RTx/GPS – Rocket Telematics System
User Manual

Firmware Revision 1.31

Missile Works Corporation
PO Box 1725, Lyons CO 80540
www.missileworks.com

Introduction

Overview

The RTx/GPS Rocket Telematics System is a highly capable and very scalable 900 MHz radio-based telemetry and location system designed with the features of high-end units while maintaining a modest price tag. In addition to its real-time tracking and telemetry capabilities, the RTx/GPS system is also a multi-flight GPS flight data recording unit, allowing you to fly all day without the need to stop and download your recorded GPS data in between flights.

The heart of the RTx/GPS system is built around the uBlox 7 PAM-7Q GPS module. This module has a highly sensitive GPS satellite receiver system coupled with an advanced feature set that supports "high-dynamics" operation and fast 10 Hz navigational solution capabilities. These collective features provide a very accurate and capable GPS location system for the harsh rigors of rocket flight, providing quick and accurate locational data and extremely fast coordinate re-acquisition when flying in the supersonic region.

In addition to this highly capable GPS engine, the RTx/GPS system communicates from your rocket to a base unit using the license-free 900 MHz ISM radio band (902-928 MHz). The radio modules employ a proprietary FHSS (Frequency Hopping Spread Spectrum) technology and operate with a proprietary networking feature which provides virtual interference-free operation.

Primary Features

Long range, license-free and interference-free radio operations
Autonomous base unit GPS navigation with "Turn Assist" directional arrows using LCD
Automatically saves the "Last Received Coordinates" in memory for "next day" retrieval activity
Multiple HMI (Human-Machine Interface) capable (LCD, Android, Windows PC)
Configurable Latitude/Longitude and "Units" formats
7 flight GPS data memory (at 1 Hz) @ ~68 minutes per flight
Live GPS data streaming via Bluetooth/USB and compatible with all m3 modules (LCD/USB)
Telemetry tethering capability with the RRC3 altimeter system
User-selectable beep frequency and audio cues
Configurable and operable with all Missile Works m3 modules

Specifications

Microcontroller	16MHz 16-bit MSP430 Series mCU
Onboard Flight memory	8Mbit SST Flash Memory
GPS Operational Ranges	Altitude: 50,000 meters / 160,042 feet
	Velocity: 500 meters/sec / 1640 feet/sec
Radio Operational Ranges	902 to 928 MHZ (software selected channels)
	Range up to 9 miles (with 2.1 dipole antennas)
Operational Voltage	3.5 volts to 10 volts (1S Lipo recommended)
Operational Current	@9V / ~70ma (quiescent) / ~190ma (peak)
Dimensions	28.5mm x 114.3mm (1.125" x 4.5")
Radio Network Addressing	XBee Pro 900HP Preamble ID: 5
	XBee Pro 900HP Network ID's: 0 thru FFFF

Radio Network ID's

Network ID's are managed by Missile Works to ensure each RTx System has a unique, interference-free address. Contact us for radio replacement or RTx radio expansion. RTx Systems operate in a "one-to-many" mode (one BASE unit to one or more ROCKET units).

Handling Precautions

- Always handle the RTx/GPS in a static-free, grounded environment.
- Allow the RTx/GPS to adjust to ambient conditions prior to flying.
- Prepare your rocket with the RTx/GPS powered off for maximum battery life.
- Don't cycle the RTx/GPS power off, then immediately back on (allow a few seconds).

RTx/GPS System Options

- Computer USB interface board for configuration and data upload via *mDACS* PC software
- Bluetooth slave interface for Android/PC application usage (Rocket Locator, Bluetooth GPS)
- LCD interface terminal for field configuration of live display of GPS/Location flight data
- Master/Slave Bluetooth modules for in-rocket networking (av-bay to nosecone)
- Auxiliary High-Power 1-watt 900 MHz ISM radio modem board (long-range comm link)

NOTE: To reset all settings of the RTx/GPS back to default, use this procedure:

- Push and Hold the programming pushbutton.
- Apply power to the RTx/GPS while the pushbutton is pressed (the LED will flicker).
- Continue holding down the push button for approximately 5 seconds.
- Release the pushbutton once it starts beeping (POST code 1 is beeped).
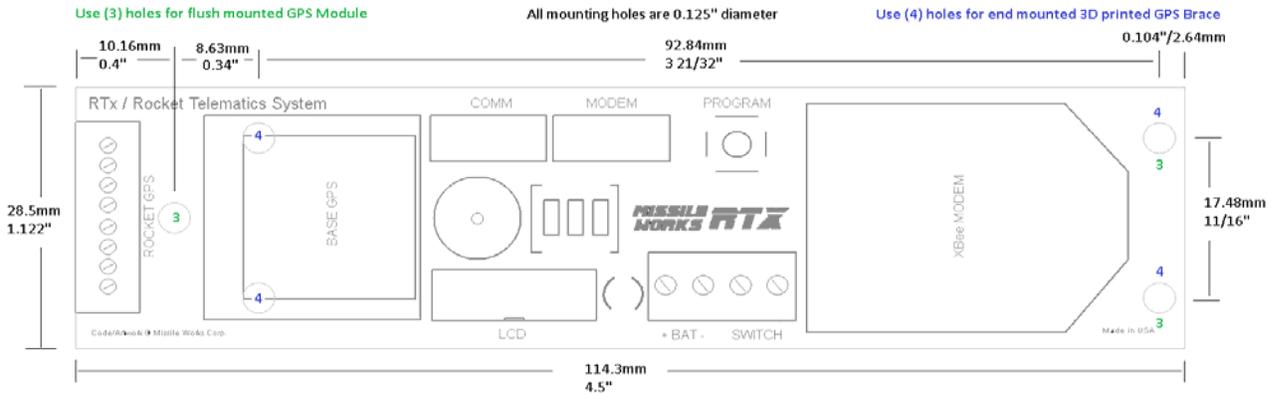*- Shut the RTx/GPS off.*

