure

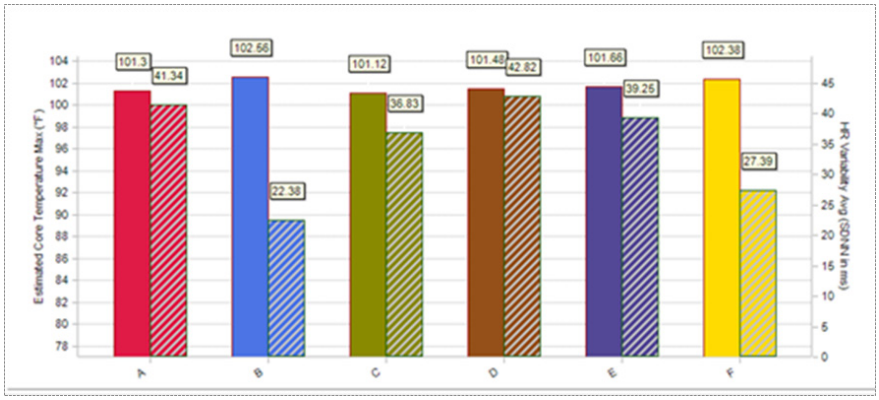


Left Axis	Right Axis
Calories	Exercise Time

- This graph shows a measure of calories burned and total session duration, which can be useful in estimating dietary replenishment needs.

FITNESS PARAMETERS
Interpreting Graphs (8/9)

Physiological Strain & Stress Indicators

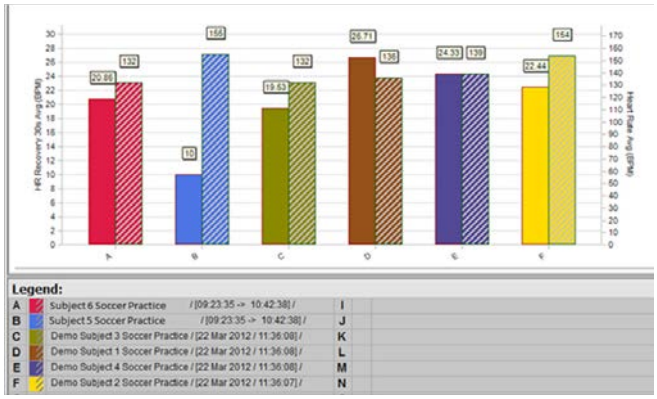


Left Axis	Right Axis
Estimated Core Temperature	Average Heart Rate Variability

- Estimated Core Temperature (Max) and Heart Rate Variability (Avg) can both be interpreted as measures of physiological strain.
- A low HRV is an indication of stress, fatigue and dehydration, and also relates to heat stress.
- Elevated Estimated Core Temperature is also an indication of heat stress and should be monitored carefully, particularly on a hot intense training session.

FITNESS PARAMETERS
Interpreting Graphs (9/9)

HR_{avg} & HRR Indicating Stress & Anxiety



Left Axis	Right Axis
HR Recovery 30s	Average Heart Rate

- Summary graph of average heart rate recovery in 30 seconds (drop in beats per minute after stopping an interval of high intensity activity), against average heart rate for the session.

- A low average recovery value indicates either a high level of anxiety, as in for bar B, and could also indicate a lower level of fitness .

APPENDIX 1
BioModule Firmware Upgrade (1/4)

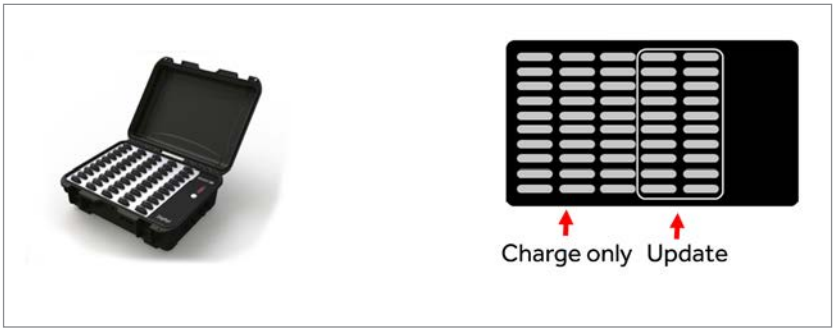
BioModules supplied with a new installation are configured with the latest firmware.

Should your OmniSense™ version be upgraded, or if you have existing BioModules, it may be necessary to upgrade the firmware in the devices.

OmniSense™ will generally support earlier versions of device firmware, but it is good practice to have the latest version of firmware in your device.

Refer to the next Appendix for more information on BioModule firmware versions.

1. Connect the BioModule(s) to your PC platform using the single or multi device cradle. In earlier system cases, the right hand 20 slots (two vertical rows) are marked as available for USB connection. The left hand 30 slots are for charging devices only.



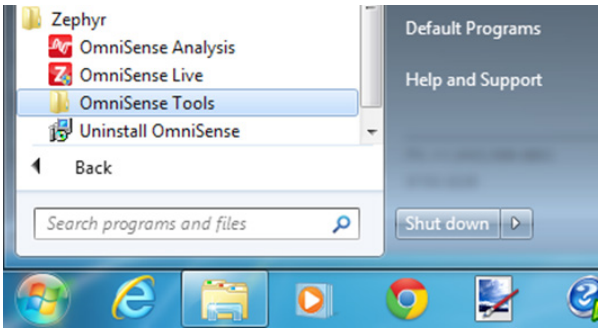
In later PSM50 system cases, all 50 slots are available for USB connection, but can only be connected to the PC 10 at a time, via 5 USB connectors on the side of the case. This is a Microsoft™* Windows™* limitation - more than 10 devices connected may affect device handling.

2. The 10 BioModules connected at any point are visible to the firmware update tool over USB. The remaining BioModules must be connected in turn.

APPENDIX 1
BioModule Firmware Upgrade (2/4)

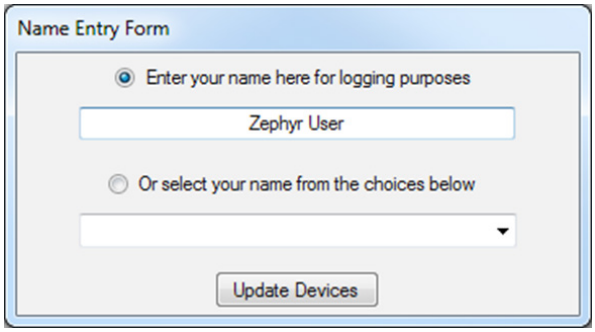
3. Locate the **ZUSBUPDATER.exe** utility, which is in the Firmware Upgrade directory of every OmniSense™ thumb drive, and double-click to start.

   It can also be found at C:\Program Files (x86)\Zephyr\OmniSense\Tools, or from the **Start > All Programs > Zephyr > OmniSense Tools**



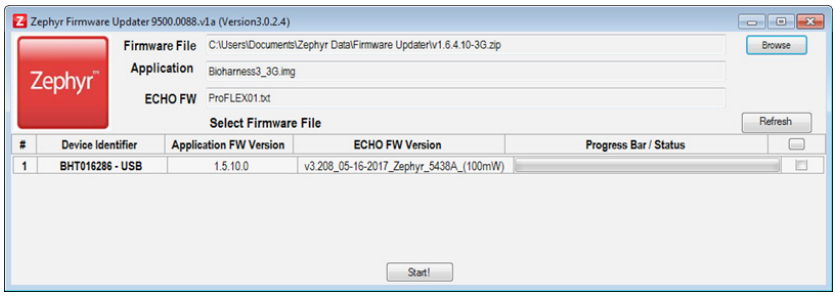
4. A dialog will display asking you to enter your name. This is **not** a security check – it merely records your name against device re-configurations made in a log file at

   C:\Program Data\Zephyr\ZephyrDeviceUpdateLog.csv.



   This will let system owners track configuration changes historically. Once entered, a name is saved and can be selected from the pull-down list.

5. Select **Update Devices** to display the updater tool. As of OmniSense™ 5.0, the updater tool can update the firmware for the LoRa module as well as the BioModule firmware. The firmware update file will be a .zip file if this is the case.

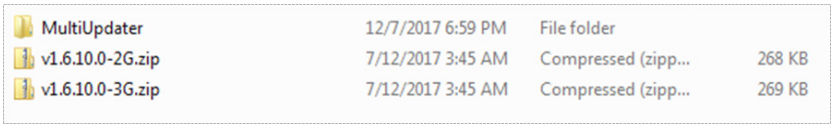


6. All detected devices will be displayed.

APPENDIX 1
BioModule Firmware Upgrade (3/4)

7. Click **Browse** to locate the desired firmware image file. Firmware image files are included in firmware upgrade directories.

   Some firmware images may consist of a single .img file. Others may be supplied as .zip files (for example, Bioharness4-1.6.10.0.zip). **Firmware images supplied as .zip files do not need to be unzipped;** the firmware updater will do this automatically.



Caution

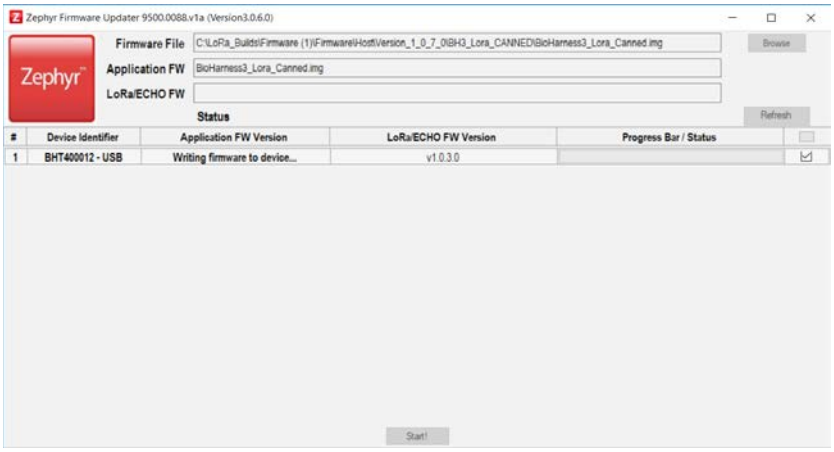
There are two variants of the BioModule, which are updated with different firmware images:

BioModule Version	Description
BioModule 3.0	Bluetooth™* 2.1 + ECHO + Bluetooth™* 4.0 (BLE)
BioModule 4.0	Bluetooth™* 2.1 + LoRa + Bluetooth™* 4.0 (BLE)

The devices are identical externally. If you are uncertain of the generation of your BioModule, use the Zephyr™ Config Tool to read its hardware part number.

