451-92750-001C

9602-BTI User Guide

Version C

Monday, April 1, 2024

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REVISION HISTORY

Revision	Date	Description
1.4.6	04/05/2021	Initial version
A	03/28/2022	Formal release; updated to new template
B	03/07/2023	- Updated Section 2.1 External DC Power Input. Changed default to higher voltage setting. - Added 9602-BTI
C	03/19/2024	9602-BTI formal release

REFERENCE DOCUMENTS

The latest revisions of the NAL documents are available from the NAL Research website at
https://www.nalresearch.com/.

Reference	Title	Revision/Date
[1]	AT Commands for 9602-BTI	Version A, 04/20/2022

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GLOSSARY

AES ....Advanced Encryption Standard

BIS.........................Bureau of Industry and Security

C/A ....Coarse/Acquisition

CE.........................Conformité Européenne

CEP ....Circular error probability

CMOS ....Complementary Metal–Oxide–Semiconductor

COCOM ....Coordinating Committee for Multilateral Export Controls

DAV........................Data After Voice

DC ....Direct Current

DGPS......................Differential Global Positioning System

DISA ....Defense Information Systems Agency

DoD........................Department of Defense

DSN ....Defense Switch Network

DTE ....Data Terminal Equipment

EAR ....Export Administration Regulations

EGNOS ....European Geostationary Navigation Overlay Service

EMI ....Electromagnetic

EMSS......................Enhanced Mobile Satellite Services

ETSI ....European Telecommunications Standards Institute

FCC ....Federal Communications Commission

FDMA......................Frequency-Division Multiple Access

GAGAN ....GPS-Aided GEO Augmented Navigation

GND ....Ground

GPS........................Global Positioning System

GUI ....Graphical user interface

ID ....Static Identifier

I/O ....Input/Output

ISP ....Internet Service Provider

ISU ....Iridium Subscriber Units

LAN ....Local Area Network

LED ....Light Emitting Diode

Li-ion......................Lithium-ion

LNA ....Low-Noise Amplifier

LP ....Low Power

MSAS ....Multi-functional Satellite Augmentation System

NIPRNet.................Non-classified Internet Protocol (IP) Router Network

NMEA ....National Marine Electronics Association

NOC ....Network Operation Center

OFAC.....................Office of Foreign Asset Controls

PDA.......................Personal digital assistant

PMS.......................PECOS message structure

PPP ....Point-to-Point Protocol

PSTN ....Public Switched Telephone Network

PWR ....Power

RF ....Radio Frequency

RHCP.....................Right-Handed Circular Polarization

RUDICS ....Router-based Unrestricted Digital Internetworking Connectivity

                            Solution

SBAS.....................Satellite-Based Augmentation System

SBD.......................Short Burst Data

SMA ....SubMiniature version A

SMS ....Short Message Service

SMSC ....Short Message Service Center

TDD.......................Time-Division Duplex

TDMA ....Time-Division Multiple Access

TTL........................Transistor–Transistor Logic

VSWR ....Voltage Standing Wave Ratio

WAAS ....Wide Area Augmentation System

1 INTRODUCTION

This user guide describes the operational features, configuration settings, and electrical and mechanical interfaces of the 9602-BTI mountable tracker. The 9602-BTI is a pocket-size, low-cost, satellite tracker designed to operate with the Iridium low-Earth orbit satellite network (see **Figure 1**). It is a variation of the original 9602-LP. It functions the same as the 9602-LP, but is built more ruggedly to be waterproof and weather-resistant to endure more hostile environments.

Figure 1: 9602-BTI Mountable Tracker

It is self-contained, relying on an extremely low-power consumption microcontroller for operation. The 9602-BTI measures 2.73" x 2.17" x 0.94", weighs less than 5 ounces, and can be attached to high-value, untethered, or non-powered assets such as shipping containers, barges, railcars, trailers, buoys, or even to a person. It can also be used to track environmentally demanding platforms including helicopters, fixed-wing aircraft, unmanned aerial vehicles, rockets, high-altitude balloons, ships, speedboats, ground vehicles, and remote unattended sensors. With the exception of smaller form-factor and wide input voltage range, model 9602-BTI is functionally compatible with the 9601-DGS-LP.

The 9602-BTI comprises an Iridium 9602 transceiver module; a built-in, 50-channel Global Positioning System (GPS) receiver; and low-power microcontrollers. The 9602-BTI allows only Short-Burst Data (SBD) connectivity to the Iridium satellite network. It does not support voice, circuit switched data, or Short Message Service (SMS). It can transmit

messages in NAL Research's defined formats compatible with models 9601-DGS and 9601-DGS-LP. The 9602-BTI can also transmit in PECOS Message Structure (PMS). The PMS complies with the Blue Force Tracking Data Format Specification. The 9602-BTI supports 256-bit AES encryption algorithm. NAL Research can enable the 9602-BTI to utilize the Department of Defense (DoD) Enhanced Mobile Satellite Services (EMSS) gateway when requested by an authorized user.

Important: EMSS-enabled 9602-BTI must first be provisioned (signed up for airtime) with EMSS SBD Service before testing or field use. Accessing the DoD EMSS gateway is not authorized until the 9602-BTI is provisioned. Unauthorized attempts to access the DoD EMSS gateway result in immediate disabling of the offending device, which must then be returned to NAL Research for repair. See https://sbd.pac.disa.mil for more information regarding EMSS service provisioning. NOTE: This is a U.S. Government Information System website, and can only be accessed by authorized users with a valid certificate.

When a Data Terminal Equipment (DTE) is connected to the 9602-BTI with SatTerm software installed (or any terminal emulator software), the DTE can be used to set up the operating parameters of the 9602-BTI via a serial connection. A DTE can be a desktop computer, a laptop computer, or a tablet.

2 MINI DB-15 CONNECTOR

The multi-interface connector on model 9602-BTI is a standard male 15-pin miniature D-Sub type (DB-15) connector, as shown in **Figure 1**.

Multi-Interface Connector
(Mini DB-15 Connector)

Figure 2: Multi-Interface Connector

The connector comprises four interfaces with the pin assignments shown in **Table 1**. These interfaces include:

- External DC power input
- 3-wire RS232 serial data interface
- TTL/CMOS I/Os
- Reserved RS232 serial data interface

Table 1: Pin Assignments for the 9602-BTI Multi-Interface Connector

Pin #	Signal	Description	Interface
1	EXT_PWR	External power input (+3.6 VDC to +5.3 VDC)	DC Power (+)
2	EXT_GND	External power input (GND)	DC Power (GND)
3	Tx1	RS232 Input	RS232 Data
4	Rx1	RS232 Output	RS232 Data
5	Signal_GND	Signal Ground, 0 V signal reference and return	RS232 GND
6	EMERGENCY	External TTL/CMOS Input S0	0–5 V TTL
7	TTL	TTL/CMOS Output 0	0–5 V TTL
8	TTL	TTL/CMOS Output 1	0–5 V TTL
9	EXT_PWR	External power input (+6.0 VDC to +32.0 VDC)	DC Power (+)

Table 1: Pin Assignments for the 9602-BTI Multi-Interface Connector

Pin #	Signal	Description	Interface
10	Rx2	Reserved	RS232 Data
11	Tx2	Reserved	RS232 Data
12	TEST	External TTL/CMOS Input S1	0–5 V TTL
13	TTL	External TTL/CMOS Input S3	0–5 V TTL
14	TTL	External TTL/CMOS Input S2	0–5 V TTL
15	TTL	TTL/CMOS Output 2	0–5 V TTL

2.1 EXTERNAL DC POWER INPUT

DC power interface comprises of two (2) DC power inputs and a ground input as summarized in **Table 1**. The 9602-BTI accepts either +3.6 VDC to +5.3 VDC input through pin #1 or +6.0 VDC to +32 VDC input through pin #9. The 9602-BTI is shipped with hardware set for +6.0 VDC to +32 VDC input. It can be changed to +3.6 VDC to +5.3 VDC input through an internal jumper—POWER MUST BE DISCONNECTED BEFORE RESETTING THE JUMPER.

To set the voltage input range:

Remove the modem's top plate to find the jumper. With the 9602-BTI held in the position shown in **Figure 3** (DB15 connector to the left),

- the 9602-BTI is set for 3.6 VDC to +5.3 VDC when the red jumper is on the middle and top pins,

- and it is set for +6.0 VDC to +32 VDC when the jumper is on the middle and bottom pins.

Each pin is also labeled with 5 V and 32 V to the left of the top and bottom pins, respectively. The power applied to the pin on the multi-interface connector must match the setting of the jumper for the unit to power up properly. For example, if +5.0 VDC ±0.5 V is applied to pin 1 then the jumper must be in the +5V DC position and if +6.5 VDC to +32 VDC is applied to pin 2, then the jumper must be in the +6.5 VDC to +32 VDC position.

Note: Do NOT apply voltage higher than 5.3 VDC on pin 1 (or accidently swap voltage between pins 1 and 9). The 9602-BTI will be damaged beyond repair with warranty voided if this were to occur.
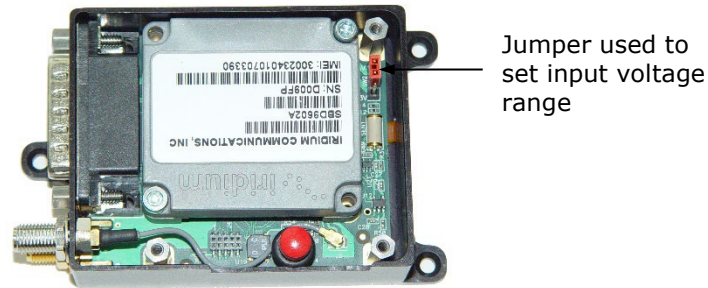
Figure 3: Power Input Setting for the 9602-BTI

Important: You can remove the 9602-BTI's top plate to set the jumper but not for repair or services. The warranty is voided, if the 9602-BTI is disassembled for any reason other than to set the jumper.

The cables that supply power to the 9602-BTI should be as short as possible to prevent significant voltage drop, which can cause the 9602-BTI to malfunction during an SBD session. Model HRC-24-12 (see below) is a data/power cable assembly is designed to work with the 9602-BTI tracker. The HRC-24-12 has a three-foot RS-232 cable for connection onto a computer and three wires for DC power inputs to a 9602-BTI. Model HRC-24-12 is available on the NAL website (www.nalresearch.com)

Figure 4: Model HRC-24-12 Data/Power Cable Assembly

A power reset by the 9602-BTI during an SBD transmission indicates the DC power source is unable to sustain voltage above 3.0 VDC at peak current demand. Plots of the DC power requirement for the 9602-BTI are in section **7**, **Power Consumption**.

2.2 RS232 SERIAL DATA INTERFACE

The 9602-BTI supports a 3-wire serial interface to a host DTE through the Multi-Interface Connector. The serial comprises a transmit (Tx) line on pin 3, a receive (Rx) line on pin 4, and a signal GND on pin 5, as described in **Table 1**.

2.2.1 BAUD RATE

The 9602-BTI does not support autobaud; the default baud rate is factory set at 19.2 Kbps. The baud rate can be reconfigured with the +IPR command ranging from 4.8 Kbps to 115.2 Kbps.

2.2.2 SERIAL PORT

The serial port allows a connected DTE to configure the 9602-BTI using NAL Research's defined AT commands and any terminal emulator software. Find these AT commands in the manual "AT Commands for Model 9602-BTI" [1]. Instead of trying to memorize the various functions of AT commands, it is easier to use the SatTerm graphical user interface (GUI) software to configure the 9602-BTI.

2.3 TTL/CMOS INPUTS/OUTPUTS

The 9602-BTI has four TTL/CMOS inputs and three TTL/CMOS outputs. All I/Os are brought out to the multi-interface connector (min DB-15 connector). Use SatTerm to configure these I/Os under the I/O tab of the *Configuration Settings* window, as shown in **Figure 5**. The four CMOS/TTL inputs, denoted as S0 through S3, have internal pull-ups, which allow the inputs to float as high. The inputs can be configured as emergency, test, or general input with a trigger on a rising and/or falling edge. The trigger activates the special functionality of the input type.

Input types:

- *Emergency* configured inputs enable the Emergency Tracking mode when triggered.
- *Test* configured inputs enable the Test Tracking mode.
- *General* configured inputs queue the transmission of an Input Report (see Appendix C in "AT Commands for Model 9602-BTI" [1]).

Regardless of the type or trigger configuration, the value of the input is included in any version 5 GPS report sent. By default, S0 is configured as an emergency input triggered by a falling edge, and S1 is configured as a test input triggered by a falling edge. S0 is shared with the onboard Emergency button (see **Figure 6**). This means both the guarded Emergency button on the 9602-BTI and S0 can be used to activate Emergency Tracking.
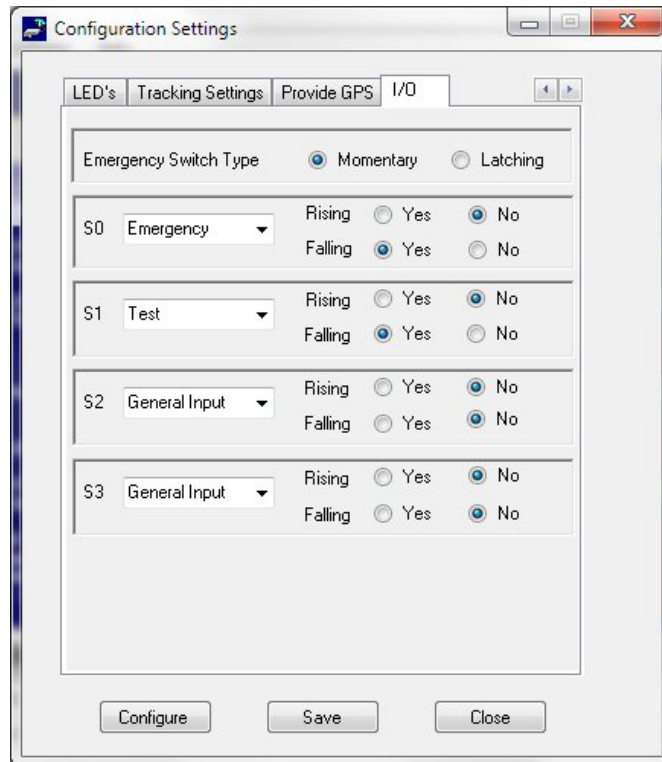
Figure 5: Configuration Settings: I/O
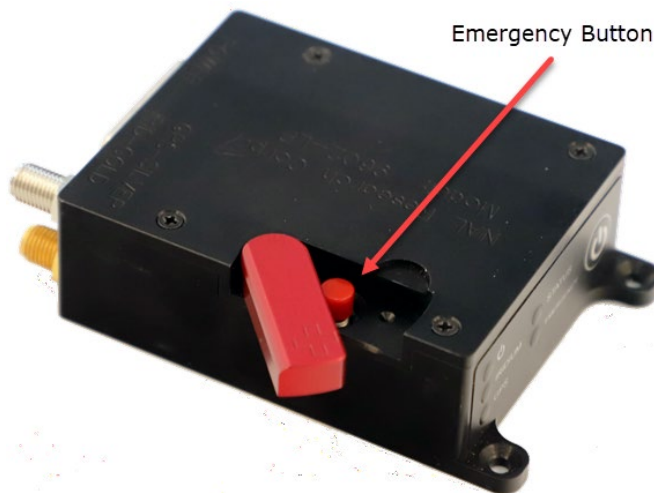
Figure 6: Emergency Button

Emergency button aspects:

- Under the default configuration, you can trigger Emergency Tracking at any time with a quick press and release of the Emergency button (momentary switch).
  - Once enabled, holding the emergency button longer than three seconds takes the 9602-BTI out of Emergency Tracking.
- When Emergency Tracking is active, the Emergency LED illuminates.
- The Emergency trigger can further be customized using the AT command ^EST.

