Issue 668 / December 30th, 2025

PEAK OF FLIGHT NEWSLETTER

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Drag Coefficients of Model Rocket Parachutes

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Drag Coefficients of Model Rocket Parachutes

Some Problems, Perils and Pitfalls

By Dave Flanagan

Introduction

Model parachutes have been used to recover rockets for over fifty years. These simple flat polygons are inexpensive, easy to make, and fairly reliable. By now an accurate value for their drag coefficient should be known. Instead, a wide range of values have been reported. Firth [1] recently conducted flight tests and reported an average value of C_D=0.72, but also a range of C_D=0.53 to C_D=1.04 [1]. One earlier study reported a range of C_D=0.64 to C_D=1.05 [2]. A NASA Glenn Research Center tutorial suggests the drag coefficient of a model rocket parachute as high as C_D=1.75 [3]. Others have reported even higher drag coefficients [4]. Knowing the drag coefficient is essential to designing a parachute recovery system.

There are several reasons for the wide range of drag coefficients claimed for the common model rocket parachute. One relates to the inherent nature of the parachute itself. Other issues involve how these parachutes are used in model rockets, both in testing of parachutes as well as their use. Finally, there can also be issues with parachute specifications.

Issues

The Model Rocket Parachute

It turns out that the drag coefficient for common model rocket

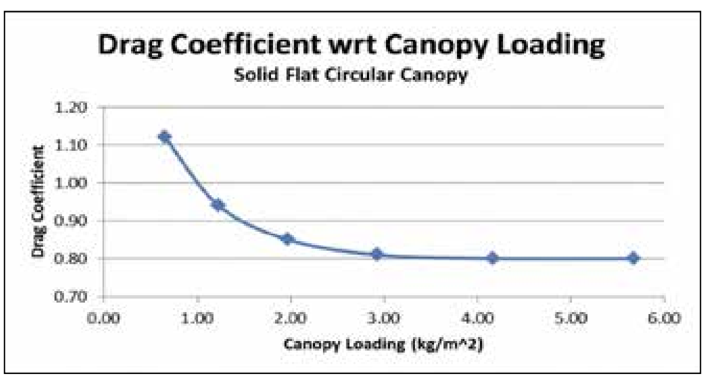

Figure 1. The drag coefficient for solid flat circular parachutes (the technical name for the common model rocket parachute) is shown with respect to canopy loading in kilograms per square meter. Graph is adapted from figure 5-18 of reference 5.

parachutes (technically called "flat circulars") is not a constant. It depends on how heavily the parachute is loaded. Canopy loading is the ratio of the recovered mass (the mass of the parachute and everything attached to it) to the area of the parachute.

Some early model rocket parachute research confirms this behavior. Doug Malewicki reported indoor drop tests with both commercial polyethylene models ("kit chutes") and some made from dry cleaner bag material. Lightly loaded parachutes glided in still air and descended slowly. Drag coefficients as high as C_D=2.2 were seen and thus the parachutes were clearly producing lift as well as drag. (Any vehicle that exhibits a steady state glide is producing lift.) More heavily loaded model parachutes oscillated, descended vertically, and exhibited lower drag coefficients. Unfortunately Malewicki's study as published does not contain enough data to yield a curve similar to Figure 1. [4].

This relationship between canopy loading and drag coefficient may be one reason why so many different values have been reported for the drag coefficient of standard model rocket parachutes –different investigators used different canopy loadings in their experiments.

Cautionary note: The data in figure 1 is not useful to most model rocketeers. The data originally came from a 1949 USAF study. The original study has been lost to time, so the exact nature of the models used in testing is unknown. The canopy material used in that time period was often permeable fabric, whereas model rocket parachute canopies are not. Were the canopies hexagons or octagons or polygons of even more sides? How many suspension lines did they have and how long were they? Did the models have apex vents ("spill holes")? All of this is not known. Figure 1 is indicative of the behavior of this type of parachute – but the actual values could vary somewhat.

Also, the data shown does not cover the range of canopy loadings most useful for model rocketry. G. Harry Stine's *Handbook of Model Rocketry* suggests the recommended canopy loading for model rockets should be less than one ounce of weight per 44 square inches of parachute area. In SI ("metric") units this limit is 1.0 kg/m2. There is little data in figure 1 covering this range.

