

ATMOSPHERIC SATELLITE DESIGN PROPOSAL

TECHNICAL SPECIFICATIONS
AND DESIGN SOLUTIONS

OVERVIEW

BALLOON TECHNICAL SPECIFICATIONS AND DESIGN SOLUTIONS

REQUIREMENTS

Payload
Altitude
Duration

RESEARCH

Relevant Data
Gas & Material
Selection

SPECIFICATIONS

Assumptions
Properties
Analysis Logic

ANALYSIS

Elevation Specs
Safety
Opportunities

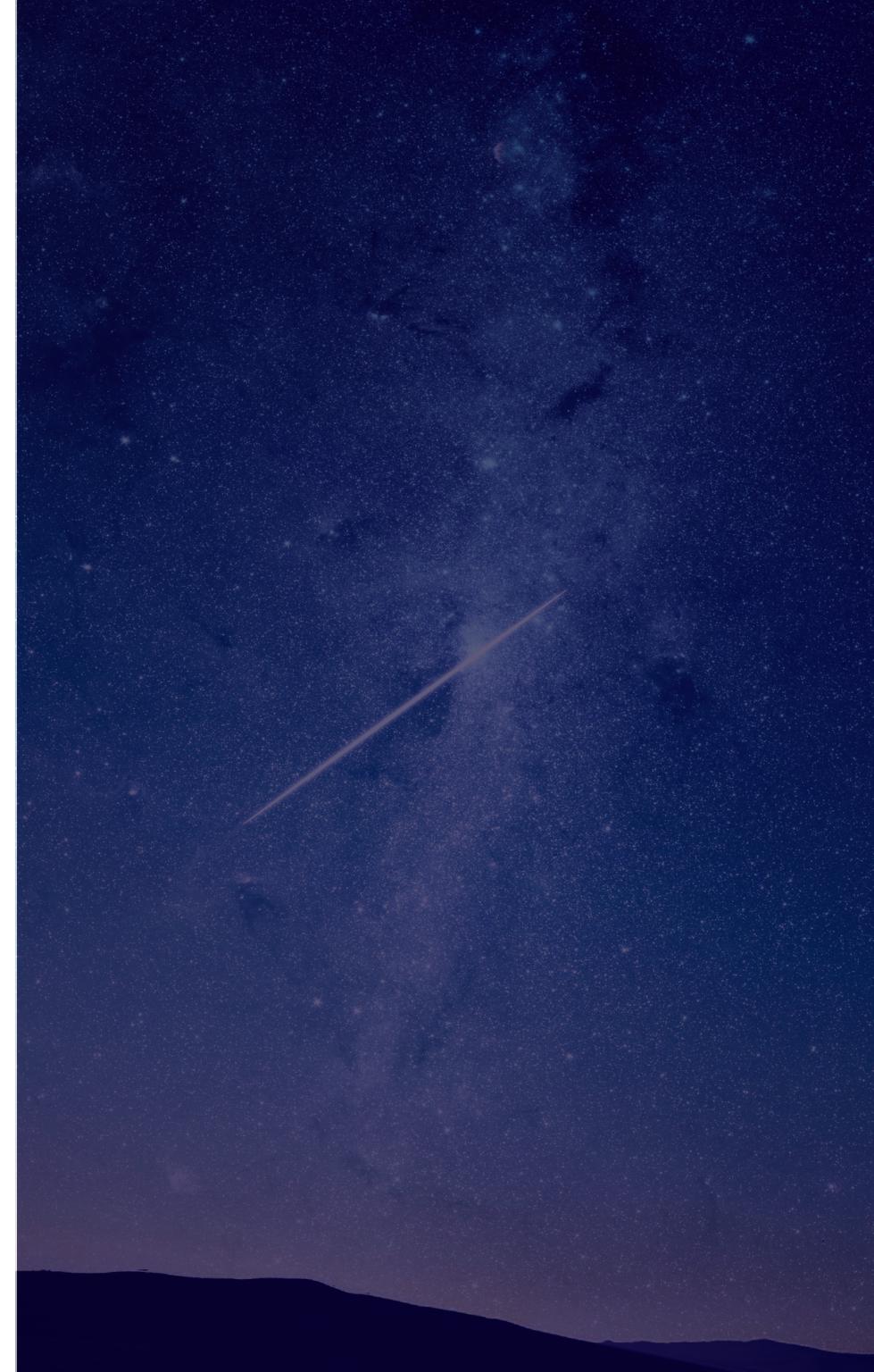


DESIGN REQUIREMENTS

PAYLOAD **500 kg**

ALTITUDE **35 km**

DURATION **24 hours**



ZERO PRESSURE BALLOONS

DURATION

2 HOURS - 3 DAYS

PAYLOAD

UP TO 6000 LBS

ALTITUDE

30-40 KM

COST

\$

SUPER PRESSURE BALLOONS

UP TO 1 MONTH

UP TO 2000 LBS

UP TO 36 KM

\$\$\$

GAS & MATERIAL SELECTION

HIGH DENSITY POLYETHYLENE

Density 962 kg/m³

Tensile Strength 21.3 MPa

Cost \$0.50 / lb

HELIUM

Density 1.29 kg/m³

Cost \$58 / 125 L

TECHNICAL SPECIFICATIONS

IMPOSED ASSUMPTIONS

Balloon shape at target altitude is a sphere

Transient effects during ascent are negligible

Payload computed as a point mass

Stresses on balloon material are also negligible

Ascent occurs during a vernal or autumnal equinox

