HAB BOUNDER™

Balloon Ascent Technologies

Balloon Cut-Down Device

User Guide

Rev. 5 — May 2020

Introduction

The *HAB Bounder™* combines four common balloon devices into a single, self-contained unit.

- Pre-programmable cut-down device that can sever a line during the balloon flight. If two are used, then redundant flight termination is assured.

- Flight computer that monitors and records pressure and temperature.

- High-altitude GPS tracker that logs position data in both CSV and KML formats.

- Thermal management device that maintains a constant temperature to ensure proper operation throughout the flight.

HAB Bounder™ Operating Specifications

Parameter	Min	Typical	Max	Unit
Operating: Temperature	-80	-	60	°C
Operating: Time (firmware defined)	-	-	18	hours
Operating: Time at cold (heater active)	6	10	18	hours
Operating: Heater Set Point	-60	-10	60	°C
Operating: Battery Type	2x Li/FeS2 AA Batteries			
Trigger: Mission Elapsed Time	1	-	1080	minutes
Trigger: Minimum Atmospheric Pressure	8	-	1200	mBar
Trigger: Pressure Ascent Rate, Threshold	8	-	1200	mBar
Trigger: Pressure Ascent Rate, Rate	-125	-	125	Pa/s
Trigger: GPS Geofence Altitude	1	-	50,000	meters
Trigger: GPS Geofence Longitude	-180	-	180	degrees
Trigger: GPS Geofence Latitude	-90	-	90	degrees
Trigger: GPS Ascent Rate, Threshold	1	-	50,000	meters
Trigger: GPS Min Ascent Rate, Rate	-12.5	-	12.5	m/s
Sensor: Pressure	8	-	1200	mBar
Sensor: Temperature	-60	-	120	°C
Sensor: GPS Altitude	-	-	50,000	meters
Sensor: GPS Altitude Accuracy	±150	±5	-	meters
Sensor: GPS Horizontal/Vertical Velocity	-	-	100	m/s
Mechanical: Mass (no Enclosure or Batteries)	28	30	32	g
Mechanical: Mass (incl. Enclosure & Batteries)	66	68	70	g
Mechanical: Suspended Payload Mass	0	-	5.5	Kg
Mechanical: Size in Foam Enclosure	102mm long, 75mm diameter			
Mechanical: Size without Foam Enclosure	94mm long, 33mm diameter			
Rigging: Dacron Line (break strength)	30	50	80	lb

Table of Contents

1 Checklist

Pre-Flight

a. **Program HAB Bounder™**

    i. Configure *HAB Bounder™* Settings in CFG.TXT file

    ii. Insert the micro-SD card

    iii. Install Two Batteries

    iv. Momentarily power-on for pre-flight check, ~10 seconds

    v. Remove the batteries and micro-SD card

    vi. Verify correct settings are in log file generated on micro-SD card

    vii. Reinstall the micro-SD card and two batteries

b. **Flight Train Rigging**

    i. Connect *HAB Bounder™* to Balloon

    ii. Attach *HAB Bounder™* to Parachute or Payload

    iii. Slide on the radiative battery cover

    iv. Check All Flight-Train Connections

Launch

c. **Inflate Balloon**

d. **Activate HAB Bounder™**

    i. Press Power-On Button, listen for indicator tones

        1. Bach's organ toccata indicates success

        2. 5Hz beeping indicates problem—unit inoperable

        3. ½ Hz beep indicates GPS still trying to acquiring lock

    ii. Start Ground Timer, if MET Trigger enabled

    iii. Join & Tape Enclosure Closed with Kapton tape

e. **Launch**

Recovery

f. **Post-Flight**

    i. Remove Batteries

    ii. Download and Analyze Data from HAB Bounder™

2 Interface

micro-SD Card

The *Bounder* is configured via a "CFG.TXT" text file on the micro-SD card. If this file does not exist on the micro-SD card when the *Bounder* is powered on, one will be created with a MET Trigger of one minute and all other triggers off.

If the GEO Trigger is enabled in the "CFG.TXT" file when the *Bounder* is powered on, a "GEO.KML" file will be created/updated with the GeoFence bounding box shown with a light-blue box. This file will allow you to verify that the GeoFence is where you intended it to be.