The Model Rocket Itself

Aerospace Industry Parachute Drag Coefficient Testing

In the aerospace engineering world, the drag coefficient of a parachute can be determined in several ways. In a wind tunnel the parachute is mounted on a "sting" which relays data to the tunnel operator. Full scale systems can be dropped from aircraft with instrumented payloads. Drones may also be used to drop test small models. Models can also be drop tested in a hangar or the high

bay of a tall building.

None of these methods interfere with the parachute. A sting is a streamlined low profile device that produces only a small wake. Payloads used in drop testing are quite compact, produce only small wakes, and have no effect on the parachute.

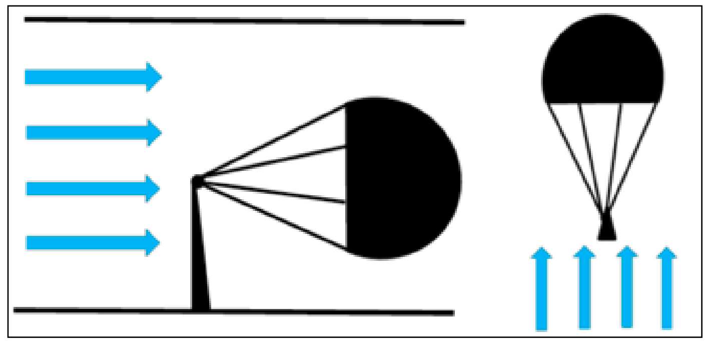

Figure 2. Wind tunnel testing (left) and drop testing both ensure "clean" airflow past the parachute being tested. There is no payload to affect parachute performance.

When parachutes are used to recover model rockets this is not true.

Forebody Wake Effects - Drag Loss and Turbulence

The distance from the leading edge (hem) of the parachute to the payload is called the rigging length. Studies have shown that a drag loss of more than 25% is possible when this distance is small, i.e., when the payload (forebody) is very close to the parachute [5]. Short rigging lengths are common in model rocketry, particularly in the case of low power models. Here the suspension lines of kit parachutes, often shorter than the canopy diameter, are connected directly to the nose cone. Short rigging lengths can cause loss

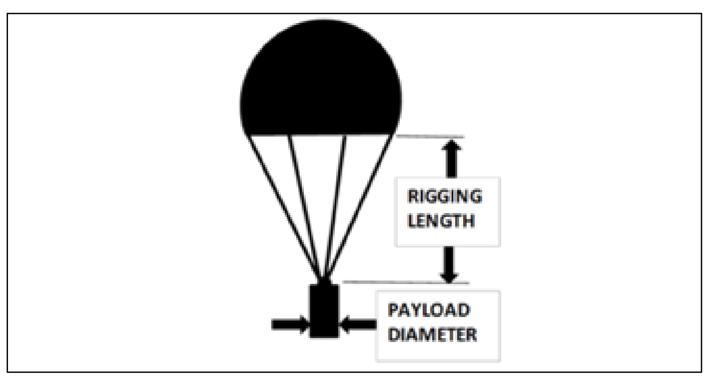

Figure 3. Rigging length

of drag.

Drag loss decreases as the distance between the parachute and the payload increases. For example, a short rigging length of only 5 payload diameters can cause a drag loss of up to 15%. If the rigging length is 10 times the payload diameter the drag loss can be 8%. A rigging length of more than 20 times the payload diameter causes negligible drag loss [5].

Another effect of the forebody is the turbulence it creates. During descent the parachute canopy "follows" the rocket. Trailing behind the rocket is a non-uniform turbulent wake, and the parachute does not experience "clean" airflow. This wake can cause buffeting of the canopy and affect parachute performance. Shorter rigging lengths increase this effect.

So rigging length may be one reason why so many different values have been reported for the drag coefficient of standard model rocket parachutes – rigging lengths used by investigators were different and drag loss and turbulence varied as a result.

Dynamic Parachute-Payload Interaction Effect

Model rocket payloads often have two components – nose and airframe – connected by bridles or risers. Often at least one of these risers or bridles is elastic. Furthermore, these payload components usually have very low ballistic coefficients (low mass 'm' and high drag area 'CDS') and as such are "aerodynamically active". They react to the relative wind caused by the descent and to any turbulence in the atmosphere.

The random actions of the payload disturb the parachute during descent. Canopy angle of attack can be affected. Elastic bridles encourage "bouncing" which varies the load on the parachute. The parachute may fly around in tight circles, or the chute may oscillate back and forth in pendulum fashion.