INTERNAL PROPERTIES

HEAT TRANSFER

$$\varepsilon_{material} = 0.94$$

$$\dot{Q}_{solar} - \dot{Q}_{balloon} + \dot{Q}_{earth} = 0$$

$$\alpha_{sb} = 0.8$$

$$T_{day} = \sqrt[4]{\frac{\alpha_{sb}q_{sun} + \alpha_{eb}q_{earth}}{4\varepsilon_b \cdot \sigma_{SB}}}$$

$$\alpha_{eb} = \varepsilon_{material}$$

$$T_{night} = \sqrt[4]{\frac{\alpha_{eb}q_{earth}}{4\varepsilon_b \cdot \sigma_{SB}}}$$

$$Pv = RT$$



NEUTRAL BUOYANCY

$$F_B = F_{W_{system}}$$

$$m_{air}g = m_{payload}g + m_{He}g + m_{material}g$$

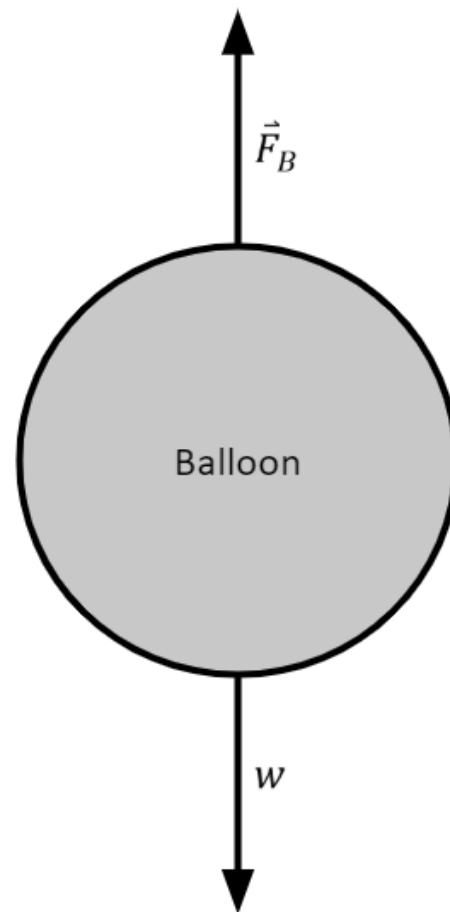
SYSTEM VOLUME

$$m_{air} = \rho_{air} V_{displaced}$$

$$m_{He} = \rho_{He} V_{displaced}$$

$$m_{mat} = \rho_{mat} V_{displaced}$$

$$V_{shell} = 4\pi r_{shell}^3 t \quad V_{disp} = \frac{4}{3}\pi r^3$$



PRELIMINARY MEASUREMENTS
FOR FLIGHT ANALYSIS

SYSTEM PROPERTIES

FACTOR OF SAFETY

$$\sigma_u = k_{safety} \frac{P_g r}{2t}$$

$$\sigma_u = 200 MPa$$

$$k_{safety} = 1.5$$

PROTOTYPE VOLUME

$$r = \sqrt[3]{\frac{m_{Load}}{\frac{4\pi}{3} (\rho_{Air} - \rho_{Gas} - 3 \times \rho_{Material} \times Thickness)}}$$

