A quick guide to small superpressure

https://github.com/richardeoin/a-quick-guide

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Superpressure is..

- Gas sealed within the envelope.
- Envelope is intended to be inelastic.

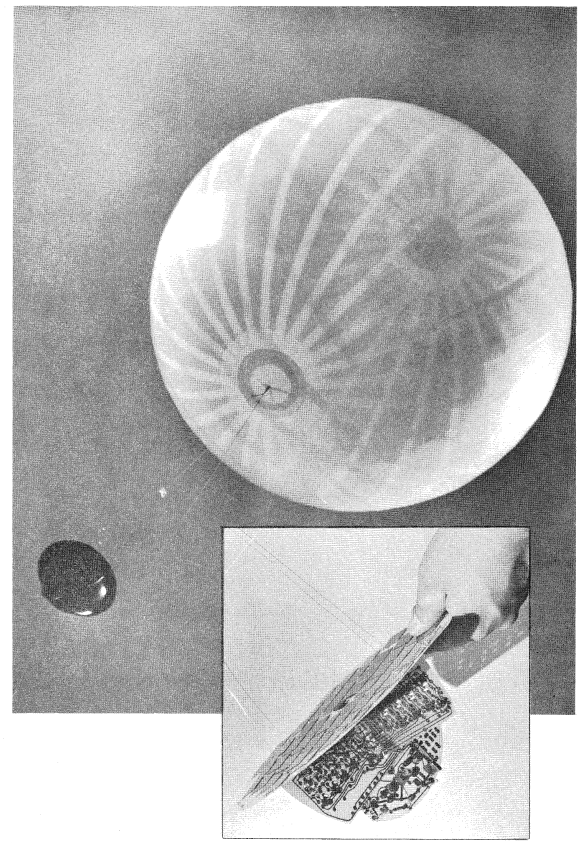


Figure : GHOST Balloon, Lally 1967

Can Amateurs do this too?

- Yes!
- See also Dan Bowen at UKHAS 2011.

