Design. Build. Launch: Recovery Procedures

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This document details the recovery systems and launch procedures for the 2013 'Purple Reign' *Design. Build. Launch.* rocket. The purpose is to describe all components of the recovery system and describe in detail the steps required for the safe launch and recovery of the rocket.

Components

The recovery systems of the rocket include the Avionics Bay ('Av-Bay'), parachutes, and explosive charges. All components *must* be in working condition to ensure safety and avoid catastrophic geo-impact conditions (i.e. 'A Crash Landing').

Av-Bay

The av-bay consists of three wooden disks ('Bulkheads') connected by metal threaded rods, and houses the electronic systems responsible for detecting the rocket's altitude. Two compartments are formed by the wooden disks, one smaller than the other. The smaller compartment houses the batteries and electronic switches. This end should be nearest the ground during flight. The av-bay is located at the center of the rocket within the small 'coupler' section.

The other compartment houses the electronics themselves: two barometric altimeters and one inclinometer are mounted to interior rails in the system. The two inclinometers are: one G-Wiz characterized by a long slender body on a blue circuit board, and one PerfectFlite Stratologger characterized by a stout body and red circuit board. An arrow

on the G-wiz indicates which direction should be pointed up during launch. Two altimeters are used for redundancy purposes.
The purpose of the altimeters is to monitor the air pressure for and deploy parachutes accordingly (see Parachutes section below).

The third component is a custom Arduino system to detect the inclination of the rocket relative to level ground. Its purpose is to prevent cruise missile conditions by firing the charges and launching the parachutes if the inclination of the rocket becomes too low. It consists of a gyroscope that reports angular acceleration to the Arduino, which integrates the signal to determine the rockets orientation in space.

Parachutes

There are two parachutes associated with the rocket: one drogue chute with a two-foot diameter, and one main chute with a 12-foot diameter. Each chute is housed in a different end of the rocket, with the drogue chute located directly above the engine and the main chute located in the nose cone section.

The purpose of the parachutes is to slow descent velocities.
When the altimeters detect that the rocket has reached its maximum altitude (‘apogee’), they will then fire a set of black-powder charges located below the av-bay to separate the body from the engine-case and deploy the drogue chute (each section is connected with shock-cord to keep all components attached).

After drogue deployment, the rocket will descent to 1000 feet above ground level, at which altitude the altimeters will fire another set of charges in the nose-cone section above the av-bay to separate the nose section and deploy the main parachute. The rocket will then descend at roughly 20 feet/second (6.7 m/s) [assuming 40 lb weight] until it impacts the ground, at which point the rocket will be recovered.

Charges

Two sets of charges are used in the rocket configuration. One set is located directly on the top surface of the av-bay in the cone section, and the other is located on the bottom surface of the av-bay in the engine section. Their purpose is to generate enough high-pressure gas within the section to break the shear pins and separate the structure.

The charges are made of black powder held inside the cut-off fingers of plastic gloves. They are fired via wires that run from the altimeters, through holes in the bulkheads, and to e-matches embedded in the black-powder.

Altimeters

Overview:

A digital altimeter called a Stratologger, as shown in Fig. 1, will be installed in the rocket to record its altitude and the ambient temperature as functions of time. It uses a barometer to determine its altitude based on the standard atmosphere and carries a small speaker to aid in recovering the rocket. The Stratologger has dimensions of 2.75" x 0.9" and records 20 data points a second with an accuracy of 0.01% (within 1 foot). It will be powered by a 9V battery and will have its data downloaded upon recovery to analyze via a DT3U data transfer hardware device. By differentiating the altitude as a function of time, the velocity will be determined. The Mach number will be determined by analyzing the velocity data and the corresponding ambient temperatures.

Stratologger:

The Stratologger will also be used to detonate charges in the rocket in order to deploy a drogue parachute at apogee and a main parachute at a determined altitude. When the Stratologger reads that the rocket is no longer gaining altitude, it will send a current to an e-match surrounded by a small amount of gunpowder. This in turn will separate the rocket into two pieces and force the drogue parachute out of the body. The same concept applies to the deployment of the main parachute.

