

# **AXTracker Users Manual**

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<b>AXTRACKER USERS MANUAL</b> .....	<b>1</b>
<b>1 AXTRACKER PRODUCT DESCRIPTION</b> .....	<b>4</b>
1.1 AXTRACKER FEATURE SET OVERVIEW.....	5
1.2 SUPERVISORY POSITION REPORTING.....	6
1.2.1 <i>Delay to Start Interval</i> .....	7
1.2.2 <i>Alarm Interval-Override Mode</i> .....	7
1.2.3 <i>Line-Powered Mode</i> .....	8
1.2.4 <i>24 hour Mode</i> .....	9
1.3 ALARM INPUTS.....	9
1.3.1 <i>External Alarm Inputs</i> .....	10
1.3.2 <i>Motion Alarm</i> .....	10
1.3.3 <i>Alarm Mode</i> .....	11
1.3.4 <i>Alarm Hysteresis &amp; Priority</i> .....	12
1.3.5 <i>Alarm Configurations Table</i> .....	13
1.3.6 <i>Alarms during Delay-to-Start interval</i> .....	17
1.3.7 <i>Wake from Alarm</i> .....	17
1.4 GEO-FENCING OPERATION.....	18
1.4.1 <i>Geofencing Interval-Override Operation</i> .....	18
1.4.2 <i>Line-Power Geofencing Boundary Exception Operation</i> .....	19
1.5 GPS LOCATION FAILURE.....	20
1.6 RAS SITE AVOIDANCE.....	20
1.7 SETUP MESSAGE.....	21
1.8 STATISTICS MESSAGE.....	21
1.9 UNIT RESET.....	21
1.10 DETAILED PRODUCT SPECIFICATION.....	22
1.10.1 <i>Environmental Product Specification</i> .....	22
1.10.2 <i>Product Battery Life</i> .....	23
<b>2 ON-AIR MESSAGE FORMAT</b> .....	<b>24</b>
2.1 STATUS BYTE.....	24
2.2 DEFAULT (STANDARD) AXTRACKER MESSAGE.....	25
2.2.1 <i>Calculating Lat/Long from AXTracker Messages</i> .....	26
2.2.2 <i>Calculating Delta Lat/Long for RAS and Geofencing</i> .....	27
2.3 TRUNCATED AXTRACKER MESSAGE.....	30
2.3.1 <i>Line-powered Truncated AXTracker message</i> .....	30
2.4 RAW PAYLOAD MESSAGE.....	31
2.4.1 <i>Line-powered Raw AXTracker message</i> .....	31
2.5 AXTRACKER SETUP MESSAGE.....	31
2.6 AXTRACKER SETUP2 MESSAGE.....	32
2.7 AXTRACKER STATISTICS MESSAGE.....	33
2.7.1 <i>Statistics Message byte 2 - Bat Low/Number of Tries</i> .....	33
2.7.2 <i>Statistics Message byte 5 - GPS Mean Search Time</i> .....	34
2.7.3 <i>Statistics Message byte 6 - # GPS Fails</i> .....	34
2.7.4 <i>Statistics Message bytes 7&amp;8 - Alarm Statistics</i> .....	34
2.7.5 <i>Statistics Message byte 9 - # Transmissions</i> .....	35
<b>3 CONFIGURATION I/O PORT INTERFACE</b> .....	<b>36</b>



3.1	CONFIGURATION PORT CONNECTOR DEFINITION .....	36
3.2	CONFIGURATION PORT PIN DEFINITIONS.....	37
3.2.1	<i>Pin 1 – External Voltage</i> .....	37
3.2.2	<i>Pin 2 – Common / Ground</i> .....	37
3.2.3	<i>Pins 3-6 – Alarm inputs</i> .....	37
3.2.4	<i>Pins 7-9 – Serial Interface</i> .....	38
3.2.5	<i>Pin 10 – OC Output</i> .....	40
3.3	DEFAULT FACTORY CONFIGURATION.....	41
3.4	UNIT ACTIVATION.....	42
<b>4</b>	<b>CONFIGURATION AND REMOTE SMART SENSORS .....</b>	<b>43</b>
4.1	SERIAL PACKET FORMAT .....	43
4.2	TRUNCATED AXTRACKER MESSAGING (SERIAL MESSAGE TYPE 0x26).....	45
4.2.1	<i>Line-Powered Truncated Messaging</i> .....	45
4.3	RAW PAYLOAD MESSAGING (SERIAL MESSAGE TYPE 0x27).....	46
4.3.1	<i>Line-Powered Raw Messaging</i> .....	46
	<b>APPENDIX A: TRACKER OPERATION OVER TEMPERATURE .....</b>	<b>48</b>
	<b>APPENDIX B: BATTERY-ONLY VS. LINE-POWERED AXTRACKER VERSION DEFINITION.....</b>	<b>50</b>
	<b>APPENDIX C: INTERVAL-OVERRIDE EXAMPLES.....</b>	<b>53</b>
	<b>APPENDIX D: REGULATORY NOTICES .....</b>	<b>57</b>



## 1 AXTracker Product Description

AXTracker is a battery operated, ready-to-go telemetry device designed to communicate with the Globalstar satellite constellation and provide cost-efficient and reliable asset tracking and fleet management.

The AXTracker features a compact rugged enclosure designed to attach easily, with either screws or automotive grade adhesive, to the top of a cargo container, railcar or trailer. Once service is established with Globalstar, AXTracker sends information to Globalstar satellites which relay the information to ground stations. The processed information is then available to the user via the internet. The device is delivered complete and ready-to-go with no need for an external antenna or power source.



### Feature Set Overview:

- Configurable location updates:
  - Programmable intervals, 30 minutes to 45 days – up to 12 sequential intervals.
  - Time of day – up to 12 specific time of day triggers.
  - Interval-override configuration to suspend scheduled location updates and provide an alternate update interval for a configurable time duration or the duration of the alarm input. Triggered by alarm or Geofence function.
- Up to four independently configurable alarm inputs
  - Dry contact alarm inputs with configurable edge detection
  - Configurable with or without GPS location determination
  - May be configured to engage interval-override
- Integral motion sensor configurable as an alarm function.
- Geofence operation
  - Region match function.
  - May be configured to engage interval-override.
- Serial interface port for configuration and smart sensor or user data input.
- 63 user-definable Geo-fencing regions used to flag device boundary exceptions
- 3 to 7+ years battery life depending on configuration
- NEMA4X, SAEJ1455 compliant packaging with quick installation using either industrial adhesives or screw mount.
- Total packaged solution. No harnesses required, no external power required, no antennas required.



- Unit initiation via harness (dongle pushbutton) or PDA setup for site configuration if desired.
- Battery and Line-power versions supported. Line power features include enhanced geofencing and message packing.
- Message types:
  - Setup message: transmitted once on device start of service life.
  - Location/Alarm: contains GPS, alarm plus Geofence match
  - Truncated location: GPS plus up to 2.75 bytes user data
  - Raw: up to 8.75 bytes of user data
  - Statistics: operational data including low battery, transmitted on programmed interval
- Special Alarm monitor features:
  - Count alarms since last statistics message
  - Count hours of alarm activity cumulative (run-time meter)

AXTracker differentiates itself by offering battery-operation with multi-year battery life (3-7+ years), easy installation and worldwide coverage. AXTracker features the Axonn simplex modem compatible with the Globalstar network system. Reliable, one-way simplex communication provides fundamentally lowest cost tracking solution available.

The AXTracker unit may be configured for use using a hand-held PDA tool or PC tool with appropriate interface cables. The PDA and PC tools support easy configuration of the AXTracker device in depot-service or field-installation environments. The tools provide graphical user entry of configuration data using the serial/configuration port of the AXTracker device.

The configuration port of the AXTracker device supports sensor connectivity as well as configuration via protocol documented in the AXTracker product specification. This document describes the use of the PDA and PC tools for configuration of the device. Users who wish to write their own configuration tools will need to conform to the protocol described in the product specification available from Axonn. A non-disclosure agreement is required to receive the detailed product specification.

## **1.1 AXTracker Feature Set Overview**

The AXTracker provides essentially three basic functions when located in clear view of the sky:

- Location of asset on a programmable supervisory interval, typically a few instances per day.
- Notification of alarm condition, example: door open, motion or motor on/off.
- Geofencing filter: notification of location based event condition concurrent with supervisory or alarm event.

The device is well suited for use with container or trailer asset tracking affixed to the top or other location as appropriate. The unit transmits periodic and/or event driven position information.

The AXTracker generates messages using a simplex modem to the Globalstar network. The system is therefore one-way with no handshake or back channel data from the network.



The AXTracker includes the sub-assemblies necessary to support the functionality described in the following sections including:

- STX Transmitter Board with antenna – Axonn simplex modem to the Globalstar network
- GPS Unit with antenna– Used to calculate location information
- Integral Battery - Capable of multi-year operation
- I/O port – to configure device, input alarms and serve smart, serial sensors.
- Controller Unit – to manage integral resources and engage reduced power states

Additionally, the AXTracker may also be connected to a smart serial sensor to process data for transmitting to the satellite network. The AXTracker will perform functions in a prioritized method where the serial interface is the highest priority followed by alarm inputs followed by supervisory reporting. The assumption is that the external interface may preempt an active GPS location determination or ongoing transmission of data. An abort of internal function due to serial interface override is recorded similar to a lost GPS signal and recorded in status bits on a subsequent message.

## **1.2 Supervisory Position Reporting**

The AXTracker shall automatically report its position at regular time intervals. The reporting interval shall be programmable by the user. This function can also be enabled or disabled by the user.

The unit allows for up to 12 sequentially executed delay intervals to time between location determination functions. The unit may be configured via the configuration port to enable between 1 and 12 discrete time delays executed in sequence. Setting a specific sequence interval to zero disables that step and subsequent sequence steps. Setting all sequence intervals to zero disables Supervisory Position Reporting.

Each sequence interval may be unique from 30 minutes to 45 days. (0-65535 where each count = one minute. Non-zero values less than 30 decimal are invalid) Up to 12 intervals may be defined. Setting the device to operate with 1 interval enables a uniform wake interval. Setting the device to operate with more than 1 interval will configure the device to sequence through each delay repeating the sequence of non-zero intervals. The AXTracker will sequence through the interval table until it encounters a zero value, then reset to the beginning of the table repeatedly through service life.

The unit will time wake intervals using an integral crystal. Time drift will occur at this crystal drift rate and be less than one (1) minute per year of operation. No real-time GPS-compensation is necessary to maintain this level of accuracy.

The default configuration for the unit is a single sequence with a 12-hour delay interval resulting in 2 position notification messages per day.

The default configuration may be overwritten using a setup tool. It is the user's responsibility to ensure the sum of interval delays suits the application requirement (i.e. total of delay cycles



divides by an integer multiple into a 24 hour day for uniform daily time reporting).

Supervisory position reporting events always generate a GPS location attempt.

At each Position Reporting Interval event, the AXTracker shall compute its location, collect alarm status, calculate geofencing exceptions then transmit the computed position with appended status data.

### **1.2.1 Delay to Start Interval**

The unit may be configured to commence operation at a specific delay following setup. The setup tool may configure a delay-to-start instructing the unit to begin service life at a specific point in time following setup. The unit may be configured to begin operation within the next 45-day period to a resolution of 1 minute. This feature may be enabled or disabled using the setup tool interface. The factory default condition is a random number less than 24 hours.

**Note:** The AXTracker accepts a delay to start, NOT a time and date to start. The setup tool must translate this delay parameter to a time and date if desired for user confirmation.

**WARNING:** Users are strongly advised that this feature should be enabled using a pseudo-random delay-to-start to secure the best network services from the Globalstar network. Configuring multiple devices to operate on the same report time will inherently cause network collisions and limit performance. It is strongly advised that the user seed the Delay-to-Start parameter with a randomized delay to stagger device initial report time. Subsequent reports will be timed from the initial report and the device will commence uniform reporting per configuration.

**For this reason, the default factory value for Delay-to-Start will be a random number less than 24 hours.**

Timing information will be preserved as long as the battery remains connected and serviceable. Internal power disconnect will require reset to configuration to restore alignment to a specific time of day if necessary. Sequence will begin at the start of the interval delay table upon power restoration.

The AXTracker will generate a first position report following completion of a delay-to-start if the delay-to-start is greater than or equal to 30 minutes. Delay-to-start values below 30 minutes will not generate a position report as it might conflict with the Setup message.

### **1.2.2 Alarm Interval-Override Mode**

The unit may be configured to override supervisory position report interval timing upon alarm assertion if the alarm is configured for Interval-Override mode. An alarm configured as such will cause the unit to suspend supervisory interval reporting and enter into override mode. While in



override mode, the device will perform GPS location determination and reporting at a new (single) interval for a new duration. Both the new interval and duration are configurable parameters. Optionally, the duration may be disabled and the device will override while the alarm is held active. In this configuration, the device will engage a new interval while the alarm is asserted, returning to the original interval schedule once the alarm is released. This mode enables the device to engage an alternate position reporting interval following an alarm then resumes the configured position-reporting schedule.

The time-base for the standard position reporting is delayed by the duration of the Interval-Override function. This will skew the schedule by the duration of override mode.

A second alarm configured for Alarm Interval-Override mode while in Alarm Interval-Override mode will restart the override process. Release of the second alarm will return the unit to the original schedule NOT the first interval-override.

Interval Override mode may engage a new interval with a minimum setting of 5 minutes. Note that if short intervals are selected, the redundant messaging of the STU device may be aborted to send the next message. Also note that short intervals and interval-override in general can significantly impact battery life. Battery estimates assume only a few transmissions a day. Interval override can make a couple of transmissions a day turn into dozens a day, reducing battery life proportionally. See appendix C for further discussion on short interval operation.

