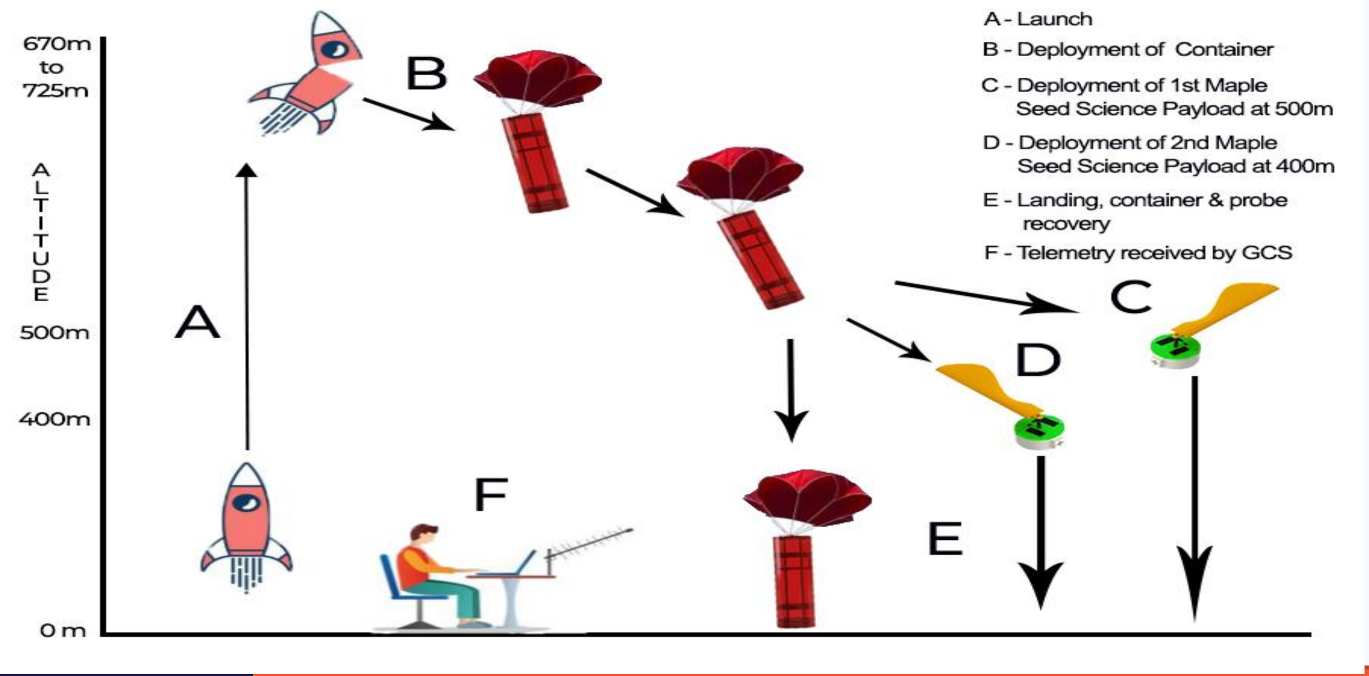
Descent Control Systems

- So up until now you have been learning about the electronic components and various related nitty gritties.
- After your last lecture on PCBs and Power Budget, the series will now cover the mechanical aspect of SATCAN!
- We will be telling you about the parachute, descent control mechanisms, payload structures and manufacturing of your SATCAN!

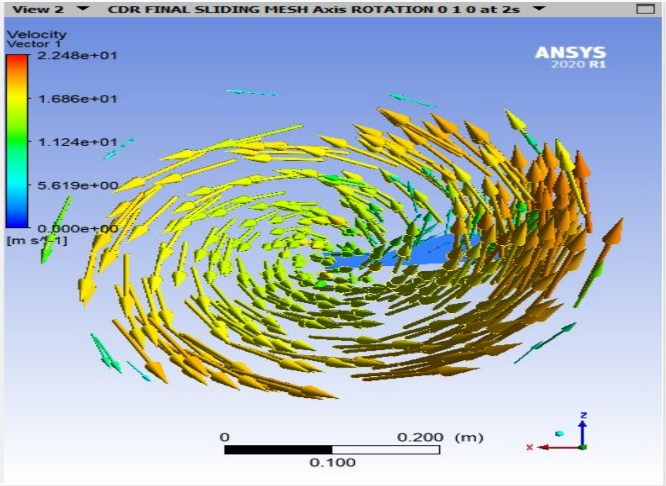
DESCENT CONTROL

Let's take the example of our CANSAT:



