Multitronix
Engineering Innovations and Technology

TelemetryPro®
Mx152 Option-10
Transmitter and Pyro Board
User Manual

Rev 1.1

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Revision History

Rev	Date	Description
1.0	Jan. 22, 2020	Initial Release
1.1	Mar. 25, 2020	Updated with adjustable sustainer motor igniter firing time. This applies to firmware v5.6.

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Table of Contents

1 Introduction

This manual will help a new user become familiar with operating the Kate 2.0 transmitter and pyro board. It will explain how to use the Mx120 Receiver to configure the pyro board. It assumes the user is at least somewhat familiar with the operation of the Mx120 Receiver. Please see the Mx120 Receiver manual for more details. The Kate 2.0 system also includes the ability to run a launch simulation. This is especially helpful for learning to use the system and to become proficient with it before an actual flight.

2 Front Side View

Downlink antenna

Keep metal, wires and other electronic devices well away from this antenna!

GPS antenna

(On the reverse side in this area)

Keep metal, wires and other electronic devices well away from the GPS antenna!

Transmitter

POWER button

Press and hold for two seconds to turn-on transmitter.

Press and hold for six seconds to turn-off transmitter.

WARNING: Do not attempt to remove the downlink antenna. The transmitter can be permanently damaged if it is powered-on without the antenna. Do not operate the transmitter with a different antenna without written approval from Multitronix LLC.

Antenna is not a handle! Do not use it as one!

Transmitter ID code

A unique three digit ID code number is pre-assigned to each transmitter. Set the receiver to this same code number in order to link it to the transmitter.

LED status indicators

USB connector

System Battery

Recovery Harness Anchor

Optional attachment point for tubular nylon recovery harness.

FRONT SIDE

3 Back Side View

Downlink antenna

Keep metal, wires and other electronic
devices well away from this antenna!

GPS antenna

Keep metal, wires and other
electronic devices well away from
the GPS antenna!

Pyro Board

Pyro Battery

**The pyro battery can be a
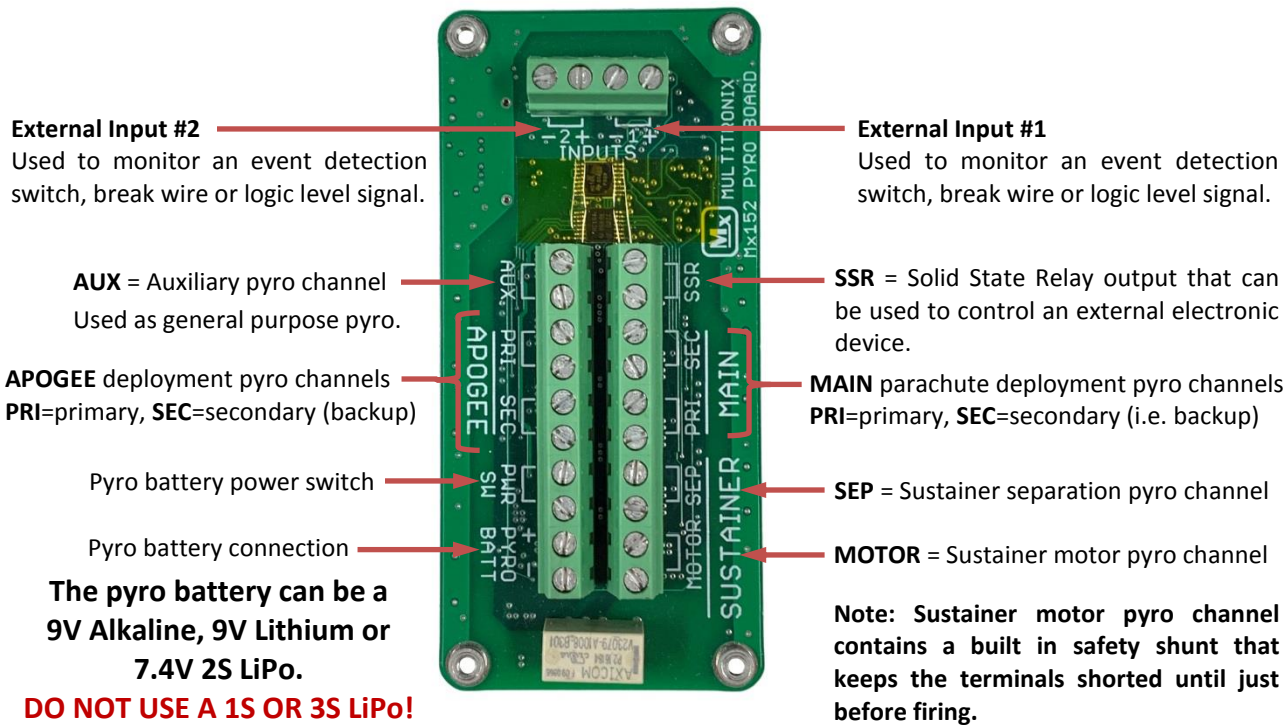9V Alkaline, 9V Lithium or
7.4V 2S LiPo.**
DO NOT USE A 1S OR 3S LiPo!

The pyro battery is mounted on its own
removable mounting board.   Remove
four screws to remove the pyro battery.
A pyro battery can be zip tied or simply
duct taped to the mounting board.

BACK SIDE

4 Pyro Board

External Input #2
Used to monitor an event detection switch, break wire or logic level signal.

AUX = Auxiliary pyro channel
Used as general purpose pyro.

APOGEE deployment pyro channels
PRI=primary, **SEC**=secondary (backup)

Pyro battery power switch

Pyro battery connection

The pyro battery can be a 9V Alkaline, 9V Lithium or 7.4V 2S LiPo.
DO NOT USE A 1S OR 3S LiPo!

External Input #1
Used to monitor an event detection switch, break wire or logic level signal.

SSR = Solid State Relay output that can be used to control an external electronic device.

MAIN parachute deployment pyro channels
PRI=primary, **SEC**=secondary (i.e. backup)

SEP = Sustainer separation pyro channel

MOTOR = Sustainer motor pyro channel

Note: Sustainer motor pyro channel contains a built in safety shunt that keeps the terminals shorted until just before firing.

4.1 Pyro Battery

The pyro battery can be a 9V Alkaline, 9V Lithium or a 7.4V 2S LiPo. **DO NOT USE A 1S OR 3S LiPo!** The voltage from a 1S LiPo is too low. The voltage from a 3S LiPo is too high.

4.2 Pyro Channels

There are a total of 7 pyro channels.   Two for apogee charges, two for main parachute charges, one for the separation charge, one for the sustainer motor igniter and a general purpose auxiliary channel.

 All of the pyro channels are designed to fire ematches such as those sold by MJG Technologies (www.electricmatch.com). This includes the regulated J-Tek ematches and the unregulated Firewire Initiators.   All pyro channels (except the sustainer motor channel) will fire for 0.5 seconds.   The sustainer motor channel fires for 1.0 seconds.   The sustainer motor channel also has a built-in safety shunt that keeps both ematch leads disconnected from the firing circuit and shorted together until just before the motor is to be fired.   The safety shunt is automatically operated so there is nothing special required for the user to do.

The main parachute and apogee deployment channels will fire their primary (PRI) outputs for 0.5 seconds, then wait 0.5 seconds and then fire their secondary (SEC) outputs for 0.5 seconds.

All pyro channels have a built-in 5 Amp electronic current limit. However, a shorted output can cause the pyro channel thermal protection circuit to engage which will reduce the current limit to 2.5 Amps.

4.3 Aux Channel

The auxiliary channel (AUX) is a spare pyro channel that works just like any of the other pyro channels in that it can fire an ematch or igniter.   It can be configured by the receiver to fire at a pre-determined time.   It can also be remotely fired by manual command from the ground.   (Firmware support for the AUX channel is expected to be released in mid-2020.)

4.4 Pyro Power Switch

The pyro board is shipped with a jumper installed between the two pyro battery power switch terminals.   **When the pyro board is installed into your rocket, the jumper should be removed and a switch wired in place.**   The switch is in series with the pyro battery and provides a mechanical disconnect as an extra level of safety.   Tripoli Rocketry Association rules now require a mechanical switch to disconnect the pyro battery anytime the rocket is anyplace other than at the launch pad.

The switch can be closed right before the rocket is raised into the vertical orientation on the launch pad. This avoids the need to climb a ladder to close the switch. The pyro board can then be powered-on remotely by sending a command from the receiver once the rocket is vertical and everyone has backed away to a safe distance.

Make sure the power switch and the wiring that you use is rated to handle the full firing current that will be required by your ematches or igniters.

4.5 Solid State Relay

The solid state relay (SSR) channel acts like a simple switch. It cannot be used to fire an ematch or an igniter.   It can however, be used to control an external electronic device such as a camera.   Maximum current rating is 1.5 Amps.   It is bipolar so there is no +/- polarity to worry about when connecting it. It can be configured by the receiver to open or close at pre-determined times.   It can also be remotely controlled by manual command from the ground to open or close.   (Firmware support for this feature is expected to be released in mid-2020.)

4.6 External Inputs

Two external inputs are provided that can be used to monitor external switch closures, break wires or logic level signals. The inputs are sampled and recorded five times per second. The input states are also transmitted to the ground where they are recorded and reported in the Excel data file along with all the other flight data.

One example of how these inputs might be used is to monitor for airframe separation at apogee during deployment. A micro-switch or break-wire could be rigged to open when the airframe separates.   This would give positive confirmation that a deployment event was successful.
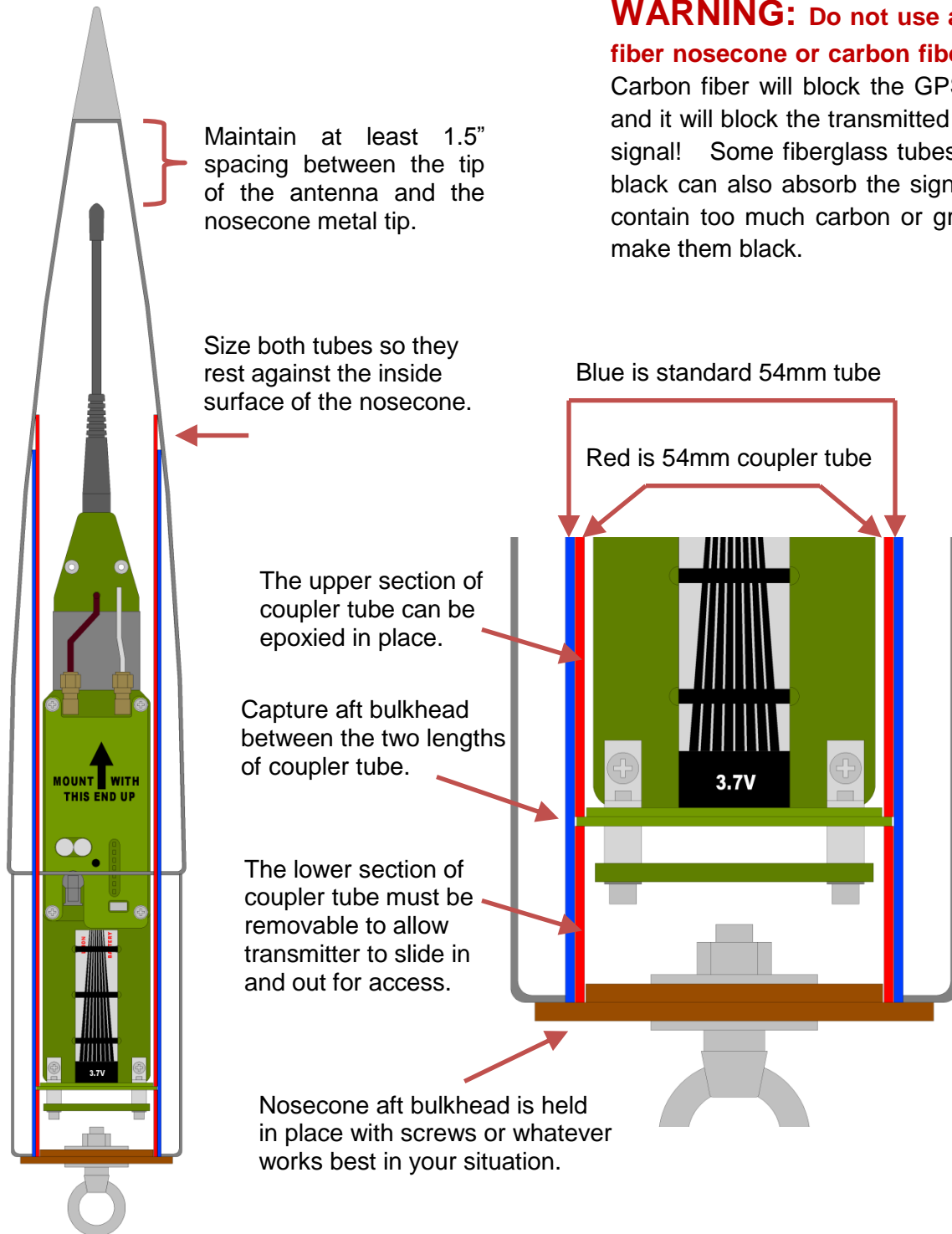
5 Safety Warnings

1. The transmitter comes with a Li-ion system battery already installed.   Never attempt to use a different type of battery other than the one Multitronix provides. Doing so will run a significant risk of damaging the transmitter and possibly even starting a fire.

2. The transmitter has a built-in charger for the system battery. Never attempt to charge the Multitronix supplied battery on a charger other than the one built into the transmitter. Doing so runs a significant risk of fire danger.   The battery may get hot, catch fire or even explode. There is no built-in charger for the pyro battery.