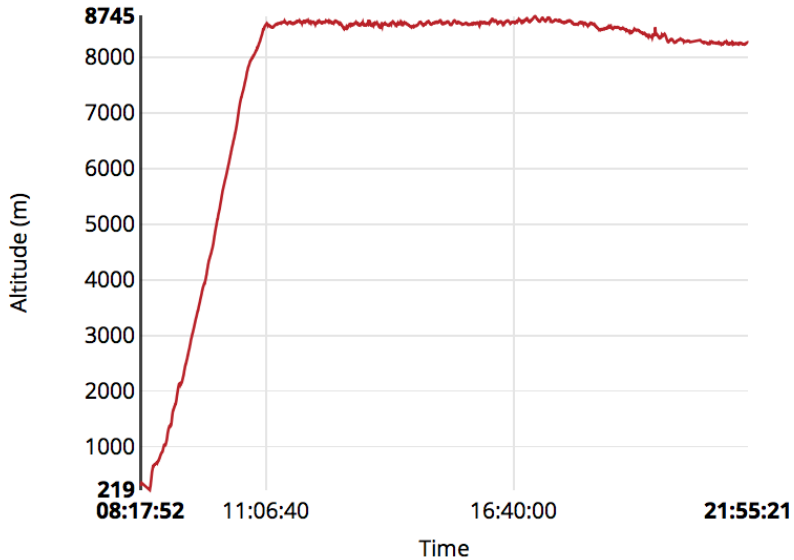


Figure : UBSEDS6, 7th June 2015

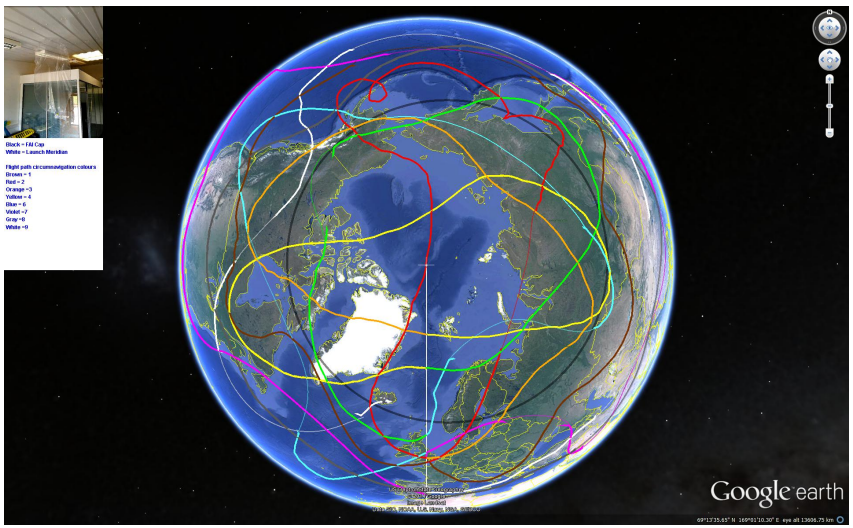


Figure : B-64, Leo Bodnar 2014

In Flight

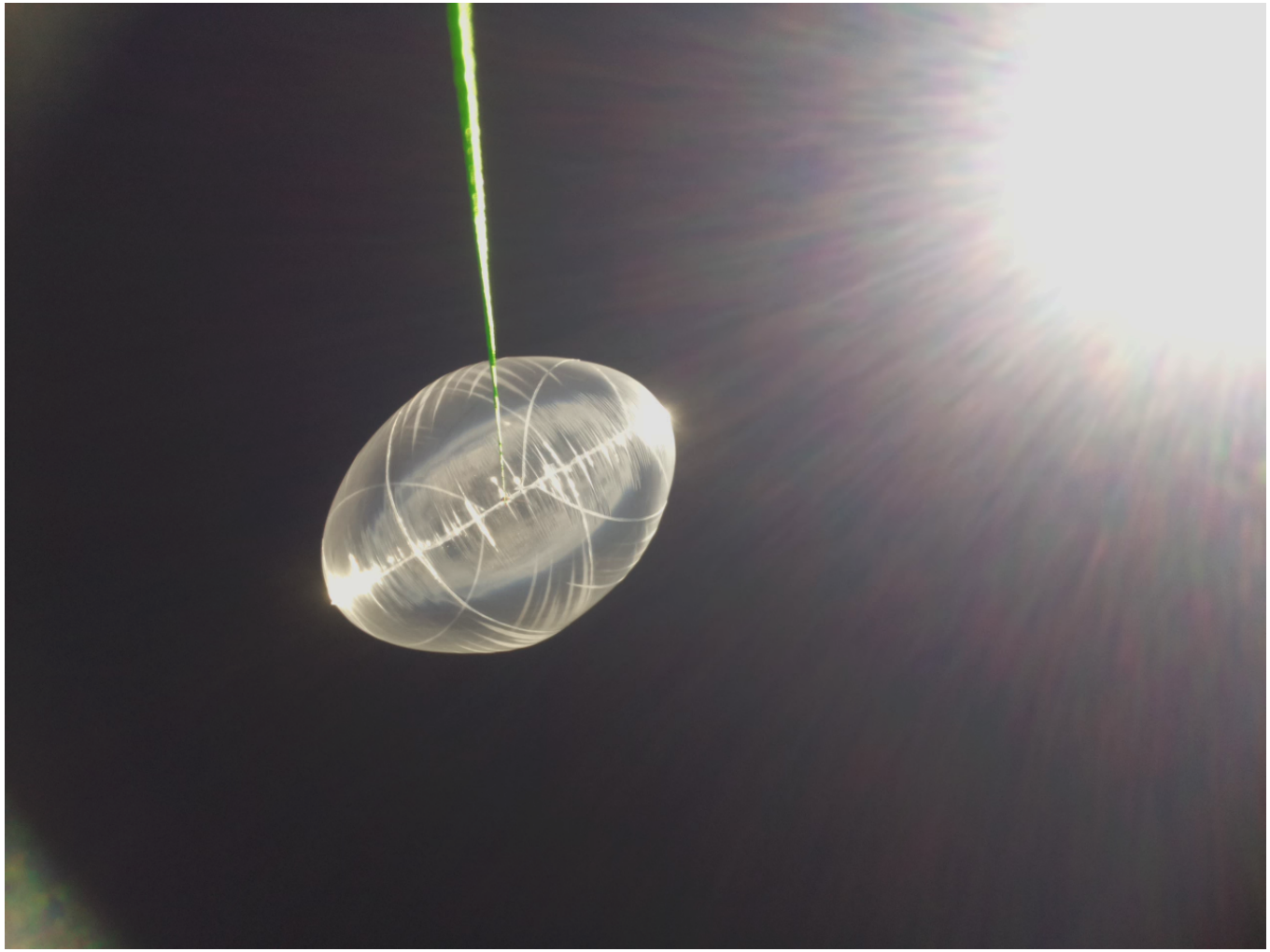


Figure : UBSEDS20 balloon at 12.5km float, 29th August 2016

Floating

Float when:

