# SAMS Ice Mass Balance Array Buoys (SIMBA version 2)

# User Instruction Manual (Software Version 7)

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## Revision History

| Revision | Changes | Date |
|---|---|---|
| a | First internal issue for review | 08/04/14 |
| 01 | First issue | 11/04/14 |
| 1a | Internal revision for checking – list of changes presented on table on next page. | |
| 02 | General revision for V7 software | 4/17 |
| 03 | General revision for V7 software update | 12/17 |


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# 1 INTRODUCTION

## 1.1 Project Background

1.1.1 SAMS Research Services Limited (SRSL) manufactures a product used for sea-ice measurement; SRSL Ice Mass Balance Array (SIMBA) buoys thermistor chain remote monitoring system.

1.1.2 A thermistor chain is a long strip of sensors which can be lowered through a hole in sea ice such that temperatures from the sea, through the ice and into the air can be recorded/monitored. One of the benefits of this is that heat flux through the ice can be derived. The product has an active mode where the sensors are gently heated and the temperature-rise characteristic can be used to determine the type of medium in which each sensor resides (i.e. air, snow, ice or water).

1.1.3 Each chain sensor is controlled by a controller unit. The results are recorded and can be reported back using the Iridium satellites network (SBD mode). The devices are also capable of remote configuration using the same link.

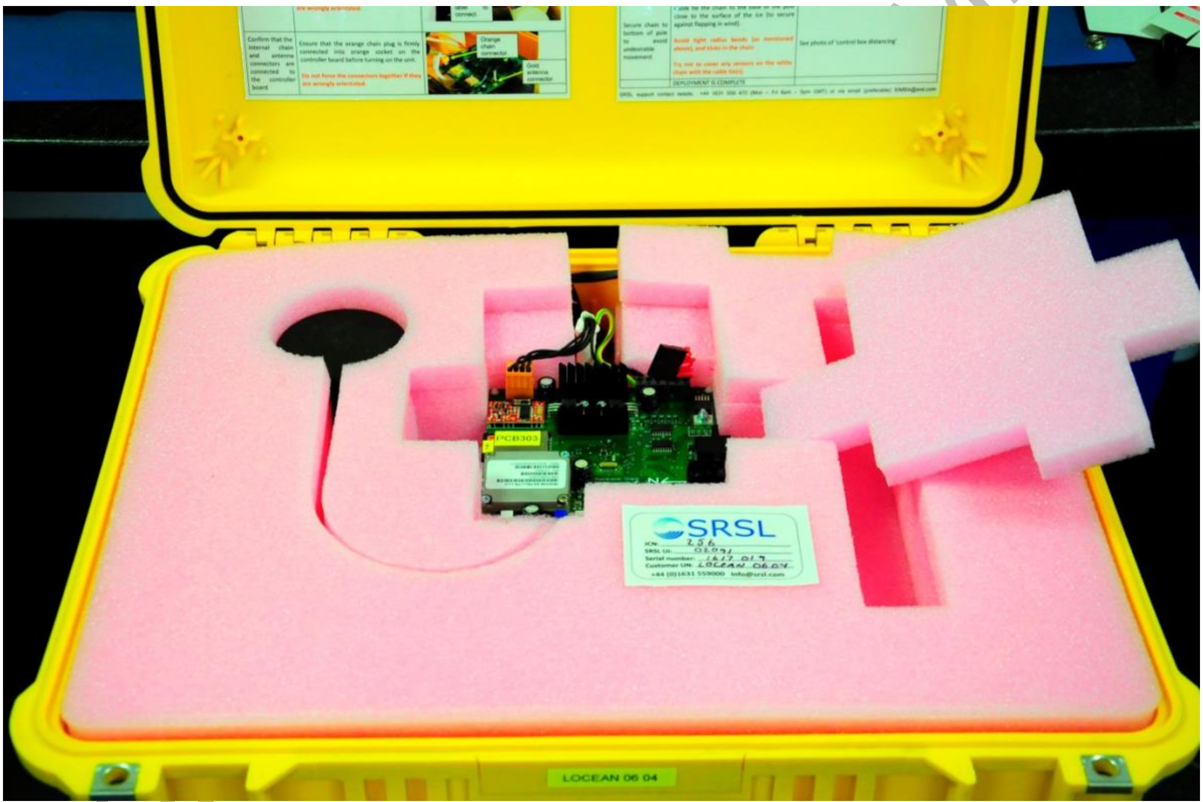



Figure 1: Simba unit with white thermistor chain packaged inside ready for shipping.

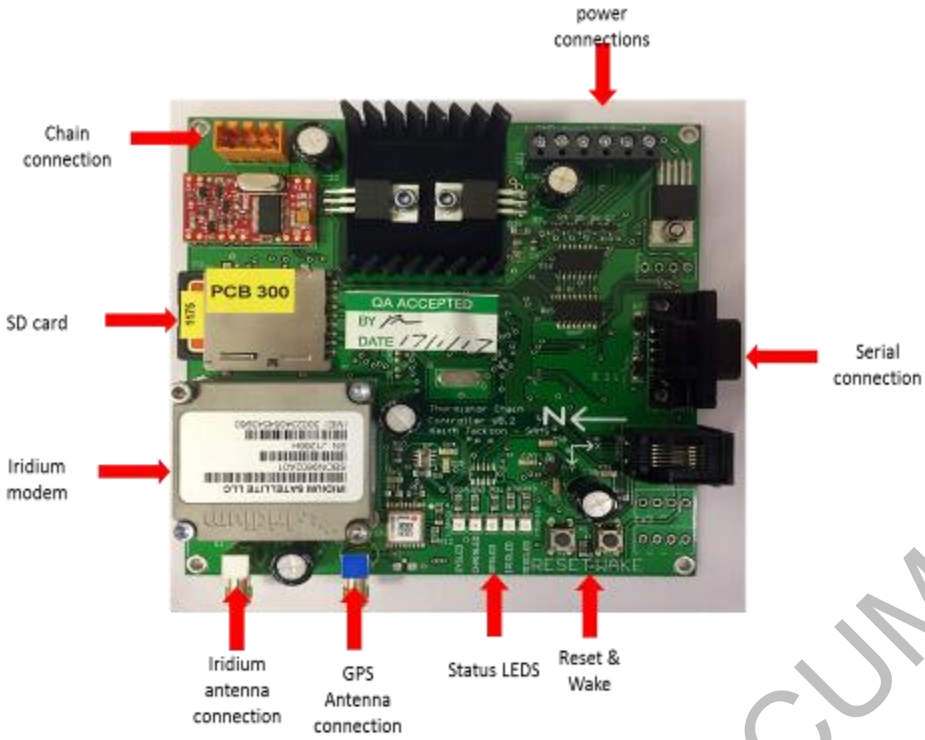



Figure 2: Simba unit V9 controller board with the key interfaces shown.

## 1.2 Document Purpose

1.2.1 This document is a user instruction manual for the SIMBA units.

## 1.3 General Safety Information & Warnings

1.3.1 **Please read all safety warnings and all instructions -** Failure to follow the warnings and instructions may result in electric shock, fire and/or serious injury:

1.3.1.1 Do not drop the product or let it fall, this may result in injury or damage to the product. When in transit please ensure that the units are secured appropriately to prevent damage or injury (from unsecured or falling loads).

1.3.1.2 A standard unit containing 1 battery pack weighs ~15kg. Units with additional battery pack may weigh more than 26kg. Noting these weights, please ensure the use of correct manual handling techniques to prevent injury to persons or damage to the unit. Where the unit weight is above the safe lifting capability of an individual, use of lifting aides and/or a two-person lift is advised.

1.3.1.3 Ensure battery unit is securely fitted with both foam sections in place and both pelicase catches in the locked position before moving or transporting the unit. Failure to do so may result in the battery shifting internally causing injury or damage to the device.

1.3.1.4 Do not touch the battery cabling and connectors with wet hands. Additionally, if the battery connections are wet or covered with dust, please dry or wipe dust off carefully before proceeding with use. Do not use if damaged unless assessed safe by a qualified electrical technician.

1.3.1.5 Bags of desiccant silica gel are shipped with units as standard. The gel is harmful if swallowed. If swallowed by mistake, force the patient to vomit and visit the nearest hospital urgently.

1.3.1.6 When the unit is turned on, please avoid contact with the main controller printed circuit board if it is taken out of the protective box. Contact could lead to the risk of shock to the user and/or cause an electrical short on the board which may lead to failure of the unit.

1.3.2 Battery packs

1.3.2.1 SRSL supplied battery packs consist of Duracell alkaline batteries (Alkaline Manganese Dioxide Cells). For further information please refer to manufacturer's data sheet provided in section 0.

1.3.2.2 When the unit is not in use disconnect, and isolate the battery pack terminal lead. Shorting of the battery terminals may result in a fire.

1.3.2.3 Avoid mechanical or electrical abuse. DO NOT short circuit or install incorrectly. Batteries may explode, pyrolize or vent if disassembled, crushed, recharged or exposed to high temperatures. Install batteries in accordance with equipment instructions.

1.3.3 Transportation Information

1.3.3.1 The battery pack within this unit is considered "dry cell" batteries and is not regulated as "DANGEROUS GOODS" for transportation.

1.3.4 Disposal

1.3.4.1 Dispose of replaced parts or old devices in accordance with the rules and regulations applicable to country of operation.

1.3.5 **DISCLAIMER**: These cautions and warnings are intended to provide a summary of our knowledge and guidance regarding the use of this device. The information contained here has been compiled from sources considered by SRSL to be dependable and is accurate to the best of the Company's knowledge. It is not meant to be an all-inclusive document on safe working practices when using this device and users must evaluate the conditions of use and design the appropriate protective mechanisms to prevent injury or damage.

# 2 DEFINITIONS

Table 1: The table below lists definitions of terms used in this document.

| Term | Definition |
|---|---|
| Airtime provider | The company used to provide the data services on the Iridium satellite network for the remote transmission of data from the simba unit. |
| Controller board | The central core of the SIMBA product, which controls/processes all functions. |
| Iridium satellite network | The network of satellites which enables communication between the SDB modem in the Simba unit, via the airtime provider to the data recipient/user. |
| Real Time Clock (RTC) | A time/date clock built into the SIMBA system |
| Remote configuration | An SBD format file sent by email via the Iridium satellite network to the SIMBA unit to change certain functions/mode of operation. |
| SBD | Short Burst Data, a format of data transfer via the Iridium satellite network |
| SD card | The method of removable data storage used on-board the controller board for data storage and unit configuration. |
| SD card configuration | A text format file saved to the SD card to change certain functions/mode of operation of the unit. |
| SBD modem | A self-contained device fitted to the controller board which allows communication with the Iridium satellite network. Each SBD modem has a unique number, known as the IMEI number. |
| Thermistor chain | A standard chain is around 5 meters long with thermistors every 2 cm with air temperature sensor (for a total of 241 sensors). The chain also has heating resistors spaced every 2cm on the reverse side, in the same position as the thermistors. The chain is connected to the Simba unit chassis by a waterproof connector. Chain variants can be used/supplied (ie, different thermistor spacing, etc). |
| Unix Epoch | A commonly used method used to encode date and time into a single binary number. It is a 32-bit binary value representing UTC time in seconds elapsed since 00:00:00 1st Jan 1970. |

# 3 SIMBA UNIT DESCRIPTION

## 3.1 General Description

3.1.1 The device consists of a controller board, batteries, antennas, sensor chain and case. The controller board is a microprocessor controlled system which gathers readings from sensors and transmits them to a secure dedicated server at SRSL. The controller carries an ultra-low power microcontroller which incorporates a built-in real time clock system, a GPS receiver, an Iridium SBD satellite modem, iridium / GPS antenna, an SD card, a magnetometer/accelerometer sensor and barometric pressure sensor. The sensor chain is a flexible strip which is deployed through a hole in sea-ice. Sea ice is made up of portions in air-snow, ice and water. Sensors can measure the temperature profile every 2cm and heaters on each sensor, these can be switched on to warm the sensors which allows for other information to be gleaned from temperature readings.

## 3.2 General operation

3.2.1 On connection of power or after the reset button on the controller is pressed the device begins an initialisation phase. Testing of all system components is undertaken and LEDs on the board are used to give a quick indication of the progress of this, a successful initialisation being indicated by all LEDs being lit. If errors occur the LEDs will flash out error codes at the end of the initialisation phase. During initialisation, the sensor chain is interrogated. A memory chip on the sensor chain carries all calibration data for the chain and this is read and stored in the controller memory. If the sensor chain is swapped for another the unit will need to be reset for this reason.

3.2.2 Once initialisation is complete the unit will send a message detailing its status and then it enters normal operation mode.

3.2.3 In normal operation, the unit is largely hibernating but will wake after a set (user defined) period to undertake a sample cycle. An incrementing counter is used to number each sample cycle. The default wake-up period is one hour. On each sample cycle the unit will check to see what types of sampling are due and if there are any transmissions waiting to be sent in a buffer queue. On most sample cycles no sampling is due and so the unit immediately hibernates unless there are pending transmissions which it will attempt to send before hibernation. If sampling is due then this is performed and the data placed in the transmission queue. After all sampling is complete the unit then attempts to clear the transmission buffer and receive any configuration messages before hibernating. All sampled data as well as a log of operation and a record of any errors or exceptions is recorded on the SD card.

3.2.4 The sample cycle period and frequency of various types of sample are all set by configuration variables. These have default values but can be set in a file on the SD card which is read at on reset or power-up. The configuration can also be set remotely via the iridium system and written to the SD card.

## 3.3 Temperature profiles

3.3.1 A temperature profile is a measurement of the temperature from each sensor along the chain starting from the top of the chain. The last sensor measured is not on the bottom end of the chain but instead is used as an air temperature sensor and mounted in the air in a suitable screen (not provided). The temperatures are reported back with a resolution of $1/16^{th}$ °C. Due to limits of the Iridium SBD system the profile is sent in two parts but the server at SRSL will recombine these when both parts are received.

## 3.4 'Heated' Temperature Profiles

3.4.1 This type of sample uses heating elements to warm each of the temperature sensors on the chain. As these warm and subsequently cool, the system takes a snapshot of the temperature at configurable points in the heating cycle. The characteristic of the temperature rise can be used to indicate what type of medium the sensor is in (i.e. air, snow, ice or water) and will give indications of air and water flow changes over a series of samples. Also, it is possible to see physical changes occurring within ice over time.

3.4.2 A heated cycle can produce up to four profiles taken during heating and four during cooling. Each profile transmitted back gives the change in temperature from the start of the cycle (i.e. “delta” values), the absolute temperatures are not reported via iridium. Values of up to ±8 °C are sent back at a resolution of 1/16 °C, one transmission for each sample profile during the heating cycle. The SD card data is different; the initial temperature is stored as an absolute value and then at each sample point the new temperature (absolute) is stored.

3.4.3 The length of the heating and the number and times of sampling during the cycle are all configurable. The sample time points are labelled HST_1 to HST_8.

3.4.4 When the “Heated or Active” temperature readings are taken, the sequence of events is as follows:

3.4.4.1 The chain temperature is read and saved as Delta0 on the SD card but is not sent via iridium.

3.4.4.2 The chain heating function is activated, which dissipates 64mW of heating power (default value of 100% heating is no longer configurable) via the heating resistors in the chain which are directly on the back of the chain board behind each of the chain thermistors,

3.4.4.3 After time HST_1 has elapsed the chain temperatures are read and saved as Delta1 on the SD card. The default time of HST_1 is 30 Seconds.

3.4.4.4 Heating continues and samples taken at times HST_2, HST_3 and HST_4. At time HST_4 the heater is also turned off and cooling commences. By default, HST_2 and HST_3 are set to zero indicating no sampling is to be made and HST_4 is at 90s. Consequently, the system will report the temperature rise at 30 and 90s during heating. Data for each sample time are saved on SD card in files Delta2 for HST_2, Delta3 for HST_3 and so on.

3.4.4.5 After time HST_4 the heating is stopped and temperature samples can taken at HST_5, HST_6, HST_7 and HST_8 to monitor the cooling characteristic. These are all set to zero by default and so these samples are skipped.

3.4.5 Figure 3 below shows the sequence diagrammatically for settings of HST_1=15, HST_2 and HST_3=0, HST_4=75, HST_5=40 and HST_6..8=0. The black dots indicate sampling points for heat changes. Note that while all chain sensors will sample the temperature at the same instant it takes time $t_s$ to read the data from the chain (typically 15s for a 240 sensor chain). The heating begins at time 0 which will be at time $t_s$ after the initial temperatures are taken. Note the HST values are relative to the last sample (i.e. cumulative) and not measured from time 0. A value of 0 for an HST value indicates no sample is taken (i.e. it is at the same point in time as the previous sample).

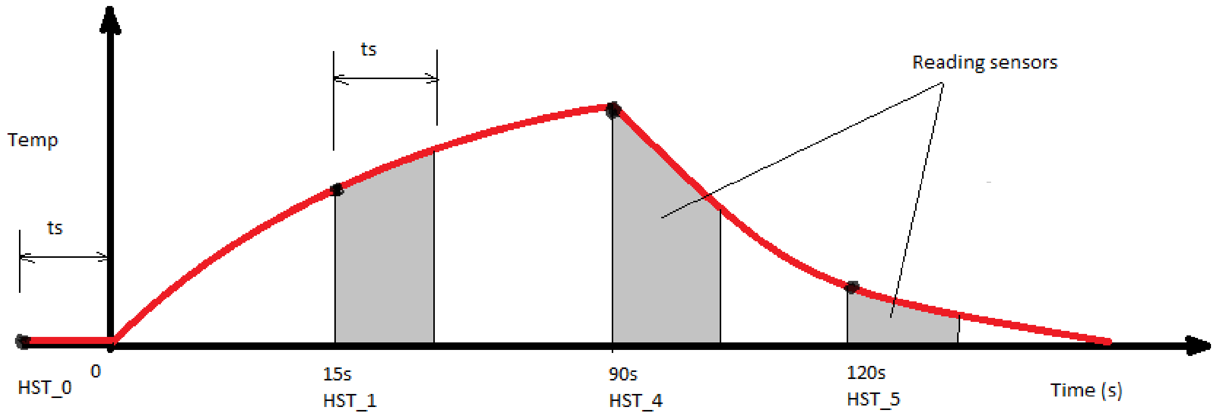



Figure 3: The black dots show actual sampling time. Note that HST_4 controls the total time of heating and its value must not be zero. Total heating time will be HST_1+HST_2+HST_3+HST_4. Note that allowance for reading back data must be made and so no value of an HST variable must be less than $t_S$ (except for a zero value).

**Note**: that to prevent overheating or severe power loss due to reconfiguration, resulting in extended heating, the total heating time is limited to 350s. An attempt to exceed this will result in the HST_1 to HST_4 values being proportionately scaled down to ensure the total does not exceed 350s.

## 3.5 GPS Receiver

3.5.1 The unit is configured by default to take a GPS reading every two sample cycles (i.e. every two hours). The GPS unit will typically get a fix within a few seconds of being powered up, but in order for it to detect as many satellites as possible (to improve the fix quality), the unit is left running for 1 minute before the location is sampled. After power-up the GPS performs a “cold start” and is allowed up to two minutes to get an initial fix. Subsequently, the unit will operate “warm starts” as it will already have downloaded almanac information from the satellite and will usually have up-to-date ephemeris data.

3.5.2 GPS results are collated into a group of six readings (the default configuration) to form a single iridium message. The magnetometer/accelerometer and barometer readings are also taken at the same time as GPS readings and included in the GPS data.

3.5.3 The system real-time clock (RTC) is driven from the GPS system. At initialisation, the clock is set from the GPS system (or if this fails the iridium system time is used). On each subsequent GPS fix the RTC is updated but this is configurable and the RTC can be left to free run.

3.5.4 The Ublox M8W unit will use GPS, GLONASS, Galileo and BeiDou systems and will make a fix using any of combination of these that is available. It also uses the SPS service and should get fixes accurate to better than 10m horizontally. The GPS unit uses an external antenna mounted in the case.

## 3.6 Magnetometer, Accelerometer and Barometer.

3.6.1 The unit is equipped with a 3-axis accelerometer (NXP FXOS8700CQ). This reports acceleration in x, y and z directions in mg. The tilt of the unit in degrees from vertical (normally 0 if level) is also calculated from this and is also reported back in the GPS message. This is useful as it can indicate ice floe ridging may be occurring or if some dramatic event (i.e. a passing curious bear!) has upset the deployment. The x and y directions are marked on the controller board, z is vertically upwards from the plane of the board.

