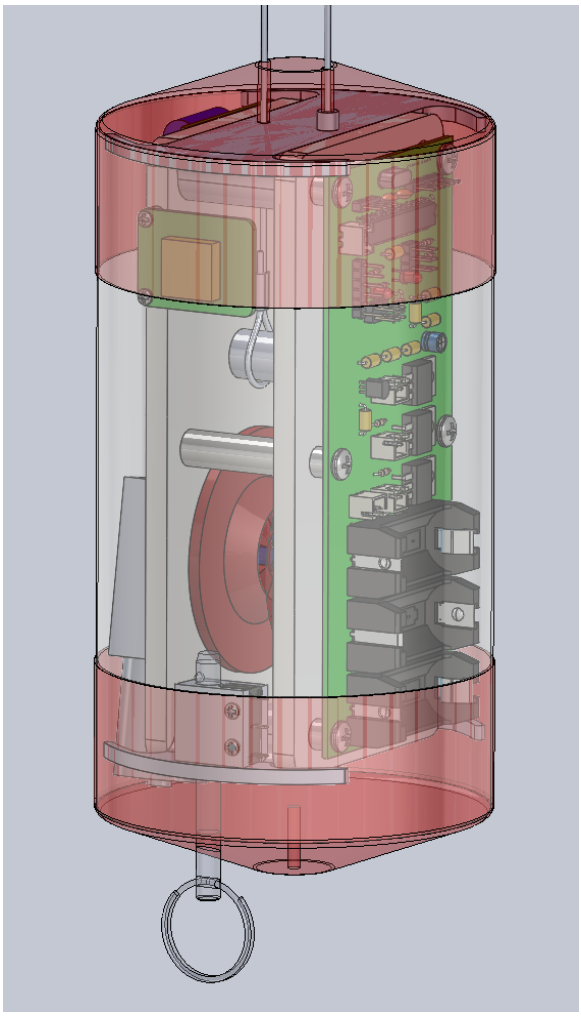
So BAD it’s good

A device for ballooning



Important Notes

Prerelease Version. This manual is currently incomplete, as the device is still under development and should be considered experimental.

Unforeseen Requirements. No set of procedures can cover all possibilities that can occur in an operational setting. The balloonist uses judgment in adhering as closely as possible to this manual, to handle situations not adequately covered by specific instructions. If procedures in this manual require changes or clarification, send them to doug.kennedy@noaa.gov for possible inclusion into future manual or handbook revisions.

Overview of capabilities

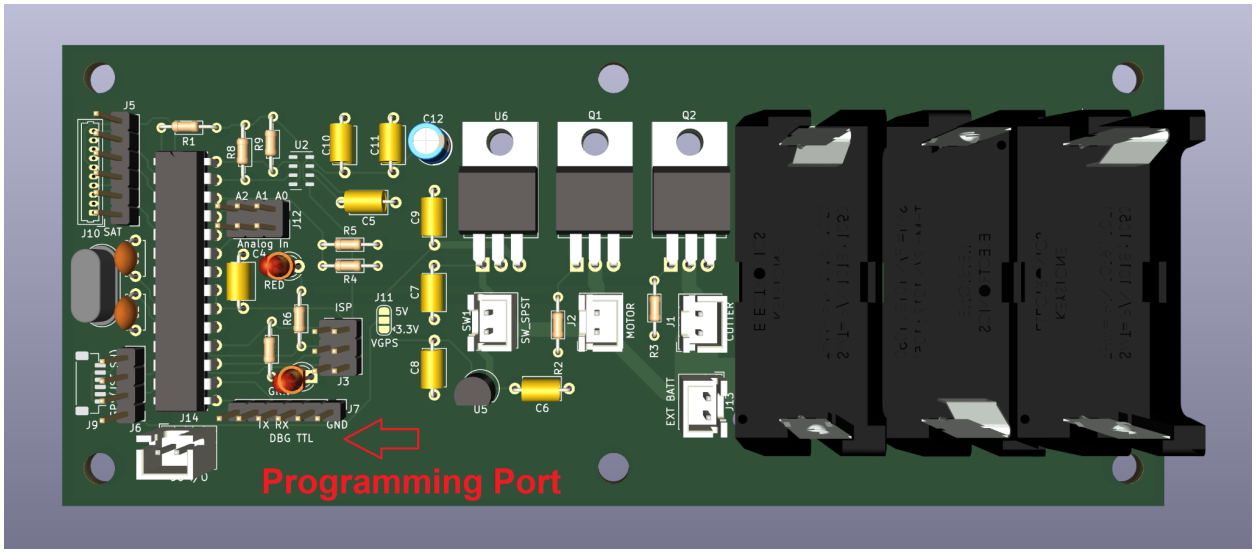
The Ballooning All-purpose Device (BAD) augments your balloon-borne experiments with several useful features. These include:

- A let down reel to lower an instrument at a regulated rate after launch. The launch is automatically detected by the measurement of the rise rate.
- An automatic or manually triggered cut-down to terminate a balloon flight using a hot wire monofilament cutter. There are many termination options, including time, pressure, geofencing, distance from the launch point, or a command transmitted by satellite.
- A tracking system to transmit GPS position data over a RockBLOCK™ satellite modem
- A database and API to retrieve KML formatted paths of multiple balloons. This can be used with Google Earth or another GIS system to visualize the balloon path.

The system has been carefully engineered for easy use in the field. After configuration, only one pin needs to be removed to activate the device. It will patiently wait for launch, let down the instrument after a configurable delay, and terminate the flight according to the selected parameters. A remote signal can terminate the flight at any time.

Configuration software

The device may be configured by transmitting a configuration string over the serial port using a 3.3V TTL serial cable, such as https://www.sparkfun.com/products/9717. Plug the cable into the port labeled J7, DBG TTL. Be sure the black wire of the cable is aligned with the GND pin of J7.



A python program is provided to ease the configuration. It is available at the project github repository, http://github.com/dwkennedy/ballooning/config tools. The configuration options available are also documented in this file. Edit the file to set the parameters required, then

execute the program to transfer the configuration. For example, if the serial device is connected to COM20:

$ python configure.py COM20

Hex string for Rockblock:
5052470101e2ff05003c0000008813550078000000000000000000000000000000000feffff7f
Connect cable and turn on device now

. . .

You should see an "OK" response after the configuration string is sent. The hex string provided can be used to send a configuration to a device over the satellite connection. This could be useful to change the frequency of transmissions (or shut them off entirely) after the device has landed to save message charges, or modify the cut down triggers as conditions change after launch.

Configuration Options (set in configure.py)

unit_id (default: 0)

This is an integer from 1 to 65,535 that identifies the balloon flight. It should be unique from other concurrent flights. It is convenient to use a different number for each successive flight, as that will simplify the retrieval of flight information from the database. Do not use 65,536 as a unit_id, as that will reset the BAD to default settings. The default setting for unit_id is 0 (zero), which indicates that the unit hasn't been configured yet.

letdown_delay (default: 30)

How many seconds to wait to activate the let down reel after launch. Special trick: if this value is negative X, the let down reel will begin unwinding after waiting X seconds after device power up. The default value is 30 (initiate let down 30 seconds after launch)

letdown_duration (default: 30)

How many seconds to actuate the let down reel motor. The reel releases waxed nylon line at approximately X meters per second, so a 50 meter letdown will require about 50/X seconds. Set this to zero to disable the let down function.

max_flight_duration (default: 0)

Number of seconds after launch to activate the hot wire cutter. The default is 0 (zero) which disables the function.

cut_pressure (default: 0)

If the current pressure measurement, averaged over the last several readings is less than cut_pressure, the hot wire cutter is activated. The default is 0 (zero) which disables the function.

cut_duration (default: 5000)

How long, in milliseconds, to activate the nichrome cutter when any of the cutting conditions are achieved. The nichrome wire should be about 3 ohms. A 3 inch piece of 0.010” (30 AWG) nichrome wire will perform well.

rise_rate_threshold (default: 85)

This controls the sensitivity of the launch detection filter. The National Weather Center elevators rise at approximately 100; a balloon launch of 5 m/s is about XXX (determine this value experimentally). The default is 85 to provide a reliable launch detection while doing elevator testing, and eliminating false launches.

update_interval_satellite (default: 120 seconds)

How often, in seconds, to attempt a satellite transmission of tracking data. The default is 120 (once every 2 minutes)

max_distance (default: 0)

The hot wire cutter is triggered if distance from the launch point to the present position exceeds the parameter. The default is 0 (zero) which disables the function.

min_latitude (default: 0)

max_latitude (default: 0)

min_longitude (default: 0)