Reference 1 describes fifteen flights of the same model rocket configuration which produced descent rates over a range of 5 m/s

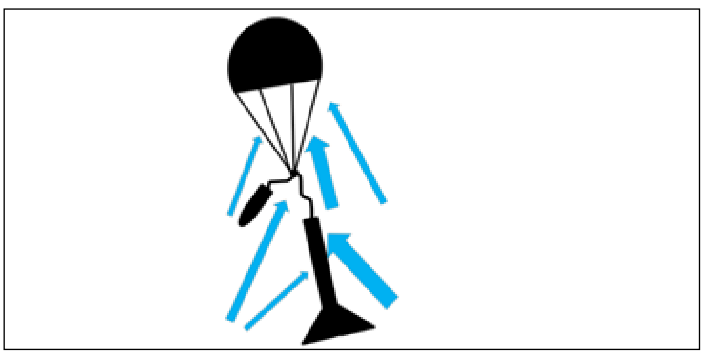

Figure 4. The parachute is likely affected by the dynamic actions of the model rocket itself as well as the turbulence and the drag loss it creates.

to 7 m/s and drag coefficients ranging from range of C_D=0.53 to C_D=1.04. As the canopy loading and rigging length were apparently constant in this study, the variation may be due to the random dynamic behavior of the payload components.

So the dynamic effect of multi-component payloads rigged differently from test to test could also explain why parachute drag coefficients determined by model rocket flight testing produce such a wide range of results.

When using model rockets for testing parachutes, these adverse effects can be minimized by recovering the airframe under a separate parachute [2], using long rigging lengths, and a compact payload.

In summary, shorter rigging lengths can cause drag loss and allow the turbulent wake of the payload to affect parachute performance. Multi-component payloads can exaggerate this effect. The dynamic behavior of multi-component payloads having low ballistic coefficients also interferes with parachute performance. (Note that truly steady state descents are rare, particularly is smaller rockets.) These issues create problems in using rockets to determine drag coefficients, and when using a drag coefficient to design a recovery system for a rocket.

Manufacturer/Vendor Issues

Nominal Area

The advertised size of a commercial parachute may be a "nominal" value rather than an actual value. This is similar to lumber. A length of 2" x 4" is called that, but it is not 2" x 4". Similarly a parachute advertised as an 18" chute may not be 18". And if it is, is this dimension across the flats or point to point? For example, a certain industry parachute is advertised as a 24" chute. Assuming that it is 24" "across the flats" and calculating the area from that dimension is inaccurate. The particular model in question is actually only 22.83" across the flats. This difference seems small but when the area is calculated the true area is less than 91% of the area calculated using the nominal dimension of 24".

Drag Area and Reference Area

The drag area of a parachute system is the drag coefficient 'C_D' multiplied by the area 'S', that is – C_DS. Drag area is important because the larger the drag area, the slower the descent of the system. For any particular parachute-payload system the drag area is a *constant*, i.e., $C_DS=k$. When specifying a drag coefficient a vendor must also specify an area of the parachute. This is then called the *reference area*. If the vendor chooses a large reference area for a system then the resulting drag coefficient can be small, and vice versa. In theory, any area can be selected as the reference area.

For example, one manufacturer that makes the typical model rocket parachute might choose the actual flat area of the chute as the reference area and publish a drag coefficient referenced to that flat area. Another manufacturer of the identical parachute might choose the (much smaller) inflated area of the parachute as the reference area. This allows the second manufacturer to claim a much larger drag coefficient. However the parachutes are identical and have the same drag area. So it is important to know the reference area when a drag coefficient is provided.

Sometimes the reference area is fairly obvious. For the polygonal model rocket parachute discussed here the reference area is generally the flat area of the parachute. But verify.

Although not important to this discussion of the common “flat circular” model rocket parachute, note that some parachutes have unusual “3D” geometries and therefore manufacturers must choose a suitable reference area.

Finally, note that manufacturers cannot now acknowledge the

Figure 5. The T-11 paratrooper parachute has a complex canopy structure. What is the reference area here? The square top? The total “wetted” area? The reference area must be specified when providing a drag coefficient of a parachute (DoD photo).

effect of canopy loading on model rocket parachute drag coefficients due to the lack of data as discussed above. If this information ever becomes available it should be provided along with reference area and drag coefficient.