PAYLOAD PROTOTYPE

WING

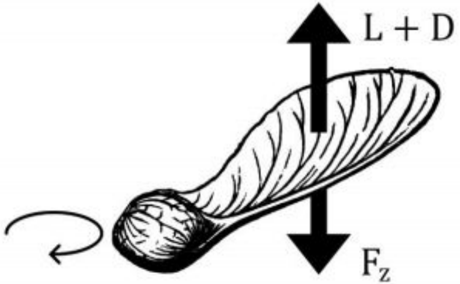


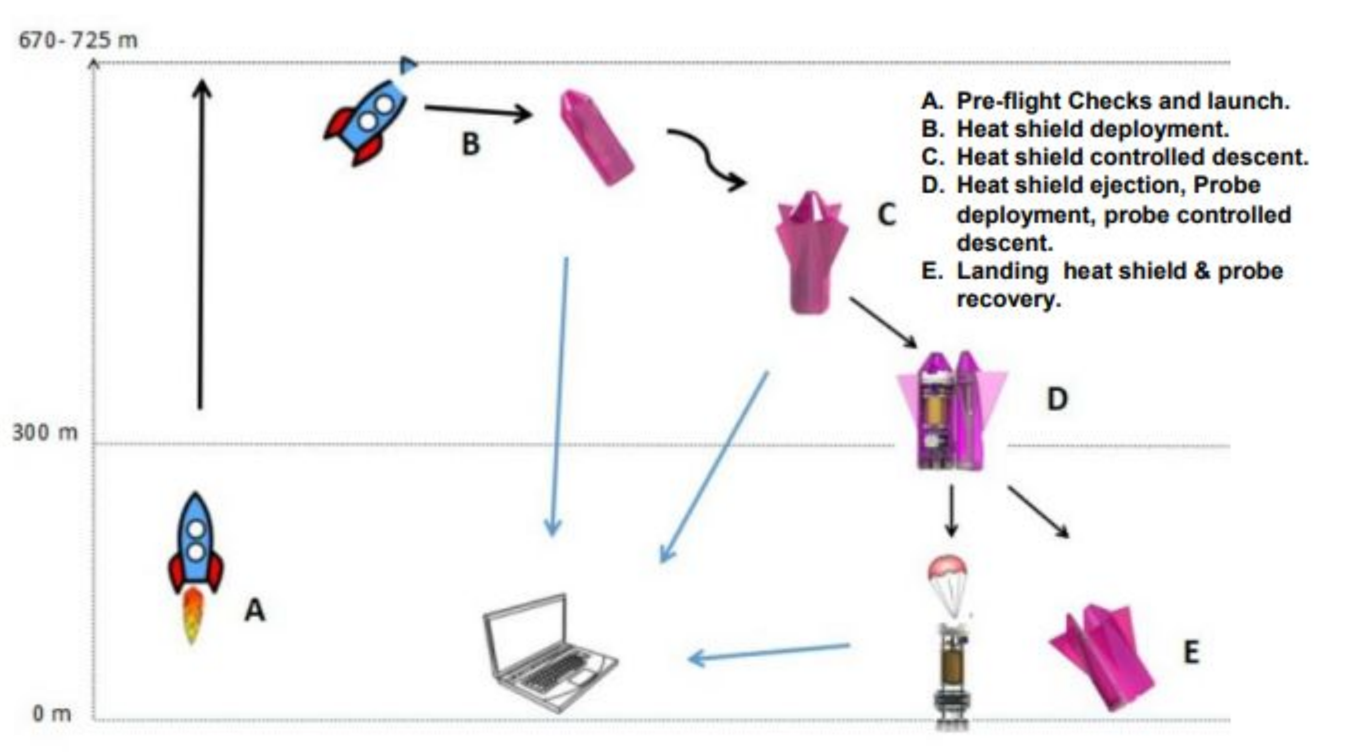
PAYLOAD CALCULATIONS

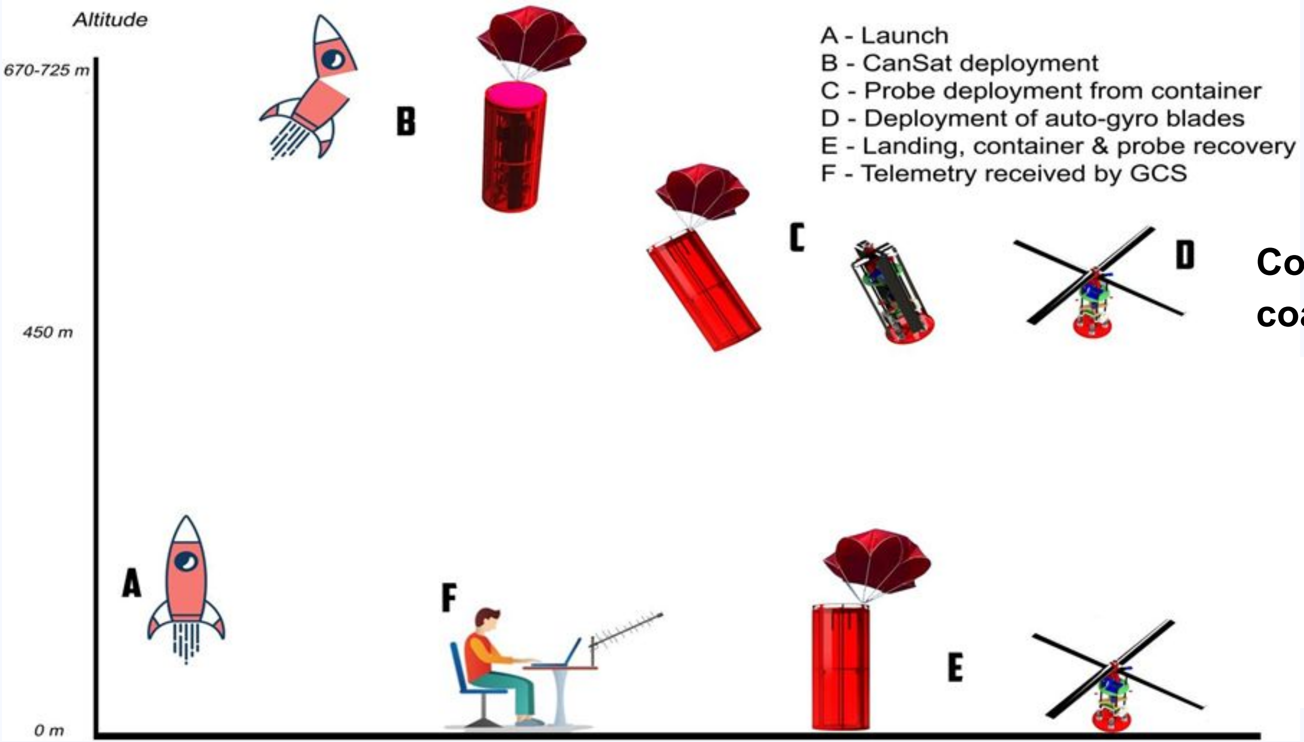
force balance can be mathematically stated.

$$F_z = L + D$$

$$\Sigma F = 0 \Rightarrow mg = \quad Lift \quad + (\tfrac{1}{2}\rho v^2 S_{frontal} C_d)$$



