# ATMOSPHERIC SATELLITE DESIGN PROPOSAL

## TECHNICAL SPECIFICATIONS AND DESIGN SOLUTIONS

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# 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 | SUPER PRESSURE BALLOONS |
|---|---|---|
| DURATION | 2 HOURS - 3 DAYS | UP TO 1 MONTH |
| PAYLOAD | UP TO 6000 LBS | UP TO 2000 LBS |
| ALTITUDE | 30-40 KM | UP TO 36 KM |
| COST | $ | $$$ |

# GAS & MATERIAL SELECTION

## HIGH DENSITY POLYETHYLENE

| | |
|---|---|
| Density | 962 $kg/m^3$ |
| Tensile Strength | 21.3 MPa |
| Cost | $0.50 / lb |

## HELIUM

| | |
|---|---|
| Density | 1.29 $kg/m^3$ |
| 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

$$\varepsilon_{material} = 0.94$$

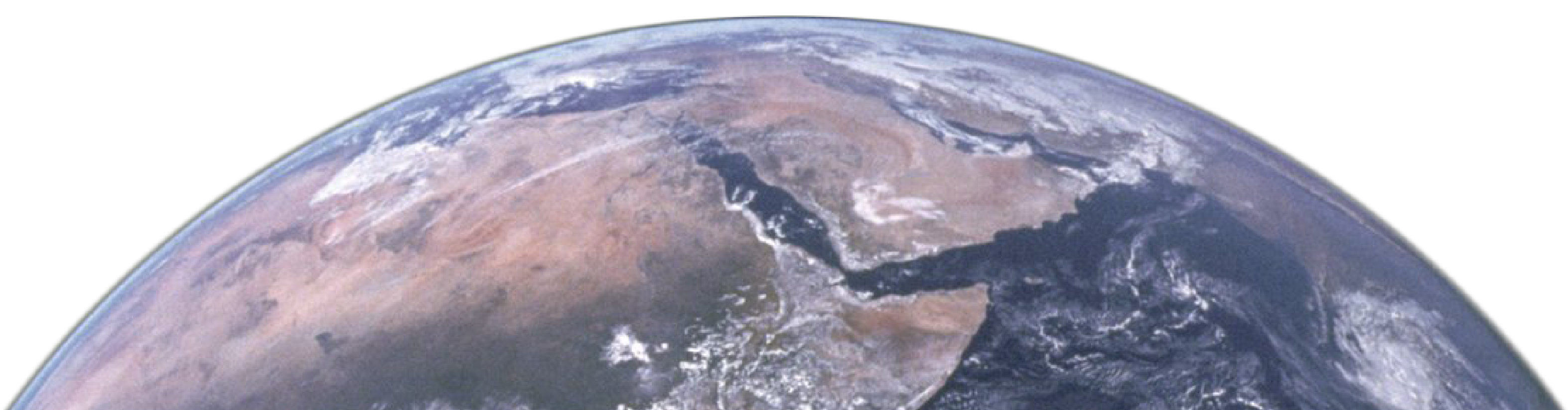
$$\alpha_{sb} = 0.8$$

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

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