BioModule Version	Hardware Part #	Firmware Image Example
BioModule 3.0	9800.0189.v9k	BioHarness3_3G_v1.7.8.0.img
BioModule 4.0	PT00121656A	BioHarness4_v1.0.0.0.img

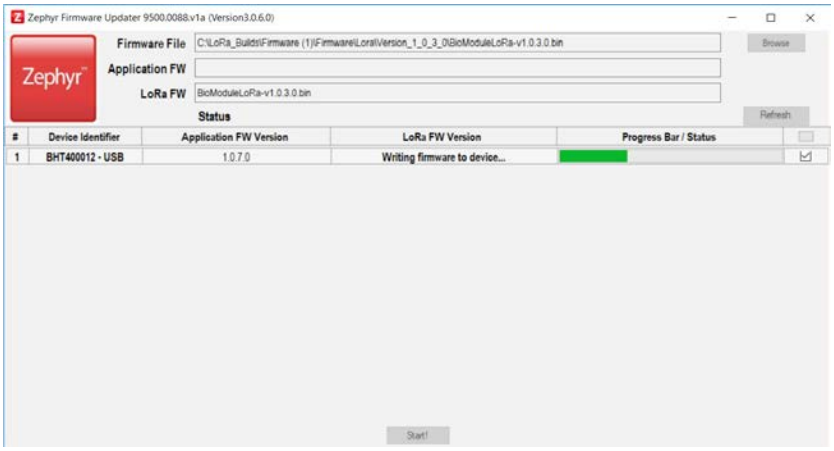
8. When the .zip or .img file is loaded into the updater, the component file(s) will be displayed individually in the **Application** and **LoRa/ECHO FW** fields.



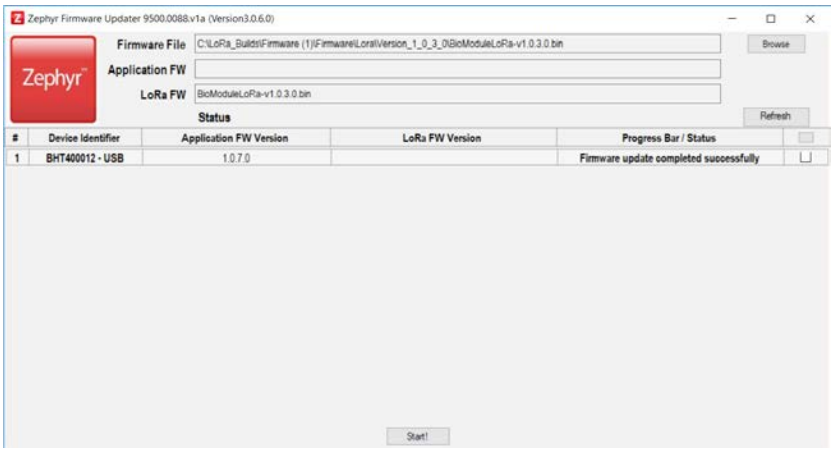
   Check the right-most boxes of those devices to be updated, and select **Start!** To update

APPENDIX 1
BioModule Firmware Upgrade (4/4)

9. The green and red LEDs will flash during the firmware image update, and the blue and orange LEDs will flash during the LoRa firmware update. The progress bar will indicate the update is taking place.



10. A **'Firmware update completed successfully'** message will display on successful update of the firmware, or a diagnostic message if the update has failed.



11. Retry if necessary.

12. Contact zephyrperformancesupport@medtronic.com if any problems persist.

Note

If you are experiencing problems with firmware updates and your BioModules are connected to the PC via a USB hub, then bypass the hub and connect the charge cradle or case direct to a USB port. Also consider replacing the USB connector.

APPENDIX 2
BioModule Firmware Versions

The table of firmware version information can be used when updating BioModule firmware.

Date	Version	Part No.	Description
Aug 2020	1.0.0.0	PT00121671A	Initial Release

APPENDIX 3
BioModule Log Data Descriptions (1/8)

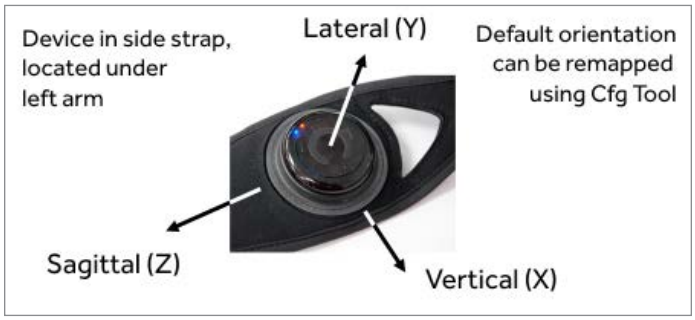
Log Data

BioModule log data can be imported into OmniSense™ Analysis using the Zephyr™ Downloader tool, This tool can also be used to generate external csv (and other formats) of log data.

The data descriptions here, and file names, refer to these external files.

Note
Not all BioModule log data is imported into OmniSense™ Analysis - logs - ECG and Accelerometer waveform data are not as they contain very large amounts of data which could not be usefully viewed in Analysis.

Accelerometer Axis Mapping



A BioModule should be configured for the appropriate garment. When setting

Garment type in OmniSense™ Live, the appropriate axis mappings will be made automatically.

Session Info

The Zephyr™ Downloader will generate a SessionInfo text file in addition to the csv log output files. The data in this file is not stored on the BioModule - it is generated by the downloader itself.

```
Sample Data:
Subject Information
~~~~~~~~~~~~~~~~~~~
Name: UNKNOWN
Gender: UNKNOWN
Birth Year: UNKNOWN
ROG Act Min/Max : UNKNOWN
ROG Resp Min/Max : UNKNOWN
ROG HR Min/Max : UNKNOWN
ROG O2R sec / sec : UNKNOWN

