SPC GlobalTrak

Product Specification

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Revision History

Version #	Date	Description of Changes	Author
2.02	20-Aug-06	Shift from V3c/p to V3d. Numerous Changes, all tracked in MS Word.	S.Mazur
2.03	28-Aug-06	Added revisions following internal review	
2.05	30-Aug-06	Added revisions following SPC review	
2.06	14-Sep-06	Added revisions following CDR	
2.07	15-Sep-06	More revision following CDR	R. Straz
2.10	14-Nov-07	Added Always on Mode Added LED Blink Codes	R. Straz

Table of Contents

1.0 Scope

1.1 Purpose and Overview

This document provides a complete product specification for the V3d and in part its predecessor the V3c. All application-level environmental, mechanical, electrical and functional requirements are specified, sufficient to enable development and subsequent design verification of the V3d product. A separate document, the SPC GlobalTrak Over-The-Air Protocol Specification, defines the air interface for satellite and cellular communications with the V3d. Note that many component-level requirements are not listed here, for example GSM or ORBCOMM transmit spectral masks, since such components are previously certified devices and integrated without significant modification into the overall V3d product.

The V3c prototype version is best considered an entry level product designed to meet the basic requirements of the intermodal sea container market. As such, it is limited in its functionality and performance and will not meet all the requirements detailed in this document and the accompanying OTA Protocol Specification.

1.2 Audience

This document is intended for V3d design, development and quality assurance personnel employed by SPC or MobiApps.

1.3 Revision Control

This document will be released under version numbers less than 1.0, until at such time it is considered to represent the customer needs at a level sufficient for the generation of detailed design specifications. Each release version will be listed in the Revision History sheet included in the third page of the document.

1.4 Conventions

Normal descriptive text is shown in a normal font.

Narrative or explanatory text is shown with emphasis.

Items requiring special attention are in bold.

1.5 Priorities

The requirements listed in Sections 3, 4 and 5 can have any of the priorities defined below. Any requirement not specifically noted is a “high priority”.

High Priority [HP] – must be included in the production build but not necessarily the prototype build. In some cases the requirement is most likely met in the prototype build, but will not be formally verified, for example mechanical requirements related to shock and vibration.

Prototype Priority [PP] – must be included in the prototype build.

Optional Priority [OP] – not required, but worth listing in the product specification should the selected design architecture enable inclusion at no cost.

Negotiable Priority [NP] – the requirement is not firm and may be modified to an alternative requirement based on trade-offs in cost, performance or desirability of feature.

Future Priority [FP] – can be added in a successive generation.

Design Goal [DG] – more aggressive, optional requirements that should be evaluated during the design phase for implementation. Implementation is dependent upon either negligible cost or strong market demand. At a minimum, the verification test plan should include the higher limits to understand how well the V3d performs against the design goals.

1.6 Design Verification

A design verification test (DVT) plan details the procedures used to verify that the finished product meets the requirements described herein. The Requirements Matrix in Appendix B serves as the master list for test case development and coverage.

1.7 Document Overview

This document is divided into 5 sections and 3 appendices. Actual requirements to be verified are included in sections 3 through 5. All other sections are for informational purposes.

- Section 1 provides an introduction and overview to the rest of this document.
- Section 2 provides an overview and a list specification references.
- Section 3 defines the functional and electrical requirements for the V3d.
- Section 4 defines the electromagnetic compatibility requirements for the V3d.
- Section 5 defines the mechanical requirements for the V3d.
- Appendix A defines terms, acronyms and abbreviations used in this document.
- Appendix B is a requirements matrix to aid V3d compliance verification.
- Appendix C provides a summary list of features in data sheet format.

1.8 References

The following documents are referenced in this product specification:

- European Telecommunications Standards Institute, EN 300 832 (A1 version 1.1.1), Electromagnetic Compatibility for Mobile Earth Stations, 2003.
- International Electrotechnical Commission, IEC 61000-4-6, Testing and Measurement Techniques — Immunity to Conducted Disturbances, Induced by Radio-Frequency Fields, Second Edition, May 2003.
- ORBCOMM, ORBCOMM Serial Interface Specification, E80050015, Revision F, April 20, 1999.
- ORBCOMM, ORBCOMM Subscriber Communicator (SC) Standards and Specifications, E25050102, Revision C, August 2, 1999.
- ORBCOMM, ORBCOMM Subscriber Communicator Type Approval Plan, A25TP0017, Revision B, September 7, 2000.
- Society of Automotive Engineers, SAE J1455, Joint SAE/TMC Recommended Environmental Practices for Electronic Equipment Design (Heavy-Duty Trucks), August 1994.
- ZigBee Alliance, ZigBee Document 053474r06 Version 1.0, Zigbee Specification, December 14th, 2004.
- European Telecommunications Standards Institute, 3GPP TS 23.040 “Technical Realization of Short Messaging Service”, Version 6.5.0, September 2004.

2.0 Product Overview

The GlobalTrak V3d enables location tracking and monitoring of containers in near real-time over GSM and ORBCOMM. The V3d uses a magnetic door switch to constantly monitor the door's status. When the door is opened, the junction in the magnetic relay is broken and an alarm is immediately sent to the Information Management Bureau (IMB). Along with door open alarms, the V3d sends periodic location reports using its internal GPS module. On request polling can also be executed from the IMB. These reports are received at the IMB where they are compared against stored routes. Using this method alarms can be programmed to alert the operator when a shipment goes off route. All batteries needed to keep the V3d operational are enclosed in the body of the main unit.

