DS Rocket Recovery System Description

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The DS rocket uses a dual-event recovery system. The first event occurs at apogee, when the Raven flight computer fires a Primary pyro charge. This results in the separation of the rocket into two sections, separating at the Aft joint. The Aft joint is where the Aft Body (which houses the motor) is mated to the Avionics Bay (which also serves as a coupler). The rocket then tumbles earthward, with the two sections connected by 3 metre long tether. When a predetermined altitude is reached, the second event occurs. The Raven fires a Main Pyro charge. This results in the separation of the rocket at the Forward joint. The Forward joint is where the Forward Body (which houses the parachute) is mated to the Avionics Bay. The momentum of the rapidly departing Avionics Bay extracts the parachute. The parachute then deploys slowing the descent to a soft touchdown. The Forward Body is connected to the Avionics Bay with a 2.2 metre long tether. The parachute is attached to this tether by a quick-link.

The Aft joint is fastened with four #4-40 nylon screws and the Forward joint is fastened with six #6-32 nylon screws. These screws shear when the respective pyro charges fire. These screws serve two purposes. To hold the jointed sections together, both on the ground (during handling of the rocket) and in flight. The nylon shear screws also serve to ensure a forceful separation of the jointed sections. This is especially important for chute extraction, which is reliant upon the momentum of the Avionics Bay. The Forward joint connection is more robust to ensure that the Forward joint does not inadvertently separate during the apogee event (due to momentum of the separating rocket sections). The consequence of such an anomaly would be chute deployment at apogee. In fact, this did occur on early DS flights. The fix was to increase the number of screws from four to six.

The parachute deployment system utilizes a piston to isolate the parachute from the heat of the ejection charge and to serve as a forward closure for the Main Pyro compartment. The bulkhead of the Avionics Bay forms the aft closure of the Main Pyro compartment. The force acting on the piston, when the pyro charge fires, is reacted by a thrust ring securely fastened to the Forward Body. The pressure developed when the pyro charge fires blows the Avionics Bay out the rocket body. The piston is pulled out at the same time, being attached to the tether connecting the Avionics Bay to the Forward Body.

The DS Rocket is illustrated in Figure 1 showing the various components of the recovery system. Figure 2 illustrates a photo of the rocket disassembled to show the key components.

The reasoning for employing dual-event recovery system is two-fold:

1) <u>Enhanced reliability of a safe descent of the rocket</u>. The primary event involves a simple process of merely separating the rocket into two pieces, generating an aerodynamically unstable and therefore relatively slow descent. If there is an subsequent anomaly with the main event (failed chute deployment), the consequence is essentially non-hazardous and minimal damage to the rocket can be expected from the resulting "hard" landing.

2) <u>Reduced range</u>. The rocket descends relatively quickly during the tumbling event, reducing the overall descent time. As such, wind has less time to carry the rocket downrange. Typically the range can be reduced to 1/3 of that expected if the parachute were to deploy at apogee. This can be an important factor if there is a brisk wind blowing at time of launch.

As mentioned, the Raven flight computer fires both the Primary apogee pyro and the Main pyro charges. The Raven also fires a Backup pyro charge a few seconds after apogee. For further redundancy, the DS rocket is equipped with an electronic Timer module which fires a Pyro charge after a predetermined time delay following liftoff. The time delay is chosen to result in pyro firing four or five seconds after apogee. The rationale for this backup system is to ensure a safe (albeit "hard") landing if the Raven were to ever malfunction during flight.

Pyro charges for the DS rocket consist of 1 gram of granular Crimson Powder enclosed in a short length of plastic drinking straw tube. A short length of 0.005" (0.13mm) diameter nichrome wire serves as the bridgewire for initiating combustion of the charge. Both ends of the tube are sealed with hot-glue.

A note on the tether. I have tried various polymer ropes over the years. I have found that braided nylon is the best, as it combines strength with a certain degree of stretch (which dissipates energy). Polyester and polypropylene do not possess enough stretch and can break as a result. The tether currently used for the DS rocket is “diamond braid” nylon 3/16 inch (5mm) nominal diameter. This rope has a rated working load of 90 lbs (40 kg). As a typical safety factor of 10 is pertinent for ropes, the breaking strength is around 900 lbs (400 kg) which has been confirmed by my own testing. Loops are knotted at each end of the tether, to attach quick-links. An excellent knot that will never slip or otherwise fail is shown in Figure 3.