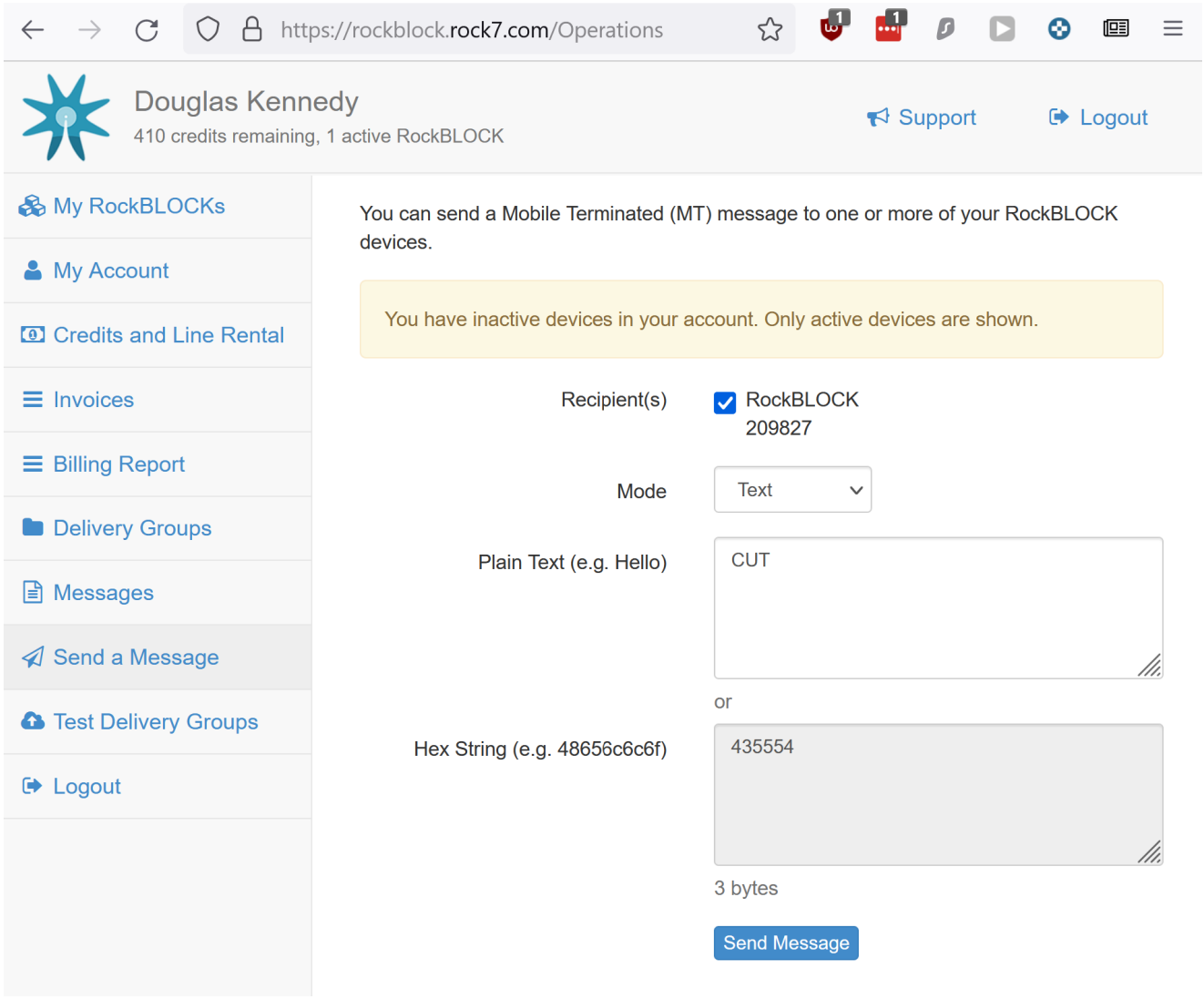
max_longitude (default: 0)

If the GPS reported latitude or longitude is less/more than this number, the hot wire cutter will activate. The default is 0 (zero) which disables the function. The latitude and longitudes are expressed in millionths of degrees: 35.220815" N, -97.446517" E would be 35220815 and -97446517, respectively.

Remote commands via satellite

It is possible to activate the let down reel, the hot wire cutter, and even reconfigure the BAD during flight or on the ground by using the satellite modem. In order to do so, navigate to the

Rock7 control website at https://rockblock.rock7.com/Operations. After logging in, click “Send a Message” and ensure the correct RockBLOCK™ serial number is selected as recipient. Simple commands can be sent in Text mode, and reconfiguration requests will be sent in Hex mode.



Simple commands (case is important!):

CUT

Activate hot wire cutter immediately for cut_duration milliseconds

LET

Activate let-down reel motor for letdown_duration seconds

These commands also work immediately after device power on; use them to test the motor polarity and hot wire cutter when necessary.

