# SIMBA

# SAMS Enterprise Snow and Ice Mass Balance Apparatus (SIMBA)

## **User Manual**



SAMS Enterprise Ltd Document SIMBA\_005 – 2024



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#### **Revision History**

Revision	Changes	Date
а	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
04	General Revision for V8.09	09/22
05	Full revision for Generation 3 SIMBA	

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#### 1 INTRODUCTION

#### 1.1 Background to SIMBA

- 1.1.1 SAMS Enterprise manufactures the product used for snow and ice measurement; Snow and Ice Mass Balance Apparatus (SIMBA). SIMBA has been sold by SAMS Enterprise to you under the Terms and Conditions for supply of SIMBA, where these refer to 'user manual' this means this document and its content. Failure by you to follow the instructions and guidance provided within this document may invalidate any warranties and/or indemnities provided to you under the Terms and Conditions for supply of SIMBA. If you have any quieries please contact <u>SIMBA@sams-enterprise.com</u> for more assistance.
- 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 and 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 and cooling characteristics 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. The controller has been developed to be robust, ultra low power and for use in extreme enviroments.





Figure 1: SIMBA unit prior to dispatch. The thermistor chain is shipped in the box in the lid.

![](_page_4_Picture_5.jpeg)

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![](_page_5_Picture_0.jpeg)

#### 1.2 Document Purpose

1.2.1 This is a detailed manual for all aspects of the SIMBA unit and its operation, including how to configure, deploy and troubleshoot the SIMBA unit. Please also refer to the deployment quick guide on the unit plate. It is strongly recommended to inform SAMS Enterprise in advance of deployment in order for the most effective support be provided and to ensure the unit is ready for operation.

![](_page_5_Picture_5.jpeg)

#### **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 It is strongly recommended if you wish to work on the unit and remove the unit plate then the unit must be powered down first by removal of the power plug.
  - 1.3.1.3 The iridium antenna is a source of radio frequency emissions which during normal use should pose little or no risk to the operator. You should seek medical device if you wear an active implanted medical device or a body worn medical device, or believe you may otherwise be at higher risk from radio frequency emissions.
  - 1.3.1.4 A standard unit containing one battery pack weighs ~15kg. Units with additional battery pack may weigh more than 27kg. Noting these weights, please ensure the use of correct manual handling techniques to prevent injury to persons or damage to the unit. The use of lifting aides is advised.
  - 1.3.1.5 Ensure the unit plate is securely fitted in place and both pelicase catches in the locked position before moving or transporting the unit. Failure to do so may result in the batteries and electronics shifting internally causing injury, or damage to the device.
  - 1.3.1.6 We strongly advise against removing the SIMBA lid unless performed by a competent electrical engineer following advice from the SIMBA team. If you are removing the unit plate please only do so inside to prevent electronics getting wet due to inclement weather. Do not touch the battery cabling and connectors with wet hands. Additionally, if the battery connections are wet or covered with debris, please wipe dry or wipe dust off carefully before proceeding with use. Do not use if damaged unless assessed safe by a competant electrical / electronic technician.
  - 1.3.1.7 Bags of desiccant silica gel are shipped with units as standard. If swallowed, the person should drink lots of water and refer to their nearest medical centre for further advice.
  - 1.3.1.8 The controller board should not be removed from the unit plate supplied. When the unit is turned on, care should be taken to keep the unit internals dry. Although protected by the plate, contact with the unboxed PCB could lead to the risk of shock to the user, fire and/or cause an electrical short on the board which may lead to failure of the unit. Ensure any work on the PCB is performed by a qualified engineer and when the unit has been powered down for at least 1 minute.

#### 1.3.2 Battery packs

1.3.2.1 SAMS Enterprise supplied battery packs consist of Duracell alkaline batteries (Alkaline Manganese Dioxide Cells). For further information please refer to manufacturer's data sheet

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provided in section 5. The manfactured battery packs are rated to 16volt, 90Ah with 4 Amp fuses. These are widely available fuses used for the automotive industry.

- 1.3.2.2 When the unit is not in use remove the power plug from the back of the unit.
- 1.3.2.3 Avoid mechanical or electrical abuse. **DO NOT** short circuit or deviate from the instructions of use provided. 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 acccording to ADR/RID, IATA and IMDG. Local regulations must always be followed. If forwarding SIMBA units on to a deployment location by air, the waybill should be marked with 'NOT RESTRICTED SPECIAL PROVISION A123' to avoid customs delays. The device must be prepared for transport to avoid the risk of short circuit and unintetional activation, by for example, insulating exposed terminals and disconnection of the battery.
- 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 SAMS Enterprise 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.

![](_page_8_Picture_0.jpeg)

#### 1.4 Definitions

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 allows
	communication with the Iridium satellite network. Each SBD modem
	has a unique number, known as the IMEI number.
SDI-12	Modern communication standard compatible with a number of
	available environmental sensors.
Thermistor chain	A standard chain is around 5 metres long with thermistors every 2 cm
	with air temperature sensor (for a total of 241 sensors). The chain also
	has unique active heaters 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 (i.e. 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.
USB-C	Direct connection with the unit in real time and ability of set
	configuration and diagnostics.

#### 2 SIMBA UNIT CAPABILITIES

#### 2.1 General Description

2.1.1 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 SAMS Enterprise. 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 seaice (or snow pack). 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 can be switched on to warm the sensors, which allows for other information to be gleaned from temperature readings. Alternative options are available for thermistor spacing and chain lengths. The SIMBA unit is able to run two chains plugged into a single unit.

#### 2.2 General Operation

- 2.2.1 Locate the 4 connectors at the back of the SIMBA unit. From left to right:
  - 2.2.1.1 Connector for power plug to activate unit.
  - 2.2.1.2 Chain 1: Connector for a single chain.
  - 2.2.1.3 Chain 2: Connector to be used if an additional thermistor chain has been purchased to be used with the unit.
  - 2.2.1.4 SDI12: Only to be used if you have a verified SDI 12 device such as a acoustic sensor. Please get in touch with SAMS Enterprise and the SIMBA team for devices we have tested and approved for use.