Summary/Recommendations

If and when data regarding the variation in model rocket parachute drag coefficient due to canopy loading becomes available, take it into account when designing a recovery system.

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by Dave Flanagan

Use long risers or bridles to increase the rigging length. Avoid elastic bridles (shock cords) where possible.

Recover the airframe separately when using rockets to test parachutes.

Know the reference area associated with the drag coefficient when dealing with parachutes.

Finally, some patient, careful, dedicated researcher needs to investigate model rocket parachute drag coefficients at the very low canopy loadings more suited to the hobby.

Extra for Experts

In steady state descent (ΣF=0) the drag equation is

$$W = mg = \frac{\rho}{2} v^2 C_D S = D$$

In this equation 'ρ' is the air density (1.22 kg/m^3) and 'g' is the acceleration of gravity (9.81 m/s^2) in standard conditions. Total system mass is 'm', parachute area is 'S', 'v' is the rate of descent, and 'C_D' is the drag coefficient. As just one degree of freedom is of interest the vector nature of the equation is suppressed.

Canopy Loading

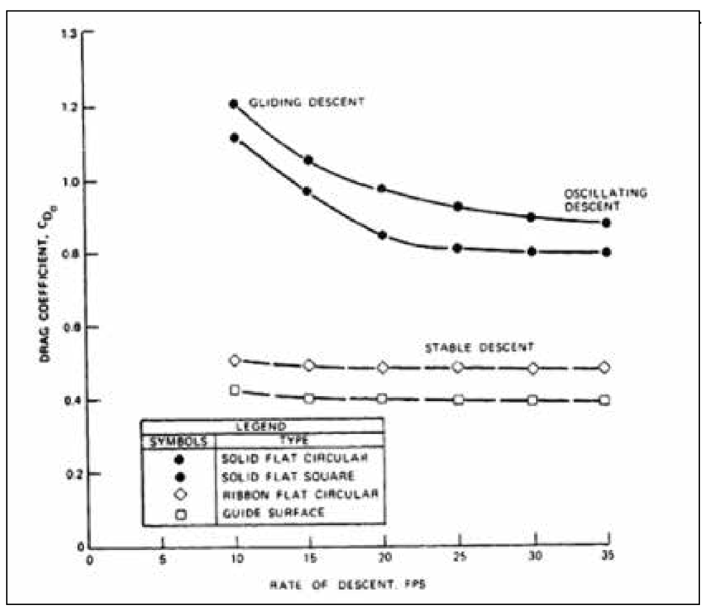

Figure 6. Drag coefficients of unstable (upper pair of curves) and stable parachutes with respect to rate of descent are shown. Solid flat circular parachutes (standard model rocket parachutes) are considered unstable. Graph is figure 5-18 from reference 5.

opy loading (m/S). The canopy loading for each data point given is determined as follows.

Solving the two middle terms of the steady state drag equation for the canopy loading

$$\frac{m}{S} = \frac{\rho v^2 C_D}{2g}$$

The velocity (rate of descent, ft/s) 'v' and the drag coefficient 'C_D' are obtained by careful examination of the graph in Figure 6. This creates the first two columns in Table 1 below. Converting the velocity in the first column to SI (metric) units gives column 3. Columns 2 and 3 are used with the equation above to obtain the canopy loading shown in column 4.

	Solid Flat Circular		
V	Cd	v	m/S (calc)
ft/s		m/s	kg/m^2
10	1.12	3.05	0.65
15	0.94	4.57	1.22
20	0.85	6.10	1.97
25	0.81	7.62	2.93
30	0.80	9.15	4.17
35	0.80	10.67	5.67

Ballistic Coefficient

Table 1. The first two columns are obtained from Figure 6. Figure 1 is created by using the fourth column as the x-axis and the second column as the y-axis.

The ballistic coefficient is the ratio of the mass of a vehicle to its drag area (m/C_DS). Payload components having lower ballistic coefficients (most model rocket components) are more subject to turbulence during descent. As an aside, the terminal velocity of an aerodynamic vehicle is directly proportional to the square root of its ballistic coefficient. Solving the drag equation for velocity

$$v^2 = \frac{2mg}{\rho C_D S} = \left(\frac{2g}{\rho}\right)\frac{m}{C_D S}$$

And letting k2 represent the constants (2g/ρ) and taking the square root of both sides

$$v = k\sqrt{\frac{m}{C_D S}}$$

Area

The formula for the actual total area of the common model rocket parachute (a regular polygon) is

$$S = \left[n \tan\left(\frac{180}{n}\right)\right] r_i^2$$

where n is the number of sides of the polygon (n=6 for a hexagon, n=8 for an octagon, etc.) and ri is the radius of the inscribed circle. If 'n' is an even number then r_i is half the distance "across the flats". This actual area is the usually reference area for this type of parachute.