2.1 Feature List

The product is designed to monitor an intermodal sea container and report important sensory events no matter its location. This is accomplished by equipping the V3d with the following features:

a) **Communications:** The V3d can communicate bidirectionally over satellite and cellular networks.

b) **Sensor Suite:** The V3d has sensors to send alarms in the event of unusual or unexpected sound, light, door open, temperature or device tampering.

c) **Simple Installation:** There are only five components to install: the enclosure mounting bracket, the enclosure itself, antenna, mount sensor and door switch.

d) **Location Reporting**: The on board GPS receiver calculates its position within a few meters of accuracy.

e) **Industrial Grade**: High temperature rating (-40°C to +85°C) and minimum IEC shock and vibration rating.

f) **Zigbee Equipped**: The wireless standard for low-power short-range bi-directional communications, suitable for mesh networks and sensor reads.

2.2 Asset Tracking and Monitoring

The Information Management Bureau (IMB) is a server-based application used by operators and customers to track and monitor shipments equipped with the V3d. The interaction between the IMB and the V3d is based on the existing MobiApps mTrak protocol, enabling polling of the device, over-the-air configuration, scheduled and event reporting. Reduced functionality is expected due to the required addition of power management functions, whereby the V3d is in low-power mode and only able to communicate through satellite or cellular at scheduled times or when a local sensor detects an important event.

3.0 Functional and Electrical Requirements

This section details the general functional and electrical requirements of the V3d, including the higher-level application functions, sensor response and GPS.

3.1 Sensors

3.1.1 Optic Sensor

3.1.1.1 Performance

The sensor spectral response wavelength range shall be from 320 to 840 nm λ, with sensitivity greater than 0.3 A/W across the range.

3.1.1.2 Function

The sensor output shall be sampled by / reported to the microprocessor at the configurable sensor sampling rate of range from 1 to 60 seconds, even when the V3d is in its lowest power state. The measured value is to be compared against a stored threshold, and when exceeded, a logger record is to be immediately generated and sent to the IMB. The measured value is a peak of the sensor output over the previous interval.

The sensor is re-armed after a the sensor level returns from the alarm state. At the point where the sensor level crosses the threshold back to a typical level the sensor alarm is once again active. Also, the sensor is disarmed or otherwise ignored while the illuminating indicator is known to be activated.

3.1.1.3 Configuration

The threshold shall be user programmable, changeable over-the-air through either network or locally. Also the threshold can be disabled, such that no event message is generated.

3.1.1.4 Mounting

The optic sensor is to be mounted interior to the enclosure, with exterior light presented to the optic sensor through a simple light pipe or optical window, to preserve the enclosure environmental seal.

3.1.2 Acoustic Sensor

3.1.2.1 Performance

The acoustic response frequency range shall be from 20Hz to 16kHz, with signal to noise ratio greater than 40 dB across the range, with sensor values reported on a logarithmic scale.

3.1.2.2 Function

The sensor output shall be sampled by / reported to the microprocessor at the configurable sensor sampling rate of range from 1 to 60 seconds, even when the V3d is in its lowest power state. The measured value is to be compared against a stored threshold, and when exceeded, a logger record is to be immediately generated and sent to the IMB. The measured value is a peak of the sensor output over the previous interval.

The sensor is re-armed after the sensor level returns from the alarm state. At the point where the sensor level crosses the threshold back to a typical level the sensor alarm is once again active.

3.1.2.3 Configuration

The threshold shall be user programmable, changeable over-the-air through either network or locally. Also the threshold can be disabled, such that no event message is generated.

3.1.2.4 Mounting

The acoustic sensor is mounted on a PCB inside the enclosure.

3.1.3 Door Sensor

3.1.3.1 Performance

The sensor is a reed-based, magnetic proximity sensor, implemented as a single pole, single throw (SPST) normally open contact switch. When the actuator is nearby, defined as within 0.25 and 0.7 inches (6.35 to 17.8 mm), the circuit is closed. Otherwise the circuit is open, and the door is considered open.

3.1.3.2 Function

The sensor output shall be sampled by / reported to the microprocessor at the configurable sensor sampling rate of range from 1 to 60 seconds, or edge triggered, even when the V3d is in its lowest power state.

Following first indication of a possible change of state, the sensor is sampled for an additional number of seconds, and an event is declared only after all consecutive readings indicate such.

For a door open event, the V3d immediately generates a logger record and sends to the IMB. For a door close event, the V3d only generates a logger record. The door sensor is immediately re-armed after any event.

3.1.3.3 Configuration

The minimum number of consecutive readings shall be user programmable, changeable over-the-air through either network or locally. Also the consecutive threshold can be disabled, such that no event message is generated.

3.1.3.4 Mounting

The door sensor is mounted adjacent to the door top opening, with the actuator mounted on the door itself. A short cable connects the door sensor to the V3d.

3.1.4 Temperature Sensor

3.1.4.1 Performance

The sensor range shall be from -40°C to +85°C, with accuracy within 2°C across this range.

3.1.4.2 Function

The sensor output shall be sampled by / reported to the microprocessor at the configurable sensor sampling rate of range from 1 to 60 seconds, even when the V3d is in its lowest power state. The measured value is to be compared against a stored upper and lower threshold, and when exceeded, an event message is to be immediately generated and sent to the IMB.

The sensor is re-armed after the sensor level returns from the alarm state. At the point where the sensor level crosses the threshold back to a typical level the sensor alarm is once again active.