Installation

Board Mounting

The RTx/GPS does not have an "up" orientation and can be mounted in any convenient orientation. It is important to mount the RTx/GPS securely, preventing it from suffering damage during flight. It can be affixed rigidly to a sled or foam/bubble-packed to cushion the board.

When planning the mounting layout of your RTx/GPS system, be sure to provide secure mounting for the battery. An unsecured battery can break free during recovery events, resulting in damage to the board.

Use 4/40 screw hardware to mount the RTx/GPS onto a "sled" of the rocket. Nylon standoffs or insulated washers are also recommended to provide clearance for the bottom-side components of the circuit board.

Use (3) holes for flush mounted GPS Module   All mounting holes are 0.125" diameter   Use (4) holes for end mounted 3D printed GPS Brace

10.16mm 0.4"   8.63mm 0.34"   92.84mm 3 21/32"   0.104"/2.64mm

28.5mm 1.122"

RTx / Rocket Telematics System   COMM   MODEM   PROGRAM

ROCKET GPS   BASE GPS   MISSILE WORKS RTX   XBee MODEM

CodeARuu & Missile Works Corp.   LCD   + BAT -   SWITCH   Made in USA

17.48mm 11/16"

114.3mm 4.5"

Isolate the RTx/GPS electronics from the ejection-charge heat, residue, and over-pressure during recovery events.

IMPORTANT: Inadequate sealing of the electronics bay or exposure of the electronics to ejection charge heat or BP residue can cause the RTx/GPS to malfunction.

IMPORTANT: Black powder residue is extremely corrosive to the circuit board and its components. Always immediately clean off any inadvertent residue.

IMPORTANT: Ensure your RTX/GPS is oriented in your rocket or av-bay to avoid having the patch antenna placed near or against your launch pad rail or tower rails. This proximity will block all satellite reception and prevent acquisition of a GPS coordinate fix.

Power and Wiring Considerations

The RTx/GPS can operate with a standard 9-volt alkaline battery. Standard 9V alkalines provide an inexpensive and widely available battery type with secure snap connectors. Always purchase and use premium alkaline batteries. The RTx/GPS system will operate for just over 1 hour as an active transmitter in your rocket, so be aware of life cycle when using this battery type. In a base application it will run continuously just over 2 hours.

Other higher power density battery types are a better choice for the RTx/GPS system. These include NiCd, NiMH, LiPo, or other battery chemistries. Your battery choice must source and maintain an absolute minimum of 3.5 volts, but also be limited to a maximum of 10 volts. 1S or 2S LiPo are excellent choices. A field test with a 750ma 1S LiPo operated the RTx/GPS rocket transmitter for ~10 hours continuously.

IMPORTANT: Always use a battery system of 10 Volts or less to avoid damaging the RTx/GPS. Ensure your battery can source the minimum of 3.5 volts to properly operate.

In addition, it is important to pay attention to battery polarity – the positive terminal on the battery must be connected to the positive terminal (marked with a + sign) on the board. Connecting the battery backwards will not damage the unit, however the unit will not operate. Stranded 20-22 AWG wire is recommended for the battery and power switch terminals.

Power Switch Considerations
In addition to providing a power source, a power switch should be connected to the switch terminals (next to the power terminals) on the RTx/GPS. The switch used can be as simple as a pair of wires which are twisted together prior to flight (i.e. "twist and tape"), or as complex as a magnetically activated solid-state switch.

Switches which provide positive, bounce-free contact -- such as high quality rotary or lever switches, push on/off style, and screw switches -- are recommended for their simplicity and reliability.

If you're using an "active" switch that sources power and is polarity dependent, the (+) battery power switch terminal is located adjacent to the battery negative terminal. The switched (+) power terminal is the other switch terminal.

Operating Tips for Success
- Always pretest your system as COMPLETELY as possible prior to every flight. This includes a quick run of both rocket and base units together to ensure GPS lock and Radio Telemetry integrity.

- Always pretest your batteries before each flight and ensure they have adequate power capacity for the anticipated worst case flight profile, including unplanned "on-the-pad" waiting time.