This mode is disabled for factory default alarm configuration.

### **1.2.3 Line-Powered Mode**

The unit may be hardware-configured (purchased as line-powered operable) to be connected to external voltage (12-24 VDC automotive) to enable line-powered operation. If the unit is line-powered capable, several new configurations are possible to take advantage of constant power. See Appendix B for more discussion on line versus battery product versions.

The interface connector of the unit contains three power input pins to enable line operation. The unit is designed primarily for automotive and uses these interface pins to connect to line power, typically the battery, ground and ignition. The battery pin is used to detect the presence of line power. It disengages the internal battery when voltage is present on this pin, but the device remains in battery mode, operationally no different than internal battery operation.

The ignition sense input is Alarm 3. Applying line voltage to Alarm 3 will trigger the AXTracker into line mode if configured to do so. The line-powered AXTracker may be configured to enable Geofencing boundary messages while Alarm 3 is asserted. If enabled, the AXTracker will sample the GPS module every 10 minutes. This allows the AXTracker to check location and compare against the geofencing table. Boundary crossings can be detected and a message sent at boundary exceptions. Messages are only sent in Geofencing Boundary mode on boundary crossings. Once ignition (Alarm 3) is terminated, the device reverts back to the programmed interval schedule.



The AXTracker may be configured to engage the Interval-Override interval and duration upon ignition (alarm 3) assertion. If enabled, the AXTracker will detect the presence of ignition-on and use the parameters of the interval override to suspend supervisory reporting schedule and engage a new rate for a new duration or while alarm 3 is asserted.

Additionally, the unit may be configured to “pack” reporting messages while in line-powered mode and ignition is “on”. The AXTracker will queue the supervisory location messages to aggregate 4 together before sending a 36-byte payload of location updates. Packing is only provided for message type 0 (supervisory location messages) generated through interval timeout. Alarm and serial input messages are not queued and operate as in battery mode. Packing reduces system messaging 4:1 and reduces network costs significantly. Packing is only available in line-powered mode since the internal battery cannot provide pulse current to enable 36 byte payloads. If enabled, the AXTracker will pack messages while Alarm 3 is active. When Alarm 3 becomes inactive, the AXTracker will transmit any messages currently queued (which may be 9 byte, 18 byte or 27 bytes in payload length) on the next scheduled report time; then revert back to 9 byte messaging thereafter.

#### **1.2.4 24 hour Mode**

The above discussed interval-table operation may be replaced with a time-of-day operation whereby the unit will calculate sleep intervals based on specific time of event from the table. In this mode, the interval table contains time events (hours and minutes). The parameter range is limited to minutes in a day with values exceeding the limit treated as end of table. Setting a bit in the advanced features command (type 0x35) enables this mode of operation.

While in 24-hour mode, the AXTracker will ascertain real time from all successful GPS fix determinations. Following each position report function, it will calculate the appropriate interval to the next report event time in the table (managing roll-over at midnight appropriately).

Delay to start and interval-override operation remains unchanged. The unit may require an off-schedule location report following delay to start or interval override to recalculate the appropriate delay to get back onto the 24-hour schedule. The unit may be provided with correct time of day information at configuration that will enable the device to calculate first report correctly. If the correct time of day is not available at end of delay to start, it will be determined on first GPS fix for subsequent report event alignment.

Specific event times are modified by the Dither parameter to force randomization and limit network collisions. Values in the table are GMT based, with no correction for Daylight Savings Time.

### **1.3 Alarm Inputs**

The AXTracker shall detect changes in state of up to 4 independent alarm inputs accessible via the I/O interface port plus an internal motion alarm. Each external alarm input is provided to the unit interface connector and weakly pulled up to internal voltage enabling dry-contact to ground type



alarm inputs.

The AXTracker shall also detect changes in the state of an internal motion sensor. The motion sensor operates as a fifth alarm source of higher priority than the external alarm inputs.

### **1.3.1 External Alarm Inputs**

The AXTracker shall detect changes in state of up to 4 independent alarm inputs accessible via the I/O interface port plus an internal motion alarm. Each external alarm input is provided to the unit interface connector and weakly pulled up to internal voltage enabling dry-contact to ground type alarm inputs. Each external alarm is independently configurable in one of four state-change definitions:

- Alarm setup 0= Disabled
- Alarm setup 1= open-to-close detection
- Alarm setup 2= close-to open detection
- Alarm setup 3= change state (either open-to-close or close-to-open)

The transmitted message (type 0) contains an alarm status byte with two bits reserved for each of the 4 external alarm inputs. One bit will indicate that an alarm occurred, and the other bit will indicate the state of each alarm input sampled following the event condition. Alarm inputs states are sampled approximately 250 msec after the alarm event. Short duration alarms under 250 msec may generate alarm level errors reported. The alarm will not be missed, but the reported level may be inaccurate.

Each alarm is independently configurable to enable a GPS location fix. If enabled, an alarm condition will result in a message with an embedded GPS location. If disabled, an alarm condition will result in a message with null (zeros) GPS location. Alarms may also be configured to enable interval-override function where the AXTracker sends position reports at an alternate rate for an alternate duration.

At each alarm event, the AXTracker shall compute its location if enabled for that alarm, collect alarm status, calculate geofencing exceptions (if GPS location is enabled) then transmit the computed position with appended status data. The geofence byte will be set to zero if no GPS fix is enabled for the alarm input.

Alarms 2 and 3 may also be configured to count alarms or accumulate hours of activity. Alarm 3 is also used to detect available line power in the line-powered version of the AXTracker.

### **1.3.2 Motion Alarm**

The AXTracker will include a motion sensor to detect if the unit is stationary or in motion. The motion sensor has a hysteresis timeout that prevents short-duration motion from changing state. The unit must remain in motion for at least the hysteresis timeout before the alarm is asserted. A similar hysteresis timeout is applied to cease-motion alarm. The motion sense alarm triggers after



the unit is in motion or ceases motion for the motion hysteresis window.

The AXTracker motion detection may be enabled or disabled. If enabled, the motion alarm may be configured to the same modes of operation as the external alarm inputs. Appendix E discloses the algorithm used to engage and disengage motion.

### **1.3.3 Alarm Mode**

Each of the alarms may be configured in one of several modes of operation triggered by the alarm setup state. The following modes are available to any of the external alarm inputs as well as the internal motion alarm. The alarm modes are defined as:

- Mode 0 = No GPS Fix
- Mode 1 = GPS Fix
- Mode 2 = Interval-Override for programmed duration
- Mode 3 = Interval-Override for alarm duration

Mode 0 configures the alarm to calculate a GPS fix to send a message containing GPS location. The transmitted message will occur following GPS fix which may take several minutes to ascertain. Failure to ascertain GPS Fix will be handled as any other fix failure, with a retry or no retry depending on GPS Retry configuration.

Mode 1 configures the alarm to send an immediate message with null GPS data. The transmitted message will occur immediately following alarm. This is the most power conservative mode for alarm processing.

Mode 2 configures the alarm to engage interval-override mode on detect using the new interval and new duration programmed via serial message type 0x34. The unit will perform a GPS fix and report on alarm start and repeat the operation separated by the override interval. The unit returns to the normal interval schedule when the duration is expired though the interval schedule will be skewed in time equal to the interval override duration.

Mode 3 configures the alarm to engage interval-override mode on detect using the new interval programmed via serial message type 0x34 for the duration of the asserted alarm. The unit will perform a GPS fix and report on alarm start and repeat the operation separated by the override interval. The unit returns to the normal interval schedule when the alarm is unasserted though the interval schedule will be skewed in time equal to the alarm duration.

#### **1.3.3.1 Interval-Override operation with Alarm Setups**

Each of the alarms is configured for state detection as well as mode of operation. The modes of operation are triggered by the state of detection, so users should be aware that certain configurations might have serious impact to battery life. Interval-Override for specific mode configurations should be carefully selected to prevent undesired operation.



External alarm inputs trigger the mode of operation on negative, positive or both. If the unit is configured for both (setup state 3), the device will perform the desired mode on both falling and rising edges of the alarm input pin. Interval override modes (2 & 3) for alarm state 3 are not permitted, as it will create a situation where the device could remain in interval override forever. Interval-override modes (2&3) require the user select alarm states (0, 1 or 2) as a trigger state.

Configuring the device for NEG alarm state (1) and interval-override will initiate interval override on transition of high to low (switch open to switch closed) on the alarm pin. Similarly, configuring interval-override for the motion sensor on motion enable will initiate interval-override on motion detect.

Configuring the device for POS alarm state (2) and interval-override will initiate interval override on transition of low to high (switch closed to switch opened) on the alarm pin.

### **1.3.4 Alarm Hysteresis & Priority**

The AXTracker will initiate a hysteresis timeout on the detection of any alarm input including motion. This hysteresis window is a programmable value ranging from 0 to 63 minutes in one-minute resolution. The purpose of the hysteresis window is to prevent alarms from interrupting ongoing alarm function for a blanking window.

The first release product had this hysteresis function fixed (not configurable) as set by the transmit sequence time. The AXTracker now has the ability to select the appropriate hysteresis window based on the application with possible degradation of data reliability as a tradeoff.

Each of the alarm inputs uses the same hysteresis window. The hysteresis window starts on detection of an activated (enabled) alarm. While the hysteresis timer is running, subsequent enabled alarms will be detected but not acted upon. The “missed” alarms are logically OR’d into the status byte alarm mask to denote the alarm was not acted upon. If the message has not yet started to be transmitted, the logical OR’d missed alarm information will be sent along with the first alarm data. For example, if the first alarm is configured to perform a GPS fix, and the GPS acquisition is in progress when the second alarm occurs, the second alarm is “missed” with a record of the missed alarm being recorded in the status byte of the GPS data message when ready.

If on the other hand the message transmission has started upon receipt of the second alarm, the missed alarm information is stored for the next valid transmit sequence. For example, if the first alarm was sent and the unit is still in the sequence of sending the redundant copies of the first alarm, the second alarm “missed” bits will not be added to the ongoing message transmission sequence but stored for subsequent transmission.

Both of these examples assume the alarm hysteresis window is active when the second alarm occurs. If the hysteresis window has expired when the second alarm occurs, the AXTracker will begin acting on the alarm depending on the configured mode. Any previous transmissions or action for previous alarms or lower priority events will be terminated. Terminated alarms that have not yet sent a transmission will be logically OR’d into the status byte as “missed” alarms.



Terminated events that have begun transmission sequence will be aborted. This may truncate the programmed number of redundant transmissions and reduce network data throughput reliability.

### 1.3.5 Alarm Configurations Table

Some of the alarm configurations are incompatible in function. For example, the AXTracker will not accept interval-override configuration on the “ANY” mode as it could engage interval override indefinitely. The following tables depict the different alarm configurations, functions and allowable settings:

**Alarms 1 or 4 Configuration Matrix**

Alarm	Setup	Mode	Count/ Accum	Comment
1 or 4	Disable (0)	Any	NA	Disables alarm input from any action
	NEG (1)	Disable GPS (0)	NA	Transmits alarm message immediately on alarm pin short to GND.
	NEG (1)	Enable GPS (1)	NA	Transmits alarm message following GPS location fix on alarm pin short to GND.
	NEG (1)	Interval-override for time duration (2)	NA	Suspends supervisory reporting and starts performing GPS fix with report at new I-O interval for I-O duration on alarm pin short to GND.
	NEG (1)	Interval-override for alarm duration (3)	NA	Suspends supervisory reporting and starts performing GPS fix with report at new I-O interval while alarm is LOW (shorted to GND).
	POS (2)	Disable GPS (0)	NA	Transmits alarm message immediately on alarm pin open-circuit from GND.
	POS (2)	Enable GPS (1)	NA	Transmits alarm message following GPS location fix on alarm pin open-circuit from GND.

**Alarms 1 or 4 Configuration Matrix continued**

Alarm	Setup	Mode	Count/ Accum	Comment
1 or 4 cont.	POS (2)	Interval-override for time duration (2)	NA	Suspends supervisory reporting and starts performing GPS fix with report at new I-O interval for I-O duration on alarm pin open-circuit from GND.
	POS (2)	Interval-	NA	Suspends supervisory reporting and



	override for alarm duration (3)		starts performing GPS fix with report at new I-O interval while alarm is HIGH (open-circuit to GND).
ANY (3)	Disable GPS (0)	NA	Transmits alarm message immediately on open OR close of alarm pin to GND.
ANY (3)	Enable GPS (1)	NA	Transmits alarm message following GPS location fix on open OR close of alarm pin to GND.
ANY (3)	Interval-override for time duration (2)	NA	Invalid configuration. Device will NAK this setting.
ANY (3)	Interval-override for alarm duration (3)	NA	Invalid configuration. Device will NAK this setting.

**Alarms 2 or 3 Configuration Matrix**

Alarm	Setup	Mode	Count/ Accum	Comment
2 or 3	Disable (0)	Any	NA	Disables alarm input from any action
	NEG (1)	Disable GPS (0)	Count (0)	Transmits alarm message immediately on alarm pin short to GND. Alarms counted for Statistics.
	NEG (1)	Disable GPS (0)	Accum (1)	Transmits alarm message immediately on alarm pin short to GND. Hours accumulated for Statistics.
	NEG (1)	Enable GPS (1)	Count (0)	Transmits alarm message following GPS location fix on alarm pin short to GND. Alarms counted for Statistics.