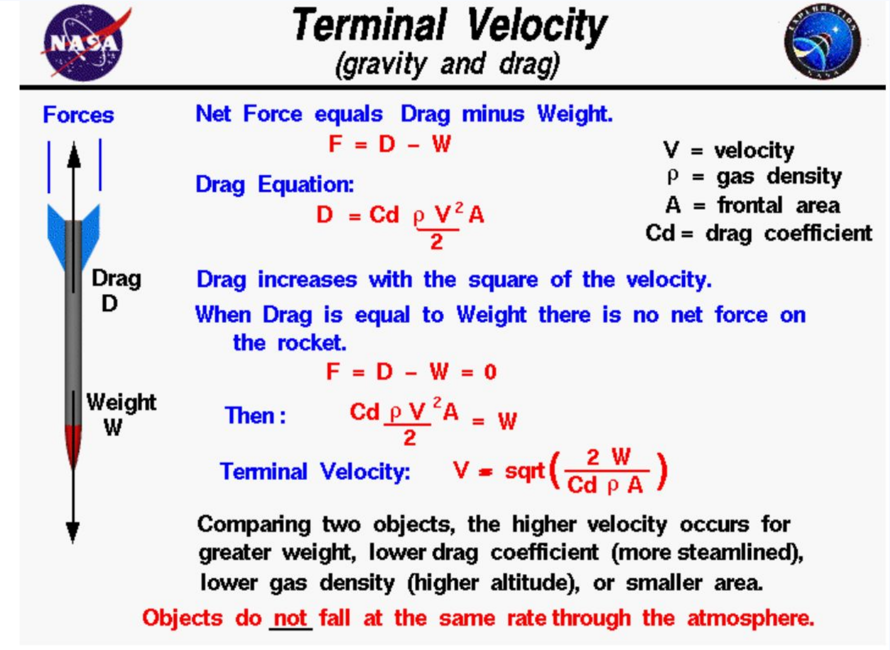

670-725 m
300 m
0 m
A
B
C
D
E
A. Pre-flight Checks and launch.
B. Heat shield deployment.
C. Heat shield controlled descent.
D. Heat shield ejection, Probe deployment, probe controlled descent.
E. Landing heat shield & probe recovery.