![](_page_9_Picture_12.jpeg)

![](_page_9_Picture_13.jpeg)

SAMS	SIMBA Start Up Manual APPROVED	Revision:005
ENTERPRISE		APPROVED: 28NOV24

2.2.2 Please follow the quick guide printed on the SIMBA unit plate below:

![](_page_10_Picture_2.jpeg)

Figure 3: Images of the SIMBA unit plate (please note the GSM SIM is currently not offered)

- 2.2.3 Ensure your iridium modem is activated by getting in touch with us at <u>SIMBA@sams-enterprise.com</u> in advance of your test and/or deployment.
- 2.2.4 It is important to ensure the chain weight, housed in the lid foam insert, is removed prior to switching on the unit as the presence of the weight can distrupt the magentometer readings and return nonsense data.
- 2.2.5 It is essential that chains and any SDI12 devices **are plugged in before powering the unit up**. Also please ensure the SD card is inserted into the holder prior to powering the unit up.
- 2.2.6 Simply screw the chain connectors into the relevant connector at the back of the unit. Chains will work irrespective of the connector but a single chain plugged into chain 2 will provide data tagged as chain 2.
- 2.2.7 Once thermistor chain(s) and SDI 12 devices are connected, to power the unit up, the "Power Plug" must be removed from its housing within the lid foam insert and screewed into the left hand connector at the back of the case (see figure 4 below).
- 2.2.8 All the plugs are orientated and have unique number of pins for each function so power plug cannot be mistakenly plugged into the chain or SDI connector etc.
- 2.2.9 Ensure all connectors are fully screwed into the back of the unit for functionality.

![](_page_10_Picture_11.jpeg)

![](_page_11_Picture_0.jpeg)

![](_page_11_Picture_3.jpeg)

Figure 4: Power plug inserted (note no chain)

- 2.2.10 The reset button on the controller must be pressed, enabling the device to begin an initialisation phase. IT IS CRITICAL THIS IS DONE BEFORE SETTING OUT TO REMOTE AREAS FOR DEPLOYMENT AND WITH A CLEAR VIEW OF THE SKIES. 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 is indicated by all LEDs being lit and flashing together 3 times. If errors occur, the LEDs will flash out error codes at the end of the initialisation phase (refer to section 5).
- 2.2.11 During initialisation, the sensor chain is interrogated. The sensor chain stores all calibration data for that specific chain and this is read and retained in the controller memory. If the sensor chain is swapped for another chain, the unit will need to be reset so the correct chain information can be read and used in the controller memory.

![](_page_11_Picture_7.jpeg)

- 2.2.12 Once initialisation is complete the unit will send a message detailing its status and then it enters normal operation mode. Note only if connected via iridium with an active airtime contract for that modem.
- 2.2.13 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.
- 2.2.14 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.

#### 2.3 Temperature profiles

2.3.1 A temperature profile is a measurement of the temperature from each sensor along the chain starting from the top of the chain sensor 0 from the chain lead. The last sensor measured is not on the bottom end of the chain but instead is used as an air temperature sensor (no heating function) and mounted in the air in a suitable screen (not provided). The temperatures are reported back with a resolution of 1/16<sup>th</sup> °C. Due to limits of the Iridium SBD system the profile is sent in two parts for a 240 sensor standard length and spaced chain (5 metre length, 2 cm spacing between thermistors) but the server at SAMS Enterprise will combine these when both parts are received. Data will be labelled according to the number of chains connected to the device and into which connector (ie chain 1 and chain 2).

#### 2.4 'Heated & Post-Heated' Temperature Profiles

- 2.4.1 This type of sampling uses heating elements to warm each of the temperature sensors on the chain. As these warm and subsequently post heating (cooldown), 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.
- 2.4.2 A heated cycle can produce up to four profiles taken during heating and four during post heating (or as the thermistors cool and the heat is dissapated). 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.

![](_page_12_Picture_11.jpeg)

- 2.4.3 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.
- 2.4.4 When the "Heated and Post-Heated" temperature readings are taken, the sequence of events is as follows:
  - 2.4.4.1 The chain temperature is read and saved as Delta0 on the SD card but is not sent via iridium.
  - 2.4.4.2 The chain heating function is then 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,
  - 2.4.4.3 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.
  - 2.4.4.4 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. By Default this occurs every 24hrs.
  - 2.4.4.5 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.
- 2.4.5 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<sub>s</sub> 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<sub>s</sub> 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).

![](_page_13_Picture_11.jpeg)

![](_page_14_Picture_0.jpeg)

Figure 5: 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 periods, the total heating time is limited to 240s. 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 240s. **Note:** HST2 and subsequent values must be greater than the time required to read the chain. In the case of a std 240sensor chain that is 15 seconds.

If you wish to configure the heating cycle it is highly recommended to consult with the SAMS Enterprise technical team.

#### 2.5 GPS Receiver

- 2.5.1 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.
- 2.5.2 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 within the GPS data. Iridium derived position data is also available in case of GPS failure, however this is less accurate.
- 2.5.3 The system real-time clock (RTC) is set from the GPS system. At initialisation, the clock and SDI-12 sensor data (if fitted) 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 set only from iridium for areas with poor GPS signal.

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2.5.4 The Ublox unit will use GPS, GLONASS, Galileo and BeiDou systems and will make a fix using any of combination of these that is available. Typical GPS fixes accurate should be better than 10m horizontally but this is dependent on conditions and local topography. The GPS unit uses an external antenna mounted in the case.

#### 2.6 Magnetometer, Accelerometer and Barometer

- 2.6.1 It is important to ensure the chain weight, housed in the lid foam insert, is removed prior to switching on the unit as the presence of the weight can distrupt the magentometer readings and return nonsense data.
- 2.6.2 The unit is equipped with a 3-axis accelerometer. 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.
- 2.6.3 The accelerometer also incorporates a 3-axis magnetometer. This device is calibrated for internal offsets, hard-iron effects and soft-iron effects by SAMS Enterprise (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 and with the ordered batteries fitted). The three axes are reported back in µT and also a compass heading is derived which is compensated for tilt.. However the heading is of low accuracy at latitudes nearer the poles so the heading value gives a general indication of floe rotation only (and not to be used for navigation!).
- 2.6.4 An barometer chip is fitted which reports an indication of local atmospheric pressure change. Please note this is not a meterological standard device . Also 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 which is useful for monitoring battery temperature. The readings are reported back within the same GPS fix messages.