- o This command specifies the type of emergency switch as either *momentary* (default) or *latching* (similar to the toggle switch on the 9601-DGS-LP).
- o The *momentary* switch type functions as described above.
- o When set to *latching*, Emergency Tracking is enabled only when the trigger is active. For example, setting the emergency trigger to the falling edge and the switch type to *latching* causes Emergency Tracking to enable when the input level is pulled from high to low, and then it disables when the input level returns to high.

The Emergency trigger can further be customized using the AT command ^EST.

- o This command specifies the type of emergency switch as either *momentary* (default) or *latching* (similar to the toggle switch on the 9601-DGS-LP).
- o The *momentary* switch type functions as described above.
- o When set to *latching*, Emergency Tracking is enabled only when the trigger is active. For example, setting the emergency trigger to the falling edge and the switch type to *latching* causes Emergency Tracking to enable when the input level is pulled from high to low, and then it disables when the input level returns to high.

The AT command ^PR controls input value reporting. When ^PR is enabled and a pin changes, an unsolicited response, ^PV, is sent on the serial port, indicating the values of the input pins. Setting the outputs is controlled by the AT command ^Pn. Outputs can also be set by remote update. For detailed information regarding I/Os, refer to the manual "AT Commands for Model 9602-BTI."

3 CONFIGURATION SETTINGS

3.1 MODES OF OPERATION

The 9602-BTI can be in one of two operating modes when turned on: (1) Command mode, or (2) Tracking mode.

3.1.1 COMMAND MODE

When in Command mode, AT commands can be entered to configure the 9602-BTI's operating profiles, or the 9602-BTI can be operated as a 9602-G (standard SBD-modem with GPS). As a reminder, developers are encouraged to use SatTerm GUI software to set up the 9602-BTI instead of using AT commands.

3.1.2 TRACKING MODE

When in Tracking mode, the 9602-BTI automatically transmits GPS reports as defined by parameters in the *active operating profile* (see description below). There are three different types of Tracking modes—Normal Tracking, Emergency Tracking, and Test Tracking. The 9602-BTI is factory-set for AT^START0 to turn on in Command mode and can be reset to turn on in Tracking mode with the AT^START1 command. After the 9602-BTI is turned on, use the AT^TRK command to switch from Command mode to Tracking mode; switch from Tracking mode back to Command mode with the +++ escape sequence. The flow chart in **Figure 7** describes operating modes of the 9602-BTI.

There are three types of operating profiles—active operating profile, factory-default operating profile, and user-defined operating profile.

- The *active operating profile* is the set of parameters currently in use by the 9602-BTI.
- There are two *user-defined operating profiles*, profiles 0 and 1, available for the 9602-BTI. Each user-defined operating profile can be edited and saved at any time through the AT command &Wn.
- The *factory-default operating profile* is stored permanently on the 9602-BTI's memory and cannot be changed by the user. Profiles 0 and 1 are initially set as the factory default profile.

When turned on and as a default, the 9602-BTI loads *user-defined operating profile 0* into the active operating profile. However, either one of the two user-defined operating profiles can be designated as the active operating profile when turned on through the use of the AT&Yn command. When turned on, the factory-default operating profile can be loaded (soft

reset) into the active operating profile using the AT&Fn command. The active operating profile reverts back to the user-defined operating profile designated under the AT&Yn command at power reset. Similarly, the active operating profile can be soft reset with either one of the two user-defined operating profiles during power up with the ATZn command. Again, the active operating profile reverts back to the user-defined operating profile designated under the AT&Yn command at power reset.
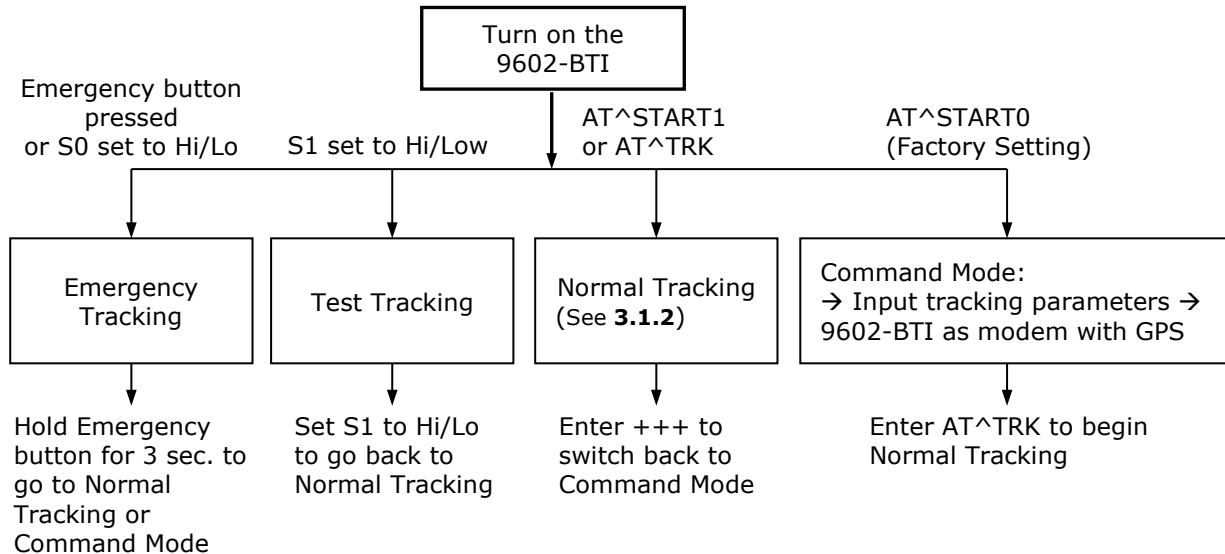
```
                                    ┌──────────────┐
                                    │  Turn on the │
                                    │   9602-BTI   │
                                    └──────────────┘
  Emergency button                         │        AT^START1          AT^START0
      pressed                              │        or AT^TRK          (Factory Setting)
  or S0 set to Hi/Lo    S1 set to Hi/Low   ▼
         │                    │            │              │                 │
         ▼                    ▼            ▼              ▼                 ▼
  ┌──────────────┐   ┌──────────────┐  ┌──────────────┐  ┌─────────────────────────────┐
  │   Emergency  │   │              │  │Normal Tracking│  │Command Mode:                │
  │   Tracking   │   │ Test Tracking│  │(See 3.1.2)   │  │→ Input tracking parameters →│
  │              │   │              │  │              │  │9602-BTI as modem with GPS   │
  └──────────────┘   └──────────────┘  └──────────────┘  └─────────────────────────────┘
         │                    │            │                          │
         ▼                    ▼            ▼                          ▼
  Hold Emergency      Set S1 to Hi/Lo  Enter +++ to            Enter AT^TRK to begin
  button for 3 sec. to to go back to    switch back to          Normal Tracking
  go to Normal        Normal Tracking  Command Mode
  Tracking or
  Command Mode
```

Figure 7: Different Operating Modes of the 9602-BTI

3.1.2.1 NORMAL TRACKING MODE

Normal Tracking is the mode when the 9602-BTI is configured to turn on with the AT^START1 command or after transitioning from Command mode to Tracking mode with the AT^TRK command. Normal Tracking provides a wide range of unique settings, as shown in **Figure 8**. Each setting can be tailored to meet specific applications. For example, the 9602-BTI can be preprogrammed to transmit reports at fixed intervals, to transmit reports triggered by the internal motion sensor, to transmit reports triggered by the Emergency switch, or to transmit reports triggered by external devices. The "Callable (No)" option is implemented when lowest power consumption is required because of limited battery capacity, or "Same Place Skip Reports" is chosen so that the 9602-BTI does not repeatedly send the same location information back to a command center.
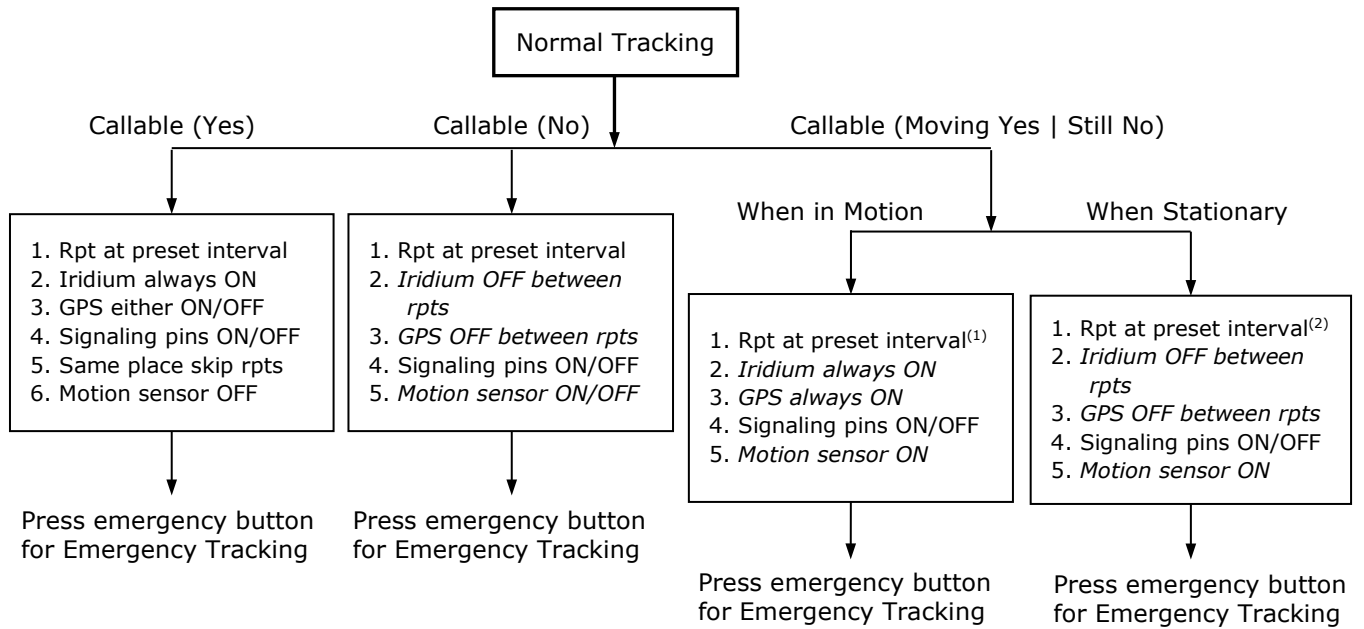
Figure 8: Normal Tracking Mode: Settings

Settings that control report intervals:

(1) The interval is determined by setting Time Between Reports Awake (**AT^TBRA**).
(2) The interval is determined by setting Time Between Reports (**AT^TBR**).

During Normal Tracking and when *Callable* is set to *Yes*, the 9602-BTI automatically transmits GPS reports at a preset interval ranging from continuous to one report every seven days. The Iridium RF board is ON in between reports, allowing the 9602-BTI's operating profile to be reconfigured remotely in real-time. Because the Iridium RF board is ON at all times, the 9602-BTI consumes the most power in between reports (approximately 110 mA at 5 VDC). The GPS receiver can be left either ON or OFF in between reports to reduce power by approximately 40 mA at 5 VDC. Any of the four input pins (S0 through S3) on the multi-interface connector can be selected to trigger immediate transmission of GPS report(s) when a rising edge or a falling edge of a TTL/CMOS input signal is detected. Once the last GPS report is sent, the 9602-BTI goes back to Normal Tracking. The "Same Place Skip Reports" option prevents GPS reports from being transmitted if the 9602-BTI does not move outside a defined radius. When you select the *"Callable (Yes)"* option in the SatTerm Configuration Settings window, the motion sensor signal is ignored by the tracker (see **Figure 9**).
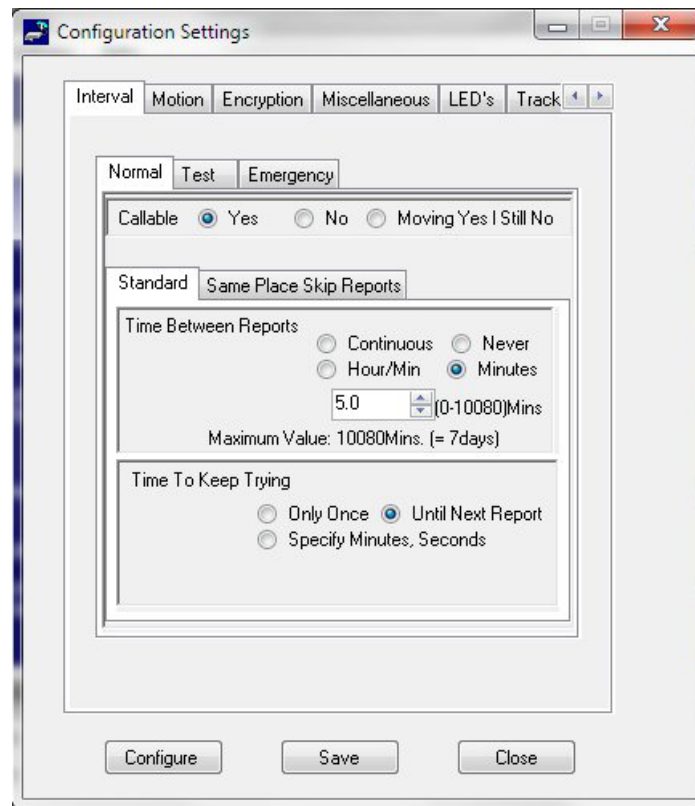
Figure 9: Normal Tracking "Callable (Yes)" Option

During Normal Tracking and *Callable* is set to *No*, the 9602-BTI automatically transmits GPS reports at a preset interval ranging from continuous to one report every seven days. All internal circuits of the 9602-BTI are turned OFF in between reports, including the GPS receiver, GPS antenna's LNA, Iridium RF board, DC-DC converters, and serial interfaces. The only active components are the microcontroller and the motion sensor. The 9602-BTI draws the lowest current in between reports of around 60 µA at 5 VDC. The 9602-BTI will not respond to any entered commands, including the +++. The +++ command works only while the tracker is waiting for GPS acquisition or is transmitting a report. An updated operating profile sent to the 9602-BTI from a command center remains at the Iridium gateway until the 9602-BTI wakes up and retrieves it. Any of the four input pins (S0 through S3) on the multi-interface connector (DB-15 connector) can be selected to trigger immediate transmission of GPS report(s) when a rising edge or a falling edge of a TTL/CMOS input signal is detected. Once the last GPS report is sent, the 9602-BTI goes back to Normal Tracking.
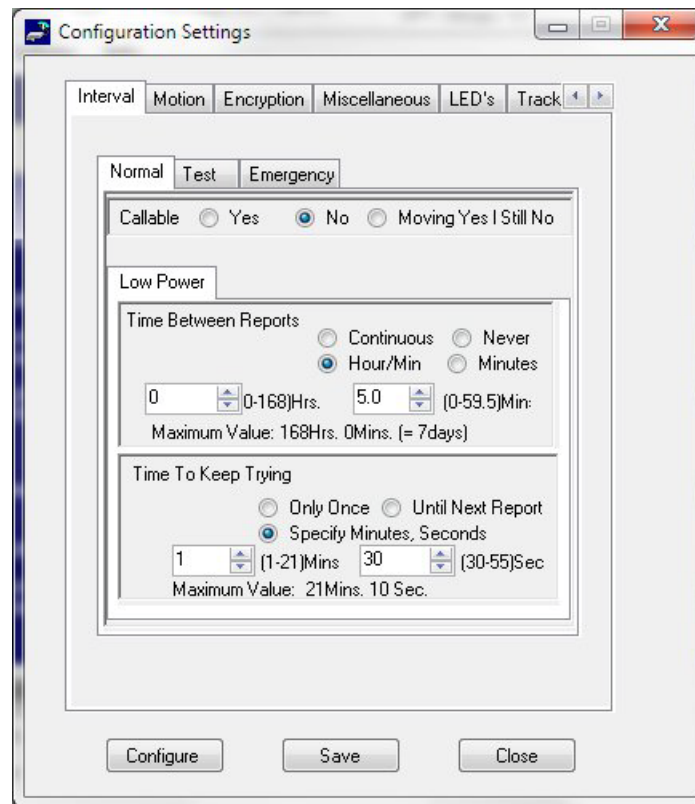
Figure 10: Normal Tracking "Callable (No)" Option

When you select the *"Callable (No)"* option (see **Figure 10**) and select the *Awake on Motion* option (see **Figure 11**), the 9602-BTI can be triggered by an internal motion sensor to send a GPS report. The 9602-BTI has a built-in motion sensor that works regardless of how the 9602-BTI is mounted or aligned. It is sensitive both to tilt (static acceleration) and vibration (dynamic acceleration). When in motion, the sensor produces continuous on-off contact closures (a series of TTL-level logic or pulse train) as it chatters open and closed. The signal level is fed directly into the 9602-BTI's micro-controller. When at rest, it normally settles in a closed state.