3.1.4.3 Configuration

All thresholds shall be user programmable, changeable over-the-air through either network or locally. Also the thresholds can be disabled, such that no event message is generated.

3.1.4.4 Mounting

The temperature sensor is located on a PCB within the enclosure.

3.1.5 Mount Sensor

3.1.5.1 Performance

The sensor is a reed-based, magnetic proximity sensor, implemented as a single pole, single throw (SPST) normally open contact switch attached to the inner wall of the plastic enclosure. When the actuator is nearby, defined as within 0.25 and 0.7 inches (6.35 to 17.8 mm), the circuit is closed. Otherwise the circuit is open, and the enclosure is considered removed from its mount.

3.1.5.2 Function

The sensor output shall be sampled by / reported to the microprocessor at the configurable sensor sampling rate of range from 1 to 60 seconds, or edge triggered, even when the V3d is in its lowest power state.

Following first indication of a possible change of state, the sensor is sampled for an additional number of seconds, and an event is declared only after all consecutive readings indicate such.

For an unattached mounting event, the V3d immediately generates a logger record and sends to the IMB. For an attached mounting event, the V3d only generates a logger record. The mount sensor is immediately re-armed after any event.

3.1.5.3 Configuration

The minimum number of consecutive readings shall be user programmable, changeable over-the-air through either network or locally. Also the consecutive threshold can be disabled, such that no event message is generated.

3.1.5.4 Mounting

The enclosure mount actuator is fastened to the sea container wall at a position in line with one particular circular bracket cutouts, corresponding to the location of the magnetic sensor located inside the V3d cover.

3.1.6 Analog Input

3.1.6.1 Performance

The single analog input is translated to 10-bit digital representation. Furthermore, the analog input provides for the following:

i) ESD protection (8 kV contact, 15 kV air)

iii) Circuits interface to the analog to digital converter (ADC) through a voltage conditioning circuit, which includes individually selectable voltage divider and amplifier gain stage.

iv) Circuits are easily accessible on the SAS board in order to allow customization of the circuits for different inputs.

3.1.6.2 Function

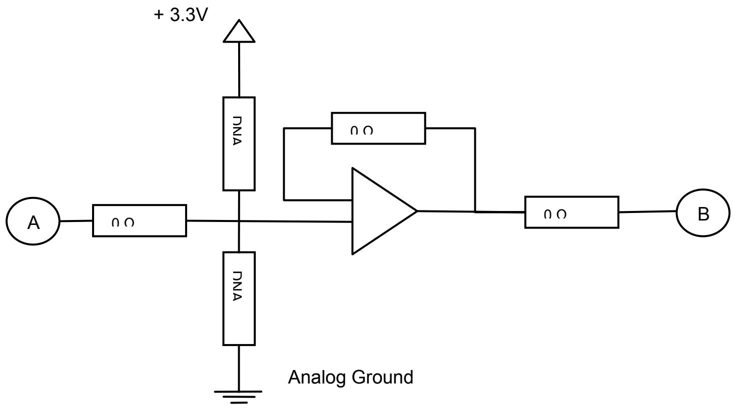
The sensor output shall be sampled by / reported to the microprocessor at the configurable sensor sampling rate of range from 1 to 60 seconds, even when the V3d is in its lowest power state. The measured value is to be compared against a stored upper and lower threshold, and when exceeded, an event message is to be immediately generated and sent to the IMB.

The sensor is re-armed after the sensor level returns from the alarm state. At the point where the sensor level crosses the threshold back to a typical level the sensor alarm is once again active.

3.1.6.3 Configuration

The threshold shall be user programmable, changeable over-the-air through either network or locally. Also the threshold can be disabled, such that no event message is generated.

The circuit enables physical customization of the inputs to adapt to varying sensors. The basic diagram is shown below. Rectangular blocks represent spaces where SMT 1/8W resistors can be placed (possibly 0 ohm). Production values are shown in the blocks. The translation of voltage to the full range of 10-bit digital values at point B is to be included in subsequent design documentation.



3.1.7 Digital Input

A single digital input circuit is to be wired to the front panel 20-pin Conxall connector. As a minimum, the circuit has the following characteristics:

i) ESD protection (8 kV contact, 15 kV air)

ii) Circuits interface to the MCU through a voltage conditioning circuit, which includes a modifiable voltage divider.

iii) Circuits to be easily accessible on the SAS board in order to allow SPC to customize the circuits for different inputs.

iv) Logic 1 occurs when input (point A) is between 2.5 V and 16 V. Logic 0 occurs when input is below 2.5 V.

The expected use of the circuit is as an indicator of the presence of external power. With this information the application would be able to operate more intelligently, for example to transmit reports at a higher rate or stay awake and not sleep if external power is present.

3.1.7.1 Function

The sensor output shall be sampled by / reported to the microprocessor at the configurable sensor sampling rate of range from 1 to 60 seconds, or edge triggered, even when the V3d is in its lowest power state.

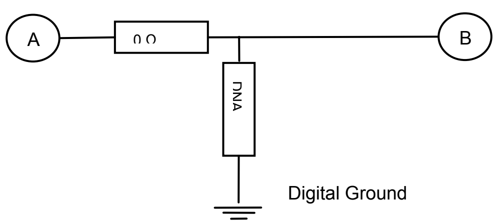
Following first indication of a possible change of state, the sensor is sampled for an additional number of seconds, and an event is declared only after all consecutive readings indicate such.