$$\text{Atmospheric Density} = \text{System Density} = \frac{\Sigma m}{V}$$

However, the balloon envelope stretches somewhat:

$$V = V_{initial} \times \Gamma$$

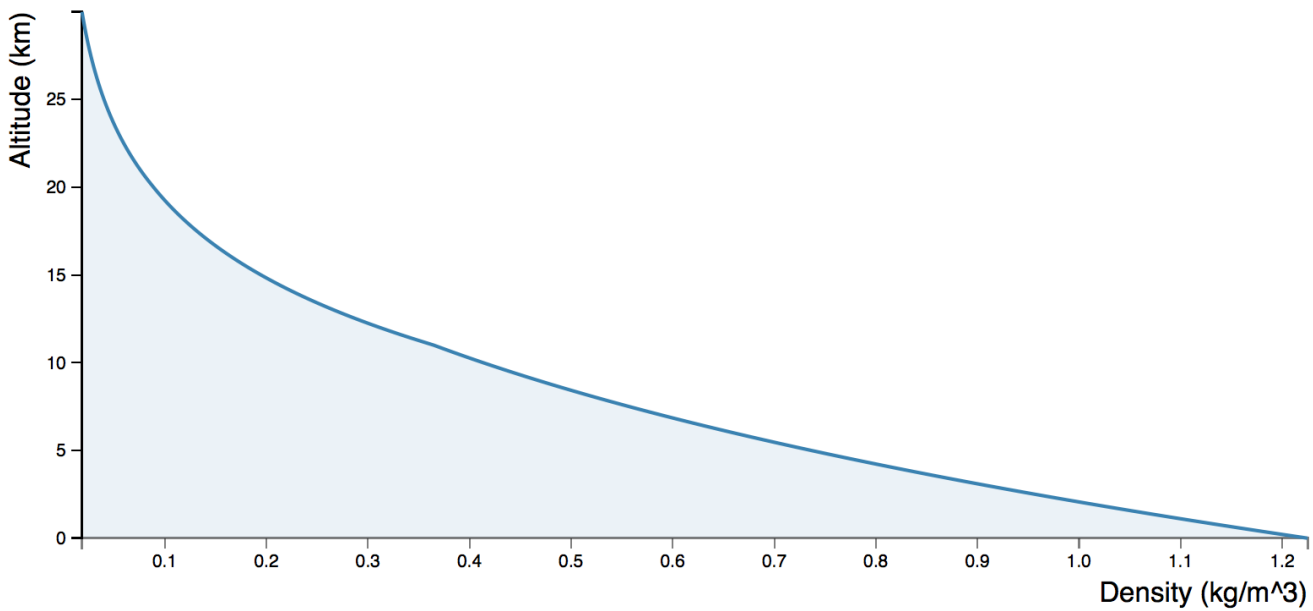


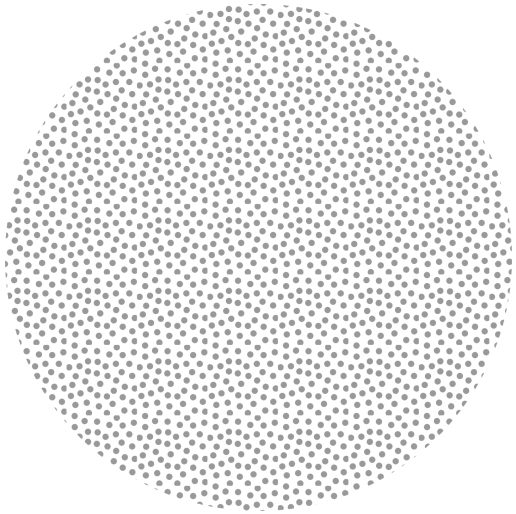
Figure : Density in the International Standard Atmosphere

