Parachutes vs. Parasheets

Harold Larson

The majority of what are called ‘parachutes’ in model rocketry are actually parasheets, that is, flat pieces of flexible material with multiple shroud lines going to different points around an approximately circular edge. Parasheets can lay on a flat surface, and if they are circular, it is easy to determine their diameter.

A true parachute has an approximately spherical shape, and cannot lay on a flat surface. Determining the diameter of a parachute is more difficult, and the way that TARC uses is to fit precut discs into the inflated parachute. A 15” diameter disc should fit, a 14” disc should be too small, and a 16” disc too large.

To determine whether there is any advantage to a parachute vs. a parasheet, the rocket at the right was flown with a 15” commercial parasheet, a 15” parachute sewn together from rip-stop nylon, and a 15” parachute made from plastic sheet about 1 mil in thickness. Launch masses were 302-311 grams (heavier for the rip-stop parachute launch, which was about 10 grams heavier than the other two), and Aerotech E30-7 motors were used for all launches. The rocket included a 60 gram clay mass simulating an egg, and a Perfectflite “P-nut” altimeter to record altitude and time-of-descent data. The rocket went to about 1,050 feet, higher than the TARC 2013 goal, but this allowed for greater descent time, and a more accurate measurement of parachute effectiveness.

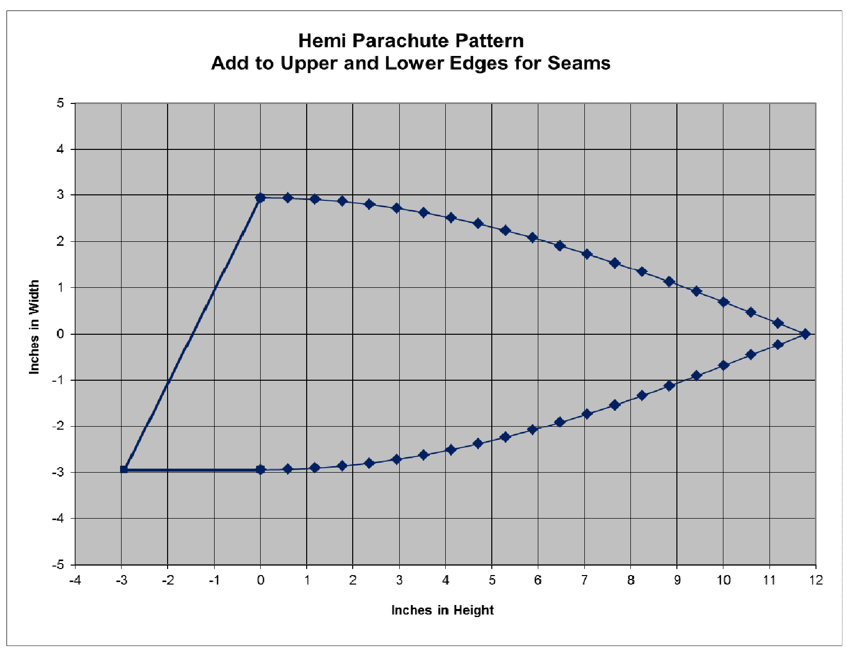
The commercial parasheet used appears at the right. Diameter is slightly less than 15”, material appears to be nylon but without the usual rip-stop reinforcing, and shroud lines are 14” long and appear to be 1/16” braided nylon. Mass of this parasheet is 11 grams.

The rip-stop parachute used was sewn together from 8 alternating gores of red and yellow rip-stop nylon purchased from Hancock Fabrics. Shroud lines are 16” lengths of kite string, and parachute mass is 21 grams. A swivel was used to connect the parachute to the rocket (not shown).

The plastic parachute used was assembled from 8 alternating gores of disposable plastic tablecloth material, available at Wal-Mart. Any plastic material, such as plastic lawn-and-leaf bags, could be used. For TARC, thickness should be about 1 mil (0.001”), and the four points where shroud lines attach should be reinforced. Shroud lines were 16” lengths of kite string, and parachute mass is 13 grams. As above, a swivel was used to connect the parachute to the rocket.

