Project Aethera PDR

What is Project Aethera

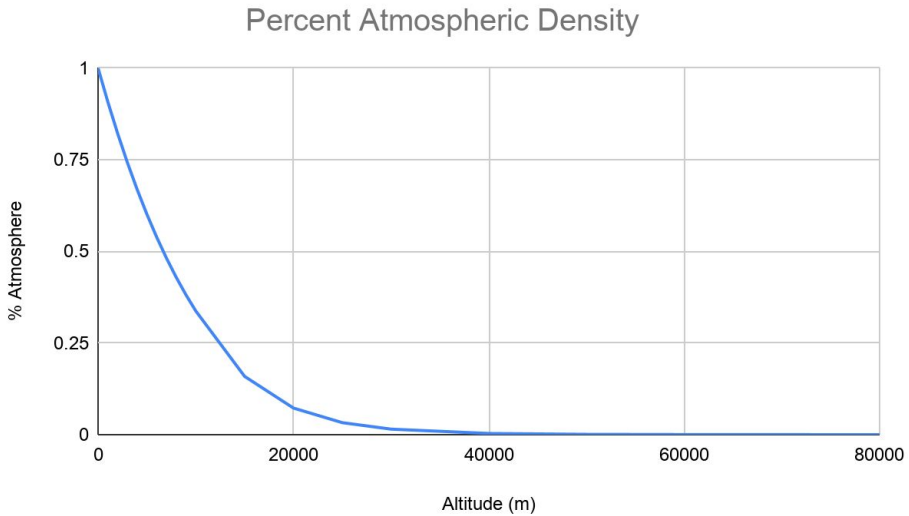
Aethera is an autonomous dirigible platform that will carry the necessary infrastructure for a standard high powered rocket launch to a high altitude. This platform will be able to execute a launch, and be recovered. The platform will be able to be reused with minimal refurbishment. The final test of the platform will be the launch of a space bound rocket.

Why Project Aethera

With the completion of this platform RIT Launch's rockets will be able to reach higher altitudes than ground based launches. The cost savings of using a lighter than air stage as opposed to multi stage rockets will offset initial development costs as the platform is reused.

Ultimately Aethera will expand RIT Launch's launch capabilities in a novel and cost effective manner.

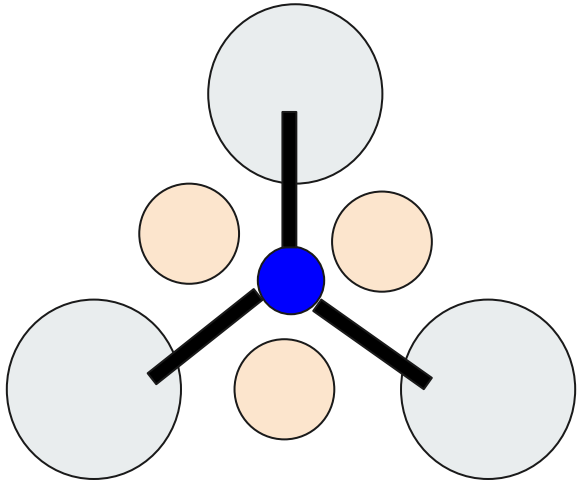
High Altitude Launch



- Motor Performance (net altitude/mass) is Significantly Improved
- Diminishing Returns past 20000m
  - 65000 ft

Aethera Systems

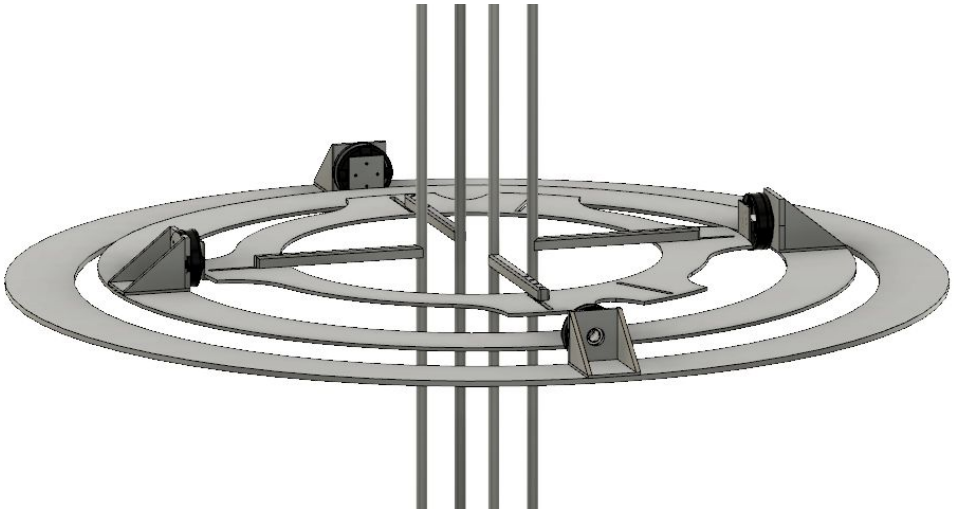
- Balloon Management
- Structural Booms
- Silo Stabilization
- Avionics & Control