#### 2.7 Unit Status and Configuration

- 2.7.1 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.
- 2.7.2 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. The unit will still run without an SD if its accidentally missing, however it does mean no data will be stored on the unit only transmitted and could result in lost data if transmissions fail. We only recommend the 32gb SanDisk Extreme MicroSD, other SD cards will not work.

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![](_page_16_Picture_1.jpeg)

# NOTE: Testing configurations is extremely important and you can discuss your requirements with SAMS Enterprise. There are countless permutations which cannot all be tested but some have been found to create fatal outcomes for the unit which cannot be remotely recovered by SIMBA engineers.

2.7.3 Please ensure that configurations are 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, allowing the configuration to be changed if a mistake is made!. NOTE: Remote configuration of units with no SD card is possible but the changes will be lost if the unit is reset or powered down.

#### 2.8 Iridium System

- 2.8.1 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, with small messages and the message buffer system data tranfer is reliable. 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.
- 2.8.2 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 SAMS Enterprise data server.

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

- 2.8.3 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).
- 2.8.4 Note: the system is designed for use with mobile phone modems, however this is not yet available so the modem plug on the SIMBA unit plate is currently NOT in use and the unit will communicate with Iridium ONLY.

#### 2.9 Power Usage and Battery Life

- 2.9.1 The system will power from the batteries until they drop to about 8V where upon the heating cycle voltage to the heating elements cannot be supported. When the voltage drops below 8V 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 the power is the same across all heating cycles, this helps protect the integrity of the results from the heated cycle
- 2.9.2 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 8V may be reached earlier. However, since we have many packs in parallel the maximum current is reduced and so the issue becomes less pronounced.
- 2.9.3 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 but units in the field working down to -50°C so fresh batteries at the start of a deployment are always recommended.
- 2.9.4 The calculations suggest that for default configuration a 15V battery of 10x6 cells would run the unit for a year and this is born out from a field deployment to -50°C for 18 months with 2 battery packs. Changes to configuration would require reassessment of this as higher sampling rates, and in particular increased heating cycles and running 2 chains, will impact the power usage significantly.

#### 2.10 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.

https://www.sams.ac.uk/t4-media/sams/pdf/SIMBA-Reference-List-MAY24.pdf

SIMBA
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![](_page_18_Picture_0.jpeg)

#### 3 DATA TRANSFER

#### 3.1 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.
USB-C	Pre-deployment testing, laboratory testing or during
	deployment if access can be gained to the unit.

#### 3.2 Iridium Satellite Network Data Transfer

- **3.2.1** 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 SAMS Enterprise, who can manage airtime supply on the customers/users behalf.
- 3.2.2 IMPORTANT: even if there is no active airtime contract the Simba unit will still send data and appear to work BUT the data will not be sent by email it will be will be lost.
- 3.2.3 These emails are decoded from SBD format either via the SAMS Enterprise web interface which can be purchased with the airtime, or separately by the customer/user.

Note: SAMS Enterprise <u>deactivates all SBD modems on point of despatch after testing</u>, which helps to avoid unwanted data charges during transit and prior to deployment. It will be necessary for the user to contact SAMS Enterprise (if airtime is being supplied by SAMS Enterprise) or their own airtime supplier <u>in advance of deployment</u>, to re-activate the modem 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 4, until it has been confirmed that data transfer emails are being correctly received).

#### 3.3 Web Interface

3.3.1 If the web interface is purchased from SAMS Enterprise, then the most recent data will be displayed decoded at:

<u>https://simba.sams-enterprise.com/data</u>. Login details are provided on dispatch of your SIMBA unit. Figure 6 below presents an overview of the web data interface page provided by SAMS Enterprise.

![](_page_18_Picture_15.jpeg)

![](_page_19_Picture_0.jpeg)

![](_page_19_Figure_3.jpeg)

Figure 6: When the web interface option is provided by SAMS Enterprise, emails with the data files attached from the SIMBA unit are automatically collected, decoded and archived on the SAMS Enterprise servers, and made available as comma separated values (CSV) files. The CSV data files can be accessed via the disk symbols at the far-right side of each line.

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![](_page_20_Picture_0.jpeg)

#### 3.4 SD Card Data Transfer

- 3.4.1 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.
- 3.4.2 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 Error! Reference source not found.). 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.

#### 3.5 USB-C Data Transfer

3.5.1 The SIMBA unit can be monitored via the USB-C port on the SIMBA unit plate, which also allows data extraction. This is particularly useful when conducting lab tests and pre-deployment checks.

Please contact SAMS Enterprise before accessing the USB-C There are functions in the **test menu** which can result in damage to the unit or chain if used incorrectly, which cannot be rectified without return to SAMS Enterprise.

- 3.5.2 Use of the USB-C requires:
  - A computer with USB-C cable and connector

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- Suitable interface software such as PuTYY (see PuTTY setup below),
- A clear view of the sky for GPS (transmission <u>may</u> be possible near a window or antenna / repeater system),
- 3.5.3 Once in place, connect the computer to the SIMBA USB-C and then power up the SIMBA unit and use device manager (or similar) to identify COM port to set within PuTTY.
- 3.5.4 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 USB-C is connected.

![](_page_21_Picture_13.jpeg)

#### 4 DEPLOYMENT GUIDE

#### 4.1 Pre-Deployment Testing

- 4.1.1 IMPORTANT: Please refer to section 5 of the SAMS Enterprise Terms and Conditions for information on testing during the "Pre-Deployment Period".
- 4.1.2 Upon delivery, the Client shall have a period of two (2) months to test the Products from the receipt of the Products (the "Pre-Deployment Period) and advise the Seller of any issues with the Products. During this period SAMS Enterprise warrants that the products shall:
  - 4.1.2.1 conform in all material respects with the Specification;
  - 4.1.2.2 be free from material defects in design, material and workmanship;
  - 4.1.2.3 be fit for any purpose held out by the Seller.
- 4.1.3 It is strongly advised that pre-deployment tests are also made (or repeated) 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.
- 4.1.4 In addition, this time frame allows technical support to take place in the event of an issue being discovered.
- 4.1.5 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 can "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.
- 4.1.6 During testing, events can be monitored using the USB-C as already described, as this shows more information than the SD card files. This may be useful if problems are encountered.
- 4.1.7 Test programs the test routines **are not** designed for end-user use but may be used **under the direction of SAMS Enterprise** to assist with debugging a problem. Changes to the test routine outside our guidance will invalidate any warranty and could potentially fatally damage the SIMBA unit.
- 4.1.8 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. <u>Some routines are for calibration purposes. These are identified and must not be used as there is a risk of permanently damaging the unit or chain.</u>
- 4.1.9 The consequences of running these calibration tests may mean the unit must be returned to SAMS Enterprise for recalibration, repair or replacement.