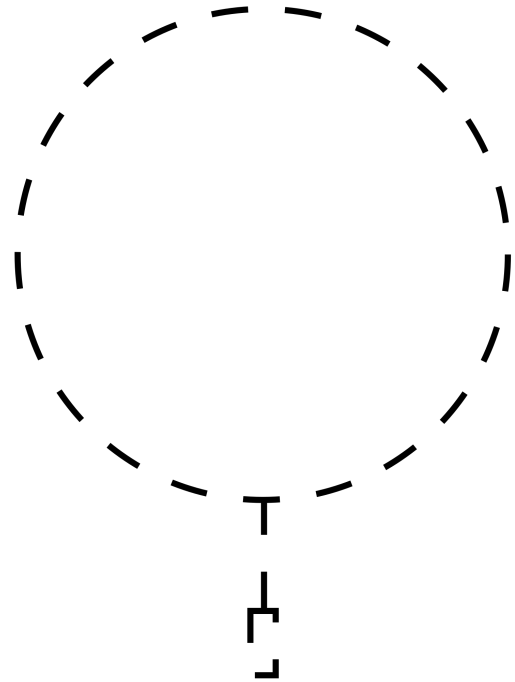
The Origins of Superpressure

- Free lift
- Supertemperature
- Vertical Air Currents (Lally 1967, VI. D. p.31)

Calculating Superpressure 1

Ideal gas law $PV = nRT$





$$P_{gas}V = \frac{m_{gas}}{M_{gas}}RT_{gas}$$

$$P_{air}V = \frac{m_{system}}{M_{air}}RT_{air}$$

Calculating Superpressure 2

Definitions of Superpressure and Supertemperature:

$$P_{super} = P_{gas} - P_{air}$$

$$T_{super} = T_{gas} - T_{air}$$

Assuming volumes are equal:

$$P_{super} = \frac{R}{V}\left[\left(\frac{m_{gas}}{M_{gas}} - \frac{m_{system}}{M_{air}}\right)T_{air} + \frac{m_{gas}}{M_{gas}}T_{super}\right]$$

The second term dominates, so:

$$\frac{P_{super}}{T_{super}} \approx \frac{m_{gas}}{M_{gas}}\frac{R}{V}$$

Supertemperature

Table 9

RADIATION ENVIRONMENT FOR SUPERPRESSURE BALLOON

Altitude	Season	Air Temperature °C	Mylar balloon (α_o = 0.05)		
			Temperature increase per w/m² increment, °C	Maximum added solar flux w/m²	Maximum daytime temperature increase, °C
9 km (300 mb)	Temperate, winter	-50	0.36	40	14
	Temperate, summer	-35	0.34	40	13
	Tropic	-30	0.34	40	13
12 km (200 mb)	Temperate, winter	-55	0.36	45	16
	Temperate, summer	-55	0.36	45	16
	Tropic	-50	0.36	45	16
16 km (100 mb)	Temperate, winter	-60	0.42	45	19
	Temperate, summer	-65	0.42	45	19
	Tropic	-80	0.47	45	21
24 km (30 mb)	Temperate, winter	-55	0.45	45	20
	Temperate, summer	-55	0.45	45	20
	Tropic	-55	0.45	45	20

Figure : Lally 1967, Table 9 p.24 (edited)