Device Information
~~~~~~~~~~~~~~~~~~
Serial number: UNKNOWN
MAC address: UNKNOWN
Device Friendly Name: UNKNOWN

Session Information
~~~~~~~~~~~~~~~~~~~
Log Format: 0011
Log Date: Tuesday, 24 July 2012
Log Time: 4:19:37 p.m.
Log Duration: 00:03:32
Page Period(ms): 1000
```

APPENDIX 3
BioModule Log Data Descriptions (2/8)

Logging Formats

The logging format of a BioModule is configurable using the Zephyr™ Config Tool. The more comprehensive log formats use more device memory, which reduces the total hours of data which can be stored in the device.

Users should configure the device to suit their parameter configuration and total log duration needs.

Supported logging formats:

- Summary
- Summary + Waveform
- Summary + Development
- Enhanced Summary
- Enhanced Summary + Waveform
- Enhanced Summary + Development

The output from the Zephyr™ Downloader may generate more than one output file for a given log format, as individual parameters are reported at different frequencies.

The Zephyr™ Downloader can also export log files in varying file formats, selected from the menu in the downloader.

Note:

Some waveform log parameters such as ECG are only available via external files generated using the Zephyr™ Downloader. The waveforms cannot be displayed within OmniSense™ Analysis itself.

File Type	Description
.csv	Comma Separated Values which can be opened in Microsoft™* Excel™*, Notepad™* or similar, or imported into many data processing applications.
.dat/.hed file pairs	Designed for input of large data sets into 3rd party data processing applications such as DaDISP™*
.kml	For GPS data display using Google™* Earth™* - the BioModule must be used in conjunction with a supported GPS device.

Invalid Values

Variants on the Summary Log Formats may contain data values which indicate an invalid value – the data is not available, or the device does not support the parameter. Invalid values are provided where applicable.

APPENDIX 3
BioModule Log Data Descriptions (3/8)

Memory Capacity

The BioModule will continue to log until the memory capacity is full. When this happens, it will erase the oldest log in memory, and continue to write the current log in the space available. This process will repeat until the current logging session is terminated.

When an old log is overwritten by the current one – all of that log will be erased, even if only part of the freed space is used.

If the device is configured to log in Summary and Development mode, then the maximum possible log duration with new batteries (~35 hours) will exceed the maximum memory capacity of the device (~30 hours). In this situation, the saved part of the current log will be erased, freeing up all memory space. When the logging session is terminated, the only data saved and available for download will be that which was logged **after** the initial 30 hours.

Logging Format	Memory Capacity (Hrs)
Summary	450
Summary + Waveform	60
Summary + Development	30
Enhanced Summary	450
Enhanced Summary + Waveform	60
Enhanced Summary + Development	30

Timestamp Formats

A variety of time stamp formats are used in Zephyr™ csv files. Some are user-friendly, others less so. The latter are normally associated with data parameters which are likely to be of more use to an engineer who is integrating BioModule data into other software applications, who is less concerned with the data being human readable when processed internally.

APPENDIX 3
BioModule Log Data Descriptions (4/8)

General Log Format Output (Legacy)

This describes the actual external .csv files generated by the Zephyr™ Downloader tool.

Log Format	Reporting Frequency	Parameters	File Name
General	1 Hz	Heart Rate Breathing Rate Posture Activity Acceleration Battery BR Amplitude ECG Amplitude ECG Noise X Acc Min X Acc Peak Y Acc Min Y Acc Peak Z Acc Min Z Acc Peak	yyyy_mm_dd-hh_mm_ss_General
	18 Hz	Breathing Waveform Heart RR	yyyy_mm_dd-hh_mm_ss_BR_RR
	Per Event	Event Code Event Type Source Event ID Event Specific Data	yyyy_mm_dd-hh_mm_ss_Event_Data
	Per Download	Subject Information Device Information Session Information	yyyy_mm_dd-hh_mm_ss_SessionInfo.txt
General + ECG	250 Hz	ECG	yyyy_mm_dd-hh_mm_ss_ECG
General + Acc	100 Hz	Acceleration Magnitude (g)	yyyy_mm_dd-hh_mm_ss_AccelMag

APPENDIX 3
BioModule Log Data Descriptions (5/8)

Summary Log Format Output

Descriptions for the external .csv files generated by the Zephyr™ Downloader tool.

Log Format	Reporting Frequency	Parameters	File Name
Summary	1 Hz	Heart Rate Breathing Rate Posture Activity Peak Acceleration Battery Voltage Battery % BR Amplitude BR Noise BR Confidence ECG Amplitude ECG Noise HR Confidence HRV System Confidence GSR Status ROG Time ROG Vert Acc Min Vert Acc peak Lateral Acc Min Lateral Acc Peak Sagittal Acc Min Sagittal Acc Peak Device Temperature Status Info Link Quality RSSI Tx Power Core Temperature Aux ADC1/2/3	yyyy_mm_dd-hh_mm_ss_Summary
	Per Event	Heart RR	yyyy_mm_dd-hh_mm_ss_RR
	Per Event	Breathing BB	yyyy_mm_dd-hh_mm_ss_BB
	Per Download	Subject Information Device Information Session Information	yyyy_mm_dd-hh_mm_ss_SessionInfo.txt
	Per Event	Event Code Event Type Source Event ID Event Specific Data	yyyy_mm_dd-hh_mm_ss_Event_Data

APPENDIX 3
BioModule Log Data Descriptions (6/8)

Summary Log Format Output (Continued)

Descriptions for the external .csv files generated by the Zephyr™ Downloader tool.

Log Format	Reporting Frequency	Parameters	File Name
Summary + Waveform	250 Hz	ECG	yyyy_mm_dd-hh_mm_ss_ECG
	100 Hz	Vertical Acc Lateral Acc Sagittal Acc	yyyy_mm_dd-hh_mm_ss_Accel
	25 Hz	Breathing Waveform	yyyy_mm_dd-hh_mm_ss_Breathing
Summary + Development	1000 Hz	ECG Waveform	yyyy_mm_dd-hh_mm_ss_ECG
	100 Hz*	Vertical Acc Lateral Acc Sagittal Acc	yyyy_mm_dd-hh_mm_ss_Accel
	25 Hz	Breathing Waveform	yyyy_mm_dd-hh_mm_ss_Breathing
+ GPS	1 Hz	Location (Lat/Long) Altitude GPS fix Quality Speed Over Ground Track Angle HDOP	yyyy_mm_dd-hh_mm_ss_GPS

* Accelerometer data is reduced in resolution from 12 bit to 10 bit to accommodate the additional ECG data.

APPENDIX 3
BioModule Log Data Descriptions (7/8)