DIP Switch Settings

The RTx/GPS system utilizes a "Single Board Design Concept". The board must operate as a transmitter inside your rocket and also operate as a base receiving station on the ground. To support this basic configuration and avoid having to program any settings, the DIP switches reflect these basic operational configurations. All in all, these switch combinations configure the following 8 modes of operations the RTx/GPS board can provide:

ROCKET Modes

GPS Only Logger - No radio is used, GPS data is captured to onboard non-volatile flash.
GPS Only Downlink - Live GPS data is radio linked to the Base Station.
GPS RRC3 Downlink - Live GPS data and RRC3 data is radio linked to the Base Station.

BASE Modes

RRC3 Only Base - Receive/Display live RRC3 data from an RRC3/XBee modem.
GPS Only Base - Receive/Display live GPS data from the Rocket RTx unit.
GPS RRC3 Base - Receive/Display live GPS & RRC3 data from the Rocket RTx unit.

<u>GPS Only NAV Base</u> - Receive/Display live GPS data from the Rocket RTx unit and display live navigational data to the Rocket Unit using the optionally installed BASE GPS module.

<u>GPS RRC3 NAV Base</u> - Receive/Display live GPS/RRC3 data from the Rocket RTx unit and display live navigational data to the Rocket Unit using the optionally installed BASE GPS module.

Set your DIP switch positions as follows for a ROCKET or BASE unit:

ROCKET unit

SW1	SW2	SW3
OFF = Rocket	OFF = No Radio (GPS Log Only)	OFF = No RRC3 Tether
	ON = Downlink Radio	ON = Tethered RRC3

BASE unit

| SW1	SW2	SW3
ON = Base Station	OFF = No Downlinked GPS	OFF = No Downlinked RRC3
	ON= Downlinked GPS	ON = Downlinked RRC3

HMI (Human Machine Interface) Considerations and Features

The RTx/GPS system supports several different HMI options:
- Streaming Bluetooth Link using our m3 Bluetooth slave module (for Android or PC HMI Hosts)
- Streaming USB Link using our m3 USBIO module (for PC HMI Hosts)
- Local LCD display using our LCDT module

The following section defines the operations and specific displays of the RTx/GPS system when using the LCD Terminal Module as an HMI Device.

When initially powered on, the LCD display will show a "Splash Screen" like this:
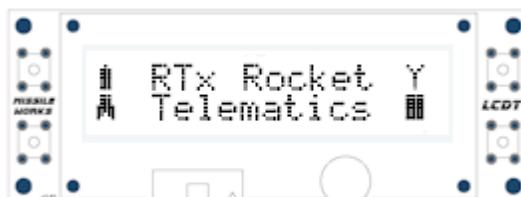
Next, while the RTx/GPS is running internal diagnostics and initializing components, you'll see an "RTx Initializing / Stand By…" screen while it performs POST operations and initialization.

Once the RTx/GPS unit is ready for operations, it displays "Waiting for sync from Rocket RTx ". When radio packets are received it will transition into live display and operations mode. If radio packets are not received within 60 seconds, a "POST Code" screen appears (see Page 10).

The LCD screens will automatically scroll at 2-second intervals (by default). You can "freeze" and "restart" the scrolling at any time by tapping the PROGRAM button. You can also modify the automatic update rate to 1-second intervals or choose the Manual Update method where you'll need to tap the PROGRAM button to advance to the LCD screen you want.

GPS Latitude/Longitude Display

The Latitude coordinate is always shown on top with the Longitude coordinate always shown on the bottom. Coordinates are displayed in the Lat/Lon Format you have selected. This data represents the current or last received coordinates of the ROCKET transmitter.

GPS Data Display
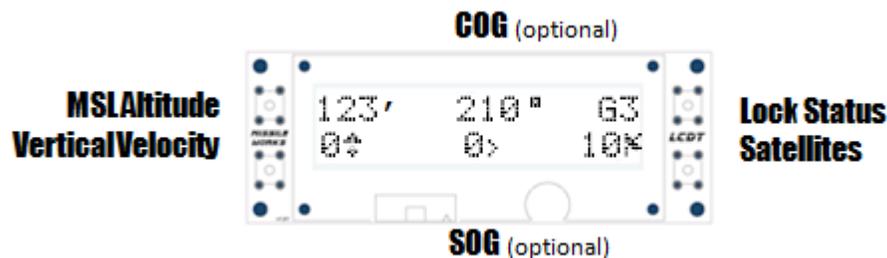
This display shows the additional GPS data available from the ROCKET unit. The data displayed here is affected by the current value of the LCD Update Options setting. By default, the COG and SOG values (Course Over Ground and Speed Over Ground) are not shown.

| GPS Lock Status	Notes
NF = No Fix	**Don't fly your Rocket if there's no GPS FIX data**
G2 = 2D Solution	Lat/Lon only (no altitude). 3 satellite minimum.
G3 = 3D Solution	3D position of Lat/Lon/Altitude. 4 satellite minimum.
D2 = Diff 2D Solution	Lat/Lon only with SBAS* (no altitude). 3 satellite minimum.
D3 = Diff 3D Solution	3D position of Lat/Lon/Altitude with SBAS*. 4 satellite minimum.
	SBAS = Space Based Augmentation System