Mylar Balloon Shape 1

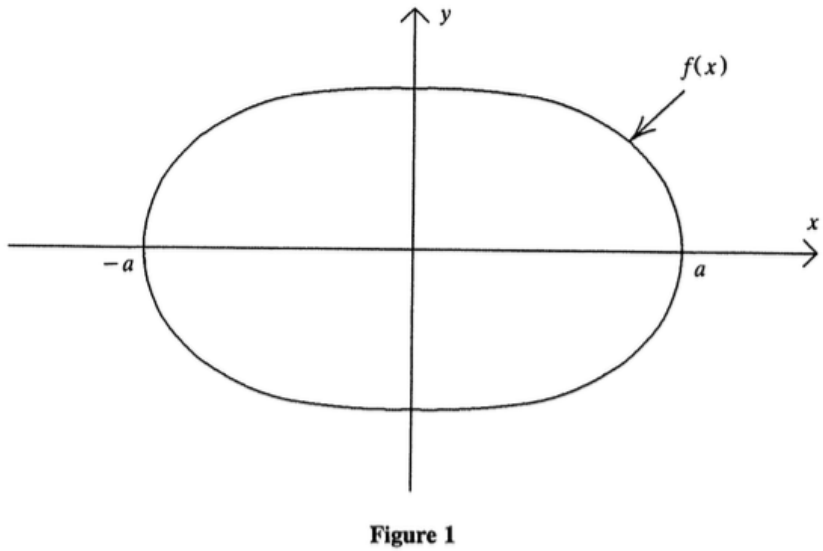


Figure 1

Figure : Paulsen 1994, Figure 1

$$\int_0^a \sqrt{1 + f'(x)^2}\, dx = r$$

Mylar Balloon Shape

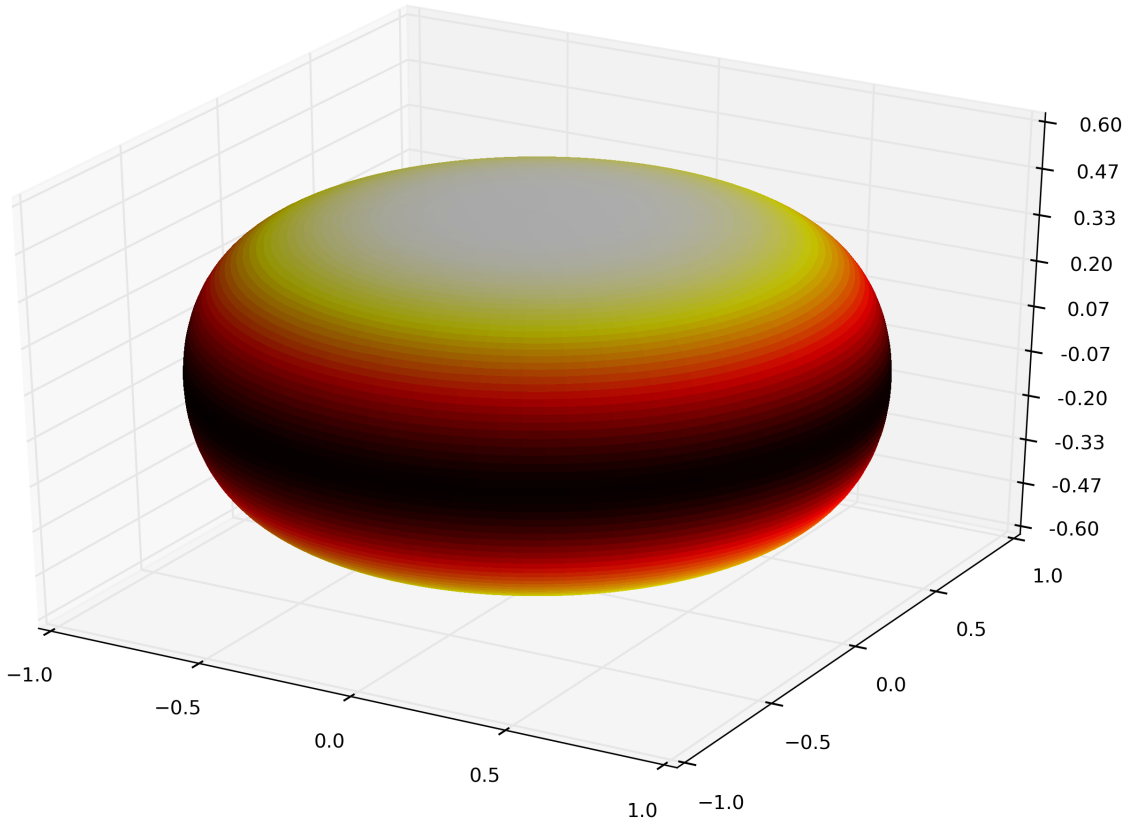


Figure : Crimping means a small area the in centre is stressed.

The Magic of Pre-stretch

- Minimise Creep and relieve manufacturing stresses (Lally 1967, VI. C. p.28)
- Increases Γ, leading to higher float and lower superpressure.
- Re-distributes stresses around mylar balloon shape.

