Swarm Tracker Product Manual

Swarm Tracker User Manual
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Revision History

Revision	Date	Comment
0.9	3/13/2019	Tracker User Manual - Initial Release

1 Safety Information and Compliance

The Tracker is designed to comply with the standards for Radio Emissions Compliance and Electromagnetic Compatibility in the United States, Canada, Australia, New Zealand, United Kingdom, and the European Union.

1.1 FCC Compliance

1.1.1 FCC Interference Statement (Part 15.105 (b))

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one 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.

This device complies with part 15 of the FCC Rules. Operation is subject to the condition that this device does not cause harmful interference.

1.1.2 FCC Part 15 Clause 15.21:

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

1.1.3 FCC Part 15.19(a):

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.

1.1.4 FCC ID:

The FCC ID for the Tracker is 2AVE9-TRKR01

1.2 ISED Compliance

1.2.1 ISED RSS-Gen Notice:

This device complies with Industry Canada's licence-exempt RSSs. Operation is subject to the following two conditions:
(1) This device may not cause interference; and
(2) This device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes :
1) l'appareil ne doit pas produire de brouillage;
2) l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

1.2.2 IC ID:

The IC ID for the Tracker is 25817-TRKR01

1.3 RF Exposure Guidance

In order to comply with FCC / ISED RF Exposure requirements, this device must be installed to provide at least 25 cm separation from the human body at all times while using either Swarm ½ Wave or Swarm ¼ Wave antennas.

Afin de se conformer aux exigences d'exposition RF FCC / ISED, cet appareil doit être installé pour fournir au moins 25 cm de séparation du corps humain en tout temps lors de l'utilisation des antennes Swarm ½ Wave ou Swarm ¼ Wave

2 Product Overview

The Swarm Tracker satellite data modem transmits and receives data to and from Swarm's space network and is designed as a standalone product. Swarm backend systems can support the delivery of customer data via a REST API to the cloud service of each user's choice.

The Tracker is a ruggedized device suitable for a variety of low-bandwidth use cases: from connecting people and tracking vehicles, ships, or other assets to relaying sensor data for agriculture, energy, and industrial Internet of Things (IoT) applications.

Using proven IoT technologies, the Tracker is easy to use on its own or with a third party device requiring connectivity. The Tracker communicates via a standard USB-C serial cable, over Bluetooth, or via WiFi.

Category	Description
Satellite data	Message transmission access will be <1 min (90% of the time) by late 2020. As Swarm's network grows, transmission latencies of <60s will be achieved.
Components	GPS, VHF radio with integrated T/R switch, integrated Bluetooth and Wifi Antenna, SMA connector for VHF antenna, ARM Cortex-M4 processor, indicator LEDs, serial TTL interface
Sensors	Onboard GPS (lat/lon/alt), 1 Hz
Dimensions and Mass	95 mm x 58 mm x 20 mm, 205 g (without antenna) See detailed description in "Mechanical Specification" section.
Communication Protocol	WiFi, Bluetooth, USB-serial
Data rate	1 kbps (2020), 2.7 kbps (2021). Max packet size of 200 bytes

Table 1: Overview of the Swarm Tracker

3 Mechanical Specification

A diagram of the Tracker is shown in **Figure 1**.