**Alarms 2 or 3 Configuration Matrix continued**

Alarm	Setup	Mode	Count/ Accum	Comment
2 or 3 cont	NEG (1)	Enable GPS (1)	Accum (1)	Transmits alarm message following GPS location fix on alarm pin short to GND. Hours accumulated for Statistics.
	NEG (1)	Interval-override for	Count (0)	Suspends supervisory reporting and starts performing GPS fix with report



	time duration (2)		at new I-O interval for I-O duration on alarm pin short to GND. Alarms counted for Statistics.
NEG (1)	Interval-override for time duration (2)	Accum (1)	Suspends supervisory reporting and starts performing GPS fix with report at new I-O interval for I-O duration on alarm pin short to GND. Hours accumulated for Statistics.
NEG (1)	Interval-override for alarm duration (3)	Count (0)	Suspends supervisory reporting and starts performing GPS fix with report at new I-O interval while alarm is LOW (shorted to GND). Alarms counted for Statistics.
NEG (1)	Interval-override for alarm duration (3)	Accum (1)	Suspends supervisory reporting and starts performing GPS fix with report at new I-O interval while alarm is LOW (shorted to GND). Hours accumulated for Statistics.
POS (2)	Disable GPS (0)	Count (0)	Transmits alarm message immediately on alarm pin open-circuit from GND. Alarms counted for Statistics.
POS (2)	Disable GPS (0)	Accum (1)	Invalid configuration. Device will NAK this setting.
POS (2)	Enable GPS (1)	Count (0)	Transmits alarm message following GPS location fix on alarm pin open-circuit from GND. Alarms counted for Statistics.
POS (2)	Enable GPS (1)	Accum (1)	Invalid configuration. Device will NAK this setting.
POS (2)	Interval-override for time duration (2)	Count (0)	Suspends supervisory reporting and starts performing GPS fix with report at new I-O interval for I-O duration on alarm pin open-circuit from GND. Alarms counted for Statistics.

**Alarms 2 or 3 Configuration Matrix continued**

Alarm	Setup	Mode	Count/ Accum	Comment
2 or 3 cont	POS (2)	Interval-override for time duration (2)	Accum (1)	Invalid configuration. Device will NAK this setting.



POS (2)	Interval-override for alarm duration (3)	Count (0)	Suspends supervisory reporting and starts performing GPS fix with report at new I-O interval while alarm is HIGH (open-circuit to GND). Alarms counted for Statistics.
POS (2)	Interval-override for alarm duration (3)	Accum (1)	Invalid configuration. Device will NAK this setting.
ANY (3)	Disable GPS (0)	Count (0)	Transmits alarm message immediately on open OR close of alarm pin to GND. Alarms counted for Statistics.
ANY (3)	Disable GPS (0)	Accum (1)	Transmits alarm message immediately on open OR close of alarm pin to GND. Hours accumulated for Statistics.
ANY (3)	Enable GPS (1)	Count (0)	Transmits alarm message following GPS location fix on open OR close of alarm pin to GND. Alarms counted for Statistics.
ANY (3)	Enable GPS (1)	Accum (1)	Transmits alarm message following GPS location fix on open OR close of alarm pin to GND. Hours accumulated for Statistics.
ANY (3)	Interval-override (2) or (3)	NA	Invalid configuration. Device will NAK this setting.



### 1.3.5.1 Motion Alarm Hysteresis & Priority

The motion alarm is treated as the highest priority alarm function if enabled. Motion start & stop alarms will interrupt ongoing supervisory location events; interval-override events and other alarm events including ongoing motion events. The alarm hysteresis timer will restart following the motion event.

For example, an Alarm 1 event that is not yet finished sending all redundant copies of the alarm message may be aborted if a motion alarm occurs independent of the hysteresis setting. Also, alarms that follow the motion event will only be serviced if they are outside the hysteresis window.

Additionally, if the unit is configured to send many redundant messages, it may be possible for a motion event to interrupt an ongoing report of previous motion event. The hysteresis window of the motion detection function mitigates this case.

Setting the hysteresis term to zero allows for motion and alarms to interrupt each other.

### 1.3.6 Alarms during Delay-to-Start interval

The AXTracker will process alarms normally following the Setup message including the Delay-to-Start interval. **Note: The entire Setup message including all redundant copies must be complete before alarms will be accepted.** Setup message operates at the same priority as serially commanded messages.

All alarms are serviced during delay to start including the internal motion alarm.

### 1.3.7 Wake from Alarm

Asserting an alarm input (low) to a device currently in inventory sleep will cause the unit to begin service life. Each of the 4 alarms may be used to wake the device, though each will perform a unique wake function as specified in section 3.4. The sequence of events following alarm is as follows:

- Wake, poll alarm of wake and reprogram intervals based on alarm (see section 3.4)
- Initiate a Setup message (transmits configuration data).
- Enable alarms and statistics message timer
- Resume low-power sleep with duration set by Delay-to-Start parameter (if non-zero)
- Generate first Position Reporting message (if delay-to-start is  $\geq 30$  minutes)
- Resume low-power sleep and begin executing interval delay(s)



## **1.4 Geo-fencing Operation**

The geofencing function provides limited ability for the AXTracker to detect that it has crossed the boundary of any of a set of circular areas (geofencing areas). The geofencing function is performed following successful GPS location determination. As such, the geofencing information is only provided upon interval timer wakeup with location determination or alarm wakeup with location determination (if enabled).

Up to 63 geofencing areas may be user defined and stored for use by the AXTracker in non-volatile memory. The geofencing areas are downloaded into the device via the configuration interface setup tool. Setting the number of geofencing areas to zero disables geofencing function.

The geofencing function compares the current location with the set of geofencing regions stored in memory. The AXTracker will sequentially evaluate each of the valid entries in the stored geofencing table, stopping at the first table match. If a geofencing match is found, the geofence ID field of the message will indicate the index of the area of exception. If the geofencing table is exhausted without match found, the geofencing ID field is set to zero.

Note that since the geofencing function is only calculated on scheduled or alarm wakeup, it is possible for the mobile device to transition geofencing areas without detection. Additionally, it is possible for the device to leave one area and enter a second area only recording one or the other. The only area to be reported will be the area first match found in the search list (smallest index).

While this is limited in function, it provides utility for many applications. The user should be aware of limitations and plan region definition accordingly.

Up to 63 geofencing areas may be programmed into the AXTracker. Each geofencing area is defined by a lat/long center with associated delta lat/long.

### **1.4.1 Geofencing Interval-Override Operation**

The AXTracker Geofencing interval-override function allows for the device to engage interval-override if the unit is determined to be outside all geofencing regions. This mode of operation is enabled or disabled only. If enabled, the device will engage the interval-override function enabling the new override interval when the location is detected to be outside all of the defined geofence regions. Once the location is determined to return inside one of the defined geofencing regions, it will return to normal interval operation. If the unit remains outside all geofencing regions, it will remain in interval-override mode indefinitely.

The interval-override duration parameter is not used for geofencing interval-override operation. The location is simply determined on the I-O interval with a decision to continue or not based on match to geofencing table. The device will not enter I-O if a Geofence table is not programmed.



**Warning: Care should be taken in selecting Geofencing triggered Interval-Override operation as it may seriously impact battery life of the product.**

### **1.4.2 Line-Power Geofencing Boundary Exception Operation**

The AXTracker Geofencing function becomes much more powerful in the line-powered version of the unit. The AXTracker may be enabled to detect geofence boundary crossings and generate messages on region change. If enabled, and the unit is powered externally, the AXTracker will operate in a modified interval-override function, sampling the GPS location every 10 minutes and comparing the sampled location to the geofence table. The sampled GPS location is not transmitted each sampling as in standard interval-override mode. The AXTracker will only send location data if it detects it has changed Geofence regions. The device will not enter boundary-exception mode if a Geofence table is not programmed.

Users should carefully design geoboundaries to help reduce boundary ambiguities for static device installations. For example, boundaries that bisect a yard or location of stationary storage should be avoided as they could result in messages being generated as often as once every 10 minutes, causing costly network billing.

Line-powered geofencing operation is active only while Alarm 3 (ignition) is asserted and if enabled. In the line-powered version, this will be detected by the AXTracker as a logic low as it is inverted by the internal power conditioning board.

#### **1.4.2.1 Line-Powered Boundary Exception Operational Conflicts**

Line-powered Geofencing Boundary Exception operates as a special case of interval-override. If enabled, the device will poll the Alarm 3 input every minute to determine if line-power (ignition) is ON. This is independent of any configuration setting for Alarm 3. If it detects the ignition is on, it will engage the boundary exception function. The boundary exception function uses the internal timers of interval-override to perform the 10-minute delay between GPS fixes.

While in boundary exception mode, as with standard interval-override mode the supervisory reporting intervals are disabled. Alarms are higher priority than interval-override and also boundary exception mode. Alarms will be processed as normal with the exception of alarms configured for interval-override. Non-interval-override alarms will complete their function and return to geofencing boundary exception mode.

**Warning: Alarms or other triggers enabled for interval-override will terminate boundary exception mode. The new interval-override will then be terminated again when the line-power is sampled a minute later. As a result, line-powered boundary exception mode should be the only interval-override enabled source configured if geofencing boundary detection is desired.**



## 1.5 GPS Location Failure

If the AXTracker cannot determine GPS location, it enters a reacquire algorithm. The AXTracker assumes that if the integral GPS elements cannot secure location information, visibility to the sky must be obscured. The AXTracker will enter a reduced power state for 15 minutes and then re-attempt to secure GPS location.

The AXTracker will attempt to secure information a total of 2 times separated by 15 minutes before aborting. If GPS location is derived in any of the 2 attempts, the location message is sent.

If a location is not available for 2 successive attempts, the AXTracker will abort the event (supervisory or alarm) and log each GPS failed attempt in the status byte of the next successful transmission. The status byte contains a 4 bit-mask field retaining the logical OR of alarm events plus a 2-bit count field used to count missed transmission attempts. The next successful transmission will contain this information indicating to the network that the device failed to secure GPS location and further indicating if any alarms were lost as a result of any event aborts. The count field will increment on each failure. The abort count will max at count 3. A successful GPS Fix acquisition clears the status byte following transmission.

**NOTE: Significant GPS failure events will impact AXTracker battery life performance. A maximum length GPS search uses 4 times the power from battery as a triple redundant STX transmission. The battery life estimate assumes the unit can predominately view the sky.**

Alternatively, GPS Retry may be disabled via setup configuration. If a GPS location is not determined and GPS Retry is disabled, the AXTracker will transmit a null (0 filled LAT/LONG) message. Default configuration of the AXTracker is GPS Retry enabled.

## 1.6 RAS Site avoidance

The AXTracker shall be configurable to operate on one of four selectable frequencies or in one of several multi-frequency modes. The configured transmit frequency shall be overridden if the AXTracker determines the location to be within close proximity to a table of Radio-astronomy sites (RAS).

When the AXTracker determines the location is within close proximity of the RAS site, it shall automatically use channel C as specified in the STX Simplex Modem specification. The RAS site proximity determination is identical to geofencing function as previously described.

The transmitter setup for RAS Avoidance shall use an alternate configuration as specified by Globalstar. Unique Power, Number of Attempts, Min and Max Intervals shall be used while transmitting in channel C. These settings shall be fixed and not configurable via the serial interface. Channel C settings = 5 messages, low power, Min=240, Max=360.

Up to 63 RAS sites are stored for use in the AXTracker at manufacture. Each site is characterized



by a lat/long origin and a delta-lat/long, which completely encloses a 100-mile radius area.

Once the unit is located out of range of the RAS site, it shall resume the configured frequency use function.

RAS site avoidance cannot be disabled. The AXTracker specification contains a table of the RAS regions defined for the product.

### **1.7 Setup Message**

The first message generated following inventory low-power sleep mode will be a Setup message. The Setup message contains operational parameters instructing the user and network provider how the device was configured for use.

The Setup message is only sent one time with configured repetitions. It is initiated upon any valid initiation method including commanded Run, Alarm initiation from inventory sleep or commanded Setup message via the configuration port.

This feature enables users to auto-confirm Globalstar provisioning for devices in field. Devices are provisioned by Globalstar or a Globalstar network provider, which essentially binds the transmitter's ID (ESN) to a user. Operational parameters are required by Globalstar to properly process the signals long term. The Setup message is generally received by the Globalstar network and relayed to the user. The user may parse the payload and generate a provisioning confirmation message with the content of the Setup message for sending back to Globalstar. Globalstar may confirm and update their database as necessary to ensure the operational configuration of the endpoint device matches the network database structure.

### **1.8 Statistics Message**

The unit may be configured to send a periodic message relaying operational statistics parameters, which can be used to measure unit performance on an ongoing basis. The parameters of the statistics message include transmitter setup configurations, battery low and GPS acquisition data. Data provided in the statistics message can be used to detect poor installation, imminent failure of device by battery and unit network throughput. The statistics message may be disabled or configured to report on a routine time base.

### **1.9 Unit Reset**

The AXTracker shall have the capability to determine whether it is functioning properly or not. If not, it shall reset itself and return to its previous operational configuration. Timing for message generation is restarted. A watchdog or other method may provide this safeguard. The unit sends a SETUP message if a reset during operation is detected (with watchdog bit set to 1).



## 1.10 Detailed Product Specification

This section provides a sample of the detailed product specifications. Additional data is available from the complete product specification. The complete product specification has precedence over this document.

### 1.10.1 Environmental Product Specification

The first message generated following inventory low-power sleep mode will be a Setup type message. The Setup message contains operational parameters instructing the user and network provider how the device was configured for use.

The following table is a summary of the environmental requirements of the unit. Mechanical shock and vibration shall be done with the unit mounted in a way similar to its operational configuration.