System Status Display
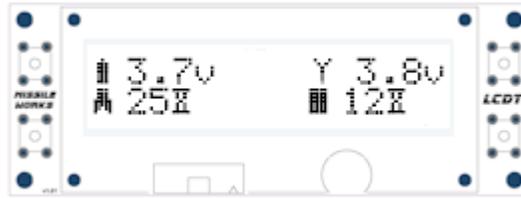
This display shows the ROCKET unit Battery Voltage and Up Time on the left side of the display, and the BASE unit Battery Voltage and Up Time are on the right side of the display. Uptime is displayed in minutes and denoted with the "hourglass" icon as a time value.

Navigational Display (Optional)

This display is dependent on the installation of the optional BASE GPS module. This screen reflects the current BASE unit position relative to the ROCKET unit location. The values on the left side of the display are the Course and Distance to the ROCKET, and the values on the right side of the display reflect the COG (Course Over Ground) of the BASE unit and the ETA estimate to arrive at the ROCKET's coordinates (based on your current Speed Over Ground).

**NOTE: Navigation can be invoked from the RTx Menu. See the LCDT User Manual for more.**
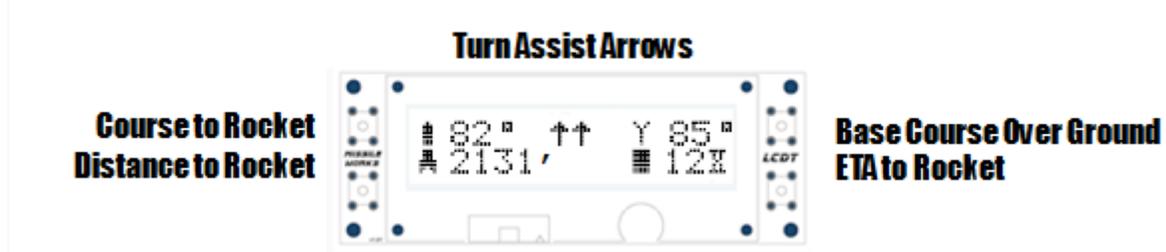
The Course and Distance to Rocket are continuously displayed. The Turn Assist Arrows, ETA (Estimated Time of Arrival), and BASE COG (Course Over Ground) are ONLY displayed when the BASE unit is moving >= 1 Km/Hour , otherwise the arrows are not shown and the COG/ETA are displayed as a question mark (?) , depicting their uncertainty when the BASE unit is stationary.

Once you're moving with the BASE unit, use the Turn Assist Arrows to turn left (<<) or right (>>) to converge your Course Over Ground with the Course to the Rocket. When both courses (headings) are within +/- 3 degrees of each other, the Turn Assist Arrows will point straight up (^^) indicating you're effectively heading straight toward your rocket.

RRC3 Display (Optional)

This display is dependent on the optional tethering connection made to an onboard RRC3 altimeter. The data displayed here is affected by the current value of the LCD Update Options setting. By default, the TEMP and TIME values are not shown. Also, depending upon which version RRC3 firmware is actively used, the data content will also be slightly different.

***IMPORTANT: DIP Switch settings for RRC3 tethering are required for BASE & ROCKET!
The RRC3 also requires Telemetry Settings. See pages 6 and 11 for these references.***
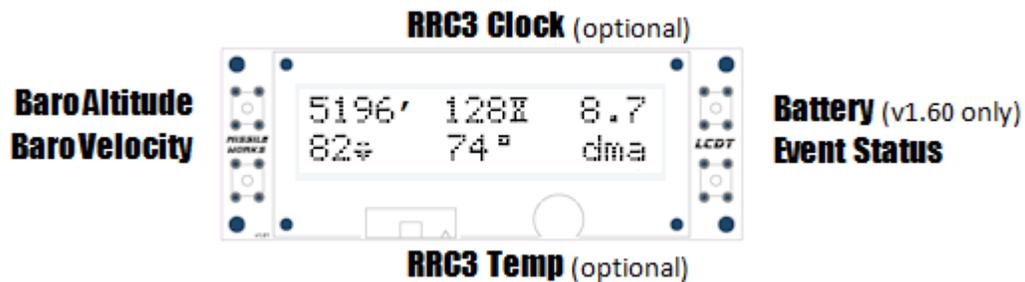
The Event Status characters shown above indicate the state of each RRC3 output event. They are always listed from left to right as (D)rouge/(M)ain/(A)ux. Based upon your RRC3 firmware version, the status characters have slightly different definitions:

Firmware	Pre-Launch	During Flight
RRC3 v1.54	- - - (not activated)	DMA (event active)
		dma (event activation complete)
RRC3 v1.60	??? (no continuity)	DMA (event activated)
	dma (continuity status)	

Advanced Features and Operation

The RTx/GPS provides a number of advanced features and operations while still maintaining and providing the basics of simple and reliable plug and play operation. These advanced features are easily accessible but don't interfere with the basic functions buy and fly operation that the RTx/GPS System provides.

