Parachute Selection and Snatch Force

(Note: all equations sourced from NASA at link, and rocketmime at link)

The drogue parachute is the parachute in a multi-chute system that deploys at apogee and controls the fall of the rocket until the main parachute deploys.

The main parachute is what slows the rocket to its final landing speed. If there is no drogue parachute in the rocket, the main parachute is just referred to as the parachute. The primary concern for the main parachute is landing speed. If used with a drogue parachute, then snatch force must also be considered.

Descent Speed

The descent speed of a drogue parachute should be as fast as possible, to minimize the drift distance between the launch pad and landing site, while not being so fast as to create an extremely high snatch force when the main parachute deploys.

The descent speed for a main parachute is also known as the landing speed. Landing speed, as the name implies, is the speed at which your rocket hits the ground as it lands. A slower landing speed means less of a chance of your rocket being damaged, but means that the rocket will drift further, possibly out of the launch site or out of radio range. The general ideal landing speed is 10-15 feet per second. Some rockets with large or thin fins may want to come down slightly slower, since the fins are usually what hit the ground first. The maximum allowable landing speed is around or under 30 feet per second for all launch sites around the US.

Calculating Parachute Size

In order to calculate the size of your parachutes you must know and assume several things. As an example, this was the procedure for determining the parachute size for Third Time's the Charm. First we decided on a safe landing speed (15 ft/s or 4.572 m/s). We assumed air density at sea level, took the mass of the rocket from open rocket, and then utilized the equations:

\[
D_{m} = \sqrt{\frac{4 A_{m}}{\pi}}
\]

\[
A_{m} = \frac{(2 m g)}{(r C_{d} v_{i}^{2})} - \left(\frac{(\pi D_{d}^{2})}{4}\right)
\]

\[
D_{d} = \sqrt{\frac{(8 m g)}{(\pi r C_{d} v_{d}^{2})}}
\]

Where

- \(A_{m}\) is the area of the main parachute in meters\(^2\)
- \(D_{m}\) is the main chute diameter in meters
- \(D_{d}\) is the drogue chute diameter in meters
- \(m\) is the rocket mass in kilograms
- \(g\) is the acceleration of gravity = 9.8 m/s\(^2\)
- \(\pi\) is 3.14159265359
- \(r\) is the density of air = 1.22 kg/m\(^3\)
- \(C_{d}\) is the drag coefficient of the chute, which is given by the manufacturer (0.97 for Rocketman).
- \(v_{i}\) is the speed we want at impact with the ground (between 15-20 ft/s or 4.572-6.096 m/s is good).
- \(v_{d}\) is the speed we want during descent (variable, a good round number to start with is 50 ft/s (15.24 m/s), but make sure you verify the snatch force won't be too much).

NOTES:

- You will need to calculate/know your drogue chute diameter first in order to calculate your main.
- This equation will give you an exact diameter, but you most likely won't be able to buy a 8.723451 ft diameter parachute, so you'll need to round.
- Round both up and down to the nearest integer, plug these values into OpenRocket, and see what gives you better performance.

If using OpenRocket, or another rocket design software, it can automatically calculate descent velocity using this equation.

Snatch Force

Snatch force is the forces of the parachute deploying, that will pull up on the shock cord and eye bolt of the parachute. Snatch force is a series of multiple forces on the system, but the largest of them is the canopy loading force, or the force of the parachute opening. This immense force is often 2 to 3 times greater than the constant drag force of the parachute. To a lesser extent there is also the deployment snatch force, which is the force of the mass of the parachute pulling the shock cord taught, but it is usually a fraction of canopy loading force so it can be ignored and is considered for in the factor of safety for the canopy loading force. In general, snatch force is a function of the size of the parachute, the parachute's drag force, and the speed of the rocket.

Therefore, a smaller drogue parachute means a higher snatch force for the same size main parachute. Snatch force is not a major consideration for parachutes deployed at apogee, since in theory the rocket should not be moving. It is still good to design everything connected to an apogee parachute to 2 times max drag force as a factor of safety, and for larger or higher-flying rockets it never hurts to run OSCALC for the drogue as well. A common practice is to also consider what the snatch forces would be if the parachute deployed +/- 1 second from apogee, and use those velocities.
While snatch force can be modeled mathematically, it is a bit difficult. You can definitely do it by hand by looking up some old NASA technical manuals, but the easiest way to do it is using OSCALC. OSCALC can be installed from the Software Access page. OSCALC is also nice in that it will include the deployment snatch force in its maximum snatch force, so you do not need to worry about that. When using OSCALC values, a factor of safety of around 1.25 to 1.5 is needed on the maximum force number, or a factor of safety of 2 to 2.25 on the average force number, whichever is greater.

Another approach that can be taken for a quicker and easier calculation of snatch for is to fine the acceleration needed to go from the drogue parachute speed to the main parachute speed, then use that to find force.

A third approach for calculating snatch force is to use this equation from NASA, using the same variables from the “Calculating Parachute Size” section:

\[ F = 0.5 \cdot r \cdot V_d^2 \cdot C_d \cdot D_m \]

Once you calculate the snatch force, you need to go through and check it against all the components of your recovery connection, such as the shock cord and swivel link, as well as rocket parts like the parachute bulkhead. It is also a consideration for things like friction-locking battery connectors or mounts in the avionics section. There are stories of parachute snatch forces being so great that they pulled the battery off of the tracking radio, thus the rocket was lost.