Parameter	Specification	Operational Range
Temperature	SAE J1455	-30 / +60 C normal, 40 / +80 C with battery life impact
Humidity	507.3 / I (cycle 2)	507.3 / I (cycle 2)
Salt Fog	509.3	509.3
Pressure Washing	SAE J1455	SAE J1455
Dust & Sand, Gravel	SAE J1455	SAE J1455
Vibration	SAE J1455	Vertical Fig 11 Transversal, Fig 8 div 5 Longitudinal, Fig 8 div 5 1 hr/axis
Shock	SAE J1455	SAE J1455
Solar radiation	SAE J1455	SAE J1455
Rain/ Blowing rain	SAE J1455	SAE J1455
Icing/Freezing Rain	SAE J1455	SAE J1455

**Summary Environmental Specifications**



### 1.10.2 Product Battery Life

Field-replaceable primary cell batteries shall power the AXTracker. The operational battery life shall comply with Table 1. The battery shelf life at 25C shall exceed 5 years.

Supervisory Position Reporting Per day	Alarms with Position Reporting Per day	Message Repetition	Calculated Battery Life	10% GPS Fail Battery Life
2	0	3	8.0 yrs	6.75 yrs
4	0	3	4.3 yrs	3.6 yrs
6	0	3	2.9 yrs	2.4 yrs
2	1	3	5.6 yrs	4.7 yrs
4	1	3	3.5 yrs	2.9 yrs
6	1	3	2.5 yrs	2.1 yrs

**Table 1, Battery Life**

These numbers assume the unit operating the majority of its life at 25C and low power TX mode. Extended temperature of use (outside -30 to +60 C) can significantly shorten battery life.

The 10% GPS fail column assumes that the GPS acquire attempts failed to have clear view of the sky and searched for max time and retried once.

These numbers corresponds to a digital input in Normally Open alarm type. Using the unit for Normally Close alarm applications may decrease slightly the battery life due to additional current required for weak pull-ups of alarms.

**NOTE: Significant GPS failure events will impact AXTracker battery life performance. A maximum length GPS search uses 4 times the power from battery as a triple redundant STX transmission. The battery life estimate assumes the unit can predominately view the sky.**

#### 1.10.2.1 Line-powered Battery Life

The line-powered version of the AXTracker uses the identical primary battery as the standard product providing the same battery life if unpowered. When connected to power, the internal primary battery is disabled, further extending the service life of the internal battery. See appendix B for more information about differences in the battery-only and line powered device.



## 2 On-Air Message Format

The on air AXTracker message follows the Axonn simplex modem standard compatible with the Globalstar network. This section specifies the data payload within the simplex modem protocol. Data is sent byte ordered, MSBit first.

### 2.1 Status byte

The AXTracker generates an on-air message containing at least one byte of information. The first byte of any on-air message is the status byte, which contains several bit fields. The two least significant bits of this byte denote message type. The remaining bits of the status byte are defined differently for each message type.

The AXTracker supports 4 unique message types defined by the message type bit field of the status byte. The message type encoded in the 2 least significant bits of the status byte. The upper 6 bits of the first byte denote a subfield function for message types 1, 2 and 3. Message type is encoded as:

Status Byte (1:0)	Message type
0	Default (standard) AXTracker message
1	Truncated AXTracker message
2	Raw payload message
3-0	Statistics messages – subfield 0 denotes SETUP Message
3-1	Statistics messages – subfield 1 denotes SETUP2 Message
3-2	Statistics messages – subfield 2 denotes STATISTICS Message
3-3	Statistics messages – subfield 3 denotes TEMPERATURE SENSOR Message

The standard AXTracker message (type 0) is the default message format for all internal AXTracker generated data. The status bits of message type 0 (Standard AXTracker message) are cleared following any valid type 0 message transmission.

Two auxiliary message types are supported by the AXTracker for use with external sensors via the serial interface of the configuration port. The configuration port of the AXTracker supports setup as well as in circuit use to connect external sensors for messaging. Message types 1 and 2 support this function.

Message type 3, Statistics, provides several different types of operational messages denoted by subfield code. Type 3-subfield 0 message is a Setup message that provides configuration data to the user and network provider upon activation of a device in field. Message type 3-0 is sent only once upon begin of service life of product or as directed via the configuration serial port.

Type 3-subfield 1 message is reserved for future additional setup type data.



Type 3-subfield 2 message is a Statistics message that provides operational data on a periodic basis that may be used to measure ongoing unit performance.

Type 3-subfield 3 message is an External Serial Sensor (ESS) Temperature Sensor message that provides temperature profile data for up to two temperature sensors. Operation, configuration and protocol for the ESS Temperature Sensor is disclosed in the AXTracker Temp Sensors Users Manual (Document # 9100-0138-01) available from Axonn.

## 2.2 Default (Standard) AXTracker message

Message type 0 shall be a standard AXTracker message. The standard AXTracker message is the default message format for all internal AXTracker generated data. The standard AXTracker message will follow the following on-air format:

Variable	Bits	Description
Status Byte	8	Bit (1:0) = 0 = Standard AXTracker message type: Bit (5:2) = logical OR for missed alarms Bit 2= Alarm1 Bit 3= Alarm2 Bit 4= Alarm3 Bit 5= Alarm4 Bit (7:6) = GPS fail abort counter
Latitude/Longitude	48	Byte 1 = Latitude MSByte Byte 2 = Latitude Byte 3 = Latitude LSByte Byte 4 = Longitude MSByte Byte 5 = Longitude Byte 6 = Longitude LSByte  360 degrees of longitude coded in signed binary with 3 bytes and 180 degrees of latitude coded in signed binary with 3 bytes. Positive longitude correspond to East Longitudes Positive Latitude correspond to North Latitudes
Digital Input Status	8	Bit 0: 0 = DI0 No alarm                    1= DI0 Alarm Bit 1: 0 = DI0 Level is 0                1= DI0 Level is 1 Bit 2: 0 = DI1 No alarm                   1= DI1 Alarm Bit 3: 0 = DI1 Level is 0                1= DI1 Level is 1 Bit 4: 0 = DI2 No alarm                   1= DI2 Alarm Bit 5: 0 = DI2 Level is 0                1= DI2 Level is 1 Bit 6: 0 = DI3 No alarm                   1= DI3 Alarm Bit 7: 0 = DI3 Level is 0                1= DI3 Level is 1 The “alarm” bit is set to 1 if the transmission was triggered by a status change matching configuration on the digital input.
Geo-fencing Location	6	Bits (5:0) define the index of the geo-fencing area coincident with current location. 0 = no geo-fencing area match
Motion	1	Bit (6) 0 = unit is stationary, 1 = unit in motion
2D/3D	1	Bit (7) 0=3D GPS Fix found, 1=2D GPS Fix found



### 2.2.1 Calculating Lat/Long from AXTracker Messages

- The AXTracker encodes 180 degrees of LATITUDE as a 24-bit (3-byte) signed integer.
- The AXTracker encodes 360 degrees of LONGITUDE as a 24-bit (3-byte) signed integer.
- The encoded LATITUDE data is the first three bytes of the data payload following the Status byte.
- The encoded LONGITUDE data is the next three bytes of the data payload.

Status	Lat2	Lat1	Lat0	Long2	Long1	Long0	Alarm	Geo
--------	------	------	------	-------	-------	-------	-------	-----

- **Lat2** – Latitude MSB
- **Lat1** – Latitude
- **Lat0** – Latitude LSB
  
- **Long2** – Longitude MSB
- **Long1** – Longitude
- **Long0** – Longitude LSB

#### ***CALCULATING LATITUDE FROM ENCODED TRACKER MESSAGES***

The latitude is converted in a similar manner. Latitude may be calculated by converting the 3 encoded latitude bytes represented in hexadecimal to a decimal number and multiplying this decimal integer by the **DEGREES\_PER\_COUNT\_LAT** conversion factor.

$$\text{DEGREES\_PER\_COUNT\_LAT} = 90.0 / 2^{23}$$

Since the latitude is signed and can range from -90 to 90 degrees, if the above result is greater than or equal to 90 degrees, 180 must be subtracted from the result.

Negative Latitude corresponds to Latitude in the SOUTHERN Hemisphere.  
 Positive Latitude corresponds to Latitude in the NORTHERN Hemisphere.

#### **Latitude Calculation Example:**

Tracker Data Payload:  
 0x002AB69CBFF46BAA00 (Hexadecimal)

The 24-bit encode latitude is 0x2AB69C (Hexadecimal)

This number converted to decimal (base 10) is: 2,799,260.

$$2,799,260 * (90.0 / 2^{23}) = 30.032802$$

Since this result is less than 90 degrees, no subtraction is necessary.

$$30.032802 \text{ degrees} = 30.032802 \text{ degrees NORTH}$$



## ***CALCUATING LONGITUDE FROM ENCODED TRACKER MESSAGES***

The longitude may be calculated by converting the 3 encoded longitude bytes represented in hexadecimal to a decimal number. This decimal integer is multiplied by the **DEGREES\_PER\_COUNT\_LONG** conversion factor.

$$\boxed{\text{DEGREES\_PER\_COUNT\_LONG} = 180.0 / 2^{23}}$$

If the above result is greater than or equal to 180 degrees, 360 must be subtracted from the result since the longitude is signed and can range from -180 to 180 degrees.

Negative Longitude corresponds to Longitude in the WESTern Hemisphere.  
Positive Longitude corresponds to Longitude in the EASTern Hemisphere.

### **Longitude Calculation Example:**

AXTracker Data Payload:  
0x002AB69CBFF46BAA00 (Hexadecimal)

The 24-bit encode longitude is 0xBFF46B (Hexadecimal)

This number converted to decimal (base 10) is: 12,579,947.

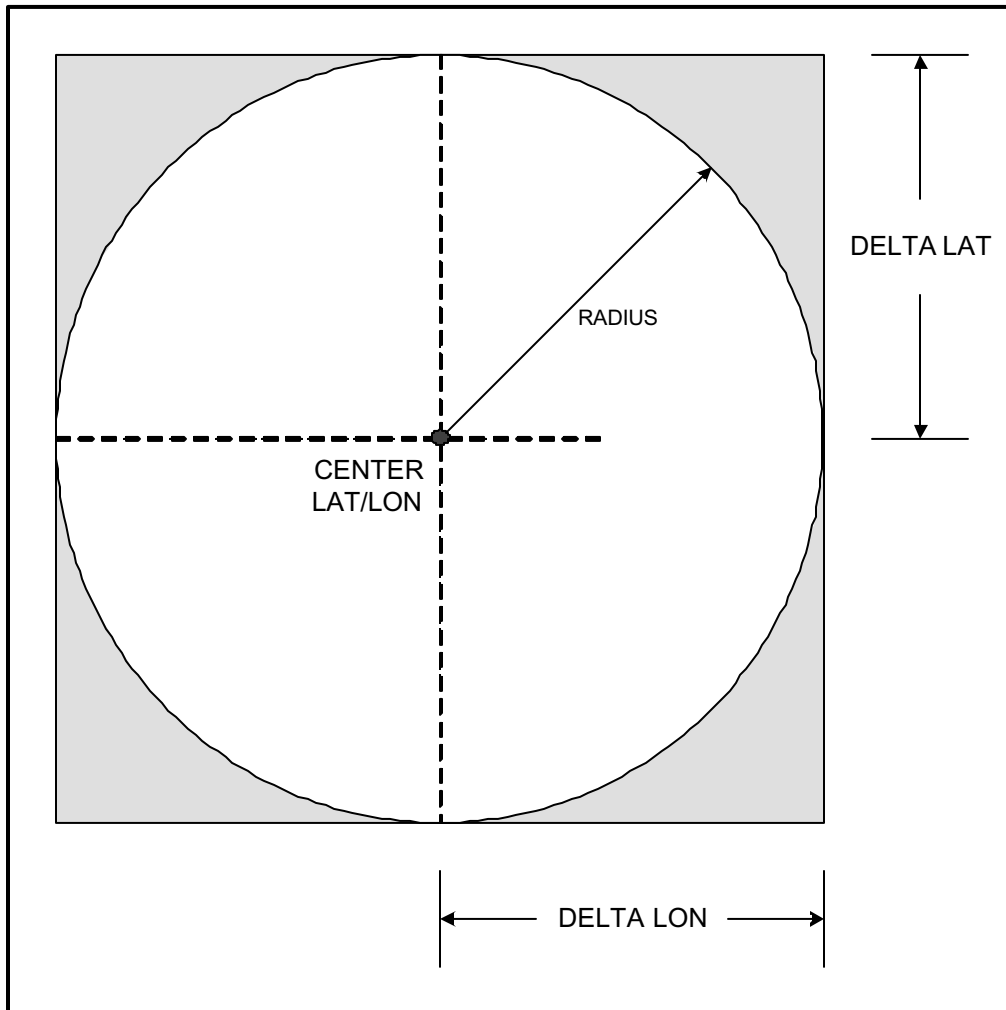
$$\boxed{12,579,947 * (180.0 / 2^{23}) = 269.936378}$$

Since this result is greater than 180 degrees, subtract 360 degrees from the result to create the correct signed representation.

$$\boxed{269.936378 \text{ degrees} - 360 \text{ degrees} = -90.063622 \text{ degrees} = 90.063622 \text{ degrees WEST}}$$

### **2.2.2 Calculating Delta Lat/Long for RAS and Geofencing**

- The AXTracker encodes degrees of DELTA LATITUDE as a 24-bit (3-byte) signed integer. (Same format as LATITUDE from above)
- The AXTracker encodes delta degrees of DELTA LONGITUDE as a 24-bit (3-byte) signed integer. (Same format as LONGITUDE from above)
  
- Each RAS and GEOFENCE area approximates a circular area defined by a center LAT/LON and a radius. Each area is defined in the AXTracker by a center LAT/LON and a DELTA LAT/ DELTA LON. It can be seen in the diagram below, that the shaded GEO/RAS area approximation completely encloses the area defined by the center LAT/LON and radius. This approximation is valid for center latitudes up to 80 degrees.