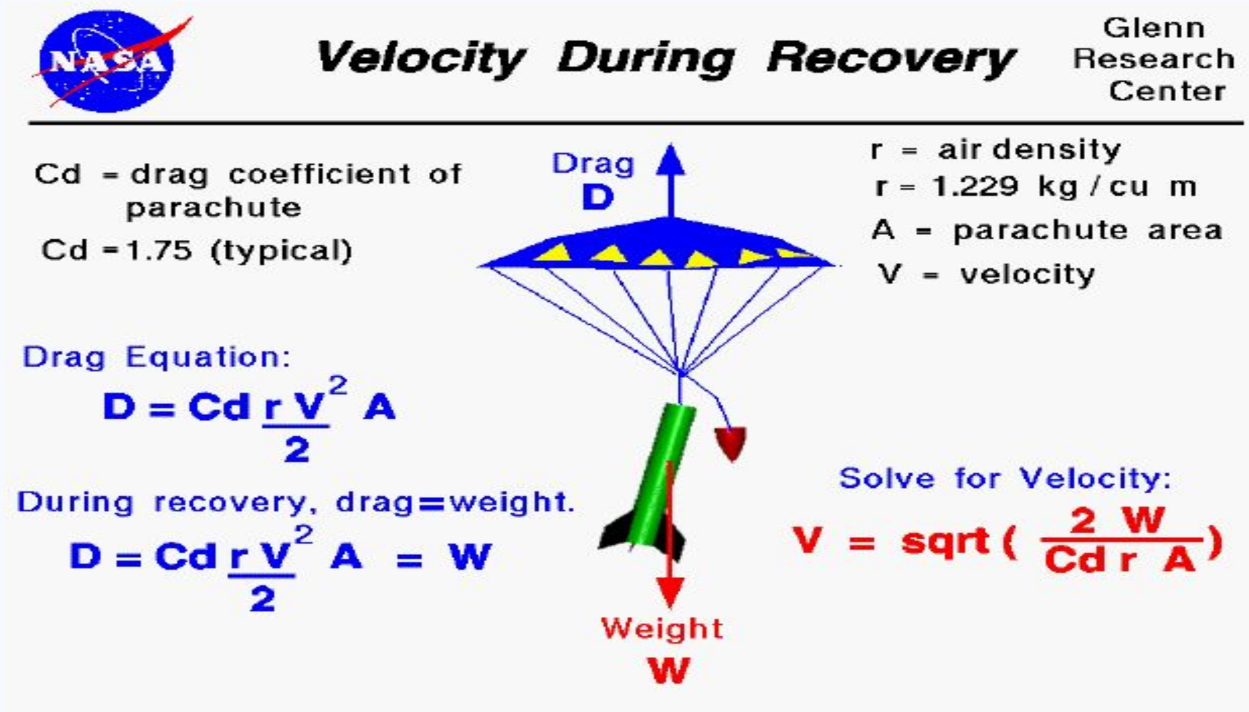
Contra-rotating coaxial rotors

Terminal velocity

Terminal velocity is the maximum constant velocity attainable by an object as it falls through a fluid



HOW DO PARACHUTES WORK?



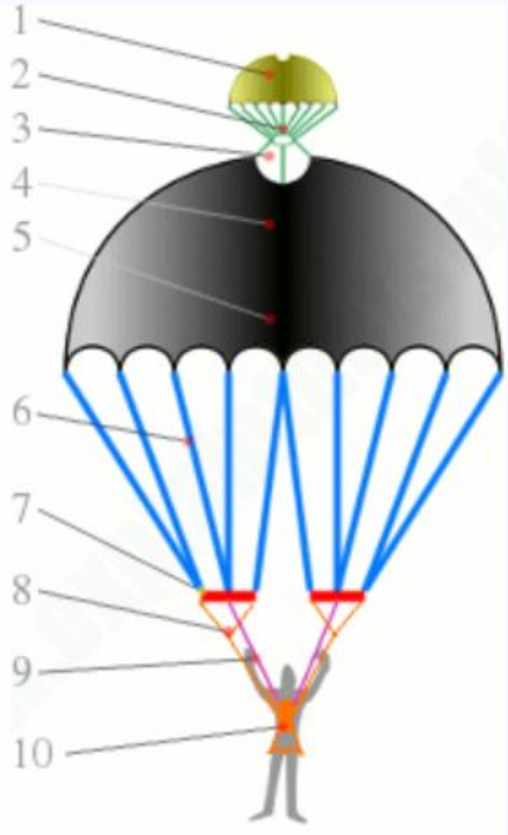
Components of a Parachute

The design and construction of a parachute and its components are based on the old idea that a chain is only as strong as its weakest link.