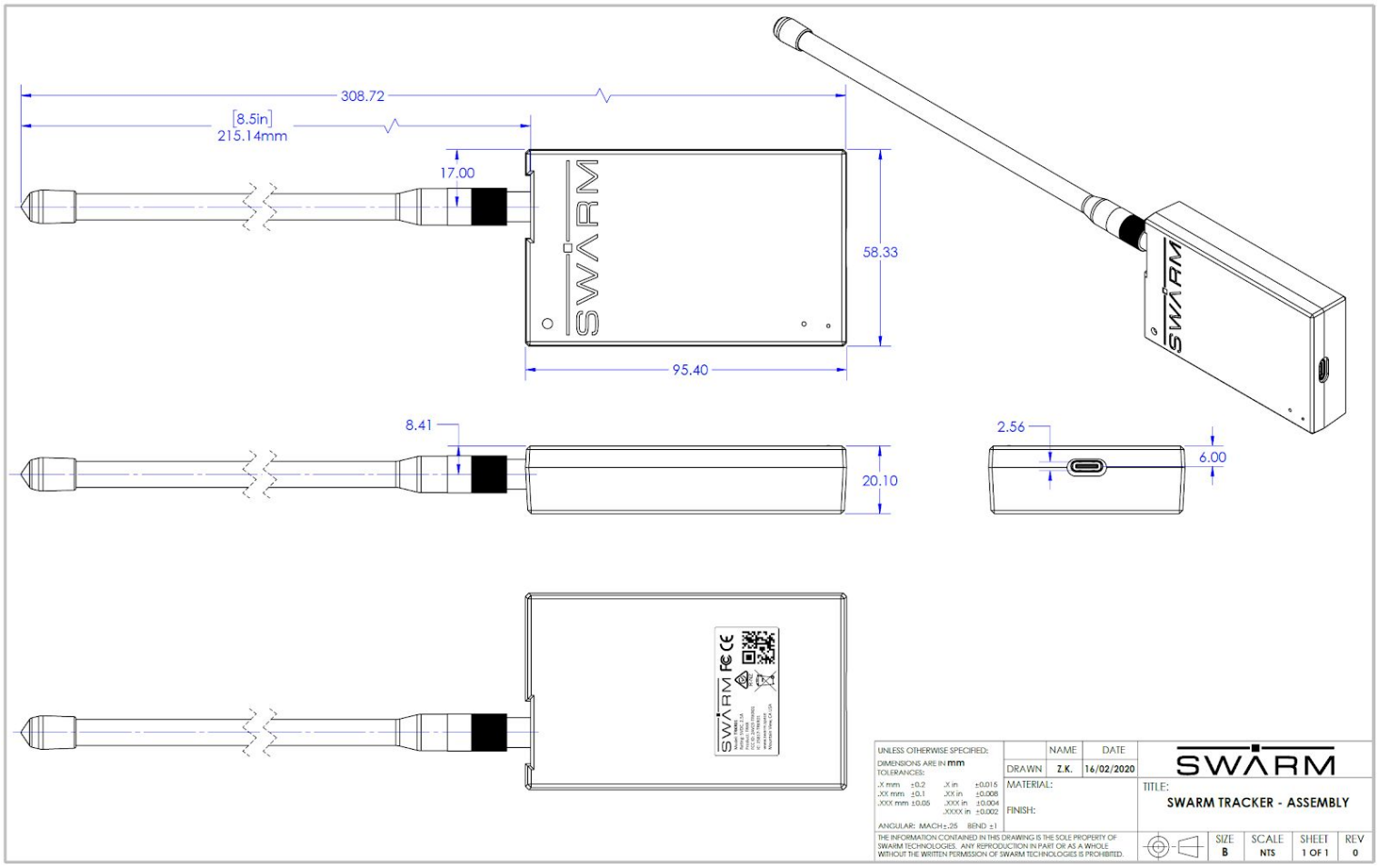

Figure 1: Tracker front, back, and side views

3.1 Tracker Dimensions

The overall dimensions of the Tracker and its weight without an attached antenna are summarized in **Table 2**.

Parameter	Value
Length	95 mm
Width	58 mm
Depth	20 mm
Weight	205 g

Table 2: Tracker Mechanical Dimensions and Weight

3.2 Environmental

The environmental specifications of the Tracker are summarized in **Table 3** below.

Parameter	Value
Operating Temperature Range	-10 °C to +45 °C
Survivable Temperature Range	-60 °C +60 °C
Ingress Protection	IP68 (Dust Tight, Immersion in water to 2 m depth) MIL-STD-810G, Method 512.5, Procedure I, Immersion to 2 m depth

Table 3: Environmental Specifications

3.3 Physical Interface Connectors

The Tracker incorporates a single SMA-female connector for attachment of the VHF antenna, or a coaxial cable to a VHF antenna. The Tracker also has a USB-C port for charging the battery and providing a USB-C serial connection for wired data transfer.

4 Electrical Interfaces

The following subsections contain information for the electrical interfaces of the Tracker. The RF interfaces are covered in section 5.

4.1 Battery and charging

The Tracker contains an internal single cell lithium polymer battery with a 5000mAh, 18.5Wh capacity that can be fast charged via a standard USB-C cable with the following parameters in **Table 4**. The battery may only be charged by a UL rated 5V/3A 15W maximum supply:

Parameter	Value
USB-C charging Voltage	5V
USB-C Maximum Charging Current	2.7A
Estimated battery lifetime (continuous receive mode)	3 days
Estimated battery lifetime (continuous sleep mode)	12 months

Table 4: Tracker Charging and Battery Specifications

4.2 Power On/Off Control

The Tracker can be reset by depressing a recessed push button (see **Figure 2**) located on the front of the Tracker for at least 7 seconds with a paperclip or comparable device. The Tracker will remain on until complete depletion of its battery

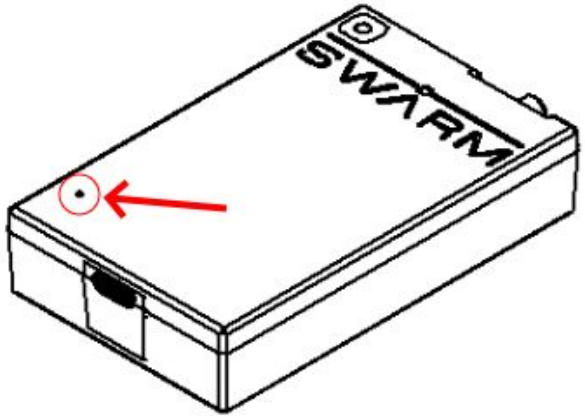

Figure 2: Location of recessed push button on Tracker

4.3 Data interface

4.3.1 Serial Data Interface overview

The serial interface is what the Tracker uses to transfer commands, responses, and message data. The default serial communication parameters are found below in **Table 5**:

Parameter	Value
Baud Rate	115200
Data Bits	8 Bits
Parity	None
Stop Bits	1 Bit
Flow Control	None

Table 5: Serial Interface Specifications

4.3.2 WiFi Interface overview

The Tracker can act as a WiFi access point that a third party device can connect to in order to send and receive commands. After pairing with the Tracker, a serial connection can be set up using the parameters in **Table 5**.