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

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



## NEUTRAL BUOYANCY

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

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

## SYSTEM VOLUME

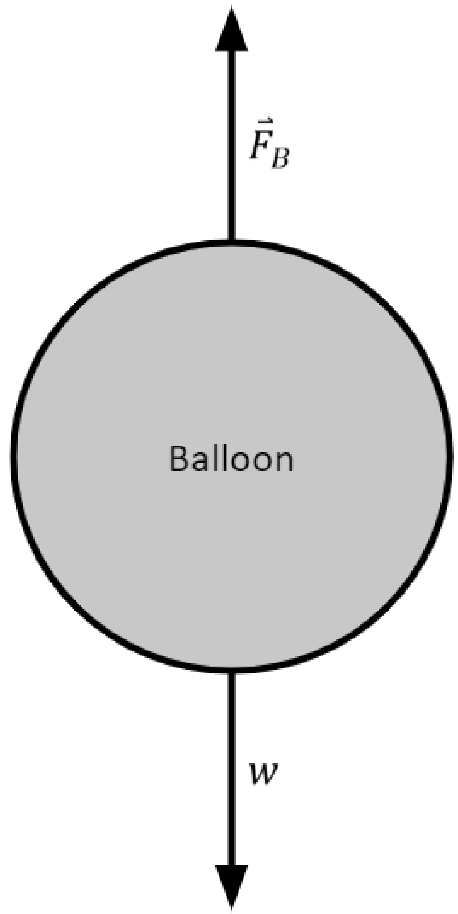
$$m_{air} = \rho_{air}V_{displaced}$$

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

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

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

$$Pv = RT$$




# PRELIMINARY MEASUREMENTS FOR FLIGHT ANALYSIS

# SYSTEM PROPERTIES

## FACTOR OF SAFETY

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

$$\sigma_u = 200MPa$$

$$k_{safety} = 1.5$$

## PROTOTYPE VOLUME

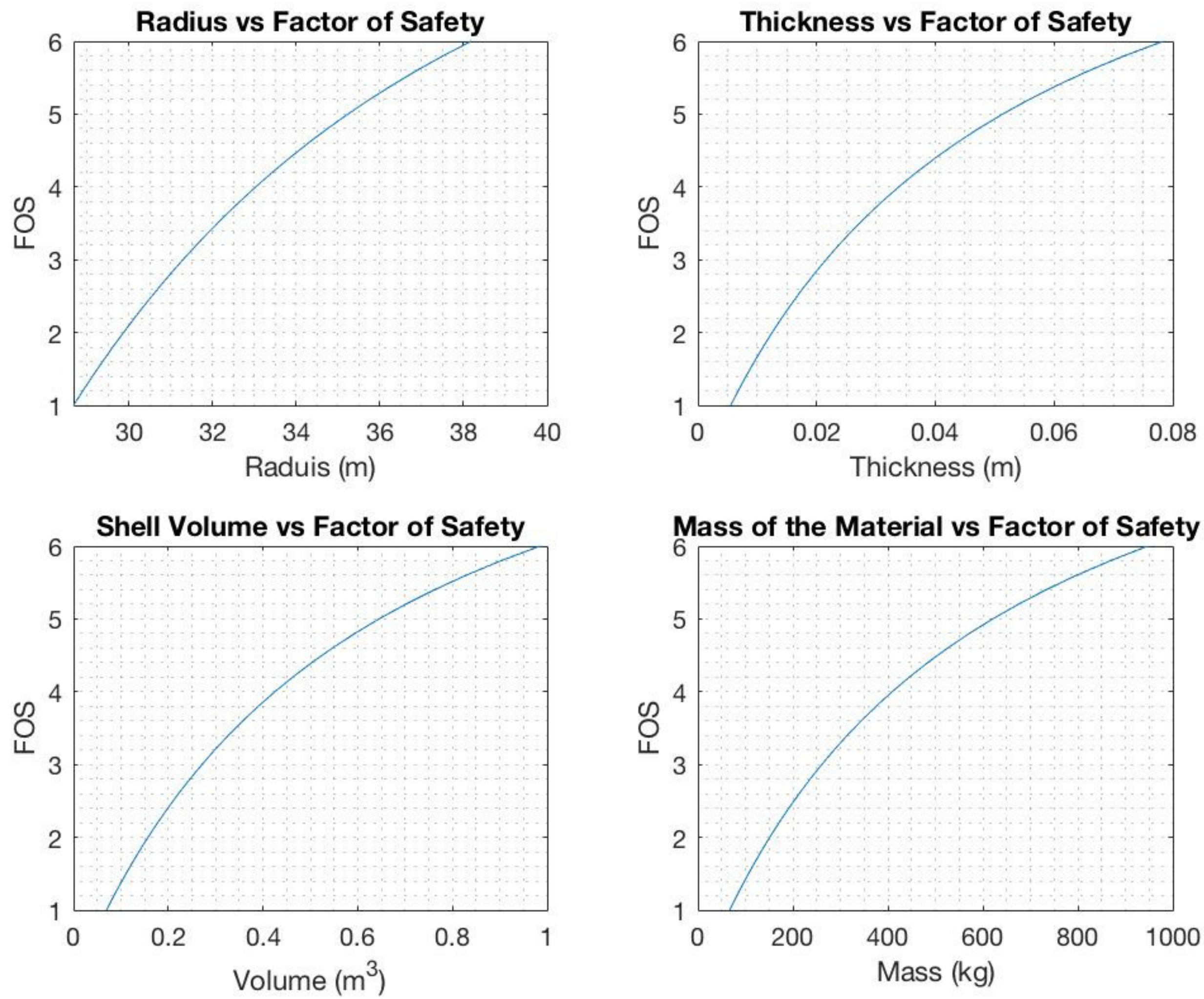
$$r = \sqrt[3]{\frac{m_{Load}}{\frac{4\pi}{3}(\rho_{Air} - \rho_{Gas} - 3\times\rho_{Material}\times Thickness)}}$$