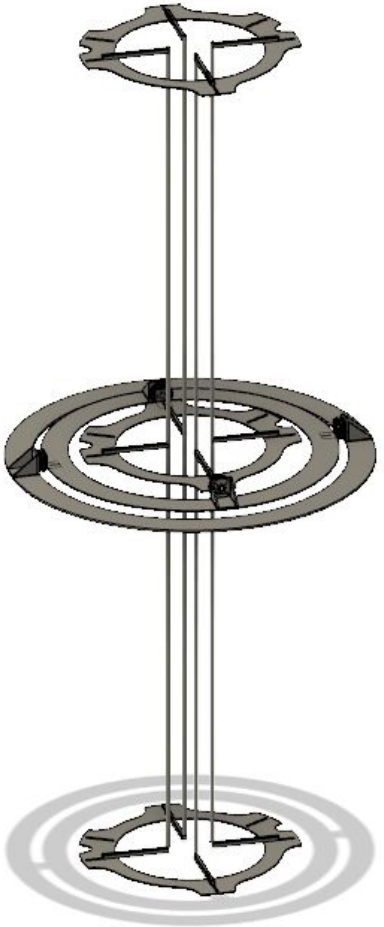


Gimbaled Silo Parameters

- Adjustable Launch Tower
- 3 & 4 Fin Rail
- 5-8 in Body Tube Range
- 8ft Tall (variable to adjust for other rockets)
- Stabilized for Launch
    - Stabilization Begins when launch criteria are acceptable
    - Correct Stabilization is Critical for Safe Launch

Silo Design





Silo Stabilization

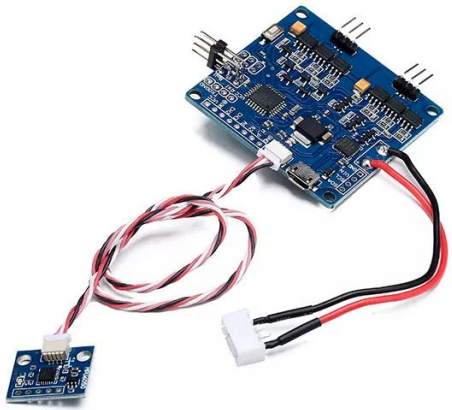
COTS Gimbal Controller

- 3 axis accelerometer
- 2 axis Motion Control
- 4 Brushless motors
  - 2 Paired per Axis
- Motor Specification based off of I for cylinder about center
- FS 2x Torque Requirements
- Battery Sizing is To Be Determined
  - Calculations are needed to determine stabilization run length
  - 95 % CI for acceptable altitude range for launching

$$T = \frac{\left(WK^2\right)\Delta N}{308t}$$

and

$$WK^2 = (1/2)WR^2$$

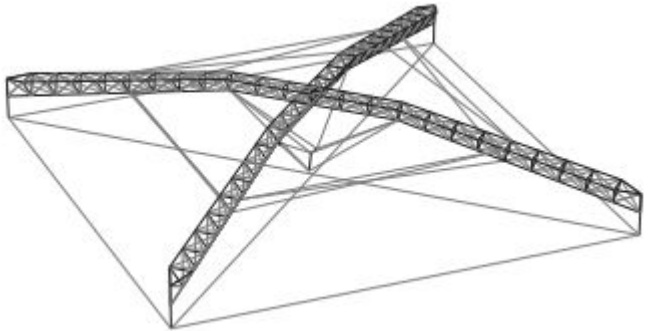


Booms

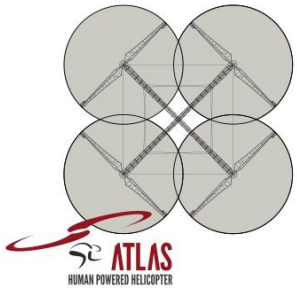
The unique aspect of this platform is its use of three booms to connect multiple latex balloons to the structure. This allows the vertical silo system to be employed, as well as increasing the total volume for lifting gas.