RTx/GPS Operational Modes
The RTx/GPS has several distinct modes of operation throughout the course of its initialization. These modes of operation are identified by the behavior of the piezo, LED, and the specific phase of initialization or operation.

Power-up Initialization Mode
When power is first applied to the unit, it will provide a continuous 5-second beep to indicate it has been switched on. During this 5-second time period, the RTx/GPS is looking for either a tap of the "Program" button (invoking the DIP Switch Operations Mode or the LCD Menu Mode). The LED will remain on continuously during the Power-up Initialization Mode.

POST Mode (Power On Self Test) and CONNECTION MODE
After the Power-up operation is complete, the RTx/GPS performs a voltage and DIP switch operational settings test to ensure the flight configuration matches the onboard

peripherals. If there are any detected system faults, the RTx/GPS enters a POST Fault Code loop repeatedly beeping the specific fault encountered. The RTx/GPS is unable to fly until the fault or warning is corrected. POST Fault Codes are preceded by a very distinct warning tone (7 very quick low beeps) followed by the beep/flash of the specific fault code as follows:

POST Fault Code	Description
1 - SETTINGS_DEFAULT	User-performed factory settings default
2 - LOW_VOLTAGE_FAULT	Battery Voltage Lockout alarm
3 - ROCKET_SETUP_FAULT	Rocket Configuration not supported
4 - BASE_SETUP_FAULT	Base Configuration not supported
5 - GPS_MODULE_FAULT	GPS Module required and not detected
6 - NMEA_INIT_FAILURE	Unable to disable default NMEA sentencing
7 - NAV_RATE_INIT_FAIL	Invalid ACK to Nav Rate Configuration
8 - MODEL_INIT_FAIL	Invalid ACK to Dynamic Model Initialization
9 - PACKET_SYNC_FAIL	Timed out attempting radio packet sync or RRC3 tether

POST Fault Code Notes:
- Code 1 is beeped/flashed whenever the user performs a Factory Default Operation.
- Code 2 is beeped/flashed if your battery voltage < Low Voltage Lockout Level.
- Codes 3 and 4 indicate an unsupported configuration based on your DIP settings.
- Codes 5 thru 8 indicate a hardware fault. Contact Missile Works for more assistance.
- Code 9 indicates a 1-minute timeout (after power up only) that a connection is not active:
   At the rocket, a tethered RRC3 data packet was not detected.
   At the base unit, a radio packet from the rocket was not detected.
   In both conditions, recheck connections and equipment status and reboot the RTx/GPS

If the unit passes all POST operations, there's an additional 10 second mDACS "Host Connection" delay that checks for a connection character from a Host PC via the USB-IO or Bluetooth Module. Host Mode operations are covered in the mDACS User Manual.

GPS Initialization Mode
After the POST mode, the unit goes through a GPS initialization start-up sequence. The LED will flash at a 1Hz rate while in this mode. The GPS is placed into a high-dynamics mode and a 10Hz update rate to provide superior rocket flight operations. When complete, the LED will flash at a 2Hz rate.

Packet Sync Mode
For a unit that's configured for ROCKET operations, Packet Sync mode will only apply if you're tethering a connection to an onboard RRC3 altimeter. After the RTx/GPS unit is booted up, it will wait up to 60 seconds for the RRC3 to begin streaming its data.

A BASE unit also waits for 60 seconds after boot-up for radio data packets from the ROCKET unit; always boot up the ROCKET unit first, then power up your BASE unit. **When tethering to an RRC3, turn on the ROCKET unit, wait for no-sync tone, then boot up the RRC3.**

In both cases for ROCKET and BASE unit configurations, after receiving a successful data packet in Packet Sync Mode, the unit transitions to full operations mode having completed all of its initialization requirements.

IMPORTANT: The minimum compliant RRC3 firmware version is v1.54. ALL PREVIOUS RRC3 FIRMWARE VERSIONS WILL NOT OPERATE WITH THE RTx/GPS SYSTEM. Contact Missile Works directly for firmware upgrade information.

Here's the RRC3 TELEMETRY setting for your altimeter when tethering a connection:
(*adjustable via RRC3 DIP/Program switches, or via LCDT, or via the USB-IO and mDACS*)

v1.54 / v1.60 RRC3 firmware / Data Controls = 2
Telemetry Pre-Launch @ 1.0 sec packet update rate

v1.54 RRC3 firmware / Data Items = 31
ALL Data Items: Timestamp, Altitude, Velocity, Temperature, Events

v1.60 RRC3 firmware / Data Items = 63
ALL Data Items: Timestamp, Altitude, Velocity, Temperature, Events, Voltage

RTx/GPS Settings

The RTx/GPS "***Settings***" are a collection of user-adjustable items that provide all the basic control of system functions. The following list defines the ***Settings*** of the RTx/GPS system:

Description	Default Setting
Epoch Log Trigger	(1) / Start with first valid GPS Fix
LCD Lat/Lon/Units Format	(1) / Decimal Minutes / Imperial Units
LCD Update Options	(1) / Auto Refresh (2 sec rate)
Streaming Format	(1) / $GGA message only
GPS MSL Offset	(1) / Disabled
Audio Notifications	(15) / All audio notifications enabled
Piezo Tone	(8) / 1.56 KHz
Low Voltage Lockout	(2) / Disabled

Epoch Log Trigger   ***Range: 1 to 30 / Default: 1***
This setting establishes when the GPS data collected by a ROCKET unit begins writing the "GPS Epochs" (a complete record of GPS data) to its onboard Flash memory chip. You can control this based on your specific mission needs and start recording data with the first valid fix; or you can defer data recording for up to 30 minutes while you're prepping at the pad.

Value	Trigger Option
1	LOG AFTER FIRST 3D FIX
2-30	LOG AFTER *X* MINUTES (X = Setting Value)

LCD Lat/Lon/Units Format   ***Range: 1 to 8 / Default: 1***

This controls the LCD display format for your BASE GPS Latitude and Longitude data and also the measurement units for height, distance, and velocity (Feet or Meters). If you're using a secondary GPS unit or Smartphone app for navigation, you can set the Lat/Lon format to match the coordinate formats used by that secondary device.

Value	Display Option	Display Format
1	DECIMAL MINUTES IMPERIAL	ddmm.mmmmm - feet/fps/mph
2	DEGREES MINUTES IMPERIAL	dd mm.mmmm - feet/fps/mph
3	DECIMAL DEGREES IMPERIAL	dd.dddddd - feet/fps/mph
4	DEGREES MINS SECS IMPERIAL	dd mm ss.sss - feet/fps/mph
5	DECIMAL MINUTES METRIC	ddmm.mmmmm - meters/mps/kmh
6	DEGREES MINUTES METRIC	dd mm.mmmm - meters/mps/kmh
7	DECIMAL DEGREES METRIC	dd.dddddd - meters/mps/kmh
8	DEGREES MINS SECS METRIC	dd mm ss.sss - meters/mps/kmh

LCD Update Options   ***Range: 1 to 16 / Default: 1***

This setting controls the LCD update rate, data contents, and the method used to display each of the individual "stream screens" that contain GPS, Navigational, and System Status. The setting is specified in a binary-based value according to the following table:

Auto Scroll LCD / 2 sec refresh rate	Setting Value + 1
Manual Scroll LCD screen via PROGRAM button	Setting Value + 2
Display ROCKET COG/SOG values on GPS screen	Setting Value + 4
Display TIME/TEMP on RRC3 screen	Setting Value + 8
Auto Scroll LCD / 1 sec refresh rate	Setting Value = 16

Streaming Format   ***Range: 1 to 6 / Default: 1***

This controls how data is streamed from a BASE unit COMM port while receiving live data packets from the ROCKET unit. The COMM port can connect to a Missile Works m3 Bluetooth module to enable wireless data streaming to a Smartphone or PC, or you can use the m3 USBIO module for hardwired USB streaming. If you're receiving both GPS and RRC3 telemetry data, you can adjust this setting to include or exclude the RRC3 stream data.

Value	Display Option	Usage
1	GGA Only Sentence Format	3rd party apps (Rocket Locator)
2	CSV Only Format	Text stream telemetry capture
3	RTx Only Format	Missile Works RTx Android app
4	GGA & RRC3 Format	Text stream telemetry capture
5	CSV & RRC3 Format	Text stream telemetry capture
6	RTx RRC3 Format	Missile Works RTx Android app

GPS MSL Offset   ***Range: 1 to 99 / Default: 1***

When using a GPS device for altitude, the value is always expressed as Mean Sea Level (MSL) or sea-level relative. Often it's more meaningful when looking at GPS altitude data during your flight to have this displayed as an AGL value (above ground). By using the MSL offset, you can subtract your approximate launch field MSL elevation and display an effective AGL value. Set your MSL Offset to the nearest 100' elevation for your launch field and what you'll see on your LCD for GPS Altitude will be automatically compensated. Negative values are forced to zero.

Value	MSL Offset
1	Disabled
2-99	MSL Offset = Value * 100

Audio Notifications   ***Range: 1 to 15 / Default: 15***

The Audio Notifications settings control how the onboard piezo/beeper is utilized throughout flight operations. Some users might find these notifications annoying and may choose to disable them. By default they are all activated initially. The setting is specified in a binary-based value according to the following table:

Packet Loss / Packet Sync Tone	Setting Value + 1
Epoch Logging Tone	Setting Value + 2
Navigational Solution Tone	Setting Value + 4
Downlinked Packet Ping	Setting Value + 8

Packet Loss / Packet Sync - Packet Loss is a low frequency, 1-Hz repeating tone generated whenever packet data has yet to be acquired or is lost. Packet Sync is a quick "5-pulse" tone indicating that packet data has been initially acquired or reacquired after loss. For a BASE unit this applies to radio packets; and for a ROCKET unit, it applies to an optionally tethered RRC3.