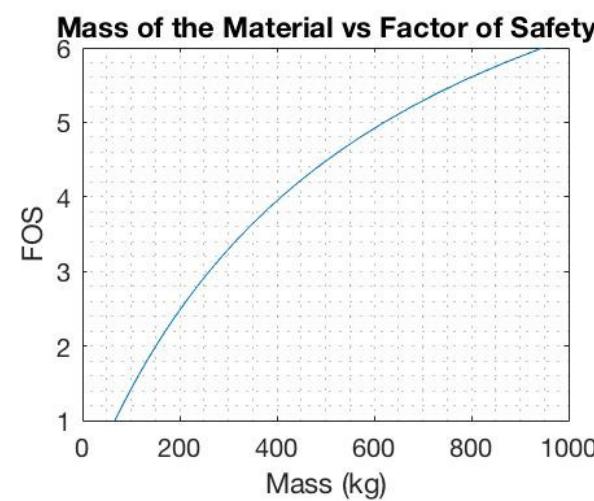
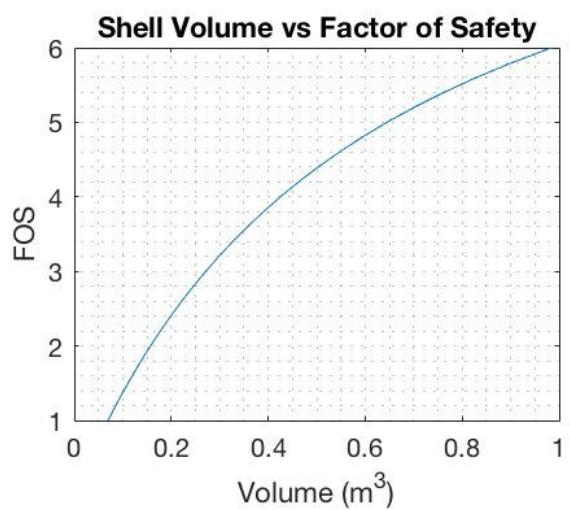
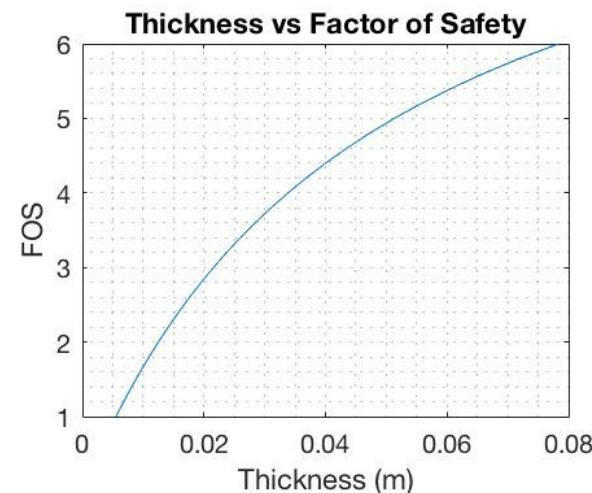
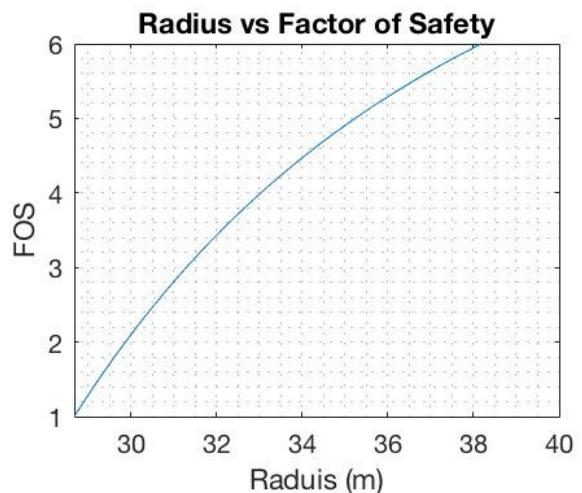
$$\frac{Thickness}{r} = \frac{P_g \times SF}{2\sigma_u}$$