Each boom will be a 15ft truss, each connected to a central ring; this ring serves as the connection between the silo and balloon structure. These truses will be made of carbon fiber or fiberglass poles. On the end of each boom will be a connector which will serve to mount the primary/secondary balloons and connect them to the gas management system.

Booms Reference Material



When designing the structure we looked at Aerovelo's human-powered helicopter Atlas.



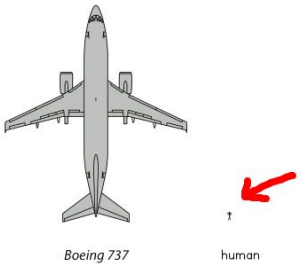
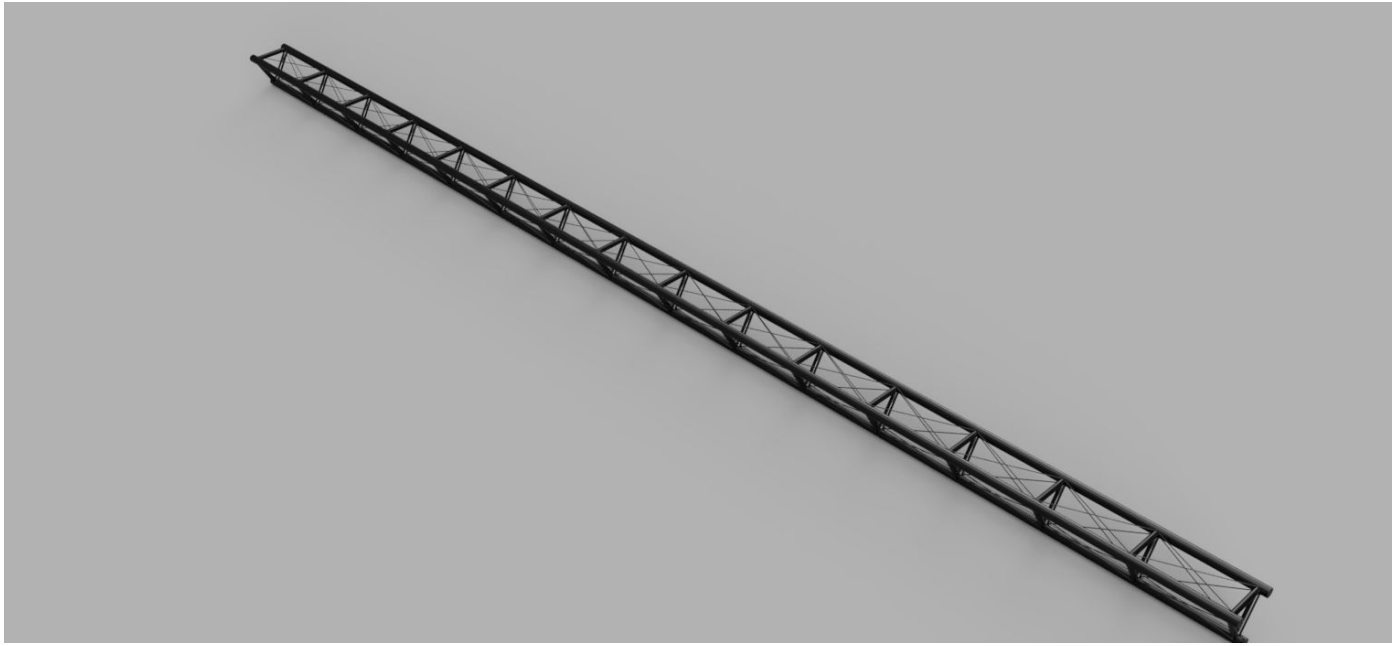


Table 6 Atlas mass breakdown

Component	Metric, kg	Imperial, lb
Rotor blades	24.38	53.70
Rotor hubs	6.91	15.21
Airframe/truss structure	19.23	42.36
Control lines	0.12	0.26
Cockpit/bike frame	4.74	10.45
Total	55.26	121.72

Boom Cad



Balloon Management

We will be implementing a six balloon design. Three for main thrust propulsion, and three for recovery. While the Main Balloons will span a distance of 15’ diameter at max altitude, the smaller balloons will be supported between the ends of the support rods, attached solely by a string.