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![](_page_23_Picture_0.jpeg)

#### 4.2 Deployment Guide

- 4.2.1 The following pages present the deployment guide for the SIMBA unit on sea-ice. Additional deployment equipment is required for environments such as river and mountains. These deployments are not covered in this guide.
- 4.2.2 There may be specific conditions at your deployment site that require bespoke deployment solutions. Although we cannot offer site specific guidance our technical team are happy to discuss options and solutions with you pre-deployment. Please contact SAMS Enterprise as soon as possible. Issues relating to incorrect deployment are not covered by SAMS Enterprise's SIMBA terms and conditions.
- 4.2.3 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 varies but can be shortened due to some effects 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.
  - 4.2.3.1 It is extremely important that the chain is deployed as described in the deployment guide below, other methods may lead to premature chain failure. Deploying the chain in a way that creates 90° angle at the header section (connecting the tehrmistor boards to the chain lead) or in the thermistor sections of the chain will cause terminal damage to that chain.
  - 4.2.3.2 General breakup of floes. Obviously, deployment near open water, during spring or on rapidly drifting ice all heighten the possibility of the floe disintegrating.
  - 4.2.3.3 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.
  - 4.2.3.4 **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.
  - 4.2.3.5 **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!
  - 4.2.3.6 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.

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![](_page_24_Picture_0.jpeg)

#### 5 POWER UP AND FAULT CODES

5.1.1 The below sequence denotes power up results only if the unit is tested outside with a clear view of the sky.

![](_page_24_Picture_5.jpeg)

Figure 7: LED on controller board visible through SIMBA plate

- 5.1.2 On power up (ie, connection of the power plug), press reset and the LEDs on the controller will flash for a few a seconds from left to right when power is first applied.
- 5.1.3 Then the "SYS" LED (1<sup>st</sup> LED on left) will flash while the system initialises and once complete will stay on.
- 5.1.4 Next the "MOM" (data) LED (4<sup>th</sup> LED from the left) will flash and once complete will stay on.
- 5.1.5 Then "CHN" or Chain LED (2<sup>nd</sup> left LED) will flash and stay on if the chain is successfully detected and read.
- 5.1.6 Then "GPS" LED (3<sup>rd</sup> left LED) flashes and remains on if the GPS chip is successfully read.
- 5.1.7 Then "MISC" LED (LED far right) flashes and remains if a status message has been successfully recorded.
- 5.1.8 Finally all LEDs flash on and off 3 times together and a successful power up is displayed by the "SYS" LED remaining on as the unit completes its first sampling process.
- 5.1.9 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).
- 5.1.10 In this case of a GPS or MOM LED remaining off, repeat the process using the RESET button and confirm the error. It might be necessary to repeat a few times as the error will likely be due to temporary satellite coverage drop out common at higher latitudes or due to test site not having a clear view of the sky.
- 5.1.11 If the "CHN" LED does not remain lit then check the chain connector is properly screwed in and RESET the unit.
- 5.1.12 If the errors are confirmed during the power-up operation the following steps can be applied:
  - 5.1.12.1 Go back through all the earlier steps, and check connections, etc also noting that the quick start deployment guide is provided on the plate of the SIMBA Unit (check those steps). Reset the unit.
  - 5.1.12.2 The error codes can also be found at the bottom of the status message on the web interface page, a status message is sent at every restart of the unit to verify operation and also in the

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Err file on the SD card. Read off the table below and/or report to <u>SIMBA@sams-</u> <u>enterprise.com</u> the LED sequence to help us diagnose the fault.

5.1.12.3 If the problem persists then remove the SD card and extract the logfile and Err file and email to SAMS Enterprise for examination (SIMBA@sams-enterprise.com). If necessary, you can also call on +44 (0)1631 559 470, and ask for SIMBA support. Monday to Friday 0900 – 1700 only.

#### SIMBA unit Fault codes

- 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.

	Code	Abbrv in logfile		Description and action		
	0	Null	Error	Null error. Used to indicate start of the displation LEDs. All good no issues !!	ay cycle	
	1	Battery Low		<u>Low Battery -</u> (<8Volts) common rail. Heater w operate by default (configurable)as battery pro measure.	vill not otection	
	2	RTC Osc Error		<u>RTC oscillator not running</u> – Hardware fau persistent after resetting then contact SRSL	ult. If	
	3	No Chain	Sensors On	<u>No sensors detected on chain -</u> Check chain p chain for damage & RESET !	lugs or	
	4	No EE	PROM Chain	<u>No EEPROM detected on chain -</u> Check chain plugs of for damage Check chain plugs & RESET !	or chain	
	5	Too Senso	Many Broken rs	<u>Too many broken sensors -</u> More than 10% sensors in chain. Indicates significant chain damage.	s failed	
	6	No InitGPSFix		<u>No initial GPSFix -</u> Move unit outside with a sky view. System will if subsequent GPS fix obtained.	recover	
	7	SDCard missing/unusable		<u>No SD Card detected -</u> Check SD is inserted corrupted, only use approved SD card types. Syst function without SD card.	and not tem will	
	8	Heater Volts Low		<u>Heater voltage low - Set default to 8V below voltage low - Set default to 8V below voltage but is set of the </u>	w <u>hich we</u> Probably not the Fault.	
	9	1-wire no response		<u>1-wire unit bad or no response –</u> Hardware fa persistent after reseting	ult. If	
Ī	10	BadAddrFromEEPROM		Bad address read from EEPROM - Visually Check chain plugs or chain for damage & RESET !		
	11	No ChainFound		<u>No Chain detected -</u> Visually Check chain plugs of for damage & RESET !	or chain	
	12	No Modem Found		<u>No Iridium modem detected –</u> Hardware fau persistent after resetting then contact SAMS E	ılt. If nt.	
[	13					
B	A		Created By	y: Phillip Thompson, Mark Hart and Craig Livingstone ht © SAMS Enterprise, All rights reserved	Page	