$$V_{disp} = \frac{4}{3}\pi r^3$$

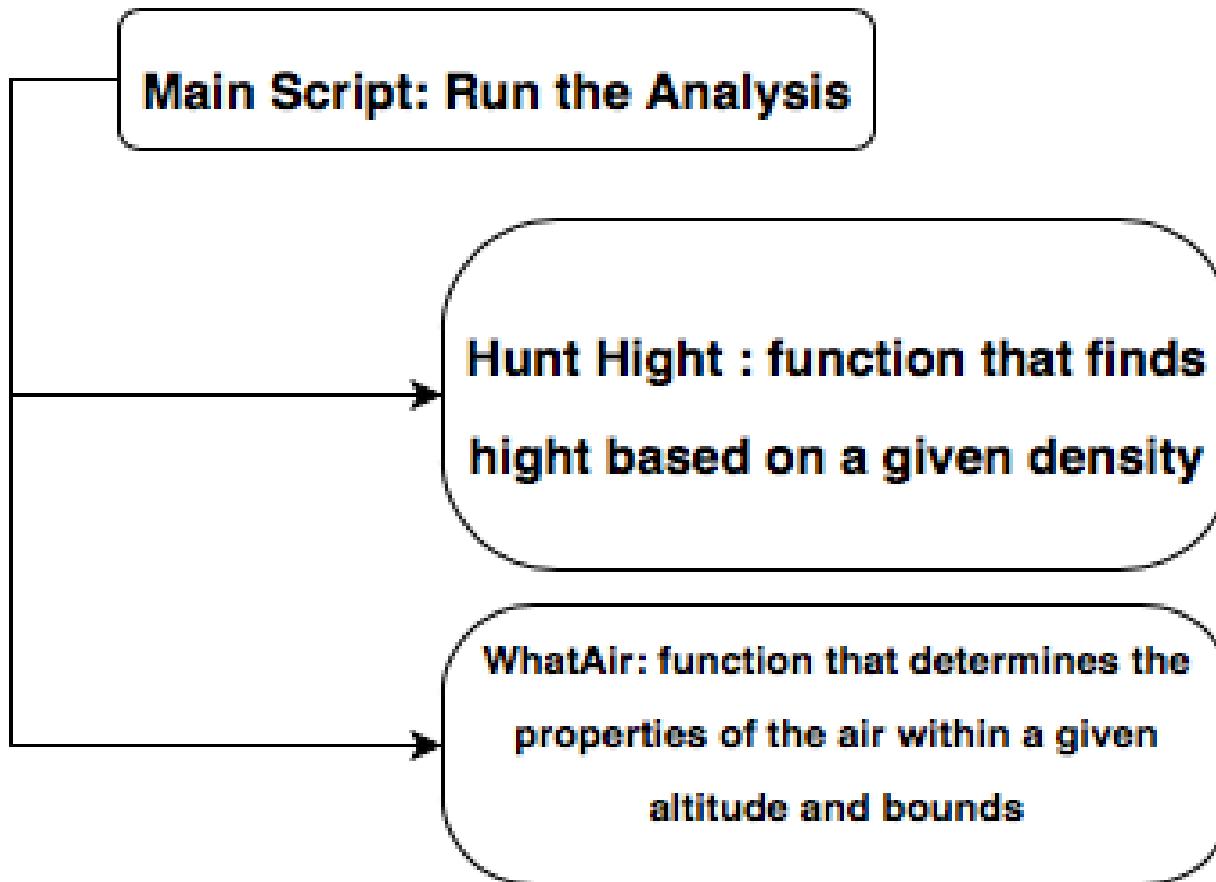
$$V_{0km} = 6.177 \cdot 10^2 m^3$$

$$V_{35km} = 8.767 \cdot 10^4 m^3$$





CODE FLOW CHART



PROTOTYPE TECHNICAL SPECIFICATIONS



DAY CYCLE

Mylar: Exceeds the bounds

Polyethylene (without coating):
Extremely exceeds the bounds

Polyethylene (with coating):
Reflective coating of Hughson
White Paint A-276+1036 to
reduce amount of heat in