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

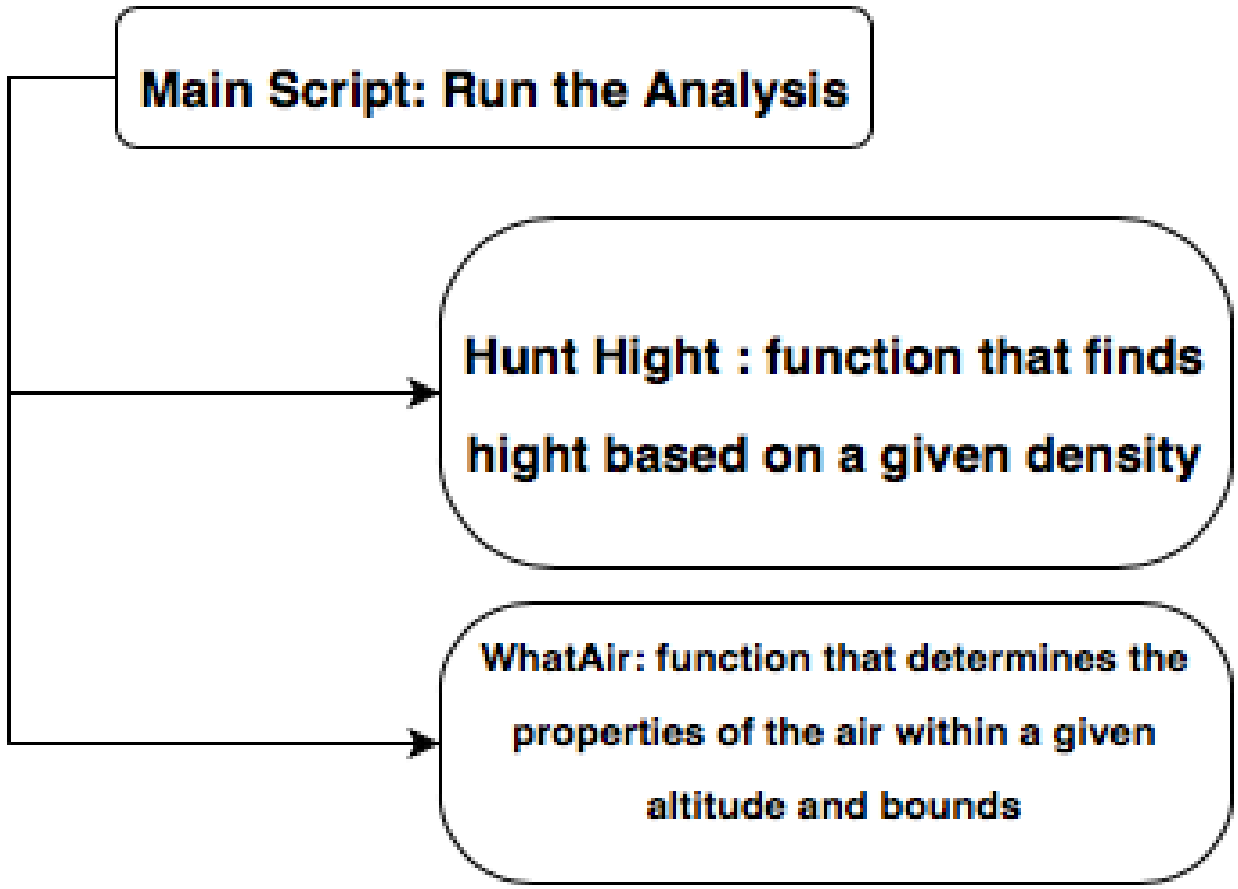
$$V_{disp} = \frac{4}{3}\pi r^3$$

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

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


Radius vs Factor of Safety
FOS
Raduis (m)
Thickness vs Factor of Safety
FOS
Thickness (m)
Shell Volume vs Factor of Safety
FOS
Volume ($m^3$)
Mass of the Material vs Factor of Safety
FOS
Mass (kg)