3. **Do not charge the battery unattended. This is recommended just in case there has been some internal damage to the battery due to a hard landing or other flight anomaly.   If the battery gets hot while being charged then immediately stop charging it.   Replacement batteries are available from Multitronix.**

4. Do not charge the battery if it has been damaged.

5. Discontinue use if the battery is ever damaged, leaks fluid, feels hot, has an odor or appears abnormal in any way.

6. Do not short circuit the battery.

7. Do not disassemble or modify the battery.

8. Do not allow the battery to get wet.

9. Do not dispose of the battery in fire.

> **Failure to observe these safety warnings may cause the battery to become hot, catch fire or explode and cause serious injury.**

6   Recommended Mounting Scheme

The transmitter is designed to be mounted inside a standard 54mm phenolic or fiberglass tube. Phenolic or fiberglass coupler tubes above and below it should be used to hold it in place within the main tube. **It must be mounted with the antenna facing up.** This is required for proper operation of the accelerometer.

WARNING: **Do not use a carbon fiber nosecone or carbon fiber tubes.** Carbon fiber will block the GPS signals and it will block the transmitted downlink signal!   Some fiberglass tubes that are black can also absorb the signal if they contain too much carbon or graphite to make them black.

Maintain at least 1.5" spacing between the tip of the antenna and the nosecone metal tip.

Size both tubes so they rest against the inside surface of the nosecone.

Blue is standard 54mm tube

Red is 54mm coupler tube

The upper section of coupler tube can be epoxied in place.

Capture aft bulkhead between the two lengths of coupler tube.

The lower section of coupler tube must be removable to allow transmitter to slide in and out for access.

Nosecone aft bulkhead is held in place with screws or whatever works best in your situation.

7 Charging the Battery

The transmitter has a battery charger built-in to charge the Li-ion system battery. **It does not charge the pyro battery.** The charger only runs when the transmitter is off. To charge the battery simply turn-off the transmitter and connect the USB to a computer or other dedicated USB charging device. If a dedicated USB charging device is being used, it works best to first connect everything together and then plug the dedicated charger into a 120V outlet.

1. The yellow **CHARGE** LED will be on when the battery is being charged.

2. The green **CHG DONE** LED will be on when the battery is fully charged.

3. The red **CHG FAIL** LED will come on if the battery failed to charge or took far longer to charge than expected.

The battery will charge faster when the transmitter is connected to a dedicated USB charging device than to a computer. This is because it can draw more power from a dedicated charger than from a computer USB port. However, either way works fine. Charging times vary a great deal depending on how low the battery was and how much power can be drawn over the USB. Typical times range from one to three hours.

To avoid damaging the battery, the charger will suspend charging (switch itself off) if the temperature of the battery is out of limit. This will occur below 32°F and above 120°F. Charging will automatically resume when the temperature returns within these limits.

Caution

Never charge the battery unattended. This is recommended just in case there has been some internal damage to the battery due to a hard landing or other flight anomaly. If the battery gets hot while being charged then immediately stop charging it. Replacement batteries are available from Multitronix.

8   Turn-on Coil

The transmitter can be turned-on by pressing the power button on it. Press and hold the power button for two seconds to turn it on. Press and hold the power button for six seconds to turn it off. However, it can also be turned-on by passing a special induction coil around the outside of the rocket. This means the transmitter can be turned-on after already being installed into the rocket.

To turn-on the transmitter, press and hold the silver button on the turn-on coil while sliding the coil around the outside of the rocket such that the rocket passes through the middle of the coil.   Slide it somewhat slowly. A few inches per second is ideal.   The turn-on coil just needs to be approximately even with the top of the transmitter for just over one second. Listen for a beep that will come from the transmitter when it powers up. When you hear the beep, you can release the silver button.

When the transmitter powers up, it generates a one second beep to let the user know. It then beeps out its transmitter ID code and repeats that every so often in case it is needed for setting the receiver to the same code. The beeping also serves as an audible "I am still alive" indicator.

Turn-on Coil
Model Mx105

The turn-on coil generates a high frequency magnetic field that fills the entire loop area and is detected by a special circuit built into the transmitter.   The field generated by the turn-on coil cannot penetrate a metal airframe.   It may also not work with carbon fiber airframes.

The turn-on coil has a green LED that indicates the battery voltage is good and that the unit is operating. The LED is extremely bright and can easily be seen in direct sunlight. **Do not stare directly into the green LED!**   There is no power switch for the turn-on coil itself. Just one silver button that powers it on and activates the coil.

The turn-on coil can only power-on a transmitter. It cannot power it off.   However, the transmitter can be powered-off remotely by selecting the **TURN-OFF TRANSMITTER** menu option on the receiver. Please see the receiver manual for more details.

9 Transmitter ID code

The transmitter will only link with a receiver if they are both set to the same ID code. ID codes are three digit numbers and are listed on the front of each transmitter. Each transmitter is assigned a unique ID code at the factory so that there are no conflicts at a large launch where multiple TelemetryPro systems are being used at the same time.

For convenience, the transmitter beeps out its ID code at regular intervals. Each digit in the ID code is represented as a series of beeps. There is a short delay in-between digits. Beeping out the ID code is handy in case you cannot remember it after the transmitter has already been installed into a nosecone. It also serves as an indicator that the transmitter is powered-on and is operating in flight mode.

Example   If the transmitter ID code is 235 then the transmitter will beep twice for the first digit. It will then pause with a short delay of silence and then beep three more times to represent the second digit. It will pause again with another short delay and then beep five more times to represent the last digit. If there is a zero in the ID code then that digit will be represented as a single longer beep.

Multiple TelemetryPro systems can be on and running at the same time and they will not interfere with each other provided they use different ID codes.

It is also possible to link up to four receivers to one transmitter if some tracking redundancy is desired. In that case, the same ID code is used in all the receivers and must match the code used by the transmitter.

10 Establishing a Link

When a transmitter and receiver are first turned-on it will typically take about 20-60 seconds for them to link-up. This is normal. The radio link is a spread spectrum frequency hopping link so the receiver needs time to find and synchronize with the transmitter. The signal strength indicator in the upper right corner on the receiver display will be blinking **LOS** (Loss of Signal) until a link is established. Once it is established, the signal strength indicator will show the strength as 0 to 5 bars. "5 bars" represents the highest signal.   If the link is ever lost, the two will automatically try to relink. There is nothing the user needs to do other than make sure the receiver antenna is pointed at the transmitter if the transmitter is a long ways away.

The blue **LINK** LED on the transmitter will be lit when the transmitter is linked to a receiver.

⚠️ Avoid Receiver Overload

When the transmitter is in close proximity to the receiver (within 200 feet) then it is best to avoid pointing the receiver antenna directly at the transmitter.   This is because when the two are really close together the signal strength from the transmitter can overload the receiver and cause communications errors and dropped data packets.   In fact, they may not be able to stay linked or may also have trouble getting linked in the first place. Overloading the receiver does not damage it. It just causes the link to fail.

If the link is not established within 60s then double check that you have set the receiver to the correct transmitter ID number. Also try moving the receiver further away from the transmitter.

It also helps to stand with your back to the transmitter while holding the receiver and pointing the antenna away from the transmitter because your body helps block and attenuate the signal.

Once you are at a safe distance from the rocket and ready to launch then you should be able to point the antenna directly at the rocket. In fact, it is very important to keep pointing it at the rocket during the entire flight!   **It is easy to get distracted and forget to do this but pointing the antenna at the rocket during flight is important for optimum reception and longest range.**

11 Transmitter Power Setting

The transmitter normally uses 100mW to transmit data packets while the rocket is still on the launch pad. This is more than adequate for all but the most extreme situations.   Using only 100mW reduces the drain on the battery and also helps avoid overloading the receiver when it is relatively close to the rocket.   At liftoff, the transmit power is automatically increased to 500mW for the flight.   It will then eventually increase to 1 Watt based on altitude and distance.

If a receiver needs to be more than a mile away from the launch pad, then it may be necessary to increase the 100mW transmit power in order to obtain a reliable link prior to liftoff.   In that case, the user can access the TRANSMIT POWER menu in the TelemetryPro Receiver and manually increase the power level to 500mW or even 1W if needed.

The ability to increase the transmitter power while on the ground is also very useful for range testing to see how far the signal can be received after a transmitter has been configured and mounted in a rocket.

The Mx120 Receiver User Manual has more information about adjusting the transmitter power.
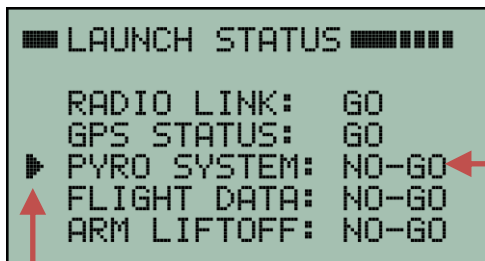
12 Pyro System Setup

The Mx152 Pyro board needs to be powered-on, configured and armed before launch. This is done remotely by sending commands from the Mx120 Receiver. Therefore, this section assumes the user is at least somewhat familiar with the operation of the Mx120 Receiver. Please see the Mx120 Receiver manual for more details.

```
▰▰▰MAIN MENU▰▰▰▰▰▰▰▰▰▮▮▮▮

▶ LAUNCH        ⌐ May 1
  RECOVER       | 8:19pm
  TELEMETRY     |
  DATA          | ▭▬36%
  COMMANDS      | ▭▬80%
```
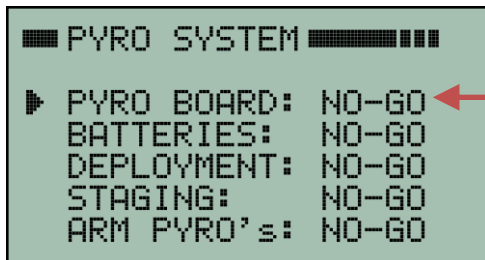
This is the MAIN MENU screen on the M120 Receiver.

To setup the pyro board, go to the MAIN MENU and position the small triangular cursor so that it is pointing to **LAUNCH**, as is shown here. Then press the right arrow button to see the LAUNCH STATUS screen.

```
▰▰▰LAUNCH STATUS▰▰▰▰▰▮▮▮▮

  RADIO LINK:   GO
  GPS STATUS:   GO
▶ PYRO SYSTEM:  NO-GO
  FLIGHT DATA:  NO-GO
  ARM LIFTOFF:  NO-GO
```
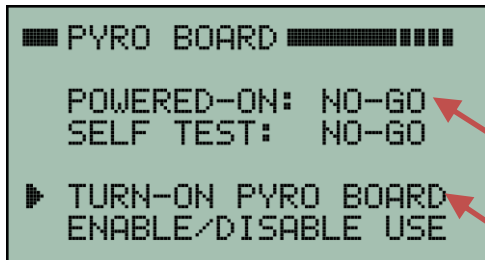
This is the LAUNCH STATUS screen.

The PYRO SYSTEM defaults to a **NO-GO** status at power-on. To configure it, position the cursor pointing to **PYRO SYSTEM** and press the right arrow button.

```
▰▰▰PYRO SYSTEM▰▰▰▰▰▰▮▮▮▮

▶ PYRO BOARD:   NO-GO
  BATTERIES:    NO-GO
  DEPLOYMENT:   NO-GO
  STAGING:      NO-GO
  ARM PYRO's:   NO-GO
```

Now position the cursor at the **PYRO BOARD** line and press the right arrow button.

Powering on the transmitter does not automatically power-on the pyro board that is attached to it. **A command needs to be sent to power-on the pyro board when the time is right.** This is usually done once the rocket is vertical and everyone has backed away from the launch pad and is at a safe distance.

```
▰▰▰PYRO BOARD▰▰▰▰▰▰▰▰▰▮▮▮▮

  POWERED-ON:  NO-GO
  SELF TEST:   NO-GO

▶ TURN-ON PYRO BOARD
  ENABLE/DISABLE USE
```

The pyro board power is currently off. Therefore, it is shown as **NO-GO**.

To send a command to power-on the pyro board, position the cursor to the **TURN-ON PYRO BOARD** line and press the right arrow button.

```
▰▰▰▰▰▰▰▰▰▰▰▰▰▰▰▰▰▰▰▰▰▰▰

  READY TO POWER-UP
  THE PYRO BOARD?

▶ YES
  NO
```
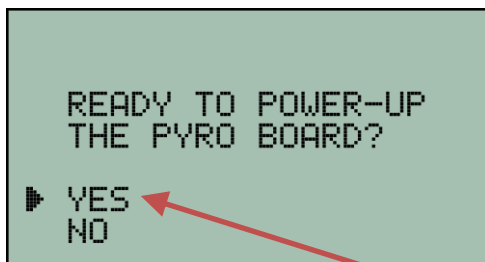
The next screen will ask you to confirm that you really are ready to power-on the pyro board. Once again, for added safety, this is usually only done once the rocket is vertical and everyone has backed away from the launch pad and is at a safe distance.

When you are ready to power-on the pyro board then position the cursor to **YES** and press the right arrow button.

```
▬▬PYRO BOARD▬▬▬▬▬▮▮▮▮

   POWERED-ON:  GO
 ▶ SELF TEST:   GO

   TURN-OFF PYRO BOARD
   ENABLE/DISABLE USE
```

When the pyro board is powered-on, it performs an internal self-test to make sure there are no detectable hardware failures. If self-test passes then it will be a **GO** as is shown here.   If self-test fails, then position the cursor pointing to **SELF TEST** and press the right arrow button to see why it failed.

```
▬▬PYRO SYSTEM▬▬▬▬▬▮▮▮▮

   PYRO BOARD:  GO
 ▶ BATTERIES:   GO
   DEPLOYMENT: NO-GO
   STAGING:    NO-USE
   ARM PYRO's: NO-GO
```

Now that the pyro board is powered-on, press the left arrow button to return to the previous screen that shows the status of the PYRO SYSTEM.

Now position the cursor so it is pointing to **BATTERIES** and press the right arrow button to enter the BATTERIES status screen.

```
▬▬BATTERIES▬▬▬▬▬▬▮▮▮▮

   PYRO-BATT   SYS-BATT
   8.92v       4.04v
   97%         100%
   TYPE: 9V
 ▶ CHANGE TYPE
```

The BATTERIES screen shows the status of the pyro battery and the system battery. The voltages are shown along with an estimate of remaining battery life.