Every component, or link from the jumper to the canopy must carry its share of the maximum load that is applied during the opening shock

Parts of a Parachute

1. Pilot chute
2. Bridle
3. Apex or top vent
4. Canopy
5. Skirt
6. Suspension lines:
7. Links
8. Risers
9. Control lines
10. Harness and container



Parachute Types

Solid Textile Parachutes

- Parachutes with canopies fabricated mainly from cloth materials
- Typically these types of parachutes have no openings other than the vent
- Relatively easy to manufacture

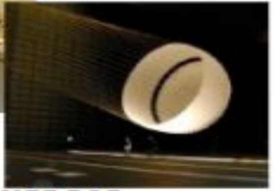
We'll be using solid parachutes

Guide Surface Parachute

Slotted Textile Parachutes

- Parachutes with canopies fabricated from either cloth materials or ribbons
- These types of parachutes have extensive openings through the canopy in addition to the vent
- Can be expensive to manufacture
- Most common parachute type used in planetary exploration missions

Galileo Ribbon Parachute



MER DGB Parachute

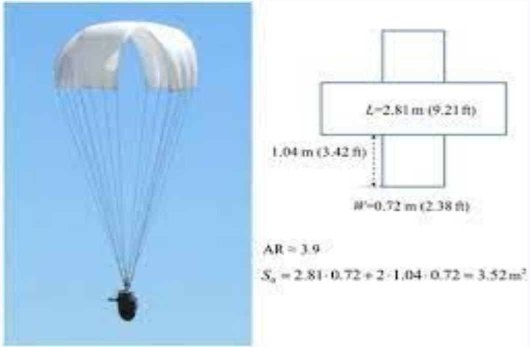
TYPES

Some of the following canopies are rarely, if ever, used these days. However, it always pays to know your stuff.

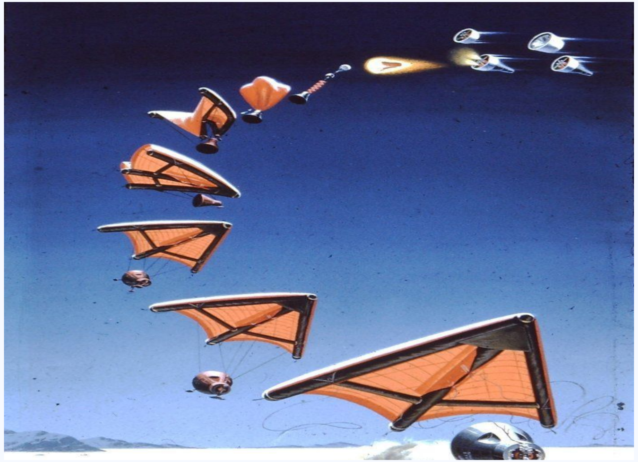
Parachutes are divided into two types – ascending and descending; descending varieties are used during fall. Ascending refers mostly to paragliding

- Round-type parachutes
- Cruciform parachutes
- Rogallo-wing parachutes
- Annular parachutes
- drogue parachute

Round



Cruciform



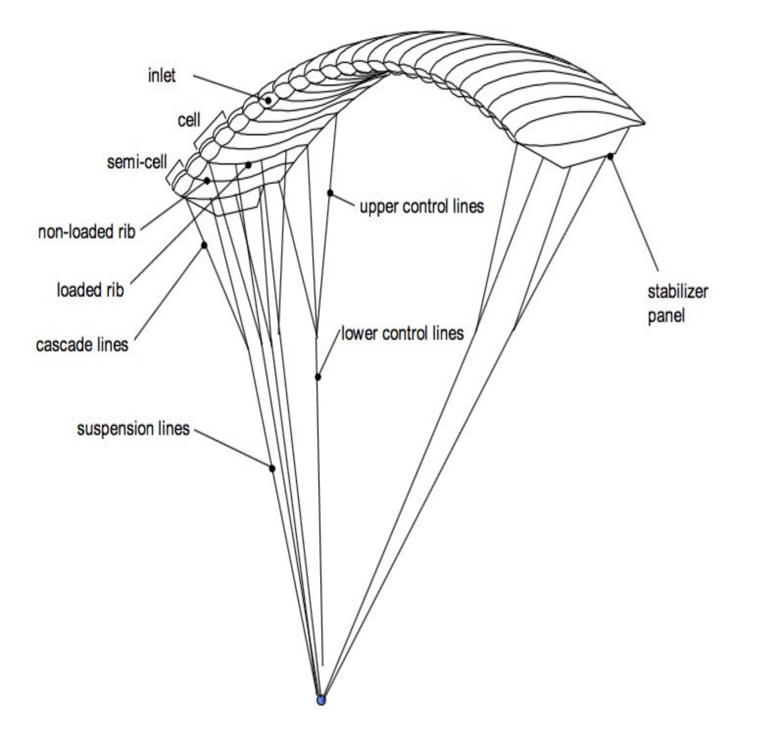
Rogallo

Annular

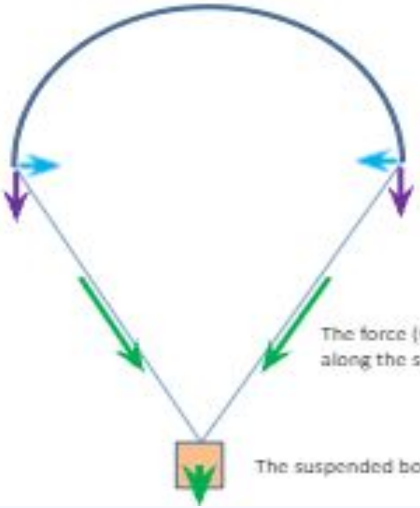
Ram-Air

How are ram air parachutes the best?