The *Bounder* creates two data log files each time it is powered on. Both of these files will be numbered the same, for example "001.CSV" and "001.KML". The CSV file's header is used to verify that the trigger settings were interpreted correctly from the "CFG.TXT" file. It also contains the recorded data at 1Hz.

The KML file contains 1/10 Hz position data. The point where the burn-wires were activated is noted with a "Termination" pin.

Power-On Button

Pressing this button will turn the *Bounder* on. Repeated pressing or constant pressing will have no impact on the *Bounder's* operation except a negligibly higher power draw from the batteries. It can not turn off the *Bounder*, remove one of the batteries to accomplish that.

The Indicator LED flashes are visible through this button.

Micro-SD Card   Power-On Button

Audio Tunes

Initial Tune: When the *Bounder* powers on, the intro to Bach's *Toccata* and *Fugue in D Minor* will play at the completion of a successful self-check power-on sequence.

ERROR Tune: If an error is detected during the power-on sequence, a continuous rapid 5-beeps-per-second will sound. The *Bounder* is unusable while this rapid continuous beeping is sounding.

GPS Lock: After the initial power-on tune, the Bounder will beep briefly once every two seconds to indicate that GPS position fix has not yet been obtained and should not be launched. Once the *Bounder's* GPS acquires a valid GPS position fix, a longer two-note tune will play to indicate that the *Bounder* is ready to be launched. Assuming the *Bounder* maintains a good view of the sky, then an accurate and valid GPS position will be updated at 1 Hz from this point onwards.

Burn-Wire Activation Tune: A single note will be played twice in the following pattern: two-second tone, two-second silence, two-second tone, two-second silence, burn-wire activation.

Indicator LED

The *Bounder* has one LED, visible through the power-on button. In normal operations, the status LED will flash at 1/2Hz until GPS lock is acquired (0.5-12 minutes); at which point it will will flash at 1Hz for the duration of the flight.

If there is an error, the STATUS LED will flash rapidly, indicating that the *Bounder* is unusable until the error is corrected.

Error Mode

The *Bounder* will enter Error Mode if any of the following problems are encountered:

- micro-SD Card Problem—No card present, incorrect formatting, or no available space

- Broken Burn-Wire—One or more of the burn-wires was determined to be broken

- Pressure Sensor Problem—An issue was detected with an onboard sensor

- GPS Problem—An issue was detected with the onboard GPS sensor

Check the CSV data file's header section for an indication of which subsystem failed.

3 Programming

Create CFG.TXT File on Empty micro-SD Card

1. Insert an empty FAT32 formatted micro-SD card into the *Bounder*
2. Insert two batteries
3. Press the Power-On button and wait for the power-on tune to play
4. Remove the batteries and then the micro-SD card

Program Desired Triggers

5. Mount the micro-SD card on a computer and open the "CFG.TXT" file
6. Set any combination of the five trigger options
7. Save the file, unmount the micro-SD card from the computer

Verify Triggers Correctly Set

8. Insert the programmed micro-SD card into the *Bounder*
9. Insert two batteries
10. Press the Power-On button and wait for the power-on tune to play
11. Remove the batteries and the micro-SD card from the *Bounder*
12. Insert the micro-SD card into the computer and open up the latest xxx.CSV file
13. Confirm that the Settings at the top of the xxx.CSV file correspond to the desired settings in CFG.TXT.
    1. If not, see *Troubleshooting: CFG.TXT Programming Issues* and repeat steps 8-13
14. Programmed micro-SD card, proceed to the Rigging instructions on Page #10

Other Programmable Options

Heater Set-Point: This is the temperature at which the heater turns on. The heater ensures that the batteries and sensors remain in an operable temperature range. For proper operation, it is recommended to operate with this set-point at or above -15 °C.

Note: Value entered in CFG.TXT must be positive. *Bounder* interprets this positive value as the number of degrees below zero. Thus no negative sign. Example: [HSP=10] results in the heater set-point being -10 °C.

Power Save Mode: When enabled, the GPS will use a low-power mode. Assuming the *Bounder* maintains a good view of the sky, no-heater power consumption will be reduced by approximately 65%.

Note: the Power Save Mode frequently (~5 min) results in short gaps (< 15 second) in the GPS data. If high-frequency GPS data is needed (either for logging or GAR, GAT, GEO triggers), then DO NOT enable this option.