4.3.2.1 Enabling WiFi Interface

To enable the Wifi interface, first provision the Tracker by connecting to it via its USB-serial port and issue the following command followed by a reset of the Tracker:

$config wifi ap wpa2 *SSID PASSWORD VISIBILITY APIPADDRESS*

SSID - User configurable access point name
PASSWORD - User configurable password
VISIBILITY - User configurable. Use hidden or visible. If hidden is selected, the Tracker will not broadcast its access point name
APIPADDRESS - User configurable IP address (ex: 10.0.0.1) that the access point will use

To reset the Tracker, issue the following command:

$reset

4.3.2.2 Disabling WiFi Interface

To disable the Wifi interface, issue the following command followed be a reset of the Tracker:

$config wifi disabled

To reset the Tracker, issue the following command:

$reset

4.3.2.3 Sending and receiving commands through WiFi Interface

After connecting to the Tracker's WiFi access point, the connected device can send and receive commands after connecting via telnet.

4.3.3 Bluetooth Interface overview

The Tracker can act as a Bluetooth access point that a third party device can connect to to send commands. After pairing with the Tracker, a serial connection can be set up using the parameters in **Table 5**.

4.3.3.1 Enabling Bluetooth Interface

To enable the Bluetooth interface, first provision the Tracker by connecting to it via its USB-serial port and issue the following command followed by a reset of the Tracker:

$config bt enabled

To reset the Tracker, issue the following command:

$reset

4.3.3.2 Disabling Bluetooth Interface

To disable the Bluetooth interface, issue the following command followed be a reset of the Tracker:

$config bt disabled

To reset the Tracker, issue the following command:

$reset

4.3.3.3 Sending and receiving commands through Bluetooth Interface

After enabling the Bluetooth interface on the Tracker, the Tracker will broadcast it's address as:

Swarm-XXXXXX (Where **XXXXXX** [ex: 033FEA] are the last 6 digits of the Tracker's bluetooth MAC address)

If your device is connected to the Tracker through its wired serial port, the Bluetooth pin will display as:

BT PIN: Please compare the numeric value: YYYYYY (where **YYYYYY** [ex: 123876] is the Bluetooth PIN)

After pairing, a serial connection can be opened over the bluetooth connection.

5 RF Interface

This section describes the physical characteristics of the RF connectors and specifications of the RF Interface.

5.1 Antenna

For illustrative purposes the certified Swarm antennas are shown in **Figure 3.** Professional installation is required to install the authorized antennas

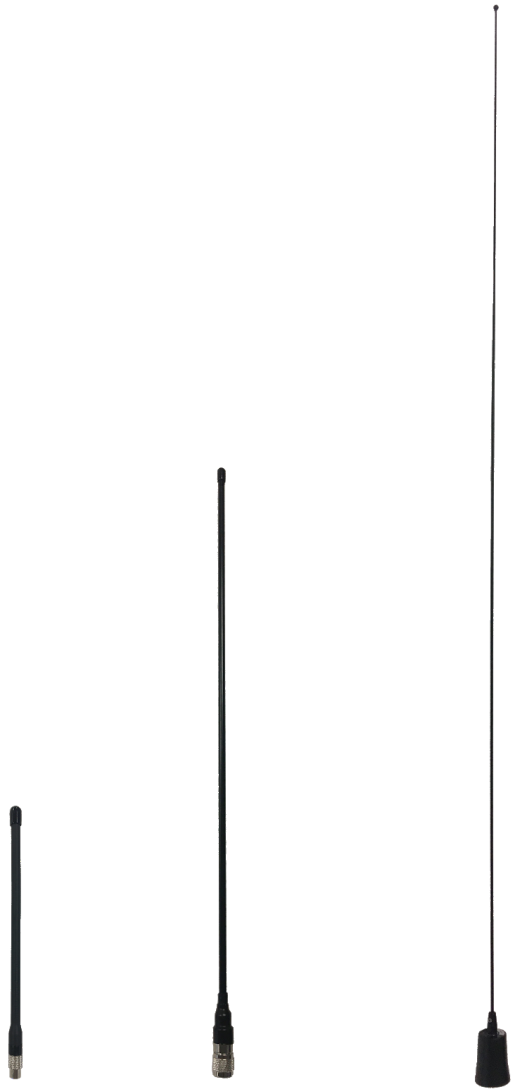

Figure 3: Swarm Antennas. From left to right: Coiled ¼ Wave 8.5” Antenna, ¼ Wave Antenna, and ½ Wave Antenna

5.2 Antenna Characteristics

The Tracker is certified with the following antennas as described in **Tables 6-8**. Only the Swarm Coiled ¼ Wave 8.5” Antenna may be used with the Tracker when it is body mounted.