### ***CALCUATING DELTA LATITUDE***

- Delta latitude is calculated using the radius defined by the WGS84 reference ellipsoid, and the desired effective Geofencing radius.

$$r(\Phi) = \frac{a^2}{\sqrt{a^2 \cos^2 \Phi + b^2 \sin^2 \Phi}}, \text{ Where } \Phi \text{ is the latitude of the center LAT/LON,}$$

$a = 6378137$ , and  $b = 6356752.314$ . The units are in meters.

- Let R be the desired effective geofencing radius in meters. The delta LAT is given by the following formula:

$$\Delta LAT(\text{deg}) = \frac{180R}{\pi r(\Phi)}$$

Once computed, the delta latitude is encoded using the same scale as AXTracker latitude. (See example below)



### ***CALCUATING DELTA LONGITUDE***

- To calculate the delta longitude, first calculate the delta latitude at the center LAT/LON.
- Once the delta LAT has been computed, the delta LON is given by the following formula:

$$\Delta LON(\text{deg}) = \frac{\Delta LAT}{\cos \Phi}, \text{ Where } \Phi \text{ is the latitude of the center LAT/LON.}$$

- Once computed, the delta longitude is encoded using the same scale as AXTracker longitude.

### ***DELTA LAT/LONG EXAMPLE***

- Define a geofencing area centered at 30.5 degrees N, 90.25 degrees W with an effective radius of 50 miles.

$$r(30.5) = 6383643.48034 \text{ meters.}$$

$$R = 50(\text{mi}) * 1.61(\text{km/mi}) * 1000(\text{m/km}) = 80500 \text{ meters.}$$

$$\Delta LAT(\text{deg}) = \frac{(80500)(180)}{\pi(6383643.48034)} = 0.722520 \text{ degrees.}$$

$$\Delta LON(\text{deg}) = \frac{0.722520}{\cos(30.5)} = 0.838551 \text{ Degrees.}$$

Next, encode the delta LAT/LON values.

**To encode delta LAT, multiply by 1/DEGREES\_PER\_COUNT\_LAT = 2<sup>23</sup> / 90.0.**

$$0.722520 * 2^{23} / 90.0 = 67593.53912.$$

Round the result to the nearest whole integer, and convert to hexadecimal.

$$\text{Int2Hex}(67594) = 0x01080A \text{ (24-bit)}$$

**To encode the delta LON, multiply by 1/DEGREES\_PER\_COUNT\_LONG = 2<sup>23</sup> / 180.0.**

$$0.838551 * 2^{23} / 180.0 = 39079.31074.$$

Round the result to the nearest whole integer, and convert to hexadecimal.

$$\text{Int2Hex}(39079) = 0x0098A7 \text{ (24-bit)}$$



### 2.3 ***Truncated AXTracker message***

Message type 1 shall be a Truncated AXTracker message. This message type provides for up to 2 bytes plus 6 bits of user data to be appended to the status byte and GPS location information. The alarm and geofencing data of the standard AXTracker message are replaced with user data from the serial configuration port zero padded as necessary. The Truncated AXTracker message will follow the following on-air format:

Variable	Bits	Description
Status Byte	8	Bit (1:0) = 1 = Truncated AXTracker message type: Bit (7:2) = submask data from Truncated user data
Latitude/Longitude	48	Byte 1 = Latitude MSByte Byte 2 = Latitude Byte 3 = Latitude LSByte Byte 4 = Longitude MSByte Byte 5 = Longitude Byte 6 = Longitude LSByte  360 degrees of longitude coded in signed binary with 3 bytes and 180 degrees of latitude coded in signed binary with 3 bytes. Positive longitude correspond to East Longitudes Positive Latitude correspond to North Latitudes
User Data	16	Byte 1 = User data byte 1 Byte 2 = User data byte 2

#### 2.3.1 ***Line-powered Truncated AXTracker message***

The line-powered version of the AXTracker may send up to 29 bytes plus 6 bits of user data extending the total payload to a maximum of 36 bytes. On-air payload length will be integer multiples of 9 bytes zero padded as necessary.

Variable	Bits	Description
Status Byte	8	Bit (1:0) = 1 = Truncated AXTracker message type: Bit (7:2) = submask data from Truncated user data
Latitude/Longitude	48	Byte 1 = Latitude MSByte Byte 2 = Latitude Byte 3 = Latitude LSByte Byte 4 = Longitude MSByte Byte 5 = Longitude Byte 6 = Longitude LSByte  360 degrees of longitude coded in signed binary with 3 bytes and 180 degrees of latitude coded in signed binary with 3 bytes. Positive longitude correspond to East Longitudes Positive Latitude correspond to North Latitudes
User Data	16- 232	Byte 1 = User data byte 1



## 2.4 Raw Payload message

Message type 2 shall be a Raw Payload message. This message type provides for up to 8 bytes plus 6 bits of user data to replace all the standard AXTracker information. This mode is provided to enable the user to directly send a single data burst through the network. The only bits not accessible to the user are the message type bits needed by the receiving data processor to delineate message type associated to the TXID. User data less than the full payload will be zero padded as necessary. The Raw Payload message will follow the following on-air format:

Variable	Bits	Description
Status Byte	8	Bit (1:0) = 2 = Raw Payload message type: Bit (7:2) = submask data from Raw Payload user data
User Data	64	Byte 1 = User data byte 1 Byte 2 = User data byte 2 Byte 3 = User data byte 3 Byte 4 = User data byte 4 Byte 5 = User data byte 5 Byte 6 = User data byte 6 Byte 7 = User data byte 7 Byte 8 = User data byte 8

### 2.4.1 Line-powered Raw AXTracker message

The line-powered version of the AXTracker may send up to 35 bytes plus 6 bits of user data extending the total payload to a maximum of 36 bytes. On-air payload length will be integer multiples of 9 bytes zero padded as necessary.

Variable	Bits	Description
Status Byte	8	Bit (1:0) = 2 = Raw Payload message type: Bit (7:2) = submask data from Raw Payload user data
User Data	64-280	Byte 1 = User data byte 1

## 2.5 AXTracker Setup message

Message type 3 shall be system statistics type messages with a subfield denoting specific type of message. The subfield 0 message (SETUP) shall be sent by the AXTracker on begin of service life or as commanded by the serial configuration port. The Setup message contains the operational configuration of the device usable by the customer to assist in STX provisioning at Globalstar.

The Setup message can be used to send the configuration data through the satellite network to the end customer. The customer can detect the Setup message using the 2 bit message type field, parse the information and automatically generate a provisioning report to Globalstar confirming configuration and initiation of the device in field.



The AXTracker Setup message will follow the following on-air format:

Variable	Bits	Description
Status Byte	8	Bit (1:0) = 3 = AXTracker Statistics message type: Bit (7:2) = submask, set to 000000 for SETUP message
RF Channel	8	RF Channel configuration Bit 0 = 1: use channel A Bit 1 = 1: use channel B Bit 2 = 1: use channel C Bit 3 = 1: use channel D Bit 6:4 = undefined (set to 0) Bit 7 = TX Power Level, 0= LOW, 1=HIGH
Number of Tries / Watchdog	8	B7:=0=OK, B7=1=unit reset on watchdog B6:0 = number of tries (1 to 10 Tries)
Min Interval	8	Minimum Interval between transmission attempts ( 5 second resolution) Default is 240 seconds (0x30)
Max Interval	8	Maximum Interval between transmission attempts. Usable range of operation is 125 to 600 seconds inclusive with resolution of 5. i.e. valid data values range from 0x19 to 0x78 and must be greater than Min Interval. Default is 360 seconds (0x48)
Alarm Config	16	Configured Alarm States Bit 1:0 = Alarm 1 config 0 : Disable Alarm 1 : Enable Alarm on transition from 1 to 0 (neg edge) 2 : Enable Alarm on transition from 0 to 1 (pos edge) 3 : Enable Alarm on any transition (any edge) Bit 3:2 = Alarm 1 mode 0 : Disable GPS Fix (Transmit Alarm only) 1 : Enable GPS Fix (Report Position on Alarm) 2 : Enable GPS Fix and Interval-Override for duration 3 : Enable GPS Fix and Interval-Override while alarm active (low) Bit 5:4 = Alarm 2 config Bit 7:6 = Alarm 2 mode Bit 9:8 = Alarm 3 config Bit 11:10 = Alarm 3 mode Bit 13:12 = Alarm 4 config Bit 15:14 = Alarm 4 mode
Geofence Config	8	Number of Geofence areas active
RAS Config	8	Number of RAS areas active

## 2.6 AXTracker Setup2 message

SETUP2 is reserved for future setup type data. This message type is currently not supported by the product.



## 2.7 AXTracker Statistics message

Message type 3 shall be system statistics type messages with a subfield denoting specific type of message. The subfield 2 message (STATISTICS) shall be sent by the AXTracker on a routine scheduled basis as commanded by the serial configuration port. The Statistics message contains an abbreviated operational configuration of the transmitter as well as statistics on device operation since last reported message. The data provides information on the operation of the device in the field that can be used to update battery life estimates and field installation procedure.

The Statistics message includes information about GPS operation and alarm usage as well as battery low condition detection.

The AXTracker Statistics message will follow the following on-air format:

Variable	Bits	Description
Status Byte	8	Bit (1:0) = 3 = AXTracker Statistics message type: Bit (7:2) = submask, set to 000010 for a Statistics message
Bat Low/ Number of Tries	8	Bits(3:0) = Number of Tries (1 to 10 Tries) Bits (7:4) = Bat Low detect count (0= no bat low)
Min Interval	8	Minimum Interval between transmission attempts ( 5 second resolution) Default is 120 seconds (0x18)
Max Interval	8	Maximum Interval between transmission attempts. Usable range of operation is 125 to 600 seconds inclusive with resolution of 5. i.e. valid data values range from 0x19 to 0x78 and must be greater than Min Interval.
GPS Mean Search Time	8	Unsigned binary count in seconds for mean GPS search to acquire
# GPS Fails	8	Unsigned binary count in of failed GPS attempts since last msg
Alarm Statistics	16	Byte 1: # of Alarm2 since last message (b7=0) / accum hours (b7=1) Byte 2: # of Alarm3 since last message (b7=0) / accum hours (b7=1)
#Transmissions	8	# of transmissions since last statistics message

### 2.7.1 **Statistics Message byte 2 - Bat Low/Number of Tries**

The second byte of the Statistics Message payload contains information about the condition of the integral battery and setup of the transmitter.

The lower 4 bits contain the number of transmission events per message. Data is sent redundantly as set in the configuration of the device. Globalstar uses this data in the provisioning of the integral satellite transmitter.

The upper 4 bits contain a count of the occurrence of battery low indication since the last statistics message sent. The battery terminal voltage is measured at end of transmission and compared to a fixed threshold. Voltage detected below the threshold indicates a stressed battery and the battery low count is incremented in this field. A battery low condition does not necessarily indicate the battery requires replacement. Weather conditions of extreme temperature may yield a few battery counts. Consistent



battery low indication (max counts) however may be used to schedule battery replacement of field units.

### **2.7.2 Statistics Message byte 5 - GPS Mean Search Time**

The fifth byte of the Statistics Message payload contains information about the average time to acquire GPS location. Typically, the GPS function should yield location with a mean time equal to the GPS module installed. A problem with the GPS hardware may be detected in mean time to search as indicated by this data.

Fleet managers may use this data to find problematic installations as well as make better estimates for terminal battery life of the product.

Mean time is calculated using an even weighted average algorithm with a time base of at least 16 most recent transmissions.

### **2.7.3 Statistics Message byte 6 - # GPS Fails**

The sixth byte of the Statistics Message payload contains a count of the number of times the unit failed to acquire a GPS fix since the last statistics message. This count is cleared following transmission of the Statistics message.

Fleet managers may use this data to find problematic installations as well as make better estimates for terminal battery life of the product.

### **2.7.4 Statistics Message bytes 7&8 - Alarm Statistics**

The seventh and eighth bytes of the Statistics Message payload contain alarm count information for alarm 2 and alarm 3 only. Alarm 1 and 4 counts are not provided. These counts are cleared following transmission of the Statistics message.

Bit 7 denotes the type of count contained in these parameters. Count data is limited to lower 7 bits of each byte (range 0-127).

Bit 7 = 0 denotes straight count of the number of alarms observed since last statistics message. This count is reset to zero upon transmission and counts and holds at a maximum of 127

Bit 7 =1 denotes cumulative hours of alarm active (low). Hours counted are maintained at one-minute resolution but reported in truncated hours (not rounded), meaning that the reported hours-count rolls to the next hour after the hour is accumulated at the minute resolution. Hours count are cumulative and not reset to zero following transmission. The count rolls over to zero at one minute past 127 hours. Users must configure the statistics message interval to ensure at least one report per 127 hours of cumulative alarm active time occurs to unwrap the rollover ambiguity. **Cumulative hours are**



**calculated only on “NEG” or “ANY” alarm settings.** Alarm settings of POS are not compatible with hours accumulated and the message will be rejected (NAK) by the device.

Alarm count or accumulated hours are cleared (set to zero) on device program or wake from sleep.