Enhanced Summary Log Format Output

The parameters below are contained in the Enhanced Summary log format in addition to all of the parameters previously described in the Summary log format.

Log Format	Reporting Frequency	Parameters	File Name
Enhanced Summary	1Hz	Impulse Load Walk Steps Run Steps Bounds Jumps Minor Impacts Major Impacts Average Rate Force Development Average Step Impulse Average Step Period Jump Flight Time Peak g Phi Angle Peak g Theta Angle	yyyy_mm_dd-hh_mm_ss_ SummaryEnhanced
	Per Event	Heart RR	yyyy_mm_dd-hh_mm_ss_RR
	Per Event	Breathing BB	yyyy_mm_dd-hh_mm_ss_BB
	Per Download	Subject Information Device Information Session Information	yyyy_mm_dd-hh_mm_ss_ SessionInfo.txt
	Per Event	Event Code Event Type Source Event ID Event Specific Data	yyyy_mm_dd-hh_mm_ss_Event_Data

APPENDIX 3
BioModule Log Data Descriptions (8/8)

Enhanced Summary Log Format Output (Continued)

The parameters below are contained in the Enhanced Summary log format in addition to all of the parameters previously described in the Summary log format.

Log Format	Reporting Frequency	Parameters	File Name
Enhanced Summary + Waveform	25 Hz	ECG	yyyy_mm_dd-hh_mm_ss_ECG
	100 Hz	Vertical Acc Lateral Acc Sagittal Acc	yyyy_mm_dd-hh_mm_ss_Accel
	25 Hz	Breathing Waveform	yyyy_mm_dd-hh_mm_ss_Breathing
Enhanced Summary + Development	1000 Hz	ECG Waveform	yyyy_mm_dd-hh_mm_ss_ECG
	100 Hz*	Vertical Acc Lateral Acc Sagittal Acc	yyyy_mm_dd-hh_mm_ss_Accel
	25 Hz	Breathing Waveform	yyyy_mm_dd-hh_mm_ss_Breathing
+ GPS	1 Hz	Location (Lat/Long) Altitude GPS fix Quality Speed Over Ground Track Angle HDOP	yyyy_mm_dd-hh_mm_ss_GPS

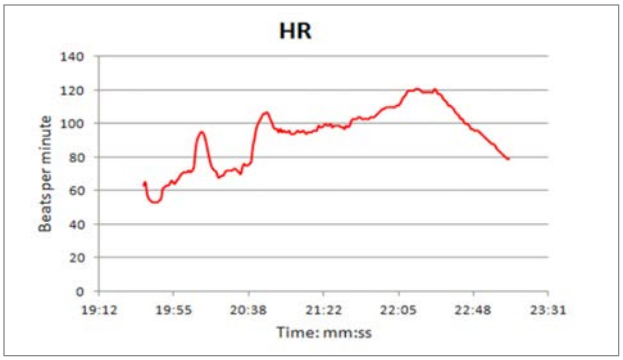
* Accelerometer data is reduced in resolution from 12 bit to 10 bit to accommodate the additional ECG data.

APPENDIX 4
BioModule Log Data Parameters (1/53)

Index of Parameters

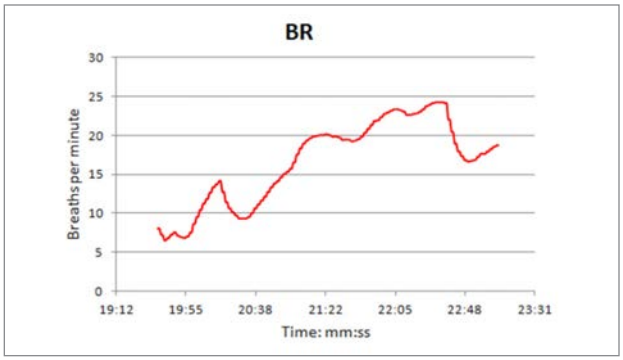
APPENDIX 4
BioModule Log Data Parameters (2/53)

Heart Rate

Log Format	All formats
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	105, 106, 95, 89, 86...
Range	25 - 240
Units	Beats per minute
Invalid Value	
Sample Graph	
Notes	Values consistently above 200+ beats per minute may indicate a noisy ECG signal. Causes include: ▪ Dry sensor pads or skin ▪ Loose strap ▪ Poorly located strap ▪ Poor device/receptacle connection ▪ Device or strap fault Dropouts to 0 usually indicate a mechanical connection problem ▪ Check connection between device and receptacle – handle spring contacts carefully to avoid breaking them Raw ECG data is filtered to account for false or missed R detections, and some smoothing is applied. HR is determined mainly from the preceding 15 seconds of ECG data. The HR detection algorithm initializes at 65 beats per minute. This may show at the beginning of a log file for ~7 seconds, but will be flagged invalid, as the algorithm processes initial data. A flag in the **Status Info** channel of the **Summary** Log will indicate whether the HR data is valid.

APPENDIX 4
BioModule Log Data Parameters (3/52)

Breathing Rate

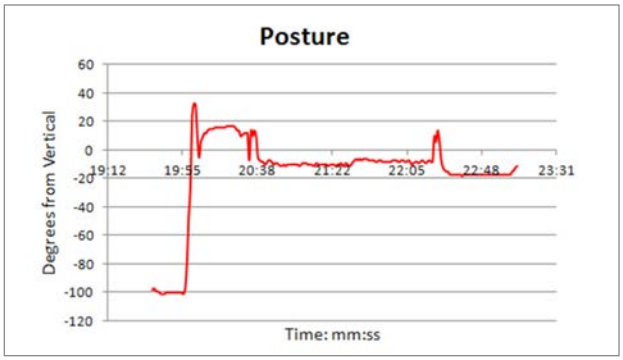
Log Format	All formats
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	8.1, 8.1, 7.3, 7.3, 6.6, 6.6
Range	4 - 70
Units	Breaths per minute
Invalid Value	
Sample Graph	
Notes	Breathing is detected by a pressure sensor in the Zephyr™ Strap which detects torso expansion and contraction due to breathing. Several breath cycles are necessary for initial breathing rate indication to stabilize (15 – 45 seconds). Spontaneous adjustment of strap tension or location, or abrupt changes in posture, talking, coughing etc may cause changes in the range of pressure detected by the strap which produce temporary artefacts (peaks or troughs) in breathing rate indication. These should be anticipated and potentially ignored when analyzing data.

APPENDIX 4
BioModule Log Data Parameters (4/53)

Skin Temperature

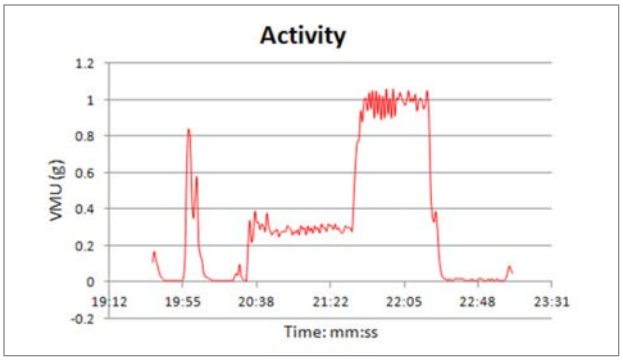
Log Format	General log formats
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	-3276.8, -3276.8, -3276.8...
Range	10 - 60
Units	Deg C
Invalid Value	-3276.8
Sample Graph	Not supported by BioModule 3.0. BioModule 3.0 always reports the invalid value.
Notes	The BioModule 3.0 has replaced this parameter with Estimated Core Temperature in the Summary and Enhanced Summary log formats.

Posture

Log Format	All formats
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	-98, -97, -99...
Range	± 180
Units	Degrees from vertical
Invalid Value	
Sample Graph	
Notes	0 ° = subject vertical. 90 ° = subject prone (face down). -90 ° = subject supine (face up). ± 180 ° = subject inverted. There is likely to be an offset of 5-15 ° from 0 for a 'vertical' subject due to variations in torso shape and actual posture.

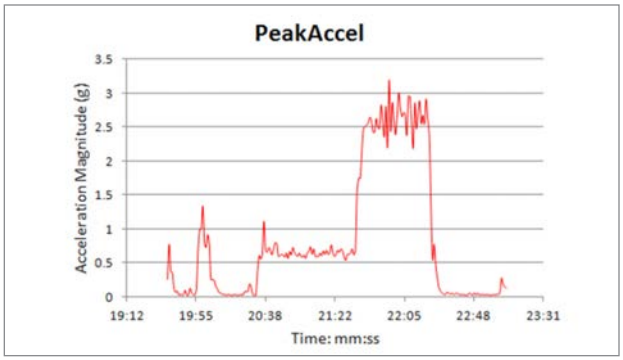
APPENDIX 4
BioModule Log Data Parameters (5/53)

Activity Level

Log Format	All formats
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	0.11, 0.17, 0.12...
Range	0 - 16
Units	Vector Magnitude Units (VMU), measured in g
Invalid Value	
Sample Graph	
Notes	VMU = $\sqrt{(x^2+y^2+z^2)}$ where x, y and z are the average of the three axial acceleration magnitudes over the previous 1 second epoch, sampled at 100Hz. Walking ~ 0.2 VMU or greater Jogging ~ 0.8 VMU or greater Axial accelerometer output is band pass filtered, to remove non-human artefacts, and gravity.

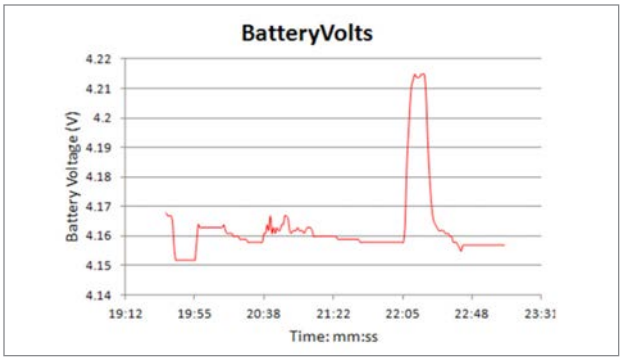
APPENDIX 4
BioModule Log Data Parameters (6/53)

Peak Acceleration

Log Format	All formats
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	0.26, 0.78, 0.38...
Range	0 - 16
Units	g
Invalid Value	
Sample Graph	
Notes	The Peak Acceleration Magnitude is calculated for the previous second: Peak Accn = $(\sqrt{(x^2 + y^2 + z^2)})_{max}$ where x, y and z are the 3 axial acceleration values, sampled at 100 Hz. Raw accelerometer output is filtered to remove non-human artefacts, and gravity. The maximum value is capped at 16g.

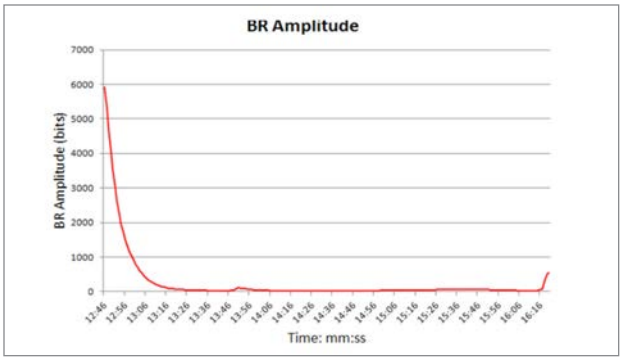
APPENDIX 4
BioModule Log Data Parameters (7/53)

Battery Voltage

Log Format	All formats