The Stratologger communicates through beeps upon startup. Shorter beeps represent

individual digits with a short pause before the next digit. Ten beeps are used to indicate the number zero. For example, the number 124 would be represented by **beep**-pause-**beep**-**beep**-pause-**beep**-**beep**-**beep**-**beep**.

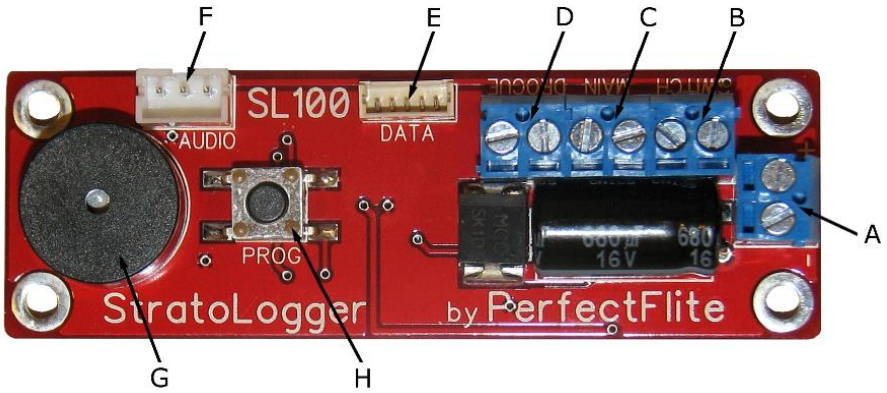
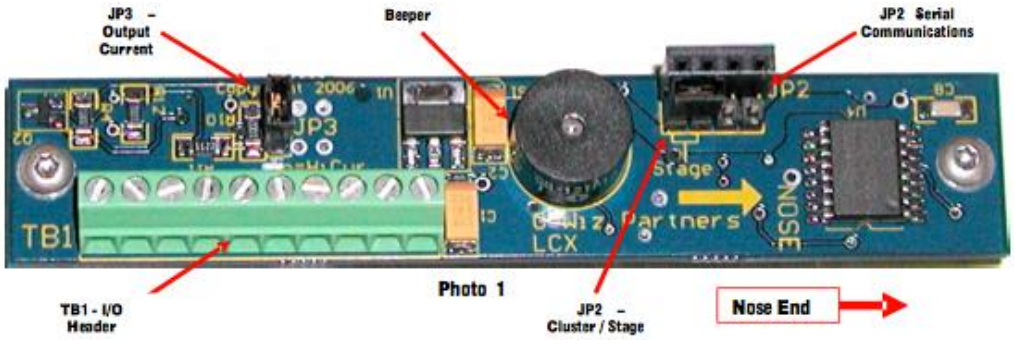


Fig. 1. Stratologger altimeter used for altitude and speed verification as well as controlling parachute ejection charges.

A 3.9” x 0.7” G-Wiz LCX altimeter/accelerometer, shown in Fig. 2, will also be used in the rocket. It samples data at 64 times per second and samples the averaged data down to 16 test points per second. It does not store any data except the maximum altitude, velocity, and acceleration during the flight and will be used as a backup in case the Stratologger fails to deploy either of the parachutes.

The G-Wiz also communicates through beeps. Shorter beeps represent individual digits with a short pause before the next digit. A long beep is used to indicate the number zero. For example, the number 120 would be represented by **beep**-pause-**beep**-**beep**-pause-**long beep**.



Use the following guide to wire batteries, charges and igniters to the terminal bar. This information is also printed on the PC board under the connector.

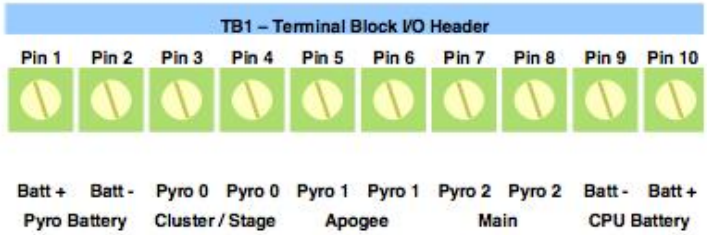


Fig. 2. G-Whiz altimeter/accelerometer used for altitude and speed verification as well as a backup for controlling parachute ejection charges.