4 Trigger Options

MET — Maximum Mission Elapsed Time

This trigger activates after a user-specified amount of time elapses. The Mission Elapsed Time (*MET*) can range from 1 minute to 1080 minutes (18 hours). This trigger can be disabled by setting it to 'OFF'. It starts incrementing immediately after the power-on tune is played.

Example: You would like the *Bounder* to sever the line 120 minutes after power-on. The CFG.TXT line would read:

```
[MET=120], Mission Elapsed Time Trigger (1 to 1080 min)
```

MAP — Minimum Atmospheric Pressure

This trigger activates once the device measures a user-specified atmospheric pressure level during balloon ascent. The Minimum Atmospheric Pressure (MAP) value can range from 1200 mBar (approximately 1.5km or 5,000ft below sea-level) to 8 mBar (approximately 30km or 100,000ft). This trigger can be disabled by setting it to 'OFF'.

Example: You would like to sever the Device Line when the *Bounder* measures a pressure of 75 mBar or less. The CFG.TXT line would read:

```
[MAP=75], Min Atmospheric Pressure Trigger (8 to 1200 mBar)
```

PAR — Pressure Ascent Rate Trigger

The Pressure Ascent Rate (PAR) trigger activates from the atmospheric pressure sensor when both:

A) The ambient pressure is less than the *Pressure Threshold* setting (hPa), and

B) The *Bounder*'s rate of pressure change (Pa/s) goes **above** the rate setting.
   Note that a positive *Pressure Rate* equals a descending altitude (i.e. after balloon burst).

The *Pressure Threshold* value can range from 1200 mBar (approximately 1.5km or 5,000ft below sea-level) to 8 mBar (approximately 30km or 100,000ft). The *Pressure Rate* value can range from -125 to 125 Pa/s. This trigger can be completely disabled by setting it to 'OFF'.

Example: You would like the *Bounder* to cut away the balloon if it unexpectedly bursts during the flight. First, set the *Pressure Threshold* (value entered immediately to the right of the equal sign). This arms the *PAR Trigger* to react at pressures below 750 mBar (above approx 2.5 km altitude. Second, set the trigger to sever the line when the *Bounder* detects a *Pressure Rate* increase of ≥3 Pa/s (descending altitude). The CFG.TXT line would read:

```
[PAR=750:3], Pressure Ascent Rate Trigger (8 to 1200 hPa: -125 to 125 Pa/s)
```

GAR – GPS Min Ascent Rate Trigger

The GPS Min Ascent Rate (GAR) trigger activates from the GPS sensor when both:

A) The altitude is above the *Threshold Altitude* setting (m), and

B) The *Bounder*'s rate of altitude change (m/s) goes **below** the *Ascent Rate* setting

The *Threshold Altitude* value can range from 0 to 50,000 meters. The *Ascent Rate* value can range from -12.5 to 12.5 m/s. This trigger can be completely disabled by setting it to 'OFF'.

Example: You would like to protect against an underinflated balloon that isn't providing enough free lift. First, set the *Threshold Altitude* to arm the *GAR Trigger*, say at an altitude of 3 km. Second, set the trigger to activate when the *Bounder* detects an *Ascent Rate* of ≤2 m/s. The CFG.TXT line would read:

[GAR=3:2], GPS Min Ascent Rate Trigger (1 to 50 km: -12.5 to 12.5 m/s)


GF[x] – GPS GeoFence Triggers

The *Bounder* has two GeoFence Triggers, GF1 & GF2. These triggers allow the user to specify a volume of any size, bounded by a min/max latitude, min/max longitude, and threshold altitude. This trigger can be disabled by setting it to 'OFF'.

Both of these triggers are identical, and each can be configured to one of the six modes outlined below. Each GeoFence trigger is evaluated independently, so configuring a large IB zone with a small OA inside of it will work, while setting a large OA zone with a small IB zone inside of it will always result in the Bounder immediately terminating.