Swarm Coiled ¼ Wave 8.5” Antenna	
Parameter	**Value**
Length	21.5 cm
Diameter (Connector)	11.2 mm
Diameter (along major length)	7.6 mm
Weight	32 g
Operating Temperature	-60 °C to +60 °C
Operating Humidity	0-100% humidity, condensable
Impedance	50 Ohms nominal
Polarization	Linearly Polarized
VSWR (in Swarm Bands)	1.8
Frequency	137-138 and 148-150 MHz
Connector	SMA male
Antenna Classification	Portable
Minimum separation distance from body	0cm

Table 6: Antenna characteristics for Swarm Coiled ¼ Wave 8.5” Antenna

Swarm ¼ Wave Antenna	
Parameter	**Value**
Length	53.5 cm
Diameter (Connector)	20.0 mm
Diameter (along major length)	7.15 mm
Weight	61 g
Operating Temperature	-60 °C to +60 °C
Operating Humidity	0-100% humidity, condensable
Impedance	50 Ohms nominal
Polarization	Linearly Polarized
VSWR (in Swarm Bands)	1.8
Frequency	137-138 and 148-150 MHz
Connector	N Male
Antenna Classification	Mobile, Fixed
Minimum separation distance from body	25cm

Table 7: Antenna characteristics for Swarm 1/4 wave Antenna

Swarm ½ Wave Antenna	
Parameter	**Value**
Length	108.5 cm
Diameter (Connector)	40.65 mm
Diameter (along major length)	3.3 mm
Weight	150g
Operating Temperature	-60 °C to +60 °C
Operating Humidity	0-100% humidity, condensable
Impedance	50 Ohms nominal
Polarization	Linearly Polarized
VSWR (in Swarm Bands)	1.8
Frequency	137-138 and 148-150 MHz
Connector	NMO Female
Antenna Classification	Mobile, Fixed
Minimum separation distance from body	25cm

Table 8: Antenna characteristics for Swarm 1/2 wave Antenna

5.3 RF Interface Specifications

The RF interface requirements for the Tracker are summarized in **Table 7** below.

Parameter	Value
Transmit Frequency Range	148-150 MHz
Receive Frequency Range	137-138 MHz
Duplexing method	Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA)
Input/output impedance	50 Ω

Table 7: General RF Parameters

5.4 Radio Characteristics

The radio characteristics of the Tracker can be found below in **Table 8**.

Parameter	Value
Maximum transmit power during a transmit slot	800 mW

Table 8: In-Band Characteristics

6 Instructions for the safe Installation and use of the Tracker

The Tracker is intended for integration with a finished product. The integrator of the Tracker is required to connect an appropriate antenna, along with a USB-C cable to charge the Tracker.

To ensure that the Tracker is correctly installed the following general instructions (sub-section 6.1) are provided for the installer:

The integrator will be required to supply the end user of the integrated product, incorporating the Tracker, with operating instructions and any other information relating to the maintenance and safety of the equipment (sub-section 5.2).

The power supply used to charge the Tracker must be checked to ensure it meets the requirements of sub-section 4.1 of this document.

The Tracker shall not be located in close proximity to sources of extreme temperature which will cause it to be operated outside of its temperature specification (-10ºC to +45ºC).

The Tracker shall not be operated without an appropriate antenna connected to its antenna connector via a suitable 50 Ohm SMA connector.

The Tracker may be body worn, or mounted on other equipment. When body worn, only the Swarm 8.5” Coiled Antenna may be used.

Figure 4: Example of mounting of Tracker with use of ½ Wave Antennas

Figure 5: Example of body-mounted Tracker with Coiled 8.5” Antenna

7 Software interface

Message types

The Tracker transmits two types of messages:

- Unsolicited messages, which include status messages, date/time and GPS information, and notifications that messages have been received by the Tracker
- Command responses, which include responses to message and power management commands, as well as notifications that messages have been sent or settings have been updated

General command structure

All messages to and from the Tracker are NMEA formatted messages. NMEA messages begin with a `$` and end with a single newline `'\n'` character. In addition, the last three characters prior to the newline are `*xx` where `xx` is a checksum of the characters in the command from next character after the `$` up to, but not including, the `*`. The checksum is the same as used by NMEA. Messages with a bad checksum are silently ignored and are not stored anywhere.

A `$` will never occur within a command, and may be used to reset the receiving state machine.

A `*` may occur within a command. The receiving state machine will verify the last three characters in the command are `*xx` after the `\n` is received. The `x` may be any legal ASCII character in the range `0..9`, `A..F`, or `a..f`.

An example command is provided below to illustrate the command structure. The below command returns the most recent datetime message from the Tracker:

```
$DT @*70
```

Command timing

Once the `$` is received, the next character must occur within 5 milliseconds of the previous character. If the inter-character delay exceeds 5 ms, the command will be silently discarded, and the receiving state machine will consume and ignore any characters received until the next `$`.