For an unattached mounting event, the V3d immediately generates a logger record and sends to the IMB. For an attached mounting event, the V3d only generates a logger record. The mount sensor is immediately re-armed after any event.

3.1.7.2 Configuration

The minimum number of consecutive readings shall be user programmable, changeable over-the-air through either network or locally. Also the consecutive threshold can be disabled, such that no event message is generated.

The circuit enables customization of the inputs to adapt to varying sensors. The basic diagram is shown below. Rectangular blocks represent spaces where SMT 1/8W resistors can be placed (possibly 0 ohm). Production values are shown in the blocks. The translation of voltage to digital 1 or 0 value at point B is to be included in subsequent design documentation.



3.1.8 Digital Output

A single digital output circuit is to be wired to the front panel 20-pin Conxall connector. It is a simple 3.3V digital output, ESD protected, and limited to 100 mA.

3.2 Wireless Communications

3.2.1 GSM Cellular

The Short Message Service (SMS) is the ability to send and receive text messages to and from mobile devices, over traditional GSM. The text can be comprised of words or numbers or an alphanumeric combination and can be no greater than 160 characters (140 octets) in length.

A message sent to a device is first received by a Short Message Service Center (SMSC), which then directs it to the appropriate mobile device. To do this, the SMSC sends a SMS Request to the home location register (HLR) to find the roaming device. Once the HLR receives the request, it responds to the SMSC with the device's status: 1) inactive or active 2) where device is roaming. If the response is 'inactive', then the SMSC holds onto the message for a period of time. When the device awakens, the HLR sends a SMS Notification to the SMSC, and the SMSC attempts delivery.

The SMSC transfers the message in a Short Message Delivery Point-to-Point format to the serving system. The system pages the device, and if it responds, the message gets delivered. The SMSC receives verification that the message was received by the end user, then categorizes the message as 'sent' and will not attempt to send again.

3.2.1.1 Quad Band Operation

The GSM transceiver used within the V3d must be capable of communicating on any of the four globally regulated GSM frequency bands, commonly referred to as the 850, 900, 1800 and 1900 MHz bands, making it usable across the globe.

3.2.2 ORBCOMM Satellite System

The ORBCOMM system is a two-way system that supports communication to and from mobile or fixed Subscriber Communicators (SCs). In most applications, a message or other data is first generated by an SC. From that source, the data is transmitted to the nearest ORBCOMM satellite. The satellite downlinks the data to the selected Gateway Earth Station (GES), which then transmits the data to the desired Gateway Control Center (GCC). Within the GCC, the data is processed and forwarded to its ultimate destination by the Gateway Message Switching System (GMSS). The destination may be another SC, a pager, a corporate resource management system or any personal or business e-mail or Internet address.

The ORBCOMM system is available to transfer information for an end user whenever a satellite is in view of the SC. If the satellite is connected to a GES, the satellite is considered in real-time messaging mode and the message is passed immediately through to the GCC for routing to its final destination. If the satellite is not connected to a GES, the satellite switches to a store-and-forward mode to accept GlobalGrams. GlobalGrams are short messages (up to approximately 200 bytes) stored on-board the satellite until it connects to the SC's host GCC through an affiliated GES.

3.2.3 ZigBee Wireless

The Zigbee wireless link is a designed to be a very low-cost, very low-power, two-way wireless communications standard. The IEEE 802.15.4 standard defines the lower two layers: the physical layer and the medium access control (MAC) sub-layer. The ZigBee Alliance builds on this foundation by providing the network layer and the framework for the application layer.

The IEEE 802.15.4 standard has two physical layers that operate in two separate frequency ranges: 868/915 MHz and 2.4 GHz. The lower physical layer covers both the 868 MHz European band and the 915 MHz band that is used in countries such as the United States and Australia. The higher frequency layer, 2.4 GHz, is used virtually world-wide, and is the band to be used for V3d functions.

3.2.3.1 Mesh Communications

A planned future capability of the V3d includes wireless communications with enabled devices and other V3d's using ZigBee protocols[1]. The ZigBee wireless link is to be used for future sensor integration, whereby discrete sensors located in the container are linked and bound to the V3d without wires. Also, in a mesh network configuration, buried V3d devices may be able to communicate and gain access to a satellite or cellular link through a neighboring V3d device.

3.2.3.2 Transmit Power Level

Allowable ZigBee transmit power, in the 2.45GHz band, varies by country. In the U.S., the FCC maximum is 1000 mW, ETSI (Europe) is 100 mW, and Japan is 10 mW. The upper transmit power used in the V3d is to be determined, based on field tests and regulatory constraints. The lower transmit power is to be a minimum of 1 mW.

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[1] The described functionality is not delivered by MobiApps but is expected to be realized by software developed by SPC and hosted partly on the Blackfin, partly on the EM250 ZigBee IC.

3.2.3.3 Operating Scenario

A planned future capability of the V3d includes networking with other V3d's using ZigBee protocols[1]. Local star networks inside each shipping container connect to a large mesh network outside. The coordinators assign themselves when an outside network is available, for example the top container in a stack. The "routers" (other V3d's without an outside network) automatically connect to an accessible coordinator through other routers or directly.