- α (sun-material) = 0.44
- ε (material) = 0.88



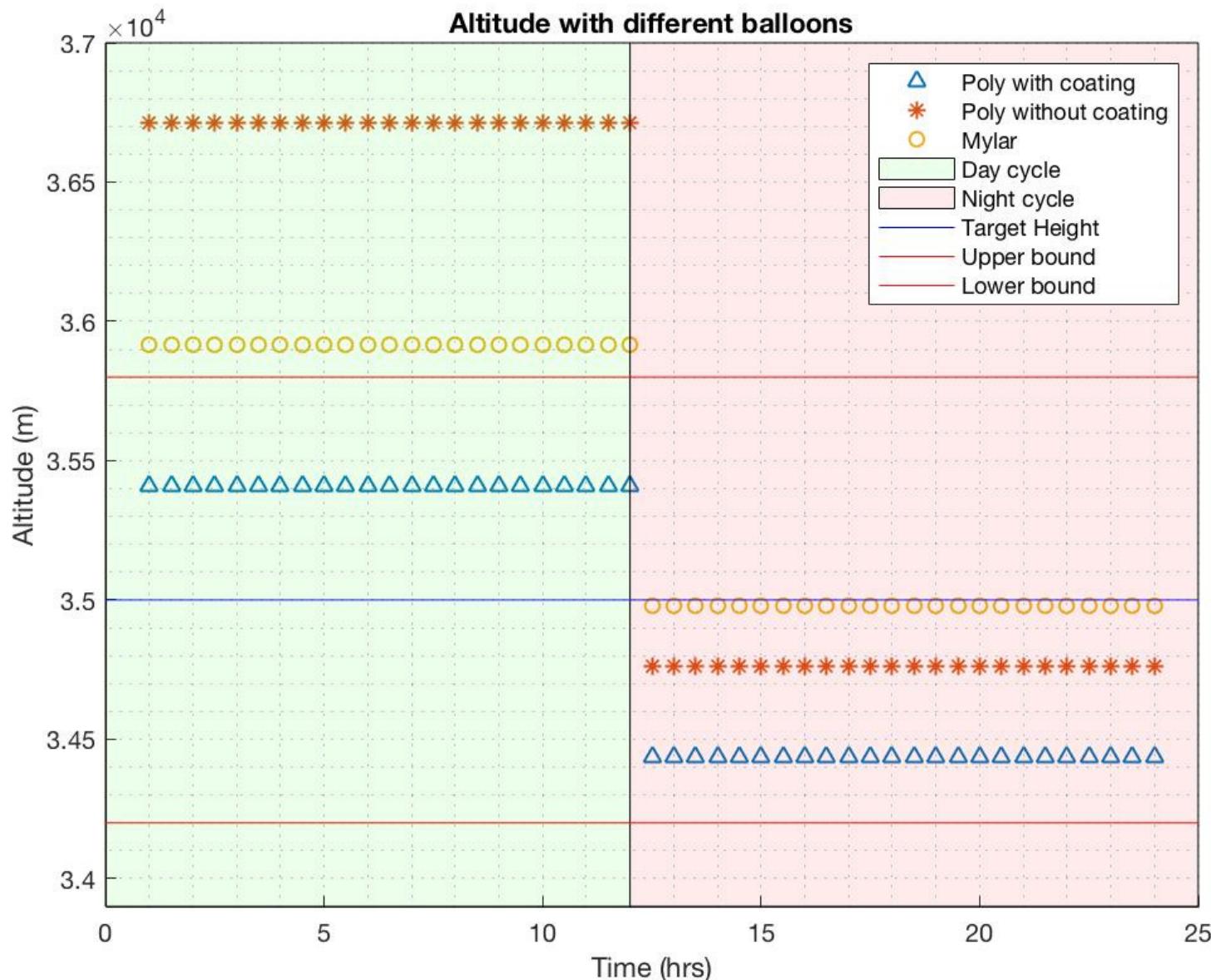
NIGHT CYCLE

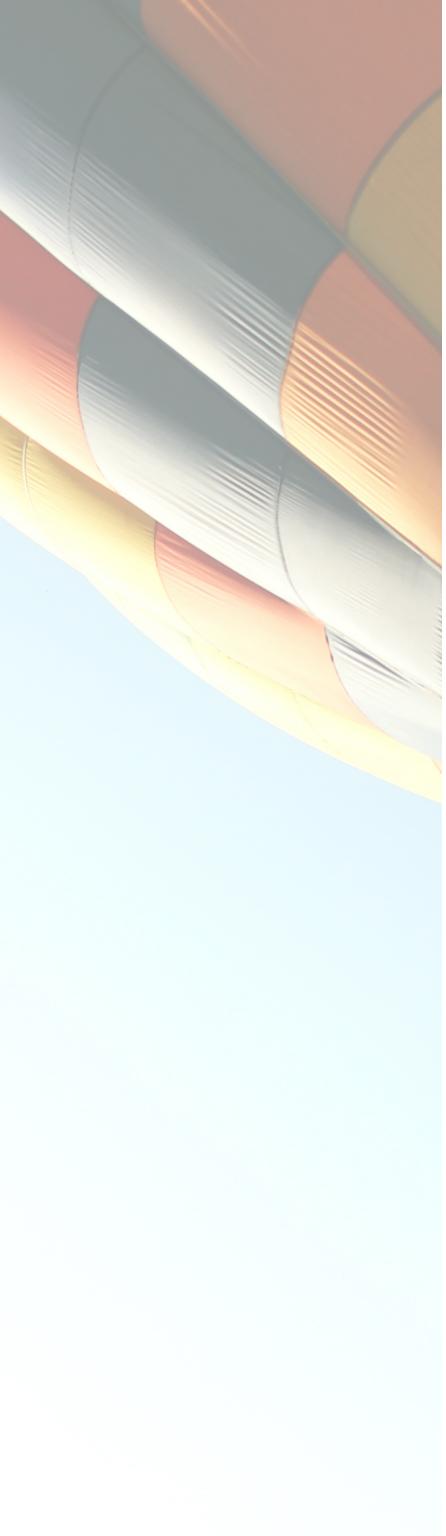
Mylar: Stays within the bounds

Polyethylene (without coating):
Stays within the bounds

Polyethylene (with coating) :
Mass ejection of 100 kg of
sand to maintain altitude (treated
as part of the
payload, chosen arbitrary to be
helpful in the future and keep
some safety margin)