Hex mode commands:

PRG{configuration}

Reconfigure the parameters; configuration is a 36 byte binary string. It can be generated by the configure.py program.

UPD{XX}

Change the frequency of satellite updates. “5550440000” will set the update interval to zero, which will disable further updates. This is useful to save message credits after the device has landed and presumably won’t be moving further. Also, “5550447800” will set the update interval to 120 seconds. 0x0078 is 120 in hexadecimal (note that the LSB comes first!)

Preparing the BAD for launch

Insert fresh CR123A batteries, observing polarity markings

Wind appropriate length of waxed nylon line on the letdown reel using the forthcoming reel winding device. Note the time required to wind the line, use this as the letdown_duration, minus a few seconds

Ensure the nichrome cutting wire is tightly wound on the balloon monofilament line

Thread the balloon monofilament out the top of the device and through the rubber cap

The parachute monofilament pigtail can be reused for many flights; only the balloon monofilament is cut and must be replaced

Assign a unique unit_id; this could be different for each flight

Configure device with desired parameters, including the aforementioned unit_id. Use either the configure.py script and serial cable, or test the satellite communication by sending the configuration string

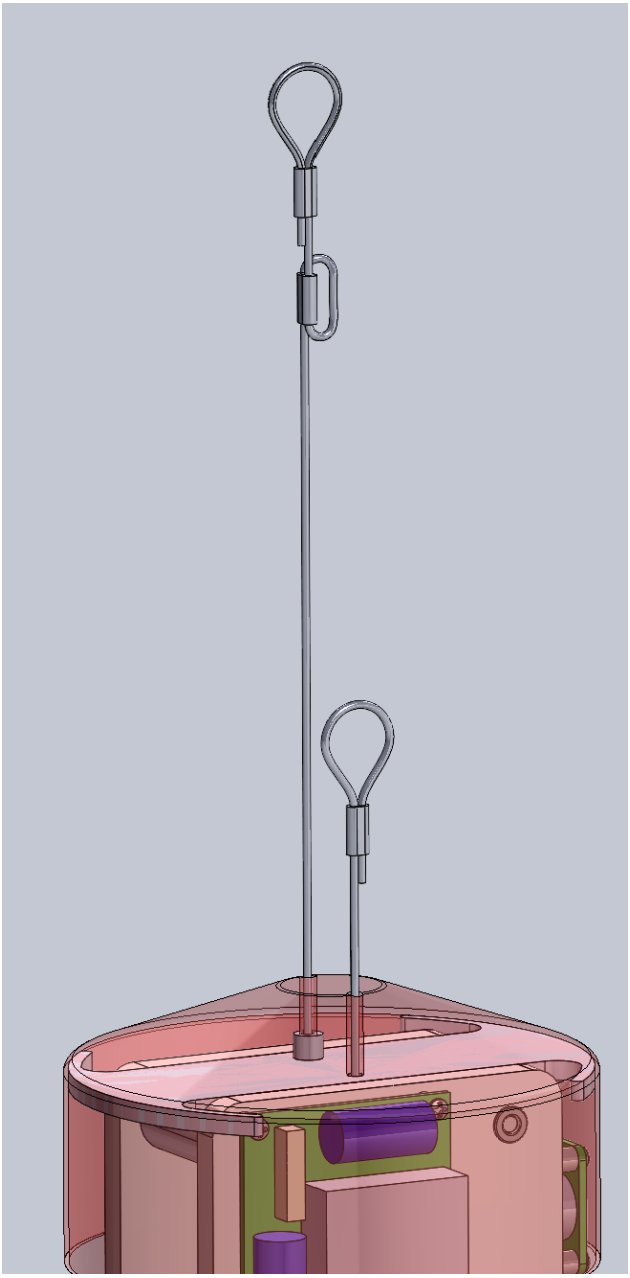
Make careful note of the satellite serial number, as this is what is used to transmit commands to the unit during flight.