- A ram-air parachute looks like a **low-aspect ratio wing** once it is inflated,
- The **ellipsoidal shape is maintained** by *airfoil-shaped ribs* stitched chord-wise to the upper and lower membranes and disposed at regular span-wise intervals
- Suspension lines are usually attached to every other rib to reduce drag. They are used to steer the parachute. A cell is demarcated by two **loaded ribs**
- The leading edge is usually open across the whole span to allow the **inflation mechanism** to take place.
- By this means, the air inside the canopy reaches stagnation pressure and the positive outwards difference of pressure results in the canopy maintaining its inflated shape.



What keeps the parachute open?

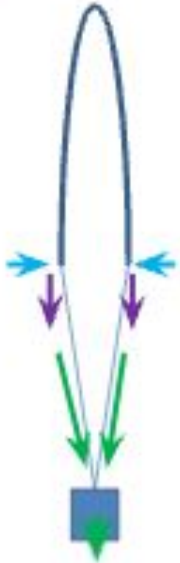


The force applies a vertical force component and a horizontal force component to the base of the canopy.

The force (weight) is transferred along the suspension lines.

The suspended body has weight.

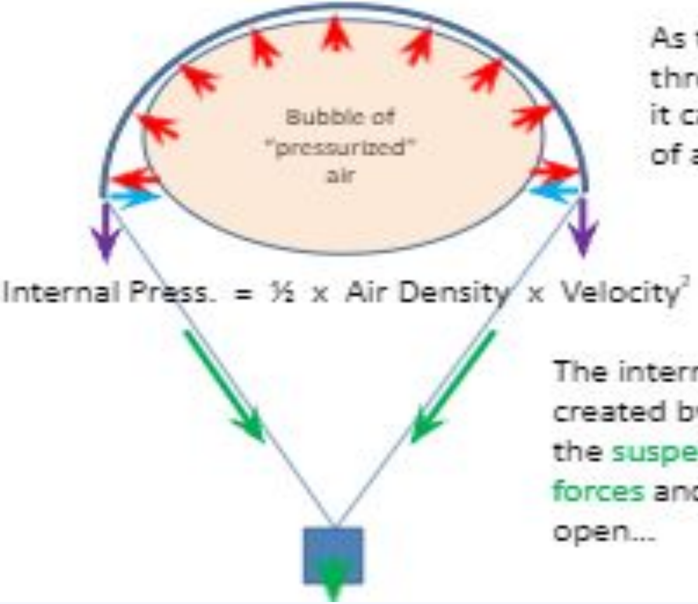
What keeps the parachute open?



These forces tend to pull the canopy closed...

Which is not a good thing to see if you are a sky diver...

What keeps the parachute open?



As the canopy moves through the atmosphere it captures a huge bubble of air.

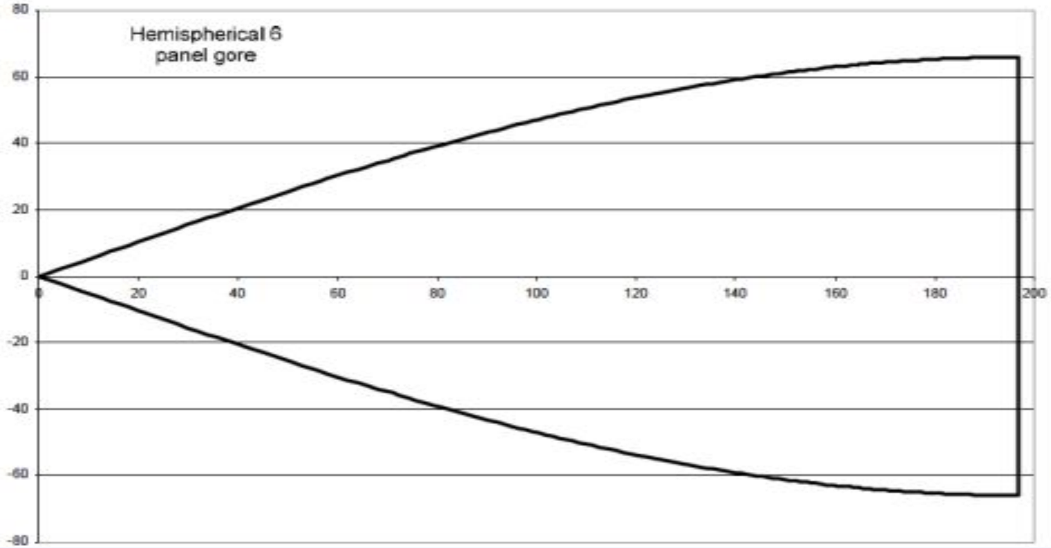
The internal pressure forces created by this bubble offset the suspension line tension forces and the canopy stays open...