3.6.2 The accelerometer also incorporates a 3-axis magnetometer. This device is calibrated for internal offsets, hard-iron effects and soft-iron effects by SRSL (N.B. Soft iron effects as the batteries magnetise in various ways and distort the field as unit rotates and the calibration is only valid in the location of the calibration process). The three axes are reported back in µT and also a compass heading is derived which is compensated for tilt. However, the bearing has poor absolute accuracy in the UK and performance at higher latitudes is likely to be worse. However, heading value gives can give a general indication of floe rotation.

3.6.3 An NXP MPL3115A2 barometer chip is fitted which reports atmospheric pressure. Note that the Pelican cases have Gore-tex membrane vents to allow for pressure equalisation with the exterior of the box. This device also reports the temperature inside the pelican case. The readings are reported back with GPS fixes in

## 3.7 Unit Status and Configuration

3.7.1 The SIMBA unit will periodically send a status message via iridium (by default this is at power-up/reset then once per week). This message will show values of configuration variables, voltages of battery and internal supplies and counts of error/exception occurrences. A status message is also sent after a remote configuration file is sent.

3.7.2 The configuration is set by default to values which most users adopt. If a different configuration is used it is recommended to place an appropriate configuration file on the SD card which is then read at initialisation.

**NOTE:** Testing configurations is very important, and you can discuss your requirements with SRSL. There are countless permutations which cannot all be tested but some have been found to create undesired outcomes and although there has been extensive testing this does not guarantee all permutations are reliable.

3.7.3 Please ensure that Configurations should be tested before deployment. If remote configuration is used we recommend that these are tested before the configuration is sent as untested configurations can risk throwing the unit into some unforeseen state. The remote configuration can be written to SD card remotely if required to avoid the configuration being lost in the event of a unit reset, foreseen or otherwise. Regardless of the configuration used, the unit will wake up and listen for remote messages once every 24 hours, allows the configuration to be changed if a mistake is made.

## 3.8 Iridium System

3.8.1 Data is sent from the unit via the Iridium SBD (Short-burst data) service. This is similar to mobile phone texting where a short message (320 bytes) can be sent using a simple modem unit. The system is two-way, so when connected to the network the modem can request to download any pending incoming messages which can be used for configuration purposes.

3.8.2 Each modem has a unique 13 digit IMEI number which is given to an Airtime provider, a commercial vendor who will register the unit on the Iridium network and charge for usage (typically charging per kB transmitted). When registering a modem it is possible to provide up to five email addresses to which data will be sent. Typically, one of these will be for the SRSL data server.

**NOTE:** It is strongly recommended that the SRSL web interface option is taken as this will greatly increase the level of technical assistance SRSL can provide.

3.8.3 The SBD system is dependent on good satellite coverage, but this varies as the satellites move. Consequently, messages are queued by the SIMBA unit if a transmission fails. The unit will attempt to clear the queue each time it wakes but if it fails twice it will stop and resume hibernation. Up to ten messages can be queued, beyond this data will be lost, but trials show this to be a very rare occurrence assuming the units' performance is not compromised (e.g. by being buried in snow or flipped over).

## 3.9 Useful References

The following reference provides details on the development of the Simba unit:

Jackson, K., Wilkinson, J., Maksym, T., Meldrum, D., Beckers, J., Haas, C., MacKenzie, D. (2013) **A Novel and Low-Cost Sea Ice Mass Balance Buoy**. Journal of Atmospheric and Oceanic Technology Vol 30, No 11, pp 2676-2688

And as per the following link:

http://journals.ametsoc.org/doi/abs/10.1175/JTECH-D-13-00058.1

There are several useful citations to be found here which have details of deployments and results from SIMBA deployments.

# 4 DATA TRANSFER

## 4.1 Methods of Data Transfer

Table 2: The table below lists the options for data transfer from a SIMBA unit.

| Transfer Method | When It Would Typically Be Used |
|---|---|
| Iridium satellite network | When the unit is remotely deployed |
| SD card | Pre-deployment testing, laboratory testing or during deployment if access can be gained to the unit/card. |
| Serial port | Pre-deployment testing or during laboratory testing. |

## 4.2 Iridium Satellite Network Data Transfer

4.2.1 Most deployments involve remote locations, with Iridium transfer being the only practical solution for data transfer. The unit uses a Short Burst Data (SBD) protocol for data transfer via an SBD modem on the controller board. With this system, data is sent from the unit to the user in email form. The email comes from the airtime provider. Airtime can be arranged by the user/customer directly, or via SRSL, who can manage airtime supply on the customers/users behalf.

4.2.2 These emails are decoded from SBD format either via the SRSL web interface which can be purchased with the airtime or separately by the customer/user.

**Note:** SRSL deactivates all SBD modems on point of despatch after testing, which helps to avoid unwanted data charges during transit and prior to deployment. It will be necessary for the user to contact SRSL (if airtime is being supplied by SRSL) or their airtime supplier in advance of deployment, to get the modem re-activated for testing and deployment. It is recommended that reactivation is undertaken at least 15 days before deployment, and that the unit and associated data transfer is tested prior to deployment (by turning on the unit as per the recommended start-up procedure, see section 10, until it has been confirmed that data transfer emails are being correctly received).

4.2.3 If the web interface is purchased from SRSL, then the most recent data will be displayed decoded at:

https://simba.srsl.com/ your project name. Your project name is shown on the Simba ID label on the front of the case for example "UI****** ABC 09" will be project name "ABC". Figure 4 below presents an overview of the web data interface page provided by SRSL.

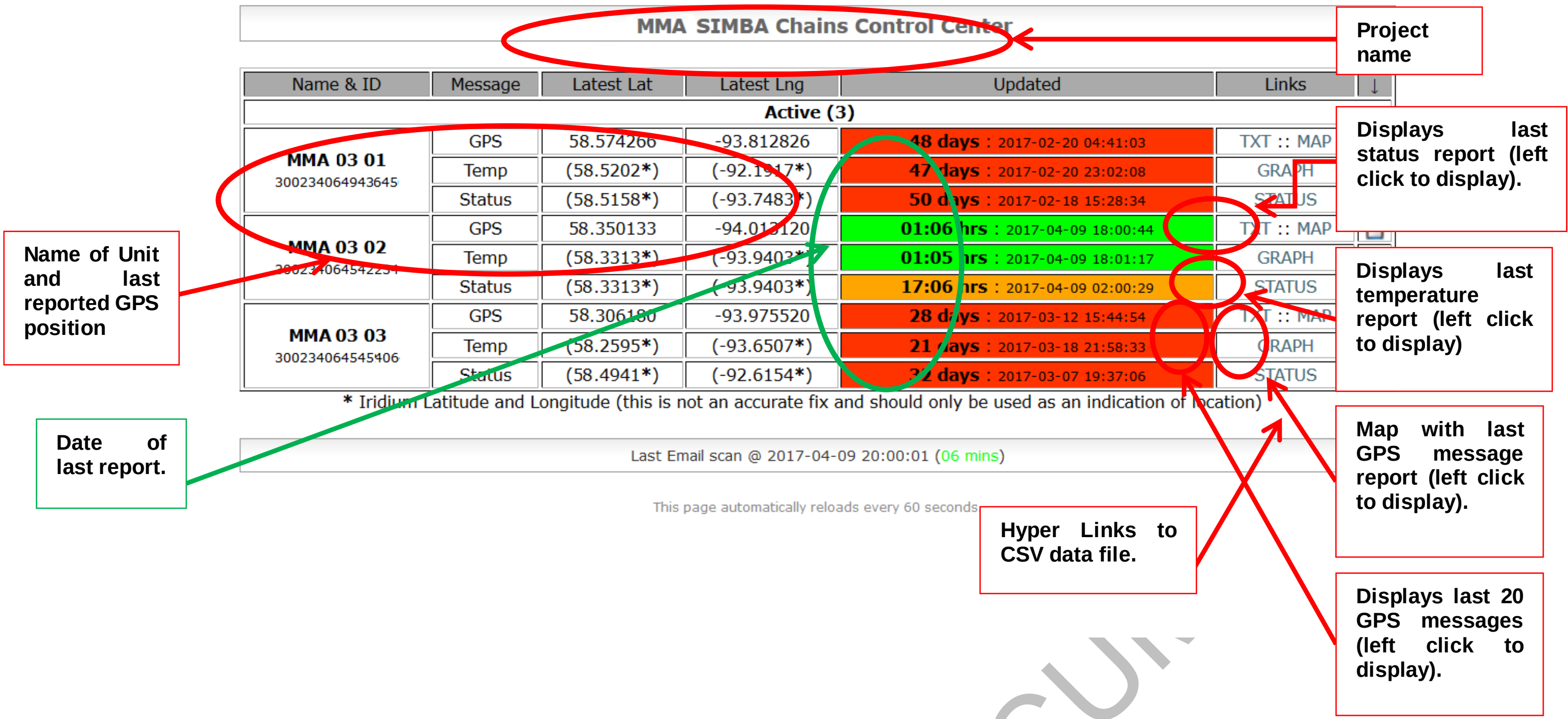



Figure 4: When the web interface option is provided by SRSL, emails with the data files attached from the SIMBA unit are automatically collected, decoded and archived on the SRSL servers, and made available as comma separated values (CSV) files. The CSV data files can be accessed via the disk symbols at the far left of each line.

## 4.3 SD Card Data Transfer

4.3.1 The SD flash card (on the controller board) is used mainly for data logging and log file retention. The SD card can also be used to reconfigure the SIMBA unit (see below). Data is acquired and logged to the card via single logfile to record all events and exceptions. Data is date and time stamped and stored as a string of ASCII floating point numbers.

4.3.2 The SD card can contain a configuration file “CONFIG.TXT” to allow users to set the configuration of the SIMBA unit at power-up or reset if they wish to alter it from the default settings (see section 5). Where a SIMBA unit is to be used in its default configuration (see table 7), then initially the SD card should be left blank, but formatted.

The table below lists out all of the files that may be stored/found on the SD card.

Table 3: Files stored on the SD card.

| File name | Data stored in file |
|---|---|
| LOGFILE.TXT | Log of device activity |
| TEMPDATA.TXT | Temperature profile data |
| DELDATA0.TXT | Temperatures at start of heating cycles |
| DELDATA1.TXT | Temperatures after time HST1 during heating cycle |
| DELDATA2.TXT | Temperatures after time HST2, the end of the heating cycle |
| DELDATA3.TXT | Temperatures after time HST3, the end of the heating cycle |
| DELDATA4.TXT | Temperatures after time HST4, the end of the heating cycle |
| DELDATA5.TXT | Temperatures after time HST5, the end of the heating cycle |
| DELDATA6.TXT | Temperatures after time HST6, the end of the heating cycle |
| DELDATA7.TXT | Temperatures after time HST7, the end of the heating cycle |
| DELDATA8.TXT | Temperatures after time HST8, the end of the heating cycle |
| ERRFILE | This is the log of the any error messages. |
| GPSDATA.TXT | GPS, barometer and magnetometer data |
| CONFIG.TXT | A file that allows users to set the configuration of the SIMBA unit at power up, if they wish to alter it from the default settings. |
| | |

The format of these files is described in detail later in this document.

## 4.4 Serial Port Data Transfer

4.4.1 The SIMBA unit can be monitored via the serial port on the controller board, which also allows data extraction. This is particularly useful when conducting lab tests and pre-deployment checks.

4.4.2 Use of the serial port requires:

- A computer with a serial port or a USB to serial adaptor (more common these days),
- A serial cable with a male 9 pin DType connector (to connect to the SIMBA unit controller board),
- Suitable interface software such as PuTYY (see PuTTY setup below),
- A clear view of the sky for GPS (transmission may be possible near a window or antenna / repeater system),

4.4.3 Once in place, connect the computer to the SIMBA serial port, and then power up the SIMBA unit.

4.4.4 For any terminal program the serial port setup must be set correctly. The settings are as follows:-

- 38400 baud
- no parity
- no flow control
- eight data bits
- one stop bit

Generally, you must also identify which “COM” port is being used. This is determined by the computer in use and how the serial line is connected.

4.4.5 The diagram (Figure 5) below shows typical output from the serial port once the system has been reset.

```
***********************************
SIMBA Chain Software V7.06
Keith Jackson. SAMS/SRSL.
Compiled on Mar  3 2017 14:01:09.
XC16 compiler 1.031.
Compiled for PIC24FJ256GA106
***********************************

----/--/-- --:--:-- | System started ******************************
----/--/-- --:--:-- | SD card found
----/--/-- --:--:-- | External reset
----/--/-- --:--:-- | On-board EEPROM detected
----/--/-- --:--:-- | Loading Chain sensor Addresses.
----/--/-- --:--:-- | ROM Address are 43A8832400000086 437C7E24000000D4.
----/--/-- --:--:-- | No. of sensors found is 46
----/--/-- --:--:-- | No. of Chain sensors as stored in EEPROM is : 46
----/--/-- --:--:-- | Chain calibration date 24/04/2016
----/--/-- --:--:-- | Chain ID : 101
----/--/-- --:--:-- | Reading Chain sensor addresses from EEPROM
----/--/-- --:--:-- | Reading Chain sensor cal coefficients
----/--/-- --:--:-- | Mag. cal. offsets: x=34.00uT y=-8.20uT z=-47.95uT -- x= 0.00g y=-0.01g z=-0.03g
----/--/-- --:--:-- | Magnetometer response OK
----/--/-- --:--:-- | Barometer response OK
----/--/-- --:--:-- | Getting time from GPS
----/--/-- --:--:-- | Getting GPS fix. Timeout after 100s
2017/04/05 14:26:14 | Simba Clock Time updated from GPS
2017/04/05 14:26:14 | GPS Date 05/04/2017 14:26:14,(1491402374)
2017/04/05 14:26:14 | Fix 5721.4580 N (57357633)   222.2490 W (-2370815)
2017/04/05 14:26:19 | Iridium modem powered up
2017/04/05 14:26:21 | Iridium modem 300234062422080 detected
2017/04/05 14:26:21 | Test iridium signal strength
2017/04/05 14:26:31 | Signal strength 0
2017/04/05 14:26:42 | Signal strength 0
2017/04/05 14:26:52 | Signal strength 0
2017/04/05 14:26:52 | ** Error 13 (1) - No iridium signal. Antenna?
2017/04/05 14:26:54 | Iridium message buffer initialised. Queue size of 10 packages.
2017/04/05 14:26:54 | No configuration file config.txt found.
2017/04/05 14:26:55 | Sample number set to 3523
2017/04/05 14:26:55 | Creating initial status message. It takes a few seconds...
2017/04/05 14:27:45 | Starting sample sequence 3523 ************************
2017/04/05 14:27:45 | Message queue size 1. Timeout at 2017/04/05 14:31:45
2017/04/05 14:27:50 | Iridium modem powered up
2017/04/05 14:27:50 | Sending packet type 31, length 166, SN 352[]
```

Figure 5: The example above shows a SIMBA unit started without an iridium signal being detected.

4.4.6 Data can be exported from the PuTTY screen by left clicking on the mouse and highlighting the text and then by right clicking on the mouse. This can then be pasted into many software packages as text (eg, word, notepad, etc). It is notable that temperature data can be exported directly from the SD card more easily.

# 5 SIMBA CONFIGURATION

## 5.1 Configuration File

5.1.1 The SIMBA units are shipped with a default sampling configuration in the software. However, it is possible to change the sampling configuration, by placing a configuration file (‘config.txt’) on the SD card on the SIMBA controller board.

5.1.2 Standard sampling configuration consists of: 4 temperature profiles per day; 1 heated profile per day; GPS every 2 hours; 1 status message per week. The unit will wake every hour but will not necessarily take any samples if not required. On each wake up cycle the unit will attempt to transmit any queued messages over the Iridium system before hibernating. Every 24hrs the unit wakes regardless of configuration to check for incoming iridium messages.

5.1.3 The configuration file has a number of commands that allow various aspects of the SIMBA unit’s operation to be modified.

5.1.4 The text on the configuration file must not exceed 150 characters. This file is read and processed by the SIMBA unit at power-up or reset and will set the configuration as specified in the file. Please note that when there is no configuration file present on the SD card, the SIMBA unit will use the default configuration settings.

5.1.5 Please note only the parameters deviating from the default configuration need to be included on the configuration file on the SD card.

5.1.6 Some functions relate to instructing the unit what to transmit. It is worth noting that all data produced by the SIMBA unit gets saved onto the SD card, even if it does not get transmitted.

**NOTE**: if generating a configuration file, please check and verify it is correct before use, because if programmed incorrectly, the SIMBA unit will not function properly. When creating configuration files, it is advised that the text incorporated into the file is confirmed within Microsoft Word before it is sent (in order to check for erroneous characters). To do this:

- Create the file completely and check/confirm that the command names and values are correct,
- Copy all of the contents of the file you have created and paste that into a new blank Microsoft Word document,
- Ensure that the show/hide function in Microsoft Work is turned on, which will display all of the characters contained in the message, including hidden ones. At this point, double check for any hidden/incorrect characters that may have been added by mistake.

5.1.7 Figure 6 below show a standard reconfiguration file, which on examination in ‘Notepad’ would appear to be correct.

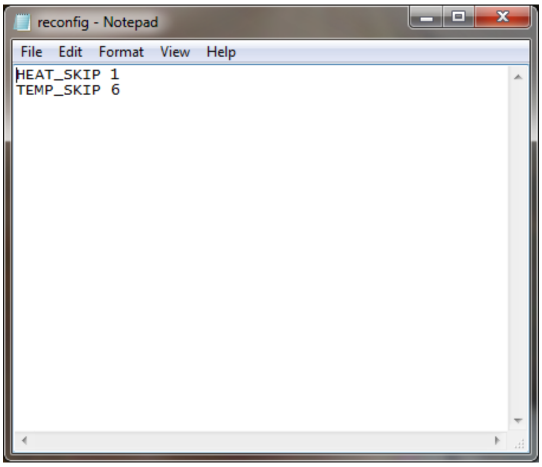



Figure 6: Standard configuration file.

Figure 7 below shows the exact text from the 'Notepad' example pasted into word. With the 'show/hide' function enabled it can be seen that there is an additional hidden character (highlighted in yellow) after the word 'TEMP' – this would have caused the process to fail. The red circle shows the button that enables the 'show/hide' function in Microsoft Word.

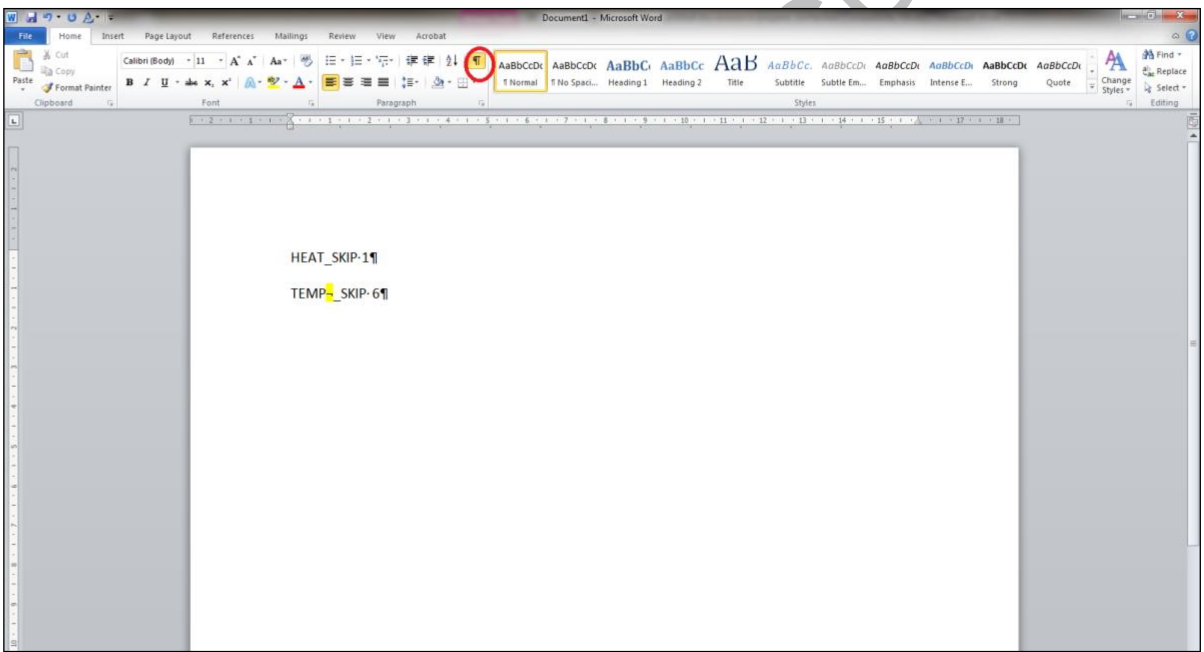



Figure 7: 'Notepad' example pasted into word.