Note: The altitude reported by GPS can contain a larger error than the horizontal position. "Generally, Altitude error is specified to be 1.5 x Horizontal error specification." The *Bounder* does not filter or average the altitude; it relies completely on what the GPS is reporting in order to determine whether or not the burn-wires should be activated. As a result, the *Bounder* is not designed or intended to operate where altitudes need to be more accurately determined to better than ±150m.
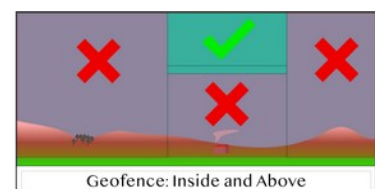

Mode 1 – Stay Inside and Below (IB)

It activates if the Bounder goes outside of the bounding box or above the threshold altitude.
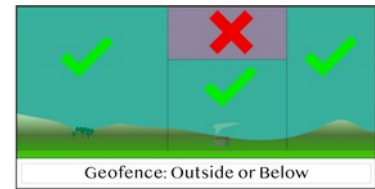

Geofence: Inside and Below
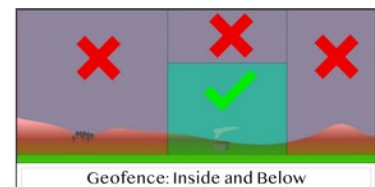
Mode 2 – Stay Inside and Above (IA)

It arms when the *Bounder* goes 100 meters above a threshold altitude. Then it activates when the *Bounder* comes back down

Geofence: Inside and Above

below the user-specified altitude. It also activates if, at any point, the *Bounder* goes outside of the lat/lon bounding box.
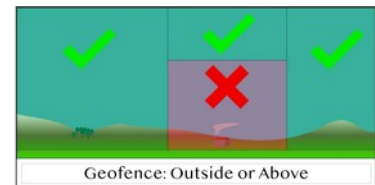
Mode 3 – Stay Outside and Below (OB)

It <u>activates</u> if the Bounder comes inside of the bounding box, unless it is below the threshold altitude.

Mode 4 – Stay Outside and Above (OA)

It <u>activates</u> if the Bounder comes inside of the bounding box, unless it is above the threshold altitude.

Mode 5 – Maintain Altitude Below (B)

It <u>activates</u> when the *Bounder* goes above the threshold altitude. The lat/lon coordinates are not used to determine when the trigger activates. This mode is represented by a grey bounding box in the GEO.KML file (where the lat/lon coordinates are displayed).

Mode 6 – Maintain Altitude Above (A)

It <u>arms</u> when the *Bounder* goes 100 meters above a threshold altitude. It then <u>activates</u> when the *Bounder* comes back down below the user-specified altitude. The lat/lon coordinates are not used to determine when the trigger activates. This mode is represented by a grey bounding box in the GEO.KML file (where the lat/lon coordinates are used to create the box image).

Geofence Example

You would like the *Bounder* to sever the line when it moves outside of a region bounded by the following longitude coordinates: -70.58500, -70.59000, and latitude coordinates: 41.59500, 41.60000. No altitude threshold is desired, so it is set to 50 km. The CFG.TXT lines would read:

```
[GF1=1], GeoFence Trigger #1 (1=IB 2=IA 3=OorB 4=OorA 5=B 6=A)
  [Gx1=-70.58500], Lon Min (-180 to 180)
  [GX1=-70.58901], Lon Max
  [Gy1=41.59500], Lat Min (-90 to 90)
  [GY1=41.60000], Lat Max
  [GZ1=50000], Altitude (1 to 50000 m)
```

Note: The *Bounder* expects and uses **lat/lon numbers with 5 decimal places.** Any variation from this will likely cause errors. Check xxx.CSV data file to ensure values are as desired.

Method for Determining GPS GeoFence Coordinates

1) Open Google Earth
2) Zoom to the desired GeoFence region
3) Select the "Add Polygon" tool
4) Place a polygon point in one corner of the desired GeoFence region
5) Place a second polygon point in the opposite corner of the desired GeoFence region
6) Click "OK" on the "New Polygon" window to close it
7) Right-click on the new, "Untitled Polygon" under the "Places" list
8) Select "Save Place As" and select a location and name for the file
9) Choose KML File Type, then select OK
10) Open the file you just saved in a text editor
11) Look for the coordinates. Example:

    <coordinates>
    -70.5857335399473,41.59513011441263,0
    -70.5857335399473,41.59693338708662,0
    -70.5918077928395,41.60213011441263,0
    </coordinates>

