Dual-Stage Recovery *for a 1/16 Scale V2*

by Chuck Pierce

Having recently flown and lost a scratch-built 1/16 scale (4-inch diameter) V2/A4 rocket, due to winds aloft hijacking and depositing the rocket into a nastily overgrown briar thicket, I decided that the next time I built a 4-inch (or larger) V2, I would configure the rocket for dual deployment. The opportunity to do so presented itself when LOC/Precision offered a pre-release 1/16 sport scale V2 for evaluation by the model rocketry community.

First off, there are quite a few ways to build a dual deployment capability into a rocket, such as building the altimeter bay into the nose cone, into the motor mount area, or into a center section of the airframe. My preferred method has always been the latter: to build a modular avionics bay that fits between the fin can and the nose cone. The big constraint for this method of dual deployment is real estate, as there must be available volume between the forward centering ring in the fin can and the aft bulkhead of the avionics bay for a drogue chute compartment, volume in the avionics bay for the altimeter, and volume between the forward bulkhead of the avionics bay and the nose cone for a main chute compartment. For most 4-inch rockets, there is ample internal volume into which to build these necessary compartments. A 1/16 scale V2/A4, however, is another story altogether since the airframe is only 10 inches long and the remainder of the 36-inch rocket length is nose cone and boat tail. My quest was to overcome the real estate problem and to build a V2 that had a centrally located avionics compartment. The following is brief description of how I achieved this goal.

Figure 1: V2/A4 Boat Tail

Building the Boat Tail

The most significant feature of the V2 boat tail for allowing dual deployment is the available volume between the forward centering ring and the forward lip of the boat tail. I decided to limit my motor choices to 38/360 cases, which meant that my motor tube needed to be approximately 7 inches long. The outer diameter of the forward centering ring was turned down slightly to allow the CR to be bonded in place approximately 4 inches from the forward lip of the boat tail. Into the forward centering ring, a loop of 1/8 inch tubular Kevlar was installed, onto which the shock cord would later be attached. Since the boat tail is heavy, it has a negative static stability margin after separation, which means that a drogue chute is not