NOTE: You can MUTE the packet loss tone after landing by performing a PRESS & HOLD operation of the Pause/Program button while it's beeping.

Epoch Logging Tone - The Epoch Logging tone is generated by a ROCKET unit whenever the *GPS Epoch Recording Trigger* criteria has been met and GPS Epochs are starting to be logged to Flash Memory. This tone is a single, one-second continuous tone.

Navigational Solution Tone - This tone is generated by a BASE unit when it can successfully compute a valid navigational solution to your ROCKET unit using the optional local GPS receiver coordinates in your BASE unit and the GPS coordinates received by radio from the ROCKET unit. The tone is a moderate "3-pulse" signal that occurs when both ROCKET and BASE GPS coordinates have valid fix data.

Downlinked Packet Ping - This "ping" tone is generated by a BASE unit whenever a successful radio data packet is received and decoded from the ROCKET unit. This occurs at 1-Hz intervals as data packets are transmitted by the ROCKET unit at 1-Hz intervals. When you've configured your ROCKET/BASE units to downlink a tethered RRC3, you will hear 2 pings (one for each packet) as these packets are individually multiplexed over the radio system.

<u>Low Voltage Lockout</u>   ***Range: 2 to 9 / Default: 2***
This setting will validate that the RTx/GPS battery voltage is above a minimum voltage level that's appropriate for your battery system. A setting of (2) disables this lockout feature. If this lockout feature is enabled and the battery voltage is at or below the specified setting, the unit will not arm itself for flight and instead will activate the POST fault code report mode (see the *POST fault codes*)

<u>Piezo Tone</u>   ***Range: 2 to 12 / Default: 12***
This setting determines the frequency at which the piezo "beeper" will operate. The lowest setting will result in a higher frequency (6.25 KHz), and the highest setting results in the lowest frequency (1.04 KHz). Use this when multiple electronics are onboard your rocket to distinguish the beeping of one unit from another or to adjust the tone to a frequency you can hear.

DIP switch and pushbutton operations

Access to all the ***RTx/GPS Settings*** is made available via the RTx/GPS DIP switch and pushbutton interface. The value of all these settings can be verified or reconfigured at any time without the use of the optional LCD Terminal or mDACS PC Software and USB Interface module.

To start a setting session, ensure the RTx/GPS is powered off, and that it has a battery and power switch attached and ready. Apply power to the RTx/GPS by activating the power switch. You should hear the start of the 5 second "init" tone. At any point during this 5 second tone, tap the **PROGRAM** button. The beeper and LED should go out, and the unit will begin its Base Settings operation.

The position of DIP Switches 1 thru 3 determines which of the 8 ***Base Settings*** that you want to verify or reprogram. The Base Settings operation follows a simple process flow:

1. The RTx/GPS reads the position of DIP Switches.
2. The RTx/GPS beeps/flashes the current value of the associated setting.
3. The RTx/GPS pauses for 5 seconds and then repeats Step 1.

You can change DIP Switches 1 thru 3 at any time to select a new setting for verification. Using this process, you can validate the values of all 8 ***Base Settings***. The DIP switch / Settings positions are as follows:

SW1	SW2	SW3	
OFF	OFF	OFF	GPS Epoch Logging Trigger
ON	OFF	OFF	LCD Lat/Lon/Units Format
OFF	ON	OFF	LCD Update Options
ON	ON	OFF	Streaming Format
OFF	OFF	ON	GPS MSL Offset
ON	OFF	ON	Audio Notifications
OFF	ON	ON	Piezo Tone
ON	ON	ON	Low Voltage Lockout

Step 3 of the above process flow is what we'll refer to as the *"Programming Pause"*. If you want to reprogram the setting you currently have selected, tap in a new value during this pause time. Let's say you wanted to reprogram the Main Altitude setting from the default of 1 to 10, for example (a 1000' MSL offset); here are the steps you'd perform:

- Select the MSL Offset Setting via DIP Switch (1 OFF / 2 OFF / 3 ON)
- Verify the current default setting value of 1 via beep/flash
- During the "Programming Pause" tap the Program push button 10 times
- The RTx/GPS should provide a double-beep "acknowledge tone" (new setting is saved)
- Verify the NEW setting value of 10 via beep/flash (10 x 100' = 1000')
- Done... Programming complete!

Repeat the sequence again should you want to change it to something else or select a new setting via DIP switch to verify or change. When you're done, power off the RTx/GPS. It's now ready to fly with the newly programmed settings.

Additional notes on RTx/GPS communication

RRC3 Tethering and RRC3 communication loss
Should there be any point during a flight that your rocket RTX/GPS board loses communication with the tethered RRC3 altimeter (after its initial sync), it will wait for a maximum of 5 seconds to resync with the RRC3. If this fails to occur, the RTX/GPS system will bypass all further attempts to synchronize with the RRC3. When this occurs, the RTx/GPS system will instead transmit the "RRC3 Comm Loss Packet". This packet contains all ZEROs for data and all QUESTION MARKS for event status.