#### Table 4: LED and error code

SIM

Code	Abbrv in logfile	Description and action		
14	RTC Not Set	Clock has not been set from either GPS or coms system		
		reset. System will recover if GPS obtains a fix bu		
		best to reset and start again. May indicate GPS issue		
15	Chain sensor count	1+ persistent atter reset. Chain exceeds Max No. of Sensors 290 -Contact SAMS Ent		
	> Max			
16	No Mag Response	<u>Magnetometer no response</u> - Hardware fault, contact SAMS Ent. System will run but with invalid magnetometer data.		
17	Mag Cal Missing	Magnetometer Calibration Data Not Found – Hardware fault or calibration not performed. Contact SAMS Ent. System will run but magnetometer data may be invalid		
18	No Response Baro	Barometer bad or no response - Hardware fault, contact SAMS Ent. Hardware fault. System will run but with invalid pressure readings.		
19	No Response GPS	<u>No response from GPS -</u> Hardware fault, contact SAMS Ent. System will run, also see error 14 but reported		
20	No Response PCB EPROM	No response from on-board EEPROM - Hardware fault, contact SAMS Ent. System will run but magnetometer calibration may be invalid and sample number will default to start at 1.		
21	Reset after Osc. failure	Reset prompted by oscillator failure		
22	Reset after Stack error	Reset prompted by memory stack failure		
23	Reset after Addr. error	Reset prompted by memory address failure		
24	Reset after Maths error	Reset prompted by Math error failure		
25	NonFatal			
27	SD Card Write Protected	<u>SD Card write protected</u> - Cneck read-only tab on SD card. System will run but data not saved to card.		
28	Wake time_in Past	<u>Wake time in past</u> - Usually a spurious issue which will resolve itself.		
29	Bad reply - chain sensor	<u>Non-hex char from sensor</u> – If persistent indicates a chain hardware fault.		
30	Chain data line shorted	<u>Chain data bus short circuited to ground –</u> While this is serious it will be flagged up by errors 3,4 and 11 at startup.		
31	Transmission buffer full	<u>Iridium buffer overflow</u> - check antenna connection unit orientation "Skyside" up, Contact SAMS Ent if problem persists. Will only occur after considerable data is accumulated for transmission but cannot be sent.		
32	BrownOut Reset	<b><u>Brownout reset</u></b> – Often occurs when first connecting batteries or if batteries provide insufficient power and this will be flagged by other errors at startup. If persistent contact SRSL		
33	Watchdog Reset	<u>Watchdog reset</u> - Usually spurious but if persistent then contact SRSL		
34	Config Mismatch Reset	<u>Config. mismatch reset -</u> A software issue. Contact SRSL if problem persists.		
35	Illegal Opcode Reset	Illegal opcode reset - Software issue, if persistent after reset then contact SRSL		
36	Trap conflict Reset	<u>Trap conflict reset -</u> Software issue, if persistent after reset then contact SRSL		
37	Woken by WDT	<u>Woken by WDT - If persistent indicates clock circuit</u> failure or configuration of system needs checking.		
38	Wake source unknown	<u>Wake source unknown -</u> Software issue. Contact SRSL if problem persists		
39	UnUsedError3			
40	Failed to get GPS fix	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.		

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Code	Abbrv in logfile	Description and action
41	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.
42	UnUsedError4	Tuidium actual. Did act complete consists in time
43	ineout during	Iridium network. Did not complete session in time -
		reported back by the Tridium network. No response to
44	Can't write SD	Unable to write SD card data file - Check SD is inserted
	data file	and not corrupted, only use approved SD card types
		Contact SRSL if problem persists
45	Iridium network	Iridium network. Did not complete session in time -
	error	Contact SRSL if problem persists. This is an error
		reported back by the Iridium network.
46	Iridium modem	
	error	
47	Undefined iridium	<u>Iridium network Undefined iridium error-</u> Contact SRSL
	error	if problem persists. This is an error reported back by
40	Described 1411	the Iridium network.
48	command	<u>KIII Commanu received - Bye Bye for ever (or till the</u> RESET is pressed)
49	Message Package	
49	Message Package oversize	
49 50	Message Package oversize Message buffer	Iridium network. Invalid segment size- Contact SRSL if
49 50	Message Package oversize Message buffer corrupted	<u>Iridium network. Invalid segment size-</u> Contact SRSL if problem persists. This is an error reported back by the
49 50	Message Package oversize Message buffer corrupted	<u>Iridium network. Invalid segment size-</u> Contact SRSL if problem persists. This is an error reported back by the Iridium network.
49 50 51	Message Package oversize Message buffer corrupted	<u>Iridium network. Invalid segment size-</u> Contact SRSL if problem persists. This is an error reported back by the Iridium network.
49 50 51	Message Package oversize buffer corrupted	<u>Iridium network. Invalid segment size-</u> Contact SRSL if problem persists. This is an error reported back by the Iridium network.
49 50 51 52	Message Package oversize buffer corrupted buffer Undefined error	<u>Iridium network. Invalid segment size-</u> Contact SRSL if problem persists. This is an error reported back by the Iridium network.
49 50 51 52	Message Package oversize buffer corrupted buffer Undefined error code undefined oppor	<u>Iridium network. Invalid segment size-</u> Contact SRSL if problem persists. This is an error reported back by the Iridium network.
49 50 51 52 53	Message Package oversize buffer corrupted buffer Undefined error code error	<u>Iridium network. Invalid segment size-</u> Contact SRSL if problem persists. This is an error reported back by the Iridium network.
49 50 51 52 53 54	Message Package oversize buffer corrupted buffer Undefined error code Undefined error code undefined error	<u>Iridium network. Invalid segment size-</u> Contact SRSL if problem persists. This is an error reported back by the Iridium network.
49 50 51 52 53 54	Message Package oversize buffer corrupted buffer code error code error code error code error	<u>Iridium network. Invalid segment size-</u> Contact SRSL if problem persists. This is an error reported back by the Iridium network.
49 50 51 52 53 54 55	Message Package oversize buffer corrupted buffer corrupted error code error code undefined error code error	<u>Iridium network. Invalid segment size-</u> Contact SRSL if problem persists. This is an error reported back by the Iridium network.
49 50 51 52 53 54 55	Message Package oversize buffer corrupted buffer corrupted error code undefined error code undefined error code error code	<u>Iridium network. Invalid segment size-</u> Contact SRSL if problem persists. This is an error reported back by the Iridium network.
49 50 51 52 53 54 55 56	Message Package oversize buffer corrupted buffer corrupted error code undefined error code undefined error code undefined error code undefined error	<u>Iridium network. Invalid segment size-</u> Contact SRSL if problem persists. This is an error reported back by the Iridium network.
49 50 51 52 53 54 55 56	Message Package oversize buffer corrupted buffer corrupted error code error code undefined error code error code undefined error code error code error code error	<u>Iridium network. Invalid segment size-</u> Contact SRSL if problem persists. This is an error reported back by the Iridium network.
49 50 51 52 53 54 55 56 57	Message Package oversize buffer corrupted buffer corrupted error code error code undefined error code error code undefined error code undefined error code error code error	Iridium network. Invalid segment size- Contact SRSL if problem persists. This is an error reported back by the Iridium network.
49 50 51 52 53 54 55 56 57	Message versize buffer oversize buffer corrupted buffer corrupted error code error code undefined error code error code undefined error code error code error code error code error code error	Iridium network. Invalid segment size- Contact SRSL if problem persists. This is an error reported back by the Iridium network.
49 50 51 52 53 54 55 56 57	Message versize Message buffer corrupted buffer corrupted error code undefined error code undefined error code Undefined error code Undefined error code	Iridium network. Invalid segment size- Contact SRSL if problem persists. This is an error reported back by the Iridium network.
49 50 51 52 53 54 55 56 57	Message versize Message buffer corrupted Undefined error code Undefined error code Undefined error code Undefined error code Undefined error code	Iridium network. Invalid segment size- Contact SRSL if problem persists. This is an error reported back by the Iridium network.