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	4.168, 4.167, 4.167...
Range	~ 3.6 to ~ 4.2 for a functioning battery
Units	Volts
Invalid Value	
Sample Graph	
Notes	Fully charged ~ 4.2V, fully discharged ~ 3.6V The device processor will turn the device off when battery voltage < 3.6V, to prevent further discharge causing permanent damage to the battery.

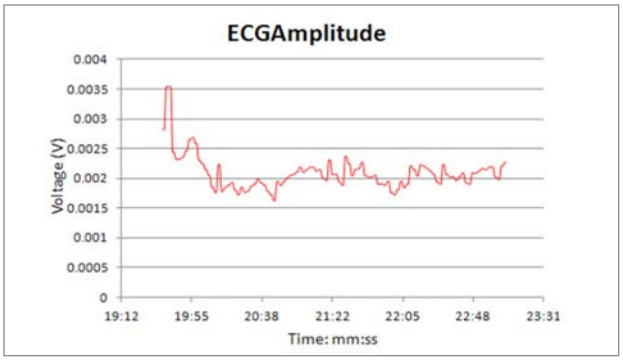
APPENDIX 4
BioModule Log Data Parameters (8/53)

Breathing Wave Amplitude

Log Format	All formats
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	5864, 5307, 4698...
Range	0 - 65534
Units	N/A
Invalid Value	
Sample Graph	
Notes	This is a metric extracted from the breathing detection algorithm, and is used for internal development only. Initial value is large, but reduces rapidly as the algorithm has data to process.

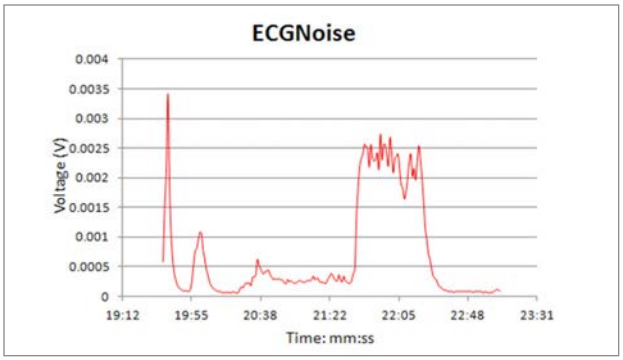
APPENDIX 4
BioModule Log Data Parameters (9/53)

ECG Amplitude

Log Format	All formats
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	0.00282, 0.00282, 0.00354...
Range	0 – 0.05
Units	Volts
Invalid Value	
Sample Graph	
Notes	Indicative only – this parameter represents an un-calibrated amplitude (measured from peak of the R wave to peak of the S wave) of the QRS complex. This value is filtered to attempt to remove noise related variation, however will increase during periods of high noise.

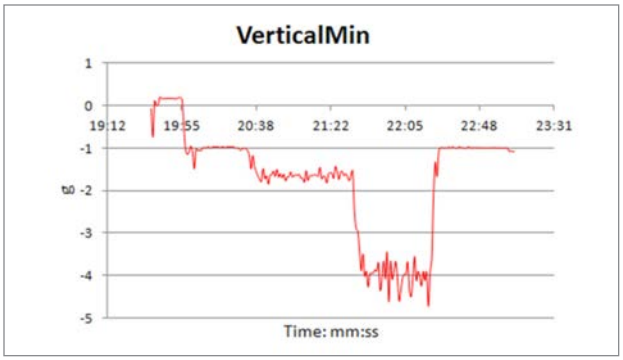
APPENDIX 4
BioModule Log Data Parameters (10/53)

ECG Noise

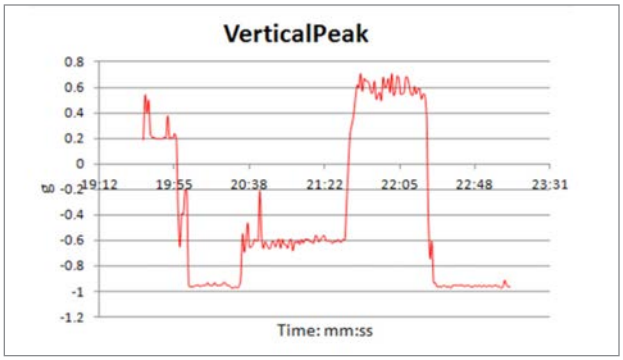
Log Format	All formats
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	0.00058, 0.0015, 0.00216...
Range	0 – 0.05
Units	Volts
Invalid Value	
Sample Graph	
Notes	Indicative only – this parameter represents an un-calibrated amplitude of noise signals measured between QRS complexes. This is directly comparable to the ECG amplitude for SNR calculations.

APPENDIX 4
BioModule Log Data Parameters (11/53)

X Acceleration Minimum (VerticalMin)

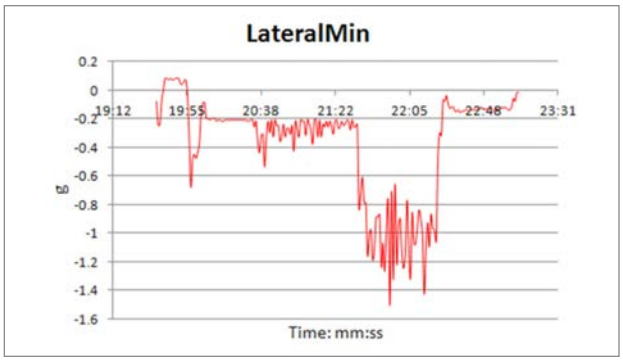
Log Format	All formats
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	-0.08, -0.75, 0.1...
Range	±16
Units	g
Sample Graph	
Notes	X axis = subject vertical. Minimum value during previous second, sampled at 100Hz. This is raw, unfiltered data.

X Acceleration Peak (VerticalPeak)

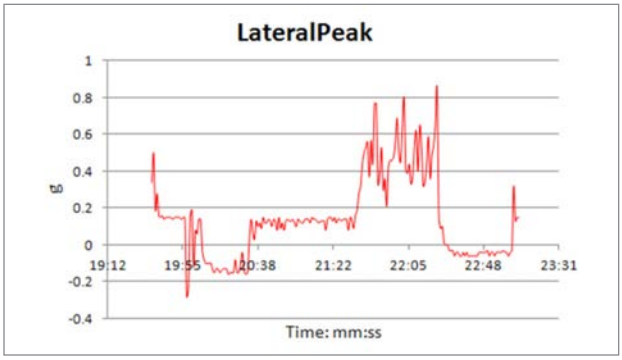
Log Format	All formats
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	0.19, 0.54, 0.4...
Range	±16
Units	g
Sample Graph	
Notes	X axis = subject vertical. Maximum value during previous second, sampled at 100Hz. This is raw, unfiltered data.

APPENDIX 4
BioModule Log Data Parameters (12/53)

Y Acceleration Minimum (LateralMin)

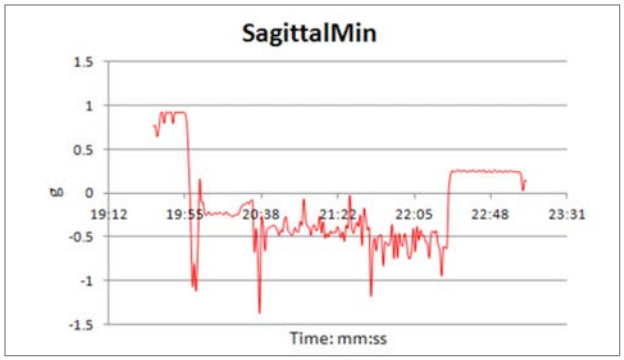
Log Format	All formats
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	0.19, 0.54, 0.4...
Range	±16
Units	g
Sample Graph	
Notes	Y axis = subject lateral. Minimum value during previous second, sampled at 100Hz. This is raw, unfiltered data.

Y Acceleration Peak (LateralPeak)

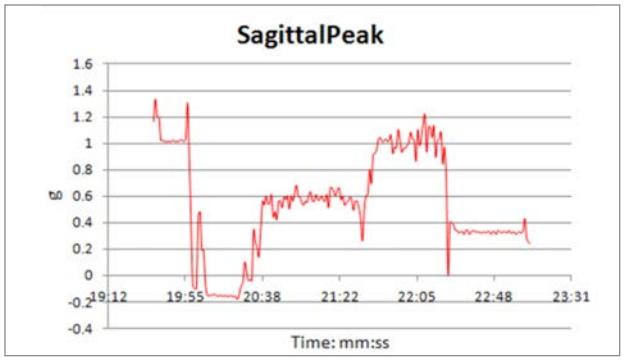
Log Format	All formats
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	0.19, 0.54, 0.4...
Range	±16
Units	g
Sample Graph	
Notes	Y axis = subject lateral. Maximum value during previous second, sampled at 100Hz. This is raw, unfiltered data.

APPENDIX 4
BioModule Log Data Parameters (13/53)

Z Acceleration Minimum (SagittalMin)

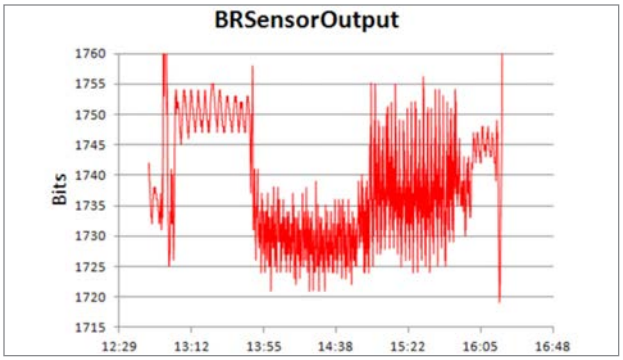
Log Format	All formats
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	-0.08, -0.25, -0.24...
Range	±16
Units	g
Sample Graph	
Notes	Z axis = subject sagittal (front/rear). Minimum value during previous second, sampled at 100Hz. This is raw, unfiltered data.

Z Acceleration Peak (SagittalPeak)

Log Format	All formats
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	0.34, 0.5, 0.19...
Range	±16
Units	g
Sample Graph	
Notes	Z axis = subject sagittal (front/rear). Maximum value during previous second, sampled at 100Hz. This is raw, unfiltered data.

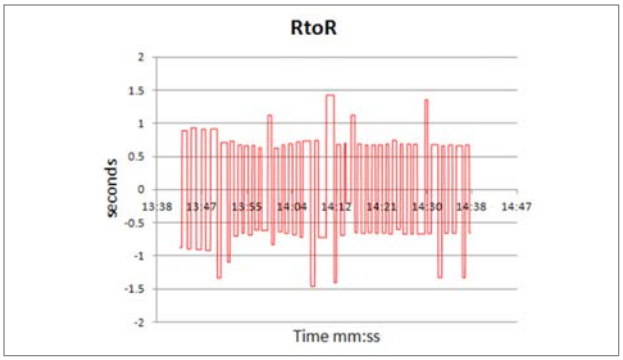
APPENDIX 4
BioModule Log Data Parameters (14/53)

Breathing Waveform

Log Format	General - Breathing & RR
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	18 Hz
Sample Data	1741, 1742,1741...
Range	0 - 4096
Units	bits
Invalid Value	
Sample Graph	
Notes	Reported at 18Hz. This is the raw unfiltered breathing sensor output. Its main use is to determine whether there is sufficient dynamic range to indicate that the sensor is functioning correctly – this may be a few tens to a few hundreds of bits, depending on subject breathing mechanics. The data is then heavily filtered and processed in order to establish a respiration rate. The data is reflecting changes of pressure on the breathing sensor if used with a Zephyr™ strap. This will vary according to an individual's breathing mechanics, their body composition, and how tight the strap is fitted. As such **no inference** can be made on breathing depth or volume from this data.

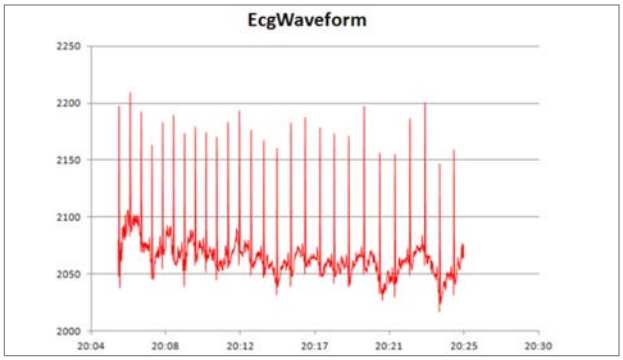
APPENDIX 4
BioModule Log Data Parameters (15/53)

Heart R-R

Log Format	General - Breathing & RR
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	-0.702, -0.702, 0.857...
Range	0 – 32.767
Units	Seconds
Invalid Value	
Sample Graph	
Notes	Reported at 18Hz. The last detected R interval is repeated until a new R detection is calculated. Fresh detections are toggled positive/negative so that identical-magnitude detections in sequence can be distinguished. This method is used because the parameter must be reported at regular intervals, but changes irregularly.

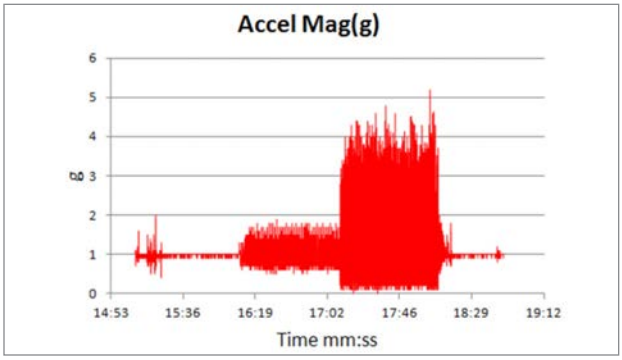
APPENDIX 4
BioModule Log Data Parameters (16/53)

ECG Waveform

Log Format	Summary & Waveform Summary & Development Enhanced Summary & Waveform Enhanced Summary & Development
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	250 Hz (1000 Hz in Development formats)
Sample Data	2167, 2167, 2166...
Range	0 - 4095
Units	bits
Invalid Value	
Sample Graph	
Notes	Sampled at 1KHz Conversion to mV: 2048 bits = 0mV 1 bit = 0.00625mV

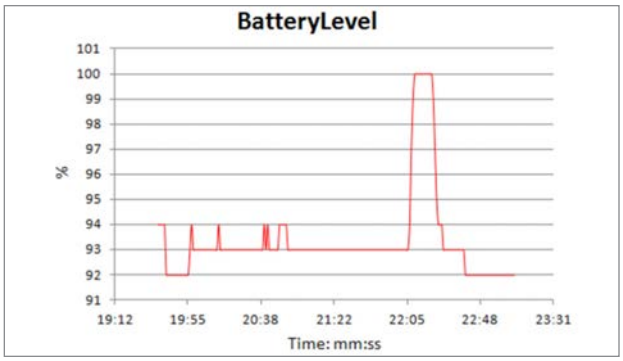