Additional notes

The user application connected to the Tracker should ignore any characters received from the Tracker after startup until the `$TRACKER BOOT,RUNNING*49` string is received. The bootloader will output messages as it starts up. These messages include, but are not limited to: status messages, firmware update progress messages, and error messages.

7.1 Unsolicited Messages

Date/time

This message indicates the current date/time obtained from the Tracker's GPS. This message is not sent until the GPS has obtained a fix sufficient to set its internal date and time. If the GPS loses its fix, the message is sent with a flag indicating an invalid state. Date/time messages can be enabled or disabled using the `$DT` or `$OP` command.

```
$DT <YYYY><MM><DD><hh><mm><ss>,<flag>*xx
```

Parameter	Description
`YYYY`	Year (1970..2038)
`MM`	Month (01..12)
`DD`	Day (01..31)
`hh`	Hour (00..23)
`mm`	Minutes (00..59)
`ss`	Seconds (00..59)
`flag`	`I` Date/time is invalid `V` Date/time is valid

Tracker status

Status messages indicate that the Tracker has booted and acquired date/time and position information from the GPS network. Error and debug messages are also sent as status messages. Tracker status messages cannot be disabled.

```
$Tracker <msg>,[<data>]*xx
```

Parameter	Description
`msg`	`BOOT` Tracker has booted and is ready to receive commands `DATETIME` Tracker has acquired date/time from the GPS network `POSITION` Tracker has acquired position from a valid 3D fix from the GPS network `ERROR` Error message (typically text) `DEBUG` Debug message (typically text)
`data`	`RUNNING` The Tracker is running and can now accept commands `POWERON` The Tracker has detected power applied to it `UPDATED` A firmware update was performed `FAULT` A firmware crash occurred and the Tracker restarted

Notes:

A `data` message follows the `BOOT` message to indicate the reason for the startup. The `DATETIME` will be sent once the GPS has acquired the date/time from the GPS network. The `POSITION` will be sent once a valid 3D fix has been acquired from the GPS network. The `POSITION` message will typically occur before the `DATETIME` message. Depending on the GPS signal quality, it may take several minutes before the `DATETIME` or `POSITION` message is emitted.

Geospatial information

This message provides standard NMEA-formatted positional information, including latitude, longitude, altitude, course, and speed. Geospatial information messages can be enabled/disabled using the `$GN` or `$OP` command.

```
$GN <latitude>,<longitude>,<altitude>,<course>,<speed>*xx
```

Parameter	Description
`latitude`	Latitude in d.ddddddd format (float). The latitude is presented in the N basis (negative latitudes are in the southern hemisphere)
`longitude`	Longitude in d.ddddddd format (float). The longitude is presented in the E basis (negative longitudes are in the western hemisphere)
`altitude`	Altitude in meters (integer)
`course`	Course in degrees (0..359) (integer). Course proceeds clockwise, with 0=north, 90=east, 180=south, and 270=west
`speed`	Speed in kilometers per hour (0..999.99) (integer * 100)

GPS fix quality

This message provides a standard NMEA-formatted description of the type of GPS fix currently in use. GPS fix quality messages can be enabled/disabled using the `$GS` or `$OP` command.

```
$GS <hdop>,<vdop>,<gps_sats>,<glonass_sats>,<fix_type>*xx
```

Parameter	Description
`hdop`	Horizontal dilution of precision (integer *100)
`vdop`	Vertical dilution of precision (integer *100)
`gps_sats`	Number of GPS satellites used in solution (integer)
`glonass_sats`	Number of GLONASS satellites used in solution (integer)
`fix_type`	`NF` No fix `DR` Dead reckoning only solution `G2` Standalone 2D solution `G3` Standalone 3D solution `D2` Differential 2D solution `D3` Differential 3D solution `RK` Combined GPS + dead reckoning solution `TT` Time only solution

GPS spoofing indicator

This message provides a standard NMEA-formatted value of the quality of GPS signals received. GPS spoofing indicator messages can be enabled/disabled using the `$GS` or `$OP` command.

`$GJ <flag>,value>*xx`

Parameter	Description
`flag`	`0` Spoofing unknown or deactivated `1` No spoofing indicated `2` Spoofing indicated `3` No reliable GNSS position fix (likely due to spoofing)
`value`	Value ranging from 0 to 255 indicating how much spoofing the Tracker detects. 0 = no spoofing, 255 = 100% spoofing

Received data

This message contains ASCII-encoded hexadecimal data received from the Swarm network. Received messages can be enabled/disabled via the `$OP` command.

`$RD <data>*xx`

Parameter	Description
`data`	ASCII-encoded hexadecimal data in packet

7.2 Commands and Responses

Date/time

This command repeats the most recent `$DT` message, or queries or sets the `$DT` message rate.