Three parameters must be provided when choosing the *Awake on Motion* option—*Minutes of Motion Before Waking*, *Sensitivity*, and *Motion Sensor Wait* (see **Figure 11**)*.

- *Minutes of Motion Before Waking* is a user-defined duration within which valid motion must exist before the 9602-BTI sends a GPS report. For example, a car must experience continuous motion for three minutes before a GPS report is sent. Otherwise, a slight bump by a person or by a gust of wind might initiate a report. The duration of *Minutes of Motion Before Waking* is divided into one-minute blocks.
- *Sensitivity* is defined as the number of motion sensor on-off contact closures the 9602-BTI must detect in each of the one-minute blocks for motion within that block to be considered valid motion. All contiguous one-minute blocks must have valid

motion before a GPS report is sent. Any time a block has an invalid motion, the *Minutes of Motion Before Waking* timer is reset and the motion detection process starts over again.

- After valid motion is detected and a successful GPS report is sent, the 9602-BTI goes back to sleep with all circuits OFF. It ignores the motion sensor input signal for *Motion Sensor Wait* minutes. All other parameters and I/O pins are still observed by the 9602-BTI.
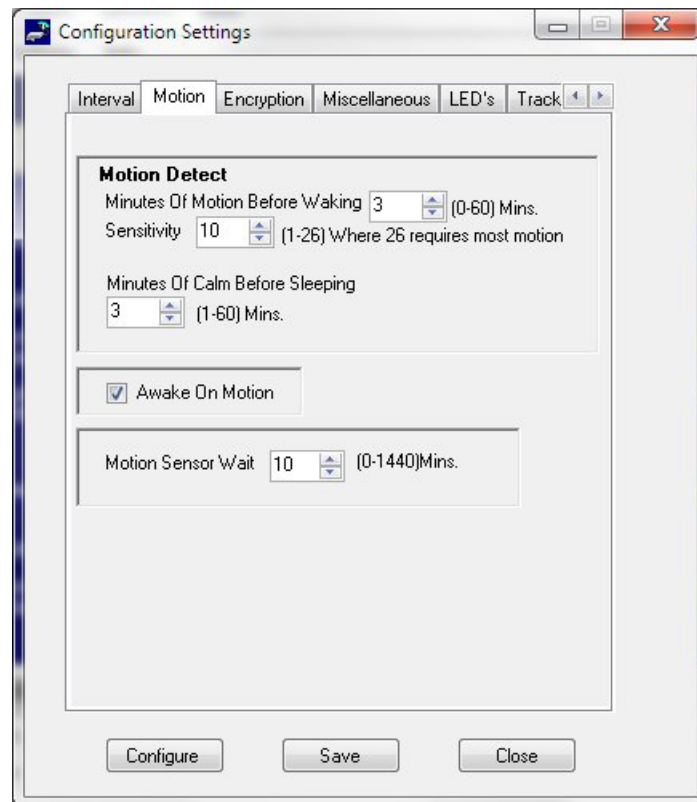

Figure 11: Normal Tracking "Awake on Motion"

The third Normal Tracking option is "Callable (Moving Yes | Still No)." This is a hybrid between the "Callable (Yes)" and "Callable (No)" configurations. When in motion, the 9602-BTI uses a set of "Callable (Yes)" parameters to send GPS reports; when not in motion, the 9602-BTI uses a set of "Callable (No)" parameters to send GPS reports. This allows the flexibility to define different sets of parameters for different operating conditions. For example, a stationary vehicle only needs to send position report perhaps once a day. However, when in motion, a higher reporting frequency is required.

The setup parameters for "Callable (Moving Yes | Still No)" and *Not in Motion or Low Power* are shown in **Figure 12**. These parameters are very similar to the standard "Callable (No)" option, except there is no *Awake on Motion* option. The 9602-BTI uses *Minutes of Motion Before Waking* and *Sensitivity* to determine if valid motion is observed by applying the same

approach described previously. Once valid motion is determined, the 9602-BTI switches to "Callable (Moving Yes | Still No)" and "in motion" mode.

The setup parameters for "Callable (Moving Yes | Still No)" and *In Motion or Motion* are similar to the "Callable (Yes)" option, except the motion sensor is active. The 9602-BTI uses *Minutes of Motion Before Waking* and *Sensitivity* to determine if valid motion is observed by applying the same approach described above. If valid motion is not detected before the *Minutes of Calm Before Sleeping* expires, the 9602-BTI switches back to "Not in Motion or Low Power" mode.
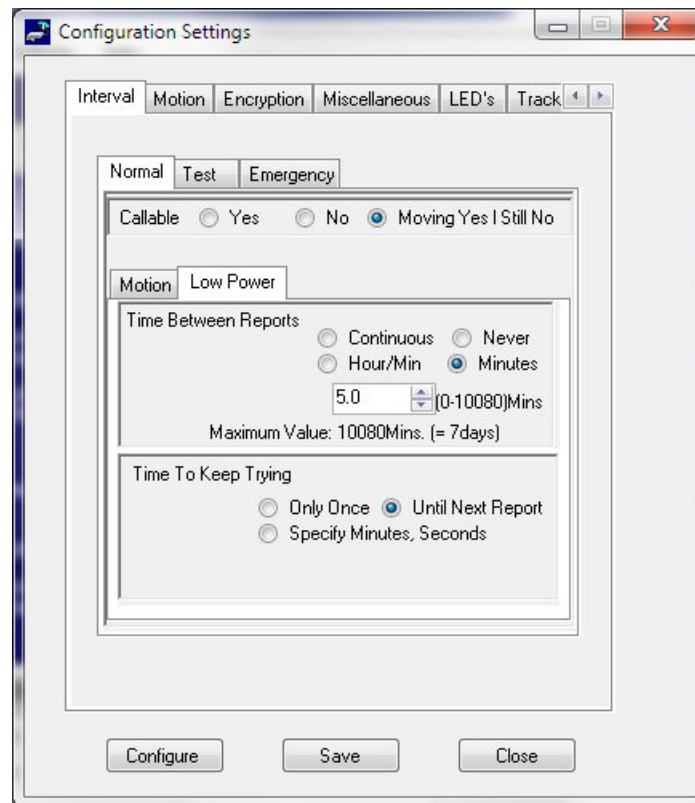

Figure 12: Normal Tracking "Callable (Moving Yes | Still No)" Option

3.1.2.2   EMERGENCY AND TEST TRACKING MODES

Emergency Tracking can be triggered by the Emergency button (see **Figure 6**) or by input pin S0. Test Tracking can be triggered by input pin S1. Emergency Tracking and Test Tracking operate similarly to Normal Tracking in that they have individually configurable reporting parameters. While in Emergency Tracking, the 9602-BTI does not respond to the +++ escape sequence, and at least one "report send attempt" must be completed before transitioning back to Normal Tracking. The Emergency GPS reports have a special data bit activated to alert the recipient of the message type. The 9602-BTI allows GPS reports to be saved on its nonvolatile memory when an Iridium satellite is not available.

3.2 ENCRYPTION SETTING

You can send GPS reports in AES 256-bit encrypted format. From the SatTerm *Change Encryption Settings* window, you can change the Crypto Officer Password, enable or disable the encryption, and set or change the encryption or decryption key (see **Figure 13**).
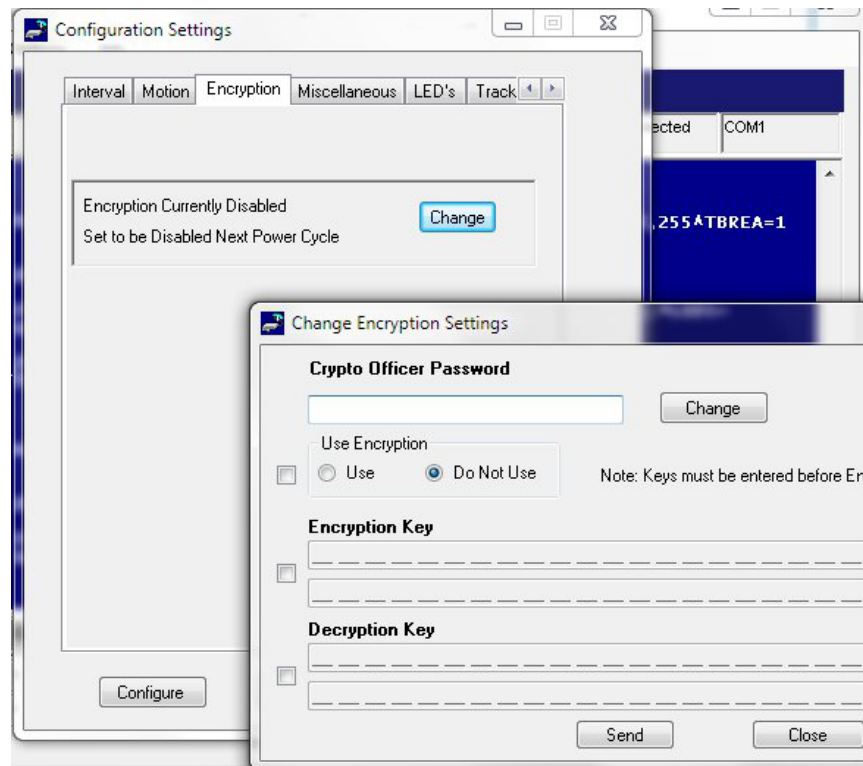

Figure 13: Change Encryption Settings: AES-256 Bit Encryption

A factory-default Crypto Officer Password is initially set and saved into the 9602-BTI. This default password must be changed before any encryption properties can be set or changed. To change the default password:

1. Click Change to open the *Change Crypto Officer Password* window.

2. Complete the form. The default password is displayed as the *Old Password*.

3. Click Send.

Once the default password has been changed, set the encryption and decryption keys in order to use encryption for the first time.

1. In the *Change Encryption Settings* window, select the Use Encryption check box and select the Use option.

2. Select the Encryption Key check box and enter the key two times.

3. Select the Decryption Key check box and enter the key two times.

4. Click Send. The message "Update Made" is displayed.

After the default Crypto Officer Password has been changed and the encryption and decryption keys have been set, encryption properties can be modified via the *Change Encryption Settings* window using the current Crypto Officer Password.

3.3 MISCELLANEOUS SETTINGS

The *Miscellaneous* tab has four settings: *Remote Update Password, Identifier in Reports, Startup Information*, and *Initial Power State*.
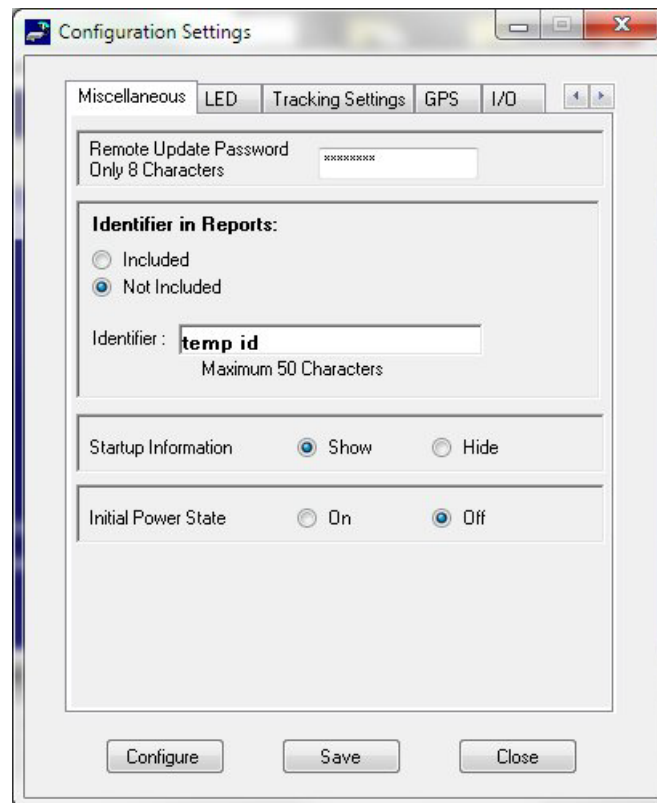

Figure 14: Configuration Settings Window: Miscellaneous Options

- *Use Remote Update Password* to set the required password when a remote update to the current active operating profile is made from a command center while the 9602-BTI is in the field. The <password> entered must be eight characters in length and all printable characters are allowed. The factory-set password is 12345678, and there is no requirement to change this password.
- Use *Identifier in Reports* to enter a unique static identifier of up to 50 characters (platform identifier of the 9602-BTI) and add it to the GPS report.
- Use *Startup Information* to either display or hide the startup text.
- *Initial Power State*: The 9602-BTI has a single power on/off button. With the correct internal voltage jumper setting, the 9602-BTI is defaulted to turn on automatically

when DC power is first applied to either pin 1 or pin 9 on the multi-interface connector. It can be turned off/on again by momentarily holding down and releasing the power button. Using AT command ^IPS, the 9602-BTI can also be set to turn on by pressing the power button when DC power is first applied to pin 1 or pine 9. If the device is sleeping in between reporting cycles, pressing the power button turns the 9602-BTI on for 10 seconds. During this time, you can exit Tracking mode by sending +++.

3.4 LED SETTINGS

The 9602-BTI has five status LEDs. These include Power indicator, Iridium signal strength, GPS availability, SBD transmission status, and Emergency mode alert (see Figure 15).

Figure 15: LED Status

They provide a quick visual check to ensure proper operations. These LEDs provide the following information during Normal Tracking mode:

- **Power LED**: Lights up when power is applied to the 9602-BTI and power-on button is pressed.
- **GPS LED**: Stays solid when there is a valid GPS position fix, blinks when there is 2-D fix or when using dead reckoning, and stays off when unable to obtain a position fix. Watch closely for the LED because it can briefly stay on.
- **Iridium LED**: Stays solid when the Iridium signal strength is between 3–5 bars, blinks when the Iridium signal strength is between 1–2 bars, and stays off when the Iridium signal strength is at 0 bars. Because the Iridium modem is on over a short period during a location report, this LED lights up very briefly and you might need to watch closely to see it.
- **Status LED**: When first entering Tracking mode, the LED does not light up. This LED stays solid if the last SBD transmission had a valid GPS fix and successfully received it by the gateway; blinks if the last SBD transmission was unsuccessfully sent or did not have a valid GPS fix, but one was sent since the unit was turned on; and stays off if no SBD transmission with a valid GPS fix was sent to the gateway.