The pyro battery type needs to be set to match the type of battery you are actually using. **You can use either a standard 9V alkaline battery, 9V Lithium battery or a 2S LiPo battery.** If the battery type shown on this screen does not match the battery you are using, then select **CHANGE TYPE** to select the proper battery type.

Now that pyro battery type has been properly set, press the left arrow button to return to the previous menu.

12.1 Deployment Setup

This Pyro System menu can be reached via: MAIN MENU ⇨ LAUNCH ⇨ PYRO SYSTEM

```
▰▰▰PYRO SYSTEM▰▰▰▰▰▰▰▰▰▰

   PYRO BOARD:  GO
   BATTERIES:   GO
 ▶ DEPLOYMENT:  NO-GO
   STAGING:     NO-USE
   ARM PYRO's:  NO-GO
```

To configure the deployment system, position the cursor pointing to **DEPLOYMENT** and press the right arrow button.

```
▰▰▰DEPLOYMENT▰▰▰▰▰▰▰▰▰▰▰

 ▶ CONTINUITY:  GO
   SETTINGS:    NO-GO
```

The DEPLOYMENT status screen shows the continuity status for the apogee and main parachute deployment changes. As shown here they are **GO**. That means the four deployment charges all have good continuity. Position the cursor pointing to **CONTINUITY** and press the right arrow button to see the status of each deployment firing channel.

```
▰▰▰CONTINUITY▰▰▰▰▰▰▰▰▰▰

   APO  PRI: GOOD
   APO  SEC: GOOD
   MAIN PRI: GOOD
   MAIN SEC: GOOD
 ▶ SPECIFY USE
```

The deployment CONTINUITY screen shows the status for each of the four deployment charges. Here they are all **GOOD**. If one has no continuity then it will be listed as **OPEN**.   All four channels must have good continuity in order for the pyro system to be **GO FOR LAUNCH**. Therefore, if one or more of these channels is not being used, you will need to tell the system to not use it.

```
▰▰▰SELECT PYRO▰▰▰▰▰▰▰▰▰

 ▶ APO  PRI: USE
   APO  SEC: USE
   MAIN PRI: USE
   MAIN SEC: USE
```

To specify which deployment channels are being used, select **SPECIFY USE**.

Then select the channel that needs to be changed and set it to **NO-USE** or **USE** as is appropriate for your flight.

APO PRI = Apogee Primary
APO SEC = Apogee Secondary
MAIN PRI = Main parachute Primary
MAIN SEC = Main parachute Secondary

Primary charges are always fired first.   Then after a 0.5 second delay the secondary (backup) charge is fired.

```
▰▰▰DEPLOYMENT▰▰▰▰▰▰▰▰▰▰▰

   CONTINUITY:  GO
 ▶ SETTINGS:    NO-GO
```

When you are finished with the deployment continuity checks, press the back button as needed to return to the DEPLOYMENT status page shown here.   Then select **SETTINGS**.

12.1.1 Deployment Settings

The Deployment Settings menu shown below can be accessed via:
MAIN MENU ⇨ LAUNCH ⇨ PYRO SYSTEM ⇨ DEPLOYMENT ⇨ SETTINGS

```
▰▰▰▰▰DEPLOYMENT▰▰▰▰▰▪▪▪▪
▶MAIN CHUTE:   1000 ft
  GPS ALTITUDE: USE
  BARO SENSOR:  USE
  ACCELEROMETER:USE
  APOGEE TIMER: NO-USE
  APPROVE SETTINGS
```

All of the deployment settings are shown on this screen.

The **MAIN CHUTE** setting specifies what altitude above ground level the main parachute should be deployed. To change it, position the cursor to that line and press the right arrow button.

```
▰▰▰MAIN PARACHUTE▰▰▰▰▰▪

▶ DUAL DEPLOY: YES
   MAIN DEPLOY:1000 ft
```
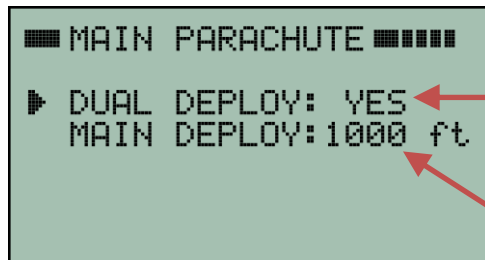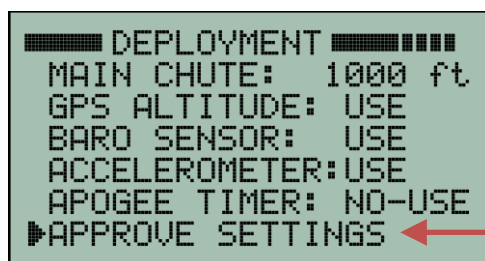
Selecting **MAIN CHUTE** in the previous screen will bring up the MAIN PARACHUTE screen shown here. In this case, it shows the deployment system is set to **DUAL DEPLOY** mode. That means the apogee charges will fire at apogee and the main charges will fire at 1000 feet.

Select **DUAL DEPLOY** and choose **APOGEE** if you want the main parachute deployed at apogee instead of a predetermined lower altitude.

```
▰▰▰▰▰DEPLOYMENT▰▰▰▰▰▪▪▪▪
  MAIN CHUTE:   1000 ft
  GPS ALTITUDE: USE
  BARO SENSOR:  USE
  ACCELEROMETER:USE
  APOGEE TIMER: NO-USE
▶APPROVE SETTINGS
```

You can also select **MAIN DEPLOY** and then change the number from 1000 feet to be something else if you need to use a different altitude for deploying the main parachute.

Now press the back button (left arrow) to return to the DEPLOYMENT settings screen shown here.

```
▰▰▰▰▰DEPLOYMENT▰▰▰▰▰▪▪▪▪
  MAIN CHUTE:   1000 ft
  GPS ALTITUDE: USE
  BARO SENSOR:  USE
  ACCELEROMETER:USE
  APOGEE TIMER: NO-USE
▶APPROVE SETTINGS
```

The DEPLOYMENT settings screen contains a number of other settings besides just the main parachute altitude.

Once all the deployment settings are set the way you want them, press **APPROVE SETTINGS** (if none were changed) or **UPDATE PYRO BOARD** if one or more settings were changed.

GPS ALTITUDE: USE indicates that GPS altitude will be used to fire the apogee and main parachute deployment charges. GPS altitude is always the primary source for firing deployment charges. It cannot be disabled.   It is listed in the settings screen simply as a reminder that GPS altitude is being used. However, if for some reason GPS fixes are not available, then there are also backup sensors that can be used to fire the deployment charges.   All of those sensors can be enabled or disabled as listed below.

BARO SENSOR: USE indicates the barometric pressure sensor will be used as a backup sensor for firing the main parachute deployment charge at a specified altitude if GPS readings are not available. If you plan to use the baro sensor as a backup for main parachute deployment then you must also provide proper vent holes in the airframe so that the outside air pressure can be monitored**. If you do not wish to provide these vent holes, then be sure to select NO-USE for the BARO SENSOR setting!** However, it is highly recommended that you plan on using the baro sensor as a backup for main chute deployment.

ACCELEROMETER: USE indicates that the accelerometer will be used as a backup sensor for firing the apogee deployment charges. It is highly recommended that it be used. However, if the flight is going to be so high (>150,000 feet) that it might start tumbling above the atmosphere, then you have an option to use the apogee timer instead of the accelerometer for apogee deployment. If that is the case, then position the cursor pointing to **ACCELEROMETER** and press the right arrow button. Then change the **USE** to **NO-USE**.

APOGEE TIMER: NO-USE indicates the apogee timer will NOT be used as a backup sensor for apogee deployment. This is the recommended default setting. However, if the flight is going to be so high (>150,000 feet) that it goes above most of the atmosphere then using a timer to fire the apogee charge becomes a reasonable thing to consider because deployment timing will not be very critical. Even if the timing is not optimum and the rocket is still traveling at fairly high speed when the apogee timer fires, there will be no harm done to the rocket since there is little to no air. If you wish to use the timer, then position the cursor on that line and press the right arrow button. Then ENABLE the timer and set the time after liftoff that you want it to fire.

Once all the deployment settings are set the way you want them, press **APPROVE SETTINGS** (if none were changed) or **UPDATE PYRO BOARD** if one or more settings where changed. You must approve the settings for flight in order to be GO for launch. Even if you did not make any changes to them. This serves as a double check just to make sure you are happy with all the settings.

Proceed to section 12.2 on page 19 if you need to disable staging for this flight. Otherwise, proceed to section 12.3 on page 20 if you want to enable staging operations for this flight.

12.2 Disable Staging

If the rocket is just a single stage rocket then it is necessary to disable the pyro system staging operations.   This page explains how to do that.   Note: Pyro staging operations can be used to fire a second stage sustainer motor or to fire air starts.

```
▬▬PYRO SYSTEM▬▬▬▬▬▮▮▮▮

   PYRO BOARD:  GO
   BATTERIES:   GO
   DEPLOYMENT:  GO
 ▶ STAGING:     NO-GO
   ARM PYRO's:  NO-GO
```

After the deployment settings are configured the way you want them, press the back button to return to this PYRO SYSTEM status page.

The deployment system is now **GO** for launch.

We are now ready to deal with the staging settings.

Position the cursor pointing to **STAGING** and press the right arrow button.

```
▬▬STAGING▬▬▬▬▬▬▬▮▮▮▮

   STAGING ENABLED!

   CONTINUITY: NO-GO
   SETTINGS:   NO-GO
 ▶ ENABLE/DISABLE
```

Here the STAGING status screen shows that staging is ENABLED.   **If your flight is not a two-stage flight, then you should disable the staging pyro channels.**

To disable staging, position the cursor on the **ENABLE/DISABLE** line and press the right arrow button.

```
   PLEASE CONFIRM YOU
   WANT TO DISABLE
   PYRO BOARD STAGING

 ▶ CONFIRM
   CANCEL
```

The next screen will ask you to confirm that you want to disable pyro board staging.

Select **CONFIRM** and press the right arrow button.

```
▬▬STAGING▬▬▬▬▬▬▬▮▮▮▮

   STAGING DISABLED!

 ▶ CONTINUITY: NO-USE
   SETTINGS:   NO-USE
   ENABLE/DISABLE
```

The STAGING status screen will now show that staging has been disabled.

Consequently, the staging **CONTINUITY** and **SETTINGS** will also now be specified as **NO-USE**.

```
▬▬PYRO SYSTEM▬▬▬▬▮▮▮▮

   PYRO BOARD:  GO
   BATTERIES:   GO
   DEPLOYMENT:  GO
 ▶ STAGING:     NO-USE
   ARM PYRO's:  NO-GO
```

Pressing the back button brings you back to the PYRO SYSTEM status page.

STAGING is now specified as **NO-USE**. That means you have successfully disabled all staging operations.

With staging disabled, you can now skip to section 12.6 on page 27 in order to ARM the pyro system for launch.

12.3 Enable Staging

If the rocket has two stages then pyro system staging operations need to be enabled and properly configured. This page explains how to enable staging.   Note: Pyro staging operations can also be used to fire air starts.

```
▰▰▰PYRO SYSTEM▰▰▰▰▰▰▰▰▰▰

   PYRO BOARD:  GO
   BATTERIES:   GO
   DEPLOYMENT:  GO
 ▶ STAGING:     NO-USE
   ARM PYRO's:  NO-GO
```

After the deployment settings are configured the way you want them, press the back button to return to this PYRO SYSTEM status page.

The deployment system is now GO for launch.

We are now ready to deal with the staging settings.

Position the cursor pointing to **STAGING** and press the right arrow button.

```
▰▰▰STAGING▰▰▰▰▰▰▰▰▰▰▰▰▰

   STAGING DISABLED!

   CONTINUITY: NO-USE
   SETTINGS:   NO-USE
 ▶ ENABLE/DISABLE
```

Here the STAGING status screen shows that staging is currently disabled.   **If your flight is a two-stage flight, then you will need to enable the staging pyro channels.**

To ENABLE staging, position the cursor on the **ENABLE/DISABLE** line and press the right arrow button.

```
   PLEASE CONFIRM YOU
   WANT TO ENABLE
   PYRO BOARD STAGING

 ▶ CONFIRM
   CANCEL
```

The next screen will ask you to confirm that you want to enable pyro board staging.

Select **CONFIRM** and press the right arrow button.

```
▰▰▰STAGING▰▰▰▰▰▰▰▰▰▰▰▰▰

   STAGING ENABLED!

 ▶ CONTINUITY: NO-GO
   SETTINGS:   NO-GO
   ENABLE/DISABLE
```

The STAGING status screen will now show that staging has been enabled.

The staging **CONTINUITY** and **SETTINGS** are listed as **NO-GO**. Therefore, they are the next items on this checklist to deal with.

Position the cursor pointing to **CONTINUITY** and press the right arrow button. This will take you to the staging CONTINUITY status screen shown in section 12.4 on page 21.

12.4 Staging Continuity Checks

Continuity of the separation charge ematch and the sustainer motor igniter should be checked before launch. Both must indicate good continuity in order for the flight to be GO FOR LAUNCH. If the pyro board is NOT connected to a separation charge ematch then the pyro system needs to be informed of that by setting the SEP pyro channel to NO-USE. This section explains how to perform the continuity checks and how to set the pyro channels to NO-USE when necessary.

```
■■■STAGING■■■■■■■■■■■■■■■■

    STAGING ENABLED!

▶ CONTINUITY: NO-GO
  SETTINGS:    NO-GO
  ENABLE/DISABLE
```

The STAGING status screen shown here is reached by selecting MAIN MENU ⇨ LAUNCH ⇨ PYRO SYSTEM ⇨ STAGING.

Select **CONTINUITY** to see the continuity status screen shown below.

```
■■■CONTINUITY■■■■■■■■■■■■■

  SEP:   GOOD
  MOTOR: NEEDS CHECK

▶ CHECK MOTOR IGNITER
  SPECIFY USE
```

This shows the separation charge ematch has **GOOD** continuity. If there was no continuity then it would be shown as **OPEN**.

This also shows that the sustainer motor igniter still needs to be checked.