#### 6 APPENDIX B- STANDARD CONSTRUCTION FOR ENVIRONMENTAL PURPOSES

Standard Components and their materials

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

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

![](_page_28_Picture_7.jpeg)

![](_page_29_Picture_0.jpeg)

#### 7 APPENDIX C – MANUFACTURER BATTERY SAFETY DATA SHEET

#### DURACELL

#### **Article Information Sheet (AIS)**

This Article Information Sheet (AIS) provides relevant battery information to retailers, consumers, OEMs and others users requesting a GHS-compliant SDS. Articles, such as batteries, are exempt from GHS SDS classification criteria. The GHS criteria is not designed or intended to be used to classify the physical, health and environmental hazards of an article. Branded consumer batteries are defined as electro-technical devices. The design, safety, manufacture, and qualification of branded consumer batteries follow ANSI and IEC battery standards. This document is based on principles set forth in the following hazard communication approaches: ANSI Z-400.1, GHS, JAMP AIS, IEC 62474, and ANSI C18.4M.

1. Document Information	
Document Name	Duracell Alkaline Batteries (Major and Specialty Cells)
Document ID	AIS-ALK
Issue Date	1-May-15
Version	6.0
Preparer	Duracell North America Product Safety & Regulatory
Last Revision	1/11/2022
Information Contact	SDS@duracell.com
2. Company Information	
Name & Address	Duracell US Operations, 14 Research Drive, Bethel, CT USA 06801. Duracell Batteries BV, Nijverheidslaan 7, 3200 Aarschot, Belgium. Duracell International Operations Sàrl, Rue du Pré- de-la-Bichette 1, CH-1202, Geneva, Switzerland.
Global Website	www.duracell.com
Consumer Relations: North America	North America: 1-800-551-2355 (9:00 AM - 5:00 PM EST)
Consumer Relations: E&A	<ul> <li>(UK) 0800 716434, (FR) 0800 346 790 Service &amp; appel gratuits,</li> <li>(IRL) 1 800 509 176, (DE) 800 101 2112, (AT) 0800 1025 1956,</li> <li>(CH) 0800 000 885, (BE) 0800 509 95, (NL) 0800 265 8616,</li> <li>(IT) 800 125 662, (ES) 900 800 522, (PT) 800 781 012,</li> <li>(GR) 210 66 75 000, (CY) 22-210900, (DK-FI-NO-SE) 4687991926, (IS) 3545222700</li> <li>(ZA) +27211403500, (RO) 021 3361915, (MD) 022472402,</li> <li>(BG) 02 40 24 500, (BIH) 033756000, (MNE) 020261920,</li> <li>(PL) 22 692 42 77, (LT) (8) 37 401 111, (LV) 67798667,</li> <li>(EE) +3726505555, (C2) +42023332010, (SK) +42153419601,</li> <li>(HU) 0620 770 7099, (HR) 0800 0099, (SI) 01/588 6800,</li> <li>(AZ) 812 3100949, (UA) +380444909771 (ДП «CAB 92») &amp; +380442476704 (TOB «IHBECTKOM»),</li> <li>(KZ) +7 727 250 05 50, (TM) 00865 530070,</li> <li>(KG) 0312 41 77 04 (Apple City International),</li> <li>(TR) 0 850 502 61 40.</li> </ul>
3. Article Information	
Description	Duracell branded consumer alkaline battery
Product Category	Electro-technical device
Use	Portable power source for electronic devices
Global sub-brands (Retail)	Coppertop, Coppertop with PowerBoost Technology, Plus, Simply, Ultra, Basic, Optimum, Original, Deluxe, Chhota Power, Classic, Professional
Global sub-brands (B2B)	OEM/OEA
Physical Descriptions (IEC Designations)	<u>Major Cells</u> : AA (LR6), AAA (LR03), C (LR14), D (LR20) & 9V (6F22, 6LR61)
Physical Descriptions (IEC Designations)	<u>Specialty Cells</u> : AAAA (LR8D425), MN11, MN21 (8LR932, A23, 23A), MN27, MN175, PX76/A76/76A (LR44), PX28, PX625, (LR9), 186 (LR43), 191/LR1130 (LR54), N (LR1), J (4LR61), 4.5V, 625A
Physical Descriptions (IEC Designations)	Lanterns: MN903, MN908, MN915, MN918; MN1203

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#### **Article Information Sheet (AIS)**