APPENDIX 4
BioModule Log Data Parameters (17/53)

Acceleration Magnitude

Log Format	[Enhanced] Summary & Waveform
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	100 Hz
Sample Data	1.1, 1.1, 1...
Range	0 - 16
Units	g
Invalid Value	
Sample Graph	
Notes	Sampled and reported at 100Hz. Magnitude = ($\sqrt{(x^2 + y^2 + z^2)}$) where x,y & z are the three axial accelerometer values. This is raw, unfiltered data.

APPENDIX 4
BioModule Log Data Parameters (18/53)

Battery Level

Log Format	Summary & Enhanced Summary
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	94,94,93
Range	0 - 100
Units	% Fully Charged
Sample Graph	
Notes	100% ~ 4.2V 0% ~ 3.6V If battery discharged curves are stored historically, battery health can be monitored.

Breathing Noise Level

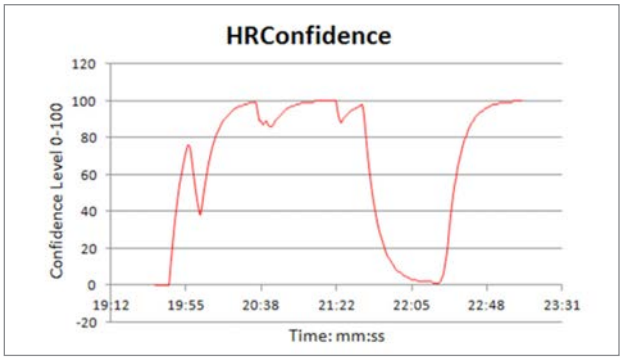
Log Format	Summary & Enhanced Summary
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	
Range	0 - 65534
Units	Bits
Invalid Value	65535
Sample Graph	Invalid value of 65535 is always reported.
Notes	This parameter is not currently implemented – an invalid value is always reported.

APPENDIX 4
BioModule Log Data Parameters (19/53)

Breathing Confidence

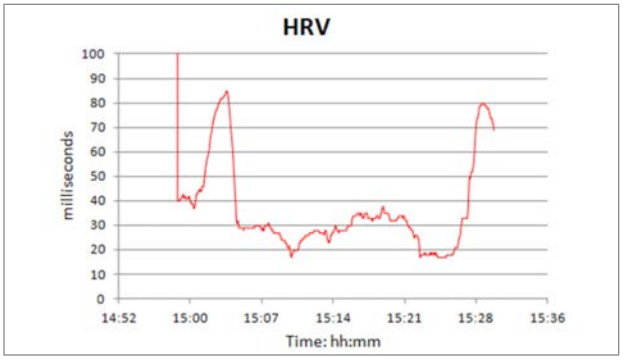
Log Format	Summary & Enhanced Summary
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	255, 255, 255...
Range	0 - 254
Units	Bits
Invalid Value	255
Sample Graph	Parameter not supported - a constant invalid value of 255 reported.
Notes	This parameter is not currently implemented – an invalid value is always reported.

Heart Rate Confidence

Log Format	Summary & Enhanced Summary
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	0,23,75
Range	0 -100
Units	%
Sample Graph	
Notes	An algorithm which takes into account a worn detection indication, and the signal-to-noise ratio of the ECG signal is used to establish HR confidence. Above 20% indicates a reliable heart rate. 0% indicates not worn indication or an extremely noisy ECG signal.

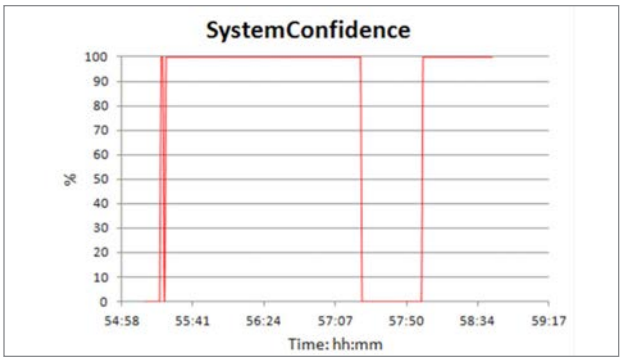
APPENDIX 4
BioModule Log Data Parameters (20/53)

Heart Rate Variability

Log Format	Summary & Enhanced Summary
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	65535 initially, till calculated, then 50,52,54...
Range	0 - 65534
Units	Standard deviation in milliseconds
Invalid Value	65535
Sample Graph	
Notes	Two optional metrics can be configured using the Zephyr™ Config Tool. ▪ SDNN - an algorithm calculates a rolling 300 heartbeat value. This is updated once per second. For the first 300 beats of the log, the invalid value will be reported. ▪ RMSSD - an algorithm calculates a rolling 15-second value. The invalid value is reported prior to the first calculation. ▪ For both algorithms, if heart rate data becomes invalid, then the last valid HRV value will be reported for a maximum of 1 minute. After this, an invalid value will be reported, and the algorithm re-initialized when the heart rate becomes valid again. ▪ If heart rate is invalid for less than one minute, then the invalid values will be ignored and the algorithm will continue processing.

APPENDIX 4
BioModule Log Data Parameters (21/53)

System Confidence

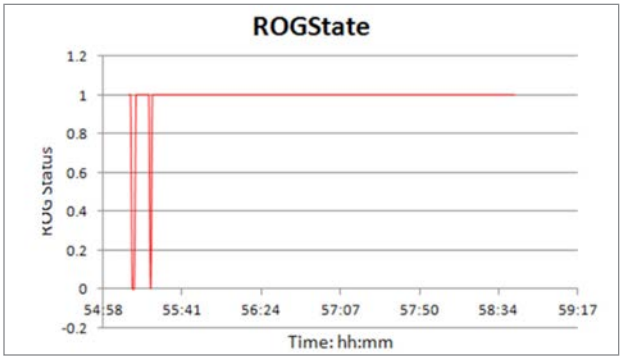
Log Format	Summary & Enhanced Summary
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	0, 100
Range	0 - 100
Units	%
Sample Graph	
Notes	System Confidence is a development parameter which will combine HR confidence with other parameters as they become available. At present System Confidence is identical to HR Confidence.

APPENDIX 4
BioModule Log Data Parameters (22/53)

Galvanic Skin Response (GSR)

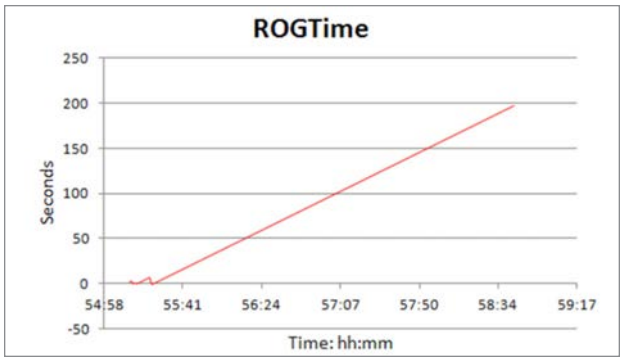
Log Format	Summary & Enhanced Summary
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	65535, 65535, 65535
Range	0 - 65534
Units	Siemens
Invalid Value	65535
Sample Graph	A constant invalid value of 65535 is always returned.
Notes	GSR was originally implemented in the BioModule 2.0. It is not supported in the BioModule 3.0

ROG Subject Status

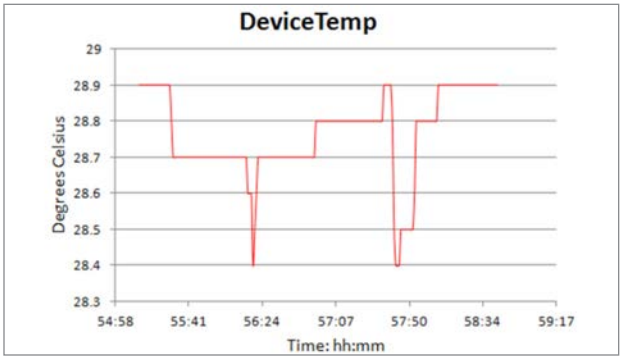
Log Format	Summary & Enhanced Summary
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	1,1,0...
Range	0,1,2,3
Units	Status indication
Invalid Value	0
Sample Graph	
Notes	0=Invalid 1=Green, 2=Orange, 3=Red

APPENDIX 4
BioModule Log Data Parameters (23/53)

ROG Time

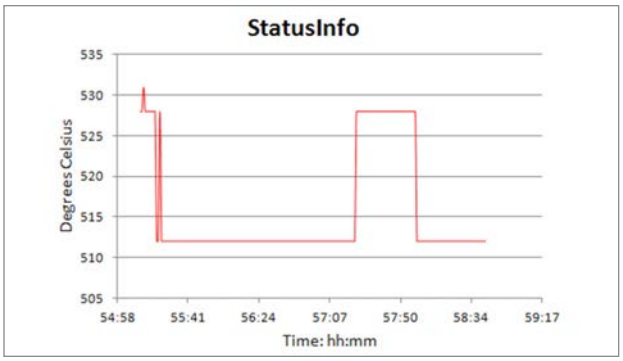
Log Format	Summary & Enhanced Summary
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	0, 1, 2...
Range	0 - 8291
Units	Seconds
Sample Graph	
Notes	Time duration in current status. This value resets to 0 each time status changes, and increments for every second the status remains unchanged.

Device Temperature

Log Format	Summary & Enhanced Summary
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	28.9, 28.9, 28.9...
Range	10 - 60
Units	Degrees Celsius
Sample Graph	
Notes	Temperature as measured by a thermistor inside the BioModule. Some conductive heating from the subject will occur as time progresses, resulting in a slow increase of temperature, in the absence of other factors.

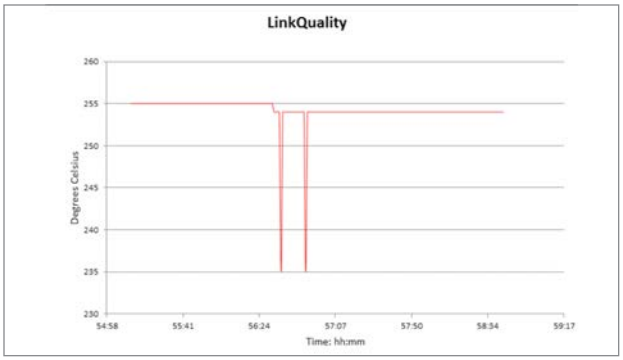
APPENDIX 4
BioModule Log Data Parameters (24/53)

Status Info

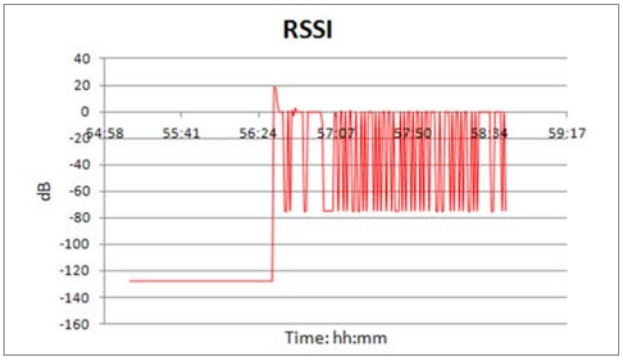
Log Format	Summary & Enhanced Summary
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	528, 528, 531...
Range	
Units	Status Info code
Sample Graph	
Notes	Status codes are reported in hexadecimal format must be converted to binary for interpretation. Refer to the Bluetooth™* Comms Link document in the BioModule SDK for further interpretation. Details may determine: ▪ Worn detection confidence ▪ Button press detection ▪ Not fitted to garment indication ▪ Heart Rate reliability ▪ Respiration rate reliability ▪ Skin temperature reliability ▪ Posture reliability ▪ Activity reliability ▪ HRV reliability ▪ Estimated Core Temperature Reliability

APPENDIX 4
BioModule Log Data Parameters (25/53)

Link Quality

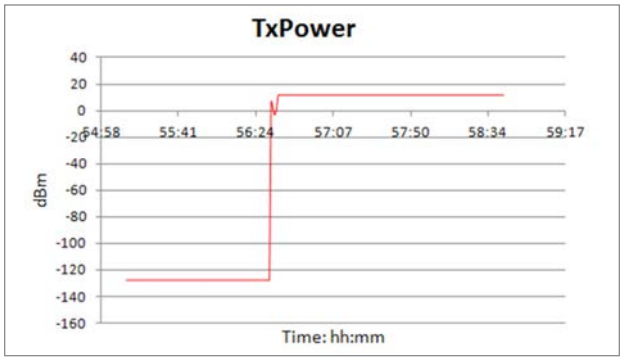
Log Format	Summary & Enhanced Summary
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	255, 255, 255...
Range	0 - 255