To check the sustainer motor igniter continuity, position the cursor to this line and press the right arrow button.

```
OKAY TO MOMENTARILY
REMOVE SAFETY SHUNT
TO CHECK MOTOR
IGNITER CONTINUITY?

▶ YES, DO IT!
  NO,  NOT NOW
```

You will now be asked if this is a good time to momentarily remove the sustainer motor igniter safety shunt in order to check igniter continuity. **Normally, this is done once the rocket is vertical and everyone has moved back to a safe distance from the launch pad.** If that is the case then select **YES** and let the continuity test be automatically performed. Otherwise, select **NO** and come back to this screen at a later time when you are ready to perform the check from a safe distance.

```
    CHECKING MOTOR
  IGNITER CONTINUITY


  PLEASE STAND BY...
```

This screen is shown for a few seconds while the test is being performed.

```
  IGNITER CONTINUITY
       IS GOOD!


SAFETY SHUNT RESTORED
```

Another screen will then be shown for a few seconds that indicates ignitor continuity was good. It also shows a reminder that the igniter safety shunt has been put back in place.

```
▦ CONTINUITY ▦▦▦▦▦▦▦▪▪▪▪

   SEP:    GOOD
   MOTOR: GOOD

   CHECK MOTOR IGNITER
 ▶ SPECIFY USE
```

GOOD status will be shown here after the motor igniter continuity check has passed.   If the continuity check failed then it will be shown as **OPEN**.

If you are not using either the separation charge or the motor igniter firing channels then select **SPECIFY USE** to disable it.

```
▦ SELECT PYRO ▦▦▦▦▦▦▪▪▪▪

 ▶ SEP:     USE
   MOTOR: USE
```

Position the cursor to the desired channel and press the right arrow button in order to change the **USE** to **NO-USE** or vice versa.

12.5 Staging Settings

```
■■■STAGING■■■■■■■■■■■■■■■
   STAGING ENABLED!

   CONTINUITY:  GO
▶  SETTINGS:    NO-GO
   ENABLE/DISABLE
```

```
■■■STAGING■■■■■■■■■■■■■■■

▶  SEPARATION:    NO-GO
   MOTOR ARMING:  NO-GO
   MOTOR FIRING:  NO-GO
   FIRING TIME:   3.0 s
```

12.5.1 Separation Firing Criteria

```
■■■FIRE SEP■■■■■■■■■■■■■■■
▶  TIME>LIFTOFF +4.0 s
   TIME>BURNOUT +2.0 s
   VELOCITY>300    ft/s
   VELOCITY<1200   ft/s
   ALTITUDE>1000   ft
   APPROVE SETTINGS
```

```
■■■FIRE SEP■■■■■■■■■■■■■■■
   TIME>LIFTOFF +4.0 s
   TIME>BURNOUT +2.0 s
   VELOCITY>300    ft/s
   VELOCITY<1200   ft/s
   ALTITUDE>1000   ft
▶  APPROVE SETTINGS
```

```
■■■STAGING■■■■■■■■■■■■■■■

   SEPARATION:     GO
▶  MOTOR ARMING:  NO-GO
   MOTOR FIRING:  NO-GO
   FIRING TIME:   3.0 s
```

Use the back button to return to the STAGING status page shown here.

Staging CONTINUITY should now be shown as a **GO**.

Now position the cursor to **SETTINGS** and press the right arrow button.

There are three categories for the settings that control staging:

SEPARATION are settings that determine when the separation charge is fired.

MOTOR ARMING are settings that arm the firing of the sustainer motor igniter.

MOTOR FIRING are more settings that control when the sustainer motor igniter is fired.

Let's first deal with the separation charge settings. Position the cursor pointing to **SEPARATION** and press the right arrow button. It will bring up the FIRE SEP screen shown next.

There are five different parameters that can be specified to control the firing of the separation charge. To change one of the parameters, position the cursor onto the corresponding line and press the right arrow button. Then enter the value you need and press the center button to finish it. **If a parameter is not needed then just enter a value that will always be true or at least is easily met given the expected flight profile.**

Once all the parameters are set to the values you want, you will need to either **APPROVE SETTINGS** (if none were changed) or **UPDATE PYRO BOARD** if one or more were changed.

In either case, position the cursor to the last line on the display and press the right arrow button.

Now press the back button (left arrow) to return to the STAGING settings top level menu screen shown here.

At this point, the **SEPARATION** charge settings should now be shown as **GO**.

Next step is to select the **MOTOR ARMING** settings and press the right arrow button.

12.5.2 Sustainer Motor Arming Criteria

```
▓▓▓ARM STAGING▓▓▓▓▓▓▓▓▓▓
▶ TIME>LIFTOFF +5.0 s
  TIME<LIFTOFF+99.9 s
  BOOSTER ACCEL > 5 G
  VEL>400 fps AT  3 s
  ALT>1500 ft AT  5 s
  APPROVE SETTINGS
```

This screen shows the parameters that can be specified for arming the firing of the sustainer motor igniter. To change one of the parameters, position the cursor on the corresponding line and press the right arrow button. Then enter the value you need and press the center button to finish it. **If a parameter is not needed then just enter a value that will always be true or at least is easily met given the expected flight profile.**

The last three parameters on this screen are intended as a "sanity check" as to the performance of the booster before committing to lighting the sustainer motor. One specifies that the acceleration during boost exceeded at least 5G. In other words, if the maximum acceleration during the booster motor burn never exceeds 5G then the sustainer motor igniter will never be armed and therefore the sustainer motor will never be fired. However, you will need to select a value that is appropriate for your flight.

As shown in the screen above, there is also a specification that the velocity during boost must exceed 400 feet/sec at 3 seconds into the flight. This too is a basic "sanity check" on the booster performance to make sure the flight is progressing as expected before committing to staging. Likewise, there is also a specification that the altitude exceed 1500 feet at 5 seconds into the flight. This too serves as a qualification on booster performance before the sustainer is ignited. This too needs to be set to a value that is appropriate for your flight.

All of these booster specifications are included in order to enhance flight safety. They are intended to help make sure staging is aborted if something odd happens during boost and the flight is not a nominal flight. The values shown here are just examples. You will need to examine your own simulations prior to flight and decide what values to use for your flight. Setting these values too tight might result in an unnecessary abort of sustainer ignition. Setting them too loose does not provide very much confidence that the flight is progressing properly before igniting a second stage. In the end, a compromise is necessary and you will have to use your own judgement as to what is best.

```
▓▓▓ARM STAGING▓▓▓▓▓▓▓▓▓▓
  TIME>LIFTOFF +5.0 s
  TIME<LIFTOFF+99.9 s
  BOOSTER ACCEL > 5 G
  VEL>400 fps AT  3 s
  ALT>1500 ft AT  5 s
▶ APPROVE SETTINGS
```

Once all these ARMING parameters are set to the values you want then select either **APPROVE SETTINGS** (if none were changed) or **UPDATE PYRO BOARD** if one or more were changed.

```
▓▓▓STAGING▓▓▓▓▓▓▓▓▓▓▓▓▓▓

  SEPARATION:   GO
  MOTOR ARMING: GO
▶ MOTOR FIRING: NO-GO
  FIRING TIME:  3.0 s
```

Now press the back button (left arrow) to return to the STAGING settings top level menu screen shown here.

At this point, the **MOTOR ARMING** settings should now be shown as **GO**.

Next step is to select the **MOTOR FIRING** settings and press the right arrow button.

12.5.3 Sustainer Motor Firing Criteria

```
████FIRE SUSTAINER████████
▶ TIME>BURNOUT +4.0 s
  TIME<BURNOUT+15.0 s
  TILT<20° FOR  2.0 s
    200<VEL<1200 ft/s
   1000<ALT<99999 ft
  APPROVE SETTINGS
```

This screen shows the parameters that can be specified to control the firing of the sustainer motor igniter.

NOTE: There is actually no real distinction between the parameters that ARM motor firing and the parameters that FIRE the motor. They are really just two different sets wherein all the parameters in each set must be true at the same time in order for the sustainer motor to be fired. The fact one set is called ARMING and one set is called FIRING is just a convenient naming convention.

```
████FIRE SUSTAINER████████
  TIME>BURNOUT +4.0 s
  TIME<BURNOUT+15.0 s
  TILT<20° FOR  2.0 s
    200<VEL<1200 ft/s
   1000<ALT<99999 ft
▶ APPROVE SETTINGS
```

Once all the sustainer FIRING parameters are set to the values you want then select either **APPROVE SETTINGS** (if none were changed) or **UPDATE PYRO BOARD** if one or more were changed.

The tilt parameter shown in the screen above specifies that the flight must be less than 20 degrees away from vertical when it is time to fire the sustainer motor. This is just an example and you should set the value as needed for your own flight. The screen above also specifies the tilt must be less than 20 degrees for the previous two seconds. The two second criteria helps make sure the tilt has been low for a sustained period of time. In other words, the tilt is not changing rapidly because of the rocket pitching over at a high rate. We would like to make sure we don't fire the sustainer motor ignitor and then have the rocket pitch over significantly before the sustainer motor comes up to pressure! Again, two seconds is just a place holder. You should pick a value that is appropriate for your flight criteria.

Tilt is measured using the GPS as the primary sensor. However, if GPS is not available (for example the rocket is traveling too fast) then the onboard 3-axis gyro is used instead. **There is also an abort limit of 45 degrees that is hardwired into the gyro and cannot be changed.** If the 3-axis gyro ever detects more than 45 degrees of tilt after liftoff, even momentarily, then sustainer motor ignition is locked out for the rest of the flight. This is a range safety feature designed to prevent a flight that is tumbling out of control from ever attempting to fire the sustainer just because it rotated back into a more vertical orientation.

```
████STAGING████████████████████

  SEPARATION:   GO
  MOTOR ARMING: GO
▶ MOTOR FIRING: GO
  FIRING TIME:  3.0 s
```

Now press the back button (left arrow) to return to the STAGING settings top level menu screen shown here.

At this point, the **MOTOR FIRING** settings should now be shown as **GO**. In fact, all the staging settings are **GO**.

Next we turn our attention to the FIRING TIME shown here as 3.0 seconds. It is the time duration that will be used to fire the sustainer motor igniter pyro channel. It is described in detail in the next section.

12.5.4 Sustainer Motor Igniter Firing Time

The length of time the sustainer motor igniter pyro channel will fire can be adjusted from 0.5 seconds to 5.0 seconds. This allows some flexibility for using different types of igniters, such as ematches or nichrome igniters.   None of the other pyro channels have adjustable firing times. They are all fixed at 0.5 seconds.

This next screen is a continuation of the sequence described in the previous section. It can also be reached via:

MAIN MENU ⇨ LAUNCH ⇨ PYRO SYSTEM ⇨ STAGING ⇨ SETTINGS

```
▄▄▄ STAGING ▄▄▄▄▄▄▄▄▄▄▄▄▄▄ ▄▄▄▄

    SEPARATION:    GO
    MOTOR ARMING:  GO
    MOTOR FIRING:  GO
  ▶ FIRING TIME:   3.0 s
```
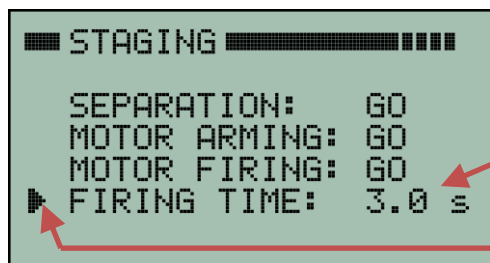
This shows the sustainer motor igniter will be fired for 3.0 seconds.

Position the cursor on **FIRING TIME** and then press the center button to enter an edit mode for changing the firing time.

```
▄▄▄ STAGING ▄▄▄▄▄▄▄▄▄▄▄▄▄▄ ▄▄▄▄

    SEPARATION:    GO
    MOTOR ARMING:  GO
    MOTOR FIRING:  G
  ▶ FIRING TIME:   3.0 s
```
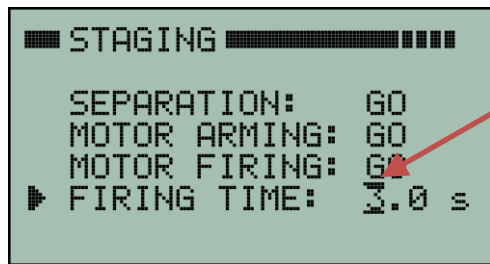
Two blinking "edit bars" will appear above and below a digit in the firing time number to show which digit will be changed.   Press the up and down buttons to increment or decrement the digit.   Use the left and right buttons to move the edit bars left and right to select different digits.

Change the firing time to be what you want and then press the center button to send the change to the pyro board.

```
        UPDATING
       PYRO BOARD


     PLEASE STANDBY...
```

This screen will appear momentarily to show the pyro board firing time is being updated.

```
        UPDATE
      SUCCESSFUL!
```

This screen appears momentarily once the update has been completed. A few seconds later the display will return to the STAGING screen shown above and will show the new firing time that is in effect.

The firing time setting in the pyro board is retained even if the pyro board is powered off and then back on again. Just like all the other staging criteria settings.

This completes the process of specifying all the settings that control staging.

12.6 Arming the Pyro System

```
▀▀▀PYRO SYSTEM▀▀▀▀▀▀▓▓▓▓▓

   PYRO BOARD:   GO
   BATTERIES:    GO
   DEPLOYMENT:   GO
   STAGING:      GO
 ▶ ARM PYRO's: NO-GO ◀
```

Press the back button (left arrow) as needed in order to return to the PYRO SYSTEM status screen shown here.

Alternatively, you can access this screen by navigating: MAIN MENU ⇨ LAUNCH ⇨ PYRO SYSTEM

Move the cursor so it is pointing to **ARM PYRO's** and then press the right arrow button.

```
▀▀▀ARM PYRO▀▀▀▀▀▀▀▀▀▓▓▓▓

   PYRO SYSTEM ARMED
      *** NO ***

 ▶ ARM PYRO's
   DISARM (SCRUB)
```

This screen shows the pyro system is not yet armed.