Preparation and Procedures

The following checklist should be closely followed at the launch site.

Pre-Launch

Step	Procedure	Initial
1.	Ensure that both parachutes are properly folded and are held in protective covers.	
2.	Remove av-bay from the coupler.	
3.	Use multimeter to ensure that each button-switch is in the OFF position (infinite resistance between the two wire leads).	
4.	Attach 3 new 9V batteries to the three power connections. • Stratologger - Pins 'A' (+,-) • G-Whiz – Pins 1, 2 (+,-) and Pins 9, 10 (+,-)	
5.	Complete Stratologger startup checklist: * EACH STEP SEPARATED BY A TWO SECOND PAUSE • Turn on Stratologger power • A one-digit number will be beeped corresponding to the selected preset. Check that correct preset is chosen. ☐ • A three or four digit number will be beeped corresponding to the main deployment altitude setting, followed by a two second pause. Check that this is correct. ☐ • 5 second tone (only if apogee delay is set). Ignore. • A three or six digit number is next corresponding to the apogee altitude of the last flight. (Warbling tone if power died during last flight). Ignore. • Two or three digit number representing battery voltages in tenths of a volt. Check that voltage is 9V ☐ • Continuity beeps every 0.8 seconds. Make sure there are three beeps ☐ - 1 beep: drogue e-match continuity - 2 beeps: main e-match continuity - 3 beeps: drogue and main e-match continuity Silence: no continuity	
6.	Complete G-Wiz startup checklist: • Turn on G-Wiz power. If there is a two-tone warble initially then the battery is low and should be replaced. No warble ☐ • Single or double beeps representing staging or clustering of Pins 3, 4. Ignore • Half second pause. A single or double higher pitch	

	beeps indication continuity for each port starting with 0. One beep means continuity, two beeps means no continuity. Check that pyro 0 has **no continuity**, and that pyro's 1 and 2 **do have continuity**. ☐	
7.	Turn off both switches. DO NOT press again until indicated.	
8.	Prepare 4 charges by filling plastic glove fingers with 6 oz. of black powder, inserting e-match tip, and wrapping the glove tightly with tape. Tape the charges to the appropriate exterior bulkhead.	
9.	Secure two e-match bundles to each end of the electronics bay and feed the wires through the bulkheads. • Attach the drogue e-matches to Pins 'D' on the Stratologger and Pins 5, 6 on the G-Whiz. • Attach the main parachute e-matches to Pins 'C' on the Stratologger and Pins 7, 8 on the G-Whiz.	
10.	Insert av-bay into coupler section. Note the ϕ and ψ symbols marked on the bulkheads and coupler interior. These should match up.	
11.	Apply caulking putty around the edges of the bulkhead and bolts and e-match wires to prevent hot gas from leaking into electronics section. Check that both ends are very well caulked. Ensure that screwholes and helicoils are aligned.	
12.	Attach parachute fasteners to each U-bolt on the av-bay and slide chutes into their sections.	
13.	Place nose and engine sections onto coupler and insert bulkhead screws.	
14.	Once rocket is assembled, insert shear pins.	
15.	Mount Rocket on launch rod.	
16.	When other preparations are complete, use rod to press switches. Ensure that each altimeter completes startup procedures. Recovery systems are now armed. Proceed with caution.	

Post-Launch

After the rocket is recovered, the following checklist should be followed.

Step		Initial
1.	Turn off altimeter switches.	
2.	Secure parachutes.	
3.	Remove bulkhead screws and remove av-bay from coupler.	
4.	Disconnect parachutes from av-bay.	
5.	Detach batteries.	
6.	Win competition.	
7.	Go home.	

Launch Failure Protocols

In the event of a launch failure, such as the failure of the motor to ignite, the following procedure should be followed.

Step		Initial
1.	Follow safety procedures established by Propulsion group. (Disable launch box, wait x amount of minutes before approaching rocket, etc.)	
2.	Press the switches to deactivate the altimeters.	
3.	Remove bulkhead screws and remove av-bay from coupler.	
4.	Detach batteries.	
5.	Determine what went wrong.	