Units	No units – 0=poor quality, 254=high quality
Invalid Value	255
Sample Graph	
Notes	A Bluetooth™* connection with an Android™* device was established during the session above.

Bluetooth™* Received Signal Strength Indication - RSSI

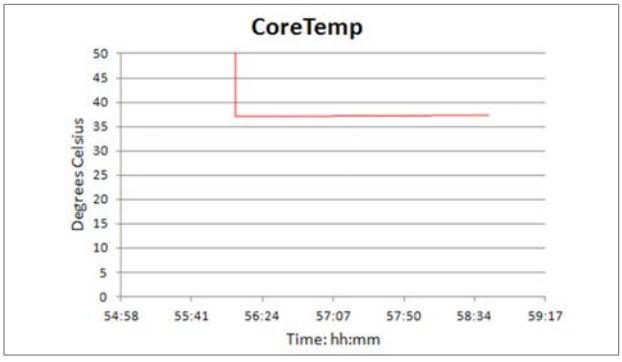
Log Format	Summary & Enhanced Summary
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	-128, 13, 19...
Range	-127 to +127
Units	dB
Invalid Value	-128
Sample Graph	
Notes	A Bluetooth™* connection with an Android™* device was established during the session above.

APPENDIX 4
BioModule Log Data Parameters (26/53)

Bluetooth™* Tx Power

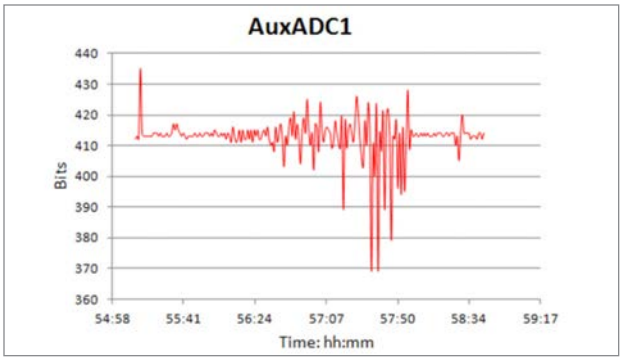
Log Format	Summary & Enhanced Summary
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	-128, 13, 19...
Range	-30 to +20
Units	dbm
Invalid Value	-128
Sample Graph	
Notes	A Bluetooth™* connection with an Android™* device was established during the session above. 10=10dbm

Estimated Core Temperature

Log Format	Summary & Enhanced Summary
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	6553.5, 37.1, 37.1
Range	33 - 41
Units	Degrees Celsius
Invalid Value	6553.5
Sample Graph	
Notes	The algorithm for calculating the Estimated Core Temperature from heart rate data will return an invalid value of 6553.5 for the first 60 seconds from power on.

APPENDIX 4
BioModule Log Data Parameters (27/53)

Aux ADC 1/2/3

Log Format	Summary & Enhanced Summary
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	449, 442, 421...
Range	0-65534
Units	Bits
Invalid Value	65535
Sample Graph	
Notes	The BioModule circuit board has three output points for additional functionality. Unless otherwise specified, the data in all three ADC channels represents hardware circuit noise.

APPENDIX 4
BioModule Log Data Parameters (28/53)

Event Data

For a full description of Event Message specifications, contact Zephyr™.

Log Format	Summary & Enhanced Summary
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	Per Event

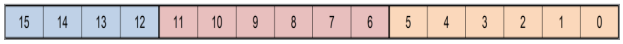
Sequence No.

Sample Data	0,1,2
Range	0 - 255

Time Stamp

Sample Data	2018 10 17 37070441
Notes	Comma separated, time in milliseconds since midnight

Event Code

Sample Data	192,4160, 4096
Range	0 – 4095
Units	Bits
Sample Diagram	
Notes	A 16 bit number. ▪ Bits 15-12 = Event Type ▪ Bits 11-6 = Event Source ▪ Bits 5-0 = Event ID

Type

Sample Data	System, Physiological, Error, Debug
Notes	No error or debug events are currently implemented

Source

Sample Data	Diagnosis, WornDetection, RogAlgorithm, HeartRateCalculation
Notes	Source of the event – source labels are self-evident

Event ID

Sample Data	0
Notes	Specific to the Event itself. Refer to Event Messaging System document

Event Specific Data

Sample Data	Worn status changed from 100% to 0%
Notes	Text description of the event. Self evident.

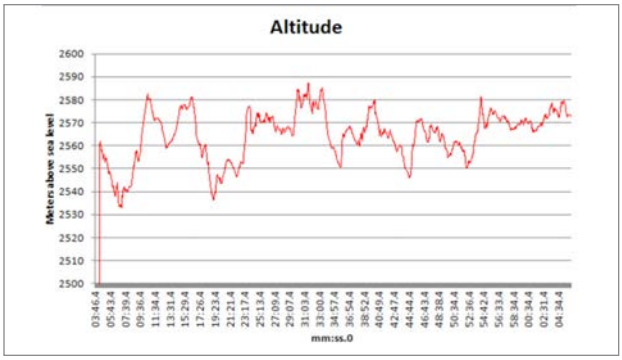
APPENDIX 4
BioModule Log Data Parameters (29/53)

GPS Location

Log Format	Summary & Waveform Enhanced Summary & Waveform
Timestamp	hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	[Latitude] 4 38 40.314 North [Longitude] 74 5 25.386 West
Range	
Units	Latitude: Degrees Minutes Seconds North/South Longitude: Degrees Minutes Seconds East/West
Sample Graph	Location is displayed directly in Google Earth™*, using the exported kml file. See GPS Location (KML)
Notes	Accuracy of GPS data is subject to the number of satellites acquired by the GPS receiver. The BioModule enables DGPS automatically as soon as a Bluetooth™* connection is made to the GPS receiver. There will be some gaps in GPS data due to dropped packets between the BioModule and GPS receiver over the Bluetooth™* connection.

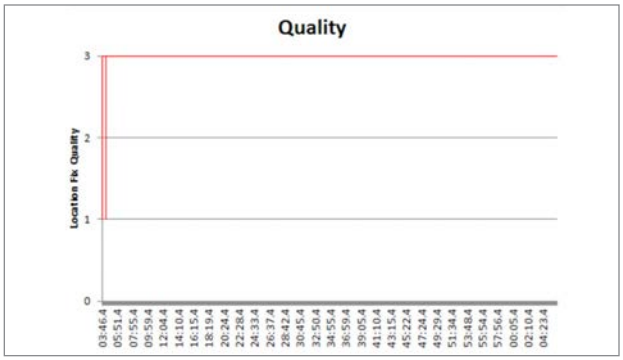
APPENDIX 4
BioModule Log Data Parameters (30/53)

GPS Altitude

Log Format	Summary & Waveform Enhanced Summary & Waveform
Timestamp	hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	147.3, 149.2, 151.1
Range	
Units	Meters above mean sea level
Invalid Value	
Sample Graph	
Notes	Accuracy of GPS data is subject to the number of satellites acquired by the GPS receiver. The BioModule enables DGPS automatically as soon as a Bluetooth™* connection is made to the GPS receiver. There will be some gaps in GPS data due to dropped packets between the BioModule and GPS receiver over the Bluetooth™* connection.

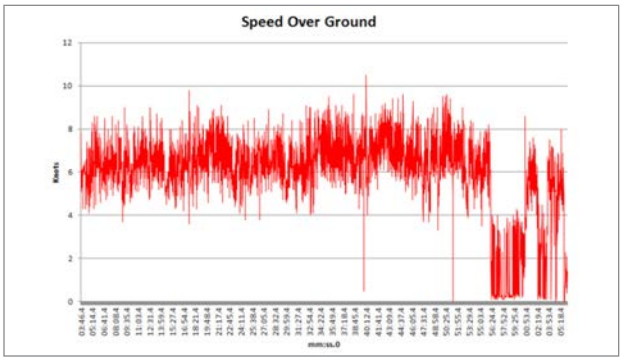
APPENDIX 4
BioModule Log Data Parameters (31/53)

GPS Fix Quality

Log Format	Summary & Waveform Enhanced Summary & Waveform
Timestamp	hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	1,3,3,2,3
Range	1,2,3
Units	See below
Invalid Value	
Sample Graph	
Notes	This is dependent on the number of satellites acquired in order to be able to give an accurate calculation of location only (2D), or location + Altitude (3D) 1 = no fix 2 = 2D fix 3 = 3D fix

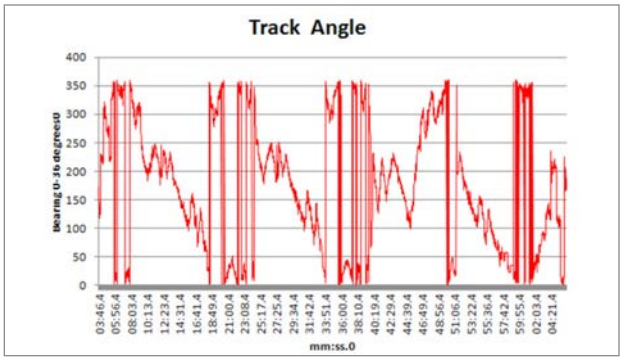
APPENDIX 4
BioModule Log Data Parameters (32/53)

GPS Speed Over Ground

Log Format	Summary & Waveform Enhanced Summary & Waveform
Timestamp	hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	9.2, 7.9, 5.1
Range	0 -
Units	Knots (1 knot = 1.15 miles per hour)
Invalid Value	
Sample Graph	
Notes	Accuracy of GPS data is subject to the number of satellites acquired by the GPS receiver. The BioModule enables DGPS automatically as soon as a Bluetooth™* connection is made to the GPS receiver. There will be some gaps in GPS data due to dropped packets between the BioModule and GPS receiver over the Bluetooth™* connection.

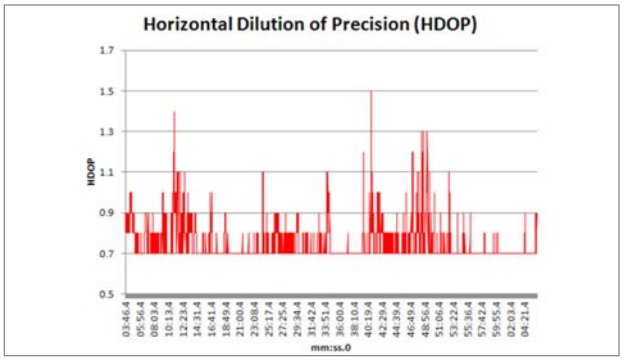
APPENDIX 4
BioModule Log Data Parameters (33/53)

GPS Track angle

Log Format	Summary & Waveform Enhanced Summary & Waveform
Timestamp	hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	173.1, 158.8, 153.3
Range	0 - 360
Units	Compass bearing in degrees [0=North, 90= East, 180=South, 270=West]
Invalid Value	
Sample Graph	
Notes	Accuracy of GPS data is subject to the number of satellites acquired by the GPS receiver. The BioModule enables DGPS automatically as soon as a Bluetooth™* connection is made to the GPS receiver. There may be some gaps in GPS data due to dropped packets between the BioModule and GPS receiver over the Bluetooth™* connection.