`$DT <@|?|<rate>>*xx`

Parameter	Description
`@`	Repeat most recent `$DT` message
`?`	Query current `$DT` rate
`rate`	Disable or set rate of `$DT` messages

Returns one of:

Value	Description
`$DT <YYYY><MM><DD><hh><mm><ss>,<flag>*xx`	The most recent `$DT` message. `<flag>` will return as `V` (valid) or `I` (invalid)
`$DT <rate>*xx`	The current `$DT` rate
`$DT OK*xx`	Parameters updated successfully
`$DT ERR*xx`	An error response

Notes:

For the query option, the return value of `$DT <rate>*xx` requires different parsing than the normal `$DT` message format. The application should check if a comma is present in the `$DT` string, and, if so, assume it is the standard date/time format. If no comma is present and the value is a number, then the value is the rate being returned in response to the `$DT ?` query.

`<rate>` is a value between 1 and 2147483647 (2^{31}-1). It will be the number of seconds in between each message.

An `OK` response confirms that the parameters have been updated in response to a command with the `<rate>` parameter. An `ERR` response indicates that additional or invalid characters were included between the `T` and the `*` of the command.

Example:

Calling the most recent date/time message:

```
$DT @*70
```

```
$DT 20190408195123,V*6d
```

Returns a date/time of `April 8th, 2019 7:51:23 PM GMT`. The date/time is `valid`

Firmware version

This command returns the Tracker's firmware version.

`$FV*xx`

Returns one of:

Value	Description
`$FV <version_string>*xx`	The current firmware version
`$FV ERR*xx`	An error response

Notes:

An `ERR` response indicates that additional characters were included between the `V` and the `*` of the command.

Geospatial information

This command repeats the most recent $GN message, or queries or sets the $GN message rate.

`$GN <@|?|<rate>>*xx`

Parameter	Description
@	Repeat most recent $GN message
?	Query current $GN rate
rate	Disable or set rate of $GN messages

Returns one of:

Value	Description
$GN <latitude>,<longitude>,<altitude>,<course>,<speed>*xx	The most recent $GN message. See Geospatial Information - Unsolicited Messages for more detail on the outputs of this message
$GN <rate>*xx	The current $GN rate
$GN OK*xx	Parameters updated successfully
$GN ERR*xx	An error response

Notes:

For the query option, the return value of $GN <rate>*xx requires different parsing than the normal $GN message format. The application should check if a comma is present in the $GN string, and, if so, assume it is the standard geospatial information format. If no comma is present and the value is a number, then the value is the rate being returned in response to the $GN ? query.

<rate> is a value between 1 and 2147483647 (2^{31}-1). It will be the number of seconds in between each message.

An `OK` response confirms that the parameters have been updated in response to a command with the `<rate>` parameter. An `ERR` response indicates that additional or invalid characters were included between the `N` and the `*` of the command.

Example:

Calling the most recent GPS message:

```
$GN @*69
```

```
$GN 37.4009492,-122.0571488,22,2,5*2d
```

Returns a location of `37.4009492N, 122.0571488W`. The Tracker's altitude is `22m`, its course is `2 degrees`, and it is moving at `5 kilometers per hour`.

GPS Fix Quality

This command repeats the most recent $GS message, or queries or sets the $GS message rate.

`$GS <@|?|<rate>>*xx`

Parameter	Description
@	Repeat most recent $GS message
?	Query current $GS rate
rate	Disable or set rate of $GS messages

Returns one of:

Parameter	Description
$GS <hdop>,<vdop>,<gps_sats>,<glonass_sats>,<fix>*xx	The most recent $GS message. See GPS Fix Quality - Unsolicited Messages for more detail on the outputs of this message
$GS <rate>*xx	The current $GS rate
$GS OK*xx	Parameters updated successfully
$GS ERR*xx	An error response

Notes:

For the query option, the return value of $GS <rate>*xx requires different parsing than the normal $GS message format. The application should check if a comma is present in the $GS string, and, if so, assume it is the standard geospatial information format. If no comma is present and the value is a number, then the value is the rate being returned in response to the $GS ? query.

<rate> is a value between 1 and 2147483647 (2^{31}-1). It will be the number of seconds in between each message.

An `OK` response confirms that the parameters have been updated in response to a command with the `<rate>` parameter. An `ERR` response indicates that additional or invalid characters were included between the `S` and the `*` of the command.

Example:

Setting the rate for geospatial information messages to 1:

```
$GS 1*05
```

```
$GS OK*30
```

Manage received messages

This command enables management of received messages.