5.1.8 The configuration is user defined with the following options:-

| | |
|---|---|
| SAMPLE_PERIOD | Time in seconds between each wake-up cycle |
| HEAT_SKIP | Number of sample cycles between each heating cycle measurement |
| TEMP_SKIP | Number of sample cycles between each temperature measurement |
| GPS_SKIP | Number of sample cycles between each GPS fix |
| STATUS_SKIP | Number of cycles between transmission of status packet |
| HEAT_THRES | Battery voltage below which heating cycles abandoned |
| HST_1 | Time from start of heating to first sample |
| HST_2 | Time from HST1 sample to second sample. |
| HST_3 | Time from HST2 sample to third sample. |
| HST_4 | Time from HST3 sample to fourth sample. Heater switched of at HST_4. |
| HST_5 | Time from HST_4 sample to fifth sample. |
| HST_6 | Time from HST_5 sample to sixth sample. |

| | |
|---|---|
| HST_7 | Time from HST_6 sample to seventh sample. |
| HST_8 | Time from HST_7 sample to eight sample. |
| SET_CLK | Controls update of system clock from GPS |
| WD | Watchdog wakeup period in 2 minute units. This period should comfortably exceed the SAMPLE_PERIOD setting. For SAMPLE_PERIOD of 1hr (3600s) WD should be about 50 (100min). |
| GPS_MESS | Number of fixes in a GPS message |
| IRIDIUM_SKIP | Skip transmissions. Allows higher sample rate to SD card. |

5.1.9 Table 4 below shows the default values of variables and the allowed ranges.

| Variable | Default Value | Effect of default | Min | Max |
|---|---|---|---|---|
| SAMPLE_PERIOD | 3600 | 1 hour wakeup cycle period | 900 | 30000 |
| HEAT_THRES | 10000 | Stop heating cycles after battery<10V | 0 | 20000 |
| HST_1 | 30 | Sample after first 15 of heating | 0 | 120 |
| HST_2 | 0 | Sample again after 0 seconds of heating (i.e. skip sample) | 0 | 120 |
| HST_3 | 0 | Skip sample. | 0 | 120 |
| HST_4 | 90 | Sample again after 90 seconds of heating (120 s in total) | 0 | 120 |
| HST_5 | 0 | Skip sample. | 0 | 120 |
| HST_6 | 0 | Skip sample. | 0 | 120 |
| HST_7 | 0 | Skip sample. | 0 | 120 |
| HST_8 | 0 | Skip sample. | 0 | 120 |
| HEAT_SKIP | 24 | One heating cycle per day | 1 | 10000 |
| TEMP_SKIP | 6 | Four temp profiles per day | 1 | 10000 |
| GPS_SKIP | 2 | Once two hours | 1 | 10000 |
| STATUS_SKIP | 168 | Once a week | 1 | 10000 |
| GPS_MESS | 6 | 4 GPS messages a day for defaults above | 1 | 8 |
| IRIDIUM_SKIP | 1 | Do not skip any transmissions | 1 | 10000 |
| WD | 50 | Watchdog wakeup time in 2min units (i.e. 100mins default) | 0 | 10000 |
| SET_CLK | 2 | System clock set at startup only | 0 | 3 |

5.1.10 Note that the device will only reconfigure when it next wakes and initiates an SBD session. It is possible to queue multiple emails and they will be queued and processed in the order sent. The queue will be emptied one transmission at a time for each homebound transmission.

5.1.11 After a status change message is received a new status message will be transmitted to confirm the update. Any values out of range are ignored.

5.1.12 The configuration variables are now discussed in detail:

5.1.13 The **SAMPLE_PERIOD:**

5.1.13.1 This parameter controls when the period between the system waking up.
5.1.13.2 The default is 1 hour (3600 seconds).
5.1.13.3 This wakeup cycle controls the period of all other functions.
5.1.13.4 When a cycle begins the system will undertake any sampling functions that are due and then transmit the results before becoming dormant.
5.1.13.5 During initialisation the second wakeup period is scheduled to occur on the next hour exactly so synchronisation with other units is possible.
5.1.13.6 All times are UTC.
5.1.13.7 Note that setting this variable will also cause setting of the WD variable to a suitable value such that it does not cause the watchdog to wake the system before the sample period time has expired. See the WD entry below for more detail.

5.1.14 **STATUS_SKIP**:

5.1.14.1 Controls how many wakeup cycles are between each status transmission.
5.1.14.2 The default is once a week for hourly wakeup.
5.1.14.3 A second transmission is also made with error registrations reported.

### 5.1.15 **TEMP_SKIP**

5.1.15.1 Controls how many wakeup cycles are between each temperature profile sample.
5.1.15.2 The default is every 6 hours for the default wakeup period.

### 5.1.16 **HEAT_SKIP**

5.1.16.1 Controls how many wakeup cycles are between each heated profile sample.
5.1.16.2 Default is 1 a day.
5.1.16.3 Note that these measurements are power intensive.

### 5.1.17 **GPS_SKIP**

5.1.17.1 Controls how many wakeup cycles are between each GPS fix.
5.1.17.2 The default is for every wakeup period.
5.1.17.3 A magnetometer and barometer measurement are also taken with each GPS fix.
5.1.17.4 A GPS fix has 60 seconds allowed so the unit can get a fix and then refine the accuracy of this by using additional satellites.
5.1.17.5 The units awakes 60 seconds earlier than scheduled so the fix can be taken exactly on the intended wakeup time so that all units are accurately synchronised.

### 5.1.18 The **IRIDIUM_SKIP**

5.1.18.1 This value allows for fixed installations that will be recovered from the field.
5.1.18.2 The number of transmitted temperature profiles and heating cycles can be reduced by skipping cycles.
5.1.18.3 A value of 1 will send back all samples.
5.1.18.4 A value of 2 will send back every second sample etc.
5.1.18.5 Generally, this will be set on the SD card config file so it’s value is not sent back via iridium, but it’s value can be changed remotely.

### 5.1.19 **Heating Cycles-HST_1**

5.1.19.1 **HST_1** is the time in seconds from the application of heat to the chain sensors to the first sampling of temperature rise.
5.1.19.2 Typically a value of 15s catches the middle of the rising curve.
5.1.19.3 Note that immediately before application of heating the chain temperatures are read so the difference can be measured and transmitted (we will refer to this as HST_0).
5.1.19.4 The initial temperatures are not transmitted but are stored on SD card. When the HST_1 sample is due all sensors immediately sample the temperature.
5.1.19.5 Note that it can take up to 10seconds to then interrogate the chain and read back all readings.
5.1.19.6 Heating will continue during this time but the value of the following sample must not follow too closely behind HST_1 to allow for this. If HST_1 is zero then the sample is skipped.

5.1.20 **HST_2** is the time in seconds from HST_1 when the second heat rise sample is taken (N.B. an important change here, HST_2 was previously measured from the start of heating, not from HST_1). When this time is reached the sensors are immediately instructed to sample. The values are then read back (again taking up to 10s of the next). HST_2 should not be zero as it’s value determines the length of heating time.

5.1.21 **HST_3** is the time from HST_2 when the next sample is taken.

5.1.22 **HST_4** is time from HST_3 to final measurement. At this time the heater is shut down. Avoid a value of zero for this as it can result in heater being delayed in turning off.

5.1.23 **HST_5-8** are all cooling cycle samples and can be set to 0 to skip.

5.1.24 The **HEAT_THRES**

5.1.24.1 Value is a voltage from the common point of all batteries (i.e. after diodes).
5.1.24.2 When the battery voltage is below 10V the 8V stabilised voltage for the heater can start to decline.
5.1.24.3 Since this will effect results and drain the dwindling power quickly the unit will not perform heated measurements.
5.1.24.4 To force it to continue this value can be set lower (to zero if desired).

5.1.25 **SET_CLK**

5.1.25.1 Controls updating of the system clock from external sources (GPS and Iridium if GPS fails).
5.1.25.2 A value of 2 means the system clock is set once at startup.
5.1.25.3 A value of 1 will force a single update (can be useful if clock drifts of initial update fails). The variable resets to 0 after this has occurred.
5.1.25.4 A value of 2 forces the system to update everytime a successful GPS fix is made.
5.1.25.5 A value of 3 means the system clock is set once at startup and after from Iridium only.

5.1.26 **WD (Watchdog)**

5.1.26.1 This parameter sets the watchdog timer period.
5.1.26.2 When awake the watchdog will cause a system reset if for any reason the system hangs.
5.1.26.3 The time out period is approximately 2 minutes (131 seconds but the oscillator used has wide tolerance).
5.1.26.4 The timer is reset during operation before key procedures which must end within this period.
5.1.26.5 Any resets due to this are not user issues but due to hardware failures or software bugs generally.
5.1.26.6 When asleep, the system will normally wakeup from an alarm driven by the system real time clock circuits, by default every hour on the hour.
5.1.26.7 However, in case this mechanism fails (it is not uncommon for the low power watch crystal oscillator to stop which drive the RTC) then the watch dog timer briefly awakens the system every 2 minutes and checks all is in order.
5.1.26.8 If it is apparent the normal wakeup mechanism has failed then the watchdog eventually wakes the system properly.
5.1.26.9 The WD value determines how many 2-minute intervals elapse before this occurs.
5.1.26.10 The default is 50 so the watchdog will kick in after 100 minutes and allow the system to limp on.
5.1.26.11 This WD timeout should be well in excess of the SAMPLE_PERIOD setting so it does not interfere with the normal mechanism when it is working.
5.1.26.12 Setting WD to 0 will shut down the WD system completely but the system will still perform normally without it.
5.1.26.13 Care is required with the watchdog and it should not be changed without good cause.
5.1.26.14 Setting the SAMPLE_PERIOD variable automatically sets the WD variable to a safe value (100min to each hour of the SAMPLE_PERIOD value, WD=SAMPLE_PERIOD/72).
5.1.26.15 If WD is set to 0 then it will not be changed. If the user wishes to set WD to another value then this must be done in a subsequent line in the config file or iridium message.

5.1.27 The reconfiguration mechanism also allows a number of commands to be sent. These are as follows:-

RESET 1

CLEAR_ERR 1

CNFG_WRT 1

These have the same form as variables and the redundant values of 1 must be present.

5.1.27.1 The RESET command if present will cause the system reset when the configuration is received. If a configuration file is present on the SD card this will be read or else default values will be assumed.

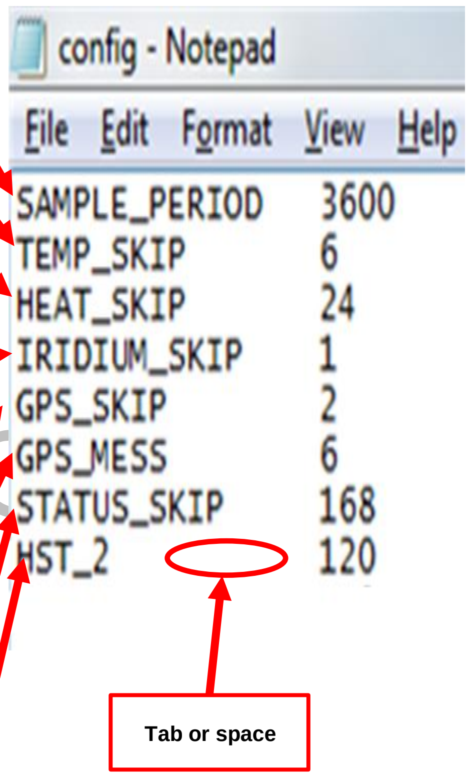
5.1.27.2 CLEAR_ERR will clear all recorded errors in the error register.

5.1.27.3 CNFG_WRT will write the present configuration to SD card. This means a reset will then reload the present configuration.

5.1.28 For all HST values observe the following. HST_4 must not be zero. The total heating time is HST_1+HST_2+HST_2+HST_4. Any other value can be zero which skips the sample and does not generate an iridium message. Each sample generates one iridium message so a heating cycle can produce from 1 to 4 messages according to the configuration. Note that to prevent overheating or severe power loss if reconfiguration results in extended heating, the total heating time is limited to 350s. An attempt to exceed this will result in the HST_1 to HST_4 values being proportionately scaled down so the total is 350.

5.1.29 At each HST point all sensors will sample instaneously but it then takes approximately 15s for a 240 sensor chain to read the values from the sensors (time ts). Therefore, no HST value should be less than ts as it will be delayed until reading has finished. The exceptions to this are a value of 0s to indicate the sample should not be undertaken and for HST_1. Because the initial state at HST_0 is taken and read back before heating commences so HST_1 can be smaller than ts.

5.1.30 Table 5 below shows a typical configuration file and details the meaning of each line.

| Command | Function | Default Setting | Screen shot from Notepad of a typical Config.txt file format |
|---|---|---|---|
| SAMPLE_PERIOD | Defines the period between sample cycles in seconds Value range 900 to 30000 (Seconds) | 3600 (1hr) |  |
| TEMP_SKIP | Number of sample cycles between each temperature measurement; 1= every sample cycle, 2 = every second cycle, etc. Value range 1 to 10000 (sample periods) | 6 | |
| HEAT_SKIP | Number of sample cycles between each heating cycle measurement; 1= every sample cycle, 2 = every second cycle, etc. Value range 1 to 10000 (sample periods) | 24 | |
| IRIDIUM_SKIP | Skips transmission of temperature and heating data, although it does get saved to the SD card. This saves on iridium airtime costs, say in the instance where it is possible to get access to the SIMBA unit SD card to retrieve the data. 1= Send all. Value range = 1 to 10000 (messages). | 1 | |
| GPS_SKIP | Number of sample cycles between each GPS sample 1= every sample cycle, 2 = every second cycle, etc. Value range 0 to 10000 (sample periods) | 2 | |
| GPS_MESS | The number of GPS (including Barometer and magnetometer, if fitted) readings that are saved before sending a GPS message via an Iridium transmission (allows reduction of unit power consumption, to save powering up for an iridium transmission). 1 = 1 GPS fix per message. Value range 1 to 8 (messages) | 6 | |
| STATUS_SKIP | Number of sample cycles between the Iridium transmission of a unit's status message. Value range 3 to 1000 (sample periods). | 168 | |
| HST_1 to 8 | Time in seconds that the heating is turned on, during a heated cycle measurement. Value range 0 to 500 (seconds) | 120 | |

## 5.2 Remote Reconfiguration

5.2.1 It is possible to reconfigure SIMBA units remotely, by sending an email via iridium to the units. The email should have attached a configuration file identical to that as described above for the SD card configuration file. In the case of remote reconfiguration by email, the file needs to be named **reconfig.sbd.** The email should be sent to the email address "data@sbd.iridium.com", and have the SIMBA units iridium modem IMEI number as the subject line as shown in the figure below.

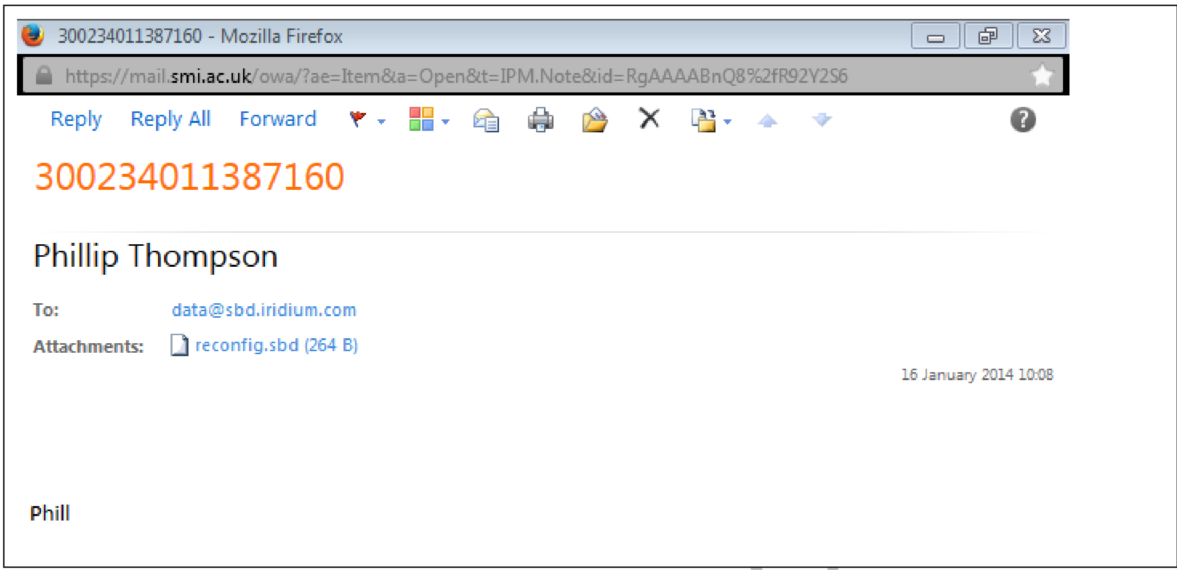



Figure 8: Example output of remote SIMBA reconfiguration.

5.2.2 Once a remote reconfiguration has been sent, the SIMBA unit will only reconfigure when it wakes up and initiates sending an iridium message or every 24hours when the Simba unit listens for any messages. It is possible to queue multiple remote reconfiguration emails but this should be avoided as all may not be downloaded in one session if, for instance, satellite coverage is lost. This will leave the unit in an unknown configuration state until the next download occurs.

5.2.3 Please note that after sending a remote reconfiguration file, if the SIMBA unit is reset at some later point, it will revert to the default SIMBA unit settings, or the configuration as per a 'config.txt' file on the SD card, if one is present.

## 5.3 Remote Reset

5.3.1 It is also possible to remotely reset SIMBA units-this has the same effect as manually resetting the unit via pressing the reset button on the controller board. In this case, a **reconfig.sbd** file should be sent by email as described above, with the file containing the following command only – "**RESET 1**".

5.3.2 Once reset, the unit will configure back to default settings, or those stored on the SD card. If remote configurations have been used and are still desired, then it will be necessary to send a subsequent remote reconfiguration email.

# 6 ERROR REPORTING

## 6.1 Overview

6.1.1 The latest V7 software has a comprehensive system to allow errors and exceptions to be detected and reported to allow for monitoring, debugging and reconfiguration to mitigate problems. A number of possible errors and exceptions have been identified and each assigned a code.

6.1.2 Some are deemed to be "fatal". These are errors that can be detected at startup and which will potentially cause the system to fail in some way immediately. These are reported on the LEDs during startup procedure. Other errors that occur during operation are not always of such consequence (e.g. loss of satellite connection during a transmission). All errors are counted and a record of the number of occurrences of each error type is kept and is transmitted with the status messages. An error log is also kept on the SD card.

6.1.3 A maximum count of 255 is possible for each error. When this limit is reached the count toggles between 254 and 255 to indicate there is activity rather than just saturating at 255.

## 6.2 Error codes

6.2.1 The table below described the errors and shows there codes. Some of these will not be of immediate used of value to end-users and their meaning is sometimes obscure but they may be of use to SRSL in the event of issues arising to assit in troubleshooting.