# 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

- $\alpha$ (sun-material) = 0.44
- $\varepsilon$ (material) = 0.88

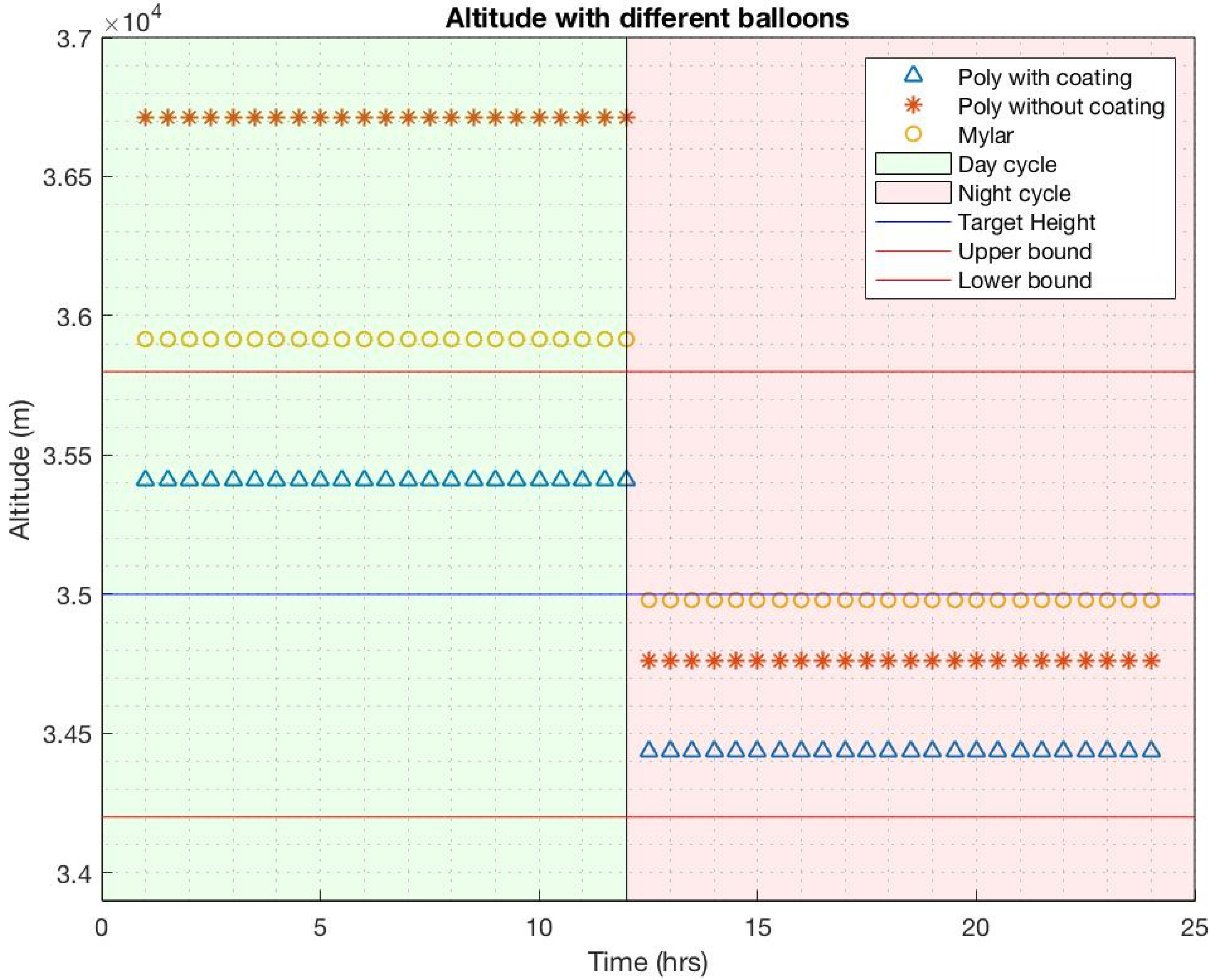
## NIGHT CYCLE

**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-Coared) VS. MYLAR

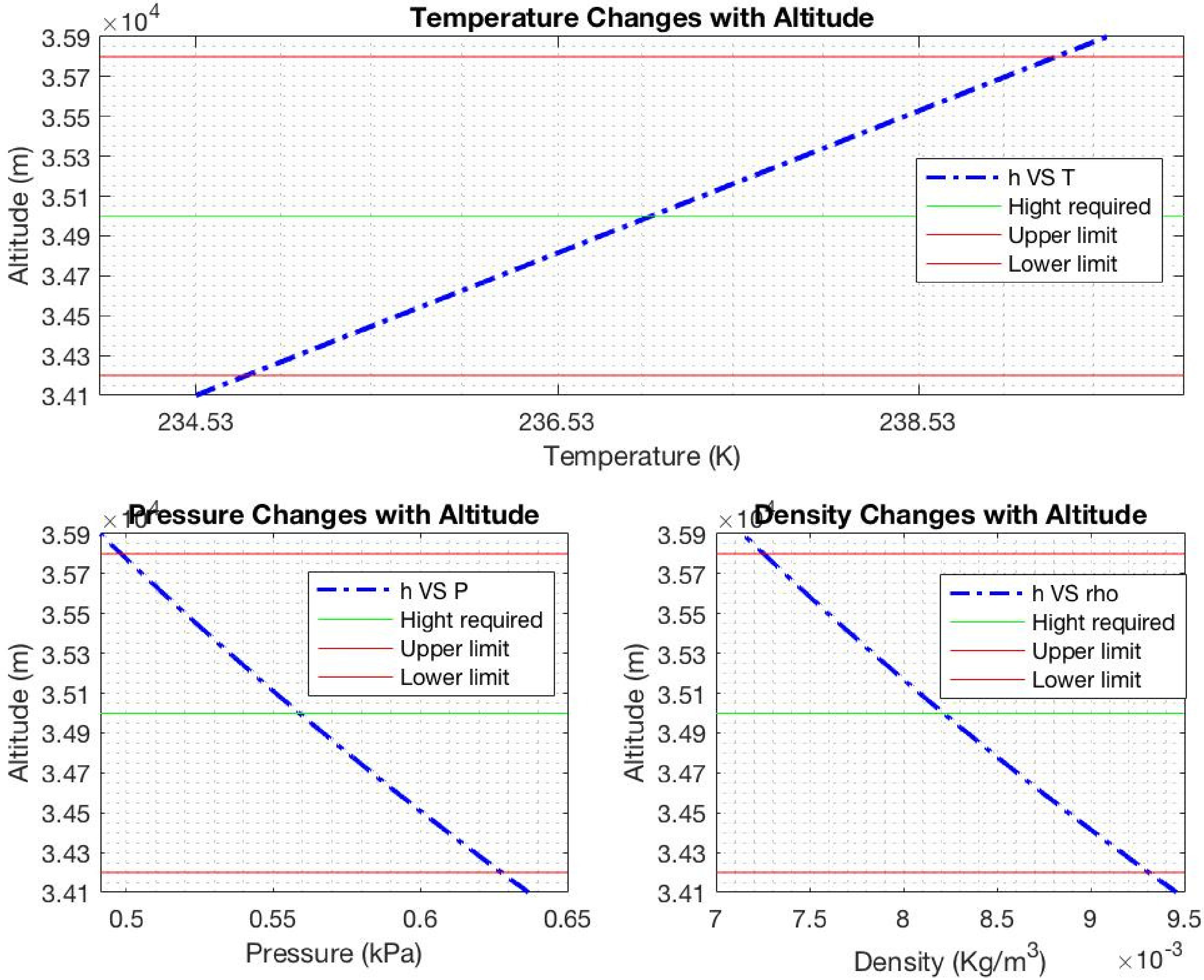


# DESIGN ANALYSIS

## FRACTIONAL MASS BUDGET

| | SCALE MODEL | PROTOTYPE |
|---|---|---|
| **BALLOON** | 0.7996 | 0.1237 |
| **HELIUM** | 0.1575 | 0.1407 |
| **PAYLOAD** | 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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