The tethers are subjected to the heat of the pyro charge combustion. Originally I gave the tethers a light coating of silicone RTV. This worked well in providing excellent thermal protection. More recently I have omitted the RTV coating and found that nylon rope stands up well to the brief heat load. Crimson Powder burns cooler and cleaner than Black Powder. After each flight I simply wash the tethers using warm water and soap to remove any residue

Table 1 lists some of the hardware components including vendor part numbers.

Figure 4 is a photo of the DS Rocket descending by parachute, with key components of the recovery system clearly seen.

Item	Supplier	Part no.
Nichrome wire	McMaster-Carr	8880K85
#4-40 nylon screw	Digikey	36-9527-ND
#6-32 nylon screw	Digikey	36-9535-ND
Quick-link	McMaster-Carr	8947T14

Table 1 – Component part numbers

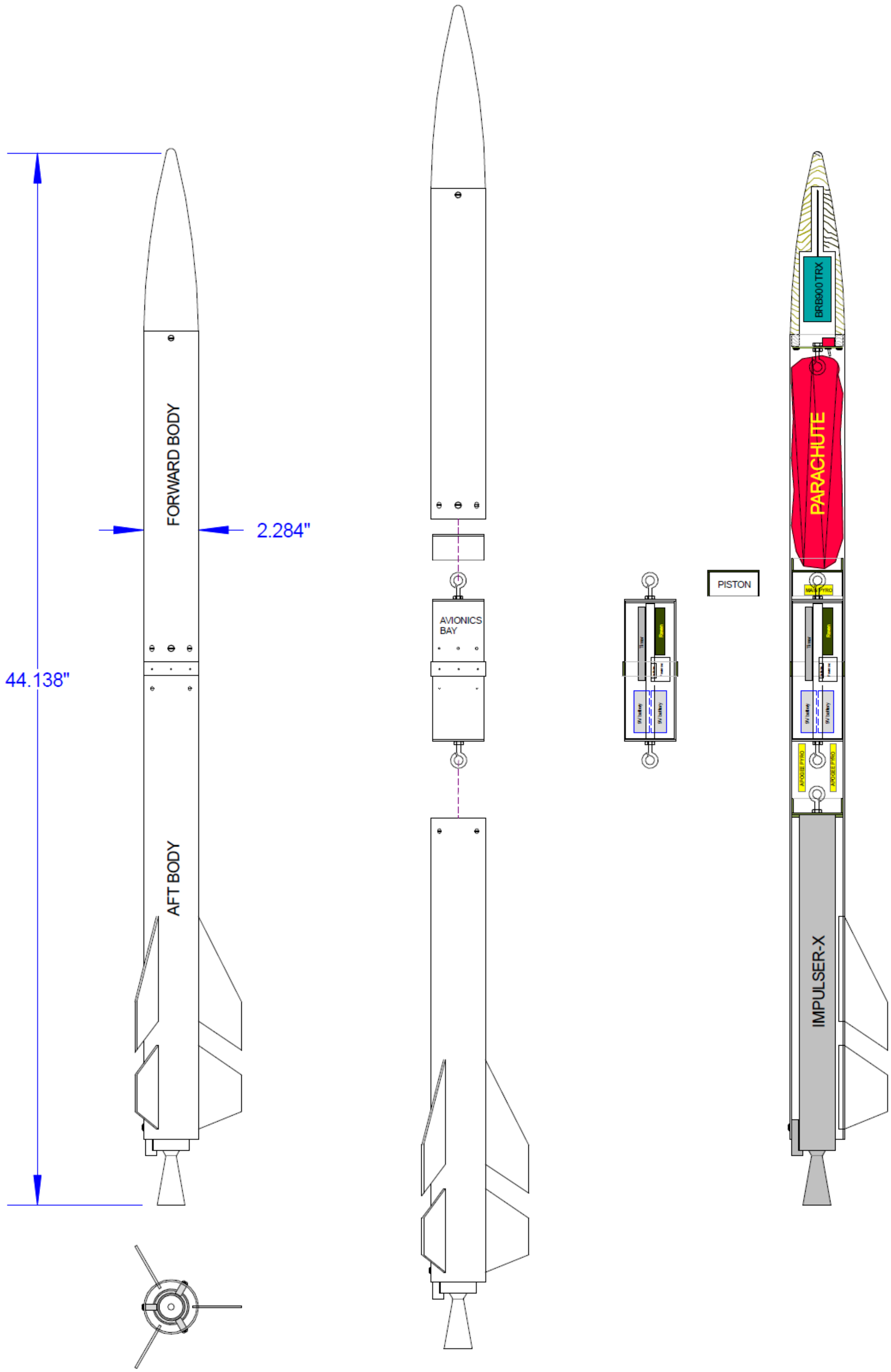

Figure 1 – DS Rocket layout

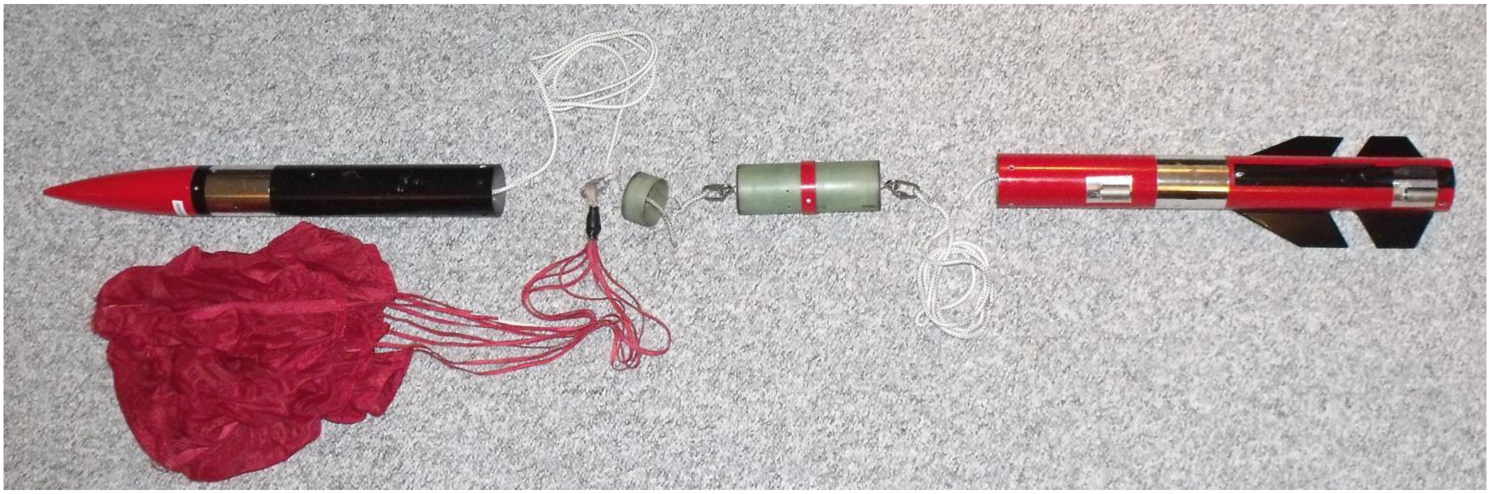

Figure 2 – DS Rocket dis-assembled to show deployment components

Table 1 – Component part numbers

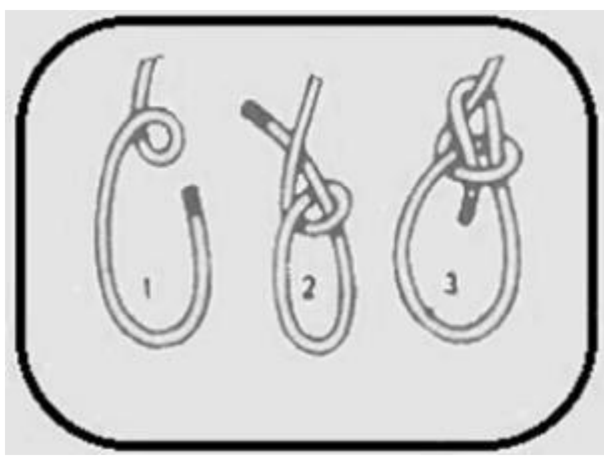

Figure 3 – Tether knot

Figure 4 – DS Rocket during final descent