PARACHUTE TESTING

1. Measure the canopy area
2. Measure the system weight
    - This will be the assumed system drag (assuming the system falls at terminal velocity during the tests)
    - **Caution** – too much suspended weight may prevent terminal velocity from be achieved quickly enough
3. Conduct drop tests
    - Make 5-10 drops for each configuration – record fall times
4. Calculate average fall times and associated descent velocities
5. Calculate Drag Coefficients
6. Tabulate and assess results

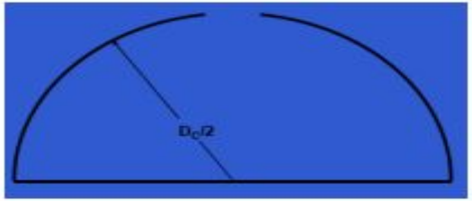
PARACHUTE SHAPES

- **Hemispherical parachute:**
  - Deployed canopy takes on the shape of a hemisphere.
  - Three dimensional hemispherical shape divided into a number of 2-D panels, called gores

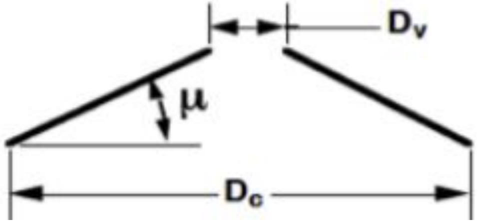


- Angle subtended on the left hand side of the pattern is 60 degrees

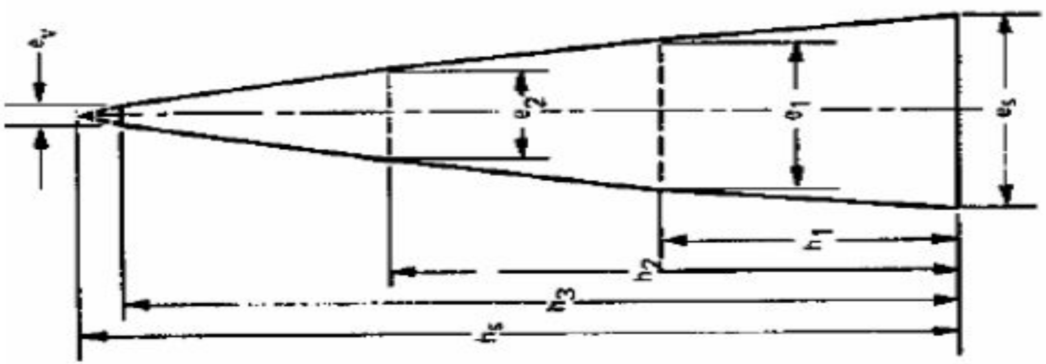
- When all six gores are joined they complete the 360 degree circle.