Table 6: SIMBA software v7 error codes. Refer to section 11 to link LED signals with error codes.

| Code | Abbrv. | Description |
|---|---|---|
| 0 | NullError | Null error. Can be ignored |
| 1 | BatteryLow | Low Battery (<10V) |
| 2 | RTCOscError | RTC osc. not running |
| 3 | NoSensorsOnChain | No sensors detected on chain |
| 4 | NoEEPROMOnChain | No EEPROM detected on chain |
| 5 | TooManyBrokenSensors | Too many broken sensors |
| 6 | NoInitGPSFix | No initial GPSFix |
| 7 | NoSDCard | No SD Card detected |
| 8 | HeaterVoltsLow | Heater voltage low |
| 9 | L12BadResponse | 1-wire unit bad or no response |
| 10 | BadAddrFromEEPROM | Bad address read from EEPROM |
| 11 | NoChainFound | No Chain detected |
| 12 | NoIridModemFound | No Iridium modem detected |
| 13 | NoAntenna | No iridium signal. Possible antenna problem |
| 14 | RTCNotValid | RTC not valid |
| 15 | ChainTooLong | Chain exceeds Max No. of Sensors |
| 16 | MagResponse | Magnetometer - no response |
| 17 | MagCalFile | No Magnetometer calibration file found |
| 18 | Baro_Response | Barometer bad or no response |
| 19 | GPS_Response | No response from GPS |
| 20 | NoAT24CEEPROM | No response from on-board EEPROM |
| 21 | Spare_Err1 | Reserved for future use |
| 22 | Spare_Err2 | Reserved for future use |
| 23 | Spare_Err3 | Reserved for future use |
| 24 | Spare_Err4 | Reserved for future use |
| 25 | NonFatal | Not an Error. Marks start of less serious errors. |
| 26 | WriteProtect | Unused error code |
| 27 | Waketime_Past | SD Card write protected |

| Code | Abbrv. | Description |
|---|---|---|
| 28 | NonHexInTempStr | Non-hex char  from sensor |
| 29 | ChainShorted | Chain data bus short circuit |
| 30 | IridBuffFull | Iridium buffer overflow |
| 31 | BrownOut | Brownout reset |
| 32 | Watchdog | Watchdog reset |
| 33 | ConfigMismatch | Config. mismatch reset |
| 34 | IllegalOpcode | Illegal opcode reset |
| 35 | TrapReset | Trap conflict reset |
| 36 | WDT_Wake | Woken by WDT |
| 37 | Unknown_Wake | Wake source unknown |
| 38 | SmplNoFile | Could not open sample No. file |
| 39 | GPSFIx_Fail | Failed to get GPS fix |
| 40 | HeatCycleSkipped | Heat cycle skipped. Volts low. |
| 41 | SigStrength | Invalid Iridium Signal Strength |
| 42 | SBDIX_Response | No response to SBDIX from modem |
| 43 | DataFile | Unable to write SD card data file |
| 44 | IridUndefFailure | Iridium network. Undefined session failure |
| 45 | IridNoTime | Iridium network. Did not complete session in time |
| 46 | IridQFull | Iridium network. Gateway queue full |
| 47 | IridSegments | Iridium network. Too many segments. |
| 48 | IridNoComplete | Iridium network. Did not complete session |
| 49 | IridSegSize | Iridium network. Invalid segment size. |
| 50 | IridAccess | Iridium network. Access denied. |
| 51 | IridLocked | Modem locked. |
| 52 | IridGateway | Iridium network. Gateway not responding. |
| 53 | IridRFDrop | Iridium network. Connection lost. RF Drop. |
| 54 | IridAntenna | Antenna fault. |
| 55 | IridDisabled | Radio disabled. |
| 56 | IridBusy | Modem is busy. |
| 57 | NoIridSession | No Irid. session in 24 hrs |
| 58 | Killed | Indicates kill command sent |
| 59 | UnUsedError1 | Undefined error code |
| 60 | UnUsedError2 | Undefined error code |
| 61 | UnUsedError3 | Undefined error code |
| 62 | UnUsedError4 | Undefined error code |
| 63 | UnUsedError5 | Undefined error code |

# 7 REAL TIME CLOCK (RTC) AND WATCHDOG

## 7.1 Clock setting

7.1.1 The built in clock and data circuit requires setting after power-on or reset. Once set it will run continuously using a low power clock circuit and crystal oscillator. The clock circuit provides all time stamping and timing control functions. The clock will set automatically from GPS at power up and will also resort to using the time information from the Iridium system if this fails. If this fails the unit will run with timestamps beginning from the reset state (around 1st Feb 2010) so time stamps will be wrong but intervals should be correct.

7.1.2 In default mode the clock will be updated from the GPS system every time a fix is obtained. With regular GPS fixes occurring the accuracy is extremely good. However, this feature can be turned off and the clock left to run without updates which means drifts in the region of 15s per month could be expected and this is why the default is set for GPS update. It is possible to request a single clock update via the Iridium system using the remote configuration feature. The clock modes are selected using the SET_CLK configuration variable. Where GPS there are issues with getting a good GPS signal such as on a ship, the system can be set to use Iridium only for RTC update.

## 7.2 Array synchronisation

7.2.1 Some studies have demanded that an array of devices all obtain GPS fixed at the same moment. This is useful in gauging floe orientation and deformation. Consequently, after start-up and an initial sample cycle occur the next wakeup time will be set to be on the next hour irrespective of the setting of SAMPLE_PERIOD variable. After the next sample cycle it will wake at the time set by the configuration. This can then ensure that all units can be coordinated to wake on the hour. A one-hour sample period is recommended for this. With period GPS updates the units can be made to obtain GPS fixes to within 2 seconds of the hour.

**NOTE:** that if the next wake-up cycle has a GPS fix scheduled the unit will wake one minute before time to allow the GPS system to obtain an accurate fix by the time the sample is taken.

## 7.3 Watchdog

7.3.1 The controller contains a low-power self-contained watchdog timer which triggers at approximately 120s intervals. When the unit is awake and active the watchdog counter is constantly reset but if some exception occurs causing the processor to crash or get caught in a loop then the watchdog will time-out and force a reset of the system.

7.3.2 During hibernation, the system sets an alarm function using the real-time clock to wake at the appointed time (usually in one hour). However, the watchdog will still run and briefly wakes the system around every two minutes for a few milliseconds. The system will count these awakenings but normally will return to sleep until the alarm system triggers. However, if the number of watchdog events grows large it could indicate an issue with the RTC. Therefore, if the system calculates from the watchdog events that the system is 50% over the anticipated wakeup period then the system will full wake and perform a normal sample cycle. The reason for this is that the low power RTC circuit is the most likely part of circuitry to fail as the crystal oscillator can fail to start at low power. If this occurs the system will limp along at a rate 50% slower than predicted and timestamps may be incorrect although information from transmission times can be used to estimate sampling.

7.3.3 The user does not need to configure the watchdog, it is done automatically but can be over-ridden or disabled using the WD configuration variable.

# 8 CSV FILE FORMATS

## 8.1 Introduction

8.1.1 This section describes the format and content of the CSV files that are available from the SRSL web interface. As per Figure 4, three CSV file types are available as standard from the SRSL CSV file page, which are described in the following sections:

- 'td.txt' for temperature profile
- 'gps.txt' for GPS data,
- 'st.txt' for the (unit) status message.

8.1.2 These files are best opened in and manipulated in Excel with comma delimiters

## 8.2 Temperature Data CSV File – td.txt

8.2.1 The file is a standard text file containing comma separated values. Each iridium message consists of a long line of text, with a carriage return at the end. The Figure below shows a typical td.txt file output.

8.2.2 The box below shows a typical section of output for a temperature (& heating) data CSV file (td.txt). The yellow highlight area shows one record with a carriage return at the end.

```
874,2017-02-04 20:22:35,58.70459,-92.62451,77,3,6,1,2,10,2017-02-04 20:21:59,298,241,703,2,132,273,0,0,0,0,84.75,-
0.1875,-22,-22.0625,-22.1875,-22.125,-22,-21.9375,-21.75,-21.5625,-21.625,-21.75,-21.75,-21.75,-21.75,-21.75,-
21.8125,-21.8125,-21.875,-22,-22.0625,-22.125,-22.1875,-22.25,-22.25,-22.25,-22.25,-22.1875,-22.3125,-22.25,-
22.3125,-22.25,-22.3125,-22.3125,-22.3125,-22.3125,-22.375,-22.3125,-22.1875,-22.1875,-22.0625,-22,-22,-22,-22,-
22.0625,-22.0625,-22.0625,-22.0625,-22,-22,-21.9375,-21.875,-21.9375,-22,-21.9375,-21.875,-21.875,-21.875,-21.75,-
21.8125,-21.75,-21.8125,-21.75,-21.75,-21.75,-21.8125,-21.875,-21.9375,-22.125,-22.1875,-22.25,-22.25,-22.1875,-
22.25,-22.25,-22.3125,-22.25,-22.25,-22.1875,-22.3125,-22.25,-22.3125,-22.1875,-22.25,-22.25,-22.3125,-22.25,-
22.3125,-22.25,-22.3125,-22.125,-22.125,-22.0625,-22,-22,-21.875,-21.8125,-21.875,-21.8125,-21.8125,-21.875,-
21.9375,-22,-21.875,-21.875,-21.75,-21.6875,-21.75,-21.8125,-21.9375,-21.875,-22,-21.9375,-22.125,-22.0625,-22.1875,-
22.125,-22.125,-22,-22.1875,-22.1875,-22.1875,-22.125,-22.125,-22.125,-22.1875,-22.25,-22.3125,-22.1875,-22.25,-
22.1875,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-
99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-
99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-
99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-
99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-
99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-
99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-
99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9

875,2017-02-04 20:22:50,58.70459,-92.62451,78,3,6,2,2,10,2017-02-04 20:21:59,252,241,703,2,109,273,0,0,0,0,-
22.125,-22.125,-22.125,-22.0625,-22.0625,-22.125,-22.0625,-22.125,-22.125,-22.0625,-22.0625,-22,-21.8125,-21.8125,-
21.875,-21.9375,-21.875,-21.875,-21.875,-21.8125,-21.9375,-21.875,-22,-22.0625,-22.0625,-22.125,-22.125,-22.25,-
22.1875,-22.25,-22.1875,-22.1875,-22.125,-22.125,-22.1875,-22.1875,-22.1875,-22.1875,-22.1875,-22.1875,-22.25,-
22.25,-22.25,-22.25,-22.25,-22.3125,-22.3125,-22.3125,-22.375,-22.25,-22.1875,-22.1875,-22.1875,-22.125,-22,-
22.0625,-22.0625,-22,-22,-22.0625,-22.0625,-22,-22,-21.9375,-21.9375,-21.9375,-21.9375,-22,-22.0625,-22,-22,-
22.0625,-22.1875,-22.125,-22.125,-22,-21.875,-22,-22,-22.0625,-22.125,-22.1875,-22.0625,-22.125,-22.125,-22.125,-
22.1875,-22.125,-22.125,-22.0625,-22,-21.9375,-21.9375,-21.9375,-21.8125,-21.875,-21.75,-21.8125,-21.8125,-21.8125,-
21.8125,-21.8125,-21.8125,-21.625,-21.8125,-21.6875,-21.6875,-21.625,-21.8125,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-
99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-
99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-
99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-
99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-
99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-
99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-
99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-
99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-99.9,-
99.9,-99.9,-99.9,-99.9,-99.9
```

8.2.3 Note that both normal temperature profiles and heated profiles are available in this file. The MsgType field identifies the type of record. For unheated profiles the data is sent as two messages. If the server can match the two parts it will merge them into a single record into the CSV file. If this is not possible then the message will represent only part of the data and missing values are padded with -99.9.

8.2.4 During a heated mode cycle many messages may be created. To be able to identify the records belonging to a cycle, the SerialNum field may be used, as this will be the same for all profiles taken during a single wake-up cycle.

Details of the fields are shown in the following table (Table 7).

Table 7: Details of heated mode cycle messages.

| No. | Message type | Format |
|---|---|---|
| 1 | MOMSN | The iridium message serial number for that modem. A sequential number for each message it sends. |
| 2 | IridDate | Date and time of the message according to the Iridium satellite network system and **not the on-board SIMBA unit clock** |
| 3 | IridLat | SIMBA unit latitude position derived from the Iridium satellite network system and **not the on-board SIMBA unit GPS** |
| 4 | IridLng | SIMBA unit longitude position derived from the Iridium satellite network system and **not the on-board SIMBA unit GPS** |
| 5 | IridCEP | A measurement of position uncertainty in kilometres of the iridium satellite network system provided lat and long. |
| 6 | EmailTime | Not normally used, time of reception of clock email system. |
| 7 | SerialNum | Sample period number (increments each time the SIMBA unit wakes up) |
| 8 | TotalMsgPart | Number of iridium SBD transmissions used to send a data message (1 or 2 typically). This mostly a value of 1 but for temperature profiles there is too much data for a single transmission (320 byte limit) and so the profile data is sent as two transmissions and hence this value will be 2 in both messages. Heated temperature profiles are single transmission messages since less data is transmitted compared to absolute temperature profiles (i.e. just the small changes in temperature are sent). |
| 9 | MsgPart | Message part number of the data transmission. For single transmission messages this is always 1, for messages requiring two transmissions this will be 1 or 2 (i.e. to indicate 1-of-2 or 2-of-2). |
| 10 | MsgType | Message type:<br>10 = Unheated temperature profile<br>The following relate to the heated mode. Each set of measurements is the change (positive is a rise) relative to the initial temperature.<br>11 = Temperature change at time HST1.<br>12 = Temperature change at time HST1+HST2.<br>13 = Temperature change at time HST1+HST2+HST3.<br>14 = Temperature change at time HST1+HST2+HST3+HST4. Heater off.<br>15 = Temperature change at time HST1+HST2+HST3+HST4+HST5.<br>16 = Temperature change at time HST1..HST5+HST6.<br>17 = Temperature change at time HST1..HST6+HST7.<br>18 = Temperature change at time HST1..HST7+HST8. |
| 11 | SendTime | Time of sample according to the SIMBA unit clock (in ASCII format). |
| 12 | MsgLength | Length of message in bytes – determined by number of sensors on chain. |
| 13 | TotalRecs | Total number of records in message (total of both parts if message split). Usually the same as the number of sensors on the chain. |
| 14 | SoftwareVer | Software version. Used be server to apply correct decoding |
| 15 | DataRecSize | Size of data (2bytes for temperature,1byte for heating rise) |
| 16 | DataRecNum | Number of records in this transmission. For split transmissions this is the number in this part. Generally, the server will merge parts of message into a single csv file entry if both parts received so this can then be ignored. |
| 17 | ChainSN | Serial number of the chain attached to the SIMBA unit |
| 18 | ChainSenSep | Always 2cm. |
| 19 | H_MeasureTime | Total time of heating for heating cycles from start of heating (in seconds) |
| 20 | H_DutyCycle | No longer used. Always 0 |
| 21 | H_EndVolt | Reported voltage applied to heaters (measured at end of heating cycle). Should be 8V with healthy batteries. Only applies to heated profiles |
| 22+ | T0,T1 to T287 | Reported Sensor temperatures or temperature change in the case of heating cycles Celsius. Unused records set to default -99.9 |

## 8.3 (Unit) Status Message CSV File – st.txt

8.3.1 The file is a standard text file containing comma separated values. Each record consists of a long line of text, with a carriage return at the end. Each record represents the data from a single status message sent by the SIMBA unit.

```
873,2017-02-04 20:20:48,58.70171,-92.76243,95,2,2,1,1,31,2010-02-03 23:33:11,166,1,703,132,1,2010-02-03 23:30:00,168,3600,6,2,24,6,1,30,0,0,90,0,0,0,0,2,45,10000,15.015,15.015,15.05,15.05,3.185,4.935,14.77,8.015,E3=1:E4=1:E6=1:E11=2:E13=1:E14=1:E16=1:E39=1

958,2017-02-04 23:36:38,58.75529,-93.80488,2,2,168,1,1,31,2017-02-04 23:35:18,166,1,703,132,1,2010-02-03 23:30:00,168,3600,6,2,24,6,1,30,0,0,90,0,0,0,0,2,45,10000,15.015,14.98,15.015,15.015,3.22,1.225,14.7,8.015,E0=1:E3=2:E4=2:E6=1:E11=3:E13=1:E14=2:E16=85:E37=165:E39=3:E44=2:E53=15
```

8.3.2 The file includes some general header data, then the values of the configuration variables, voltage readings and then error counts. Fields are comma delimited but the errors form a variable length single text field which is internally delimited by colons. The error subfields show the error code and the count unless the count is zero in which case it is supressed.

8.3.3 Table 8: The information presented in a (unit) status message CSV file (st.txt) is presented below (in order).

| No. | Message type | Format |
|---|---|---|
| 1 | MOMSN | The iridium message number for that modem. A sequential number for each message it sends. |
| 2 | IridDate | Date and time of the message according to the Iridium satellite network system and **not the on-board SIMBA unit clock** |
| 3 | IridLat | SIMBA unit position derived from the Iridium satellite network system and **not the on-board SIMBA unit GPS** |
| 4 | IridLng | SIMBA unit position derived from the Iridium satellite network system and **not the on-board SIMBA unit GPS** |
| 5 | IridCEP | A measurement of position uncertainty in kilometres of the iridium satellite network system provided lat and long. |
| 6 | EmailTime | Not normally used, time of reception of clock email system. |
| 7 | SerialNum | Sample period number (increments each time the SIMBA unit wakes up) |
| 8 | TotalMsgPart | Number of iridium messages used to send the data (1 for status messages). |
| 9 | MsgPart | Message number of the data transmission (always 1 for status messages). |
| 10 | MsgType | Should display '30' for a status message. |
| 11 | SendTime | Time of sample according to the SIMBA unit clock (in ASCII format). |
| 13 | MsgLength | Length of message in bytes. |
| 14 | SoftwareVer | Software version. Used be server to apply correct decoding |
| 15 | DataRecSize | Size of data, a single 132 byte record in a status message. |
| 16 | DataRecNum | Number of records in this transmission, always 1 in a status message |
| 17 | StatusChanges | Number of changes (unit remote reconfigurations) made remotely since last reset. |
| 18 | LastChangeTime | Time of last change according to the SIMBA unit clock (in ASCII format) |
| 19 | StatusSkip | Current configuration setting for STATUS_SKIP |
| 20 | SamplePer | Current configuration setting for the sample period |
| 21 | TempSkip | Current configuration setting for TEMP_SKIP |
| 22 | GpsSkip | Current configuration setting for GPS_SKIP |
| 23 | HeatSkip | Current configuration setting for HEAT_SKIP |
| 24 | FixPerMess | Current configuration setting for GPS_MESS |
| 25 | IridiumSkip | Current configuration setting of IRIDIUM_SKIP |
| 26-33 | HST_1 to HST_8 | Current configuration setting of HST_1 to 8 |
| 34 | SetClk | Current configuration setting of SET_CLK |
| 35 | Watchdog | Current configuration setting of WD |
| 36 | HeatThres | Current configuration setting of HEAT_THRES |
| 37-41 | ADCCh0 to ADCCh3 | The current voltages on the 4 battery connections, 6 connections from the battery pack, some are doubled up. |
| 42 | ADCCh4 | The value of the 3.3V regulated supply on controller board |
| 43 | ADCCh5 | The value of the 5V regulated supply on controller board |
| 44 | ADCCh6 | The current SIMBA unit voltage of all batteries after being commoned through diodes used for input protection. |
| 45 | ADCCh7 | The current voltage being supplied to heating resistors in the thermistor chain. |
| 46-109 | Err_0 to Err_63 | Count of occurrences of each error type |

## 8.4 GPS Message CSV File – gps.txt

8.4.1 The file is a standard text file containing comma separated values. Each iridium message consists of a long line of text, with a carriage return at the end. Note that typically a single Iridium transmission is used to send a number of GPS samples (default is 6). The server will split these so each fix is displayed as a single record. Consequently, it will be observed that different records will contain identical data which relates to the actual transmission. A GPS fix includes magnetometer and barometer data. The box below shows a typical gps.txt file output. The yellow highlighted area shows one complete GPS message (note the carriage return at the end of the highlighted section, which ends the message).

```
876,2017-02-04 20:27:35,58.706,-93.8003,3,3,12,1,1,21,2017-02-04 20:26:33,238,6,703,34,6,0,0,0,0,0,0,2010-02-03 23:37:47,0,0,20.6875,1008.000,0,0,0,0.000,0.000,0.000,65535,0,2
876,2017-02-04 20:27:35,58.706,-93.8003,3,3,12,1,1,21,2017-02-04 20:26:33,238,6,703,34,6,0,0,0,0,0,0,2017-02-04 20:18:50,58.737893,-93.81872,4.9375,1008.000,0,0,0,0.000,0.000,0.000,65535,0,4
876,2017-02-04 20:27:35,58.706,-93.8003,3,3,12,1,1,21,2017-02-04 20:26:33,238,6,703,34,6,0,0,0,0,0,0,2017-02-04 20:21:57,58.73792,-93.81868,3.4375,1008.000,0,0,0,0.000,0.000,0.000,65535,0,6
876,2017-02-04 20:27:35,58.706,-93.8003,3,3,12,1,1,21,2017-02-04 20:26:33,238,6,703,34,6,0,0,0,0,0,0,2017-02-04 20:24:04,58.737913,-93.81868,2.375,1008.000,0,0,0,0.000,0.000,0.000,65535,0,8
876,2017-02-04 20:27:35,58.706,-93.8003,3,3,12,1,1,21,2017-02-04 20:26:33,238,6,703,34,6,0,0,0,0,0,0,2017-02-04 20:25:18,58.737913,-93.818733,1.8125,1008.000,0,0,0,0.000,0.000,0.000,65535,0,10
876,2017-02-04 20:27:35,58.706,-93.8003,3,3,12,1,1,21,2017-02-04 20:26:33,238,6,703,34,6,0,0,0,0,0,0,2017-02-04 20:26:32,58.737906,-93.81872,1.1875,1008.000,0,0,0,0.000,0.000,0.000,65535,0,12
881,2017-02-04 20:39:31,58.88526,-97.03028,194,2,24,1,1,21,2017-02-04 20:38:04,238,6,703,34,6,0,0,0,0,0,0,2017-02-04 20:30:59,58.7379,-93.81868,-0.75,1009.000,0,0,0,0.000,0.000,0.000,65535,0,14
```