- **Emergency LED**: Lights up when the Emergency button is pressed or the Input S0 is activated.

During Command mode or while operating the 9602-BTI as a 9602-G modem, the LEDs display information in the same manner as during Normal tracking mode. In addition, the Status LED provides:

- Status LED: When first entering the Command mode, this LED does not light up. If the last SBD session does not have an error, the LED stays solid. An error occurs when a transmitted SBD message is not being acknowledged by the gateway or if a message received from the gateway contains an error(s). The LED blinks only after the 9602-BTI is turned on with the last SBD session having an error but the next SBD session is error-free.

For those applications where prolonging battery life is essential, the LEDs can be turned OFF using the ^LEDS AT command or using the SatTerm LED's tab, as shown in **Figure 16**. The 9602-BTIs are shipped with all LEDs set to ON.
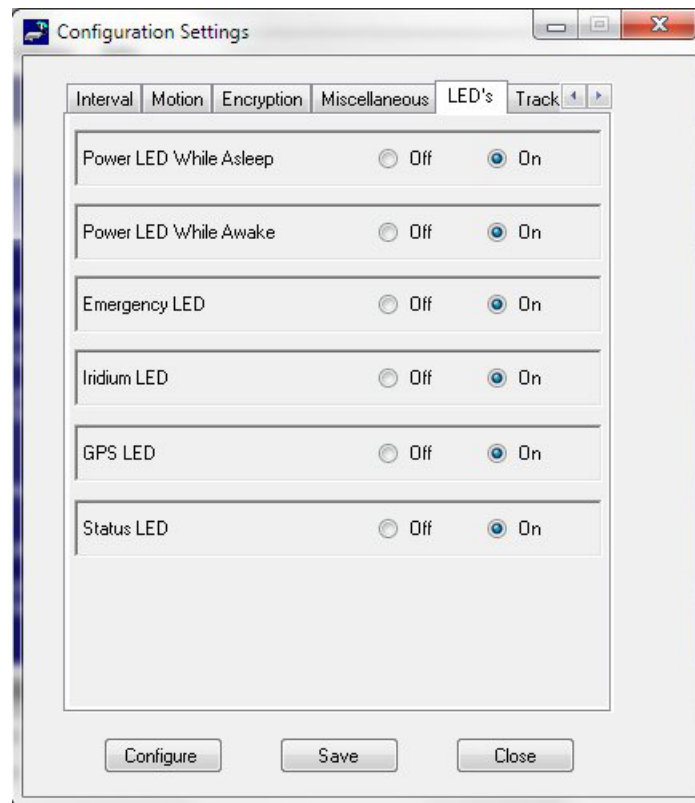

Figure 16. Configuration Settings Window: LED's Option

3.5   TRACKING SETTINGS

The *Tracking Settings* tab provides multiple settings: *Emergency Report Flood, Remote Message Format, GPS Always ON, Start-Up Mode, Data Log Tracking, Block Invalid Reports, and Test Report Flood.*

- *Emergency Report Flood* sets how many GPS reports are sent out continuously when first entering Emergency Tracking. After <n> GPS reports have been sent, the preprogrammed reporting interval takes effect.

- *Remote Message Format* sets format of the messages that will be sent to the command center.

- *GPS Always ON* forces the GPS receiver to stay on in between reports, allowing hot-start each time the 9602-BTI wakes up.

- *Start-Up Mode* sets the power-up mode of the 9602-BTI.

- The 9602-BTI allows GPS reports to be saved on its nonvolatile memory with the *Data Log Tracking* option turned on. When its memory is full, the oldest reports are overwritten. SatTerm can be used to retrieve all position reports at a later time through the multi-interface serial port.

- When *Block Invalid Reports* is enabled and a tracking mode is selected, reports with invalid GPS fix are not sent.

- *Test Report Flood* sets how many GPS reports are sent out continuously when first entering Test Tracking. After <n> GPS reports have been sent, the preprogrammed reporting interval takes effect.
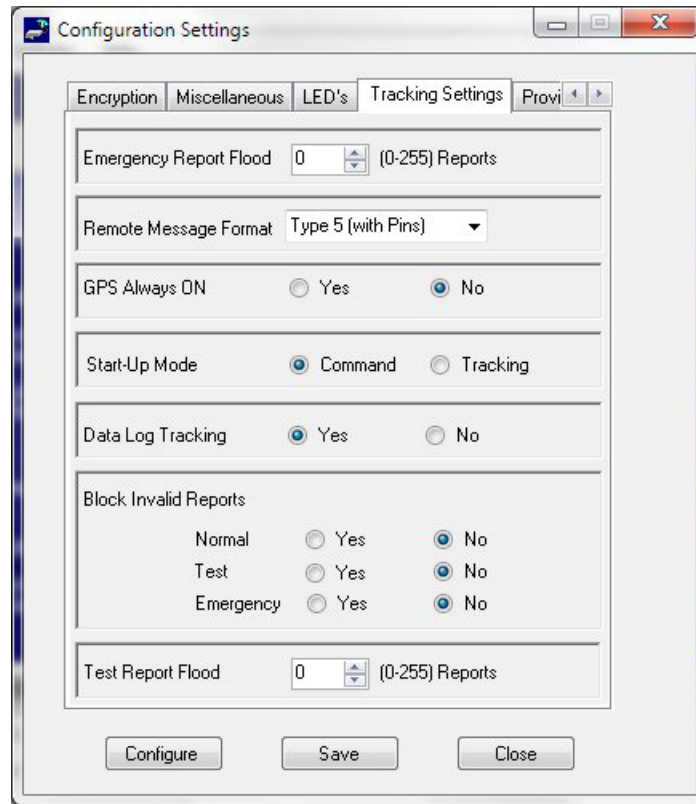
Figure 17: Configuration Settings Window: Tracking Options

3.6   GPS SETTINGS

From the *Configuration Setting* window, the *GPS* option allows you to obtain GPS information from the 9602-BTI serial port while the unit is in Command mode or Tracking mode (similar to the command ^PG). Both GPS NMEA formats and updating (streaming) rate can be defined (see **Figure 18**).
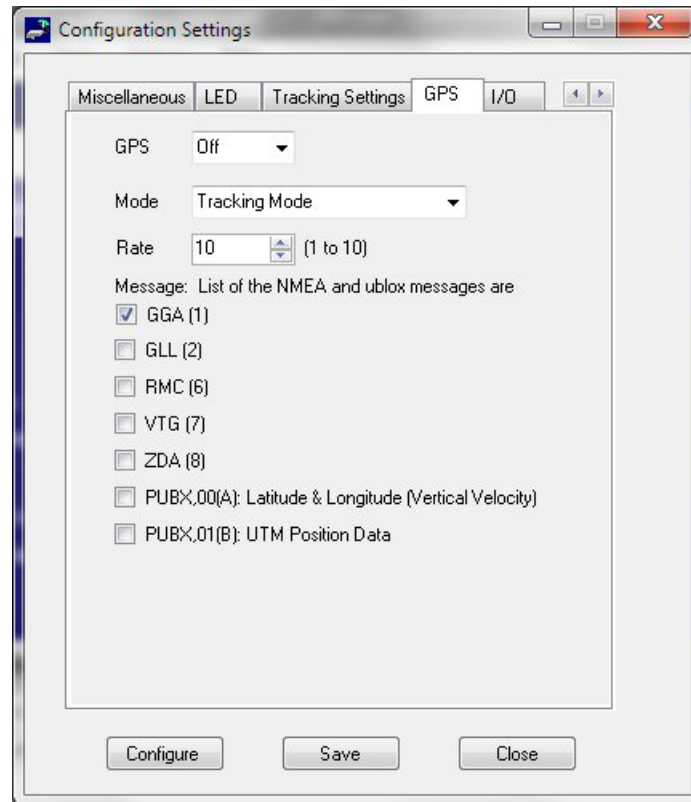

Figure 18: Configuration Setting Window: GPS Options

4 MOTION SENSOR

The 9602-BTI has a built-in sensor that can reliably detect motion. It is truly an omnidirectional movement sensor and functions regardless of how the 9602-BTI is mounted or aligned. It is sensitive to both tilt (static acceleration) and vibration (dynamic acceleration). The sensor produces a series of TTL level logic or pulse train. The signal level is fed directly into the 9602-BTI's microcontroller to "wake up" the 9602-BTI out of sleep mode when activity is sensed and to transmit location report.

The 9602-BTI's motion sensor can be enabled or disabled through the AT command (^MSA). When enabled, the motion sensor has a user-defined time-out to prevent false alarm. The user-defined time-out is the duration in which the 9602-BTI must remain in motion before the signal level is asserted to the microcontroller. Additional motion sensor settings can be found in the AT manual. The motion sensor draws approximately 4 μA at 4 VDC power input, regardless of whether it is software-enabled or not.

5 IRIDIUM ANTENNA CONNECTOR

The 9602-BTI uses a single SMA female 50-ohm antenna connector for both transmission and reception of the Iridium signal, as shown in **Figure 19**. The mating SMA male connectors are readily available from many RF hardware vendors/suppliers. Cable and connector losses between the 9602-BTI and the antenna are critical and must be kept to less than 2 dB at the operating frequency of 1616 to 1626.5 MHz.

NAL Research offers several types of antennas for use with the 9602-BTI. These antennas include the fixed mast, mobile magnetic/permanent mount, and portable auxiliary. For low-cost and applications where small form-factor and light weight are required, NAL Research highly recommends model SYN7391-C, as shown in **Figure 20**.
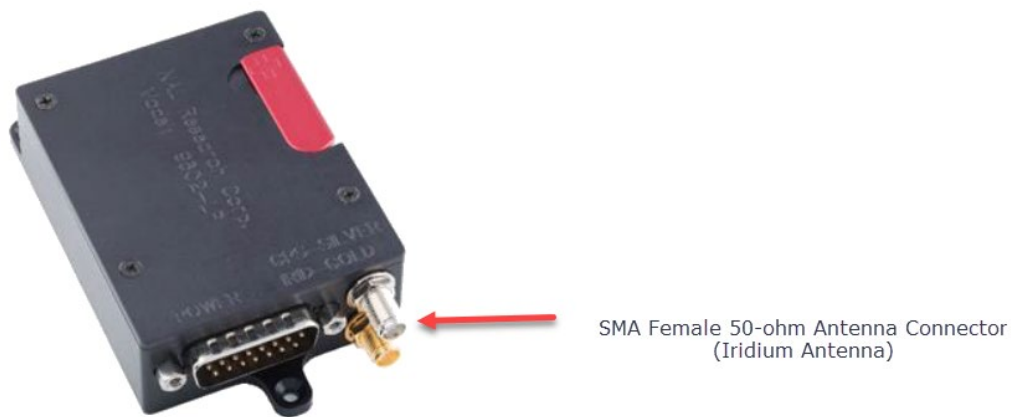

Figure 19: SMA Female 50-ohm Antenna Connector (Iridium)

Figure 20: Model SYN7391-C Antenna

If a custom-designed antenna is required, it must meet the specifications shown in **Table 2**.

Table 2: Recommended Iridium Antenna's Design Specifications

Parameter	Value
Measurement Frequency Range	1616 to 1626.5 MHz

Table 2: Recommended Iridium Antenna's Design Specifications

Parameter	Value
Return Loss (Minimum)	9.5 dB
Gain	0.0 dBic (weighted average minimum)
VSWR	1.5:1
Minimum 'Horizon' Gain	−2.0 dBic (82° conic average)
Nominal Impedance	50 Ohms
Polarization	Right-handed circular (RHCP)
Basic Pattern	Omni directional and hemispherical

6 GPS ANTENNA CONNECTOR

The 9602-BTI tracker uses a SubMiniature Version A (SMA) female connector for the GPS antenna, as shown in **Figure 21**. Any active antenna accepting a bias voltage of 3 VDC is appropriate. However, the Low Noise Amplifier (LNA) gain should not exceed 30 dB. NAL Research offers a magnetic mount GPS antenna as well as dual Iridium/GPS antennas for use with the 9602-BTI. For low-cost and applications where small form-factor and light-weight are required, NAL Research highly recommends model SAF7352-IG, as shown in **Figure 22**.
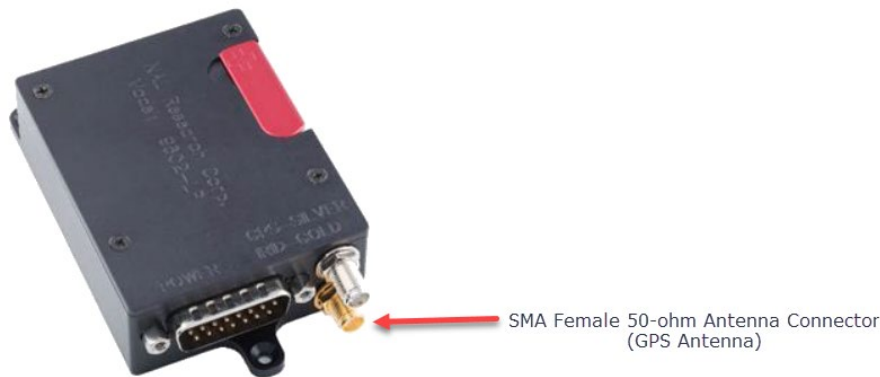

Figure 21: SMA Female 50-ohm Antenna Connector (GPS)

Figure 22: Model SAF7352-IG Antenna

Important: DO NOT CONNECT OR DISCONNECT THE GPS ANTENNA WHEN THE 9602-BTI IS TURNED ON.

- The internal GPS receiver calibrates the noise-floor when turned on; and

- Connecting the GPS antenna after power-up can result in prolonged acquisition time and possibly damage the GPS receiver.

- To test GPS signal reacquisition, physically block the signal to the antenna rather than disconnect and reconnect the antenna.

Important:

- Never feed external supply voltage into the active GPS antenna.

- Always use the bias voltage supplied by the 9602-BTI via the SMA antenna connector to power an active GPS antenna.

- Feeding voltage to the GPS antenna other than the provided bias voltage will damage the 9602-BTI.

