

User Guide

HAB BOUNDER

Balloon Cut-Down Device



Balloon
Ascent
Technologies

The sky's not the limit; it's where we start.



Overview

The *HAB Bouncer*[™] 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.

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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

Checklist

Pre-Flight

1. Program *HAB Bouncer*
 - a. Configure *HAB Bouncer* Settings in the config/Flight.cfg file
 - b. Insert the micro-SD card
 - c. Install Two Batteries
 - d. Press the power-on button for 3+ seconds
 - e. Wait for GPS fix to be acquired and Launch tune to play
 - f. Remove the batteries
 - g. Remove the micro-SD card
 - h. Verify correct settings are in the Flight.log file
 - i. Reinstall the micro-SD card and two batteries

2. Flight Train Rigging
 - a. Connect *HAB Bouncer* to Balloon
 - b. Attach *HAB Bouncer* to Parachute or Payload
 - c. Slide on the radiative battery cover
 - d. Check all Flight-Train Connections

Launch

3. Inflate Balloon

4. Activate *HAB Bouncer*
 - a. Press Power-On Button for 3+ seconds, listen for indicator tones
 - i. Beethoven's Für Elise indicates success
 - ii. 5 Hz beeping indicates problem—unit inoperable
 - iii. Double-beep every 2 seconds indicates GPS trying to acquiring fix
 - b. Start Ground Timer, if MET Trigger enabled
 - c. Join & Tape Enclosure Closed with Kapton tape

5. Launch

Recovery

6. Post-Flight
 - a. Remove Batteries

 - b. Download and Analyze Data from HAB Bouncer

Interface

The HAB *Bouncer* uses a micro-SD card for both programming and data logging, a single button to turn it on, and an audio buzzer and LED to indicate status.

Programming Overview

The HAB *Bouncer* looks on the micro-SD card for “/Config/Flight.cfg” to load the desired settings from. Settings are entered in a json-like format, outlined in the Programming section on pg 7.

Data Logging Overview

The HAB *Bouncer* creates a new directory each time it is powered on and acquires GPS time. This directory is named in the following format: YYYYMMDD.XXX where XXX is an auto-incrementing value to distinguish multiple flights that occur on the same day.

Inside of this directory are the following files:

- Flight.CSV – Contains comma-separated data recorded at up to 2 Hz
- Flight.KML – Contains position data in a format that programs like Google Earth use
- Flight.LOG – Contains a time-stamped system log for post-flight analysis

Power-On Button

Pressing this button will turn the *HAB Bouncer* on. Repeated pressing or constant pressing will have no impact on the *HAB Bouncer*’s operation. It can not turn off the *HAB Bouncer*

To shut down the *HAB Bouncer* remove one of its batteries.

The Indicator LED flashes are visible through this button.



Audio Tunes

GPS Wait: the *HAB Bouncer* will play a 2-tone beep briefly once every two seconds to indicate that GPS position fix has not yet been obtained. It should not be flown until GPS fix is acquired.

GPS Time Tune: Once the *HAB Bouncer* has successfully acquired GPS time and the config file has been read, the intro to Beethoven’s Für Elise.

Launch Tune: Once the *HAB Bouncer* has successfully acquired GPS fix the intro to Bach's *Tocatta and Fugue in D Minor* will play to indicate that the *HAB Bouncer* is ready to be flown.

ERROR Tune: If an error is detected during the power-on sequence, a continuous rapid 2-tone sound will be played. The *HAB Bouncer* is unusable while this rapid continuous beeping is sounding.

Burn-Wire Activation Tune: A user configurable note can be played multiple times to indicate command activation.

Status LED

The *HAB Bouncer* has one green Status LED. Possible blink patterns are:

- While acquiring GPS lock it will double-flash at 1/2 Hz with the GPS Wait tune.
- In normal operations the status LED will flash at 4 Hz (with varying flash durations).