APPENDIX 4
BioModule Log Data Parameters (34/53)

GPS HDOP (Horizontal Dilution of Precision)

Log Format	Summary & Waveform Enhanced Summary & Waveform
Timestamp	hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	0.8, 0.6, 0.5
Range	
Units	See below
Invalid Value	
Sample Graph	
Notes	A smaller value of HDOP indicates greater GPS location accuracy. Accuracy of GPS data is subject to the number of satellites acquired by the GPS receiver. The BioModule enables DGPS automatically as soon as a Bluetooth™* connection is made to the GPS receiver. There may be some gaps in GPS data due to dropped packets between the BioModule and GPS receiver over the Bluetooth™* connection.

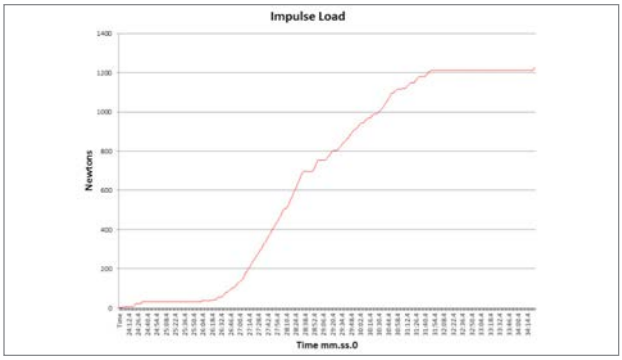
APPENDIX 4
BioModule Log Data Parameters (35/53)

GPS Location (.kml)

Log Format	Summary & Waveform Enhanced Summary & Waveform
Timestamp	yyyy-mm-dd hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	Location: 174.852145 -36.9087683333333 40.0999984741211 for location – additional tags for physiological data
Range	
Units	Longitude Latitude Altitude
Invalid Value	
Sample Graph	
Notes	To access physiological data within the kml file (heart rate, estimated core temperature, activity level, peak acceleration) – right-click the file in the Google Earth™* Places navigation tree and select **Show Elevation Profile** from the context menu. Click on the various parameter links below the earth image to display in the graph below.

APPENDIX 4
BioModule Log Data Parameters (36/53)

Impulse Load

Log Format	Enhanced Summary
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	3, 3, 9...
Range	Cumulative during session
Units	Newtons
Invalid Value	None specified
Sample Graph	
Notes	A cumulative measurement of mechanical load – the sum of the areas under the accelerometer magnitude curve for all impulses. Reset when the BioModule is power cycled.

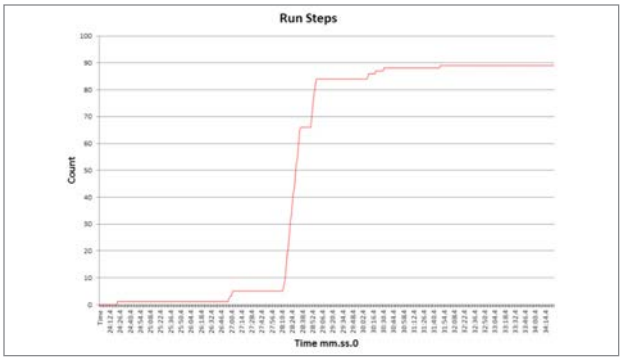
APPENDIX 4
BioModule Log Data Parameters (37/53)

Walking Step Count

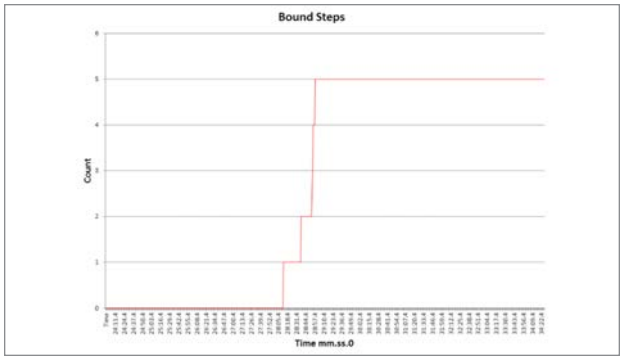
Log Format	Enhanced Summary
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	0, 1, 2...
Range	0 – 262143
Units	Number
Invalid Value	None specified
Sample Graph	
Notes	A cumulative count of detected walking steps. Impulse data is analyzed for magnitude, duration and angle as well as interval from preceding impulse, to determine whether the impulse is an impact or a step. Reset when the BioModule is power cycled.

APPENDIX 4
BioModule Log Data Parameters (38/53)

Run Step Count

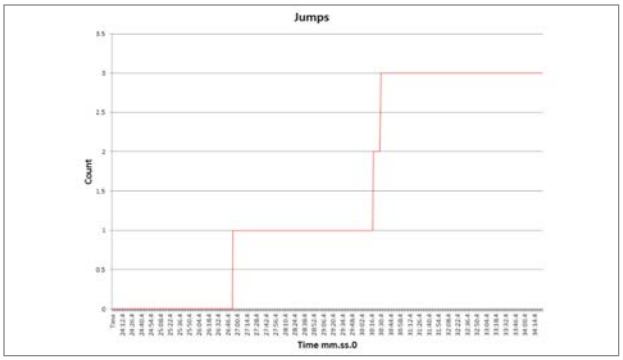
Log Format	Enhanced Summary
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	3, 3, 9...
Range	0 – 262143
Units	Number
Invalid Value	None specified
Sample Graph	
Notes	A cumulative count of detected running steps. Reset when the BioModule is power cycled.

Bound Count

Log Format	Enhanced Summary
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	1,2,3
Range	0 – 1023
Units	Number
Invalid Value	None specified
Sample Graph	
Notes	A cumulative count of detected bounds. Bounds differ from running steps by the time in the air between steps. Reset when the BioModule is power cycled.

APPENDIX 4
BioModule Log Data Parameters (39/53)

Jump Count

Log Format	Enhanced Summary
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	0, 1, 2...
Range	0 – 1023
Units	Number
Invalid Value	None specified
Sample Graph	
Notes	A cumulative count of detected jumps. Reset when BioModule power cycled.

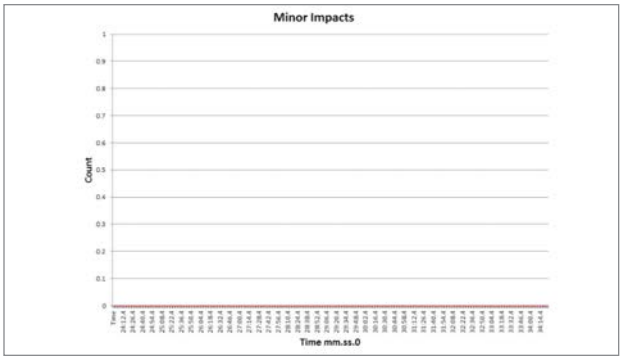
Note:

Walk, run, jump and bound step impulses are determined by analysis of the raw accelerometer data, taking into account the step frequency, time in the air and nature of adjacent impulses.

A jump event is specified as a static jump - the subject crouches, pauses and then jumps vertically. Basketball players are tested for jumping ability by this method. Dynamic jumps during heightened activity will not pass the jump event criteria.

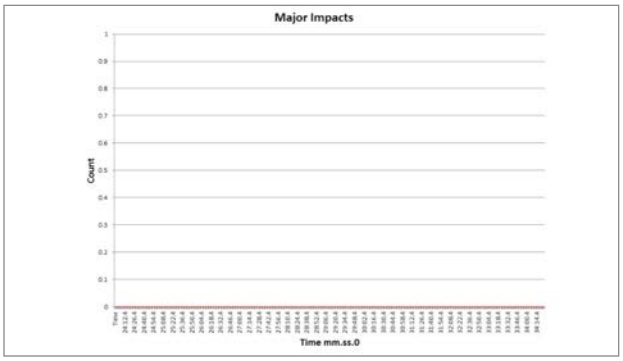
APPENDIX 4
BioModule Log Data Parameters (40/53)

Minor Impact Count

Log Format	Enhanced Summary
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	0, 1, 2...
Range	0 – 1023
Units	Number
Invalid Value	None specified
Sample Graph	
Notes	A cumulative count of impulses classified as minor impacts – peak accelerometer magnitude during the impact is between 3 and 7g and angle of impact meets the criteria for an impact, as opposed to a step.

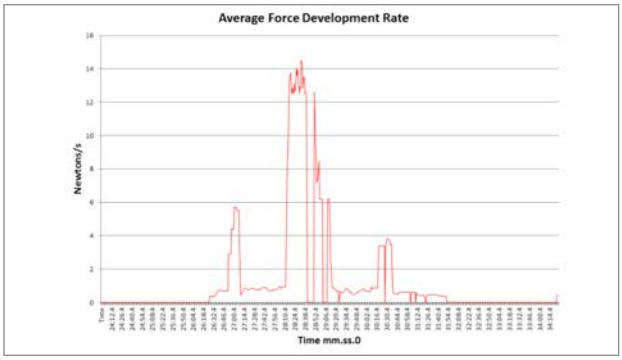
APPENDIX 4
BioModule Log Data Parameters (41/53)

Major Impact Count

Log Format	Enhanced Summary
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	0, 1, 2...
Range	0 – 1023
Units	Number
Invalid Value	None specified
Sample Graph	
Notes	A cumulative count of impulses classified as minor impacts – peak accelerometer magnitude during the impact is greater than 7g and angle of impact meets the criteria for an impact, as opposed to a step.

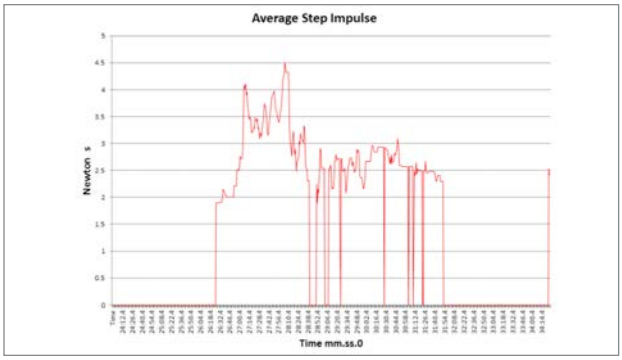
APPENDIX 4
BioModule Log Data Parameters (42/53)

Average Force Development Rate

Log Format	Enhanced Summary
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	0.94, 3.21, 5.78...
Range	0 – 4095
Units	Newtons per second
Invalid Value	None specified
Sample Graph	
Notes	A measure of explosive power. The gradient of the accelerometer magnitude curve during initiation of the impulse. Averaged for the previous 10 steps. Zero if no steps detected for 5 seconds.

APPENDIX 4
BioModule Log Data Parameters (43/53)

Average Step Impulse

Log Format	Enhanced Summary
Timestamp	DD/MM/YYYY hh:mm:ss.000
Reporting Frequency	1 Hz
Sample Data	2.75, 2.48, 2.67...
Range	0 – 1023
Units	Newton seconds
Invalid Value	None specified
Sample Graph	
Notes	Area under the accelerometer magnitude curve for a detected step. Averaged over previous 10 steps. A measure of the efficiency of steps, i.e. how much energy is expended during a step. Shorter (in duration) steps expend less energy. Zero if no steps detected for 5 seconds.