8.4.2 Table 9: The information presented in a GPS message CSV file (gps.txt) is presented below (in order).

| No. | Message type | Format |
|---|---|---|
| 1 | MOMSN | The iridium message number for that modem. A sequential number for each message it sends. |
| 2 | IridDate | Date and time of the message according to the Iridium satellite network system and **not the on-board SIMBA unit clock** |
| 3 | IridLat | SIMBA unit position derived from the Iridium satellite network system and **not the on-board SIMBA unit GPS** |
| 4 | IridLng | SIMBA unit position derived from the Iridium satellite network system and **not the on-board SIMBA unit GPS** |
| 5 | IridCEP | A measurement of position uncertainty in kilometres of the iridium satellite network system provided lat and long. |
| 6 | EmailTime | Not normally used, time of reception of clock email system. |
| 7 | SerialNum | Sample period number (increments each time the SIMBA unit wakes up). In this case it represents the cycle when a number of GPS fixes were bundled into a single message, not the cycle when the sample was taken. The last field represents the actual sample cycle. |
| 8 | TotalMsgPart | Number of iridium messages used to send the data. Always 1 for GPS messages |
| 9 | MsgPart | Message number of the data transmission (e.g. 1 of 2) |
| 10 | MsgType | Should display '20' for a gps message. |
| 11 | SendTime | Time of sample according to the SIMBA unit clock (in ASCII format) |
| 12 | MsgLength | Length of message in bytes |
| 13 | TotalRecs | Total records sent in message (usually six). However, a single record in the CSV file will be one of these. |
| 14 | SoftwareVer | Software version. Used be server to apply correct decoding |
| 15 | DataRecSize | Size of data record (34 bytes for GPS messages) |
| 17 | DataRecNum | Number of records in this transmission, default is six |
| 18 | - | Not used |
| 19 | - | Not used |
| 20 | - | Not used |
| 21 | - | Not used |
| 22 | - | Not used |
| 23 | - | Not used |
| 24 | GPSDateTime | Time (if successfully ascertained from GPS satellites) |
| 25 | GPSLat | GPS system reported latitude (0.0000 if no fix) |
| 26 | GPSLng | GPS system reported longitude (0.000 if no fix) |
| 27 | Temperature | Temperature measure by barometer in box (°C) |
| 28 | Pressure | Barometric pressure in Millibars If no barometer is fitted, a default value of 500 is displayed. |
| 29–31 | MagX, MagY, MagZ | Magnetometer readings in MicroTeslas (if a magnetometer is fitted to the SIMBA unit). N.B. if no magnetometer is fitted, default values of 0,1,0 are displayed. |
| 32-34 | AccX, AccY, AccZ | Accelerometer readings in milli-g (mg). 0,0,1 represents a unit placed level. |
| 35 | Tilt | The angle (degrees) from horizontal of the unit (level=0). |
| 36 | Compass | Bearing (in degrees) from the magnetometer. If no magnetometer is fitted, a default value of 0 is displayed. |
| 37 | GPSserialNo | The serial number of the wake-up cycle on which the GPS fix was sampled. |

# 9 SD CARD FILE FORMATS

## 9.1 Introduction

9.1.1 This section describes the format and content of files available from a SIMBA unit SD card. **N.B. there is some variation from the CSV file format**. The files available are:

- 'GPSDATA.TXT' for GPS data,
- .
- 'TEMPDATA.TXT' which stores heating profile data
- 'DELDATA#.TXT' which is a series of files holding heated profile data
- 'STATDAT.TXT' which holds status data
- 'LOGFILE.TXT' which holds a running log of the units activity
- 'ERRFILE.TXT' which logs any errors as they occur

## 9.2 GPS Message SD File – GPSDATA.TXT

9.2.1 The file is a standard text file. The file contains two lines of data (i.e. separated by a carriage return), with data separated by spaces. The box shows a typical GPSDATA.TXT file output. Each value is delimited by spaces and each record is delimited by a carriage return

```
3306 2017/02/08 14:21:41 1486563701   57357573   -2370733  8.19  1018  -8.19  -2.80  61.05 -
0.021 -0.022  1.066     1   169

 3308 2017/02/08 16:00:12 1486569612   57357660   -2370746  5.81  1019 -10.50  -1.80  64.65 -
0.022 -0.022  1.066     1   178

 3310 2017/02/08 17:00:12 1486573212   57357606   -2370711  5.00  1019 -11.69  -1.30  62.65 -
0.022 -0.023  1.070     1   180
```

9.2.2 Table 10: The information presented in a GPS file from the SD card (GPSDATA.TXT) is shown below (in order).

| No. | Message type | Format |
|---|---|---|
| 1 | Sample Number | This first field has space for five characters. It is a sequential number, based on the sample number. |
| 2 | GPS Date & Time | YYYY:MM:DD HH:MM:SS |
| 3 | GPS Date & Time UNIX | As above in unix epoch format |
| 4 | GPSLat | µDeg. Negative is south of equator |
| 5 | GPSLng | µDeg. Negative is east of Greenwich meridian |
| 6 | Internal case temp. | Degrees Celcius. Derived from barometer sensor. |
| 7 | Pressure | Barometric pressure in Millibars If no barometer is fitted, a default value of 500 is displayed. |
| 8 | Mag X | Magnetometer X-axis reading in µTeslas |
| 9 | Mag Y | Magnetometer Y-axis reading in µTeslas |
| 10 | Mag Z | Magnetometer Z-axis reading in µTeslas |
| 11 | Acc X | Accelerometer X-axis in mG |
| 12 | Acc Y | Accelerometer Y-axis in mG |
| 13 | Acc Z | Accelerometer Z-axis in mG |
| 14 | Tilt | Measured tilt of unit from horizontal in degrees |
| 15 | Orientation | Bearing (in degrees) from the magnetometer if fitted. Orientation derived from magnetometer and accelerometer readings |

## 9.3 TEMP.TXT SD Card File.

9.3.1 A section of a typical file is shown below. Records representing one profile are delimited with carriage returns and fields within records are delimited with spaces.

```
3306 2017/02/08 14:21:43 1486563703  46 -1   0     0    8.06250     8.18750
8.43750     8.56250    -4.43750    -0.25000     8.50000     8.50000     8.43750
8.43750     8.43750     8.43750     8.56250     8.62500     8.62500     8.62500
8.62500     8.50000     8.50000     8.50000     8.43750     8.43750     8.43750
8.43750     8.31250     8.25000     8.25000     8.25000     8.25000     8.37500
8.43750     8.37500     8.18750     7.93750     7.87500     7.68750     7.62500
7.62500     7.62500     7.62500     7.68750     7.75000     7.81250     7.87500
7.87500     7.87500

 3312 2017/02/08 19:00:13 1486580413  46 -1   0     0    5.00000     4.93750
5.06250     5.18750    -4.43750    -0.25000     5.00000     5.00000     4.93750
4.93750     4.93750     4.93750     5.00000     5.06250     5.06250     5.06250
5.06250     5.00000     4.93750     5.00000     4.93750     4.93750     4.93750
4.93750     4.87500     4.81250     4.81250     4.81250     4.81250     4.93750
4.93750     4.87500     4.68750     4.50000     4.37500     4.25000     4.18750
4.18750     4.18750     4.12500     4.12500     4.18750     4.25000     4.25000
4.37500     4.43750

 3318 2017/02/09 01:00:15 1486602015  46 -1   0     0    3.31250     3.31250
3.56250     3.68750    -4.43750    -0.25000     3.50000     3.43750     3.37500
3.37500     3.37500     3.31250     3.43750     3.43750     3.43750     3.43750
3.37500     3.31250     3.25000     3.25000     3.18750     3.18750     3.25000
3.18750     3.18750     3.12500     3.18750     3.12500     3.18750     3.31250
3.37500     3.31250     3.18750     2.93750     2.87500     2.68750     2.62500
2.62500     2.62500     2.50000     2.50000     2.56250     2.62500     2.62500
2.68750     2.81250
```

9.3.2 Table 11: The format of each TEMP.TXT record is described as follows:

| No. | Message type | Format |
|---|---|---|
| 1 | Sample Number | This first field has space for five characters. It is a sequential number, based on the sample number. |
| 2 | GPS Date & Time | YYYY:MM:DD HH:MM:SS |
| 3 | GPS Date & Time UNIX | As above in unix epoch format |
| 4 | N | The number of sensors on chain |
| 5 | Tag | Always -1 in this file |
| 6 | Elapsed time | Always 0 in this file |
| 7 | Not used | Always zero |
| 8 | T1 | Temperature of first (top) sensor on chain in Degrees Celsius |
| 9 | T2 | Temperature of second sensor on chain in Degrees Celsius |
| | .. | |
| N+7 | TN | Temperature of penultimate sensor on chain in Degrees Celsius. |
| N+8 | TN | Temperature of last (bottom) sensor on chain in Degrees Celsius. Note that commonly this last sensor is physically wired and positioned as an air temperature sensor. |

## 9.4 DELDATA#.TXT SD Card Files.

9.4.1 These files hold the temperature profiles from the heating phase. The DELDATA1.TXT is the initial unheated temperature at the moment heating is applied. Then files are produced to hold data as controlled by the various HST_# settings. For example, DELDATA1.TXT holds data from samples at time HST_1. The rsults of a heating cycle will be spread over several files but records from the same cycle can be grouped by the sample number.

9.4.2 A typical file extract is shown below. A single record representing a temperature profile at one point in the heating cycle is shown in yellow.

```
3312 2017/02/08 19:01:42 1486580502  46  1  30  8120    1.37500    1.50000    1.62500
1.62500    0.00000    0.00000    2.31250    2.43750    2.43750    2.31250
2.31250    2.37500    2.37500    2.37500    2.31250    2.31250    2.31250
2.31250    2.31250    2.31250    2.31250    2.31250    2.25000    2.25000
2.12500    2.18750    2.18750    2.18750    2.18750    2.12500    2.18750
2.25000    2.25000    2.18750    2.18750    2.25000    2.18750    2.18750
2.12500    2.25000    2.31250    2.31250    2.31250    2.25000    2.18750
2.12500

 3336 2017/02/16 21:01:43 1487278903  46  1  30  8120    1.37500    1.43750    1.62500
1.62500    0.00000    0.00000    2.37500    2.37500    2.43750    2.31250
2.31250    2.37500    2.37500    2.31250    2.31250    2.31250    2.31250
2.31250    2.31250    2.31250    2.25000    2.31250    2.31250    2.18750
2.12500    2.18750    2.18750    2.18750    2.12500    2.12500    2.12500
2.18750    2.18750    2.25000    2.18750    2.18750    2.18750    2.25000
2.12500    2.25000    2.25000    2.31250    2.25000    2.18750    2.18750
2.18750

 3360 2017/02/17 21:01:43 1487365303  46  1  30  8120    1.31250    1.43750    1.56250
1.62500  0.00000  0.00000  2.37500  2.37500  2.37500  2.31250  2.37500  2.31250
2.31250  2.31250  2.25000  2.31250  2.31250  2.37500  2.25000  2.25000  2.25000
2.31250  2.31250  2.18750  2.12500  2.18750  2.18750  2.18750  2.12500  2.12500
2.18750  2.18750  2.18750  2.25000  2.18750  2.18750  2.18750  2.25000  2.18750
2.31250  2.25000  2.31250  2.18750  2.18750  2.25000  2.12500
```

9.4.3 The format is presented in Table 12.

Table 12: The format of each DELDATA1.TXT record is described as follows:

| No. | Message type | Format |
|---|---|---|
| 1 | Sample Number | This first field has space for five characters. It is a sequential number, based on the sample number. |
| 2 | GPS Date & Time | YYYY:MM:DD HH:MM:SS |
| 3 | GPS Date & Time UNIX | As above in unix epoch format |
| 4 | N | The number of sensors on chain |
| 5 | Tag | The corresponding HST value for this sample. 0 is the initial temperature, 1 is at time HST_1 etc. All values are absolute in degrees Celsius. |
| 6 | Elapsed time | The cumulative elapsed time of sample after heating began |
| 7 | Heater V | The value of the heater voltage at the time of the sample |
| 8 | T1 | Temperature of first (top) sensor on chain in Degrees Celsius |
| 9 | T2 | Temperature of second sensor on chain in Degrees Celsius |
| | .. | |
| N+7 | TN | Temperature of penultimate sensor on chain in Degrees Celsius. |
| N+8 | TN | Temperature of last (bottom) sensor on chain in Degrees Celsius. Note that commonly this last sensor is physically wired and positioned as an air temperature sensor. |

## 9.5 STATDAT.TXT SC Card File

9.5.1 This file is produced each time a status transmission occurs and contains the same data. A section from a typical file is shown below. A single record is shown in yellow and delimited by a carriage return.

```
 3306 2017/02/08 14:19:58   168  3600     6     2    24     6     1    30     0     0
90     0     0     0     0     2    45 10000     0     0     0     0     0     0 13860
0     0     0     0  4935 13510  8120    0    0    0    0    0    0    0    0    0    0    0    0    0
1    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0
 3325 2017/02/16 12:52:45   168  3600     6     2    24     6     1    30     0     0
90     0     0     0     0     2    45 10000     0     0     0     0     0     0 13825
0     0     0     0  4900 13440  8155    0    0    0    1    1    0    0    0    0    0    0    1    0
1    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0

 3327 2017/02/16 13:13:16  168  3600   6   2   24   6   1   30   0   0   90   0   0   0   0
2  45 10000   0   0   0   0   0   0 13825   0   0   0   0  4900 13440  8155  0  0  0  0
0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
```

9.5.2 The format is presented in Table 13.

Table 13: The format of each STATDAT.TXT record is described as follows:

| No. | Message type | Format |
|---|---|---|
| 1 | Sample Number | This first field has space for five characters. It is a sequential number, based on the sample number. |
| 2 | GPS Date & Time | YYYY:MM:DD HH:MM:SS |
| 3 | STATUS_SKIP | Value of corresponding configuration variable setting. Counts |
| 4 | SAMPLE_PERIOD | Value of corresponding configuration variable setting. Counts |
| 5 | TEMP_SKIP | Value of corresponding configuration variable setting. Counts |
| 6 | GPS_SKIP | Value of corresponding configuration variable setting. Counts |
| 7 | HEAT_SKIP | Value of corresponding configuration variable setting. Counts |
| 8 | GPS_MESS | Value of corresponding configuration variable setting. Counts |
| 9 | IRIDIUM_SKIP | Value of corresponding configuration variable setting. Seconds |
| 10 | HST_1 | Value of corresponding configuration variable setting. Seconds |
| 11 | HST_2 | Value of corresponding configuration variable setting. Seconds |
| 12 | HST_3 | Value of corresponding configuration variable setting. Seconds |
| 13 | HST_4 | Value of corresponding configuration variable setting. Seconds |
| 14 | HST_5 | Value of corresponding configuration variable setting. Seconds |
| 15 | HST_6 | Value of corresponding configuration variable setting. Seconds |
| 16 | HST_7 | Value of corresponding configuration variable setting. Seconds |
| 17 | HST_8 | Value of corresponding configuration variable setting. Seconds |
| 18 | SET_CLK | Value of corresponding configuration variable setting. 0,1, 2 or 3 |
| 19 | WD | Value of corresponding configuration variable setting. Seconds x 120 |
| 20 | HEAT_THRES | Value of corresponding configuration variable setting. mV |
| 21 | Spare | |
| 22 | Spare | |
| 23 | Spare | |
| 24 | Spare | |
| 25 | Spare | |
| 26 | Spare | |
| 27 | Spare | |
| 28 | Spare | |
| 29 | ADCCh0 | The current voltages on the 4 battery connections, 6 connections from the battery pack, some are doubled up. |
| 30 | ADCCh1 | The current voltages on the 4 battery connections, 6 connections from the battery pack, some are doubled up. |
| 31 | ADCCh2 | The current voltages on the 4 battery connections, 6 connections from the battery pack, some are doubled up. |
| 32 | ADCCh03 | The current voltages on the 4 battery connections, 6 connections from the battery pack, some are doubled up. |
| 33 | ADCCh4 | The value of the 3.3V regulated supply on controller board |
| 34 | ADCCh5 | The value of the 5V regulated supply on controller board |
| 35 | ADCCh6 | The current SIMBA unit voltage of all batteries after being common through diodes used for input protection. |
| 36 | ADCCh7 | The current voltage being supplied to heating resistors in the thermistor chain. |
| 37 | Error1 | Count of error 1 occurrences |
| | .. | |
| 80 | Error 63 | Count of error 63 occurrences |

## 9.6 LOGFILE.TXT SD Card File

9.6.1 This file logs activity of the unit and is useful for debugging. A typical sample is shown below:-

```
2017/02/08 14:20:40 | Starting sample sequence 3306 ************************
2017/02/08 14:20:41 | Getting GPS fix. Continue for 60s
2017/02/08 14:21:41 | Simba Clock Time updated from GPS
2017/02/08 14:21:41 | GPS Date 08/02/2017 14:21:41,(1486563701)
2017/02/08 14:21:41 | Fix 5721.4546 N (57357573)   222.2441 W (-2370733)
2017/02/08 14:21:41 | Magnetometer readings (Degrees) Heading=169, Tilt=1
2017/02/08 14:21:41 | Barometer reading 1018millibar
2017/02/08 14:21:42 | Storing fix (1 of 6)
2017/02/08 14:21:43 | Reading 46 Chain sensor Temperatures
2017/02/08 14:21:51 | Creating temperature message for transmission
2017/02/08 14:21:51 | Message queue size 2. Timeout at 2017/02/08 14:27:51
2017/02/08 14:21:57 | Iridium modem powered up
2017/02/08 14:21:57 | Sending packet type 31, length 166, SN 3306
```

## 9.7 ERRFILE.TXT SD Card File

9.7.1 This file logs errors as they occur in the unit and is useful for debugging. A typical sample is shown below:-

```
2017/03/05 10:01:59 | ** Error 42 (14) - Timeout while trying to transmit
2017/03/05 10:03:53 | ** Error 42 (15) - Timeout while trying to transmit
2017/03/05 12:00:11 | ** Error 39 (24) - Failed to get GPS fix
2017/03/05 14:00:11 | ** Error 39 (25) - Failed to get GPS fix
2017/03/05 14:02:03 | ** Error 42 (16) - Timeout while trying to transmit
2017/03/05 16:00:11 | ** Error 39 (26) - Failed to get GPS fix
```

# 10 DEPLOYMENT GUIDE

## 10.1 Pre-Deployment Testing

10.1.1 It is strongly advised that pre-deployment tests are made a minimum of 3 weeks before shipping to the deployment site. This is to verify that the unit is working as expected, any configurations are correct and the chosen data transfer method is working.

10.1.2 In addition, this time frame allows technical support to take place in the event of an issue being discovered and possible spares to be sent

10.1.3 It is recommended that the SD card is examined in a PC and any unwanted files and data is erased. The use of MAC devices as opposed to Windows PCs is not recommended as the MAC sometimes seems to corrupt the card file system. The card can be removed after testing (remove power when removing or inserting the card) so that logfiles and data can be examined.

10.1.4 During testing, events can be monitored using the serial port as already described as this shows more information than the SD card files. This may be useful if problems are encountered.

10.1.5 Test programs - The test routines are not designed for end-user use but may be used under the direction of SRSL to assist with debugging a problem.

10.1.6 There are a suite of test programs available using the serial port. In the first few seconds after reset the unit will enter the test mode if it detects a terminal is connected and a key is hit in this initial period. A menu of options then becomes available. **Some routines are for calibration purposes. These are identified and must not be used.**

10.1.7 The consequences of running these calibration tests may mean the unit must be returned to SRSL for recalibration.

## 10.2 Deployment Guide

10.2.1 The following pages present the deployment guide for the SIMBA unit.

10.2.2 In addition to the mechanics of putting the device on the ice and getting it working an important consideration to make is also the location. SIMBA units operate in an extreme, unpredictable and constantly changing environment. The lifetimes of the units is varies but can be short due to some effect of the type of installation method used and / or the environment destroying the installation rather than batteries becoming exhausted. To try and ensure the maximum period of operation then some knowledge of likely hazards is useful in assessing a deployment site. The following are possible hazards to consider.