If there is an error, the Status LED will flash rapidly, indicating that the *HAB Bouncer* is unusable until the error is corrected.

Error Mode

The *HAB Bouncer* 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
- Sensor Problem—An issue was detected with an onboard sensor

Check the Flight.LOG file for an indication of which subsystem failed. Note: if the Flight.LOG does not exist then it is likely that there is an issue with the micro-SD card itself.

Programming

The *HAB Bouncer* is programmed via the “Config/Flight.cfg” file. The following is an explanation of the various options in that file.

Configuration Section

This section is used to configure the *HAB Bouncer* and its subsystems. The following is an example of the default settings for a v5 *HAB Bouncer*.

```
Version: 1
HeaterEnableTemp: -20
SDCardData: Timestamp, System, Position, Ambient
SDCardRate: 2
CommData: Timestamp
CommBinary: false
CommHeader: true
CommDevice: Serial, 1, 57600, 10
CutterControl:
```

- Version → A user configurable version number for tracking *Flight.cfg* changes in the *Flight.log* files.
- HeaterEnableTemp → 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 -20 °C.
- SDCardData → The collection of data containers to be logged to the SD card’s *Flight.csv* file.
Arguments:
 - **Timestamp** → GPS timestamp and *HAB Bouncer*’s MET
 - **System** → System data such as Battery Voltage, Status flags, and Burn-Wire info
 - **Position** → Longitude, Latitude, Altitude, Heading, Ground Speed, Vertical Speed
 - **Ambient** → Pressure, Pressure Rate, Humidity
- SDCardRate → Record every x sensor cycles
A value of 1 results in 2 Hz data, while a value of 2 results in 1 Hz data.

Note the following section in red should go away in a future firmware update

- CommData → The collection of data containers to be transmitted on the serial link, same options as with *SDCardData*

- CommBinary → Whether to transmit binary or ASCII data over the opto-isolated serial connection
 - Arguments: true or false
- CommHeader → Whether to transmit an ASCII header at power-on to aid in decoding the subsequent binary or ASCII data [true/false]
- CommDevice → The opto-isolated serial connection (BOUNDER_TXD) settings. Arguments:
 - **Serial** → Name of the port type [not user selectable]
 - **1** → Number of the port [not user selectable]
 - **57600** → Baud rate [9600 to 115200 are supported]
 - **10** → Output interval in seconds, user selectable (1 to 600 are common)
- CutterControl → Enable the CutterControl subsystem for the burn-wires, no arguments

Command Section

The *HAB Bouncer* can be configured to have a reasonable number of commands. The actual allowable number of commands is dependent on their complexity—ultimately RAM usage. The *HAB Bouncer* will enter into the *Error Mode* and report the issue in *Flight.log* if too many commands are attempted.

Each of these commands is acted upon independently by the conditions set and results in the various actions being executed. The name, *PwrOnTest* in the below example, is user configurable and used to identify the command activation in the *Flight.log* and *Flight.kml* files.

The *PwrOnTest* command, shown below, will result in the following:

- 1) Activate once, 30 seconds after GPS fix is acquired
- 2) Play a B6 note 10 times of duration 1/4 second, separated by 1/4 second delays
- 3) Pause for 5 seconds
- 4) Activate burn-wire #0 for 10 seconds at normal power
- 5) Pause for 5 seconds
- 6) Play a C6 note 10 times of duration 1/4 second, separated by 1/4 second delays
- 7) Pause for 5 seconds
- 8) Activate burn-wire #1 for 10 seconds at normal power

```
Command: PwrOnTest
{
  Conditions:
  {
    Trigger:
    {
      Compare: Timestamp.MET    = 30.000000
    }
  }
  Actions:
  {
    PlayTone: 988, 0.25, 0.25, 10
    Pause: 5.00
    CutLine: 0, 0, 1.15, 10.00, false
    Pause: 5.00
    PlayTone: 1047, 0.25, 0.25, 10
    Pause: 5.00
    CutLine: 1, 1, 1.15, 10.00, false
  }
}
```

Conditions

This is a list of conditions that must be met for the command to be acted upon. Activate options include:

Arm → Conditions that must be met before the Trigger conditions are compared. Can permit a Command to be activated multiple times instead of the normal single activation. Not required.