7 POWER CONSUMPTION

This section provides insight to the electrical power profile of the 9602-BTI; however, does not describe every situation and permutation possible. It should be used as a starting point for continuing your own development design. The actual usage profile can vary for a number of reasons:

1. Poor visibility of the sky where clear line of sight is not available between the 9602-BTI and satellite.

2. The higher the antenna Voltage Standing Wave Ratio (VSWR), the higher the current consumed.

3. And manufacturing variation from device to device.

Power consumption of the 9602-BTI can be divided into distinct operating segments: (1) power up, (2) standby, (3) sleep between reports, (4) GPS acquisition, and (5) SBD report transmission. When turned on in command mode, typical in-rush current of approximately 3 A–4 A over a few milliseconds is mainly due to the current drawn by the 9602 (see **Figure 23**).
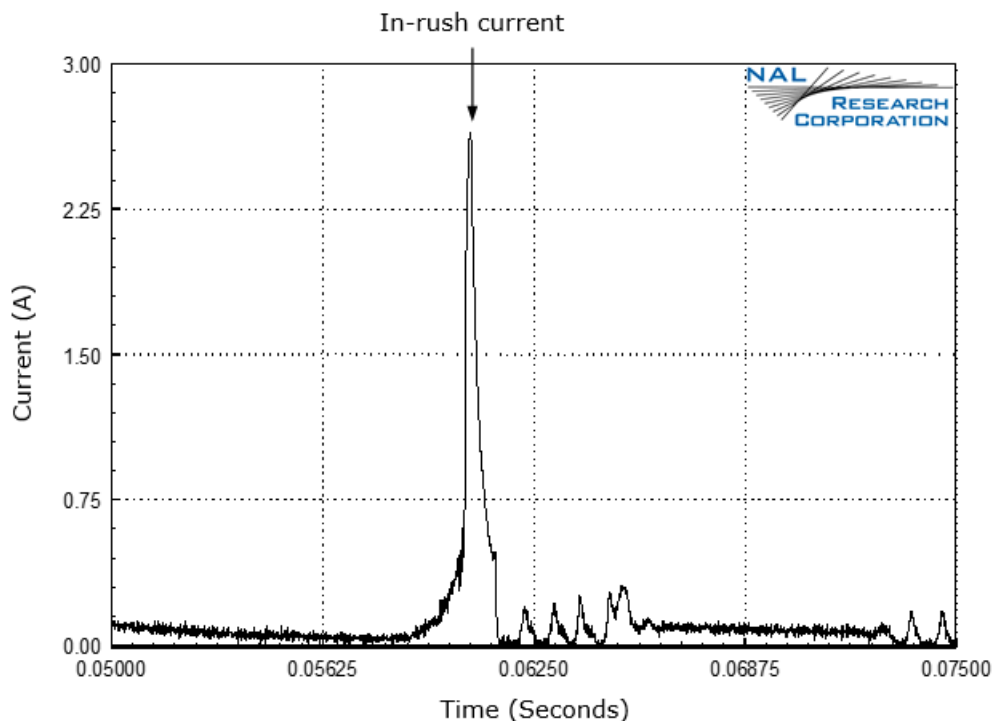
Figure 23: In-Rush Current Spike During Power-Up: Command Mode (5 VDC Input)

At standby in command mode, current is measured when all circuits are on. The average current drawn during standby with 3.6 VDC–5 VDC input and 6 VDC–32 VDC are shown in **Figure 24** and **Figure 25**, respectively.
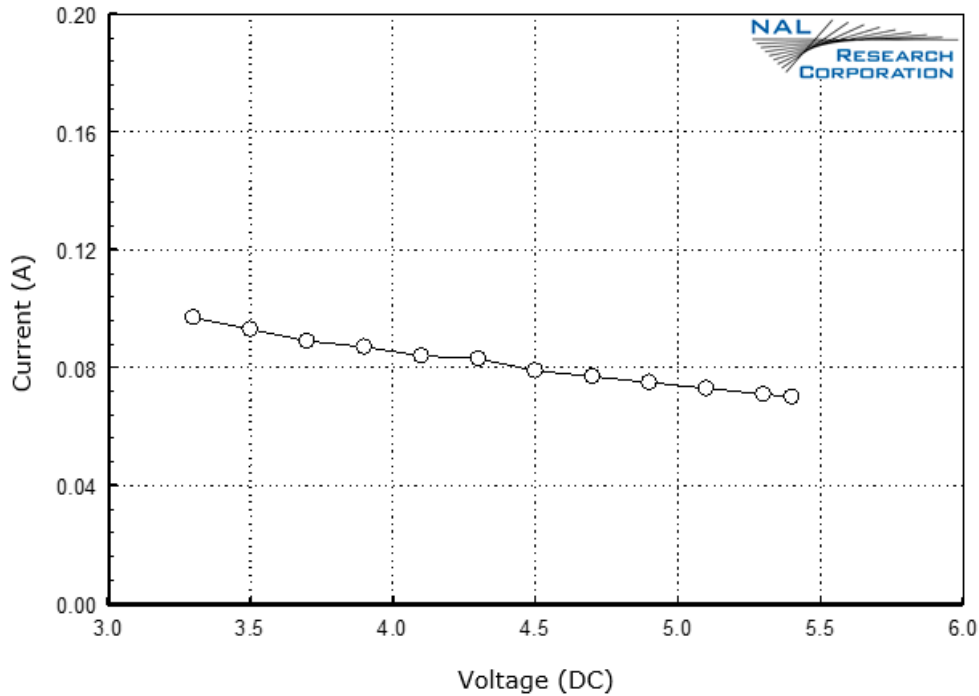

Figure 24: Average Current During Standby (3.5 VDC to 5 VDC Input)

Figure 25: Average Current During Standby (6 VDC to 32 VDC Input)

Figure 26 shows the average power consumption by the 9602-BTI at standby in command mode for the entire voltage range.
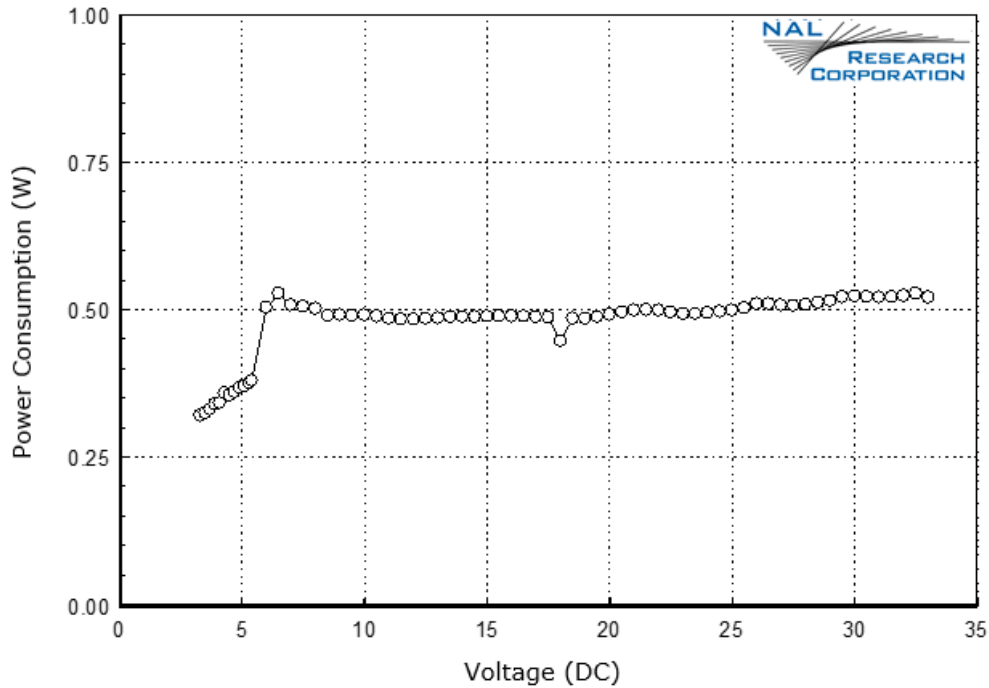
Figure 26: Average Power Consumption During Standby (3.5 VDC to 32 VDC Input)

In tracking mode, the 9602-BTI goes through three different power consumption segments:
(1) The sleep (in between reports) segment,

(2) GPS acquisition segment, and

(3) SBD transmission segment.

Figure 27 shows different stages of current drawn by the 9602 when in tracking mode. During the sleep segment, the 9602-BTI goes into power-saving mode by shutting down all its internal circuits.
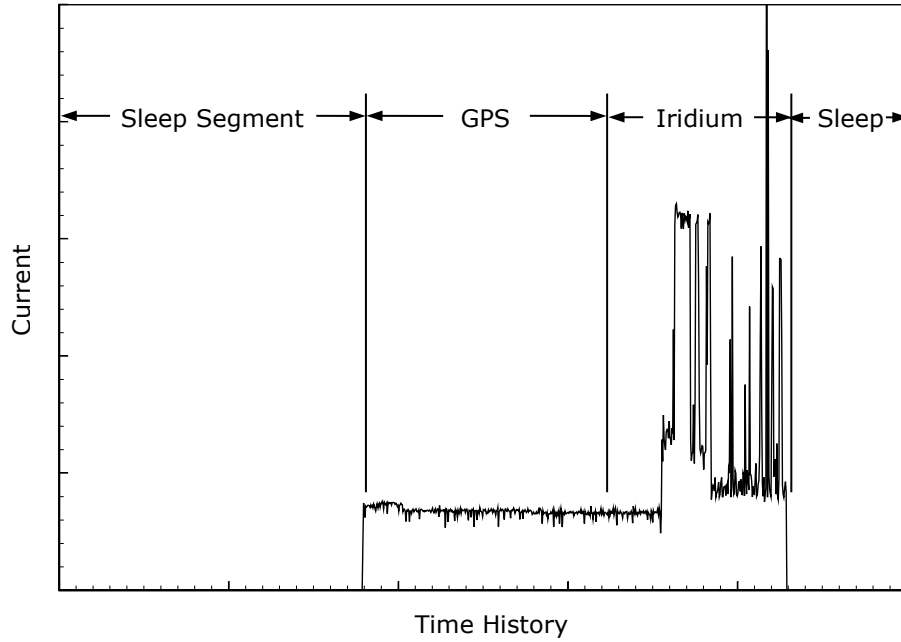
Figure 27: Stages of Current Drawn: Tracking Mode

The average current drawn by the 9602-BTI during sleep with 3.6 VDC–5 VDC input is shown in **Figure 28**.
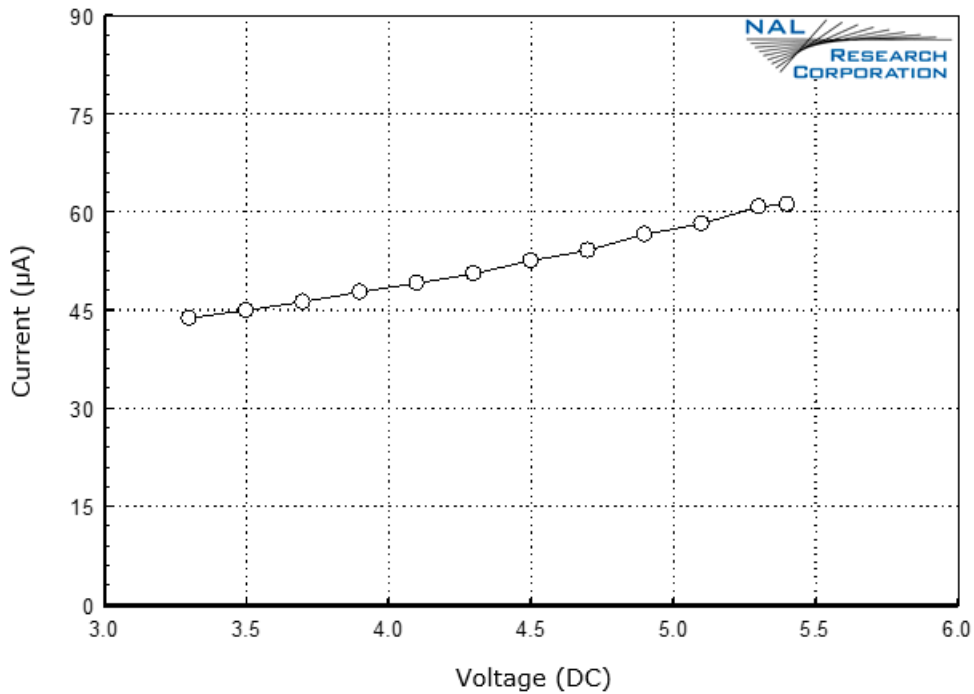
Figure 28: Average Current During Sleep (3.5 VDC to 5 VDC) Input

The average current drawn by the 9602-BTI during sleep with 6 VDC–32 VDC is shown in **Figure 29**. Due to limitations of our signal analyzer, current drawn for voltages above 15 VDC in the μA range could not be measured. The dashed line results from curve fitting (cubic spline) of the data.
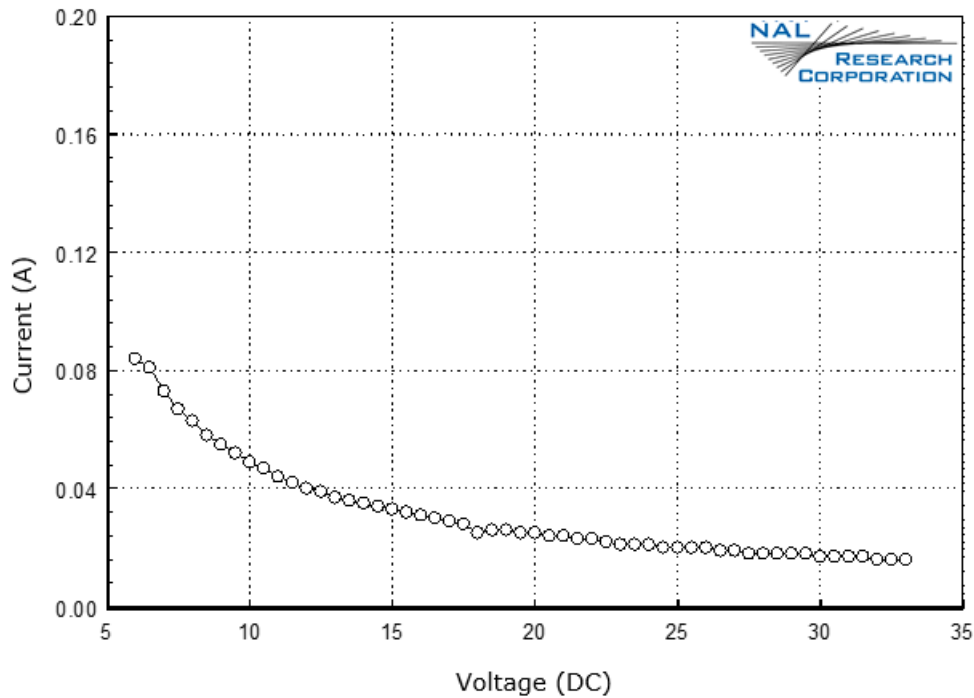

Figure 29: Average Current During Sleep (6 VDC to 32 VDC Input)

Figure 30 shows the average power consumption by the 9602-BTI during sleep for the entire voltage range.
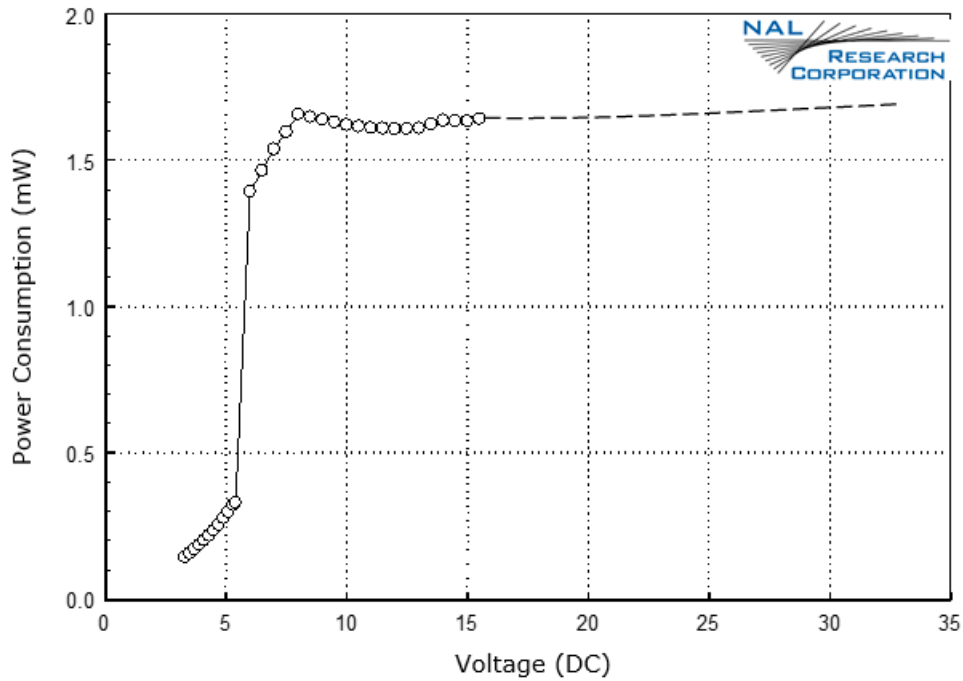
Figure 30: Average Power Consumption During Sleep (3.5 VDC to 32 VDC Input)