Arming the pyro system is usually done after the rocket has been put vertical and everyone has backed away to a safe distance from the launch pad.

To arm the pyro system, move the cursor so it points to **ARM PYRO's** and press the right arrow button.

```
▀▀▀ARM PYRO▀▀▀▀▀▀▀▀▀▓▓▓▓

   PYRO SYSTEM ARMED
      *** YES *** ◀

 ▶ ARM PYRO's
   DISARM (SCRUB) ◀
```

The screen now shows the pyro system is armed.

If it becomes necessary to scrub the launch then you can disarm the pyro system by pointing the cursor to the **DISARM** option and press the right arrow button

Alternatively, another good way to scrub a flight is to send a command to power-off the transmitter. The command to power-off the transmitter will automatically disarm the pyro board, then power-off the pyro board and then power-off the transmitter itself. The rocket can then be safely lowered back down to a horizontal orientation.

```
▀▀▀PYRO SYSTEM▀▀▀▀▀▀▓▓▓▓▓

   PYRO BOARD:   GO
   BATTERIES:    GO
   DEPLOYMENT:   GO
   STAGING:      GO
 ▶ ARM PYRO's:  GO
```

Now press the back button (left arrow) to return to the PYRO SYSTEM status screen shown here.

It shows that all aspects of the pyro system are **GO** for launch!

```
▀▀▀LAUNCH STATUS▀▀▀▀▓▓▓▓
   LAUNCH IS GO! ◀
   RADIO LINK:   GO
   GPS STATUS:   GO
   PYRO SYSTEM:  GO
   FLIGHT DATA:  GO
 ▶ ARM LIFTOFF: GO
```

Press the back button (left arrow) again in order to return to the overall LAUNCH STATUS screen as shown here.

You will see **LAUNCH IS GO!** after everything has been setup and Kate (or Lisa) is ready to narrate the launch. You can now proceed with the actual launch. **Make sure you always check to see "LAUNCH IS GO!" before you launch the rocket!**

13   Manual Deployment

The manual deployment screen allows a user to fire the apogee or main parachute charges manually at any time. The primary charge will be fired first. Then after a 0.5 second delay, the secondary (backup) change will also be automatically fired.

Altitude and velocity are displayed in real time on this screen in order to assist the user for deciding when to manually fire the charges.   Altitude is in feet above ground level.   Velocity is actually vertical velocity and is in feet/second. Positive velocity is UP and negative velocity is DOWN.

Manual deployment can also be used to ground test deployment charges. **For ground testing, just turn-on the pyro board, arm the pyro system and then fire the charges manually from a safe distance.**
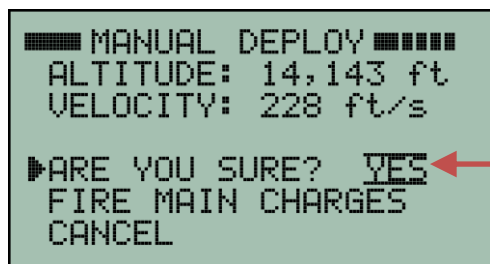
The Manual Deployment command screen shown below is accessed via:
MAIN MENU ⇨ COMMANDS ⇨ PYRO SYSTEM ⇨ DEPLOYMENT ⇨ MANUAL DEPLOYMENT

```
▰▰▰▰MANUAL DEPLOY▰▰▰▰▰
 ALTITUDE: 7626 ft
 VELOCITY: 795 ft/s

▶FIRE APOGEE CHARGES
 FIRE MAIN CHARGES
 CANCEL
```
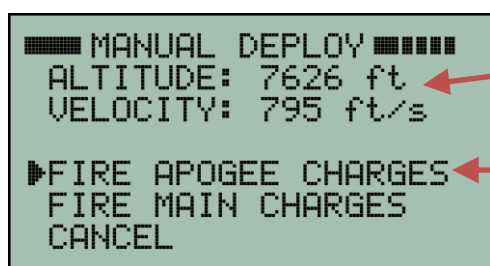
Real time altitude and velocity.

To fire the apogee charges, position the cursor so it is pointing to **FIRE APOGEE CHARGES** and then press the right arrow button.

```
▰▰▰▰MANUAL DEPLOY▰▰▰▰▰
 ALTITUDE: 14,143 ft
 VELOCITY: 228 ft/s

▶ARE YOU SURE?  YES
 FIRE MAIN CHARGES
 CANCEL
```
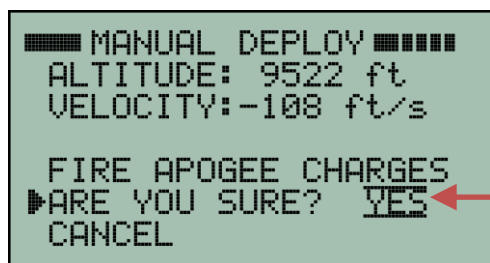
You will be asked to confirm you really do intend to fire the apogee charges. To confirm, use the up and down buttons to select **YES** and then press the center button.

As soon as you press the center button, the primary apogee charge will be fired. Then after a 0.5 second delay, the secondary apogee charge will also be fired.

```
▰▰▰▰MANUAL DEPLOY▰▰▰▰▰
 ALTITUDE: 12,732 ft
 VELOCITY:-115 ft/s

 FIRE APOGEE CHARGES
▶FIRE MAIN CHARGES
 CANCEL
```
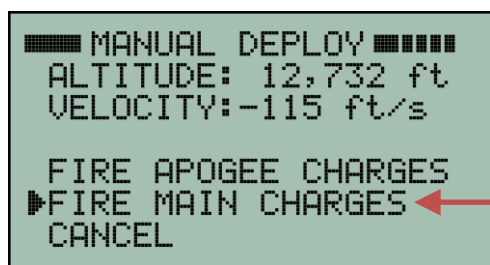
To fire the main parachute charges, position the cursor pointing to **FIRE MAIN CHARGES** and then press the right arrow button.

```
▰▰▰▰MANUAL DEPLOY▰▰▰▰▰
 ALTITUDE: 9522 ft
 VELOCITY:-108 ft/s

 FIRE APOGEE CHARGES
▶ARE YOU SURE?  YES
 CANCEL
```

You will be asked to confirm you really do intend to fire the main parachute charges. To confirm, use the up and down buttons to select **YES** and then press the center button. The primary charge will fire right away. The secondary charge will fire after a 0.5 second delay.

14 Simulated Launch

The TelemetryPro system includes a launch simulation mode that allows a user to simulate an entire flight. This is used for training and practice so that a user can become familiar with operating the system prior to an actual launch. The simulation is also a very good test to make sure the system is working properly.

Ematches or small light bulbs can be connected to the pyro board in order to see when pyro channels are fired during a simulated launch. A suitable light bulb is part number CM7371-ND available from www.digikey.com It can be fun watching the pyro board operate while Kate also narrates the simulated launch exactly the same way as for a real launch.

In simulation mode, the transmitter synthesizes telemetry data and sends it to the receiver. The receiver operates normally during a simulation.   It has no clue whether the data is real or synthesized!

Please see the Mx120 Receiver User Manual for more information on how to perform a simulated launch.

14.1 Transmit Power for Simulated Launches

A simulated launch can be used to test out the TelemetryPro system. It can also be used to see if there are any compatibility issues with other onboard electronics.   However, the transmit power used during a simulation is normally just 100mW. This helps avoid overloading the receiver when it is in close proximity to the transmitter.   If desired, the transmit power can be increased by accessing the TRANSMIT POWER menu in the Mx120 Receiver.   It allows simulations to be done with the transmitter running at 100mW, 500mW or 1W. These can be used to make sure the other electronics will still function properly even while being subjected to the high power transmissions from the Kate 2.0 transmitter.   The Mx120 Receiver User Manual has more information about setting the transmit power during a simulation.

15 Downloading Flight Data

The transmitter saves flight data in flash memory and will retain that data even after it is turned off. However, it only saves one flight. The data will span from six seconds prior to liftoff and run for about one hour after liftoff unless the transmitter was turned off before then. The Flight Data Analyzer program can be used to read the data from the transmitter.

The latest version of the Flight Data Analyzer program can be downloaded from the Multitronix website. Visit: www.multitronix.com/software
At this point, only Windows is supported. XP, Vista, Win7, Win8 and Win10 should all work.

Download and run the install package. The install process does not make any changes to the Windows system or to the registry. It simply creates a folder named "TelemetryPro" in your "Documents" directory. It also puts a shortcut to the program on your desktop. (To uninstall the program just delete the TelemetryPro folder and the shortcut.)

Run the Flight Data Analyzer program and you should see a window like this:
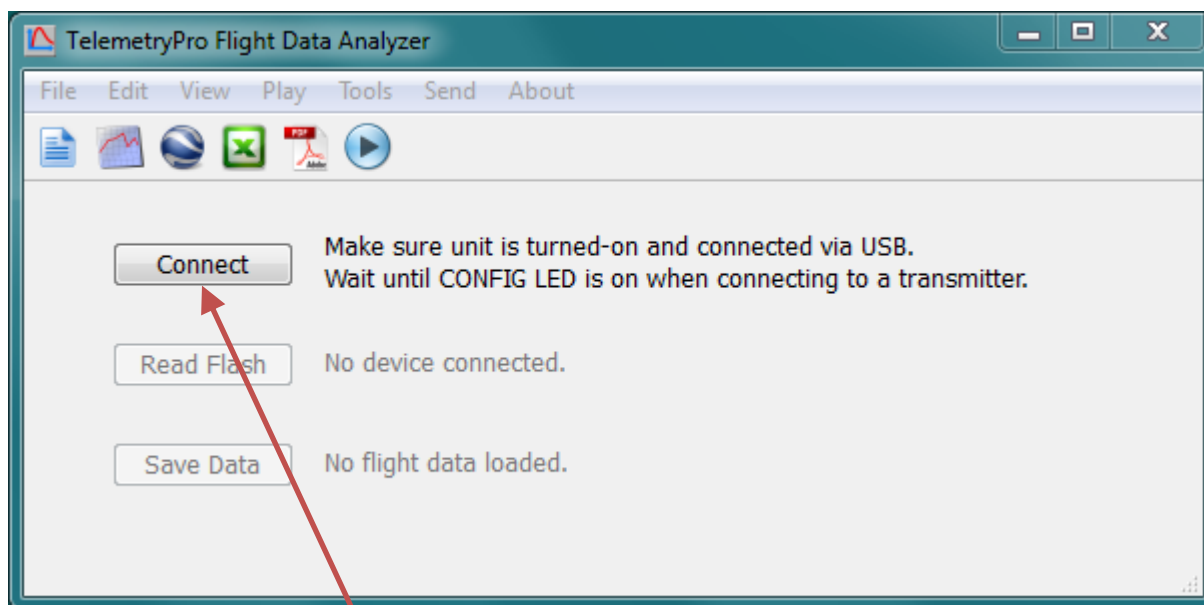
Before you can connect to the transmitter you must let the operating system install the appropriate drivers. (See next page.) It is recommended to leave the transmitter <u>turned-off</u> while Windows installs the USB drivers.

15.1 Installing USB Drivers

The first time a transmitter is connected to a computer the USB drivers need to be installed. This should happen automatically. **It is best to leave the transmitter <u>turned-off</u> while Windows is installing the drivers.** This prevents Windows from misidentifying the transmitter as some other device. The Windows operating system should automatically detect the transmitter as a new device and then search for and install the correct driver for your system. The only thing you should have to do is let it run to completion. Do not disconnect while it is still installing drivers. The whole process will typically take about one or two minutes. There are actually two separate drivers needed and Windows will automatically install both. During this process you may see windows similar to those shown below.
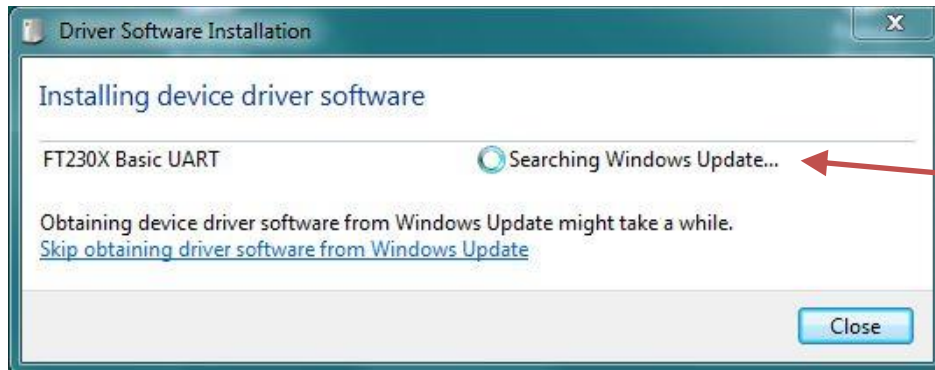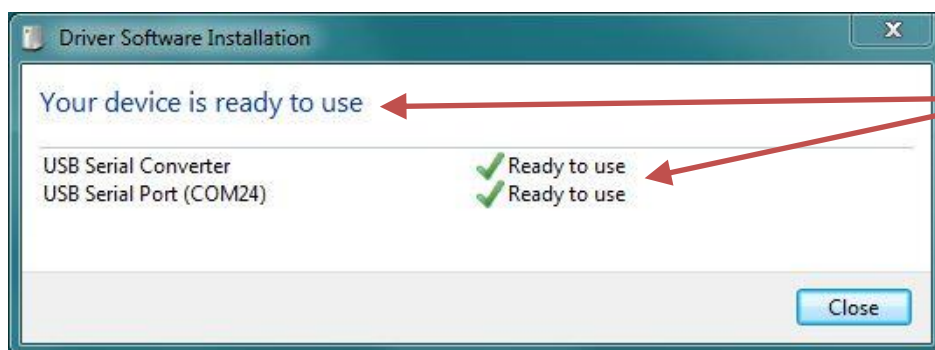

Searching for the first driver.
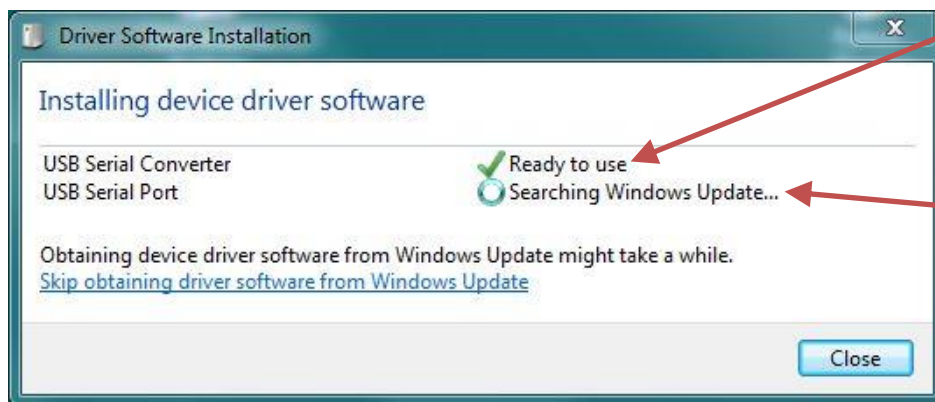
First driver installed okay.