- **Conical Parachute**
  - 2-D Canopy shape in form of a triangle

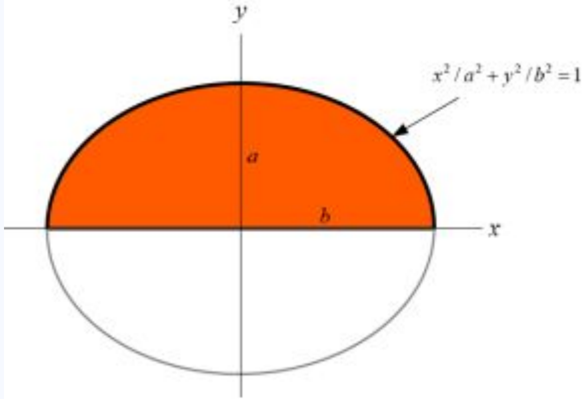


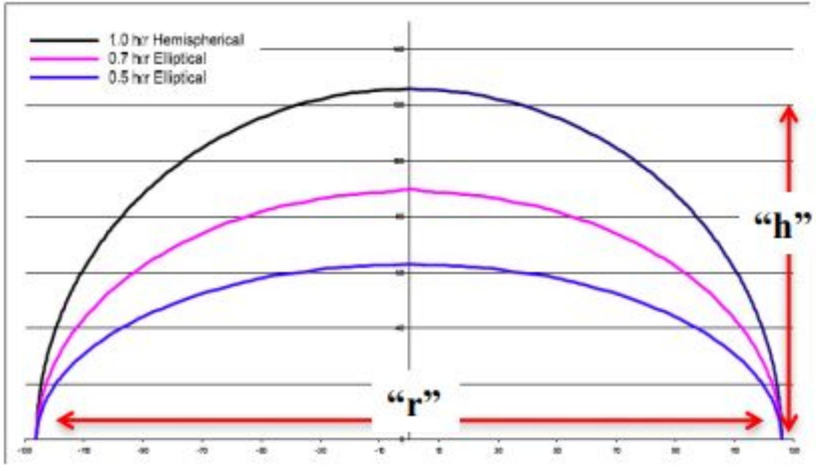
- **Conical Parachute Gore Shape**
  - 2-D Canopy shape in form of a triangle



- ***Higher drag coefficient than hemispherical parachutes, but also less stability***

- **Elliptical parachute:**
  - Parachute where vertical axis is smaller than horizontal axis
  - A parachute with an elliptical canopy has essentially the same CD as a hemispherical parachute, but with less surface material





Canopy profile for different height / radius ratios

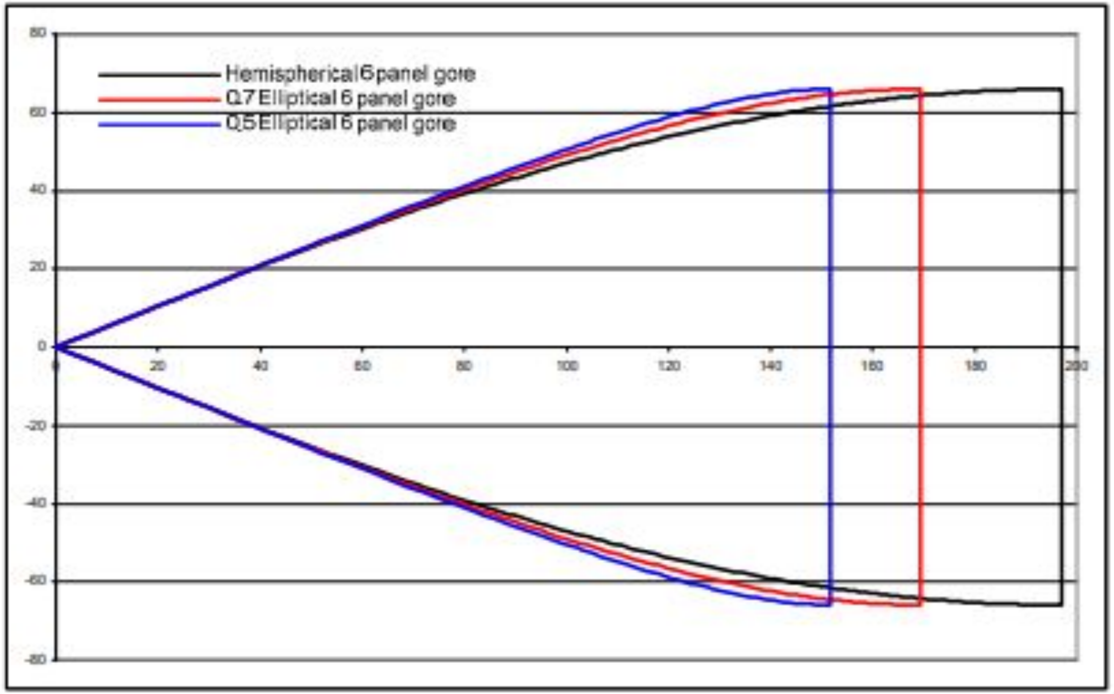


Diagram 5 - Comparison of gore shapes for different height:radius ratios

★ **SQUARE SHAPED**

PROS:

- High Cd
- Balanced load distribution

CONS:

- High probability of drift
- Difficult to fabricate

★ **ELLIPTICAL (WITH SPILL HOLE)**

PROS:

- Easy to steer
- Reduced swaying

CONS:

- Difficult to fabricate

★ **X TYPE:**

PROS:

- Reduced swaying
- Easy to fabricate

CONS:

- Low Cd

★ **DOME SHAPED (WITH SPILL HOLE)**

PROS:

- Reduced swaying
- Easy to fabricate
- Less deployment time

CONS:

- -------

CONCLUSION:

Dome shaped parachute with a spill hole was chosen considering the following requirements:

1. Low radius
2. High Cd
3. Light weight
4. Economical
5. Ease of Fabrication

- A spill hole whose radius will be 5% of the radius of the parachute will be introduced to the parachute to reduce swaying and produce a stable oriented flight.
- Since the radius of the parachute calculated is related to the surface that acts in producing the drag,the total radius of the parachute is increased by 5%.

THANK YOU