Trigger → Conditions that must be met before the actions can be executed.

Disarm → Conditions that disable the command. Not required.

Example: The following example causes a triangular geofence boundary to be active, from one minute until ten minutes after GPS fix acquisition.

```
Conditions:
{
  Arm:
  {
    Compare: Timestamp.MET = 60
  }
  Trigger:
  {
    GeoFence:
    {
      Remain: inside
      Altitude: -500, 2233
      Waypoint: -70.636642, 41.585285
      Waypoint: -70.624188, 41.579674
      Waypoint: -70.625283, 41.589149
    }
  }
  Disarm:
  {
    Compare: Timestamp.MET >= 600
  }
}
```

The following is a list of possible logical conditions for Arm, Trigger, and Disarm:

Compare:

This command compares an operational value against a preset value using “<”, “>”, “=”, “<=”, “>=”. Some possible operational values:

- Timestamp.MET
- System.BatV
- Ambient.Pressure
- Ambient.PressureRate
- Ambient.Humidity
- Position.Longitude
- Position.Latitude
- Position.Altitude
- Position.GroundSpeed
- Position.VerticalSpeed

GeoFence:

This condition compares the *HAB Bouncer*’s current position against a polygon geofence.

```
GeoFence:
{
  Remain: inside
  Altitude: -500, 2233
  Waypoint: -70.636642, 41.585285
  Waypoint: -70.624188, 41.579674
  Waypoint: -70.625283, 41.589149
  Waypoint: -70.615079, 41.586535
  Waypoint: -70.613184, 41.591485
  Waypoint: -70.629393, 41.596487
  Waypoint: -70.638358, 41.595474
}
```

Arguments include:

- **Remain** → “inside” triggers if the *HAB Bouncer* goes outside of the geofence region, while “outside” will trigger if the *HAB Bouncer* enters into the geofence region.
- **Altitude** → Minimum and maximum altitudes permitted over the entire geofence.
- **Waypoint** → Each GeoFence needs at least three and not more than twelve waypoints.

Actions

This section holds the commands that the *HAB Bouncer* will execute when the *Conditions* are satisfied. The commands are executed sequentially.

Options include:

- CutLine → Activates a cutter output. Requires the CutterControl subsystem to be enabled in the Configuration Section. The five arguments:
 - Cutter number, 0 (inner burn-wire) or 1 (outer burn-wire)
 - Cutter Condition: only activate if the selected cutter number passes its continuity test
 - Power level, 0.1 to 5.0 watts, 1.15 W is normal
 - Duration, 0.1 to 32,000 seconds
 - Remove from continuity test after activation, true or false
- PlayTone → Causes an audible tone to be played. The *Command's Action* execution will pause while the tone is played. The arguments:
 - Frequency, in Hz
 - Duration on in seconds
 - Duration off in seconds
 - Number of iterations through the on/off cycle
- Pause → Causes the Action execution to be paused
 - Argument: Seconds to delay

Example

Below is a complete example that both has a test command briefly after power-on and then ensures that the *HAB Bouncer* stays within a geofence region.