Searching for the second driver.

Both drivers installed and ready to use.

15.2 Connecting and Downloading

Once the drivers have been installed, turn-on the transmitter and wait until the CONFIG LED is on.   Then press the **CONNECT** button on the Flight Data Analyzer window.   The analyzer will automatically search for the transmitter USB address and connect to it.   Once that happens the serial number of the transmitter will show up next to the button and the button will change to be a disconnect button. See example below.

You are now connected to the
transmitter with this serial number.
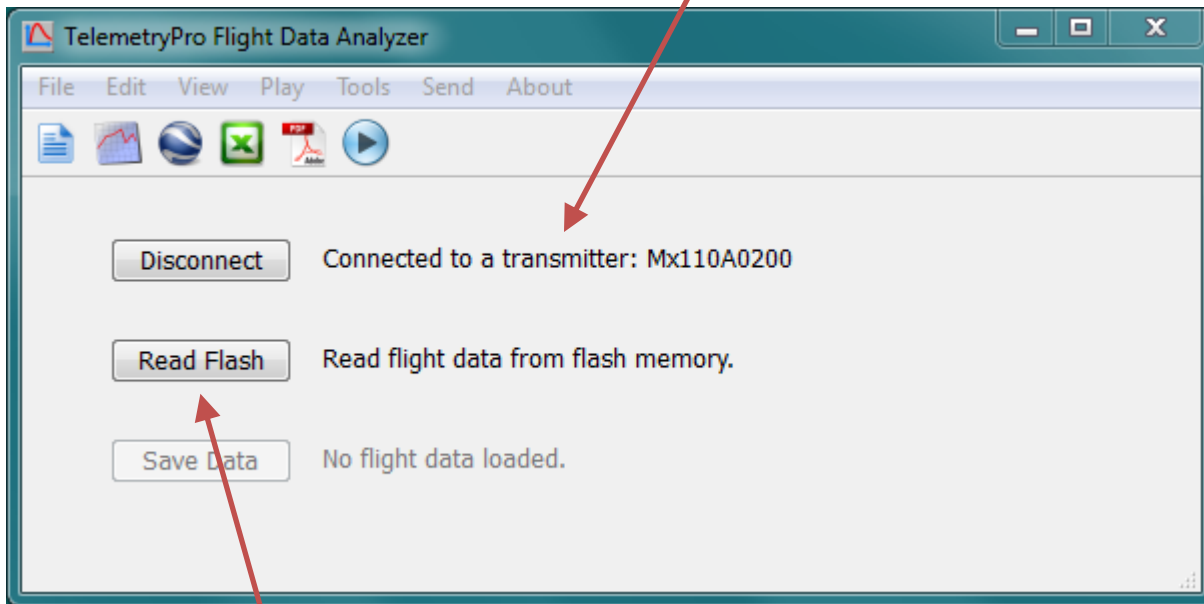
Now press the **Read Flash** button to download all of the flight data. (It is labeled as a **Read Data** button on newer versions of the software.)   It will take about five minutes to complete.

A new window will pop up while the flight data is being downloaded. It is shown below. It allows you to enter some information about the flight. It is the same kind of information usually put onto a flight card. It will get saved along with the raw flight data in order to document the data.
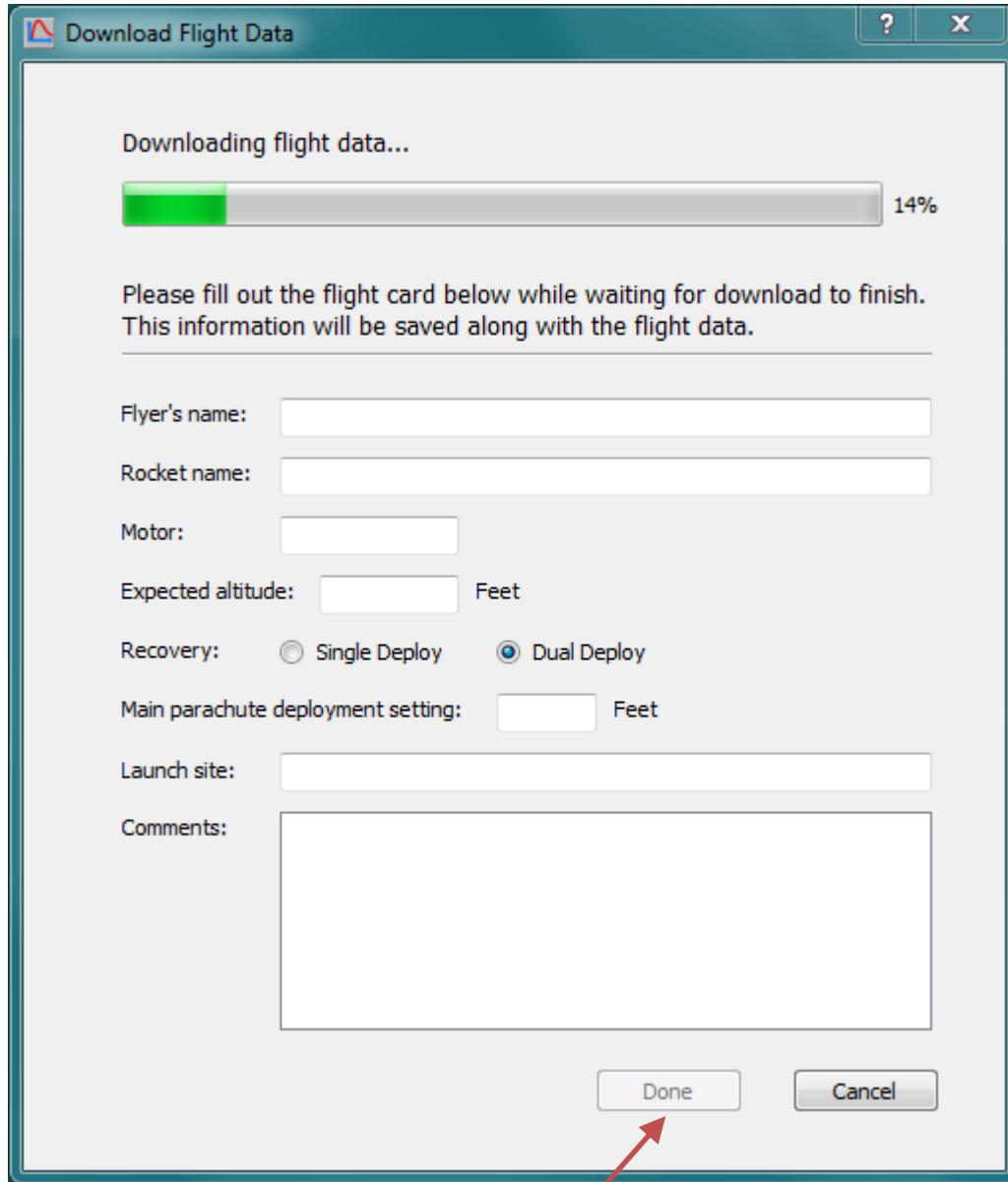
When the download has completed the **Done** button will become active.   When you have finished filling out the flight card information press **Done**.

After you click **Done** on the window with the flight card information, the program will begin processing the raw fight data and constructing a set of graphs. This typically takes about 15 seconds but may take a little longer depending on the speed of your computer. Once the graphs are ready, a graph menu window will open that looks like the one below. It shows some of the graphs that are available. To view a larger version of an individual graph, click the **View** button below it.
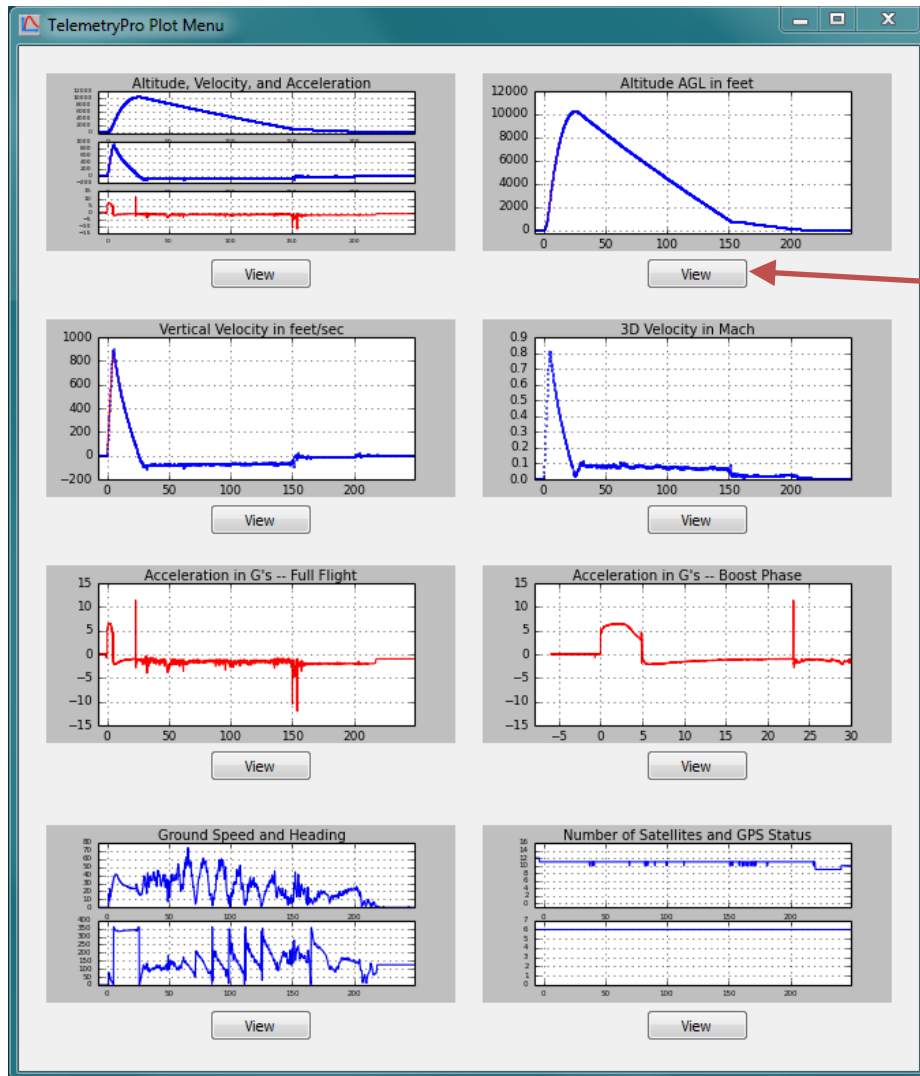
Click the **View** button below each graph to open a new window showing a larger version of the graph.

All of the graphs available in this menu are automatically included into the PDF fight summary report document. That document can be viewed by clicking the PDF icon on the main window tool bar.

Once the flight data has been processed, the program will automatically show a text window alongside the graph menu window. The text window gives a summary of the flight and the key events that occurred during the flight. An example is shown below. Use the scroll bar on the right side to see all of the text.

```
┌─ Flight Data Analysis Summary ──────────────────────────────── _ □ X ─┐
│                                                                        │
│  ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~  ▲    │
│  ¦                   Flight Card                              ¦        │
│  ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~      │
│  Launch date:    Sun Apr 12 2015                                       │
│  Launch site:    Maryland                                             │
│  Flyer's name:   Rocketman Jones                                      │
│  Rocket name:    Dark Energy                                          │
│  Motor:          N2200                                                 │
│  Expected alt:   10000 feet                                           │
│  Dual deploy:    Yes, main parachute set at 1000 feet                 │
│                                                                        │
│  Comments: Perfect flight!                                             │
│                                                                        │
│                                                                        │
│  ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~  ≡    │
│  ¦                   Flight Results                           ¦        │
│  ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~      │
│  Max GPS altitude:  10244 feet AGL                                    │
│  Max Acc altitude:  10145 feet AGL                                    │
│                                                                        │
│  Max GPS velocity:  891 feet/sec   607.5 mph   0.805 Mach             │
│  Max Acc velocity:  877 feet/sec   598.0 mph   0.792 Mach             │
│                                                                        │
│  Max Acceleration:  6.4 G's   206.7 feet/sec/sec                      │
│                                                                        │
│  Motor  burn time:  5.2 sec                                           │
│  Burnout altitude:  2340 feet AGL                                     │
│  Burnout velocity:  874 feet/sec   0.789 Mach                        │
│                                                                        │
│  Ground speed at apogee:  17 feet/sec   11.6 mph                      │
│  Heading at apogee:       357° from true north                        │
│                                                                        │
│  Distance to apogee:  643 feet   0.12 miles                          │
│  Bearing  to apogee:  343° from true north                           │
│                                                                        │
│  Descent rate on drogue:  75 feet/sec    51.3 mph                    │
│  Descent rate on main:    15 feet/sec    10.0 mph                    │
│  Touch down velocity:     14 feet/sec     9.5 mph                    │
│                                                                        │
│  Main Parachute Deployment Event                                      │
│  Deployed:  149.0 sec after liftoff                                  │
│  Altitude:  952 feet AGL                                             │
│  Vert vel: -79 feet/sec                                              │
│                                                                        │
│  Time to max velocity:      5.0 sec                          ▼        │
└────────────────────────────────────────────────────────────────────────┘
```

Use this scroll bar to view the rest of the text in the flight summary window.