The local area network, consisting of multiple sensors (end nodes) and a single V3d (router / coordinator), runs on a 4 minute beacon with a wake time of 15 ms per 4 minutes. Outside of the container, the overall mesh network linking nearby V3d devices is activated twice per day at 12 noon and 12 midnight UTC. The network is to remain powered and active for up to 1 minute to allow for network enumeration and data transmission. The 1 minute requirement is based on worse case RTC drift over a maximum 7 day period where a V3d device may not be able to receive timing information from either GPS or ORBCOMM signals.

3.2.3.4 Ember ZigBee

The V3d is to use the Ember EM250 ZigBee chipset. The V3d is to employ a 28-pin Samtec connector, identical to the Ember development kit, except with fewer active pins (detailed in table below). This is expected to enable use of a number of Ember modules from various manufacturers, including Ember's own control module supplied with their development kit[2].

Application level control and management is provided through the pins / circuits between the ZigBee controller and the V3d Blackfin / MCU. The EM250 GPIO9 and GPIO10 are required connections for serial communication. Of the four remaining pin connections, one of them needs to be used to wake up the DSP from the ZigBee module. Another pin needs to be used to wake up the ZigBee module from the DSP side. The last two pin connections are reserved for future use and should have test points to make it easier to jumper if needed.

EM250 Pin	Name	Function	Application
32	GPIO 9	TXD (UART transmit data on Serial Controller 1)	For connection to Blackfin serial port UART RX
33	GPIO 10	RXD (UART receive data on Serial Controller 1)	For connection to Blackfin serial port UART TX
31	GPIO 8	IRQ_A	Wake signal, EM250 to Blackfin
42	GPIO 14	IRQ_B	Wake signal, Blackfin to EM250
41	GPIO 15	IRQ_C	Future
40	GPIO 16	IRQ_D	Future

[2] The Ember control module supplied with the Ember development kit is expected to be useful only for software development and test and not production.

3.3 Local Access and Monitoring

3.3.1 Main Serial Interface

The main serial interface provides device management, monitoring and firmware upgrade using standard RS232 voltage levels. Serial data is carried on the Transmit (TX) and Receive (RX) lines. The specifications are as follows:

a) Baud Rate: 115200 bps

b) Stop Bits: 1

c) Parity Bits: none

Any change in configuration will not take effect until the V3d is reset (either warm or cold boot), or in the subsequent wake up from sleep, i.e. configuration is set in one debug session or via OTA and unit goes to sleep. When the unit wakes up after this sleep it will check for new configuration and the previously set configuration will take affect.

3.3.2 Device Activity Indicator

One illuminating indicator is to be located on the case to indicate device health. It is recommended that the illumination occurs through a light pipe, so the active device can be located on the PCB. Alternatively, the illuminating indicator may be an LED embedded in the power switch. Also, it is preferable that the illumination is not on the same enclosure face as the optic sensor. The operation of the indicator is as follows:

Dot = 0.5s on
Dash = 1.0s on
Space = 0.5s off

a) During normal operation the LED only illuminates for wakeup.

   a. On wake from sleep: Dot

b) Upon cold boot, additional LED blink codes are added to aid in installation and troubleshooting. The blink codes are repeated continuously until another condition is met.

Condition	**Blink Code**
Boot	Dash Dash
Successful GPS Fix (2D or 3D)	Dot Dot Dash Dash
Unsuccessful GPS Fix	Dash Dash Dot
Satellite Acquisition	Dot Dot Dash
Successful transmission	Dot Dot
Unsuccessful transmission	Dash Dash

3.4 Power Management

The main processor is provided with power control of the various subsystems. This includes the GPS receiver, the satellite modem, and the cellular modem. This high degree of control is needed to enable very low power modes, thus reducing battery power requirements.

3.4.1 Main Battery Switch

A method is to be provided which enables complete disconnection of the internal batteries from the electronics, to preserve shelf life and minimize battery recharging / replacement events. The method shall be clandestine or keyed to reduce the opportunity for deviant or accidental behavior resulting in deactivation of the V3d.

3.4.2 Battery Level Reporting

The consumed power is to be reported by the V3d, but differently depending on the battery type. For SLA and Li-ion, the V3d reports battery voltage level. For LiSOCl2, the fuel gauge is used to report state of charge. The type of battery is made known to the V3d either through serial port configuration or OTA by configuration command (TBD).

No monitoring of the power supplied by the external power source (battery charger) is planned.

3.4.3 Wakeup from Sleep

The presence of the DTR signal awakens the device if sleeping, and while DTR is present the device remains awake. Also, the V3d can be commanded to NOT remain awake by software control.

3.4.4 Real-Time Clock Function

The V3d shall maintain date and time information even when in its lowest power state. The clock is updated following contact with either network (satellite or cellular) or following a successful GPS location estimate.

3.4.4.1 RTC Accuracy

Without contact with GPS or the ORBCOMM system time reference, the RTC shall maintain accurate time to within 3 seconds per 1 year interval. Time base shall be Coordinated Universal Time (UTC), formerly known as Greenwich Meridian Time (GMT).

Runtime is essentially the time when the key switch is in the ON position and power is present, and includes both wake and sleep periods.

3.4.4.2 Hour Meter

Value of current hours of runtime is maintained as a counter type record and stored in non-volatile memory periodically. The value is observable from the diagnostic serial interface and not over-the-air. (Note: RTC is powered directly by battery and not through keyswitch).

3.4.4.3 Always On Mode

Always On mode allows the GSM receiver to remain on in an idle state. This allows for incoming SMS messages to be received be the device at any time. When an SMS is received the GSM module wakes the M100 to process the incoming message. Incoming messages can be used to poll, reconfigure, or send other commands or data to the device. Message types are listed in the Over the Air Protocol document.