During the GPS acquisition segment, the average current drawn by the 9602-BTI with 3.6 VDC–5 VDC input and 6 VDC–32 VDC are shown in **Figure 31** and **Figure 32**, respectively. The GPS acquisition time can range from 1 second (hot starts) to 28 seconds (cold starts).
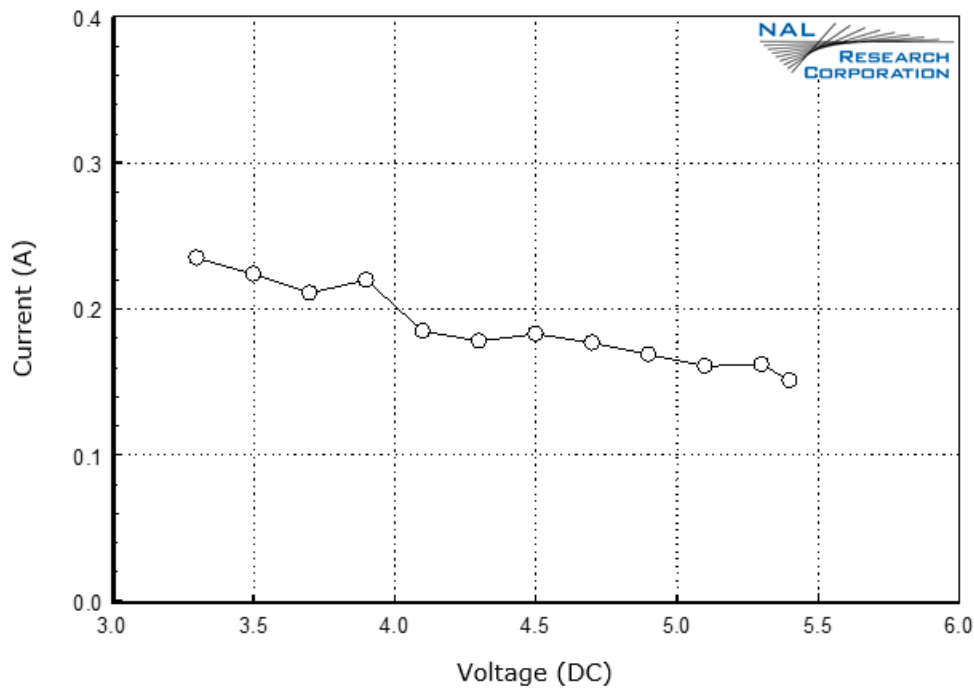
Figure 31: Average Current during GPS Acquisition (3 VDC to 5 VDC Input)
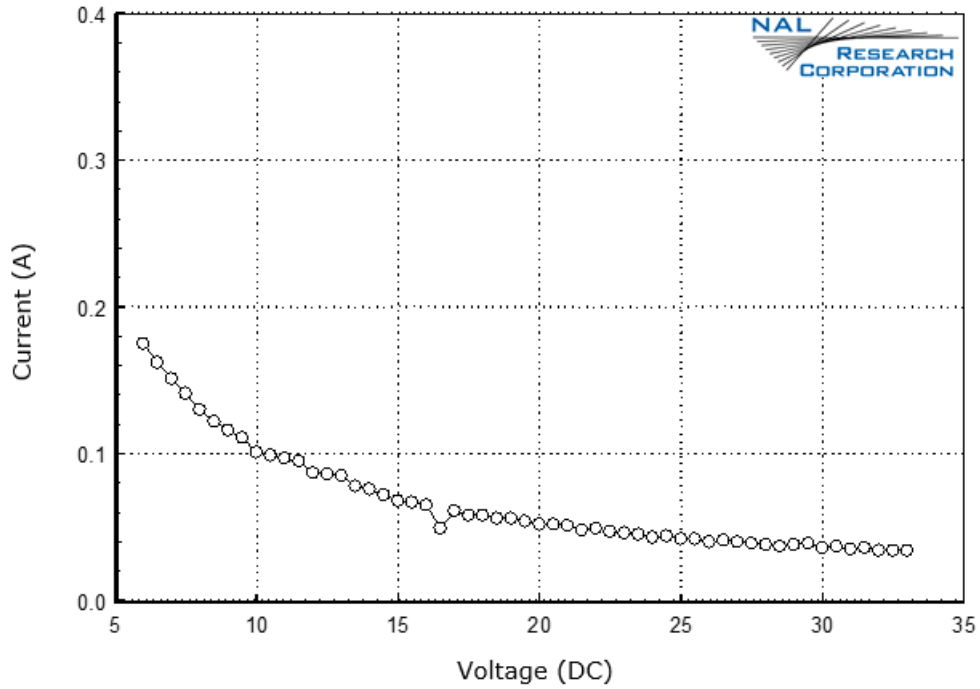
Figure 32: Average Current During GPS Acquisition (6 VDC to 32 VDC Input)

Figure 33 shows the average power consumption by the 9602-BTI during GPS acquisition for the entire voltage range.
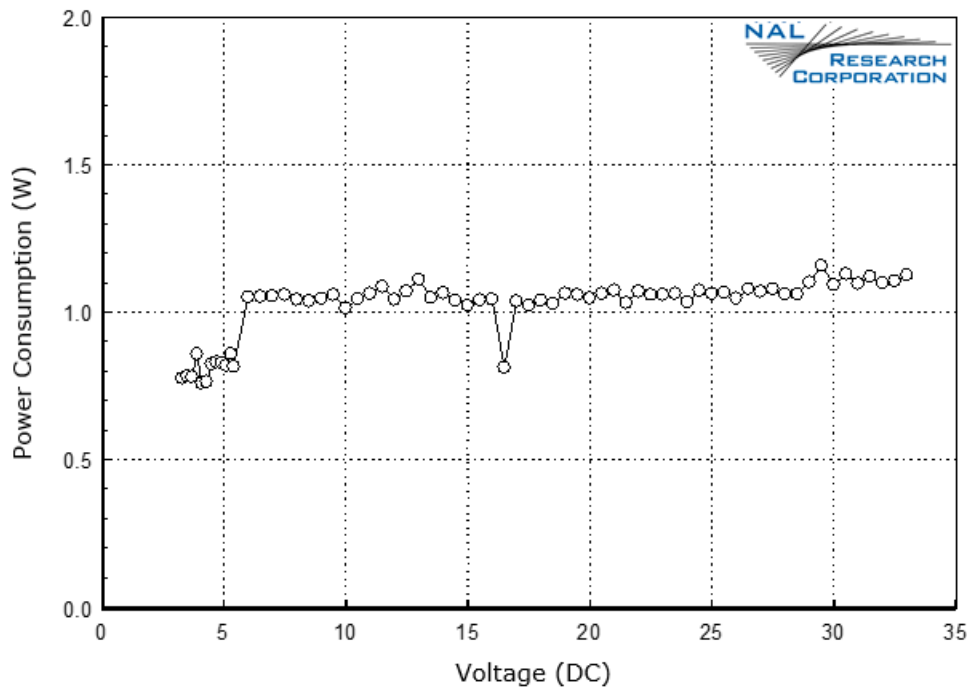
Figure 33: Average Power Consumption During GPS Acquisition (3.5 VDC to 32 VDC Input)

During the SBD transmission segment, the average current drawn by the 9602-BTI with 3.6 VDC–5 VDC input and 6 VDC–32 VDC are shown in **Figure 34** and **Figure 35**, respectively.

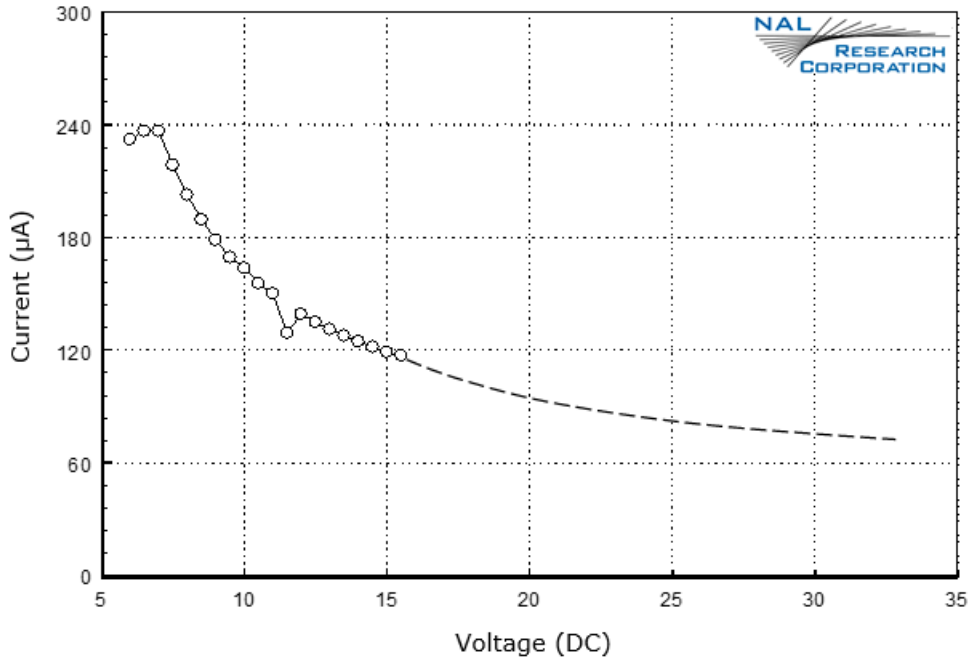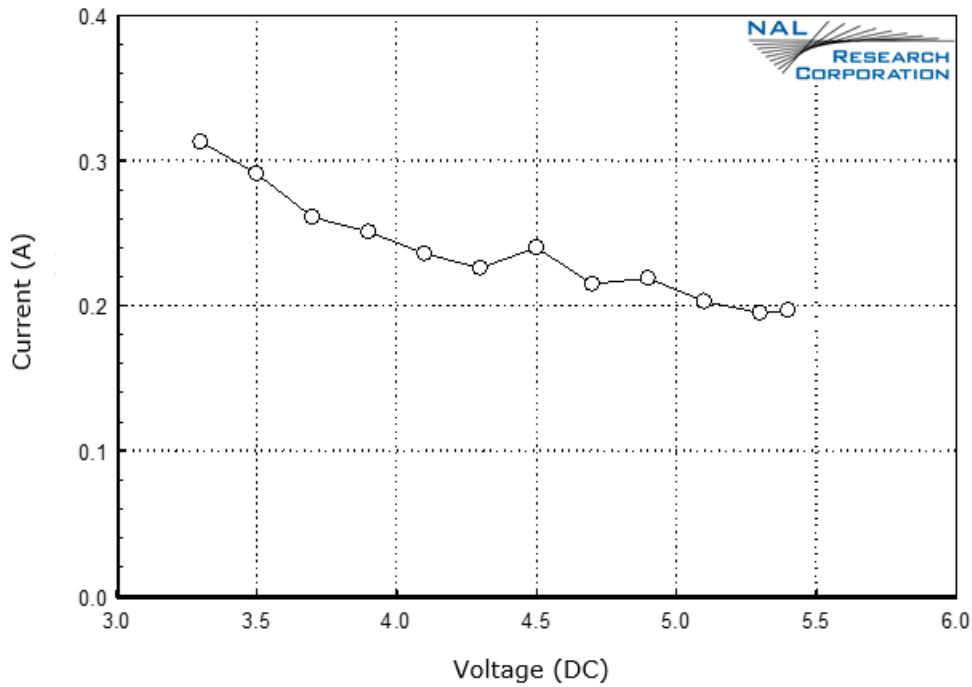*Figure 34: Average Current during SBD (3 VDC to 6 VDC Input)*
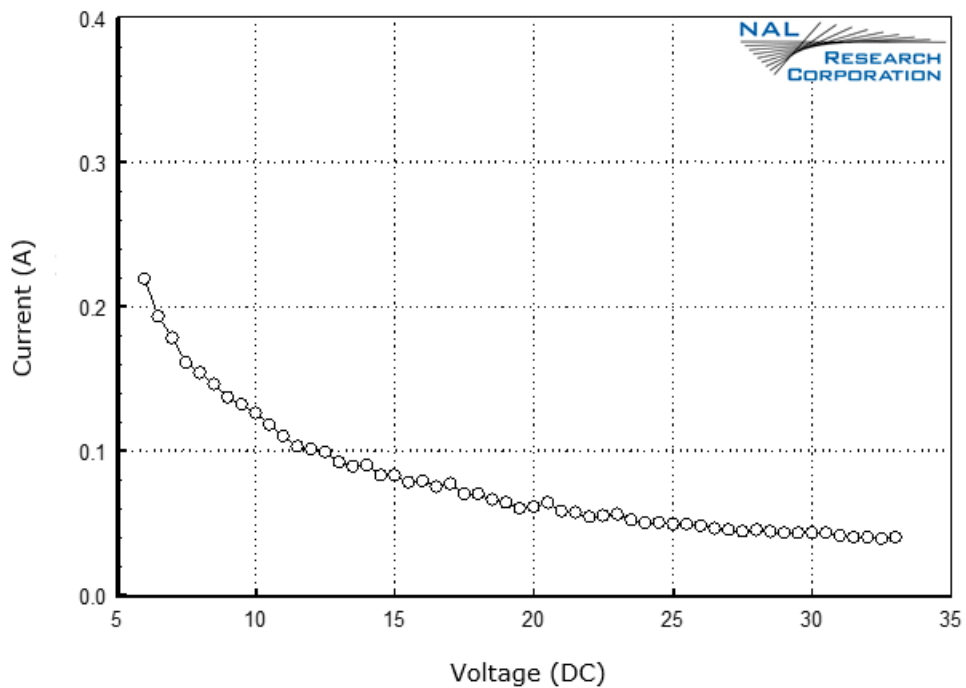
Figure 35: Average Current during SBD (6 VDC to 32 VDC Input)

Figure 36 shows the average power consumption by the 9602-BTI during SBD transmission on for the entire voltage range.
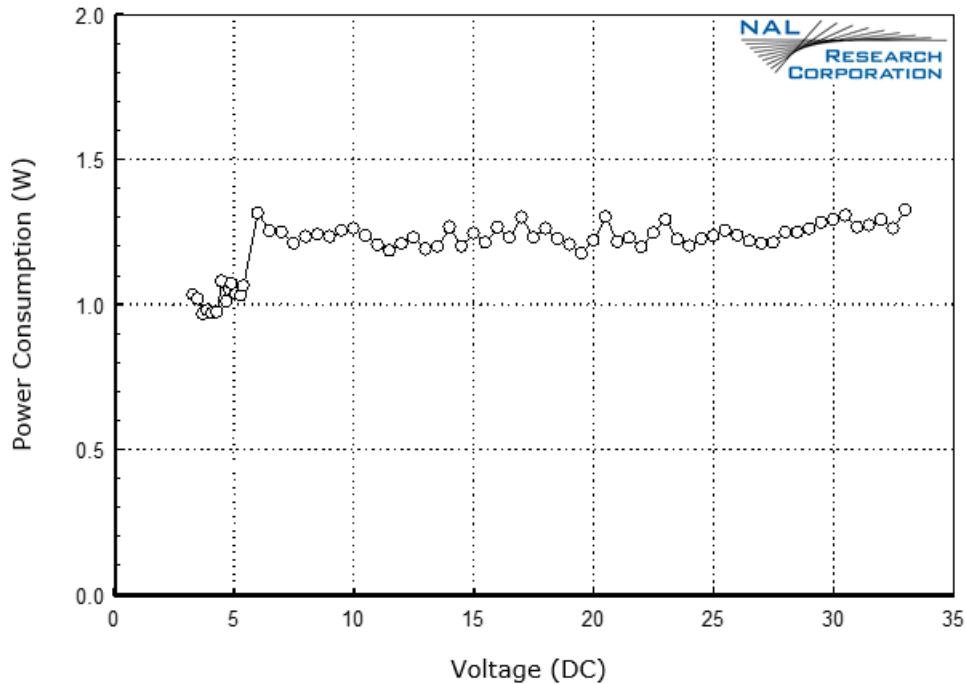
Figure 36: Average Power Consumption During SBD Transmission (3.5 VDC to 32 VDC Input)

All the plots above show that the 9602-BTI is more efficient (consumes less power) when it operates in the 3.6 VDC to 5.3 VDC input range, especially in between reports. The actual current profiles may vary for a number of reasons; optimize your setup to attain the lowest possible power consumption.