Insert pin to power off unit

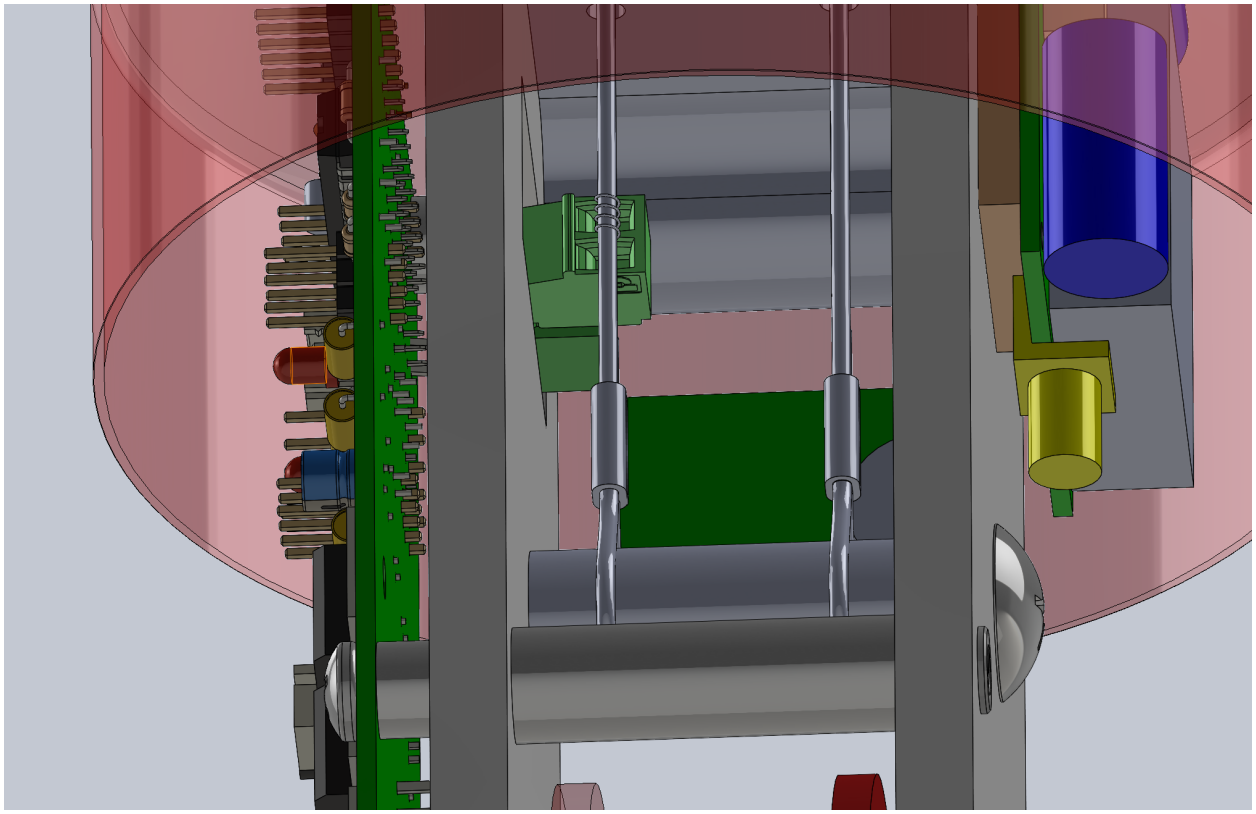
Rig the balloon and parachute according to instructions provided in the manual

Remove the pin at least a minute or two before launch. This will give the GPS time to get a lock and record the launch location. The FIX LED on the GPS board will blink about once a second when it is looking for satellites, and will blink every 10 seconds or so when a valid fix is achieved The red LED will blink about once a second when the device is ready for launch.

Balloon and parachute rigging



Use about 129.5” of 160lb test (0.060) monofilament for the balloon line. Place loops as illustrated. Modify length as required for different parachutes. The balloon monofilament will be much longer than illustrated. The parachute will be rigged in parallel with the balloon monofilament. Cut 12” monofilament for pigtail and make loops at each end. Attach swivels and carabiners as appropriate.



Wrap the monofilament tightly around the fixing post. The post can be unscrewed and removed for ease of rigging. Note placement of hot wire cutter assembly.

Warning: Thread monofilament through cap and upper enclosure brace before crimping loops!

Specifications

Batteries: 3 CR-123A batteries, nominal supply voltage of 9.0V
Nichrome wire: 30 AWG, 0.010” diameter, such as McMaster-Carr number 8880K82. Fabricate a coil of 3 ohms or about 3 inches of wire. Shorter or thicker nichrome wires can cause the device to reboot due to excessive current and supply voltage drop!
Nichrome wire holder: TERM BLOCK PLUG 2POS STR 3.5MM, DigiKey number 609-4727-ND
Weight limitation: Tested with 6 lb weight. Do not exceed without further testing and evaluation

CAD drawings, STL files, firmware, schematics and PCB designs can be found at:
https://github.com/dwkennedy/ballooning