3.5 GPS Receiver

3.5.1 Time to First Fix

The GPS receiver shall take no longer than 45 seconds (95%) to get a position fix from a warm start (i.e., almanac loaded and more than two hours since the last fix) and no longer than 15 seconds (95%) from a hot start (i.e., less than two hours since the last fix).

3.5.2 Position Accuracy

The selected GPS shall achieve Standard Positioning Service (SPS) accuracy: 95% of position measurements within 13 meters of the true location.

3.5.3 Antenna Connection Status

The antenna status shall be sensed, either connected or open circuit, only during the attempt for GPS fix

3.6 Data Storage and Logging

The V3d stores all sensor data in the form of Logging Records (refer to SPC GlobalTrak OTA Protocol Specification document) to non-volatile memory at a programmable interval (the “Logging Interval”) as well as any alarms. The logs contain peak sensor data over the logging interval along with a time stamp. The alarm logs contain the sensor data at the time of the alarm with a time stamp.

3.6.1 Log Storage Capacity

The V3d shall allow for the storage of up to 1 MB (megabyte) of sensor data in non-volatile memory.

3.6.2 Log Storage Viewing

The V3d shall allow for viewing of the Logging Record storage, initiated by command over the main serial port.

3.6.3 Log Storage Clearing

The V3d shall allow for clearing of the Logging Record storage, initiated by command over the main serial port.

3.7 Power Source

3.7.1 Battery Types

The main V3d power source is an internal battery, capable of sourcing sufficient pulse current for RF transmission with output voltage not less than 9V (even during RF transmission) and not more than 16V. Three battery types are to be used, selected based on application constraints:

- Lithium Thionyl Chloride, assembled from three 3.6V cells providing a nominal voltage of 10.8V. This is primary battery which cannot be recharged.

- Lithium Ion, assembled from three 3.6V cells providing a nominal voltage of 10.8V. This is a rechargeable battery; however charging is possible over a limited temperature range compared to discharging.

- Sealed Lead Acid, assembled from five 2V cells, providing a nominal voltage of 10V. This is a rechargeable battery.

3.7.2 Power Alternatives

To enable alternative power methods, the V3d shall accept power from an external source connected to the external power lead, but only under the condition that the V3d internal battery is physically removed from the enclosure. The external power source must be a battery or similar, such as a bench power supply. No ripple or noise can be present on the external power lead, other than what is normally produced by the chemical reaction within a battery. Allowable voltage range is 9 to 16 VDC.

Note: External power is allowed and expected on the SLA Charging Power or Li-ion Charging Power pins. The restriction stated here applies only to the External Power pin.

3.7.3 Sleep Current

The V3d is expected to support a wide range of applications, including some where sleep periods extend to 24 hours or more. Therefore the power consumption while in sleep mode is very important, and is limited to TBD uA @ 12 VDC (TBD mW).

4.0 Electromagnetic Compatibility

The relevant electromagnetic compatibility requirements for the intended product use are detailed below.

Note: All requirements in this section are expected to be met by the V3d product, based on component ratings and product design, but will not be verified in the DVT.

4.1 General Limits

The V3d shall conform to appropriate sections of the International Telecommunications Union (ITU) European Telecommunications Standards Institute (ETSI) Harmonized Standards.. Specific requirements are defined in the sections below.

4.2 Radiated Emissions

The V3d shall comply with the test methodology and test levels defined in EN 300 832 and CISPR 25.

4.3 Conducted Emissions

The V3d shall comply with the test methodology and test levels defined in EN 300 832 for conducted emissions.

4.4 Radiated Immunity

The V3d shall comply with the test methodology and test levels defined in EN 300 832 for radiated immunity.

4.5 Conducted Immunity

The V3d shall comply with the test methodology and test levels defined in EN 300 832 for conducted immunity.

4.6 Electrostatic Discharge

The external connectors on the V3d shall comply with the test methodology and test levels defined in EN 300 832.

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radi-ate radio frequency energy and, if not in-stalled and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:
-Reorient or relocate the receiving antenna.
-Increase the separation between the equipment and receiver.
-Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
-Consult the dealer or an experienced radio/ TV technician for help.

5.0 Mechanical Requirements

The relevant mechanical requirements for the intended product use are detailed below.

5.1 Lifespan

All mechanical components (RF shielding and packaging) shall have an expected availability of a minimum of 3 years.

5.2 Physical Parameters

5.2.1 Enclosure Size

The V3d enclosure shall have a maximum footprint of 18.5 x 22.1 cm (7.3" x 8.7") and shall have a height of no more than 7.6 cm (3.0").

5.2.2 Weight

The weight of the V3d unit shall not exceed 2.3 kg (5 lb), including batteries, but not including the mounting bracket.

5.2.3 Mounting

A bracket shall provide for simplified mounting of the V3d enclosure to a flat surface. Options for adhesive tape or conventional screw-down fastening shall be provided.

5.2.4 Labeling

The V3d manufacturing label shall include the V3d serial number, both in bar scan format and in plain text. All type approvals shall be included in the label. If the V3d is individually packaged, then the packaging shall also have a bar-scannable label.

5.2.5 Enclosure Color

The enclosure color shall be silver, specifically Pantone Matching System (PMS) # 877.

5.2.6 Enclosure Material

The enclosure is to be constructed of plastic to minimize weight.