The Balloons used for recovery will not be needed to be supported by any major metal rods.

The three major balloons will be attached to the end of the frame using either a CNC part, or 3D printed (FDM) part.

File | Assemble | Design | 3D Model | Sketch | Annotate | Inspect | Tools | Manage | View | Environments | Get Started | Collaborate | Electromechanical

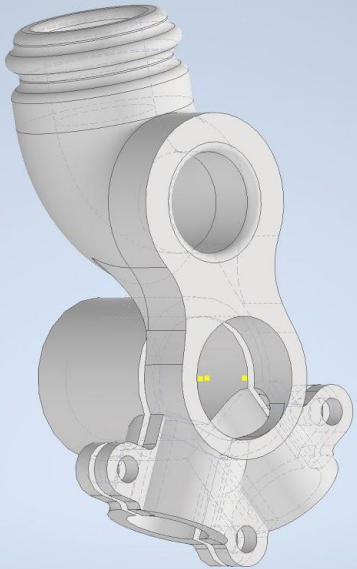
Place | Create | Free Move | Free Rotate | Joint | Constrain | Show | Show Sick | Hide All | Pattern | Mirror | Copy | Bill of Materials | Parameters | Create Derived Substitutes | Plane | Axis | Point | UCS | Shrinkwrap | Shrinkwrap Substitute

Component | Position | Relationships | Pattern | Manage | Productivity | Work Features | Simplification

Model

Assembly | Modeling

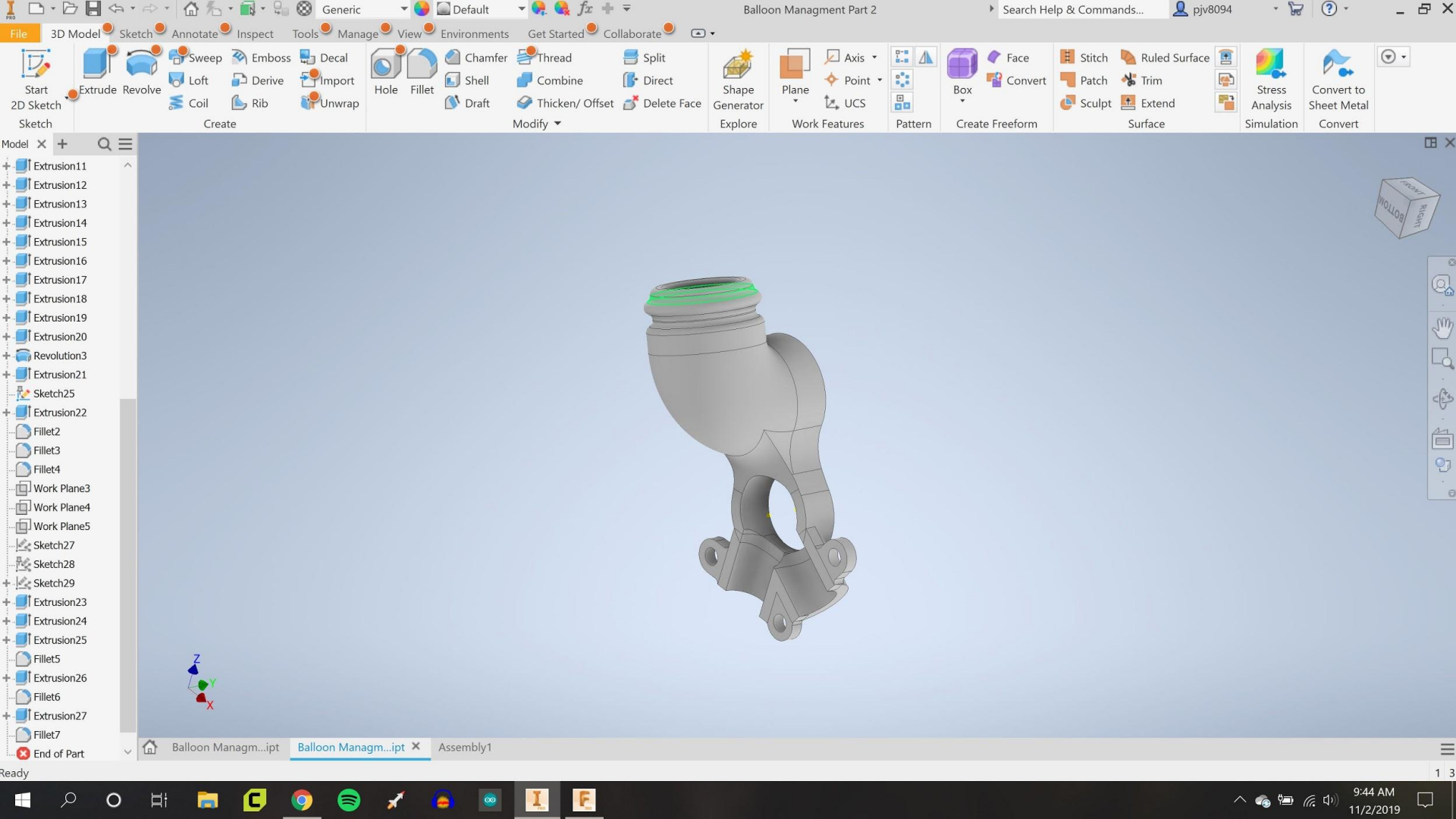
- Assembly1
  - Relationships
  - Representations
  - Origin
  - Balloon Managment:1
  - Balloon Managment Pa