`$MM <C=<U|*>|<D=<msg_id|*>|<M=<msg_id>|*>|R=<msg_id|O|N>>*xx`

Parameter	Description
`C=<U|*>`	Return count of unread (`U`) or all (`*`) messages
`D=<msg_id|R|*>`	Delete message ID (`msg_id`), all read (`R`), or all (`*`) messages
`M=<msg_id|*>`	Mark message ID (`msg_id`) or all (`*`) as read
`R=<msg_id|O|N>`	Read message ID (`msg_id`), oldest (`O`), or newest (`N`)

Returns one of:

Value	Description
`$MM OK*xx`	Delete message command succeeded
`$MM ERR,BADPARAM*xx`	Invalid command or argument to `$MM` command
`$MM ERR,DBXINVMSGID*xx`	Invalid message ID in `D` or `R` command
`$MM ERR,DBXNOMORE*xx`	No more messages when using `R=<O|N>` command
`$MM DELETED,<msg_id>*xx`	`<msg_id>` deleted successfully
`$MM MARKED,<msg_id>*xx`	`<msg_id>` marked as read successfully
`$MM <msg_count>`	Number of messages read/all/deleted (1)
`$MM <data>,<msg_id>,<es>`	Response to reading a message (2)

Notes:

Messages have three states: unread, read, and deleted. Once an unread message is read, its state changes to read. It can subsequently be read again. If a message is deleted, it can no longer be read. `All` in the above context means both read and unread messages, but does not include messages that have been deleted.

If a message is marked read using the `M=<msg_id>` or `M=*` command, marking it as read again is not an error.

(1) `<msg_count>` is a number indicating the number of messages that are unread in response to the `C=U` command, total number of read and unread messages in response to the `C=*` command, and the number of messages deleted in response to the `D=*` command.

(2) `<data>` is in the same format as an unsolicited `$RD` message. `<msg_id>` is the message ID. The message ID should be treated as a simple arbitrary number. `<es>` is the epoch seconds time when the message was received by the Tracker.

Disable/enable messages

This command allows selective disabling/enabling of messages from the Tracker, as well as setting parameters including message delivery preferences, controlling the GPIO1 pin, and controlling the red and green LEDs.

`$OP <?|p1=<val>[,p2=<val>[,...]]]*xx`

Parameter	Description
`?`	Display current settings
`DT=0|<rate>`	Disable or set rate of `$DT` messages
`GJ=0|<rate>`	`Disable or set rate of `$GJ` messages
`GN=0|<rate>`	Disable or set rate of `$GN` messages
`GS=0|<rate>`	Disable or set rate of `$GS` messages
`LG=<led_mode>`	Set operating mode for green LED
`LR=<led_mode>`	Set operating mode for red LED
`MD=I|P`	Set msg delivery immediate (default) or polled

Returns one of:

Value	Description
`$OP OK*xx`	Parameters updated successfully
`$OP ERR*xx`	An error response

Notes:

The `?` option allows reading back the current settings. This is a comma separated list of all options. NOTE: Options are in alphabetical order, therefore as new options are added, they may appear in the middle of the string. The user application should NOT rely on any given option

being at any given position; the string should be parsed using the comma as a delimiter, and the desired option retrieved by name. Note that the `TM` option does not appear in the output string.

`<rate>` is a value between 1 and 2147483647 (2^{31}-1). It will be the number of seconds in between each message. The default rate for each message type is 60 (once per minute). Messages for `DT`, `GN`, `GJ`, and `GS` will not be emitted to the user until the GPS has obtained a fully resolved fix.

The `LG` option sets the operating mode for the green LED. The available modes are:

Mode	Description
`0`	LED is off
`1`	LED is on
`2`	LED blinks 1 sec on/1 sec off until GPS fix acquired
`3`	LED follows GPS 1PPS output
`4`	LED is on when VHF radio is transmitting
`5`	LED is on when VHF radio is has received packet
`6`	LED is on when Tracker is awake (1)
`7`	LED is heartbeat indicator (50ms on/4950ms off)

(1) - The LED will be lit when the Tracker is awake, in both the user mode and system mode. If the Tracker is not put to sleep with the `$SL` command, the LED will remain on. If the Tracker is put to sleep with the `$SL` command, the LED will be lit if the Tracker wakes to perform internal housekeeping tasks.

The `LR` option sets the operating mode for the red LED. Please see the `LG` option for the available modes.

The `MD` option allows setting whether messages received from the Swarm network are delivered immediately upon reception, or if they must be polled for by the user via the `$RD` command. When `MD` is set to `I`, messages are delivered immediately via the unsolicited `$RD` message. When `MD` is set to `P`, the user periodically needs to issue the `$RD` command with one of the appropriate parameters.

The parameters are only updated if `OK` is returned. Should an error occur in one or more parameters, `ERR` is returned and none of the parameters are updated. These settings are not retained across a restart of the Tracker.

Restart Tracker

This command restarts the Tracker.

`$RS*xx`

Returns one of:

Value	Description
`$RS OK*xx`	Command has been accepted and the Tracker will immediately perform a hardware restart
`$RS ERR*xx`	An error message

Notes:

An `OK` response confirms that the Tracker will successfully restart. An `ERR` response indicates that additional or invalid characters were included between the `S` and the `*` of the command.

Sleep mode

This command puts the Tracker into a low-power sleep mode.