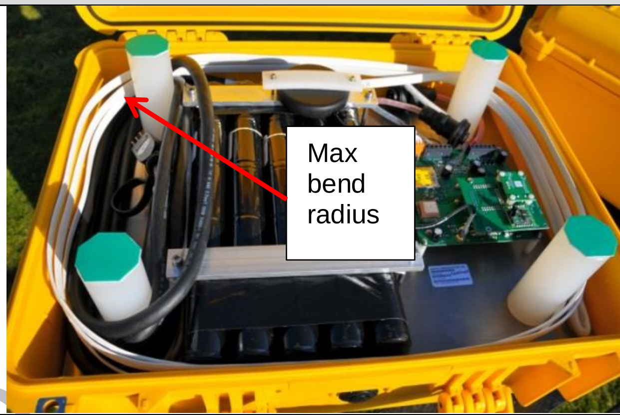
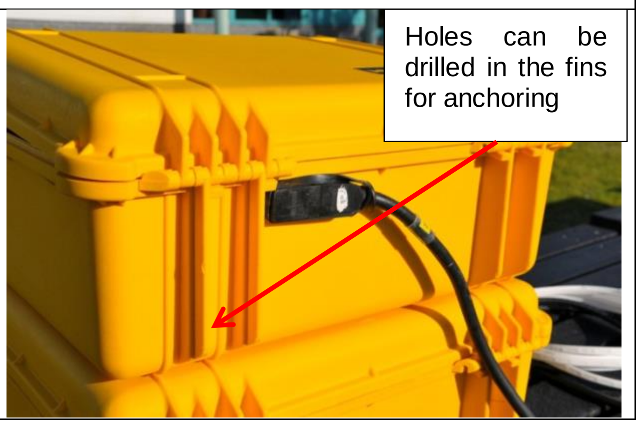
10.2.2.1 It is extremely important that the chain is deployed as described in the deployment guide below, other methods may lead to premature chain failure.
10.2.2.2 General breakup of floes. Obviously, deployment near open water, during spring or on rapidly drifting ice all heighten the possibility of the floe disintegrating.
10.2.2.3 Areas prone to ridging or already ridged. Ridging can destroy the whole installation. It's also not uncommon to see the lower section of chain lost. A theory for this is rafting has caused ice to pass under the deployment and sheer off the chain.
10.2.2.4 **Snow accumulation**. Deep snow will affect Iridium and GPS performance and can cause data transmission to cease. Raising the box above ground level on stilts has been done to

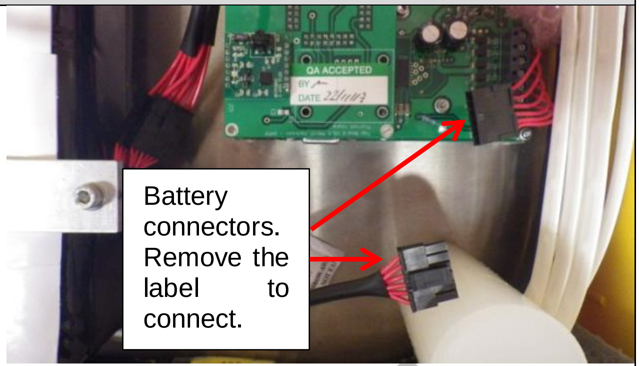
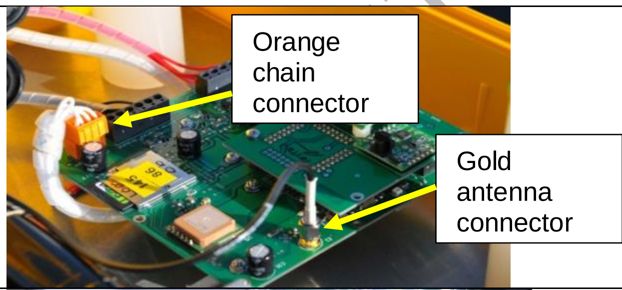
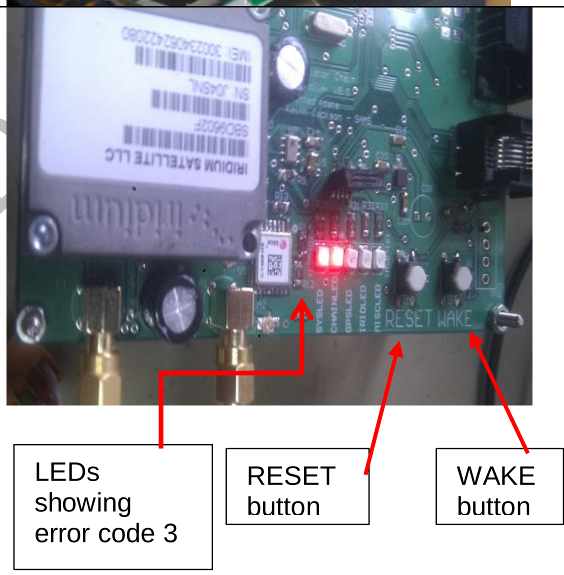
help avoid this. Avoiding areas where snow drifts may form (i.e. in the lee of a ridge) is advised.

10.2.2.5 **Bears**. It is impossible to know how many deployments are damaged by bears but it does occur. There has been an eyewitness account of a bear damaging a deployment and evidence of badly chewed cables been seen on some recovered units that failed in the field although we believe due to its low profile, Simba is less prone to attack. Penguins however have not been reported as a problem!

10.2.2.6 **Wind**. It has often been seen when deploying that cables and the upper exposed section of the chain above that can flap in strong winds. This could cause fatigue in the sensor chain (the long flat white section) and cause failure. It is unlikely that the unit can be sheltered to keeping the cables and chain tight or fixed at regular intervals should be considered.

Table 14: Deployment guide for SIMBA unit.

| STEP | DESCRIPTION | PICTURE |
|---|---|---|
| Unpacking | Remove the foam packing and **Carefully** lift of the white section of the chain, followed by the black lead. Remove the chain, by taking the free white end (with the loop) and uncoiling the opposite way that is has been packed into the case, taking care to take twists out of the chain while uncoiling. Also remove the chain weight.<br>**Take great care not to twist or bend the white section of the chain beyond the radius shown in the picture.** |  |
| Control box distancing | Position the SIMBA unit control box some distance away (~2m) from the planned chain deployment hole, in order to avoid locally heating the ice surface temperature which would affect measurements.<br>Also avoid deploying in areas surrounded by high objects, for best performance a view of the sky 8° above the horizon is recommended.<br>**The box can be secured to the ice (against wind, etc) with the holes provided in the yellow fins at the front and back of the case (ie, using pins and chord).** |  |
| Plug in the chain | Connect the chain at the back of the control box, and put the black rubber band in place to secure the connector.<br>**The chain MUST BE connected for the unit to initialise correctly !** |  |

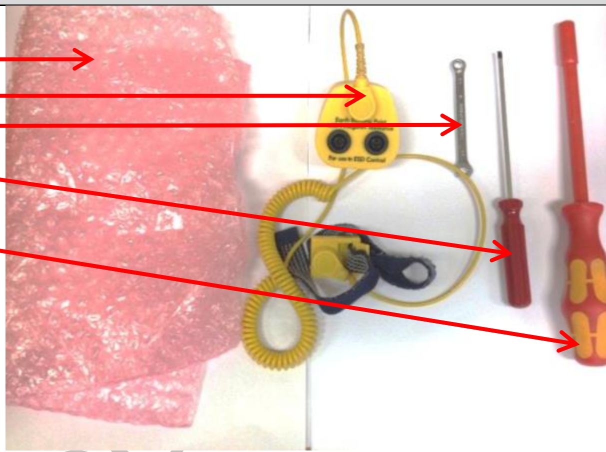
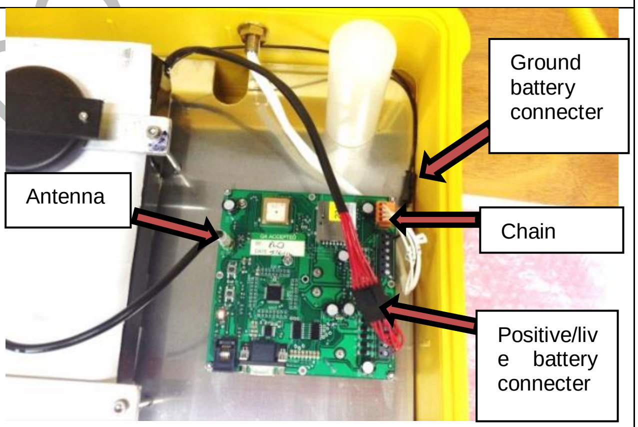
| STEP | DESCRIPTION | PICTURE |
|---|---|---|
| Connect the black power connectors | The black connectors are keyed, and need to be orientated with the tabs on the same side.<br><br>**Do not force the connectors together if they are wrongly orientated.** |   |
| Confirm that the internal chain and antenna connectors are connected to the controller board | Ensure that the orange chain plug is firmly connected into orange socket on the controller board before turning on the unit.<br><br>**Do not force the connectors together if they are wrongly orientated.** |   |
| Power up | Press the RESET button.<br>Check the LED activity. Initially they will flash in a pattern for the first 10 seconds. Then system initialisation commences and each of the five LEDs will light in turn over a period of up to around 2 minutes. Each LED should remain lit. If any are extinguished at the end of initialisation it indicates a potential fault. After initialisation, any error codes are flashed out as a binary value. The codes are flashed out in three cycles, each cycle beginning with all LEDs lit. The error codes are distinctive because the LEDs brightness ramps upwards. If there are no errors the user just sees all LEDs flashed on three times. If errors do occur the codes can be looked up in the tables in this document. The errors are also recorded on the SD card. More information on this can be found in this document.<br><br>**It is strongly recommended to power up in an open space prior to deployment such that the data can be checked.** |   |
| Drill hole for the chain | Drill a 5cm hole through the ice<br>**Try to keep the snow surface clean** | |
| Drill a second hole for the securing pole | 10 cm from the first hole to a depth of about 5m and place the securing pole in this hole | |

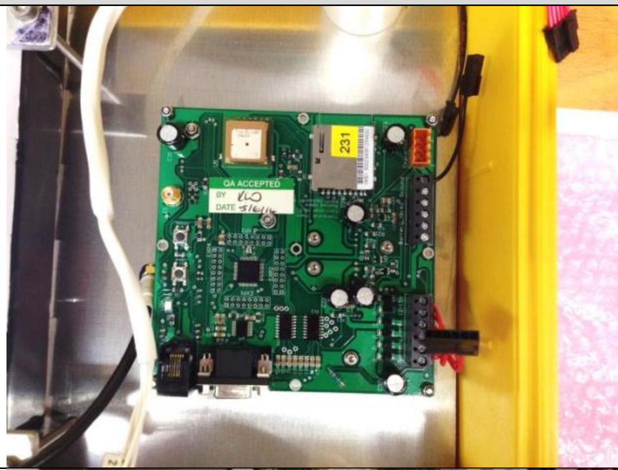
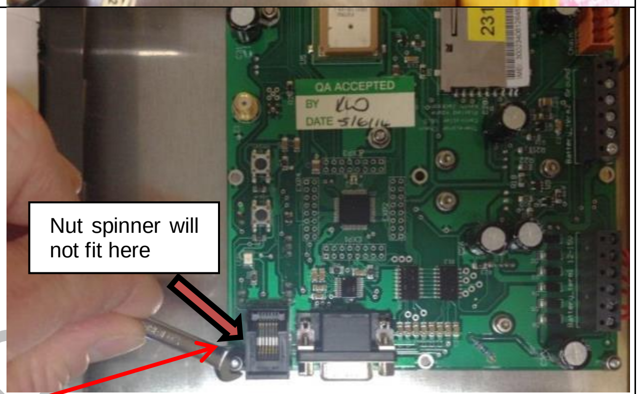
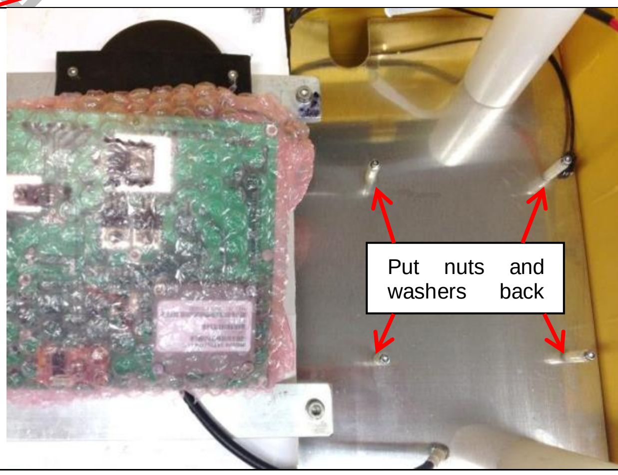
| STEP | DESCRIPTION | PICTURE |
|---|---|---|
| Secure chain to pole | Before the chain is deployed, tie-wrap the black section of the chain to the pole.<br>**Do this before deployment to save losing the chain through the ice.**<br>**Try not to cover any sensors on the white chain, with the cable tie(s).** | See photo of 'control box distancing' |
| Deploy the chain | Attach weight to end of white chain loop using 2 over hand knots<br>**Refer to full deployment manual in advance for specific instruction on chain layout options before deploying**<br>After you have attached the chain, slowly feed down the 5cm hole.<br>**Avoid sharp kinks and twists in the chain** |  |
| Secure chain to bottom of pole to avoid undesirable movement | Cable tie the chain to the base of the pole close to the surface of the ice (to secure against flapping in wind).<br><br>**Avoid tight radius bends (as mentioned above), and kinks in the chain**<br><br>**Try not to cover any sensors on the white chain with the cable tie(s).** | See photo of 'control box distancing' |
| | DEPLOYMENT IS COMPLETE | |

# 11 CONTROLLER BOARD REMOVAL

In some circumstances, it may be necessary to remove/replace the controller board for repair and or upgrade. This section provides the detail on how to remove the board (reversal of the procedure can be used for installation of a controller board).

Table 15: Guide for remove/replace controller board.

| STEP | DESCRIPTION | PICTURE |
|---|---|---|
| Preparation | Tools required from left to right are:<br>anti-static bag,<br>ESD/Precautionary wrist strap,<br>5.5mm spanner,<br>Approximately 3mm flathead screwdriver<br>5.5mm nut spinner. |  |
| Disconnection | Plug in the wrist strap. The wrist strap should be worn throughout the whole procedure if available – to protect the board from damage resulting from electro static discharge.<br>The components that need to be disconnected are the antenna, the battery connecters and the chain plug. The battery connections should be disconnected first.<br>If the battery connections are wired straight into the board they will have to be removed by undoing the screws with the 3mm flathead screwdriver. If not, the battery can be disconnected via the ground and 'live' connectors shown in the picture.<br>The antenna can be removed by unscrewing it with your fingers from the PCB. The chain plug (orange) can be pulled out easily. |  |

| STEP | DESCRIPTION | PICTURE |
|---|---|---|
| Board after disconnection | This is what the board should look like after disconnecting the parts. |  |
| Removing the board | Take the 5.5mm spanner and remove the 4 nuts from the corners of the board. If the whole pillar spins when unscrewing the nut, place some resistance against the pillar in the opposite direction of the way you are turning the nut. Place them together at the side to ensure that they aren't lost. A 'nut spinner' can 'be used here to speed up the process but note that it won't fit onto the nut shown in the picture. The side of the spanner shown in the picture will have to be used for this nut. | <br> |
| Completing removal and packaging | Once the nuts are removed, wearing the anti-static strap, take the board and place it into an anti-static bag making sure the tab is sealed so that the board will not fall out. (If a strap is not available hold the edges of the controller board either side of the battery terminals.) Take the nuts and screw them back on to the pillars within the simba unit, finger tight, to ensures that they will not be lost. | <br> |
| Shipping | Place the boards in an adequate box to allow 50cm of bubble wrap type packing to surround the boards | |



11.1.1 On power up (ie, connection of the battery connector), press reset and the LEDs on the controller will flash for a few a seconds from left to right when power is first applied. The "SYSLED" LED will become lit while the system initialises.

11.1.2 The next four LEDs will do the same and remain solid until there are 5 solid red lights which will flash together, if this occurs twice, this indicates the correct power-up procedure for the unit (null error).

11.1.3 If one LED come on and then goes out, this is an indication of a fault and which function it will affect. The fault code should be observed at the end of the sequence being shown after all the LED's flash (null error)

11.1.4 After the LED's flash, the first LED will then turn back on as the unit starts its first sequence.

11.1.5 If in doubt, pressing the reset button will restart the system (note, if the system is asleep then first press the "wake" button, the reset button is only effective when the system is awake).

11.1.6 If any of the LEDs come on and then fail to stay lit during initialisation then there is a fault with that part of the system and the fault code should be observed at the end of the sequence being shown after all the LED's flash (null error)

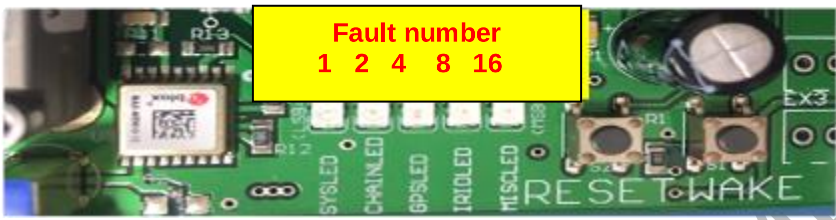


Figure 9: Power-up LED's position on the SIMBA PCB

11.1.7 If any of the LED's light up and then go off during the power-up operation the following steps can be applied

11.1.7.1 Go back through all the earlier steps, and check connections, etc – also noting that the quick start deployment guide is provided within the lid of the Simba Unit (check those steps). Reset the unit.

11.1.7.2 The LED sequence will display the binary code of the errors. These can be checked against the table below. The error codes can also be found at the bottom of the status message on the web page, a status message is sent at every restart of the unit to verify operation and also in the Err file on the SD card. Read off the table below or add up the values of the lit leds for the fault code.

11.1.7.3 If the problem persists then remove the SD card and extract the logfile and Err file and email to SRSL for examination (SIMBA@srsl.com). If necessary, you can also call on +44 (0)1631 559 470, and ask for SimbaSIMBA support.

**<u>SIMBA unit Fault codes</u>**

Green - Not to be of concern

Yellow Issues which are not necessarily detrimental to the system but should, if possible, be rectified if they occur at deployment.

Orange A significant failure but the system is still capable of performing core chain-based measurements. Other sensors may not function.

Red A significant failure threatening core functions.

**NOTE:** Those errors assigned LED codes are those which are potentially serious issues detected at start-up and so are flagged up as the system initializes. Other (non-fatal) errors are issues which occur during operation and are not apparent at start-up.

Exceptions in the Iridium system are recorded and noted. These are common as the satellites move in and out of range or other network issues arise. These generally indicate a transmission failed but the data is held in a buffer in the SIMBA unit to be transmitted at the next opportunity.