Alarms configured to count will increment on each alarm edge enabled even if the alarm edge occurs within the alarm hysteresis window. The alarm may be ignored, but the count will increment in this case.

### **2.7.5 Statistics Message byte 9 - # Transmissions**

The ninth byte of the Statistics Message payload contains a count of the number of satellite transmissions since the last statistics message. Redundant messages are not included in the count. All valid transmissions are included in the count including supervisory interval reports, alarms, truncated and raw messages. This represents a count of unique message ID numbers sent. This count is cleared following transmission of the Statistics message.

Fleet managers may use this data to find problematic installations by comparing the number of transmitted signals versus the number of received signals. Effective system throughput can be calculated on an installation-by-installation basis.

The Maximum count is 255. Counts exceeding 255 are limited at 255.



### 3 Configuration I/O Port Interface



Configuration Port

The AXTracker includes a configuration and interface port used to set up the device as well as for connecting input alarms and / or connecting smart-serial sensors.

The port is a small-outline connector that is accessible after installation to connect the setup tool harness or sensor application harness. The 10-pin connector provides for up to 4 alarm inputs, serial interface and an open-collector output which signals when the AXTracker sends satellite data.

#### 3.1 Configuration Port Connector Definition

The configuration port is accessible via an IP66 (NEMA4X) weather-resistant connector. The connector used in the AXTracker will be equivalent to that as manufactured by Hirose (part number HR30-7R-10PC)

The mating connector (user requirement for outside harness) is:

HR30-7P-10SC (Crimp type locking 10-pin connector)

HR30-SC-211 (Crimp connectors (female) – up to 10 needed per connector)

The AXTracker comes with an HR30-7R-C Receptacle Cap, which may be discarded if a user harness is attached. The Receptacle Cap or a harness is required to maintain watertight integrity of the unit.

These connectors are designed for 26 - 30 AWG wire. The AXTracker uses 28 AWG inside the unit.



### 3.2 **Configuration Port Pin Definitions**

The connector pinout is:

<b>Pin #</b>	<b>Definition / Use</b>
1	External Voltage (Automotive battery input for line-powered AXTracker version)
2	Common / Ground (Alarm & Serial return)
3	Alarm 4 (Normally Open sensors only)
4	Alarm 3 (Ignition input for line-powered AXTracker)
5	Alarm 2
6	Alarm 1
7	Serial RX (into AXTracker)
8	Serial TX (out from AXTracker)
9	Setup Enable~
10	OC Output

**Configuration Port Pinout**

#### 3.2.1 ***Pin 1 – External Voltage***

This pin is provided for Line-powered AXTracker versions. This pin is unused in the standard AXTracker because it uses an integral primary battery. Applying automotive or DC power to this pin shall have no effect to operation of the battery-only version of the AXTracker.

The Line powered version of the AXTracker uses this pin to connect to the automotive battery. When voltage is applied to this pin, the line-powered AXTracker will disconnect from the internal battery and draw power from the automotive battery. The line-powered AXTracker will still operate as if in internal battery mode to keep from excessively draining the automotive battery.

#### 3.2.2 ***Pin 2 – Common / Ground***

This pin is tied to unit battery return. It is provided for both serial interface ground return as well as alarm ground return. This pin is used to for alarm dry-contact operation (via close/open) as well as providing a ground reference for the serial interface.

#### 3.2.3 ***Pins 3-6 – Alarm inputs***

Four alarm inputs are accessible at the configuration port. Each of these alarm inputs are transient protected and low-pass filtered (debounced) to be used with dry-contact (open/close) type sensors. Typical alarm use will make or break conductivity to the common / ground pin (2) of the port.



Connecting one of the alarm pins (3-6) to the Common/Ground pin will create an alarm condition with negative edge (Normally Open dry contact switch). Opening one of the alarm pins (3-6) tied to the Common/Ground pin will create an alarm condition with positive edge (Normally Closed dry contact switch). Alarms inputs 1-3 are weakly pulled to internal voltage. Alarm 4 is pulled up with an equivalent 5K resistor and as such should be used with only Normally Open type sensors. It is different from the others to enable future serial sensor type interfaces.

Alarm events generate alarm reporting messages as well as serve to enable the device to begin service life as configured (wake from inventory sleep). Alarm inputs have higher priority than supervisory interval position events

### 3.2.3.1 Pins 3-6 – Alarm inputs

The line-powered version of the AXTracker can be configured to use Alarm 3 (pin 4) to detect ignition-on. If configured such, the line-powered AXTracker may enter into high-duty cycle (line-powered) features such as Geofence alarm and packed data mode while the ignition is on.

**NOTE: Line Powered AXTrackers reverse the sense of the Alarm 3 input. 12-24 VDC applied to Alarm 3 input results in a LOW reading to the AXTracker configuration settings.**

The line-powered AXTracker therefore has 3 modes of operation depending on the two automotive voltage tolerant inputs. The table below defines the modes of operation:

**Line-Powered AXTracker Modes of operation**

Pin 1 – External Voltage	Pin 4 – Alarm 3	AXTracker Operation
Open or GND	Open or GND	Operating on internal battery. Line powered features disabled.
12 – 24 VDC	Open or GND	Operating on external power. Line powered features disabled.
12 – 24 VDC	12 – 24 VDC	Operating on external power. Line powered features enabled.

### 3.2.4 Pins 7-9 – Serial Interface

The AXTracker configuration port contains a serial protocol interface operating at TTL voltage levels. This serial interface supports both device setup as well as sensor inputs.

The AXTracker multiplexes an internal serial interface between the configuration port, the Simplex Modem and the GPS functional block. An interrupt pin (9) on the configuration port signals the internal processor to redirect this serial functionality to the configuration port. A low (ground) generated on pin 9 performs this function. This may be accomplished by making connectivity from pin 9 to pin 2.

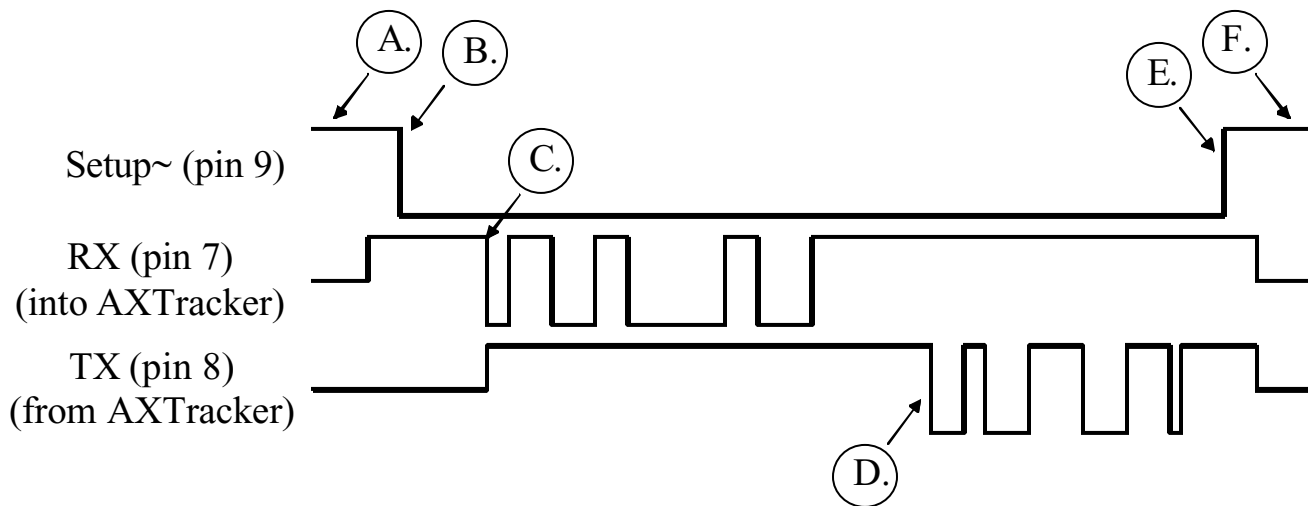


The AXTracker will service the serial port as highest priority. The assumption is that the external interface may preempt an active GPS location determination or ongoing transmission of data. An abort of internal function due to serial interface override is recorded similar to a lost GPS signal and recorded and recorded in the status byte of the next transmitted standard AXTracker message.

Specifically, if while the serial interface is active and a supervisory position report interval occurs, the regularly scheduled supervisory position event is aborted and recorded as such in the status byte. If the unit is actively seeking GPS fix when a serial interrupt occurs, the GPS fix will be aborted. The only exception is that the unit will not suspend an active RF transmission of a burst message, which may take up to 1.3 seconds to complete. As a result, an active timeout period must be observed by the outside interface assembly to wait at least 2 seconds to begin communication following interrupt assertion on pin 9. Any subsequent repetition messages pending for the STX will be lost.

Communications are via a 9600 baud 8-N-1 TTL level serial protocol. Data into the AXTracker is sent by the external unit on pin 7. Data from the AXTracker is received by the external unit on pin 8. As the communications are TTL level (0-5V) they are polarity reversed from the standard RS232 (+12/-12V) levels.

The following timing waveform describes the serial communication method.



**Step A:** While the serial interface is not in use, the external unit shall hold the serial interface pins (7,8 and 9) in open circuit to preserve AXTracker battery life. The Setup~ pin (9) is internally weakly pulled up to DC voltage.

**Step B:** The external interface unit begins serial communication by enabling the transmit signal (received by the AXTracker) to a valid resting voltage state then asserting Setup~ (pulling to ground).

**Step C:** The external interface unit waits 2 seconds then may begin sending a serial command to the AXTracker unit (any valid serial command). This allows for the unit to finish sending any active ongoing STX message.



**Step D:** The AXTracker will respond with the appropriate command response within 1 second from end of command C.

**Step E:** The external interface unit may de-assert the Setup~ pin upon receipt of serial reply. It may also continue communication as allowed by the serial message protocol until the effort is complete.

**Step F:** The AXTracker resumes normal operation one (1) minute following the last serial communication received. Optionally, the unit may immediately begin normal operation upon receipt of a “Run” command via the serial interface regardless of the Setup~ pin state. In either case, once normal operations are running, the serial interface pins should be open-circuit to the AXTracker to preserve battery life.

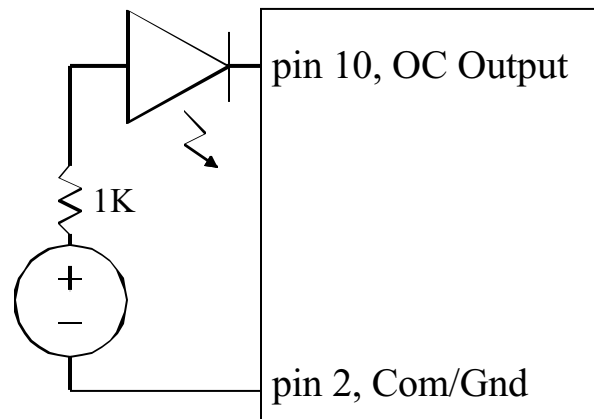
Note: This means that each time serial communication begins, the Setup~ pin must be asserted and the serial interface pins must transition from open-circuit to TTL drive levels. This requires an interface cable for connectivity to a PDA or standard PC. The interface is designed for use with smart (custom) sensors able to take advantage of the cost saving features of the interface. Optionally the serial interface can use CTS looped back to RTS of the external unit to assert the Setup~ signal with CTS. Software timing of the first character can be used to create the 2-second delay necessary to ensure communications.

### 3.2.5 Pin 10 – OC Output

The AXTracker configuration port has one open-collector output (pin 10) used to signal the external interface of either active transmit or service life begin.

The OC Output signal will switch to ground for approximately 1 second while the unit is actively transmitting a message burst. For example, the following circuit demonstrates use of this signal to light an LED upon unit transmit.

The unit provides for 56 Ohms of series resistance through this pin. Additionally, the unit will assert the OC Output for one (1) second upon any RUN mode such as setup completion (run) or alarm wake to auto-run (wake from inventory sleep) or timeout and run following setup.





### 3.3 Default Factory Configuration

The AXTracker will be factory configured with the following parameters:

Parameter	Description	Default Value
RF Channel/24Hour	Fixed frequency operation on all channel A with 24 Hour mode OFF	0x01
Number of Tries	3 transmissions for each RF message	0x03
Min Interval	240 seconds	0x30
Max Interval	360 seconds	0x48
Dither	30 minutes	0x1E
Power Level/Hysteresis	Low, 15 minute hysteresis	0x3C
Alarm1 Setup	disabled	0x00
Alarm2 Setup	disabled, count alarms enabled	0x00
Alarm3 Setup	disabled, count alarms enabled	0x00
Alarm4 Setup	disabled	0x00
Motion	disabled, motion threshold = 5	0x28
Geofence I-O	disabled	0x00
Override Interval	1 hour default	0x003C
Override Duration	24 hours duration	0x05A0
Statistics Interval	disabled	0x0000
Config switches	Geofence Boundary disabled, GPS Retry enabled, Message Packing disabled	0x00
Delay to Start	Begin service following random delay (0-24 hours) on RUN or Alarm	Random
Position Reporting Interval 0	12 Hour Delay Interval	0x02D0
Position Reporting Interval 1-11	Null	0

The Factory settings enable initiation by alarm for use on frequency channel A with 3 transmissions for each unique message. Supervisory Position Reports are generated every 12 hours with a Dither of +/- 30 minutes and retry randomization of 4 to 6 minutes.

The Factory power level is set to LOW. All of the alarms are factory configured as disabled. Hysteresis is set default to 15 minutes.