POLYETHYLENE (Coated and Non-Coated) VS. MYLAR



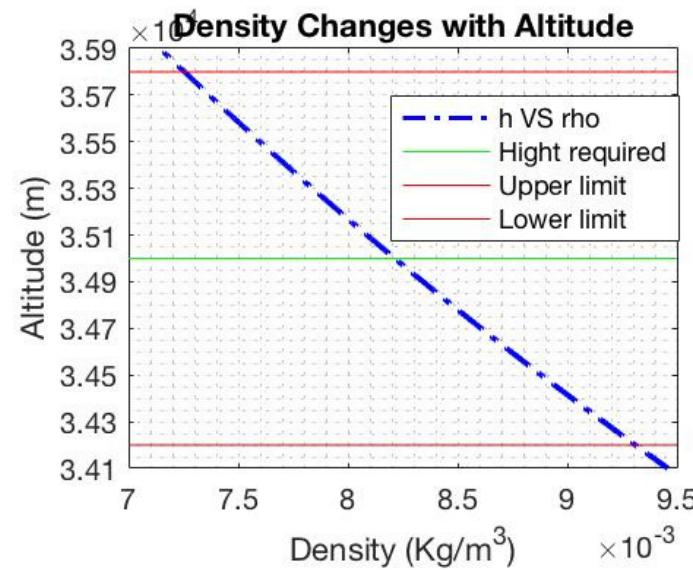
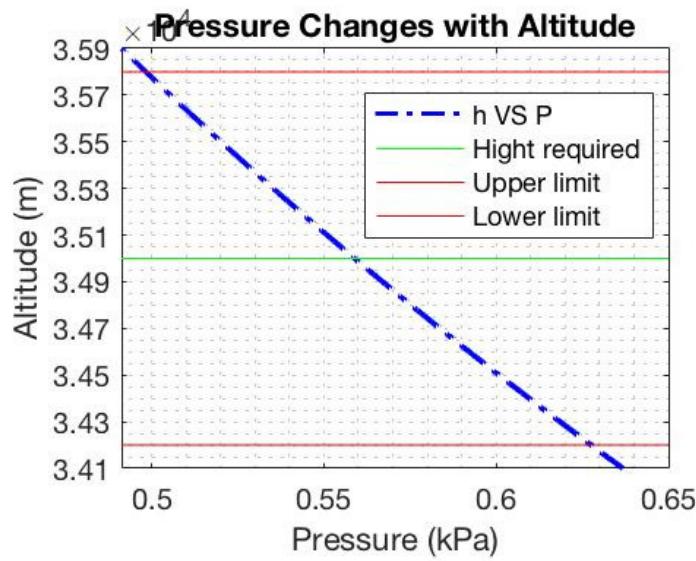
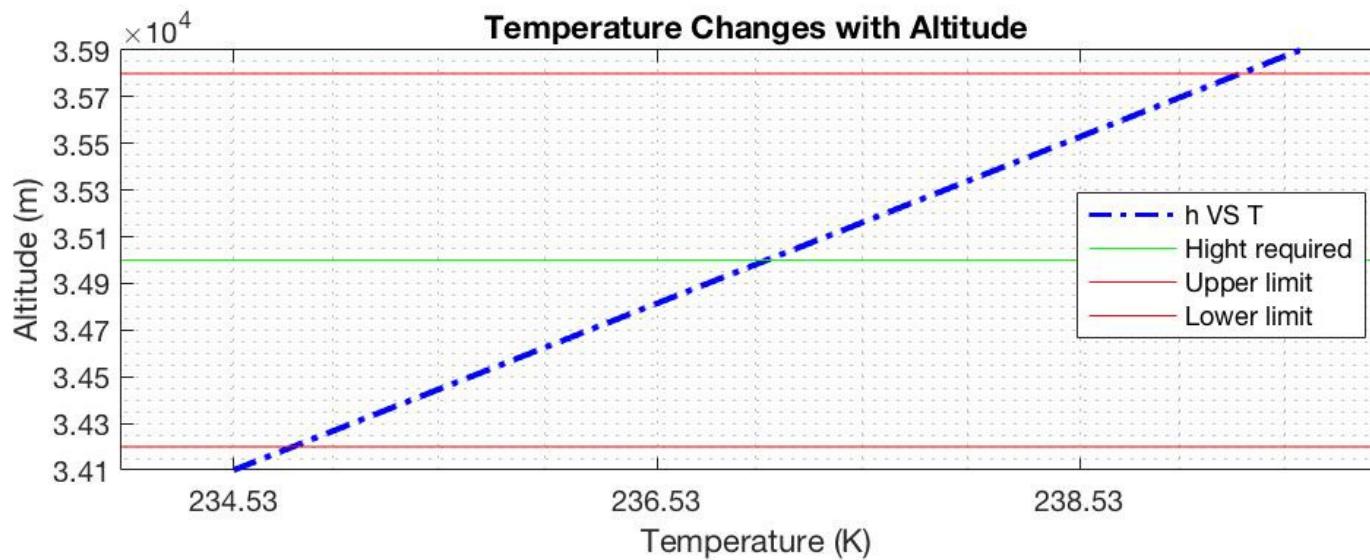


DESIGN ANALYSIS

FRACTIONAL MASS BUDGET

	SCALE MODEL	PROTOTYPE
BALLOON	0.7996	0.1237
HELIUM	0.1575	0.1407
PAYOUT	0.0428	0.7356

ALTITUDE ANALYSIS



COST ANALYSIS

	\$/unit	Total Cost
High Density Polyethylene	\$0.50/lb	\$105.50
Helium	\$0.46/L	\$44,570,660.80
Coating	\$10.00/gal	\$2720.00

Total Cost of Balloon = \$44,573,486.30

FUTURE OPPORTUNITIES

FUTURE AUGMENTATIONS TO INCREASE PAYLOAD

Increase Heat Added to System

- Add burner
- Less reflective material

Decrease System Mass

- Alternative Material with higher tensile force
- Lower Factor of Safety

Utilization of the extra mass

- Satellites
- Scientific experiments

SUMMARY



REQUIREMENTS

500 kg
35 km
24 hrs

RESEARCH

Zero Pressure
Balloon

SPECIFICATIONS

HDPE
Helium
Reflective
Coating

ANALYSIS

Elevation Specs
Cost Analysis
Opportunities

Works Cited

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