Principles of Operation	A battery powers a devi	ce by converting stored	chemical energy into ele	ctrical energy.
Representative Product Images		DURACELL OPTIMUM	DIRACEIL	
	Major Cells	Major Cells	Lantern	Specialty Button
4. Article Construction				
Applicable Battery Industry Standards	ANSI C18.1M Part 1, AN	SI C18.1M Part 2, ANSI C	C18.4M, IEC 60086-1, IEC	60086-2, IEC 60086-5
Electro-technical System	Alkaline Manganese Dic	xide		
Electrode - Negative	Zinc (CAS # 7440-66-6);	10-25%		
Electrode - Positive	Manganese Dioxide (CA	S # 1313-13-9); 35-40%		
Electrolyte	Alkali Metal Hydroxide	aqueous potassium hyd	roxide - CAS # 1310-58-3	); 5-10%
CAN - NA/Europe/China	Nickel Cobalt Plated Ste	el or Nickel Plated Steel	(CAS # 7440-02-0); 8-15%	6
Other Non-Active Materials	10-15%			
Declarable Substances (IEC 62474 Criteria 1)	None			
Mercury Free Battery (ANSI C18.4M <5ppm)	Yes			
Small Cell or Battery (ANSI C18.1M Part 2; IEC 60086-5)	Sizes: AAA and Specialty long by 1.25 inches (31.	Cells fit inside a special 70 mm) wide.	ly designed test cylinder	2.25 inches (57.1mm)
5. Health & Safety				
Ingestion/Small Parts Warning	Required for Small Cell of swallowed, consult a ph	or Battery (Sizes: AAA an ysician immediately.	nd Specialty Cells): Keep	away from children. If
Normal Conditions of Use	Exposure to contents in exposed to high temper	side the sealed battery v atures, or is mechanical	will not occur unless the ly abused.	battery leaks, is
Note to Physician	A damaged battery will	release concentrated an	d caustic potassium hyd	roxide.
First Aid - If swallowed	Do not induce vomiting call the National Battery provided below).	Seek medical attention Ingestion Hotline (telep	immediately. For inform phone numbers for the U	ation on treatment, SA and Canada are
Poison Center/North America	USA/Canada Calls Only Hotline]	: 1-800-498-8666 (Toll F	ree) [24-Hour Nationa	l Battery Ingestion
Poison Centers/World Directory	http://globalcrisis.info/	poisonemergency.htm	II#AAA	
First Aid - Eye Contact	Flush with water for at I	east 15 minutes. Seek m	edical care if irritation p	ersists.
First Aid - Skin Contact	Remove contaminated of persists.	clothing. Wash skin with	soap and water. Seek m	edical care if irritation
First Aid - Inhalation	Remove to fresh air.			
Battery Safety Standards & Testing	Duracell batteries meet standards specify tests a normal use and reasona safety. These are: <u>1-Intended use simula</u> <u>2-Reasonably foreseet</u> drop), over-discharge, a <u>3-Design consideration</u>	the requirements of AN and requirements for alk ibly foreseeable misuse. tion: Partial use, vibratic ible misuse: Incorrect in nd crush 1: Thermal abuse, mold	SI C18. 1M Part 2 and IEC caline batteries to ensure The test regimes assess on, thermal shock, and m stallation, external short stress	C 60086-5. These e safe operation under three conditions of echanical shock -circuit, free fall (user-

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#### **Article Information Sheet (AIS)**

Precautionary Statements	<b>CAUTION:</b> Batteries 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. Keep small batteries (i.e., AAA) away from children. If swallowed, consult a physician at once.
6. Fire Hazard & Firefighting	
Fire Hazard	Batteries may rupture or leak if involved in a fire.
Extinguishing Media	Use any extinguishing media appropriate for the surrounding area.
Fires Involving Large Quantities of Batteries	Large quantities of batteries involved in a fire will rupture and release caustic potassium hydroxide. Firefighters should wear self-contained breathing apparatus and protective clothing.
7. Handling & Storage	
Handling Precautions	Avoid mechanical and electrical abuse. Do not short circuit or install incorrectly. Batteries may rupture or vent if disassembled, crushed, recharged or exposed to high temperatures. Install batteries in accordance with equipment instructions.
Storage Precautions	Store batteries in a dry place at normal room temperature. Refrigeration does not make them last longer.
Spills of Large Quantities of Loose Batteries (unpackaged)	Notify spill personnel of large spills. Irritating and flammable vapors may be released from leaking or ruptured batteries. Spread batteries apart to stop shorting. Eliminate all ignition sources. Evacuate area and allow vapors to dissipate. Clean-up personnel should wear appropriate PPE to avoid eye and skin contact and inhalation of vapors or fumes. Increase ventilation. Carefully collect batteries and place in appropriate container for disposal. Remove any spilled liquid with absorbent material and contain for disposal.
8. Disposal Considerations (GHS Section	on 13)
Collection & Proper Disposal	Dispose of used (or excess) batteries in compliance with federal, state/provincial and local regulations. Do not accumulate large quantities of used batteries for disposal as accumulations could cause batteries to short-circuit. Do not incinerate. In countries, such as Canada and the EU, where there are regulations for the collection and recycling of batteries, consumers should dispose of their used batteries into the collection network at municipal depots and retailers.
USA EPA RCRA (40 CFR 261)	Classified as non-hazardous waste (not ignitable, corrosive, reactive or toxic). Federal Universal Waste Regulations (40 CFR 273) do not apply. State requirements may be more stringent than Federal.
California Universal Waste Rule (Cal. Code Regs. Title 22, Div. 4.5, Ch. 23)	California prohibits disposal of batteries as trash (including household trash).
Vermont Primary Battery Stewardship Law (ACT 139)	In Vermont, consumers must recycle alkaline batteries. For information, contact http://www.call2recycle.org.
9. Transport Information (GHS Section	14)
Regulatory Status	Not regulated by IMO IMDG/Not classified by IMO IMDG/the substance is not subject to IMO IMDG. Alkaline batteries (sometimes referred to as "Dry Cell" or "household" batteries) are not listed or regulated as dangerous goods under IATA Dangerous Goods Regulations, ICAO Technical Instructions, IMDG Code, UN Model Regulations, U.S. Hazardous Materials Regulations (49 CFR), and UNECE ADR.
UN Identification Number/ Shipping Name	None - Not Required

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#### **Article Information Sheet (AIS)**