Each AXTracker will be factory configured with a random Delay-to-Start between 0 and 24 hours (0-0x05A0). Following initiation using either alarm wakeup or RUN command, the device will generate a Setup message then execute the Delay-to-Start. The first scheduled position location report will be following the 0 to 24 hour random Delay-to-Start. Triggering an alarm will force a message (GPS or



without GPS) while in the Delay-to-Start interval.

The factory 12 hour Position Reporting Interval can be replaced by 6 or 24 hours depending on the alarm that wakes the device (see unit activation paragraph below). 24 Hour mode is disabled.

### 3.4 Unit Activation

The AXTracker comes pre-configured for use to a default configuration and in an inventory-deep-sleep operational mode. The unit is factory configured and then enters a low-power state waiting for begin of service life. The unit will remain in sleep mode even if power is disconnected and reconnected until it is initiated into RUN mode via alarm or serial command.

The AXTracker begins service life up receipt of either:

- Any alarm input – wakes up device to one of 4 configurations
- Run mode initiated via configuration tool.
- Unit is programmed (configuration change) without sleep command (auto-run following configuration change after 1 minute).

If the unit is initiated via an alarm input, the unit begins service life with whatever is currently in its configuration. This enables the devices to be factory or integrator configured and stored, then commissioned for use using a jumper-initiation cable (i.e. no PDA or computer interface required).

Any alarm will initiate this mode of service use, but each specific alarm performs the following functions:

<b>Initiate Service Life Alarm</b>	<b>Action</b>
1	Use configuration currently in the device. (i.e. use previous factory or integrator configuration)
2	Replace interval configuration with 1 step with 24 hour interval (once a day position reporting)
3	Replace interval configuration with 1 step with 12 hour interval (twice a day position reporting)
4	Replace interval configuration with 1 step with 6 hour interval (four times a day position reporting)

All other configuration parameters remain unchanged and the device begins service life immediately on any alarm. Note that if the device were programmed for 24 Hour mode, alarms 2, 3 or 4 will abort 24 Hour mode and configure the unit for standard interval mode with a single 24, 12 or 6 hour interval.



## 4 Configuration and Remote Smart Sensors

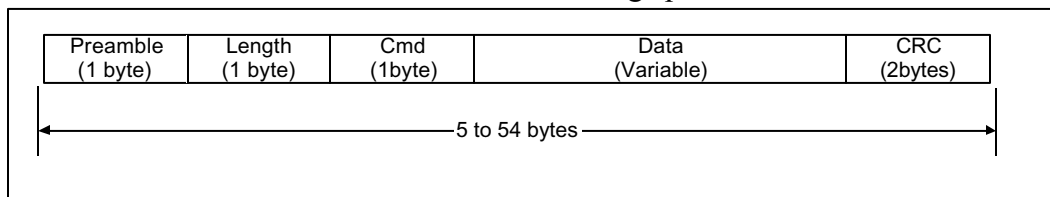
The AXTracker is factory configured to a set operational mode and set in an inventory deep-sleep state awaiting initiation into service. The unit may be reconfigured to another mode of operation using the configuration port and protocol described fully in the AXTracker Specification (Document # 8520-0127-01) available from Axonn.

The AXTracker uses the I/O port for unit configuration as well as interface to remote passive and smart sensors. Two commands are provided in the unit interface to support smart sensors. External sensors that can format and communicate to the AXTracker can send user data through the AXTracker by using these two commands.

The AXTracker can send a. This section provides the serial protocol information for the Truncated and Raw message commands.

### 4.1 Serial Packet Format

Communication to the AXTracker will follow the following specific format:



**Serial Packet Format (Commands & Answers)**

The different fields are defined as:

**Serial Packet Fields**

Preamble	Fixed pattern 0xAA
Length	Total number of bytes in the serial packet including the preamble
Cmd	Command type (See Serial Packet Type table below). Responses to commands carry the same command type as the command that initiated the answer
Data	Data associated with the command or answer
CRC low	Least significant byte of the 16-bit CRC
CRC high	Most significant byte of the 16-bit CRC

The serial format will be utilized for setup as well as sensor serial messaging as described in the sections following. All messages are acknowledged with the command field of the response equal to the command field of the initiating message. The table below consolidates all the serial messaging supported by the AXTracker.



### Serial Packet Type

Cmd	Description / Usage / Comment	Command Data Bytes	Acknowledge Data Bytes
0x26	Send Truncated AXTracker message	See paragraph 4.2 below	None
0x27	Send Raw Payload message	See paragraph 4.3 below	None

Invalid commands will result in a Negative Acknowledge (type 0xFF) reply.

The CRC checksum uses the CCITT-16 Reversed (0x8408) algorithm:

The Security Field is a 16-bit CRC of all of the previous fields including the preamble, length, and command bytes. The remainder is initialized to all 1's (0xFFFF) and the CRC is inverted before being sent. Following is a sample C routine that implements the algorithm using the "reversed" technique:

```
WORD crc16_lsb(BYTE *pData, WORD length)
{
    BYTE i;
    WORD data, crc;
    crc = 0xFFFF;
    if (length == 0)
        return 0;
    do
    {
        data = (WORD)0x00FF & *pData++;
        crc = crc ^ data;
        for (i = 8; i > 0; i--)
        {
            if (crc & 0x0001)
                crc = (crc >> 1) ^ 0x8408;
            else
                crc >>= 1;
        }
    }
    while (--length);
    crc = ~crc;
    return (crc);
}
```

As an example, for a type (0x01) "Get ID" message made up of the following bytes:

AA 05 01

The following 2 byte CRC would be calculated:

D5 50

The complete message sent by the host to the tracker is:

AA 05 01 50 D5



## 4.2 ***Truncated AXTracker Messaging (serial message type 0x26)***

The AXTracker will perform a GPS location and append user data passed to the unit via the Truncated AXTracker command 0x26.

Two bytes plus 6 bits of user data may be sent with the standard GPS location information in a messaging burst. Two bits are set in the on-air message by the AXTracker informing the recipient that the message is Raw.

Serial payload lengths of less than 2 will be zero padded to length of 2. Messages received by the Globalstar system will contain 9 bytes of payload (1 status byte, 6 GPS location bytes, 2 user data bytes).

The following table defines the message structure used to send a Truncated AXTracker message.

**Truncated Serial Message**

Byte	Bit	Parameter	Description	Default Value
0	7:2	Submask Bits	User data bits. Bits 1:0 are reserved and will be masked by AXTracker.	0x00
1-2		User Data	Any user data	

### 4.2.1 ***Line-Powered Truncated Messaging***

The line-powered AXTracker may accept longer payload data up to and including 29 bytes plus 6 bits of user data. Format of message is the same as denoted for message type 0x26. The line-powered AXTracker will accept the longer payload for transmission only while Alarm 3 is active (low) indicating ignition is on. If the ignition is off or the unit is not a line-powered version, the unit will NAK the longer message command.

User serial payload length may be 0 to 29 bytes plus 6 bits of user data inclusive. The AXTracker will pad the payload length to integer multiples of 9 bytes. For example, a 3-byte user data will result in an 18-byte payload as received by the Globalstar system (7 bytes of status and GPS data plus 3 bytes of user data plus 8 bytes of zero padding).

**Truncated Line-Powered Serial Message**

Byte	Bit	Parameter	Description	Default Value
0	7:2	Submask Bits	User data bits. Bits 1:0 are reserved and will be masked by AXTracker.	0x00
1-29		User Data	Any user data	



### 4.3 **Raw Payload Messaging (serial message type 0x27)**

The AXTracker will send raw user data in place of the standard AXTracker GPS location data using the Raw Payload command 0x27.

8 bytes plus 6 bits of user data may be sent in place of the standard AXTracker data protocol. Two bits are set in the on-air message by the AXTracker informing the recipient that the message is Raw.

Serial payload lengths of less than 8 will be zero padded to length of 8. Messages received by the Globalstar system will contain 9 bytes of payload (1 status byte, 8 user data bytes).

The following table defines the message structure used to send a Truncated AXTracker message.

**Raw Payload Serial Message**

Byte	Bit	Parameter	Description	Default Value
0	7:2	Submask Bits	User data bits. Bits 1:0 are reserved and will be masked by AXTracker.	0x00
1-8		User Data	Any user data	

#### 4.3.1 ***Line-Powered Raw Messaging***

The line-powered AXTracker may accept longer payload data up to and including 35 bytes of user data. Format of message is the same as denoted for message type 0x27. The line-powered AXTracker will accept the longer payload for transmission only while Alarm 3 is active (low) indicating ignition is on. If the ignition is off or the unit is not a line-powered version, the unit will NAK the longer message command.

User serial payload length may be 0 to 35 bytes plus 6 bits of user data inclusive. The AXTracker will pad the payload length to integer multiples of 9 bytes. For example, a 27-byte user data will result in a 36-byte payload as received by the Globalstar system (1 byte of status plus 27 bytes of user data plus 8 bytes of zero padding).

**Raw Payload Line-Powered Serial Message**

Byte	Bit	Parameter	Description	Default Value
0	7:2	Submask Bits	User data bits. Bits 1:0 are reserved and will be masked by AXTracker.	0x00
1-35		User Data	Any user data	



### 4.3.1.1 COM Functions

The PDA/PC Tool provides means select communications port and also to download (program) Geofence tables into the AXTracker. Users can choose active COM port from the COMM/OPTIONS selection.

Geofencing is a user updateable file that the PDA/PC tool can program into the AXTracker using a COM function selection. This requires that the Axt\_Geo file is placed to the PDA or PCTool directory, built using a GEOTOOL or user compilation. The GEOTOOL is a separate program that can design, store or program Geofence regions. The tool downloads the geofence regions stored in the file named Axt\_Geo into the AXTracker on selecting “DOWNLOAD GEO” function.



To access COM functions, the user must select the file pull-down menu as discussed to access Profile functions. The second tab COMM is used to display the available COM functions as shown.



## **Appendix A: TRACKER OPERATION OVER TEMPERATURE**

### *Notes on tracker operation over temperature:*

- All tracker hardware works over the entire industrial temp range (-40 to +85). This includes the STU and the GPS Module. However, the operational specification of the AXTracker remains -30 to +60 indicating the temperature range which results in the longest battery life. Extreme hot temperatures (>70 C) begin to passivate the batteries and extreme cold temperatures (< -30 C) come very close to damaging the HLC capacitor by exceeding the recommended “depth of discharge”.
- THE ONLY CAPACITOR APPROVED FOR USE IN A TRACKER BATTERY PACK IS THE HLC-1550N.
- All serial communication both with the STU and the tracker work over temperature, including the EEROM write of setup parameters.
- Hardware provisions have been made to keep both the STU and the host processor on the Tracker from resetting during the extreme battery voltage droop during STU transmit at cold temperatures.

### *Recommendations for AXTracker battery operation over temperature:*

- Since the STU output power drops approximately 4 dB at temperatures > 70 C, the tracker may be configured for high power mode. The batteries have no problem supporting high power mode at high temperatures. However high power and extreme hot temperatures can reduce battery life by as much as 50%.
- The STU power increases by approximately 1-2 dB at temperatures < -30 C. The tracker should be configured for LOW power mode if used in extreme cold temperatures. Low power mode is ideal for the batteries at cold temperatures.
- The HLC capacitor can be permanently damaged by supervisory settings less than 30 minutes @ -40C. Tracker message duty cycles should be kept as low as possible in extremely cold (< -30 C) environments. Although the tracker works in HIGH power mode @ -40C, this greatly reduces battery life and may begin to damage the battery pack.

### *General Battery Notes:*

- The battery pack shelf life is limited by the HLC capacitor. Shelf life is 10 years @ +25C, 7 years @ +60C, and 1 year @ +85C. Batteries should not be stored above +60C to avoid passivation and damage to the HLC. Trackers should not be inventoried with batteries for more than a year. Also, the Almanac will also be out of date if trackers are stored for more than a year.
- Battery life can be de-rated by as much as 50% when the tracker is used at temperatures above +55C. Battery life can be de-rated by as much as 30% when used at temperatures less than -30C.



- Annual battery capacity loss due to leakage is 1% @ +25C, 2.5% @60C and 5% @ 85C.



## **Appendix B: Battery-Only vs. Line-Powered AXTracker Version Definition**

The AXTracker unit is available in two different hardware configurations denoted in this specification as battery-powered (or standard) and line-powered. The standard configuration of the AXTracker contains a high-density primary-cell battery to power and operate the device for its service life. The line-powered AXTracker contains the same high-density battery as a backup power source and power-conditioning board to accept automotive line power for use. This appendix describes the hardware differences of the units and discloses how the host processor board of the AXTracker detects and handles each configuration differently.

### **B.1 Battery-Only AXTracker**

The battery-only or standard version of the AXTracker predominately operates in sleep mode, drawing only a few micro-amps of current to maintain sleep interval timers. It wakes up very infrequently to perform location determination functions, service alarms or serial interface and transmit messaging to the satellite modem. The feature-set of the battery-only version is designed to protect the battery life of the cell to the greatest extent possible. As the cell is not rechargeable, the unit will have a shortened service life if the unit operates in awake mode often.

Sleep durations have minimum intervals of 30 minutes and default configurations are 12 hours. Message lengths are limited to 9 bytes and there is no real-time geofencing boundary detection. All the main feature-set points defined are intentionally limited to attempt to protect battery life while providing a product which has utility for untethered (unpowered) applications.

This specification is written to define the operation of the battery-operated device as the standard or predominate mode of operation. In some sections of this specification, line-powered options are noted with changes to operation defined. The reader is cautioned to differentiate a defined feature as battery-only or line-powered in operation with associated hardware differences.