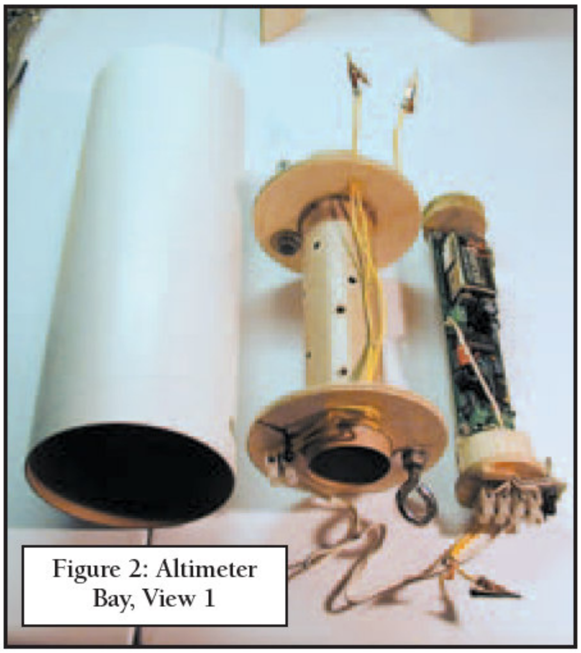

Figure 2: Altimeter Bay, View 1

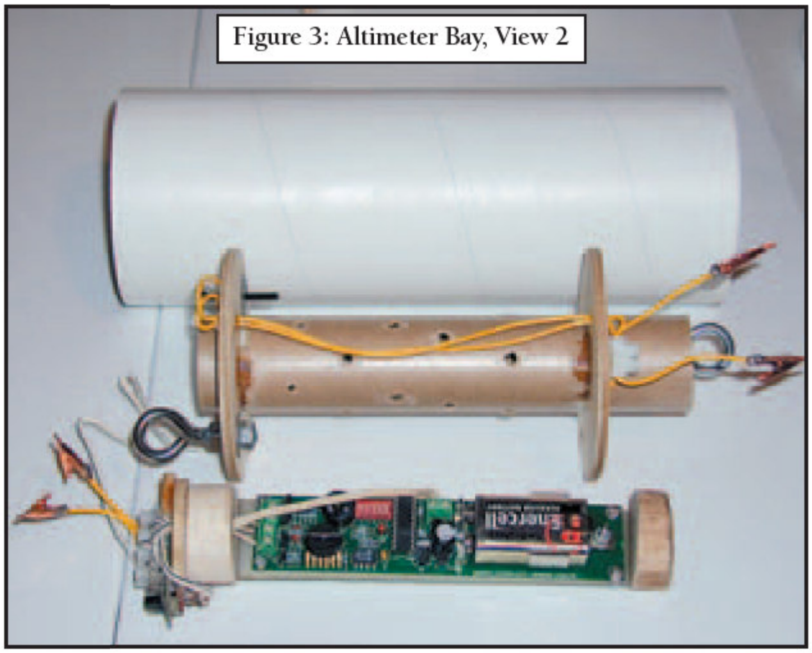

Figure 3: Altimeter Bay, View 2

required; therefore, the drogue compartment need only provide the internal volume for the drogue shock cord. The internal volume in the forward end of the boat tail is spacious enough to contain 15 to 20 feet of half-inch shock cord. The boat tail is shown Figure 1.

Building the Avionics Bay

The avionics bay was built for a Missile Works RRC2 barometric altimeter, which is approximately 6 inches long. The author's preferred altimeter bay configuration is an adaptation of the Smokin' Rockets' AltiTube concept, in which the switches and terminal blocks are built onto the altimeter subassembly, which then slides into an internal tube which has been permanently mounted into the airframe of rocket. The tremendous advantage of this type of altimeter bay configuration is that it allows quick-and-easy transfers of an altimeter assembly between multiple rockets.

When configured to mount the RRC2, the altimeter tube measures approximately 9 inches long. Therefore, in this dual deployment configuration, the entire 10-inch airframe becomes the avionics bay. Figure 2 shows the airframe (left), altitube subassembly (center), and altimeter subassembly (right), before the altitube subassembly has been permanently mounted into the airframe. Figure 3 shows the same three subassemblies, but has been rotated 90 degrees to better show the terminal block on the forward end of the altitube subassembly, and to show the relative positions of the subassemblies to each other, once the altitube subassembly has been permanently mounted inside the airframe. Please note in Figure 3 that left end of the subassemblies will face the boat tail. Numerous holes have been drilled through the altimeter tube to allow the altimeter to properly sense the external ambient pressure during flight. The altitube subassembly is mounted into the airframe, such that the distance from the aft end of the airframe to the aft centering ring of the altitube subassembly is just a hair longer than the shoulder of the boat tail. Since the V2 is being configured for drogueless dual deployment, this arrangement allows 4 inches into which the drogue shock cord will be placed.

Building the Main Chute Compartment

With the airframe converted to an avionics bay, the only available volume for the main parachute is within the nosecone. To convert the nose cone into a main chute compartment, the back end of the shoulder of the nose cone must be cut off. Since the V2 is characteristically tail heavy, due to the large fins, large boat tail, and short airframe, substantial nose weight must be added to the nose to insure a proper static stability margin. After the weight has been bonded into the vertex of the nose cone, the remaining volume of the nose can be dedicated to the shock cord and main parachute.

Final Assembly

Figure 4 shows the assembled 1/16 scale V2/A4. To provide ambient pressure into the altimeter bay, four 1/4" vent ports were drilled near the mid section of the airframe at 90-degree intervals from each other. There was no special analysis that went into determining the size and quantity of the vent ports, other than author's gut feel that four 1/4" ports would easily allow for pressure equalization within the inner tube of the avionics bay.

Since the shoulder of the boat tail is so short (about one inch long), two diametrically-opposed shear pins, are used to hold the boat tail to the airframe, until the drogue ejection charge forces the rocket to separate at that plane. Although the shoulder of the nose cone is much longer than the boat tail's shoulder, two diametrically-opposed shear pins were also used to the hold the nose cone to the airframe, prior to main deployment. Shear pins help protect the rocket from premature separation due to the inertia differences (e.g., heavy nose with a light tail), shock forces (e.g., drogue charge and/or shock cord recoil), and internal pressure build up (e.g., high altitude flights with an unvented internal cavity). Shear pins are the high-power