Table 16: LED and error code

| Code | LED pattern 1 2 4 8 16 | Abbrv in logfile | Description and action |
|---|---|---|---|
| 0 | ■■■■■ | Null Error | Null error. Used to indicate start of display cycle on LEDs. All good no issues !! |
| 1 | ■□□□□ | Battery Low | Low Battery - (<10.3V) at terminal. Heater will not operate by default (configurable)as battery protection measure. |
| 2 | □■□□□ | RTC Osc Error | RTC oscillator not running - Hardware fault. If persistent after resetting then contact SRSL |
| 3 | ■■□□□ | No Sensors On Chain | No sensors detected on chain - Check chain plugs or chain for damage & RESET ! |
| 4 | □□■□□ | No EEPROM Chain | No EEPROM detected on chain - Check chain plugs or chain for damage Check chain plugs & RESET ! |
| 5 | ■□■□□ | Too Many Broken Sensors | Too many broken sensors - More than 10% sensors failed in chain. Indicates significant chain damage. |
| 6 | □■■□□ | No InitGPSFix | No initial GPSFix - Move unit outside, check GPS antenna connection Blue lead and orientation “Skyside” up. System will recover if subsequent GPS fix obtained. |
| 7 | ■■■□□ | No SDCard | No SD Card detected - Check SD is inserted and not corrupted, only use approved SD card types. System will function without SD card. |
| 8 | □□□■□ | Heater Volts Low | Heater voltage low – Probably caused by low battery voltage but if this is not the issue then it will be a more serious hardware fault. |
| 9 | ■□□■□ | L12BadResponse | 1-wire unit bad or no response – Hardware fault. If persistent after resetting then contact SRSL |
| 10 | □■□■□ | BadAddrFromEEPROM | Bad address read from EEPROM - Check chain plugs or chain for damage & RESET ! |
| 11 | ■■□■□ | No ChainFound | No Chain detected - Check chain plugs or chain for damage & RESET! |
| 12 | □□■■□ | No Irid Modem Found | No Iridium modem detected - Hardware fault. If persistent after resetting then contact SRSL. Will occur if deployment does not require iridium and so the modem is deliberately not fitted. |
| 13 | ■□■■□ | No Antenna | No iridium signal, Possible antenna problem - Move outside, check antenna connection white lead and orientation “Skyside” |
| 14 | □■■■□ | RTC Not Valid | Clock has not been set from either GPS or Iridium at start-up – Ensure antennae have view of the sky and reset. System will recover if GPS obtains a fix but best to reset and start again. May indicate GPS issue if persistent after reset. |
| 15 | ■■■■□ | Chain Too Long | Chain exceeds Max No. of Sensors-Contact SRSL |
| 16 | □□□□■ | No Mag Response | Magnetometer no response - Hardware fault, contact SRSL. System will run but with invalid magnetometer data. |
| 17 | ■□□□■ | Missing MagCalFile | Magnetometer Calibration Data Not Found – Harware fault or calibration not performed. Contact SRSL. System will run but magnetometer data may be invalid |
| 18 | □■□□■ | No Baro_Response | Barometer bad or no response – Hardware fault, contact SRSL. Hardware fault. System will run but with invalid pressure readings. |
| 19 | ■■□□■ | No GPS_Response | No response from GPS - Hardware fault, contact SRSL. System will run but reported sample times and positions may be invalid. |
| 20 | □□■□■ | NoAT24CEEPROM | No response from on-board EEPROM - Hardware fault, contact SRSL. System will run but magnetometer calibration may be invalid and sample number will default to start at 1. |
| | | NonFatal | Not an Error. Marks start of less serious errors that follow. Will not appear on LEDs |
| 26 | □■□■■ | WriteProtect | SD Card write protected - Check read-only tab on SD card. System will run but data not saved to card. |
| 27 | ■■□■■ | Waketime_Past | Wake time in past - Usually a spurious issue which will resolve itself. |

| Code | LED pattern 1 2 4 8 16 | Abbrv in logfile | Description and action |
|---|---|---|---|
| 28 | | NonHexInTempStr | Non-hex char from sensor – If persistent indicates a chain or PCB hardware fault. |
| 29 | | Chain shorted | Chain data bus short circuited to ground – While this is serious it will be flagged up by errors 3,4 and 11 at startup. |
| 30 | | IridBuffFull | Iridium buffer overflow - check antenna connection white lead and orientation “Skyside” up, Contact SRSL if problem persists. Will only occur after considerable data is accumulated for transmission but cannot be sent. |
| 31 | Displayed on status message, SD card or Serial port | BrownOut | Brownout reset – Often occurs when first connecting batteries or if batteries provide insufficient power and this will be flagged by other errors at startup. If persistant contact SRSL |
| 32 | Displayed on status message, SD card or Serial port | Watchdog | Watchdog reset – Usually spurious but if persistent then contact SRSL |
| 33 | Displayed on status message, SD card or Serial port | ConfigMismatch | Config. mismatch reset – A software issue. Contact SRSL if problem persists. |
| 34 | Displayed on status message, SD card or Serial port | IllegalOpcode | Illegal opcode reset – Software issue, if persistent after reset then contact SRSL |
| 35 | Displayed on status message, SD card or Serial port | TrapReset | Trap conflict reset - Software issue, if persistent after reset then contact SRSL |
| 36 | Displayed on status message, SD card or Serial port | WDT_Wake | Woken by WDT - If persistent indicates clock circuit failure or configuration of system needs checking. |
| 37 | Displayed on status message, SD card or Serial port | Unknown_Wake | Wake source unknown – Software issue. Contact SRSL if problem persists |
| 38 | Displayed on status message, SD card or Serial port | SmplNoFile | Could not open obtain sample No. – Possible hardware fault with PCB EEPROM. Sample number will default to 1. Contact SRSL if problem persists |
| 39 | Displayed on status message, SD card or Serial port | GPS FIx_Fail | Failed to get GPS fix – Will occur if satellites not in favorable position of snow is blocking signal. If persistent this may be a hardware fault. |
| 40 | Displayed on status message, SD card or Serial port | Heat Cycle Skipped | Heat cycle skipped. Volts low - Heater voltage low <10.3Volts - (configurable) Battery voltage is low hence Heater voltage will not be 8 volts. Designed to extend life of unit as batteries become depleted by abandoning the heating phase. |
| 41 | Displayed on status message, SD card or Serial port | Signal Strength | Invalid Iridium Signal Strength - Contact SRSL if problem persists, possible hardware fault. |
| 42 | Displayed on status message, SD card or Serial port | SBDIX_Response | No response to SBDIX from modem - Contact SRSL if problem persists, possible hardware fault. |
| 43 | Displayed on status message, SD card or Serial port | DataFile | Unable to write SD card data file - Check SD is inserted and not corrupted, only use approved SD card types Contact SRSL if problem persists |
| 44 | Displayed on status message, SD card or Serial port | IridUndefFailure | Iridium network. Undefined session failure - Contact SRSL if problem persists. This is an error reported back by the Iridium network. |
| 45 | Displayed on status message, SD card or Serial port | IridNoTime | Iridium network. Did not complete session in time - Contact SRSL if problem persists. This is an error reported back by the Iridium network. |
| 46 | Displayed on status message, SD card or Serial port | IridQFull | Iridium network. Gateway queue full- Contact SRSL if problem persists. This is an error reported back by the Iridium network. |
| 47 | Displayed on status message, SD card or Serial port | IridSegments | Iridium network. Too many segments- Contact SRSL if problem persists. This is an error reported back by the Iridium network. |
| 48 | Displayed on status message, SD card or Serial port | IridNoComplete | Iridium network. Did not complete session - Contact SRSL if problem persists. This is an error reported back by the Iridium network. |

| Code | LED pattern 1 2 4 8 16 | Abbrv in logfile | Description and action |
| --- | --- | --- | --- |
| 49 | Displayed on status message, SD card or Serial port | IridSegSize | Iridium network. Invalid segment size- Contact SRSL if problem persists. This is an error reported back by the Iridium network. |
| 50 | Displayed on status message, SD card or Serial port | IridAccess | Iridium network. Access denied - Contact SRSL if problem persists. This is an error reported back by the Iridium network. May indicate modem registration issue. |
| 51 | Displayed on status message, SD card or Serial port | IridLocked | Modem locked - Contact SRSL if problem persists. This is an error reported back by the Iridium network. May indicate modem registration issue. |
| 52 | Displayed on status message, SD card or Serial port | IridGateway | Iridium network. Gateway not responding- This is an error reported back by the Iridium network. Contact SRSL if problem persists |
| 53 | Displayed on status message, SD card or Serial port | IridRFDrop | Iridium network. Connection lost RF Drop - This is an error reported back by the Iridium network. Network dropped during transmission , Move outside, check antenna connection white lead and orientation “Skyside”, if it persists contact SRSL |
| 54 | Displayed on status message, SD card or Serial port | IridAntenna | Antenna fault – Test has failed to detect a signal strength above 0. Move outside, check antenna connection white lead and orientation “Skyside” up |
| 55 | Displayed on status message, SD card or Serial port | IridDisabled | Radio disabled - Contact SRSL if problem persists |
| 56 | Displayed on status message, SD card or Serial port | IridBusy | Modem is busy- Contact SRSL if problem persists |
| 57 | Displayed on status message, SD card or Serial port | NoIridSession | No Irid. session in 24 hrs – Wake to receive messages and configuration files via iridium. |
| 58 | Displayed on status message, SD card or Serial port | Killed | Indicates kill command sent – this command has changed in V2 SRSL only command and is sent if unit needs to be killed off (e.g. goes haywire and spits out continuous iridium messages)!!– This should not be seen normally but system will start as normal again if reset |

# 12 APPENDIX A – PAPER REFERENCES

We are keen to keep our users connected where in the use of Simba. Here we present some references to Simba use on polar research projects. If you have a paper/reference you'd like us to add, please send us the details (inc full reference) to our contact email address (info@srsl.com).

CHARACTERIZATION OF SEA-ICE KINEMATIC IN THE ARCTIC OUTFLOW REGION USING BUOY DATA. LEI, Ruibo et al. Characterization of sea-ice kinematic in the Arctic outflow region using buoy data. **Polar Research**, [S.l.], jan. 2016. ISSN 1751-8369. Available at: <http://www.polarresearch.net/index.php/polar/article/view/22658>. Date accessed: 10 Feb. 2016. doi:http://dx.doi.org/10.3402/polar.v35.22658.

Berge, Jorgen et al. (2016). Ice-tethered observational platforms in the Arctic Ocean pack ice. Science Direct, IFAC-PapersOnLine 49-23 (2016) 494-499.

# 13 APPENDIX B-STANDARD CONSTRUCTION FOR ENVIRONMENTAL PURPOSES

Standard Components and their materials

| | | | |
|---|---|---|---|
| Pelican Case | Polypropelene | 5kg | |
| Foam inserts | polyethylene anti-static foam | 520g | ? |
| Electronics | FR4 PCB and components | 300g | |
| Batteries | Alkaline Manganese Dioxide | 9Kg per pack | |
| Sensor chain cover | polyolefin with an integral thermoplastic | | |
| adhesive liner | 250g | | |
| Sensor chain electronics | FR4 PCB and components | 50g | |
| Sensor cable | Copper core, rubber sheath | 800g? | |
| Weight | Steel | 1kg | |

Lead-free components and solder are used for electronic construction throughout.

# 14 APPENDIX C – BATTERY SAFETY DATA SHEET

## Safety Data Sheet

SECTION 1: IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND OF THE COMPANY/UNDERTAKING

**Product Name:** DURACELL® ALKALINE BATTERIES
**Product Identification**: Alkaline Manganese Dioxide Cells – **Tradenames: Plus, Ultra, Simply**

**Product Use**: Energy Source
**SDS Date of Preparation**: November 2, 2009; Updated May 19, 2010

**Duracell Designations:**

| Name/Size | Duracell Designation | Voltage | IEC Designation |
|---|---|---|---|
| Duracell Plus/Simply D | MN1300 | 1,5 | LR20 |
| Duracell Ultra D | MX1300 | 1,5 | LR20 |
| Duracell Plus/Simply C | MN1400 | 1,5 | LR14 |
| Duracell Ultra C | MX1400 | 1,5 | LR14 |
| Duracell Plus/Simply AA | MN1500 | 1,5 | LR6 |
| Duracell Ultra AA | MX1500 | 1,5 | LR6 |
| DuracellPlus/Simply AAA | MN2400 | 1,5 | LR03 |
| Duracell Ultra AAA | MX2400 | 1,5 | LR03 |
| Duracell Plus/Simply 9V | MN1604 | 9 | 6LR61 |
| Duracell Ultra 9V | MX1604 | 9 | 6LR61 |
| Duracell 4.5V | MN1203 | 4,5 | 3LR12 |
| Duracell AAAA | MN2500 | 1,5 | |
| Duracell MN11 | MN11 | 6 | |
| Duracell MN9100 N | MN9100 | 1,5 | LR1 |
| Duracell 7K67 J | 7K67J | 6,2 | 4LR61 |

**Company Identification:**

**EU Office**
Procter & Gamble UK.
The Heights, Brooklands
Weybridge, Surrey
KT13 0XP UK
Telephone: +44-1-93-289-6000

**Switzerland Office**
Procter& Gamble
Switzerland SARL
Route de Saint-Georges 47
1213 Petit-Lancy, 1, Geneva,
Telephone: +41-58-004-6111

**US Office**
Duracell, a division of P&G
Berkshire Corporate Park
Bethel, CT 06801 USA
Telephone: 203-796-4000

**Emergency Phone Number**: INFOTRAC 24-Hour Emergency Response Hotline: 1-352-323-3500 (United States of America)

SECTION 2: HAZARDS IDENTIFICATION

**Physical Appearance**: Copper top battery.

CAUTION: May explode or leak, and cause burn injury, if recharged, disposed of in fire, mixed with a different battery type, inserted backwards or disassembled. Replace all used batteries at the same time. Do not carry batteries loose in your pocket or purse. Do not remove the battery label.

EU Classification of Preparation: Not classified as a dangerous preparation.

SECTION 3: COMPOSITION/INFORMATION ON INGREDIENTS

| Chemical Name | CAS Number | EINECS Number | Amount | Classification |
|---|---|---|---|---|
| Manganese Dioxide | 1313-13-9 | 215-202-6 | 35-40 % | Xn, R20/22 |
| Zinc | 7440-66-6 | 231-175-3 | 10-25 % | N, R50/53 |
| Potassium Hydroxide (35 %) | 1310-58-3 | 215-181-3 | 5-10 % | C, Xn, R22, R35 |
| Graphite (natural or synthetic) | 7782-42-5, 7440-44-0 | 231-955-3 231-153-3 | 1-5 % | None |

Note: Some Duracell alkaline batteries contain a Duracell Power Check™ battery energy gauge, which is a small conductive strip located underneath the PVC battery label that indicates the amount of charge in the battery. It is composed of minute quantities of conductive materials. Due to the small quantity of materials and their solid form, a health or environmental risk is unlikely.

SECTION 4: FIRST AID MEASURES

**General Advice**: The chemicals and metals in this product are contained in a sealed can. Exposure to the contents will not occur unless the battery leaks, is exposed to high temperatures or is mechanically, physically, or electrically abused. Damaged battery will release concentrated potassium hydroxide, which is caustic. Anticipated potential leakage of potassium hydroxide is 2 to 20 ml, depending on battery size.

**Eye Contact:** If battery is leaking and material contacts the eye, flush thoroughly with copious amounts of running water for 30 minutes. Seek immediate medical advice.

**Skin Contact:** If battery is leaking and material contacts the skin, remove any contaminated clothing and flush exposed skin with copious amounts of running water for at least 15 minutes. If irritation, injury or pain persists, seek medical advice.

**Inhaled:** If battery is leaking, contents may be irritating to respiratory passages. Move to fresh air. If irritation persists, seek medical advice.

**Swallowed:** If battery contents are swallowed, do not induce vomiting. If the victim is alert, have them rinse their mouth are the surrounding skin with water for at least 15 minutes. Seek immediate medical attention.

Note: This SDS does not include or address the small button cell batteries which can be ingested.

SECTION 5: FIRE FIGHTING MEASURES

**Fire and Explosion Hazards**: Batteries may burst and release hazardous decomposition products when exposed to a fire situation.

**Extinguishing Media:** Use any extinguishing media that is appropriate for the surrounding fire.

**Special Fire Fighting Procedures:** Firefighters should wear positive pressure self-contained breathing apparatus and full protective clothing. Fight fire from a distance or protected area. Cool fire exposed batteries to prevent rupture. Use caution when handling fire-exposed containers (containers may rocket or explode in heat of fire).

**Hazardous Combustion Products:** Thermal degradation may produce hazardous fumes of zinc and manganese; hydrogen gas, caustic vapors of potassium hydroxide and other toxic by-products.

SECTION 6: ACCIDENTAL RELEASE MEASURES

Notify safety personnel of large spills. Caustic potassium hydroxide may be released from leaking or ruptured batteries. Clean-up personnel should wear appropriate protective clothing to avoid eye and skin contact and inhalation of vapors or fumes. Increase ventilation. Carefully collect batteries and place in an appropriate container for disposal.

SECTION 7: HANDLING AND STORAGE

Avoid mechanical or electrical abuse. DO NOT short circuit or install incorrectly. Batteries may explode, pyrolize or vent if disassembled, crushed, recharged or exposed to high temperatures. Install batteries in accordance with equipment instructions. Do not mix battery systems, such as alkaline and zinc carbon, in the same equipment. Replace all batteries in equipment at the same time. Do not carry batteries loose in a pocket or bag. Do not remove battery tester or battery label.

**Storage:** Store batteries in a dry place at normal room temperature. Do not refrigerate – this will not make them last longer.

SECTION 8: EXPOSURE CONTROLS/PERSONAL PROTECTION

The following occupational exposure limits are provided for informational purposes. No exposure to the battery components should occur during normal consumer use. **Refer to specific country regulations for additional exposure limit information.**

| **Chemical Name** | **Exposure Limits** |
|---|---|
| Manganese Dioxide | 0,5 mg/m$^3$ TWA UK WEL<br>0,5 mg/m$^3$ TWA (inhalable) DFG MAK<br>0,2 mg/m$^3$ VL Belgium<br>0,2 mg/m$^3$ TWA Denmark LV |
| Zinc | None established for zinc metal |
| Potassium Hydroxide | 2 mg/m$^3$ STEL UK WEL<br>2 mg/m$^3$ VCD Belgium<br>2 mg/m$^3$ Ceiling Denmark LV |
| Graphite | 4 mg/m$^3$ TWA UK WEL (respirable dust)<br>10 mg/m$^3$ TWA UK WEL (inhalable dust)<br>1,5 mg/m$^3$ TWA DFG MAK (respirable dust)<br>4 mg/m$^3$ TWA DFG MAK (inhalable dust) 2 mg/m$^3$ VL Belgium (respirable dust) |

**Ventilation:** No special ventilation is needed for normal use.

**Respiratory Protection:** None required for normal use.

**Skin Protection:** None required for normal use. Use neoprene, rubber or latex gloves when handling leaking batteries.

**Eye Protection:** None required for normal use. Wear safety goggles when handling leaking batteries.

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

**Appearance and Odor:** Copper top battery. **Water Solubility:** Insoluble

SECTION 10: STABILITY AND REACTIVITY

**Stability:** This product is stable.

**Incompatibility/Conditions to Avoid:** Contents are incompatible with strong oxidizing agents. Do not heat, crush, disassemble, short circuit or recharge.

**Hazardous Decomposition Products:** Thermal decomposition may produce hazardous fumes of zinc and manganese; caustic vapors of potassium hydroxide and other toxic by-products.

**Hazardous Polymerization:** Will not occur

SECTION 11: TOXICOLOGICAL INFORMATION

**Potential Health Effects**:

The chemicals and metals in this product are contained in a sealed can. Exposure to the contents will not occur unless the battery leaks, is exposed to high temperatures or is mechanically, physically, or electrically abused. Damaged battery will release concentrated potassium hydroxide, which is caustic. Anticipated potential leakage of potassium hydroxide is 2 to 20 ml, depending on battery size.

**Eye Contact**: Contact with battery contents may cause severe irritation and burns. Eye damage is possible.

**Skin Contact**: Contact with battery contents may cause severe irritation and burns.

**Inhalation**: Inhalation of vapors or fumes released due to heat or a large number of leaking batteries may cause respiratory and eye irritation.

**Ingestion**: Swallowing is not anticipated due to battery size. Choking may occur if smaller AAA batteries are swallowed. Ingestion of battery contents (from a leaking battery) may cause mouth, throat and intestinal burns and damage.

**Acute Toxicity Data:**
Manganese Dioxide: LD50 oral rat >3478 mg/kg
Potassium Hydroxide: LD50 oral rat 273 mg/kg

**Chronic Effects:** The chemicals in this product are contained in a sealed can and exposure does not occur during normal handling and use. No chronic effects would be expected from handling a leaking battery.

**Target Organs:** Skin, eyes and respiratory system.

**Carcinogenicity**: None of the components of this product are listed as carcinogens by the EU Directive on the classification and labeling of substances.

**SECTION 12: ECOLOGICAL INFORMATION**

No ecotoxicity data is available. This product is not expected to present an environmental hazard.

SECTION 13: DISPOSAL INFORMATION

Disposal should be in accordance with national and local regulations. Do not incinerate except for disposal in a controlled incinerator.

Duracell alkaline manganese dioxide batteries are labeled in compliance with EU Battery Directive 2006/66.

SECTION 14: TRANSPORT INFORMATION

**Transportation Information** – Products covered by this SDS, in their original form, are considered “dry cell” batteries and are not regulated as “DANGEROUS GOODS” for transportation.
For finished packaged product transported by ground (ADR/RID): – not regulated
For finished packaged product transported by sea (IMDG) – not regulated
For finished packaged product transported by air (IATA): – not regulated

SECTION 15: REGULATORY INFORMATION

**EU Classification of Preparation**: Not classified as a dangerous preparation.

**REACH:** These products are manufactured articles and not subject to REACH registration requirements.

**EU Labeling:** None Required

Labeling is not required because batteries are classified as articles under the both REACH and the Dangerous Preparations Directive and as such are exempt from the requirement for labeling.

SECTION 16: OTHER INFORMATION

**P&G Hazard Rating:** Health: 0 Fire: 0 Reactivity: 0

EU Classes and Risk Phrases for Reference (See Sections 2 and 3)
C Corrosive
N Dangerous for the Environment
Xn Harmful
R20/22 : Harmful by inhalation and if swallowed. R22 Harmful if swallowed. R35 Causes severe burns
R50/53 : Very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.
==========================================================================
Data supplied is for use only in connection with occupational safety and health.