`$SL [S=<seconds>|U=<[YYYY-MM-DD ]hh:mm:ss>]*xx`

Parameter	Description
`S=<seconds>`	Sleep for this many seconds
`U=<[YYYY-MM-DD ]hh:mm:ss>`	Sleep until date (optional) and time

Returns one of:

Value	Description
`$SL OK*xx`	Sleep period accepted, Tracker is now non-responsive
`$SL WAKE,TIME*xx`	Tracker has woken from selected sleep mode
`$SL CLOCKNOTSET*xx`	Clock not yet set from GPS
`$SL ERR*xx`	Invalid number of seconds or date/time value
`$SL NOCOMMAND*xx`	No `S` or `U` parameter is present
`$SL ERR,NOTIME*xx`	Attempt to sleep before time is set

The `S` parameter is the number of seconds to sleep. This value may range from 5 to 31536000 (approximately 1 year) seconds. A value not within this range will return `$SL ERR`. If the command is accepted, the Tracker will emit `$SL OK` and enter sleep mode for the requested duration.

The `U` parameter is a time and optional date the Tracker should sleep until and then wake. If the date is not specified and the time to sleep until is less than the current time, the time is presumed to be in the next day. For example, if the current time is 11:00:00 and `$SL U=09:00:00` is issued, the Tracker will wake 22 hours from now. If a date and time are

specified, and that date/time is before the current date/time, `$SL WAKE` will be immediately issued.

In sleep mode, the real-time clock is not GPS disciplined, and is therefore subject to some degree of drift. The longer the Tracker is asleep, the more the drift will accumulate. The user should be aware of this when selecting a sleep with a long duration.

Example:

Commanding the Tracker to sleep for 1 minute:

```
$SL S=60*57
```

```
$SL OK*3b
```

```
$SL WAKE,TIME @ 2019-04-11 18:58:03*77
```

Transmit data

This command transmits data to the Swarm network.

`$TD [HT=<hold_time>,]<[string|data]>[..<data>]*xx`

Parameter	Description
`HT=<hold_time>`	Expiration time of message (optional, default = 3600 seconds)
`<string|data>`	1 to 200 bytes of data (ASCII string) 2 to 400 bytes (hexadecimal written as ascii)

Returns one of:

Value	Description
`$TD OK,<msg_id>*xx`	Message accepted for sending
`$TD SENT,<msg_id>*xx`	Message was received by satellite
`$TD ERR,BUSY,<msg_id>*xx`	Channel is busy
`$TD ERR,BADDATA,0*xx`	Message has odd number or non-hex characters
`$TD ERR,BADHOLDTIME,0*xx`	Invalid hold time
`$TD ERR,ERR,0*xx`	Unspecified error
`$TD ERR,EXPIRED,<msg_id>*xx`	Unable to send within requested hold time
`$TD ERR,NOADDR,0*xx`	The Swarm ID has not yet been set
`$TD ERR,NOCOMMAND,0*xx`	`$TD` with no parameters was sent
`$TD ERR,NOSPACE,0*xx`	No space for message
`$TD ERR,NOTCID,0*xx`	The thin client ID has not yet been set
`$TD ERR,NOTIME,0*xx`	Attempt to send message before time set

`$TD ERR,QUEUEFULL,0*xx`	Queue for queued messages is full
`$TD ERR,TOOLONG,<msg_id>*xx`	Message is too large to send

Notes:

The `HT` parameter is optional but must occur before the `<data>` portion of the command.

`<hold_time>` is either the number of seconds to expire the message if it has not been sent, or an epoch second date after which the message will be expired if it has not been sent.

Hold Time Value	Description
`1` to `31536000`	The message will be considered expired if a Swarm satellite has not come into view within the specified number of seconds.
`31536001` to `1514764800`	An error message (`$TD ERR,0*xx`) is returned.
>`1514764800`	The message will be considered expired if the Tracker is unable to send it before the specified time. If the specified time is greater than `1514764800` and less than or equal to the current UTC time, the message will not be queued and an expired message `$TD EXPIRED,<msg_id>*xx` will be returned immediately. Note: `1514764800` is equal to 2018-01-01 00:00:00 in epoch seconds.
None provided	A default hold time of `3600` seconds will be used.

`<string|data>` may be expressed one of two different ways. If all the data to be sent is in the ASCII character range from 0x20 (space) to 0x7e (tilde), then the data may be sent as a string. A string is specified by enclosing the data in double quotes, e.g., "Hello, world". It is permissible for the string to contain double quotes within the string, e.g., "Today is a "new" day". If the data to be sent includes one or more character outside the 0x20 to 0x7e range, then it must be specified as pairs of hex characters ('0'..'9', 'A'..'F', 'a'..'f'), and must be a multiple of 2. Sending 'Hello' as hex would be 48656C6C6F. Illegal characters or an odd number of characters will cause a `BADDATA` message to be returned.

`<msg_id>` is assigned by the Tracker, and is an unsigned 64-bit value comprised of the device ID, a day of year counter, and a message of day counter. Responses that have a 0 as the

message ID indicates the message has not been placed in the queue and therefore has no ID. The value should be treated as a simple arbitrary number.

Example:

Sending a message from the Tracker:

```
$TD "Hello World!"*31
```

```
$TD OK,5354468575916*2c
```

```
$TD SENT,5354468575916*24
```