All of the information shown in this flight summary window is also included into the PDF fight summary report document. That document can be viewed by clicking the PDF icon on the main window tool bar.

It is a good idea to save all of the flight data. To do so, locate the main Flight Data Analyzer window and press the **Save Data** button.
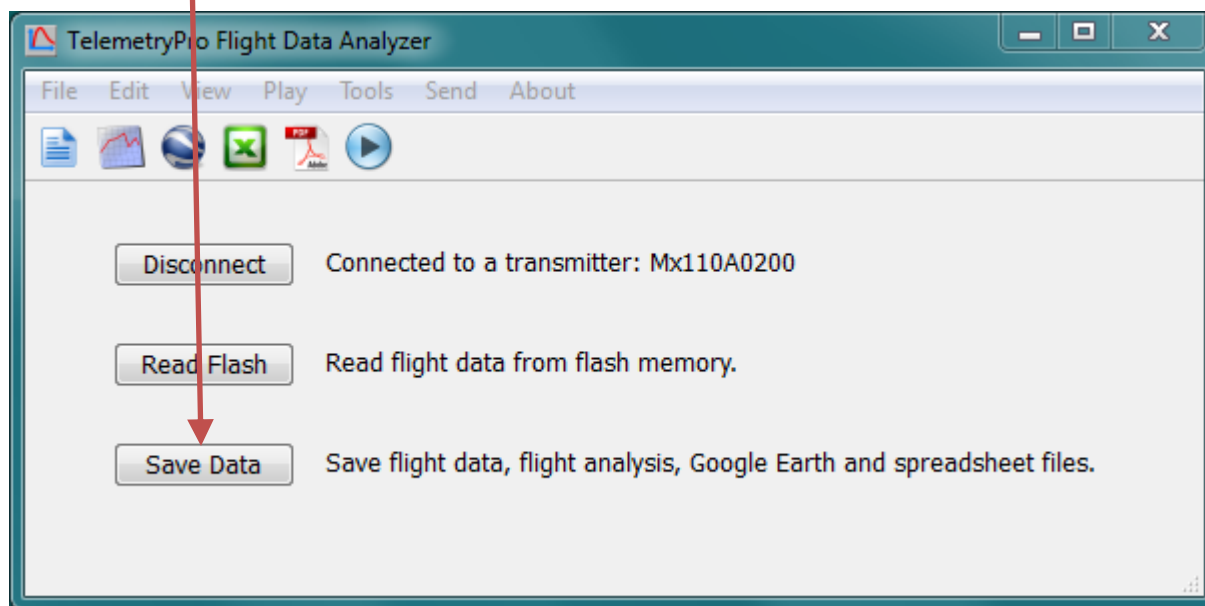

By default the flight data will get saved in your "Documents" directory in the TelemetryPro/FlightData folder.   However, you can easily change that when you save the data.

There are five data files generated by this software:

1. FlightData.bin   Raw Flight Data file.
2. Analysis.pdf   Document that contains a summary and all the graphs.
3. GoogleEarth.kml   Google Earth flight trajectory file.
4. Spreadsheet.csv   Spreadsheet of all the raw data. Opens in Excel for example.
5. Summary.txt   A simple text file that contains the flight summary.

You can open and view these files at a later time by using the File menu on the Flight Data Analyzer window to open the FlightData.bin file.   Or you can open any of the other files as desired.

You can view the flight trajectory in Google Earth by clicking on the Google Earth icon.
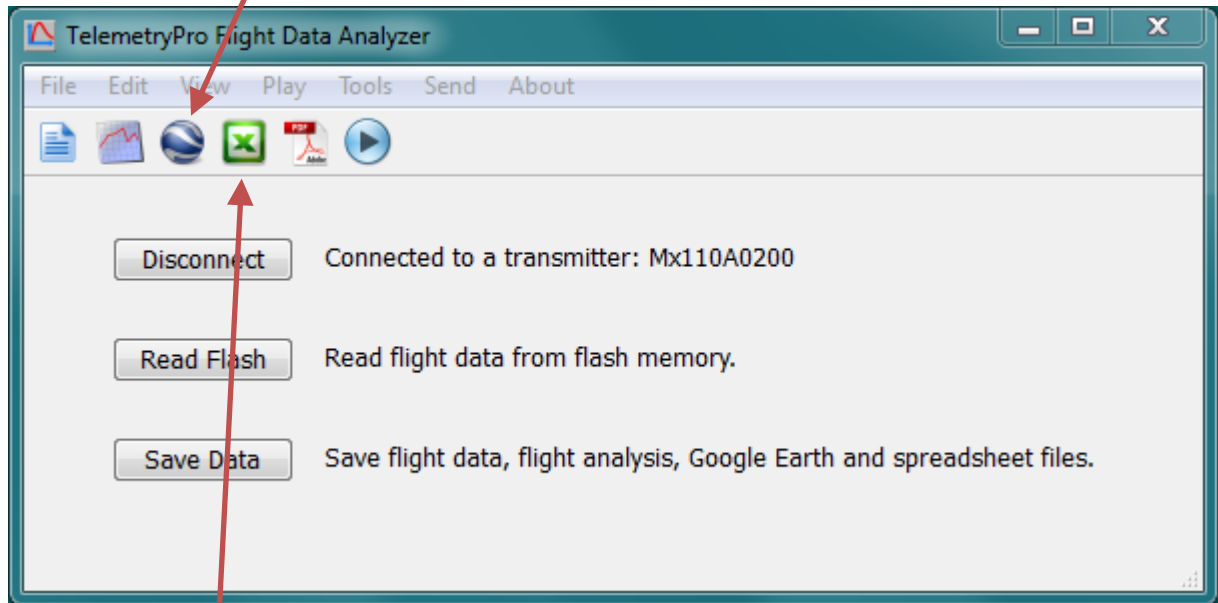
Click on the Excel icon if you want to see the spreadsheet with all the raw data. The graphs, flight summary page and full PDF flight report can also be opened by clicking on their icons.
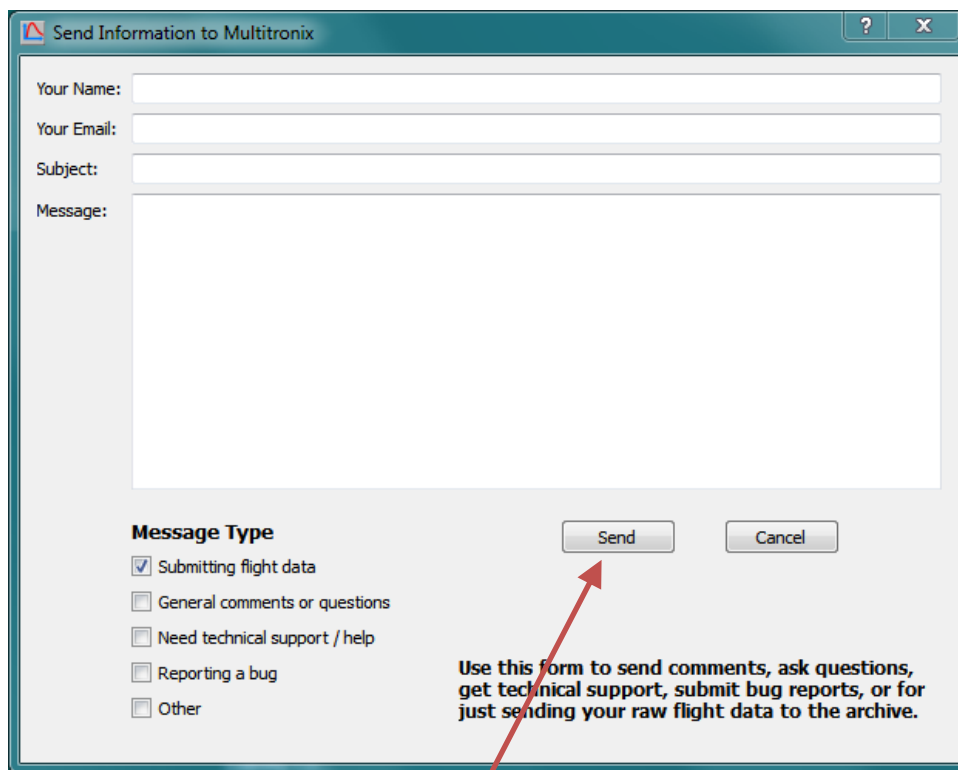
Explore the other capabilities of this program by opening up the menus on the tool bar.

15.3 Send Menu and Support/Help Feature

There is another menu on the toolbar that is worth special mention here. It is the **Send** menu. It will allow you to send your flight data directly to Multitronix to be included into our growing archive of flights. Doing so is completely optional but such information is very helpful for making future improvements to this software and to the TelemetryPro products. Of course, you will need to be connected to the internet for this feature to work.

You can also use the **Send** menu to simply ask questions or get support help from Multitronix even without sending any flight data. And lastly, if you find a programming bug please report it using the **Send** menu if possible because it will send some additional debug information to Multitronix that may help figure out what is going wrong.

Clicking **Send** on the tool bar will open another window that allows you to fill in the necessary information.

Fill out the form and click this **Send** button to send the information directly to Multitronix.

16 Firmware Updates

The Flight Data Analyzer program can be used to update the firmware in all TelemetryPro products. The program will guide you through the process. To begin the process, connect a USB cable between the computer and the device. If this is the first time the device has been connected to the computer then you must wait for Windows to automatically install the proper drivers. (See section 15.1 on page 31 for more details on installing drivers.) Once the drivers are installed you can turn-on the device, wait a few seconds and then press the **Connect** button to establish a connection. Then click on the **Tools** drop-down menu and select **Update Firmware** as shown in the window below.

Open the Tools drop-down menu.
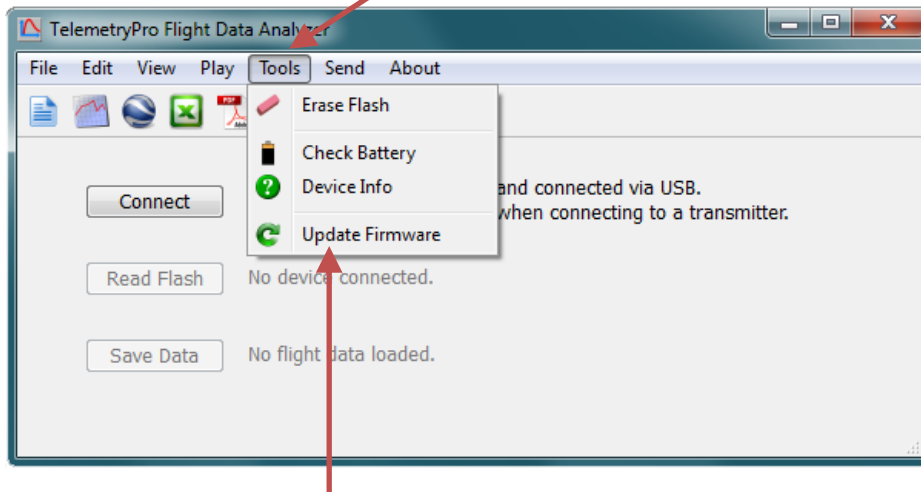
Clicking on **Update Firmware** will open a window like that shown below that makes it easy to get a firmware update file.
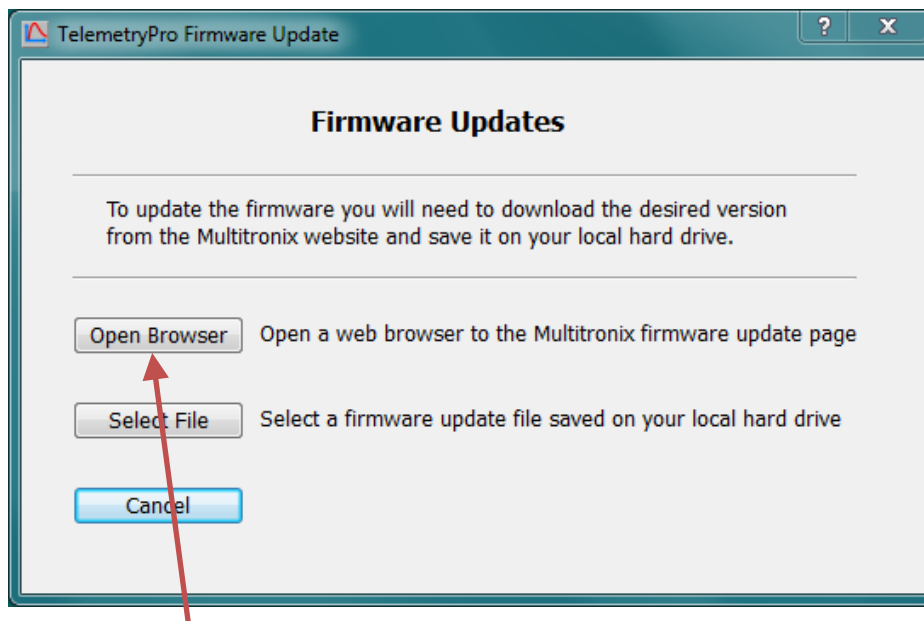
Clicking **Open Browser** will open a page on the Multitronix website that allows you to download the latest firmware for your product. Right click the download button on that web page and then select "Save target as…" to save the firmware file on your local hard drive. Once it is saved on your local hard drive, click the **Select File** button on the window shown above. Navigate to the file you saved and open it.

When you open a firmware update file a new window will appear that shows some information about the firmware. It shows the version number of the firmware and the product it is built for. You can also click on the **View Release Notes** button (optional) to see a description of all the features included into that version of firmware. Click the **Start** button to begin the actual firmware update for your device.

Click on **View Release Notes** if you would like to see a description of all the changes included into this version of firmware.

Click on the start button to begin updating your device.