Sheets of plastic can be attached to each other by overlapping the pieces to be attached, and heating the seams with an iron. A piece of wax paper should be positioned above and below the seam so that the plastic will not stick to anything except itself. If available, a Monokote sealing iron on a setting of “2” will work well.

A pattern for a single parachute gore appears to the right. Eight pieces are needed, and allowance for seams should be added to this pattern. Note that the long edges should be attached to each other, forming four points, to which shroud lines are attached. Also note that the vertical length of the base is 6”, so 8 pieces form a circle with a circumference of 48”. The diameter is therefore 48/π, or 15.3”. This meets the TARC size requirement of 14 to 16” diameter.

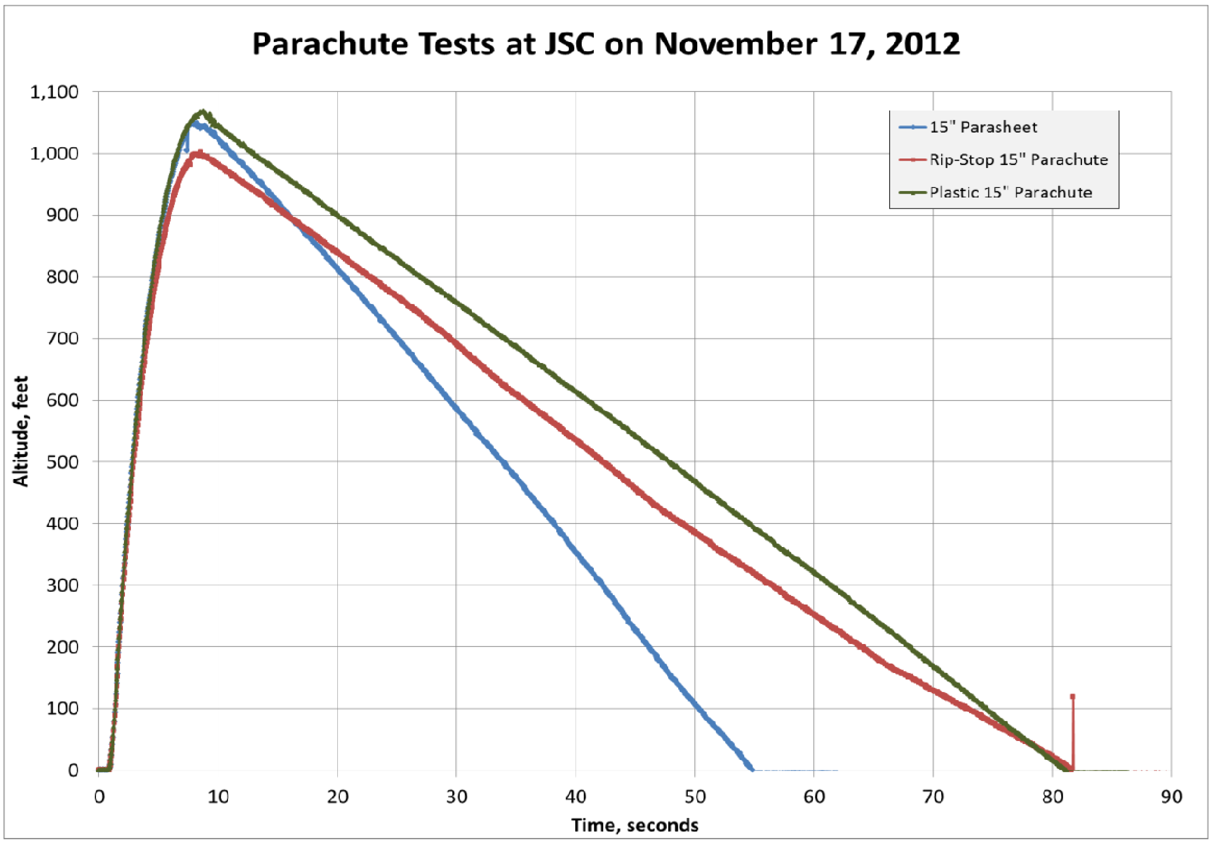


Altitude vs. time data for the three flights is plotted below.