Envelope Construction

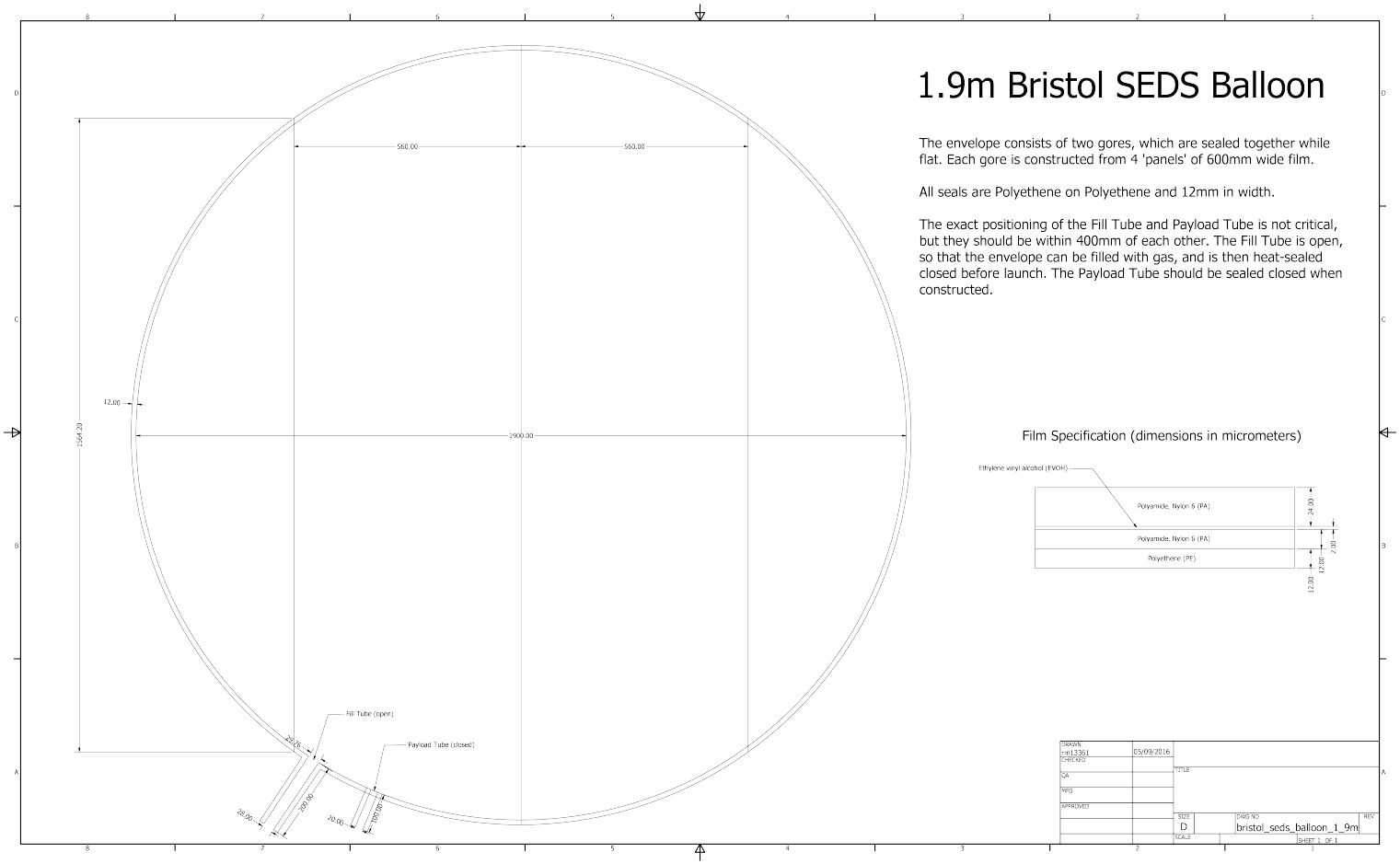


Figure : Drawing for 1.9m balloon

Envelope Construction

Film Specification (dimensions in micrometers)