- It runs a brief (5 second) test 30 seconds after GPS fix is acquired.
- It also sets a geofence that triggers if the *HAB Bouncer* is ever taken outside of a small area. If this geofence command triggers then the burn-wires are activated in a standard sequence.

```
Version: 1
HeaterEnableTemp: -20
SDCardData: Timestamp, System, Position, Ambient
SDCardRate: 2
CommData: Timestamp
CommBinary: false
CommHeader: true
CommDevice: Serial, 1, 57600, 10
CutterControl:
Command: PwrOnTest
{
  Conditions:
  {
    Trigger:
    {
      Compare: Timestamp.MET = 30.000000
    }
  }
  Actions:
  {
    PlayTone: 784, 0.5, 0.5, 10
  }
}
Command: GeoTest1
{
  Conditions:
  {
    Trigger:
    {
      GeoFence:
      {
        Remain: inside
        Altitude: -500, 2233
        Waypoint: -70.636642, 41.585285
        Waypoint: -70.624188, 41.579674
        Waypoint: -70.625283, 41.589149
        Waypoint: -70.615079, 41.586535
        Waypoint: -70.613184, 41.591485
        Waypoint: -70.629393, 41.596487
        Waypoint: -70.638358, 41.595474
        Waypoint: -70.636642, 41.585285
      }
    }
  }
}
```

```
Actions:  
{  
  PlayTone: 988, 0.25, 0.25, 10  
  Pause: 5.00  
  CutLine: 0, 0, 1.15, 10.00, false  
  Pause: 1.00  
  PlayTone: 1047, 0.25, 0.25, 10  
  Pause: 5.00  
  CutLine: 1, 1, 1.15, 10.00, false  
}  
}
```

Log Files

The *Flight.csv* file logs data at up to 2 Hz, and is written to the SD card every 10 seconds. The *Flight.kml* file logs and writes data at 1/10 Hz.

The Flight.CSV Data File

Data

- DateTime GPS date in YYYY/MM/DD HH:MM:SS format
- MET Internal second timer, starts counting from 0 after initial GPS acquisition
- Status A bit-mapped data flag
 - Bit-0 Reserved
 - Bit-1 Reserved
 - Bit-2 GPS Power Save Mode active
- LoCFS INOP
- CutV Voltage across burn-wires
- CutC Cutter Continuity
 - Bit-0 Burn-Wire #0, 0=good, 1=fail
 - Bit-1 Burn-Wire #1, 0=good, 1=fail
- Measurements
 - BatV The battery voltage
 - IntT Internal temperature in degrees Celsius
 - NumSat Number of GPS Satellites currently used by the GPS module
 - Lon /Lat GPS longitude in degree decimal
 - Alt GPS altitude in meters above Ellipsoid
 - GndS GPS ground speed in m/s
 - VerS GPS vertical rate in m/s
 - Pressure Ambient pressure, in hecta-Pascal (hPa)
 - PressureRate Ambient pressure rate of change, in Pascal per second (Pa/s)
 - Humidity Ambient humidity, in percent (%)

Note: unless otherwise noted, each data value is updated for every entry.

Note: the GPS position information has a max data rate of 1 Hz.

The Flight.LOG File

This file provides a log of the system operations, commands sent and received, as well as any issues encountered and errors generated.

Device Section

Basic information to help identify the *HAB Bouncer* for troubleshooting

Sensors Section

Displays the power-on status for each subsystem

Configuration Section

Provides a copy of the *Flight.cfg* file that was used for this flight

Flight Section

Displays when *Commands* were executed as well as any error messages that arose during the flight

The Flight.KML Data File

This file allows easy plotting of the geofences, events, and flight path in applications such as Google Earth.

Geofence boundaries are shown by a red (remain outside) or green (remain inside) box. Because KML does not support floating boxes (the *HAB Bouncer*'s geofence minimum altitude can be any altitude less than 50 km), the min/max altitudes are included as a note that shows up if the box is clicked.

Each Command event position is included as a KML <Point> to show where it occurred.

Flight Tracks are time-stamped in a KML <gx:Track> to permit reviewing the flight progression through time. Tracks are marked in blue.

Note: Command event points and Flight Tracks may be shown 'below' the ground due to GPS or map inaccuracies. Google Earth allows each point and track to be raised independently for viewing by the "Get Info" dialog -> "Altitude" tab.