The blue curve is for the 15" parasheet, which returned to the ground after 54 seconds from 1,047 feet. Average rate of descent was 23.6 feet/second with a descending mass of 276 grams, yielding a drag coefficient of 0.76. This is very close to the 0.75 Cd that Rocksim usually assigns to a parasheet.

The red curve is for the rip-stop parachute, which returned to the ground after 82 seconds from 998 feet. Average rate of descent was 15.4 feet/second with a descending mass of 261 grams, yielding a drag coefficient of 1.70. This was the lowest altitude flight, likely due to the higher mass of the rip-stop parachute. Also note that rate of descent slows at about 65 seconds…the spent motor was not found in the rocket on recovery (this is a DQ at TARC!), and possibly fell off the rocket at that point.

The green curve is for the plastic parachute, which returned to the ground after 81 seconds from 1,067 feet. Average rate of descent was 14.4 feet/second with a descending mass of 278 grams, yielding a drag coefficient of 2.09.



The two true parachutes (red and green curves) descended at very similar rates until the 65 second mark. This was despite some thermal activity (also noted by circling turkey buzzards over the field). The author could not resist launching flight 2 with buzzards circling nearby, and the buzzards quickly decided to seek rising air somewhere else. Data for the plastic parachute (green curve) is believed to be the most reliable, since the motor case was found still in the rocket upon recovery.

Parachute Mathematics

First, whenever problems like this come up, it is best to work in metric units and convert answers to familiar English units after the problem is solved. To convert, one foot is 0.3048 meter.

When a mass is descending uniformly under a parachute, the force of gravity acting on the mass is exactly balanced by the drag force acting on the parachute.

The force of gravity, measured in Newtons, is the descending mass in kilograms multiplied by the acceleration due to gravity (9.8 meter/sec*sec). In the case of the third flight, descending mass was 278 grams (0.278 kilograms), so the force of gravity is 0.278 kg * 9.8 meter/sec*sec, or 2.72 Newtons.

The drag force exerted by a parachute, measured in Newtons, is given by the equation below:

$$D=1/2*\rho*Cd*V^2*A$$

Where D = drag force in Newtons
ρ = density of air in kilograms per cubic meter, ~ 1.20 kg/meter^3 at sea level
Cd = parachute drag coefficient, dimensionless, usually about 0.75 for a parasheet
V = descent rate in meters/second, squared in the equation
A = area of inflated parachute in square meters

Given rate-of-descent data and knowledge of the descending mass, a drag coefficient can be calculated for any of the flights by rearranging the equation above, to

$$Cd = D / (1/2*\rho*V^2*A)$$

With this equation, the drag coefficient Cd of the third flight depends on D, ρ, V^2, and A. Considering the third flight, D is known, and is 2.72 Newtons from above, and ρ is known at 1.2 kg/meter^3. The rate of descent V is known since altitude was 900 feet at 20 seconds and 329 feet at 60 seconds, so rate of descent is (900-329)/40 sec, or 14.3 feet/second, or 4.35 meter/second. If the P-nut data is moved into Excel and plotted, this rate of descent can also be conveniently determined using Excel's SLOPE() function. Area of a 15" circle is 176 square inches, or 1.23 square feet, or 0.114 square meters. Plugging in these numbers,

$$Cd = 2.72 / (1/2*1.2*4.35^2 *0.114)$$

$$Cd = 2.09$$

It is left as an exercise for the reader to verify that Cd is dimensionless!