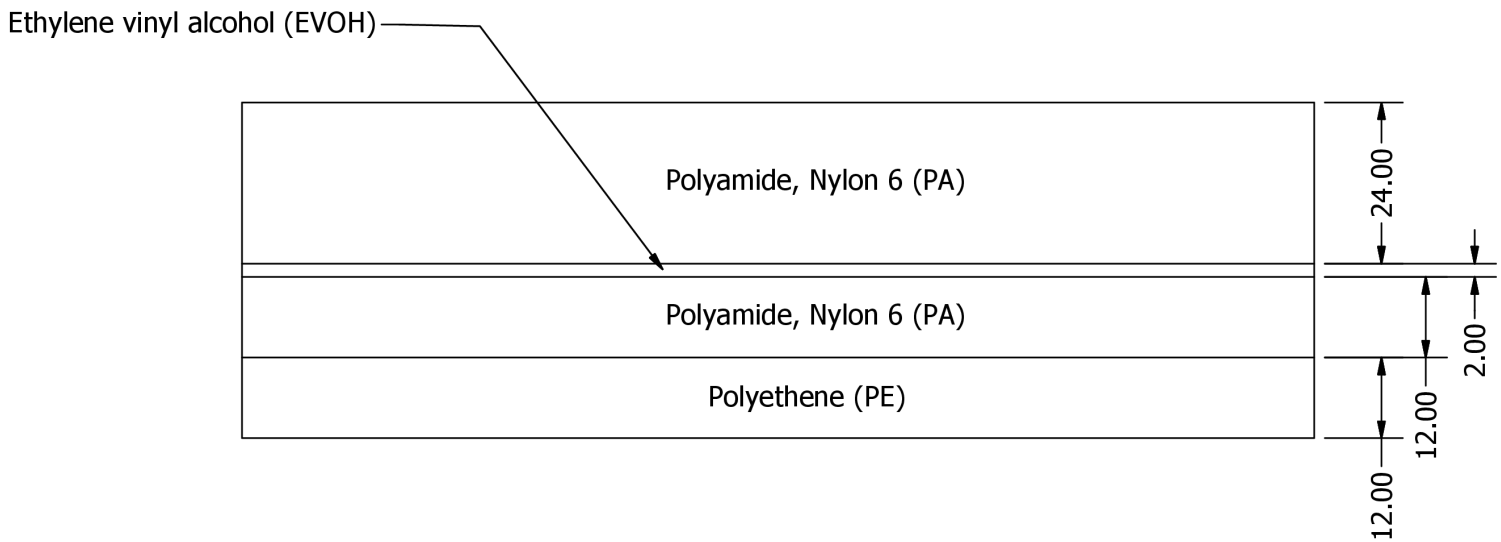


Figure : 50μm film cross section

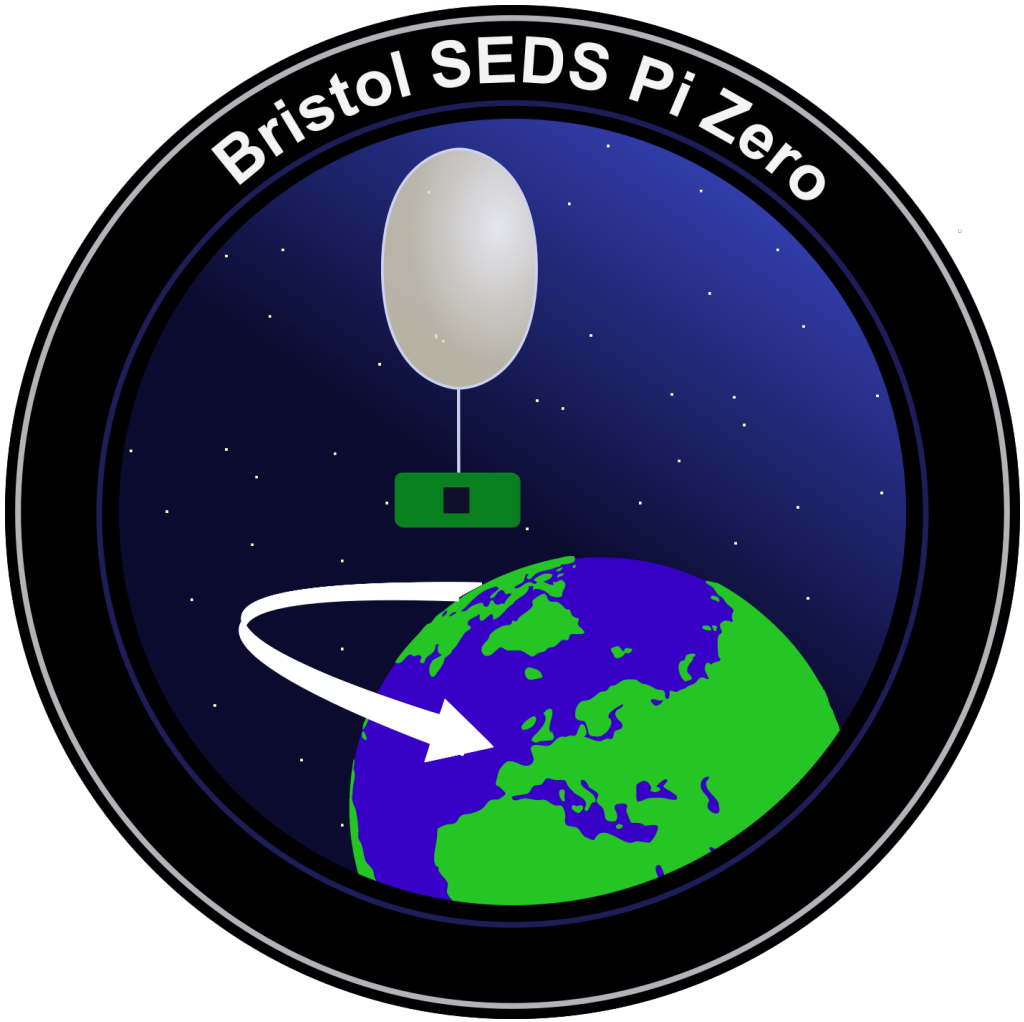
Thanks to Exploratory Ideas grant from CEOI.