Reference Area

The drag area can be isolated as follows

$$C_D S = \frac{2mg}{\rho v^2}$$

All values on the right had side of the equation are constant for a particular parachute-payload system. Therefore any adjustment of the area S requires an adjustment of the value for the drag coefficient for the equality to hold. This lets a vendor choose a small reference area and therefore claim a large drag coefficient. Some vendors may use the much smaller inflated area of a model rocket parachute as the reference area. In full scale flat circular parachutes the inflated diameter is only about 70% of the diameter when laid flat.

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Acknowledgements

The author would like to thank Steve Riegel of *Front Range Rocket Recovery* for reviewing an early draft of this article. The author is also grateful to Terry Dean who was the first of several to provide the on-line link to reference 4.

About The Author

Dave is a retired professional engineer with over twenty years of aerospace experience at NASA's JSC and MSFC. He holds BSME and MSE degrees and a BS degree in science, and while at MSFC supported NASA's University Student Launch Initiative. Although no longer actively jumping, he holds an expert skydiver rating and graduated from airborne school in the Army. Dave is an FAA certified master parachute rigger and has completed the AIAA Parachute Systems Technology Short Course. He is a licensed private pilot and an EAA certified ultralight pilot. Dave lives in North Carolina and spends most of his time scuba diving and kayaking but does fly rockets, usually ones recovered by very weird looking parachutes.

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We are always looking for quality articles to publish in the *Peak-of-Flight* newsletter. Please submit the "idea" first before you write your article. It will need to be approved first.

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Always include your name, address, and contact information with all submissions. Including best contact information allows us to conduct correspondence faster. If you have questions about the current disposition of a submission, contact the editor via email or phone.

CONTENT WE ARE LOOKING FOR

We prefer articles that have at least one photo or diagram for every 500 words of text. Total article length should be between 2000-4000 words and no shorter than 1750 words. Articles of a "how-to" nature are preferred (though other types of articles will be considered) and can be on any rocketry topic: design, construction, manufacture, decoration, contest organization, etc. Both model rocket and high-power rocket articles are accepted.

CONTENT WE ARE NOT LOOKING FOR

We don't publish articles like "launch reports." They are nice to read, but if you don't learn anything new from them, then they can get boring pretty quick... Example: "Bob flew a blue rocket on a H120 motor for his certification flight." As mentioned above, we're looking for articles that have an educational component to them, which is why we like "how-to" articles.

You can see what articles and topics we've published before at: **https://www.apogeerockets.com/Peak-of-Flight?pof_list=archives&m=education**. You might use this list to give you an idea or two for your topic.

Here are some of the common articles that we reject all the time, because we've published on these topics before:

- How to get a L1, L2, or L3 Cert
- Building cheap rockets and equipment (pads & controllers)
- How to 3D print parts, or a Rocket Kit
- How to Build a cheap Rocket Kit
- Getting Back Into Rocketry After a Long Hiatus

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Articles may be submitted by emailing them to the editor. Article text can be provided in any standard word processor format, or as plain-text. Graphics should be sent in either a vector format (Adobe Illustrator, SVG, etc.) or a raster format (such as jpg or png) with a width of at least 600 pixels for single column images or 1200 pixels for two-column images. It is preferable for images to be simple enough to be readable in a two-column layout, but special layouts can be used.

Send the images separately via email as well as show where they go by placing them in the word processor document.

ACCEPTANCE

Submitted articles will be evaluated against a rubric (available here on our website). All articles will be evaluated and the results will be sent to the author. In the evaluation process, our goal is to ensure the quality of the content in *Peak-of-Flight*, but we want to publish your article! Resubmission of articles that do not meet the required standard are heavily encouraged.

ORIGINALITY

All articles submitted to Peak-of-Flight must not run in another publication before inclusion in the *POF* newsletter, but it may be based on another work such as a prior article, R&D report, etc. After we have published and paid for an article, you are free to submit them to other publications.

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