12) Copy and paste the two latitude and two longitude values from this into the CFG.TXT file. The *Bounder* will automatically arrange the min/max if you enter them in backwards
    1) From the example above:
        1) Min LON: -70.59000
        2) Max LON: -70.58500
        3) Min LAT: 41.59500
        4) Max LAT: 41.60000
    2) NOTE: the *Bounder* expects and uses **lat/lon numbers with 5 decimal places**
13) Once the CFG.TXT file has been modified and saved, insert the micro-SD card into the *Bounder* and insert two batteries.
14) After the power-on tune plays, remove the batteries and then the micro-SD card.
15) Mount the micro-SD card back into the computer and open the GEO.KML file.
    1) The GEO.KML file is created/updated every time the GEO Trigger is enabled when the device is powered on.
16) A light-blue polygon box will indicate where the GeoFence is understood to be by the *Bounder*.

Example of a *Bounder* CFG.TXT file from firmware v13:

```
[MET=120], Mission Elapsed Time Trigger (1 to 1080 min)
[MAP=75], Min Atmospheric Pressure Trigger (0 to 1200 mBar)
[PAR=750:3], Pressure Ascent Rate Trigger (8 to1200 hPa: -125 to 125 Pa/s)
[GAR=3:2], GPS Min Ascent Rate Trigger (1 to 50 km: -12.5 to 12.5 m/s)
[GF1=1], GeoFence Trigger #1 (1=IB 2=IA 3=OorB 4=OorA 5=B 6=A)
 [Gx1=-70.58500], Lon Min
 [GX1=-70.58901], Lon Max
 [Gy1=41.59500], Lat Min
 [GY1=41.60000], Lat Max
 [GZ1=500], Altitude
[GF2=4], GeoFence Trigger #2
 [Gx2=-70.59000], Lon Min
 [GX2=-70.59401], Lon Max
 [Gy2=41.59500], Lat Min
 [GY2=41.60000], Lat Max
 [GZ2=500], Altitude
[HSP=10], Heater Set Point deg below 0 as a positive number
[PSM=OFF], Power Save Mode (1=Enabled)
```

5 Rigging

This section covers how to connect the *Bounder* into your flight-train to ensure proper termination or cut-down when programmed.

A few notes of caution:

- The burn-wires on the *Bounder* are thin and fragile. Excessive direct pressure can cause them to break. Never press down on them directly with your finger.
- Trim any excess line after the knots. Excess line can tangle and not allow the Balloon Line to separate from the Device Line. This is especially important for lighter payloads.

Line to be Cut

Typically the *Bounder* is rigged to cut the flight-train line attaching the balloon. Cutting the line immediately under the balloon is recommended to ensure it can't tangle during ascent with any other lines, preventing it from releasing after being cut. It also helps ensure that the *Bounder* doesn't interfere with the parachute during descent, which is usually tied below the *Bounder* by a 2+ meter length of line.

The line to be cut, Balloon Line (pictured as black below), is attached to the *Bounder* with a San Diego Jam Knot and passes directly over the burn-wires. The knot allows the loop around the *Bounder* to tighten, but not loosen, thus ensuring that there is always good contact between the line and the burn-wires.

Retention Line
To Parachute or Payload

Balloon Line

The retention line (pictured as red/white above) is tied through the provided hole to ensure the *Bounder* isn't lost after burn-wire activation.
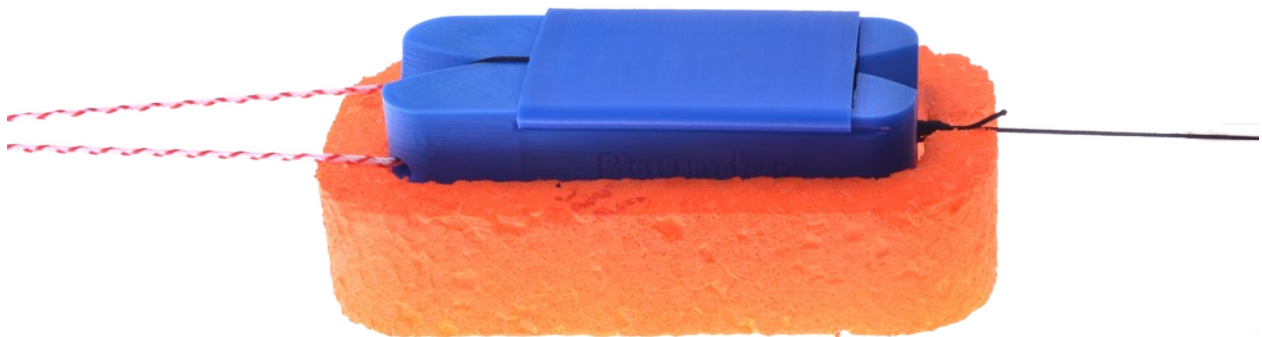
# Insulation

Foam Enclosure

The *Bounder* ships with a two-part, light-weight extruded polypropylene foam enclosure. This enclosure both insulates the Bounder during flight and protects it during landing.