V2 flight configuration

Motor:	I357 motor
Altimeter:	RRC2 altimeter (set for apogee deployment of the drogue and 300' deployment of the main)
Parachutes:	48 inch main parachute, no drogue chute
Ejection:	1 gram of BP for the main ejection charge, 1 gram of BP for the drogue ejection charge
Shock Cords:	15-foot, 1/2" diameter tubular nylon main shock cord 15-foot, 1/2" diameter tubular nylon drogue shock cord

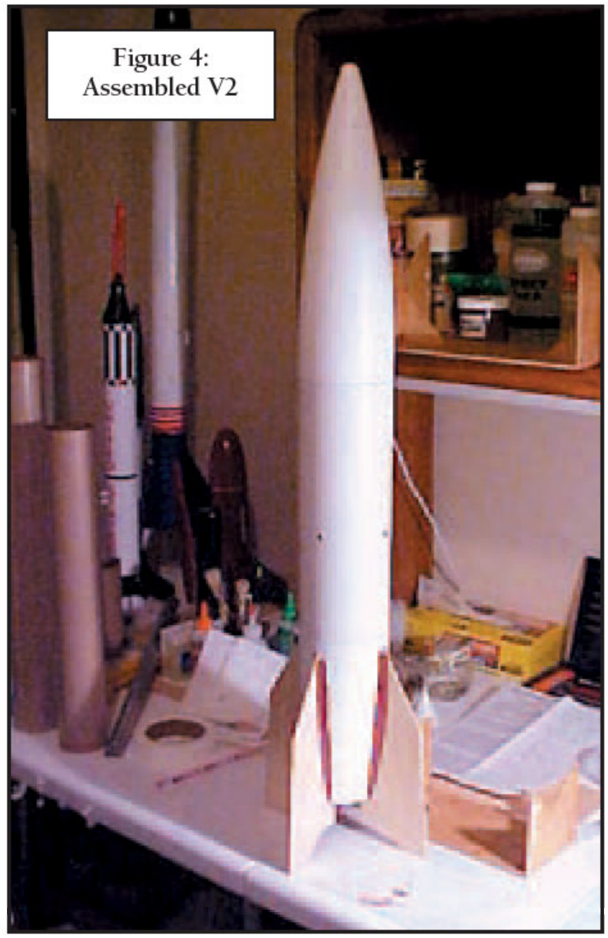
Figure 4: Assembled V2

rocketeer's friend. The author's shear pins of choice are #2 nylon screws, but there are several other options, such as styrene rod and the ubiquitous Kurt Kessler plastic pickle fork tines.

Flight and Recovery

An I357 motor was chosen for the first flight of the V2 because it was one of the smallest high-power motors in the author's pitifully small motor cache and is also one of the author's favorite motors.

The rocket weighs 72 ounces when loaded with the I357. Seven ounces of nose weight gave the model a static stability margin of 1.3 calibers.

In Figure 5, the RockSim simulation predicts that the V2 will reach an apogee of 2853 feet, at which altitude the boat tail will be separated from the airframe by the drogue ejection charge. The two rocket halves will then tumble to 300 feet, the altitude at which the altimeter will trigger the deployment of the main parachute. RockSim predicts the touchdown velocity to be 18 mph.

On February 23, 2002, at the HARA launch site in Ardmore, Alabama, the V2 was launched into a clear sky with gusty 5-15 knot winds. The ascent of the V2/A4 was nearly perfectly vertical. Per the altimeter, apogee was 2935 feet, at which altitude the boat tail was separated from the airframe. The main chute deployed on cue at 300 feet, and the rocket landed safely within a 100 yards of the pad.

Conclusion

Drogueless dual deployment is a useful and reliable method for recovering a high-altitude rocket in gusty winds and/or on short fields. For rockets with limited internal volumes, the volume of the drogue compartment can be minimized by designing the fincan to be unstable after drogue separation, which will allow the rocket to tumble from apogee (and, thus, does not usually require a drogue parachute to slow the descent). By locating the altimeter bay in the midsection of the rocket, management of the drogue and main ejection charge wiring is much simpler than when the altimeter bay has been built into either the nose cone or the fincan. As a word of caution, though, special consideration should be given to the amount of nose weight contained in a rocket which will be recovered via drogueless dual deployment. A heavily nose-weighted rocket could pull the drogue shock cord taut, forcing the tail section to align itself with the nose cone during descent, potentially resulting in a high-velocity deployment of the main chute and/or entanglement of the trailing tail section into the deployed main parachute, either of which could result in serious damage to the rocket.

Figure 5: RockSim Simulation