**DISCLAIMER**: This SDS is intended to provide a brief summary of our knowledge and guidance regarding the use of this material. The information contained here has been compiled from sources considered by Procter & Gamble to be dependable and is accurate to the best of the Company's knowledge. It is not meant to be an all-inclusive document on worldwide hazard communication regulations.

This information is offered in good faith. Each user of this material needs to evaluate the conditions of use and design the appropriate protective mechanisms to prevent employee exposures, property damage or release to the environment. Procter & Gamble assumed no responsibility for injury to the recipient or third persons, or for any damage to any property resulting from misuse of the product.

# 15 APPENDIX D – IRIDIUM MESSAGE FORMATS

It is possible for users to have raw data from the SIMBA units delivered to an email address of their choosing. The user may then decode this data themselves in a manner similar to that which the SRSL web server offers.

The iridium modem is used to send a message in binary format and the length is limited to 340 bytes. In early systems it was possible to send temperature and heating differentials in one message. However, the greater number of sensors used in recent deployments means this is not possible so instead each temperature profile is transmitted as they are taken and a series of separate transmissions is made for heating cycles, each of the phases of the heating cycle taking one transmission. The GPS fixes can be grouped together for transmission in a clump or individually as they are taken. We term the data entity to be sent a message and each transmission we term a packet. Most messages will fit into one packet but large messages are split over several packets.
The reiterate:-

- A packet is a single iridium SBD transmission which has a limit of 340 bytes.
- A message is a complete sets of records from a sample to be transmitted as a single entity. However, the 340 byte limit may mean this must be split over more than one packets and reconstructed.

The format of the packets are below, first is a common header for all packet types. Then comes a sub-header specific to the type of data being sent which is then followed by a number of data records. The common header runs from bytes 0 to 15, a sub-header dependent on message type from 16-31 and from 32 onwards are data records. The final two bytes are a checksum.

Note that integer fields are big-endian in terms of bytes (MSB occupies lower indexed byte (i.e. comes first). The bit fields are little endian (LSB is bit 0)

| Byte | Field | Abbv. | Data | Format | Units |
|---|---|---|---|---|---|
| 0-1 | 0 | SampleNum | Sample Number. Increments for each wake-up cycle of the system. A wake-up does not necessarily produce sampling but only one message of any type is produced on each wake-up. (e.g. may have just one GPS message and just one temperature profile message sent on a wake-up). This value will be the same for different packets of the same message. | 2 bytes unsigned binary integer | 1,2… |
| 2 | 1 | Package_No | Packet number within message. (e.g. 1-of-2 or 2-of-2) | 1 byte unsigned binary integer | 1,2… |
| 3 | 2 | Packages_Tot | Total number of packets to complete this message. Always 1 except for temp. profile which may need 2 packets | 1 byte binary unsigned integer | 1,2… |
| 4 | 3 | Mess_type | Measurement type<br>10 = Temperature profile<br>11 = Heat cycle, 1st period<br>12 = Heat cycle, 2nd period<br>13 = Heat cycle, 3rd period<br>14 = Heat cycle, 4th Period<br>21 = GPS/magnetometer<br>31 = Status | 1 byte unsigned binary | Enumerated |
| 5-8 | 4 | RTC_Time | System date/time. Comes from on-board clock initially set from GPS or iridium after a reset or power-up. | 4 byte unsigned | Unix time format |

| Byte | Field | Abbv. | Data | Format | Units |
| --- | --- | --- | --- | --- | --- |
| | | | Represents time of sample for temperature profile, tie of start of heating cycle for delta samples and time of transmission for GPS and status messages | | |
| 9-10 | 5 | Pckt_Len | Total package length, not including checksum | 2 byte unsigned | Bytes |
| 11-12 | 6 | Tot_Records | Total number of data records in message | 2 byte unsigned | Records |
| 13-14 | 7 | Version | Software version | 2 byte unsigned integer | Version x100<br>e.g. 123 = V1.23 |
| 15 | 8 | Head_Spare2 | Unused | 1 byte unsigned | Set to zero |
| 16-17 | 9 | Record_Size | Data record size (L) (dependent on measurement type) | 2 byte unsigned | 1- one byte record<br>2 – two byte record<br>Etc. |
| 18-19 | 10 | Records | Number of data records in this packet (N) | 2 byte unsigned | Records |
| 20-31 | - | | Sub-header with information specific to measurement type. | All 2 byte unsigned integers | |
| 32-32+(N*L)-1 | - | | Data | Records of length L | Dependent on measurement type |
| 32+(N*L) – 32(N*L)+1 | - | | check sum | 2 bytes unsigned | |

Note that each packet is received as an email attachment and the email contains additional information from the iridium system. This includes an iridium system timestamp, a mobile originated serial number (MOMSN) which increments once for each successful transmission (i.e. packet), a lat and long fix value and the uncertainty of the fix.

Format for temperature profile sub-header and data records (note bytes 16-19 are actually part of main header)

| Byte | Field | Abbrv. | Data | Format | Units |
| --- | --- | --- | --- | --- | --- |
| 16-17 | - | Record_Size | Data record size=2 | 2 bytes unsigned binary integer | Bytes |
| 18-19 | - | Records | No of records in this packet (N) | 2 bytes unsigned binary integer | Records |
| 20-21 | 0 | Chain_ID | Chain serial No. | 2 byte binary unsigned integer | |
| 22-23 | 1 | Sensor_Sep | Chain Sensor separation | 2 byte unsigned binary | 0 = 2cm<br>1 = 4cm |
| 24-25 | 2 | TempSpare1 | Unused | 2 byte unsigned binary | Set to zero |
| 26-27 | 3 | TempSpare2 | Unused | 2 byte unsigned binary | Set to zero |
| 28-29 | 4 | TempSpare3 | Unused | 2 byte unsigned binary | Set to zero |
| 30-31 | 5 | TempSpare4 | Unused | 2 byte unsigned binary | Set to zero |
| 32-32+N*2 | - | Temp0..N-1 | Temp of sensors in chain order | 2 byte signed binary | 1/16ths of a degree celcius |

The format of sub-header and data records for temperature rise after heating is below (note bytes 16-19 are actually part of main header):-

| Byte | Field | Abbrv. | Data | Format | Units |
|---|---|---|---|---|---|
| 16-17 | - | Record_Size | Data record size=1 | 2 bytes unsigned binary integer | Bytes |
| 18-19 | - | Records | No of records in this packet (N) | 2 bytes unsigned binary integer | Records |
| 20-21 | 0 | ChainD_ID | Chain serial No. | 2 byte binary unsigned integer | |
| 22-23 | 1 | SensorD_Sep | Chain Sensor separation | 2 byte signed binary | 0 = 2cm<br>1 = 4cm |
| 24-25 | 2 | ElapsedT_ID | Time elaspsed since $t_0$. (see note below) | 2 byte unsigned binary | Seconds |
| 26-27 | 3 | SpareD | Spare (formally used for duty cycle) | 2 byte unsigned binary | Set to zero |
| 28-29 | 4 | Heater_Volts | Heater voltage at start time of sample | 2 byte unsigned integer | mV |
| 30-31 | 5 | SpareD2 | Unused | 2 byte unsigned | Set to zero |
| 32-32+N | | Delta0..N-1 | Temp rise of sensors in chain order | 1 byte signed binary | 1/16ths of a degree celcius |

N.B. $t_0$ is the time the heater was turned on. All sample times are indicated relative to this in the message. Note this convention differs from specification of HST configuration parameters which are specified cumulatively. So, the time indicated in message for first sample is HST_1, for second sample is HST_1+HST_2, for third sample is HST_1+HST_2+HST_3 etc

The format for GPS/Magnetometer sub-header is as below (note bytes 16-19 are actually part of main header). There is no data in the GPS sub-header.

| Byte | Field | Abbrv. | Data | Format | Units |
|---|---|---|---|---|---|
| 16-17 | - | Record_Size | Data record size=24 | 2 bytes unsigned binary integer | Bytes |
| 18-19 | - | Records | No of records (N) | 2 bytes unsigned binary integer | Records |
| 20-21 | 0 | GPSSpare1 | Not used | 2 byte unsigned integer | Set to zero |
| 22-23 | 1 | GPSSpare2 | Not used | 2 byte unsigned integer | Set to zero |
| 24-25 | 2 | GPSSpare3 | Not used | 2 byte unsigned integer | Set to zero |
| 26-27 | 3 | GPSSpare4 | Not used | 2 byte unsigned integer | Set to zero |
| 28-29 | 4 | GPSSpare5 | Not used | 2 byte unsigned integer | Set to zero |
| 30-31 | 5 | GPSSpare6 | Not used | 2 byte unsigned integer | Set to zero |
| 32-32+N*34 | - | GPS0..N-1 | GPS data records | | |

A GPS record has the following structure Addresses are +34*(N-1) where N is record number)

| Byte | Field | Abbrv. | Description | Format | Units |
|---|---|---|---|---|---|
| 32-35 | 0 | GPS_Time | GPS derived date/time of fix 1 | 4 byte unsigned | Unix time format |
| 36-39 | 1 | Lat | Latitude (fix 1) | 4 byte signed | Micro Degrees |
| 40-43 | 2 | Long | Longitude (fix 1) | 4 byte signed | Micro Degrees |
| 44-45 | 3 | BaroTemp | Barometer Temperature (fix 1) | 2 byte signed | $1/16^{th}$ Degrees celcius |
| 46-47 | 4 | Pressure | Barometric pressure (fix 1) | 2 bytes unsigned | millibars |
| 48-49 | 5 | Mag_X | Magnetometer X-axis (fix 1) | 2 byte signed | $1/100^{th}$ uT |
| 50-51 | 6 | Mag_Y | Magnetometer Y-axis (fix 1) | 2 byte signed | $1/100^{th}$ uT |
| 52-53 | 7 | Mag_Z | Magnetometer Z-axis (fix 1) | 2 byte signed | $1/100^{th}$ uT |
| 54-55 | 8 | Acc_X | Accelerometer X-axis (fix 1) | 2 byte signed | milli-g |

| Byte | Field | Abbrv. | Description | Format | Units |
|---|---|---|---|---|---|
| 56-57 | 9 | Acc_Y | Accelerometer Y-axis (fix 1) | 2 byte signed | milli-g |
| 58-59 | 10 | Acc_Z | Accelerometer Y-axis (fix 1) | 2 byte signed | milli-g |
| 60-61 | 11 | Tilt | Tilt (fix 1) | 2 byte unsigned | Degress 0 to 180 |
| 62-63 | 12 | Heading | Tilt compensated compass bearing (fix 1) | 2 byte unsigned | Degrees 0-359 |
| 64-65 | 13 | GPSSerialNo | Serial Number of wakeup cycle when fix taken (fix 1) | 2 byte unsigned | |
| 66- | - | | Fix 2..N records repeated as above | Same format as fix 1 record | |

Sub-header and data format for Status packets below (note bytes 16-19 are actually part of main header)



Status sub-header

| Byte | Field | Abbrv. | Data | Format | Units |
|---|---|---|---|---|---|
| 16-17 | - | Record_Size | Data record size=132 | 2 bytes unsigned binary integer | Bytes |
| 18-19 | - | Records | No of records (N)=1 | 2 bytes unsigned binary integer | Records |
| 20-23 | 0 | Last_Change | Time/date of last change to configuration | 4 bytes | Unix time format |
| 24-25 | 1 | StSpare0 | Not Used | 2 byte unsigned integer | Set to Zero |
| 26-27 | 2 | StSpare1 | Not Used | 2 byte unsigned integer | Set to zero |
| 28-29 | 3 | StSpare2 | Not Used | 2 byte unsigned integer | Set to zero |
| 30-31 | 4 | StSpare3 | Not Used | 2 byte unsigned integer | Set to zero |

Status Data

| Byte | Field | Abbbrv. | Data | Format | Units |
|---|---|---|---|---|---|
| 32-33 | 0 | STATUS_SKIP | Base sample between status message | 2 byte unsigned | Number of wakeup cycles |
| 34-35 | 1 | SAMPLE_PERIOD | Base sample period Determines period of wakeup cycle. | 2 byte unsigned integer | Seconds |
| 36-37 | 2 | TEMP_SKIP | Base sample periods per temperature sample | 2 byte unsigned | Number of wakeup cycles |
| 38-39 | 3 | GPS_SKIP | Base sample periods per GPS fix | 2 byte unsigned | Number of wakeup cycles |
| 40-41 | 4 | HEAT_SKIP | Base sample periods per heat cycle sample | 2 byte unsigned | Number of wakeup cycles |
| 42-43 | 5 | GPS_MESS | GPS samples per message | 2 byte unsigned | Samples |
| 44-45 | 6 | IRIDIUM_SKIP | Skip factor to reduce Iridium transmissions | 2 byte unsigned | Samples |
| 46-47 | 7 | HST_1 | Heating sample time 1 | 2 byte unsigned | Seconds |
| 48-49 | 8 | HST_2 | Heating sample time 2 | 2 byte unsigned | Seconds |
| 50-51 | 9 | HST_3 | Heating sample time 3 | 2 byte unsigned | Seconds |
| 52-53 | 10 | HST_4 | Heating sample time 4 | 2 byte unsigned | Seconds |

| Byte | Field | Abbbrv. | Data | Format | Units |
|---|---|---|---|---|---|
| 54-55 | 11 | HST_5 | Cooling sample time 5 | 2 byte unsigned | Seconds |
| 56-57 | 12 | HST_6 | Cooling sample time 6 | 2 byte unsigned | Seconds |
| 58-59 | 13 | HST_7 | Cooling sample time 7 | 2 byte unsigned | Seconds |
| 60-61 | 14 | HST_8 | Cooling sample time 8 | 2 byte unsigned | Seconds |
| 62-63 | 15 | SET_CLK | Clock sync control | 2 byte unsigned | 0,1 or 2 |
| 64-65 | 16 | WD | Watchdog timeout “WD” | 2 byte unsigned | No. of 2 minute intervals |
| 66-67 | 17 | HEAT_THRES | Heater battery voltage turn-off threshold “HEAT_THRES” | 2 byte unsigned | Millivolts |
| 68-69 | 18 | SSPARE1 | Unused | 2 byte unsigned | Set to zero |
| 70-71 | 19 | ADC_0 | ADC Ch0. Battery 1 voltage | 2 byte unsigned | Internal temp |
| 72-73 | 20 | ADC_1 | ADC Ch1. Battery 2 voltage | 2 byte unsigned | Millivolts s of volt |
| 74-75 | 21 | ADC_2 | ADC Ch2. Battery 3 voltage | 2 byte unsigned | Millivolts of volt |
| 76-77 | 22 | ADC_3 | ADC Ch3. Battery 4 voltage | 2 byte unsigned | Millivolts of volt |
| 78-79 | 23 | ADC_4 | ADC Ch4. Battery 5 voltage | 2 byte unsigned | Millivolts of volt |
| 80-81 | 24 | ADC_5 | ADC Ch5. Battery 6 voltage | 2 byte unsigned | Millivolts of volt |
| 82-83 | 25 | ADC_6 | ADC Ch6. Commoned 12V | 2 byte unsigned | Millivolts of volt |
| 84-85 | 26 | ADC_7 | ADC Ch7. Heater voltage | 2 byte unsigned | Millivolts of volt |
| 86-100 | 27-33 | SSPARE2..8 | Unused – 7 fields | 2 byte unsigned | Set to Zero |
| 100-163 | 34-98 | Err_0 .. Err_63 | Error codes. | 1 byte unsigned x 64 | Count of occurrences of error n (n=0 to 63) |

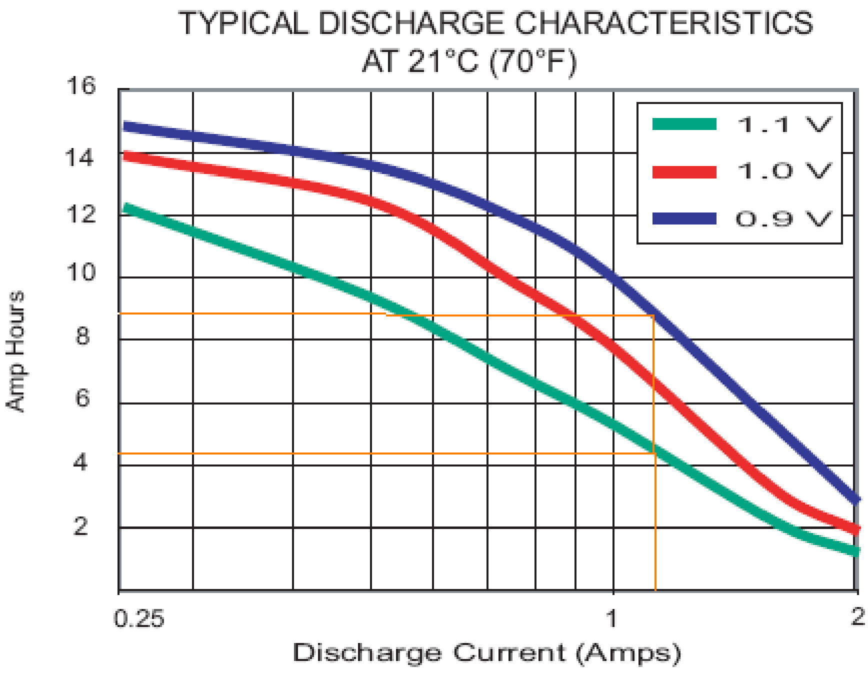
# 16 APPENDIX E – ENERGY BUDGET

SIMBA Energy budget based on default configuration

| Device | Samples per day | Time per sample (s) | Time on per day (s) | Iridium packets generated |
|---|---|---|---|---|
| GPS/Baro/Mag | 12 | 60 | 720 | 2 |
| Chain (Temp) | 4 | 10 | 40 | 4 |
| Chain(Heat) | 1 | 60 | 60 | 2 |
| Iridium | 8 | 60 | 480 | |
| | | | 1300 | 8 |

| Device | On current Amps | Time on per day Hr | Energy used per day Ah |
|---|---|---|---|
| PIC asleep | 0.0008 | 24.00000 | 0.01920 |
| PIC awake | 0.014 | 0.36111 | 0.00506 |
| GPS/Mag/Baro | 0.06 | 0.20000 | 0.01200 |
| Chain (Temp) | 0.03 | 0.02778 | 0.00083 |
| Chain (Heat) | 2 | 0.01667 | 0.03333 |
| Iridium | 0.1 | 0.13333 | 0.01333 |
| | | | |
| Tot (Day) (Ah) | | | 0.08376 |
| Tot (week) (Ah) | | | 0.58629 |
| Tot (Month) (Ah) | | | 2.51267 |
| Tot (Year) (Ah) | | | 30.57078 |

It is intended to build devices with around 12months of dry-cell capacity on default setting. A standard Simba battery pack uses Duracell Procell MN1300 cells arranged as a 15V battery pack gives the following performance. We use6parallel packs of 15V giving 90Ah. @ 21°C, we can predict from the information on the data sheet that at 0°C this could be de-rated to around 56Ah and will be less at lower temperatures.




The system will initial burn power from these batteries until they drop to about 10V where upon the 8V heating cycle voltage to the heating elements cannot be supported. So the initial period will see discharge to 1.0V (use red curve). The capacity in this interval at 0.5A (i.e. during heating at 2A total between four packs) is roughly 12Ah for a single pack from the graph (48Ah for all four). In practice, the current consumption is much less than 0.5A per pack as this is the maximum when heating the chain. If no heating is used the total capacity per pack is 15Ah (90Ah for six parallel packs). When the voltage drops below 10V the default configuration suspends heating cycles and so the unit can continue operating considerably longer in this mode to ensure the heating voltage remains at 8 Volts and ensure the power is the same across all heating cycles, this help protect the integrity of the results from the heated cycle

The effect of temperature is hard to assess. Generally, the capacity
remains the same at all temperatures but the internal resistance of the cells rises as they get cooler At low currents this is unimportant but at higher currents (i.e. heating phase) this can cause a voltage drop and so the lower threshold of 10V may be reached earlier. However, since we have many packs in parallel the maximum current is reduced and so the issue becomes less pronounced.
Data from the units in the field suggest that down to -20°C there is little change, below this voltage drops off with a notable drop below -30°C so fresh batteries at the start of a deployment are always recommended.

The calculations suggest that for default configuration a 15V battery of 10x6 cells would run the unit for a year. Changes to configuration would require reassessment of this.

**END OF DOCUMENT**