Some setup parameters to be carefully observed include:

- Have a clear view of the sky for both the GPS and Iridium antennas—poor visibility of the sky is when a clear line-of-sight is not available between the 9602-BTI and the satellites.

- Keep the Iridium antenna's VSWR low—the higher the antenna VSWR, the higher the current consumed by the 9602-BTI.

- Keep the antenna cables' loss to less than 3 dB—the higher the antenna cable loss, the higher the current consumed by the 9602-BTI.

- Select active GPS antennas with low-power consumption LNAs—a GPS antenna LNA with 30 dB gain is sufficient.

- Keep the power cable between the 9602-BTI and the power source as short as possible.

8 LIST OF KNOWN ISSUES

None

9 TECHNICAL SUPPORT

For technical support, please contact us at:

Phone: 703-392-1136 Ext. 200 or

Email: contact@nalresearch.com

Technical documents are also available to download on NAL Research's website www.nalresearch.com in the Support > Documentation & Downloads section.

APPENDIX A: STANDARDS COMPLIANCE

The 9602 transceiver is designed to meet the regulatory requirements for approval for FCC, Canada, and CE, assuming an antenna with a gain of approximately 3 dBi and adequate shielding. The 9602 transceiver is tested to the regulatory and technical certifications shown in Table 3.

Table 3: Standards Compliance

Regulatory Approvals	Radio Tests	EMC Tests	Mechanical/ Electrical Tests
CE	ETSI EN 301 441 V1.1.1 (2000-05)	ETSI EN 301 489-1 V1.8.1 (2008-04) ETSI EN 301 489-20 V1.2.1 (2002-11)	EN60950−1:2006 Part 1
FCC	FCC CFR47 Parts 2, 15, and 25	EN61000-4-2: 1995/A2: 2001 Part 4.2 EN61000-4-3: 2002 Part 4.3 EN61000-4-4: 2004 EN61000-4-6: 1996/A1: 2001 Part 4.6 EN55022: 2006	
Industry Canada	Industry Canada RSS170 Issue 1, Rev 1, November 6, 1999		

APPENDIX B: EXPORT COMPLIANCE

The 9602-BTI is controlled by the export laws and regulations of the United States of America (U.S.). It is the policy of NAL Research to fully comply with all U.S. export and economic sanction laws and regulations. The export of NAL Research products, services, hardware, software and technology must be made only in accordance with the laws, regulations and licensing requirements of the U.S. Government. NAL Research customers must also comply with these laws and regulations. Failure to comply can result in the imposition of fines and penalties, the loss of export privileges, and termination of your contractual agreements with NAL Research.

The export and re-export of NAL Research products and services are subject to regulation by the Export Administration Regulations (15 CFR 730-744), as administered by the U.S. Department of Commerce, Bureau of Industry and Security ("BIS"). See: https://www.bis.doc.gov/index.php/regulations/export-administration-regulations-ear for further information on BIS and the Export Administration Regulations (EAR). Additional export restrictions are administered by the U.S. Department of the Treasury's Office of Foreign Asset Controls ("OFAC"). See: http://www.ustreas.gov/ofac for further information on OFAC and its requirements.

APPENDIX C: IRIDIUM NETWORK

The Iridium satellite network is owned and operated by Iridium Communications Inc. It was constructed as a constellation of 66 satellites in low-earth orbit, terrestrial gateways, and Iridium Subscriber Units (ISUs). An ISU can either be an Iridium satellite phone or any of the modems. The satellites are placed in an approximate polar orbit at an altitude of 780 km. There are six (6) polar planes populated with 11 satellites per orbit constituting the 66 satellite constellation. The near polar orbits of the Iridium constellation provide truly real-time and global coverage from pole-to-pole.
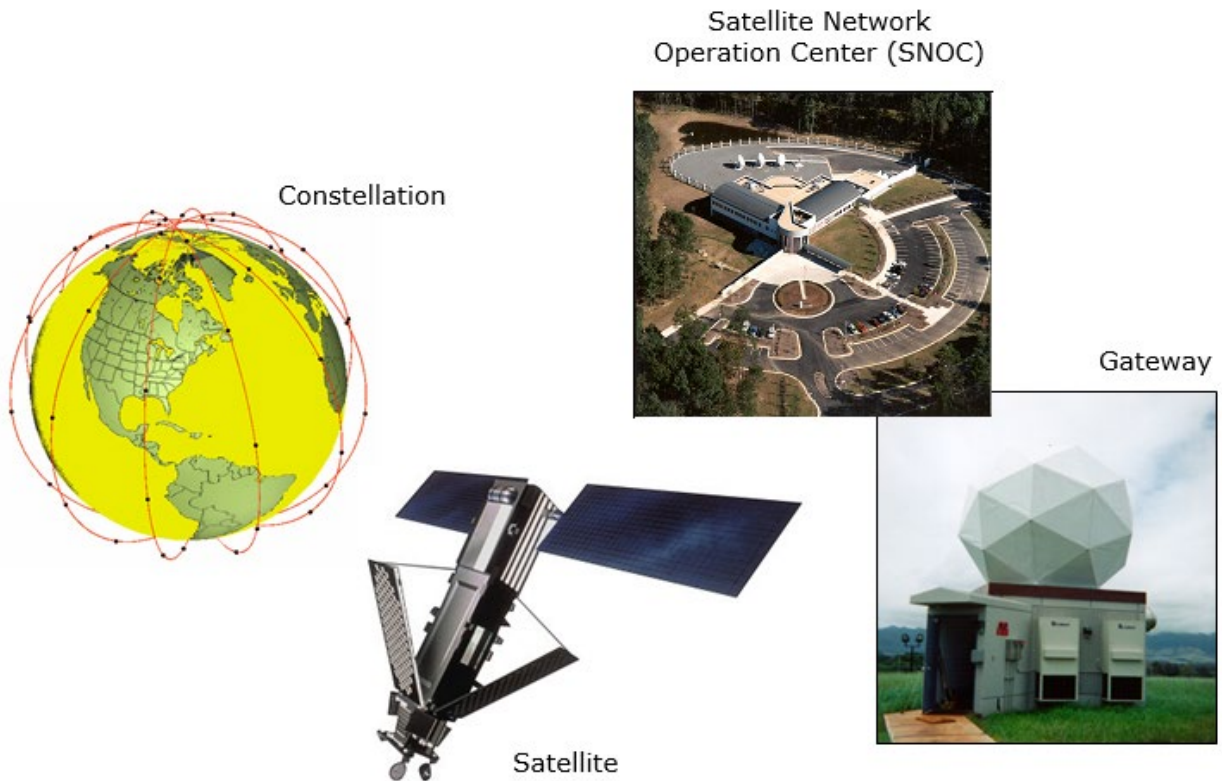
Figure 37: Iridium Network

The Iridium network is designed to operate in the band of 1616 to 1626.5 MHz, although the exact frequencies used depend on the local regulating authorities and issued licenses in any particular region. Each satellite projects 48 beams on the surface of earth, which may be viewed as providing coverage cells on the ground similar to terrestrial systems. Each beam is approximately 600 km in diameter. The 66-satellite constellation has the potential to support a total of 3,168 spot beams; however, as the satellite orbits converge at the poles, overlapping beams are shut down. The satellite footprint is approximately 4,700 km in diameter. Under each footprint, a satellite is power limited to approximately 1,100 simultaneous circuits.

The Iridium network uses a time domain duplex (TDD) method and transmits and receives in an allotted time window within the frame structure. Because the system is TDD, the ISUs transmit and receive in the same frequency band. The access technology is an FDMA/TDMA (frequency division multiple access/time division multiple access) method whereby an ISU is assigned a channel composed of a frequency and time slot in any particular beam. Channel assignments may be changed across cell/beam boundaries and are controlled by the satellite. The system provides an average link margin of 13.1 dB.

Although there are multiple gateways, a user is registered to a single gateway. The gateways perform call connection setup and administrative duties, such as billing and resource management. The satellite constellation provides connectivity between users, from a user to the Iridium system gateway, and between gateways. Within the Iridium network architecture, the satellites are cross-linked, which allows ISU to ISU communication independent of gateway intervention once the call connection is established.

There are currently two commercial Iridium gateways located in Arizona, United States; and Fucino, Italy. The U.S. government owns and operates an Iridium gateway located in Hawaii, United States. Each gateway generates and controls all user information pertaining to its registered users, such as user identity, geolocation, and billing items. The gateway also provides connectivity from the Iridium system to the terrestrial based networks, such as the PSTN.

IRIDIUM NETWORK DATA CAPABILITIES

For data communications, the Iridium network supports five different modes of operation, as shown in **Figure 38**—dial-up data service, direct Internet connection, SBD, SMS, and Router-based Unrestricted Digital Internetworking Connectivity Solution (RUDICS).
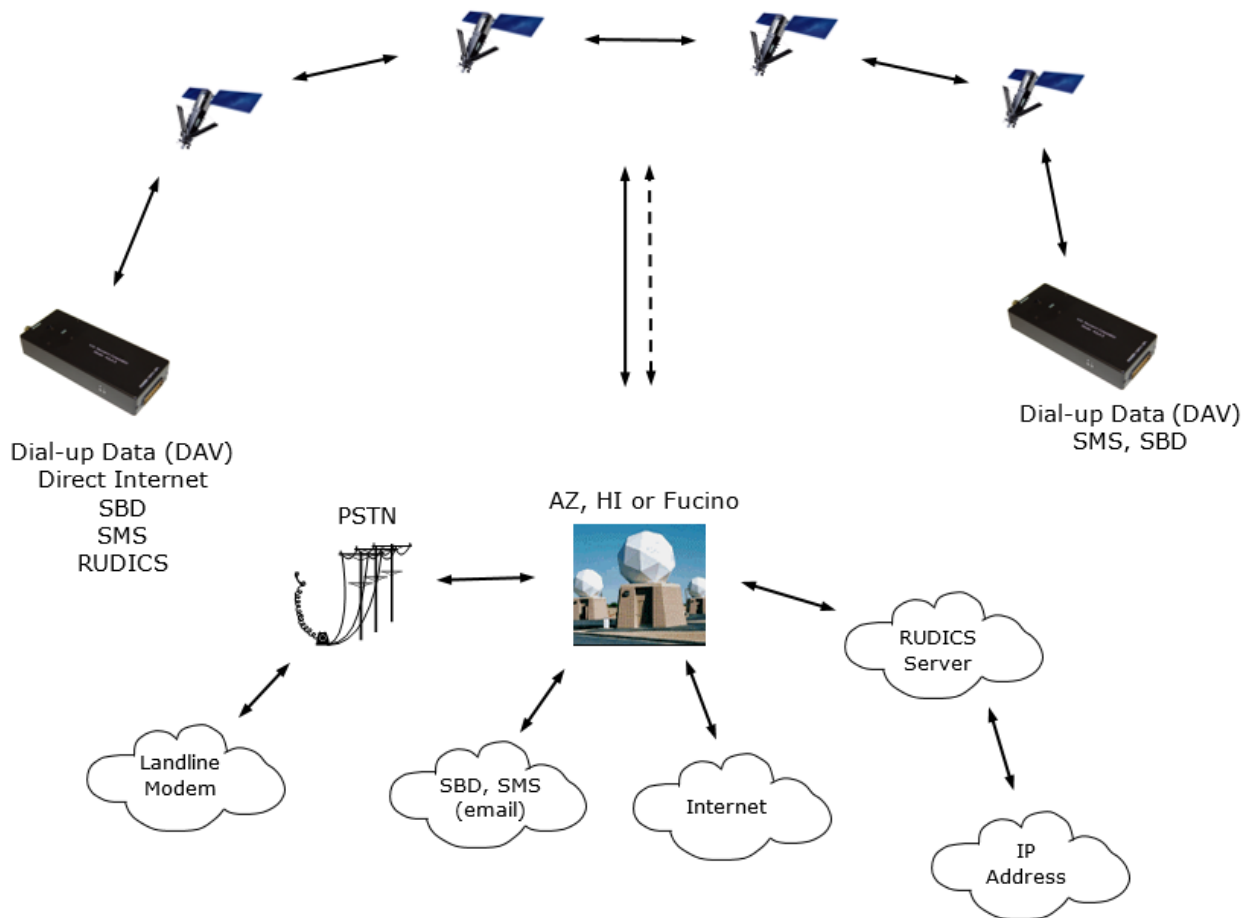
Figure 38: Iridium Network Data Capabilities

DIAL-UP DATA SERVICE

Dial-up data service provides connectivity through the Iridium satellite network to another Iridium modem, to the Public Switched Telephone Network (PSTN), to the Defense Switch Network (DSN), to a remote LAN (e.g., a corporate network), or to an Internet Service Provider (ISP) at a nominal data rate of 2.4 kilobits per second (Kbps). The connection time involving user authentication and handshaking (or modem training) can range from 15 to 30 seconds. For an Iridium-to-Iridium call, dial-up data service offers an additional option known as Data After Voice (DAV). Similar to a voice call, a DAV call is routed directly from one Iridium modem to another Iridium modem without going through the gateway.