This timeout and bypass feature is necessary to restore GPS downlink communications as the tethered communication multiplexing of the RRC3 and GPS data is dependent on synchronizing with the telemetry packet from the RRC3.

Upon landing with a tethered RRC3, it transitions into its post-flight audio "report mode" by beeping altitude, velocity, etc. This beeping operation is a "blocking" process, which means it will interrupt the telemetry stream from the RRC3 and cause a communications timeout. You will notice a 5-second dropout of communications if you are linked to the rocket.

GPS or Radio Packet loss during flight and descent

Depending on the overall velocity or peak velocity of your rocket flight, your BASE unit may experience radio packet loss due to Doppler effects and/or timing shifts caused by inertial forces to crystal components within the airborne radio module. Once the rocket starts its coast and deceleration phase, the radio data should be reacquired.

Likewise, the GPS module itself has operational limits on both altitude and velocity. (Altitude limit = 50,000 meters / 160,042 feet – Velocity limit = 500 meters/sec / 1640 feet/sec.). Should you approach these extremes during your flight, expect the GPS data to drop out and not update. The uBlox7 GPS is quick to recover after these transitions from extremes due to its fast update rate and its capability to operate in a high-dynamics environment.

You may also experience packet drop out due to the sheer distance between ROCKET and BASE unit. This distance can be affected by attenuation due to metallic items in your rocket that are in proximity to your antenna, other metallic airframe components, or the airframe itself.

Also note that when a descending rocket dips below your line-of-sight (visible or not), the radio packets will drop out and you'll lose packet sync. Both the LCD display and Bluetooth/USB will continue to send the Last Received Coordinate (LRC) Lat/Lon data as long as the BASE unit remains powered on. This LRC Lat/Lon data is also committed to flash memory when radio packets drop out. These coordinates can be used for navigational purposes should there be no radio signal from your rocket, or you need to return the following day to resume your search.

It's also a recommended practice to write down the LRC Lat/Lon coordinates on paper prior to powering down your BASE unit should there be any data corruption to your flash memory read/write operation.

Troubleshooting and FAQ's

Q: I've tethered my RRC3 to my RTX/GPS system and I'm not seeing any RRC3 data

A: Ensure your RRC3 is connected (cable or Bluetooth), booted up and running, and you've properly set the DIP switches on both the BASE and ROCKET units. Also ensure the RRC3 TELEMTERY SETTINGS are set as shown on Page 11 and matches the firmware version.

Q: My RTx/GPS is on the pad, I'm receiving radio data packets but there's NO GPS Fix

A: It's likely that your GPS patch antenna is adjacent or flush to your pad or tower rail and satellite signals are being blocked. If you've allowed adequate time for a GPS fix, pull your rocket from the pad and inspect the patch antenna position relative to your rail(s).

Q: The RTx/GPS is powered up but I'm not getting radio packet data (POST code 9)?

A: The ROCKET DIP switches must reflect the presence of a radio module, so ensure that switch has been properly set. Also ensure the BASE DIP switches reflect the configuration of your ROCKET unit. For example, if your BASE is expecting both GPS and RRC3 packets and

the rocket is only sending GPS packets, the BASE unit will not synchronize properly. No packet data may also be a case of a poor or failed antenna connection, so double check to ensure that everything is tightened and intact. It might also be a case where your radio module may have failed, there's heavy radio overload or an elevated noise floor in the ISM band. Battery power may also be a culprit here, too, so ensure your battery is up to par. Don't fly without an operational radio link.

Q: I'm getting a POST CODE of 3, 4, 5, or 6 when I boot up the RTX/GPS… Why?

A: Ensure your DIP switches are set correctly. This can occur if the unit is expecting a GPS module to be installed and it has failed. It may also be a BASE unit where there's no module installed and you've set the DIP switches to expect one.

Product Warranty

Missile Works Corporation has exercised reasonable care in the design and manufacture of this product and warrants the original purchaser that the RTx/GPS is free of defects and that it will operate at a satisfactory level of performance for a period of one year from the original date of purchase. If the system fails to operate as specified, return the unit (or units) within the warranty period for repair or replacement (at our discretion). The system must be returned by the original purchaser and be free of modification or any other physical damage which renders the system inoperable. Upon repair of replacement of the unit, Missile Works Corporation will return the unit postage-paid to the original purchaser.

Product Disclaimer and Limit of Liability

Because the use and application of this equipment are beyond our control, the purchaser or user agrees to hold harmless Missile Works Corporation and their agents from any and all claims, demands, actions, debts, liabilities, judgments, costs, and attorney fees arising out of, claimed on account of, or in any manner predicated upon, loss or damage to property of, or injuries to or the death of, any and all persons arising out of the use of this equipment. Due to the nature of electronic devices -- and the application and environments for those devices -- the possibility of failure can never be totally ruled out. It is the responsibility of the purchaser or user of this equipment to properly test and simulate the actual conditions under which the device is intended to be used to ensure the highest degree of reliability and success.