Special Provision (SP) Conformance	Special regulatory provisions require batteries to be packaged in a manner that prevents the generation of a dangerous quantity of heat and short circuits. Shippers can prepare batteries by taping the terminals, individually packaging batteries, or otherwise segregating the batteries to prevent risk of creating a short circuit. Batteries shipped in original unopened Duracell packaging is compliant.
US DOT SP	49 CFR 172.102 Special Provision 130
Air Transport IATA	Special Provision A123 NOTE: The words "NOT RESTRICTED" and "SPECIAL PROVISION A123"
63rd Edition, ICAO	must be included on the description of the substance on the Air Waybill, when air way-bill is issued.
Passenger Air Travel	No restrictions
Vessel Travel (IMDG/IMO)	Not regulated by IMO IMDG/Not classified by IMO IMDG/the substance is not subject to IMO IMDG.
Emergency Transportation Hotline	CHEMTREC 24-Hour Emergency Response Hotline
	Within the United States call +703-527-3887
	Outside the United States, call +1 703-527-3887 (Collect)
10. Regulatory Information (GHS Sect	ion 15)
10a. Battery Requirements	
USA EPA Mercury Containing &	During the manufacturing process, no mercury is added.
Rechargeable Battery Management Act of 1996	
EU Battery Directive 2006/66/EC	Compliant with marking and substance restrictions for mercury (<0.0005%); cadmium
& amendment 2013/56/EU	(<0.0020%)I and lead (<0.0040%). Global labels are marked with the special collection symbol
	and the EU qualifier in accordance with EU Battery Directive 2006/66/EC, Article 11, Paragraph
	1 on batteries and accumulators and waste batteries and accumulators (Annex II).
P.R.C. Provision on Mercury Content Limitation for Batteries (GB 8897.5- 2005, MOD, Section 9.1(e)	无汞
P.R.C. Mercury Free Battery (GB 24427-2009) < 1ppm	Yes
10b. General Requirements	
USA CPSIA 2008 (PL. 11900314)	Exempt
USA CPSC EHSA (16 CER 1500)	Consumer hatteries are not listed as a bazardous product
USA EPA TSCA Section 13 (40 CFR	For customs clearance nurnose, batteries are defined as an "Article"
707.20)	
USA EPA RCRA (40 CFR 261)	Classified as non-hazardous waste (not ignitable, corrosive, reactive or toxic). Federal
	Universal Waste Regulations (40 CFR 273) do not apply. State requirements may be more
	stringent than Federal.
California Prop 65	No warning required per 3rd party assessment.
CANADA Products Containing Mercury Regulations SOR/20140254	Mercury free
EU REACH REGULATION (EC) NO.	Regulated as an "article." No listed SVHC substances are present (>0.1% w/w) in accordance
1907/2006 and REACH SVHC	with ECJ article definition of 10 September 2015. This SVHC communication is based on the best
	available information to us. Duracell is managing compliance with EU REACH as part of our
	daily quality, safety, and regulatory activities. The Candidate List of SVHC's is updated
	approximately bi-annually and Duracell will update this declaration accordingly if the updated
	SHVC list affects the assessment herein.
EU REACH Article 31	SDS is not required for consumer alkaline batteries.
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10c. Regulatory Definitions - Articles		
USA OSHA	29 CFR 1910.1200(b)(6)(v)	
USA TSCA	40 CFR 704.3; 710.2(3)( c); and [19 CFR 12.1209a)]	
EU REACH	Title 1 - Chapter 2 - Article 3(3)	
GHS	Section 1.3.2.1	
11. Other Information		
11a. Certification & 3rd Party Approvals		
Note:	UL Listing applies to all 9Vand only AA manufactured in LaGrange USA and China.	
UL (UTGT2.S50939 Single Multiple	AA, 9V	
Station Smoke Alarms - Component)	Certification Standard: ANSI/UL 217 Single & Multiple Station Smoke Alarms	
11b. AIS Hazard Communication Approaches (consulted in developing this document):		
Globally Harmonized System (GHS)	GHS SDS requirements and classification criteria do not apply to articles or products (such as	
	batteries) that have a fixed shape, which are not intended to release a chemical. The article	
	exemption is found in Section 1.3.2.1.1 of the GHS and reads: The GHS applies to pure	
	substances and their dilute solutions and to mixtures. "Articles" as defined by the Hazard	
	Communication Standard (29 CFR 1900.1200) of the OSHA of the USA, or by similar	
	definition, are outside the scope of the system."	
Joint Article Management Promotion	JAMP is a Japanese Industry Association who developed the concept of an Article Information	
Consortium JAMP	Sheet as a supply chain tool to share and communicate chemical information in articles. The	
	AlS authoring process is based on "declarable" substances to meet global regulatory	
	requirements as well as substances to be reported by GADSL, JIG, etc.	
IEC 62474 Ed. 1.0 B:2012 Material	An international standard that came into effect in March 2012 concerning declaration for	
Declaration for Products of and for	electrical and electronic products. IEC 6274 replaces the defunct Joint Industry Guide –	
the Electro-technical Industry	Material Declaration for Electro-technical Products (JIG-101-Ed 4.1 (May 21, 2012)	
IEC 62474 Database - Publically	The general principle for a substance to be included in the database as a declarable substance	
available online (maintained by TC11:	is: 1) existing national laws or regulations in an IEC member country that are relevant to	
Environmental Standardization for	Electro-technical products and that prohibit or restrict substances, or that have a labeling,	
electrical and electronic products and	communication, reporting or notification requirement, and 2) applying IEC 62474 criteria	
systems.	results in identification of declarable substance.	
-		
ANSI C18 4M-2017 Portable Cells and	This standard provides regulatory guidance and a template to author an article information	
Rotteries - Environmental	cheet for a portable consumer battery. See Append (inforamative) C 2 Safety Data Sheets and	
batteries - Environmental	Anney E (Informative) E 2 General	
ANSI Z 400.1/Z19.1 (2010)	2.1 Scope: Applies to preparation of SDSs for hazardous chemicals used under occupational	
	conditions. Does not address how the standard may be applied to articles. It presents basic	
	information on how to develop and write a SDS. Additional information is provided to help	
	comply with state and federal environmental and safety laws and regulations. Elements of the	
	standard may be acceptable for International use.	
DISCLAIMER: This AIS 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 Duracell 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		
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product.		

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