Further Work

- Web based calcuator - like the Burst Calculator.
- Numerical analysis of previous flights.
- Guidelines for minimum free lift.
- Modelling and measuring supertemperature.
- Model for mylar tube shape.
- Explore $\Gamma > 2$
- Measuring strain on the ground (Angell and Pack, Apr. 1960).
- Relationship between stress and strain.

Further Work

- Have fun flying round the world...



Meridional Hoop

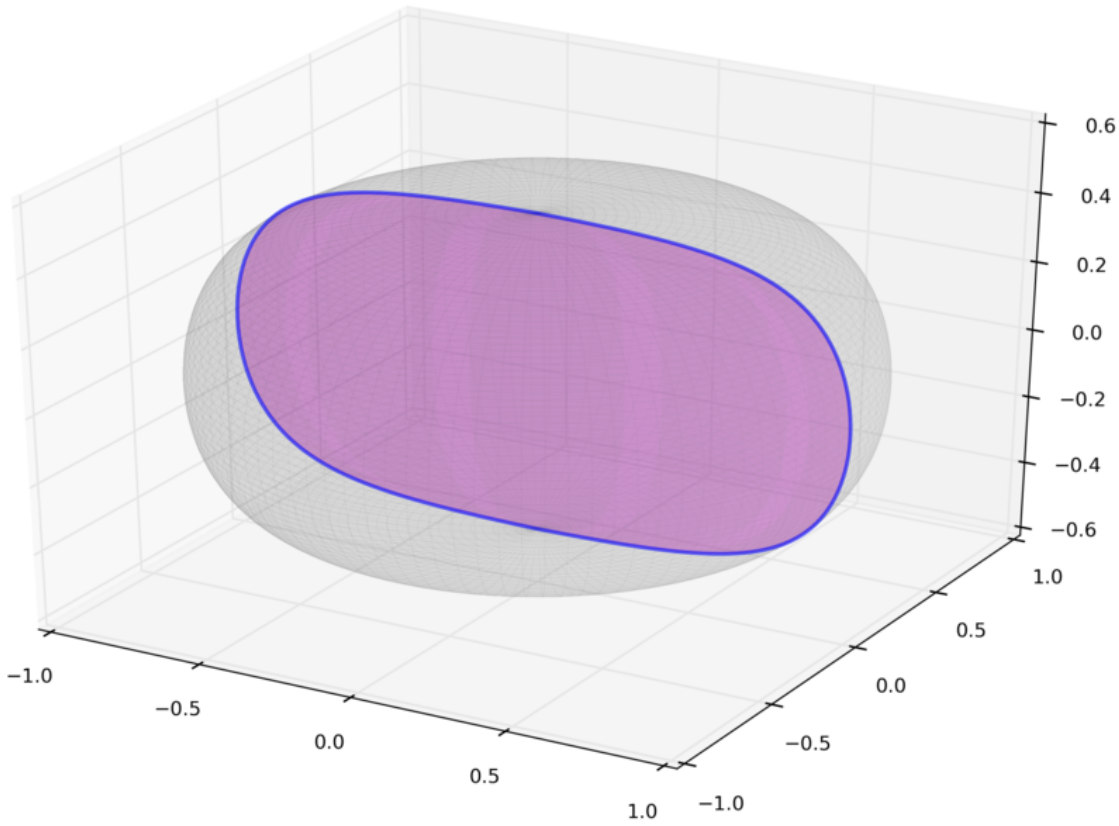


Figure : Meridional Hoop of a Mylar Balloon