The foam enclosure has a small notch at one end. This is to ensure the Balloon Line can pass freely through the enclosure after it is cut.

Radiative Shield

The *Bounder* ships with a radiative insulation device. This device (the blue cover) slides over the batteries and helps ensure that they stay warm at high altitudes. Please ensure the batteries are not touching the radiative shield after installation, as shown in the photo below.
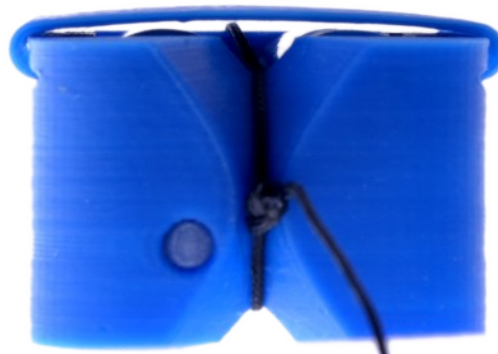
Redundant Termination

It is possible to use two *Bounders,* configured as pictured to the right, to provide redundant termination for a latex balloon flight.

Explanation from top to bottom:

- The latex balloon (not shown) is attached to the [Woffin](). Once the line below is cut by a *Bounder*, the balloon will rapidly ascend until it bursts.

- A large swivel is used so that *Balloon Line* can be shared between two *Bounders*. Once one *Bounder* cuts, the free end will pass through the swivel, releasing the balloon.

- Two *Bounders* are attached together with a wrap of tape around their foam enclosures. Only one half of each *Bounder*'s two-part foam enclosure is pictured for clarity.

- The *Retention Line* is looped through both *Bounders* and attached to either the parachute or payload—depending on how the flight-train is laid out. If attached to the parachute, additional line between the parachute and the *Bounders'* *Retention Line* is recommended so that during descent the *Bounders* do not interfere with the parachute's deployment.

Note: Shadows from the camera flash during photographing make lines appear doubled.

6 Data Analysis

The CSV Data File

Header

This section contains information about the *Bounder* and the settings it used for the flight. Please reference this section when confirming that the Bounder used the intended settings in the Programming → Verify Triggers section of this manual. If this section differs from your CFG.TXT file, please check for typos and resolve before flight. An example of what it may look like:
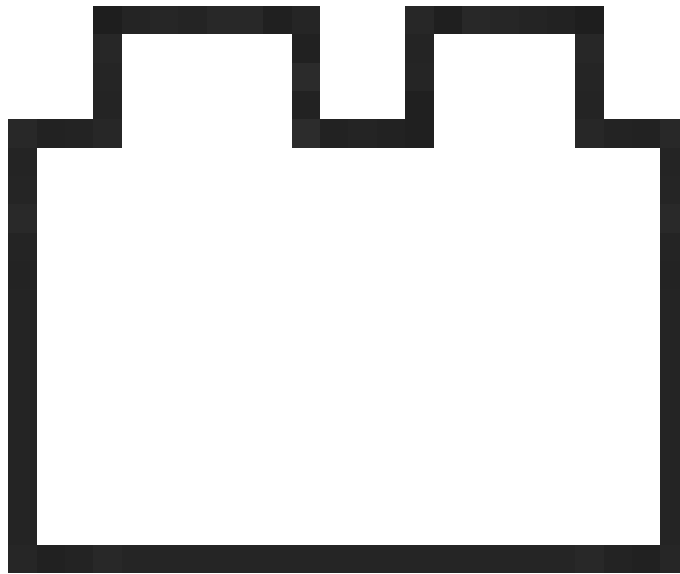
Data

- Time (s)   Internal timer, starts counting from 0 at power-on

- Status Flags   An 'X' in this column denotes this flag is activated

    ○ SEF   Sensor Error Flag, invalid data from pressure sensor

- ◦ HTR   Heater Flag, the battery heater is active

- ◦ BW0   Burn-Wire 0 continuity failed (updated every 10 seconds)

- ◦ BW1   Burn-Wire 1 continuity failed (updated every 10 seconds)

- • Trigger Flags   An 'X' in these columns denotes which trigger activated the burn-wires. The 'X' is present only during the activation sequence.