The standard AXTracker has a hardwired interface directly from the interface port of the device to the internal host controller board of the unit. The host controller board monitors the alarm inputs and services the serial interface directly. Internal resistive pull-ups on the alarm inputs are used to predominately detect short-to-ground states as alarms. The alarm inputs are transorb protected to prevent damage to unit by overvoltage on an input. Care should be taken however to not apply automotive power to an alarm input as they are resistively transorb protected, and the resulting current draw will drain the automotive battery over time. The battery-only version is designed to accept dry-contact (open/close) conditions to the alarm inputs. Applying a direct voltage to the inputs is not recommended.



## B.2 Line-Powered AXTracker

The line-powered version of the AXTracker contains an additional circuit assembly in the unit to accept automotive line power as its predominate power source. It uses two line input signals to switch modes of operation. The intent is to allow the unit to operate as in battery-only mode while on automotive battery power with an automatic switchover to internal battery if power is disconnected. A second ignition line input signals the AXTracker that it can engage in power intensive operations.

The two-input technique protects the automotive battery from becoming drained as it performs “constant-on” activities such as geofencing boundary determination or packed data mode only when the ignition is on. When the ignition is off, the host controller returns to battery-only mode and in fact cannot differentiate whether it is running on external or internal battery.

The line-powered AXTracker therefore has 3 modes of operation depending on the two automotive voltage tolerant inputs. The table below defines the modes of operation:

**Line-Powered AXTracker Modes of operation**

Pin 1 – External Voltage	Pin 4 – Alarm 3	AXTracker Operation
Open or GND	Open or GND	Operating on internal battery. Line powered features disabled.
12 – 24 VDC	Open or GND	Operating on external power. Line powered features disabled.
12 – 24 VDC	12 – 24 VDC	Operating on external power. Line powered features enabled.

The additional power conditioning board inside the line-powered tracker intercepts the alarm inputs and inverts alarm3 to the host board of the AXTracker. The host board of the AXTracker can detect if the unit contains this power conditioning board, so it knows whether it can enable line-powered features upon assertion of a low to alarm 3. A low on alarm 3 denotes line power applied to the interface connector as it is logically inverted by the power conditioning board.

**NOTE: Line Powered AXTrackers reverse the sense of the Alarm 3 input. 12-24 VDC applied to Alarm 3 input results in a LOW reading to the AXTracker configuration settings.**

~~The internal, rechargeable battery is a fraction of the energy density of the primary cell standard version. The battery is sized to last only a month or two if unconnected to power and operating with two reports a day. As such, the line-powered version expects to be predominately connected to power providing for a couple of weeks of unconnected service.~~

The availability of ample, constant line power enables the AXTracker to engage in modified behavior that enables several new applications. When enabled via the configuration port, and when the AXTracker detects ignition is on, it can leave the GPS module on continually and detect geofencing boundary exceptions. It can engage in more frequent transmissions and as such the interval-override minimums are reduced to 5 minutes even though this ~~creates~~may create overlap in redundant message



coverage. Line power provides additional features that serve some applications not available in the battery only version but removes the long-term unpowered capability.



## **Appendix C: Interval-Override Examples**

The AXTracker Interval-Override function is a powerful and useful feature that enables the device to initiate alternate transmission schedule based on local stimuli. This enables the device to provide more timely location data to asset managers triggered by endpoint events.

Examples of where interval-override has value would be alarm triggered, denoting the door has been opened, or an external security device tripped. The unit begins reporting location at a new interval substituting temporarily the original transmit schedule for an alternate rate of information.

Interval-override may also be triggered by the internal motion sensor, enabling the device to report more frequently while the unit is in motion and very infrequently while the unit is stationary.

The unit can also be configured to engage interval-override based on determining the location is outside the programmed geofencing regions. If enabled, the unit will engage an alternate reporting schedule instructing the asset manager that the device is not in an allowable area of operation.

Each of the trigger sources engage the same alternate interval-override interval. Each alarm source may however select separate modes of operation. For example, alarm1 may be configured for interval-override for the programmed duration while alarm2 could be independently configured for interval-override for the alarm duration. In each case, either alarm configured for interval-override use the same interval setting. There are **not** unique interval settings for each interval-override trigger sources.

Interval-override is very powerful but also has the ability to impact battery life of the device or reliability of message reception if not properly configured. This appendix provides some examples of configurations and highlights some configuration settings that tradeoff battery life and performance. Users should make conscious decisions for configuring alarm and interval override modes.

### **C.1 Interval-Override for time duration**

Interval-override may be configured to temporarily replace the scheduled interval table with a single alternate interval ranging from 5 minutes to 45 days and to execute the alternate interval for a fixed duration in time also ranging from 5 minutes to 45 days. Upon detection of an alarm trigger configured to launch interval-override, the AXTracker will begin by performing a first location function and message, then resume sleep timing to repeat operation at the new interval-override interval. If the unit determines there is not enough time remaining from the original duration to perform another sleep function, it resumes the originally programmed schedule where it left off.

This means that if the override interval does not evenly divide into the timed duration, the time remainder will be lost and the unit will resume original scheduled intervals early of the total override duration.



For example, if the unit is configured with an override interval of 2 hours with a override-duration of 7 hours, the alarm configured to launch interval-override will trigger the unit to generate a first location message, followed by 3 subsequent location messages. The last hour (7<sup>th</sup>) is lost when the unit calculated at hour 6 that another 2 hour interval was not possible. The original schedule was resumed starting at hour 6.

A second example where the override interval divides evenly would be if the override interval is 4 hours, the override duration is 24 hours, the unit produces 7 total messages (one at start + 6 intervals of 4 hours) and resumes normal scheduled intervals at 24 hours.

Users who wish to keep the original timing from being skewed must choose override durations carefully, such as 24 hours (or 12 hours if uniform reporting of 2 messages a day) with the override interval dividing evenly into the duration.

## C.2 Interval-Override for alarm duration

Interval-override may be configured to temporarily replace the scheduled interval table with a single alternate interval ranging from 5 minutes to 45 days for the duration of the alarm event. Upon detection of an alarm trigger configured to launch interval-override, the AXTracker will begin by performing a first location function and message, then resume sleep timing to repeat operation at the new interval-override interval. While in sleep awaiting override interval timeout, the unit samples the alarm pin once a minute to detect alarm state change. If the unit determines the alarm state change occurs prior to timeout of interval, the unit resumes normal interval processing and abort interval-override mode.

This means that the normal processing resumes on minute boundaries and does not have to wait for the override interval timeout to occur.

For example, if the alarm is configured for NEG edge trigger, when the alarm input goes low (0) the unit enters interval-override mode; generating a location message and seeding the alternate override interval for the next location message. Meanwhile, once a minute, the alarm is tested to see if it returns to the opposite (POS) state. If the interval timeout occurs while the alarm remains low, the location message is sent and the override interval timer is restarted. If the alarm input returns high, it will be sampled on the next one-minute tests and the unit will cease interval-override function.

Note the unit does not wait until the override interval expires, it resumes original scheduled intervals within a few minutes of alarm inactive.

## C.3 Cascaded Interval-Override events

Alarms may be independently configured for edge sense as well as operational mode. It is possible to configure the device to use several alarm inputs to independently trigger interval-override mode. If the device is currently engaged in interval-override mode when a second alarm also configured for interval-override occurs, the device aborts the previous interval-override function and begins again.



The most recent interval-override function with mode of operation (time or alarm duration) will govern.

Alarms not configured to trigger interval-override may interrupt ongoing interval-override functions but do not terminate the interval-override. Interval-override resumes following alarm function. **Alarms that are not interval-override enabled are higher priority than ongoing interval-override operation. As such, the interval-override function is suspended until ALL the redundant messages of the interrupting alarm are complete.**

The geofencing-triggered interval-override mode auto re-engages based on geofencing match. If Geofence interval-override is enabled, it may interrupt any other ongoing interval-override function. As such, it operates as the highest priority interval-override mode since any previous interval-override mode will be replaced by a geofencing exception if enabled.

#### C.4 Short Interval Operation

If the programmed interval is shorter than the time required to transmit all redundant copies of a message, Interval-Override operation will result in missed messages and in some instances missed interval events. This is only true when the interval between events is shorter than the time required to send the previous event messages. This section explains the behavior of the interval override operation for these configurations.

An alarm that initiates interval-override will be treated as an independent alarm. Alarms have a higher priority than supervisory of ongoing interval-override events. As such, entering into interval override will result in all redundant messages being transmitted even if it means skipping the next interval or supervisory event.

Once the alarm transmission is complete, the device will wake on next time-driven interval event and perform location determination and send the first message of that burst. If the next event time is before any subsequent redundant copies of the first message, the redundant copies are terminated and the next event function is executed.

At the end of the interval-override duration, all redundant copies are sent (there is no pending interval event to interrupt completion of transmit sequence).

For example, a device may be configured to enter interval-override on alarm with an I-O interval of 5 minutes and I-O duration of 22 minutes. If the device is also configured to send a total of 3 messages separated by 3 minutes the resulting transmit sequence may be expected:

Time (min)	Event
0	Alarm occurs, device engages GPS to determine location
1	GPS complete, 1 <sup>st</sup> message – 1 <sup>st</sup> copy sent
4	1 <sup>st</sup> message – 2 <sup>nd</sup> copy sent
5	Time when second event should occur, skipped as alarm has higher priority and 1 <sup>st</sup> sequence must complete.



7	1 <sup>st</sup> message – 3 <sup>rd</sup> copy sent
10	2 <sup>nd</sup> wakeup, get GPS data
11	2 <sup>nd</sup> message – 1 <sup>st</sup> copy sent
14	2 <sup>nd</sup> message – 2 <sup>nd</sup> copy sent
15	3 <sup>rd</sup> wakeup, abort 2 <sup>nd</sup> msg-3 <sup>rd</sup> copy. get GPS data
16	3 <sup>rd</sup> message – 1 <sup>st</sup> copy sent
19	3 <sup>rd</sup> message – 2 <sup>nd</sup> copy sent
20	4 <sup>th</sup> wakeup, abort 3 <sup>rd</sup> msg-3 <sup>rd</sup> copy. get GPS data
21	4 <sup>th</sup> message – 1 <sup>st</sup> copy sent
24	4 <sup>th</sup> message – 2 <sup>nd</sup> copy sent
27	4 <sup>th</sup> message – 3 <sup>rd</sup> copy sent, exit interval-override

The table above made the assumption that the GPS function took exactly one minute and the redundant transmissions were exactly 3 minutes in order to demonstrate the process. In reality, the GPS function may take up to 4 minutes, or may fail entirely. On GPS failure in interval-override, the event is skipped entirely with no GPS retry made.

### C.5 Battery and Reliability Trade-off Configurations

As it is possible to configure the device to use several alarm inputs to independently trigger interval-override mode, care must be taken to safeguard configurations do not create opportunities where the device remains in interval-override mode indefinitely. For example, if alarm 1 is configured as NEG with interval override for the duration of the alarm AND alarm 2 is configured as POS with interval override for the duration of the alarm AND additionally, both alarms are electrically tied to the same signal, the unit will skip from one alarm to the next and remain in interval-override mode forever. Admittedly, this is a unlikely event, but it does exemplify the possibility of a possible configuration of device that can impact battery life significantly (provided intervals are of short duration).

Additionally, setting the alternate interval shorter than the time necessary to send a message with it's redundant copies will truncate the redundant messages and reduce network reliability. The interval minimum for interval override is 5 minutes. This is much shorter than the time required to generate a message and it's redundant copies. The short interval enables some field applications where frequent data is to be provided for short durations, but should be avoided for most applications. Users should refrain from using settings inside the transmit sequence time, typically 30 minutes or more is a minimum I-O interval.

**Warning: Overall battery life of the product is drastically reduced through any aggressive interval-override setting. The device is designed to provide many years of service on the original battery provided it transmits on the average of only a couple of messages a day. Setting interval-override to transmit on the hour or less and engaging I-O once a day will bring battery life substantially lower, in many cases inside a year. Users are strongly cautioned to consider impact to battery life when configuring devices for interval override operation.**



## **Appendix D: Regulatory Notices**

The AXTracker contains a GPS radio receiver and simplex radio transmitter as well as a digital-computing host interface board. The FCC requires the following notification for the device in compliance with 47CFR 15.105 for this Class B digital device. Full product test reports are available from Axonn upon request.

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 when the equipment is operated in a residential environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, 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.

WARNING: Changes or modifications not expressly approved by Axonn may render the device non-compliant to FCC and other regulatory body standards for operation and may void the user's authority to operate the equipment.

Accessory items that can be readily obtained from multiple retail outlets are not considered to be special accessories and are not to be marketed with the equipment. Only those accessory items provided by Axonn have been tested to ensure operation consistent with the regulatory standards that the device is required to perform.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.



This ClassA/ClassB digital apparatus complies with Canadian ICES-003.

This device will operate in accordance to the standards set forth by the CE Mark Directives and standards R&TTE: (TBR41 v1.1.1 May 2000, EN 301 441), RFI: (EN61000-4-3:1996 + A1:1998 + A2:2000), ESD: (EN61000-4-2: 1995 + A1:1998)

NOTICE: This equipment complies with the FCC RF Exposure Limits. A minimum of 20 centimeters (8 inches) separation between the device and the user and all other persons should be maintained.

FCC ID: L2V070878  
ICES-003/(A/B)  
IC:3989AAXTRACKER



R&TTE: TBR41

Complies with FCC standards.  
FOR HOME OR OFFICE USE

[This device and the technology herein is protected under U.S. Patents numbers 4,977,577; 5,987,058; 6,317,029; 6,396,819. Other patents are pending.](#)