Many desktop and laptop computers are equipped with either an internal or external modem to perform dial-up data applications across the landline PSTN. On these computers, terminal emulator software or a dial-up networking connection can be configured to a specific modem with a phone number to dial, and to a specific user identification and password. The modem can then be used to call another computer, a remote Local Area Network (LAN), or

an ISP, as shown in **Figure 39**. The handshaking and protocols are established between the modems independent of the landline.
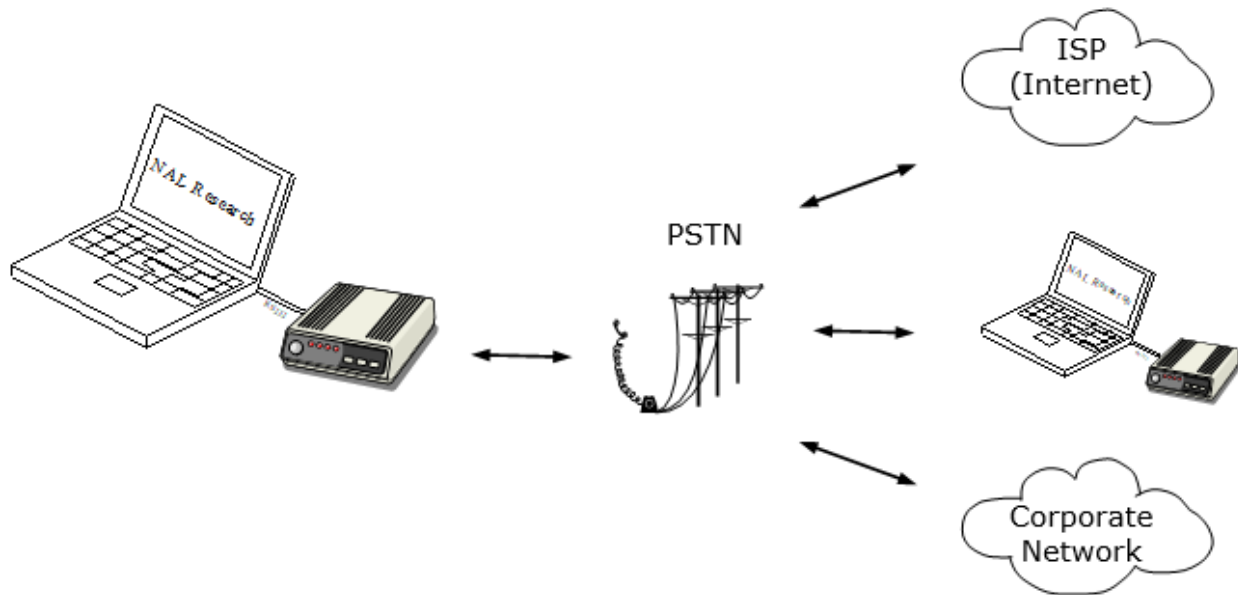
Figure 39: PSTN Dial-Up Connectivity

The Iridium dial-up data service functions in much the same way as the PSTN dial-up connectivity. From the perspective of a computer, the Iridium modem is just another external modem. The only difference is that the dialed telephone number must conform to the international dialing pattern used by Iridium. When a data call is placed, the Iridium modem actually dials and initiates a connection with the Iridium gateway through the Iridium satellite constellation. Because the Iridium modem is requesting to establish a data connection, the switch at the gateway routes the call through another modem. The modem at the Iridium gateway then dials into and connects to another modem at the other end. **Figure 40** illustrates how an Iridium dial-up data service call is routed. The handshaking and protocols are established between the modems independent of the Iridium network.

For those ISU-to-ISU dial-up calls where data transmission delay is critical, such as the application of TCP/IP protocol, DAV should be considered in the design. This option eliminates the Iridium gateway once authentication and registration is completed, allowing ISU-to-ISU communication without the gateway in the loop.
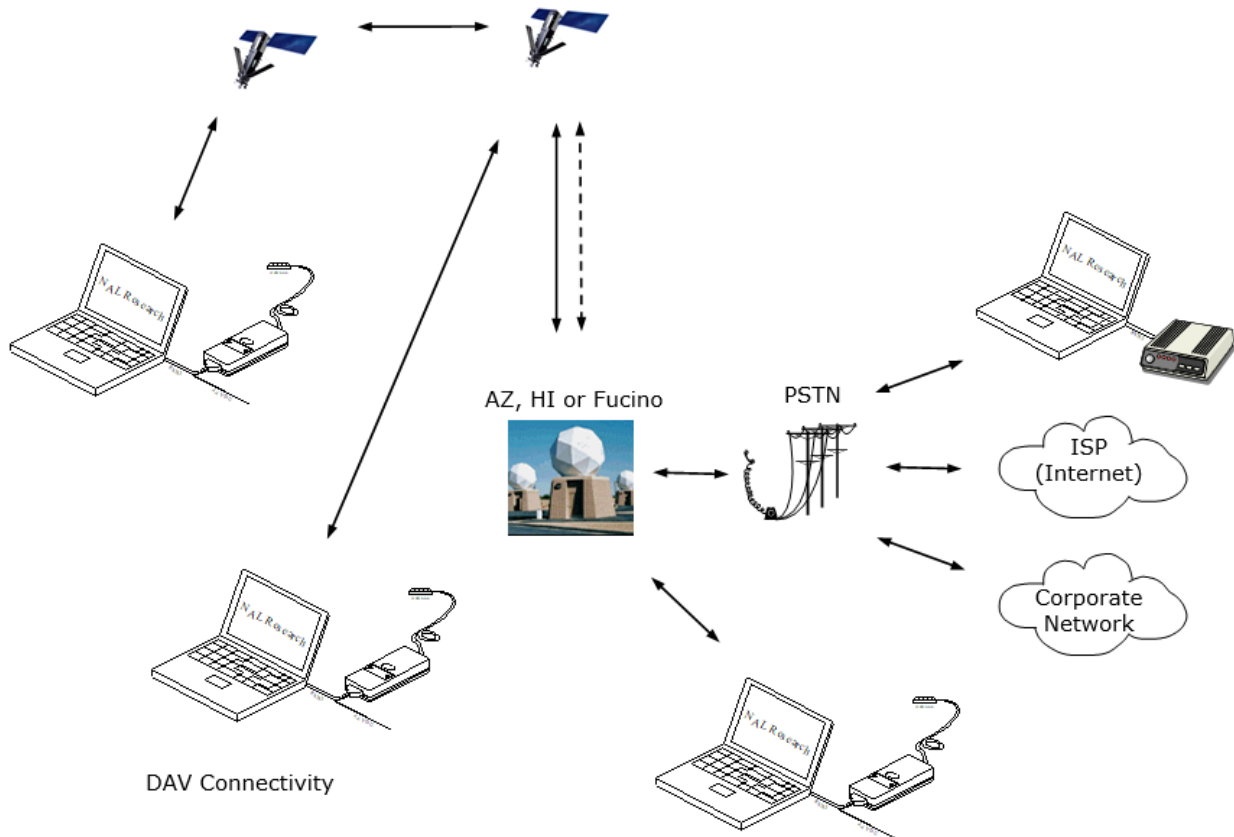
Figure 40: Iridium Dial-Up Data Service

DIRECT INTERNET CONNECTION

The Iridium Direct Internet service allows users to connect to the internet via the Iridium gateway without having to sign up with an internet service provider. This service utilizes a dedicated Apollo Server at the Iridium gateway, which provides high-speed connectivity to the internet and optimizes server-to-Iridium modem communications. The dial-up networking setup is similar to the dial-up networking setup for landline telephone. The only difference is that the dialed telephone number is an international number provided by Iridium. **Figure 40** illustrates how an Iridium internet call is routed.

Direct Internet service can be enhanced using Windows-based emulated Point-to-Point Protocol (PPP) called the Apollo Emulator. With the use of the Apollo Emulator software instead of Microsoft Windows® dial-up networking, Direct Internet service can reduce connection time and improve data throughput. In addition, the Apollo Emulator offers a feature called Smart Connect™, which manages airtime by seamlessly connecting and disconnecting a user through the Iridium system. Airtime charges accumulate only while the call is connected. Improved effective data throughput is achieved through the use of user-transparent data compression. The channel rate is still 2.4 Kbps. However, 10 Kbps

effective throughput can be achieved depending on content (graphics and images result in lower effective throughput).

SHORT BURST DATA

Short Burt Data (SBD) is a simple and efficient bidirectional transport capability used to transfer messages with sizes ranging from zero (a mailbox check) to 1960 bytes. SBD takes advantage of signals within the existing air interface, without using the dedicated traffic channels. As a result, small amounts of data can be transferred more efficiently than those associated with circuit-switched data calls. Messages that originate from an Iridium modem can be delivered to a variety of destinations. Commonly, data are delivered across terrestrial communications networks (NIPRNet and internet) to servers and applications that process data from one or multiple fielded Iridium modems. SBD service also supports the transfer of messages to Iridium modems, where messages may originate from terrestrial sources. Delivery methods and options are initially configured when the Iridium modem is first purchased and may be easily modified via web pages at a later time.

SHORT MESSAGING SERVICE

Short Messaging Service (SMS) is a mechanism to deliver short data messages over the Iridium satellite network to the NIPRNet/internet. Iridium SMS service incorporates a subset of the Global System for Mobile Communications (GSM) SMS features. Each SMS message can be up to 160 text characters (7-bit coded) in length. The text characters are based on a 7-bit alphabet, which is encoded and transmitted as 8-bit data, hence the 140 octet (byte) maximum message size.

SMS service is a store-and-forward method of transmitting messages to and from an Iridium modem. The short message from the modem is stored in a central Short Message Center (SMSC), which then forwards it to the destination. If the recipient is not available, the SMSC attempts to deliver the SMS until it is delivered or the validity period expires. SMS supports a limited confirmation of message delivery. The sender of the short message can request to receive a return message notification of whether or not the short message has been delivered. With this option, the originator receives a confirmation that the message was delivered to the SMSC. Unlike standard GSM, the Iridium SMS can only acknowledge that the message was delivered to the SMSC and not the end-destination.

SMS messages can be sent and received simultaneously while a voice call is in progress. This is possible because SMS messages travel over and above the radio channel using the signaling path, whereas the voice call uses a dedicated "traffic" radio channel for the duration of the call.

RUDICS

RUDICS is an enhanced gateway termination and origination capability for circuit-switched data calls across the Iridium satellite network. When an Iridium modem places a call to the RUDICS server located at the Iridium gateway, the RUDICS server connects the call to a predefined IP address, allowing an end-to-end IP connection between the host application and the Iridium modem. There are three key benefits of using RUDICS over the conventional PSTN circuit-switched data connectivity or mobile-to-mobile data solutions: (1) elimination of analog modem training time, (2) increased call connection quality, reliability, and maximized throughput, and (3) protocol independence.

IRIDIUM GEOLOCATION

The Iridium network makes calculations of the geographical location (geolocation) of an ISU each time a call is placed. The technique employed to determine the geolocation of an ISU is based on measurements of the ISU and satellite propagation delay and Doppler frequency shift. These measurements are used to estimate cosines of spherical angles that identify the ISU's location relative to the satellite by the gateway.

The Iridium network can locate an ISU to within 10 km only about 78% of the time. The so-called error ellipse can have a large eccentricity with the major axis oriented in the azimuth dimension and the minor axis oriented in the radial dimension. The position of the ISU in the radial dimension relative to the satellite can almost always be determined to within 10 km with just one measurement. Errors in the azimuth dimension relative to the satellite are largest along the satellite's ground path and tend to increase with distance from the satellite. Geolocation errors in the east-west dimension, therefore, are sometimes more than 100 times greater than in the north-south dimension.

APPENDIX D: DESIGN SPECIFICATIONS

MECHANICAL SPECIFICATIONS

Dimensions: ....2.73" L x 2.17" W x 0.94" D (69 mm x 55 mm x 24 mm)

Weight:...4.8 oz. (136 g)

Enclosure:..Hard anodized aluminum/EMI shielding Waterproof version of the enclosure is available (Model 9602-BTI)

Multi-Interface Connector: ....15-Pin D-Sub

Iridium Antenna:...SMA female

GPS Antenna: ....SMA female

OFF/ON Switch: ....Push Button

Emergency Switch:...Guarded Button and/or External via Multi-Interface Connector

Status LED Displays: ....Power, GPS, Iridium, SBD status and Emergency

IRIDIUM RF SPECIFICATIONS

Operating Frequency: ....1616 to 1626.5 MHz

Duplexing Method: ....TDD

Input/Output Impedance: ....50 Ω

Multiplexing Method: ....TDMA/FDMA

IRIDIUM RADIO CHARACTERISTICS

Average Power during a Transmit Slot (Max): 1.6W

Receiver Sensitivity at 50 Ω (Typical): ....−117 dBm

Maximum Cable Loss Permitted: ....2 dB

Link Margin–Downlink:....................................13 dB

Link Margin–Uplink:.......................................7dB

ELECTRICAL SPECIFICATIONS

Input Voltage Range:......................................+3.6 VDC to +5.3 VDC or +6.0 VDC to +32 VDC

Main Input Voltage Ripple: ....< 40 mV peak-to-peak

Transmit Current (Average): ....200 mA @ 5 VDC

Transmit Current (Peak): ....1.5 A @ 5 VDC

Receive Current (Average): ....45 mA @ 5 VDC

Receive Current (Peak): ....195 mA @ 5 VDC

Message Transfer Power (Average): ....<= 1.0W @ 5 VDC

Current in Between Reports:.............................Less than 65 µA @ 5 VDC

Power Input Type:...DC power or Li-ion battery

Note: The DC power requirement was measured at the 9602-BTI multi-interface connector and not at the DC power supply. Take into account voltage drop across the power supply cable to ensure adequate current provided to the 9602-BTI during SBD sessions. If input voltage does not stay above 3.0 VDC during surge or high current demand, the 9602-BTI will reset itself.

Note: The average current drawn during transmission may vary depending on the field-of-view between the 9602-BTI antenna and the Iridium satellite, the type of Iridium antenna used, and the cable loss.

ENVIRONMENTAL SPECIFICATIONS

Operating Temperature Range:..........................−40°F to +185°F (−40°C to +85°C)

Operating Humidity Range: ....≤ 75% RH

Storage Temperature Range:.............................−40°F to +185°F (−40°C to +85°C)

Storage Humidity Range: ....≤ 93% RH

Note: Operating temperature range based on a duty-cycled usage model with the stand-alone 9602 transceiver sending one SBD message per hour and is otherwise turned off during the hour.

DATA I/O SPECIFICATIONS

Short-Burst Data Mobile-Originated:...................340 bytes per message

Short-Burst Data Mobile-Terminated: ....270 bytes per message

Hardware Interface: 3-Wire RS232

Software Interface: ....AT commands

RELATED HARDWARE

Antennas: ....SYN7391 Series, SAF2040 Series,

SAF5340 Series, SAF5350 Series,

SAF4070-IG, SAF7352-IG and SAF5270-G

AC Power Adapter: ....LA-3098 (100–240VAC, 47–60Hz input)

Car Adapter:..LA-7021 (12VDC car battery input)

Power Cable: HRC-24-12, HRC-24-12A

APPENDIX E: GPS PERFORMANCE DATA

Type of GPS Receiver: ....NEO-6Q from u-blox AG

Receiver Type: ....L1 frequency

C/A code

50-Channel

SBAS: WAAS, EGNOS, MSAS, GAGAN

Update Rate: ....5 Hz

Accuracy:...Position: 8.2 feet (2.5 meters) CEP

Position DGPS/SBAS: 6.6 feet (2.0 meters) CEP

Acquisition (typical):.......................................Hot starts: 1 second

Aided starts: 1 second

Warm starts: 28 seconds

Cold starts: 28 seconds

Sensitivity: ....Tracking: –160 dBm

Reacquisition: –160 dBm

Cold starts: –147 dBm

Operational Limits:...COCOM restrictions apply

Altitude: 164,000 feet (50,000 meters)

Velocity: 1,640 feet/sec (500 m/sec)

One of the limits may be exceeded but not both

As long as power is provided to the 9602-BTI, the GPS receiver stores ephemeris data in its memory before turning off (sleeping between reports). The ephemeris data are valid up to two hours and can be used in future startup to improve time-to-first-fix. Unlike the 9601-DGS-LP, the 9602-BTI does not need an extra backup battery to retain ephemeris data.

APPENDIX F: MECHANICAL DRAWINGS

Milan will provide

Figure 41: 9602-BTI Mechanical Drawing