When the firmware update begins, a window will open that shows what is happening. The firmware will be downloaded and verified. The entire process takes about one minute to complete.
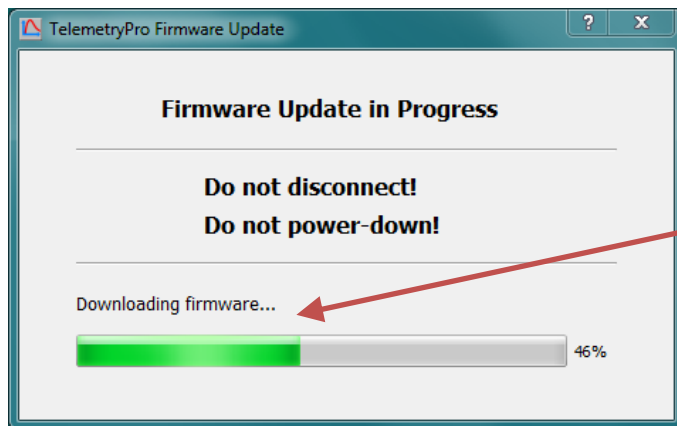
A progress bar shows what is happening during the update.

It is important to not disturb the device while a firmware update is in progress. Do not disconnect the USB cable and do not power-down the device. Let the update process run to completion. When it finishes another window will open as shown on the next page.

The device will automatically power itself off when the update process has completed programming the new firmware. A **Firmware Reboot Required** window like the one shown below will then appear. It explains what to do. You just need to power-on the device, wait at least five seconds and then press the **Connect** button on the reboot window. The new firmware will then begin executing and will be validated to confirm it was programmed correctly and is running properly.

When the **Firmware Reboot Required** window appears you just need to power-on the device, wait at least five seconds and then press the **Connect** button. This will start a validation check of the new firmware to verify it was programmed correctly.

The firmware validation check will only take about one second to complete. When it completes, a new window will appear that shows the firmware has been verified and is operating correctly.
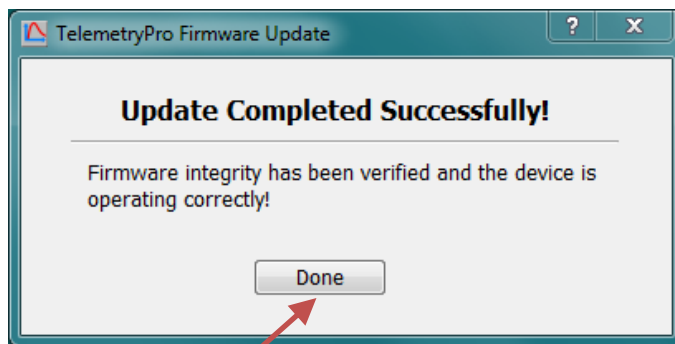
Click the **Done** button to close this window. The firmware update process is complete! Your device is now ready to be used.

17 Specifications

PLEASE NOTE: Recommended maximum acceleration during motor burn is 45 G's.   This provides some headroom and operational margin within the accelerometer hardware limit of 50 G's.

Radio Link
- ISM Band 902-928 MHz (USA) or 915-928 MHz (Australia)
- Spread spectrum frequency hopping with FSK modulation and 128-bit AES encryption.
- Maximum transmit power 1.0 W (30 dBm)
- Typical transmit power used during flight is 500 mW (27 dBm)
- Downlink radio range: 550,000 feet (100 miles)
- Transmitter antenna: 2.5 dBi, 1/2 wave dipole, omnidirectional
- Telemetry packets (binary format) transmitted every 200ms (Five per second)
- Unique ID codes for transmitter and receiver pairing.
- Two-way radio link.   Receiver can send commands to the transmitter.
- FCC certified for unlicensed operation.   FCC ID: HSW-DNT900

GPS
- Five GPS position fixes per second including altitude and velocity.
- Unlimited GPS altitude reporting.   No altitude lockout.
- GPS velocity lockout is 1700 feet/sec.
- Active patch antenna, SAW filter, 15dB LNA.
- GPS almanac retained while device is powered off.

General
- Size: 16.196 x 2.125 x 2.125 inches, 411.4 x 54 x 54 mm, mounts inside 54mm coupler tube
- Weight: 368 grams, 13 oz
- 50 G accelerometer recorded at 100 readings per second.   (See note at top of this page.)
- GPS and accelerometer data are merged into one flight data stream.
- Flight data is recorded in non-volatile flash memory.
- Flight data recording time is from T-6 seconds to T+1 hour for a flight that is 30s to apogee.
- 32-bit RISC ARM Cortex-M4 CPU, 80 MHz
- USB 2.0 compatible interface. Mini-USB connector.
- Wireless turn-on capability. 125 KHz magnetic field sensor.
- Seven LED status indicators:
  Flight Mode, Config Mode, Linked, USB Activity, Charging, Charge Done, Charge Failed
- Onboard Li-ion 3.7V, 2.6Ah battery provides at least 5 hours of standby time prior to flight.
- Built-in USB battery charger draws 900 ma on dedicated charger, 500 ma on standard USB port.
- Charging time: 1 to 4 hours depending on battery discharge state and charger power source.
- Battery charger operational temperature range: 0C to 50C, 32F to 122F
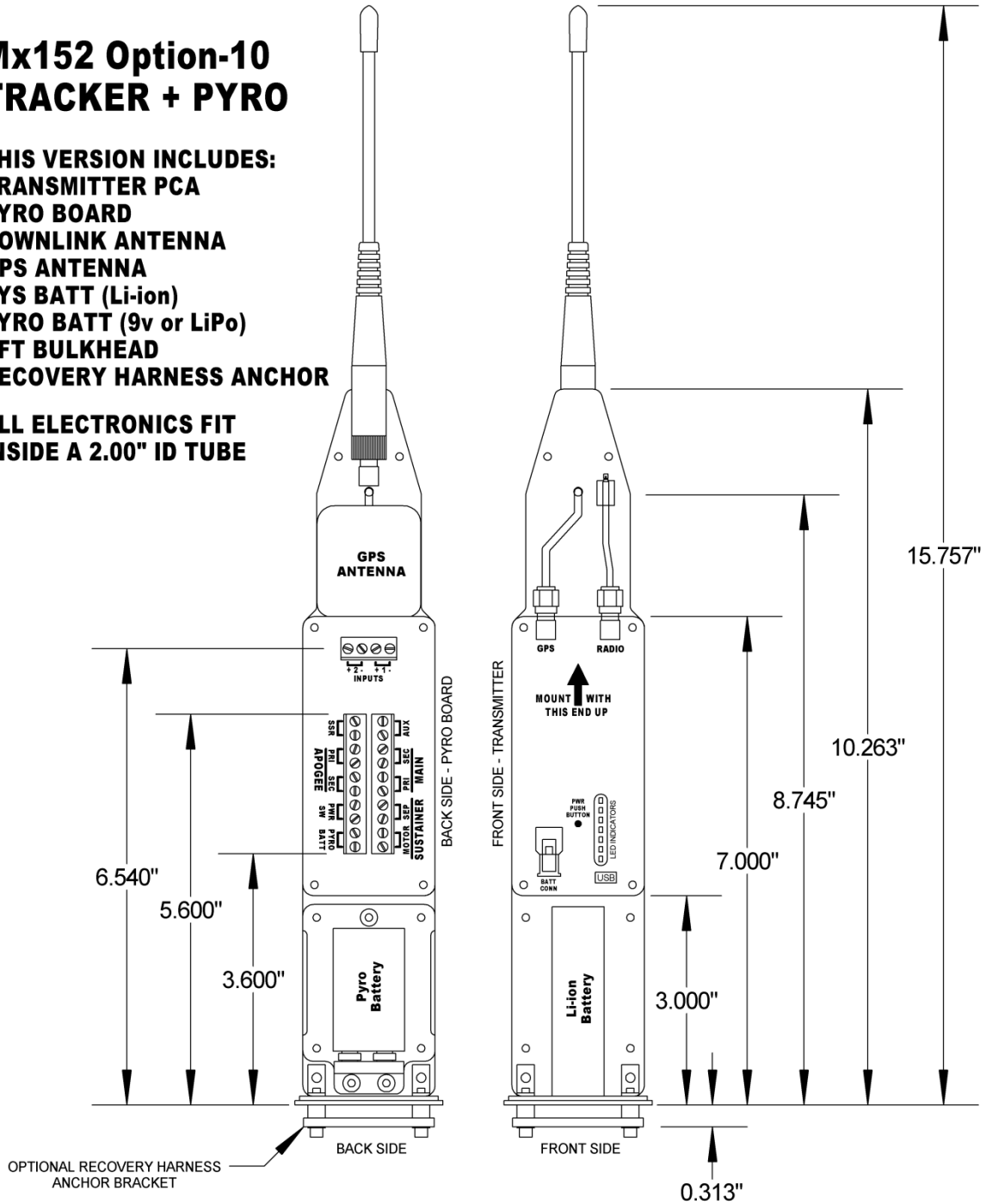
18 Dimensions

The next few pages contain various drawings with dimensions for all the key features on the boards.   All dimensions are in inches.
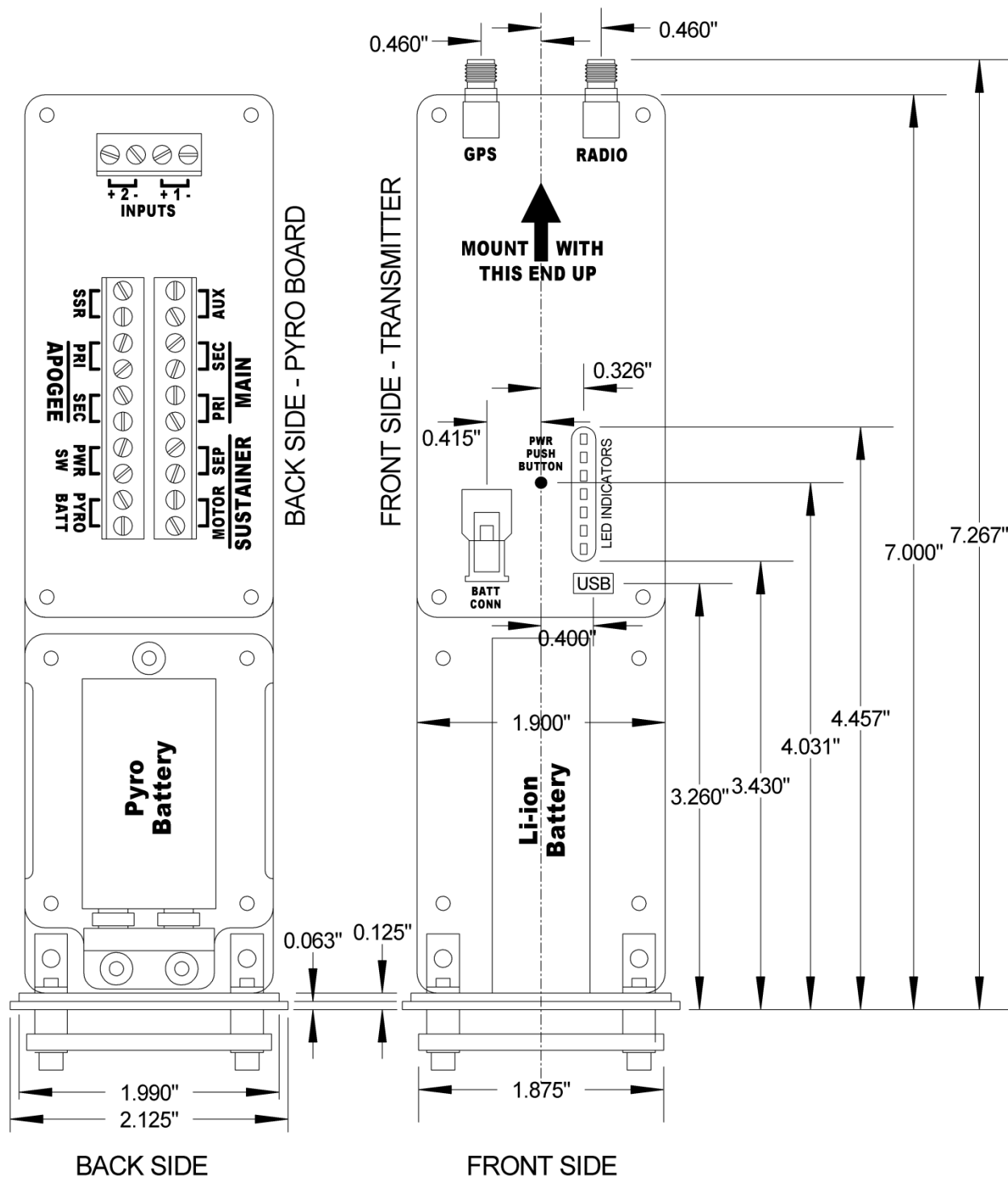
18.1 Overall Size

Mx152 Option-10 TRACKER + PYRO

THIS VERSION INCLUDES:
TRANSMITTER PCA
PYRO BOARD
DOWNLINK ANTENNA
GPS ANTENNA
SYS BATT (Li-ion)
PYRO BATT (9v or LiPo)
AFT BULKHEAD
RECOVERY HARNESS ANCHOR

ALL ELECTRONICS FIT
INSIDE A 2.00" ID TUBE

18.3 Mounting Hole Locations

4-40 threaded standoffs can be added at any of the mounting points if necessary

BACK SIDE - PYRO BOARD

INPUTS
+ 2 -   + 1 -

SSR
APOGEE PRI SEC
SEC
PWR SW
MOTOR SEP
SUSTAINER

AUX
SEC PRI
MAIN PRI
SUSTAINER BATT
PYRO BATT

Pyro Battery

BACK SIDE

FRONT SIDE - TRANSMITTER

GPS   RADIO

MOUNT WITH THIS END UP

1.563"

PWR PUSH BUTTON
LED INDICATORS
USB

BATT CONN

Li-ion Battery

6.844"

3.156"

2.684"

1.500"

0.390" 0.809"

1.500"

FRONT SIDE