5.2.7 Mounting Bracket

The enclosure mounting bracket may frequently be permanently mounted in sea containers but left behind when a V3d is moved to a different sea container. Therefore a primary consideration in its design and manufacture is low cost. Weight is also a factor in envisioned RFID tracking applications, for example when attached to pallets of goods.

5.3 External Connectors

Five connectors are required, four for RF and one for sensors, serial and power. All connectors are mounted in the same facing of the enclosure, which is normally facing downward when installed. All pins are ESD protected.

5.3.1 RF Connectors

The three RF connectors are as follows:

a) GPS: SMA Jack female

b) GSM Cellular: SMA Jack, with Reverse Polarity

c) ORBCOMM VHF: TNC Jack female

d) ZigBee: TNC Jack, with Reverse Polarity

5.3.2 Power I/O Connector

The serial, digital and analog I/O and power are combined into a single positive lock marine-grade connector. The connector shall be keyed to prevent incorrect pin to socket mating. The pin designations are as follows:

Interface	Description	Pin Count
Li-ion Charging Power	For connection to external Li-ion charger	1
SLA Charging Power	For connection to external SLA charger	1
External Power	Enables powering the device externally	1
Charging Ground	Ground for external charger, external power	1
Main Serial	RS232 TX, RX, GND	3
MCU Serial	RS232 TX, RX (for reprogramming only)	2
Door Sense & Gnd	Routed to external door sensor	2
Analog In	General purpose 10-bit	1
Digital In	For sensing external charger activity	1
Power Out	Available 3.3V, low current	1
Analog Gnd	For low-noise analog reads	1
	Total:	15

Figure 1: Power I/O Connector Designations

5.3.3 Connector Mating Durability

All connectors shall have a minimum 100 mating cycles rating.

5.3.4 Battery Pack Connector

The battery pack connector is internal to the V3d enclosure. It connects the battery pack power and ground leads to the power input circuitry of the V3d, and to the internal Power I/O Connector harness (specifically, to the charging power and charging ground pins). As the battery pack may be replaced time to time, the battery pack connector must be accessible with the cover removed. Also it is desired that the connector mate is to be mounted directly to the PCB to enable simple but secure connect and disconnect.

The connector uses a combination of pins to match board circuitry and harnesses to battery type: sealed lead acid (SLA), Lithium Ion (Li-ion) and Lithium Thionyl Chloride (LiSOCl2).

5.3.5 Connector Caps

Caps for the key-switch and power connectors are to be included with initial shipment. The four RF connectors are shipped open.

5.4 Environmental Limits

Note: All requirements in this section are expected to be met by the V3d product version, based on component ratings and product design, but will not be verified in the DVT.

5.4.1 General Limits

The V3d shall conform to appropriate sections of the ORBCOMM Subscriber Communicator Standards and Specifications, the International Electrotechnical Commission and the SAE J1455 Joint SAE/TMC Recommended Environmental Practices for Electronic Equipment Design (Heavy-Duty Trucks). Specific requirements are defined in the sections below.

5.4.2 Operating Temperature

The V3d shall operate from -40 °C to +85 °C. The lower temperature limit shall be verified per MIL-STD-810E, Method 502.3, Procedure II, 4-hour test duration. The upper temperature limit shall be verified per MIL-STD-810E, Method 501.3, Procedure II, 3-diurnal cycle test duration.

5.4.3 Operational Shock

The V3d while operating shall withstand half sine acceleration of 30 g (300 m/s^2) shock, 18 ms duration in accordance with IEC 68-2-27 Ea.

5.4.4 Operational Vibration

The V3d while operating shall withstand 3 g (30 m/s^2) vibration for 10 frequency sweeps from 25 to 500 Hz, as tested according to IEC 68-2-6 (test Fc).

5.5 Power I/O Cable Assembly

A cable assembly enables access to the Power I/O connector. Each battery charging lead is color coded 20 AWG and is terminated into a keyed shrouded power connector, accompanied by a ground wire. Similar for the external power lead. The main serial leads are color coded 24 AWG and are terminated into a 9-pin D-sub connector to enable simple connection to a PC. The digital and analog I/O leads are color coded 24 AWG and are left unterminated. Heavy duty black plastic sheathing covers the wires. Heat shrink mates the sheathing to the connector backshell. The assembly is 1 meter in length.

5.6 Component Serial Designations

The battery, antenna and enclosure are to be marked with a unique serial number, bar code scannable.

5.7 Antenna Cable

Any antennas provided with the V3d shall be equipped with an antenna cable length of 2m with a heat shrink sheath over the cables. Approximately 15cm at the end of the cable shall be left unsheathed to allow for connection to V3d.

Appendix A. Terminology

The table below defines terms, acronyms and abbreviations used throughout this document.