  - ◦ MET   Mission Elapsed Time trigger

  - ◦ MAP   Minimum Atmospheric Pressure trigger

  - ◦ PAR   Pressure Ascent Rate trigger

  - ◦ GAR   GPS Min Ascent Rate trigger

  - ◦ GF1   Geofence #2 trigger

  - ◦ GF2   Geofence #2 trigger

  - ◦ EXT   External trigger

- • Measurements

  - ◦ Pres   Atmospheric pressure, in millibar (hPa)

  - ◦ Temp   The *Bounder's* internal temperature, in °C

  - ◦ Batt   The battery voltage (updated every 10 seconds)

  - ◦ numSV   Number of GPS Satellites currently used by the GPS module

  - ◦ Lon /Lat *   GPS longitude in degree decimal

  - ◦ Alt *   GPS altitude in meters above Ellipsoid

  - ◦ Date *   GPS date in YYYMMDD format

  - ◦ Time *   GPS time in HH:MM:SS format

  - ◦ gSpeed *   GPS ground speed in m/s

  - ◦ aRate *   GPS vertical rate in m/s

  - ◦ heading * GPS heading in degrees

  Notes:

  Unless otherwise noted, each data value is updated for every entry line.

* Only populated when a valid GPS Lock is achieved.

The KML Data File

This file allows rapid plotting of the flight path in applications such as Google Earth.

> Note: it is only updated every 10 seconds and is not time-stamped. For higher resolution data that includes a timestamp, please use the values from the CSV file.

The GEO.KML File

This file allows easy verification that the geofence is in the intended and proper location. Open it with an application such as Google Earth. Please reference this file when going through the Programming → Verify Triggers section of this manual.

Geofence boxes are colored in the following manor based on the mode configured:

- Inside boxes (mode 1 & 2) are green

- Outside boxes (mode 3 & 4) are red

- Altitude-only modes (5 & 6) are grey

The point where the burn-wires were activated is noted with a yellow "Termination" pin. The flight-path before the "Termination" event is separate from the flight-path after the event.

> Note: the GEO.KML file is only generated and updated at startup when the GEO trigger is enabled.

7 Troubleshooting

Error Indicated

A 5-flash-per-second by the *Indicator LED* and rapid beeping indicates a malfunction. The *Bounder* will not operate correctly when this pattern is flashing. **Do not fly**. Possible causes include:

- **Broken Burn-Wire**: Check the two burn-wires to see if either is broken

- **micro-SD Card**: Check that a card is inserted and has a good connection (re-seat card)

- **Sensor Malfunction**: contact Balloon Ascent Technologies for repair

Check the latest CSV file for the error code(s). Each subsystem's status is reported in the <!-- Modules --> section, along with an error code if a fault is detected.

Device Will Not Turn On

The device should turn on within 1 second of the power-on button being pressed. If it doesn't, check the following:

- The power-on button not fully being depressed to actuate the switch

- Check the battery orientation

- Install new batteries. The Energizer L91 batteries should not be stored in hot conditions for extended periods of time (months). In that condition they self-discharge more quickly.
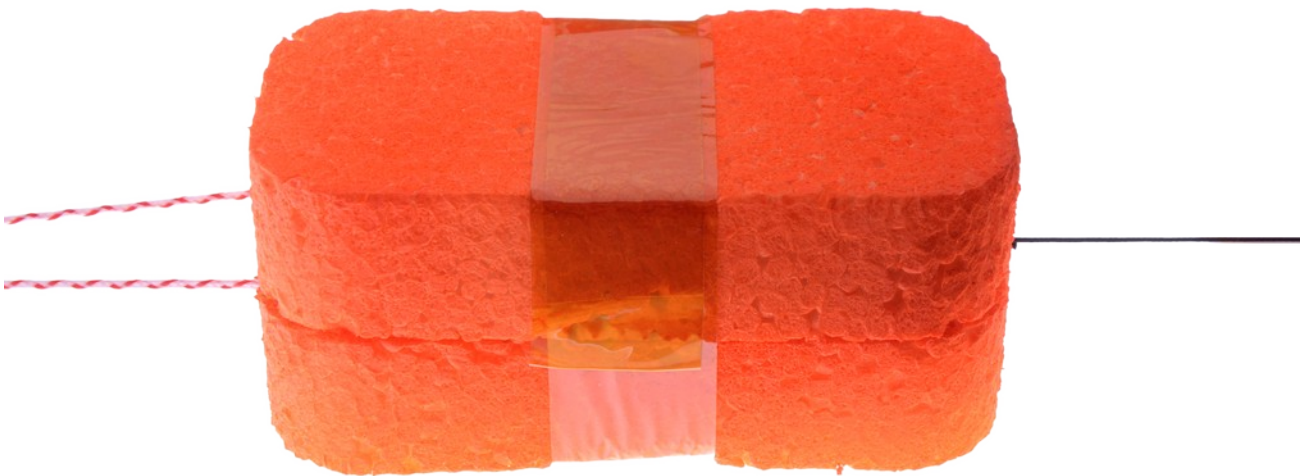
CFG.TXT Programming Issues

The CFG.TXT file contains precisely formatted instructions for the *Bounder*. Any typos in this file will likely result in undesirable results. This is why the *Programming* instructions suggest you let the *Bounder* verify the file after changes are made. This is done by quickly powering on the *Bounder* and letting it create a new xxx.CSV file. At the top of this new xxx.CSV file will be the current trigger settings, as interpreted by the *Bounder*.

To help avoid possible confusion, here is a brief overview of how the command is formatted:

`[GAR=3:2], GPS Min Ascent Rate Trigger (1 to 50 km: -12.5 to 12.5 m/s)`

- `[`   Designates the beginning of the instruction

- `GAR`   Instruction name

- `=`   Separator between instruction name and value

- `3`   First desired instruction value

- `:`   Instruction value separator (note, this is a colon, not comma)

- `2`   Second desired instruction value

- `]`   Designates the end of the instruction

- `,`   For CSV file formatting, not interpreted

- GPS Min Ascent Rate Trigger (1 to 50 km: -12.5 to 12.5 m/s)
  A comment, not interpreted

8 Consumables

Batteries

The Bounder has been designed to use primary lithium batteries in the 'AA' size. The Lithium/Iron Disulfide (Li/FeS2) chemistry has proven to work well, even at the low temperatures experienced on balloon flights. Possible suppliers of these batteries include:

- Energizer Ultimate Lithium L91 AA Battery

- Varta Ultra Lithium 6106 (FR14505) AA Battery

  - Note: the 6106 is rated at 18% less capacity than the L91 battery (2.9Ah vs 3.5Ah)

While the *Bounder* will operate on standard alkaline batteries, it is strongly recommend against using them due to their poor performance at cold.

Memory Card

Any SD/SDHD micro-SD card should work with the Bounder. We recommend using the SD Memory Card Formatter (https://www.sdcard.org/downloads/formatter/) from the SD Association to format new cards. Using the OS formatting utility (Mac OSX or Windows) can cause problems.

Rigging Line

Below are some of the rigging line options that we have used and liked. The Green-Spot line is our preferred line due to it being widely available and how well the burn-wires cut it. The Nano cord holds knots well and comes in a wide variety of colors. The Twisted Nylon line is super stretchy and can help dampen jerks and bounces on long flight-trains during the flight.

Green-Spot Dacron Fishing Line. Some manufacturers include: Izorline or Cortland

Atwood Rope Nano Cord: https://atwoodrope.com/collections/nano-cord

Twisted Nylon Mason Line: Home Depot, Amazon, Erin, etc.

9 Safety Precautions and Recommendations

Regulatory

Always adhere to the regulations governing high-altitude ballooning applicable in the country of operation. In the United States, high-altitude balloon flights are governed by "FAA Part 101".

Touch Hazard

The *Bounder's* two burn-wires are fragile and produce high temperatures when activated. Never press-down on or touch the burn-wires.

Falling Payload Hazard

Always clear the launch area prior to launch. While unlikely, balloon or line failure after release may result in a falling payload impacting the ground before the parachute fully deploys.