Rigging

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



A few notes of caution:

- The burn-wires on the *HAB Bouncer* 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 *HAB Bouncer* 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 *HAB Bouncer* doesn't interfere with the parachute during descent, which is usually tied below the *HAB Bouncer* by a 2+ meter length of line.



The line to be cut, Balloon Line (pictured as black below), is attached to the *HAB Bouncer* with a [San Diego Jam Knot](#) and passes directly over the burn-wires. The knot allows the loop around the *HAB*

Bounder to tighten, but not loosen, thus ensuring that there is always good contact between the line and the burn-wires.



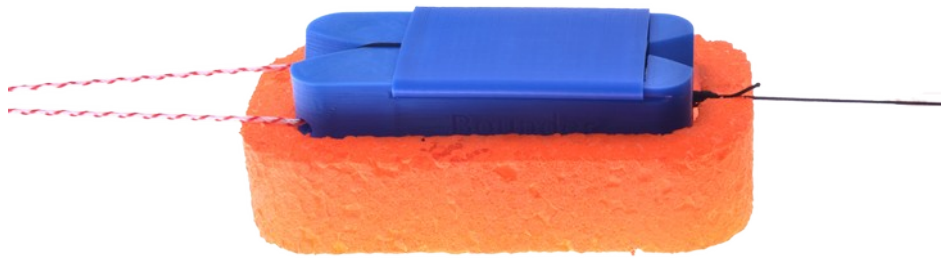
The retention line (pictured as red/white above) is tied through the provided hole to ensure the *HAB Bounder* isn't lost after burn-wire activation.

Insulation

Foam Enclosure

The *HAB Bounder* ships with a two-part, light-weight extruded polypropylene foam enclosure. This enclosure both insulates the *HAB 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 *HAB 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 *HAB 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 *HAB Bounder*, the balloon will rapidly ascend until it bursts.
- A large swivel is used so that Balloon Line can be shared between two *HAB Bounders*. Once one *HAB Bounder*™ cuts, the free end will pass through the swivel, releasing the balloon.
- Two *HAB Bounders* are attached together with a wrap of tape around their foam enclosures. Only one half of each *HAB Bounder*'s™ two-part foam enclosure is pictured for clarity.
- The Retention Line is looped through both *HAB 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 *HAB Bounders*' Retention Line is recommended so that during descent the *HAB Bounders* do not interfere with the parachute's deployment.

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



Troubleshooting

Device Will Not Turn On

The device should turn on within 3 seconds 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 and held for 3 seconds
- 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.

Error Indicated

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

Immediate error after power-on

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

Error after GPS time is acquired

- Error in the /config/Flight.cfg file: Check the Flight.log file for insight on line that is causing issues
- Broken Burn-Wire: Check the Flight.log file's ___ section to see if a wire is broken
- Sensor Malfunction: Check the Flight.log file's Sensor section for which sensor failed, contact Balloon Ascent Technologies for repair options

Updating the Firmware

- Place the UPDATE.bin file in the root directory of the micro-SD card
- Insert the card
- Press and hold the power-on button (5-7 seconds) until the tone starts playing
- Let the *HAB Bouncer* acquire GPS fix, then wait for an additional two minutes
- Power off, remove the micro-SD card
- Look at the latest *Flight.log* file to ensure that the Device section's firmware line indicates the date associated with the UPDATE.bin file you just used
-

Consumables

Batteries

The *HAB Bouncer* 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 *HAB Bouncer* 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 *HAB Bouncer*. 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.

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 HAB 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.

The owner shall be liable for any damages resulting from any use of the HAB Bounder™ and other related materials, and shall defend, hold harmless and indemnify Balloon Ascent Technologies LLC, officers, employees and agents, against any and all claims, suits, actions, costs, counsel fees, expenses, damages, judgments and decrees, by reason of any person or property being injured or damaged directly or indirectly by use of the HAB Bounder™ or activities arising therefrom.