Term	Definition
ASIC	**A**pplication **S**pecific **I**ntegrated **C**ircuit
IMB	**I**nformation **M**anagement **B**ureau
DSP	**D**igital **S**ignal **P**rocessor
DVT	**D**esign **V**erification **T**est
E^2PROM	**E**lectrically **E**rasable **P**rogrammable **R**ead **O**nly **M**emory
ESD	**E**lectrostatic **D**ischarge
GND	**G**rou**nd** signal on RS-232
GSM	**G**lobal **S**ystem for **M**obile Communications
I^2S	**I**nter-**IC** **S**ound
IEC	**I**nternational **E**lectrotechnical **C**ommission
LEO	**L**ow-**E**arth **O**rbit
MCU	**M**icro-**C**ontroller **U**nit
MTBF	**M**ean **T**ime **B**etween **F**ailure
n/a	**N**ot **a**vailable or **n**ot **a**pplicable
PA	**P**ower **A**mplifier
PCB	**P**rinted **C**ircuit **B**oard
PSI	**P**ounds per **S**quare **I**nch
RF	**R**adio **F**requency
SAE	**S**ociety of **A**utomotive **E**ngineers
SC	**S**ubscriber **C**ommunicator, i.e. ORBCOMM data modem
SCLK	**S**ystem **C**lo**ck**
SPI	**S**erial **P**eripheral **I**nterface
TBD	**T**o **B**e **D**etermined
TCXO	**T**emperature **C**ompensated Crystal **O**scillator
VCO	**V**oltage **C**ontrolled **O**scillator

Appendix B. V3d Requirements Traceability Matrix

Specification Paragraph	Compliance Statement	Remarks
3.0 Functional and Electrical Requirements		
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3.1.1.1 Performance		
3.1.1.2 Function		
3.1.1.3 Configuration		
3.1.1.4 Mounting		
3.1.2 Acoustic Sensor		
3.1.2.1 Performance		
3.1.2.2 Function		
3.1.2.3 Configuration		
3.1.2.4 Mounting		
3.1.3 Door Sensor		
3.1.3.1 Performance		
3.1.3.2 Function		
3.1.3.3 Configuration		
3.1.3.4 Mounting		
3.1.4 Temperature Sensor		
3.1.4.1 Performance		
3.1.4.2 Function		
3.1.4.3 Configuration		
3.1.4.4 Mounting		
3.1.5 Mount Sensor		
3.1.5.1 Performance		
3.1.5.2 Function		
3.1.5.3 Configuration		
3.1.5.4 Mounting		
3.1.6 Analog Input		
3.1.6.1 Performance		
3.1.6.2 Function		
3.1.6.3 Configuration		
3.1.7 Digital Input		
3.1.7.1 Function		
3.1.7.2 Configuration		
3.1.8 Digital Output		
3.2 Wireless Communications		
3.2.1 GSM Cellular		
3.2.1.1 Quad Band Operation		
3.2.2 ORBCOMM Satellite		
3.2.3 ZigBee Wireless		
3.2.3.1 Mesh Communications		
3.2.3.2 Transmit Power Level		

3.2.3.3 Operating Scenario		
3.2.3.4 Ember ZigBee		
3.3 Local Access and Monitoring		
3.3.1 Serial Interface		
3.3.2 Device Activity Indicator		
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3.4.1 Main Battery Switch		
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3.4.3 Wakeup from Sleep		
3.4.4 Real-Time Clock		
3.4.4.1 RTC Accuracy		
3.4.4.2 Hour Meter		
3.5 GPS Receiver		
3.5.1 Time to First Fix		
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3.5.3 Antenna Connection Status		
3.6 Data Storage and Logging		
3.6.1 Log Storage Capacity		
3.6.2 Log Storage Viewing		
3.6.3 Log Storage Clearing		
3.7 Power Source		
3.7.1 Battery Types		
3.7.2 Power Alternatives		
3.7.3 Sleep Current		
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4.3 Conducted Emissions		
4.4 Radiated Immunity		
4.5 Conducted Immunity		
4.6 Electrostatic Discharge		
5.0 Mechanical Requirements		
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5.2.2 Weight		
5.2.3 Mounting		
5.2.4 Labeling		
5.2.5 Enclosure Color		
5.2.6 Enclosure Material		
5.2.7 Mounting Bracket		
5.3 External Connectors		
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5.3.2 Power I/O Connector		
5.3.3 Connector Durability		
5.3.4 Battery Pack Connector		
5.3.5 Connector Caps		
5.4 Environmental Limits		
5.4.1 General Limits		

5.4.2 Operating Temperature		
5.4.3 Shock		
5.4.4 Vibration		
5.5 Power I/O Cable Assembly		
5.6 Component Serial Designations		
5.7 Antenna Cable		

Appendix C. V3d Data Sheet

General	Enclosure Dimension: 10.2 x 15.3 x 5.1 cm Configuration: Electronics & battery housed in sealed enclosure
Transmit Frequency	148 to 150.05 MHz (Satellite); 850/900/1800/1900 MHz (GSM)
Transmit Power	5W (Satellite); 1W (Cellular)
Receive Frequency	137 to 138 MHz (Satellite); 850/900/1800/1900 MHz (GSM)
Dynamic Range	40 dB minimum
Sensitivity	Minimum BER: E-5 @ -118 dBm (Satellite) Typical BER: E-5 @ -120 dBm (Satellite)
Interfaces	
Main Connector	Conxall 20-Pin carrying power, RS232, digital and analog I/O
Internal Sensor Suite	Acoustic, Optic, Temperature
Power Requirements	Internal battery, 10.8V primary or rechargeable
Environmental	Temperature: -40°C to +85°C (operating) Shock & Vibration: IEC 68-2-27 (30G); IEC 68-2-6 (3G) Radiated Emissions: EN 300 832 Ingress Protection: SAE J1455 (1020 PSI Power Wash)
VHF Antenna Connector	TNC Jack Female, 50 Ω
GPS Antenna Connector	SMA Jack Female, 50 Ω
GSM Antenna Connector	SMA Jack, Reverse Polarity, 50 Ω
ZigBee Antenna Connector	TNC Jack, Reverse Polarity, 50 Ω