Balloon Managm...ipt | Balloon Managm...ipt | Assembly1

Ready

9:43 AM
11/2/2019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Annotate
Inspect
Tools
Manage
View
Environments
Get Started
Collaborate
Start 2D Sketch
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Revolve
Sweep
Loft
Coil
Emboss
Derive
Rib
Decal
Import
Unwrap
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Fillet
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Shell
Draft
Thread
Combine
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Stitch
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Trim
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Stress Analysis
Convert to Sheet Metal
Sketch
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Explore
Work Features
Pattern
Create Freeform
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Model
Extrusion11
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Extrusion14
Extrusion15
Extrusion16
Extrusion17
Extrusion18
Extrusion19
Extrusion20
Revolution3
Extrusion21
Sketch25
Extrusion22
Fillet2
Fillet3
Fillet4
Work Plane3
Work Plane4
Work Plane5
Sketch27
Sketch28
Sketch29
Extrusion23
Extrusion24
Extrusion25
Fillet5
Extrusion26
Fillet6
Extrusion27
Fillet7
End of Part
Balloon Managm...ipt
Balloon Managm...ipt
Assembly1
Ready
9:44 AM
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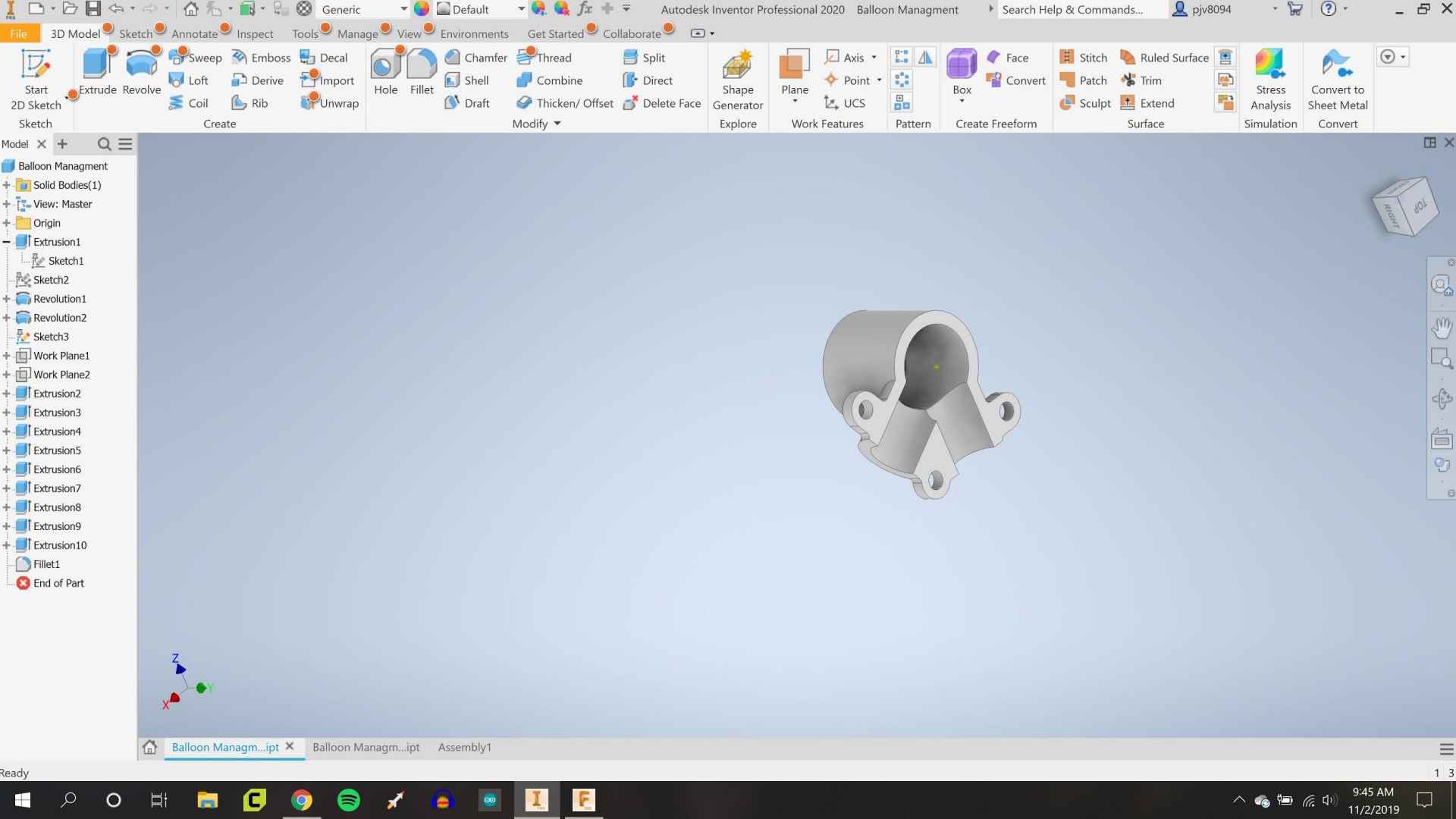
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Balloon Managment
Solid Bodies(1)
View: Master
Origin
Extrusion1
Sketch1
Sketch2
Revolution1
Revolution2
Sketch3
Work Plane1
Work Plane2
Extrusion2
Extrusion3
Extrusion4
Extrusion5
Extrusion6
Extrusion7
Extrusion8
Extrusion9
Extrusion10
Fillet1
End of Part
RIGHT
TOP
Z
Y
X
Balloon Managm...ipt
Balloon Managm...ipt
Assembly1
Ready
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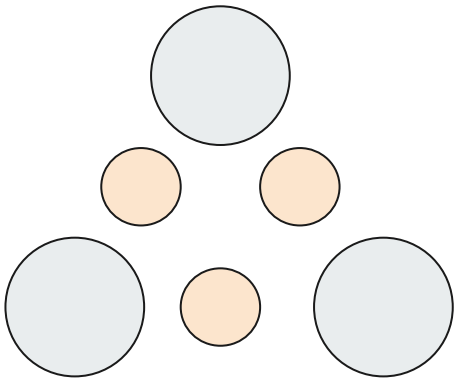
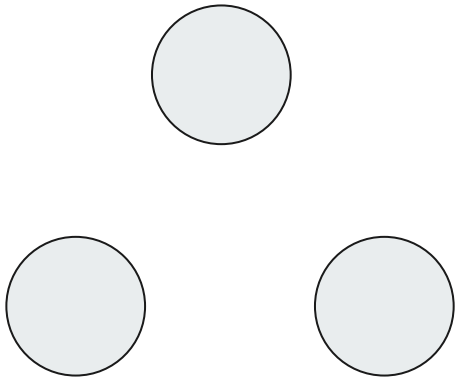
Recovery

Ascent Phase



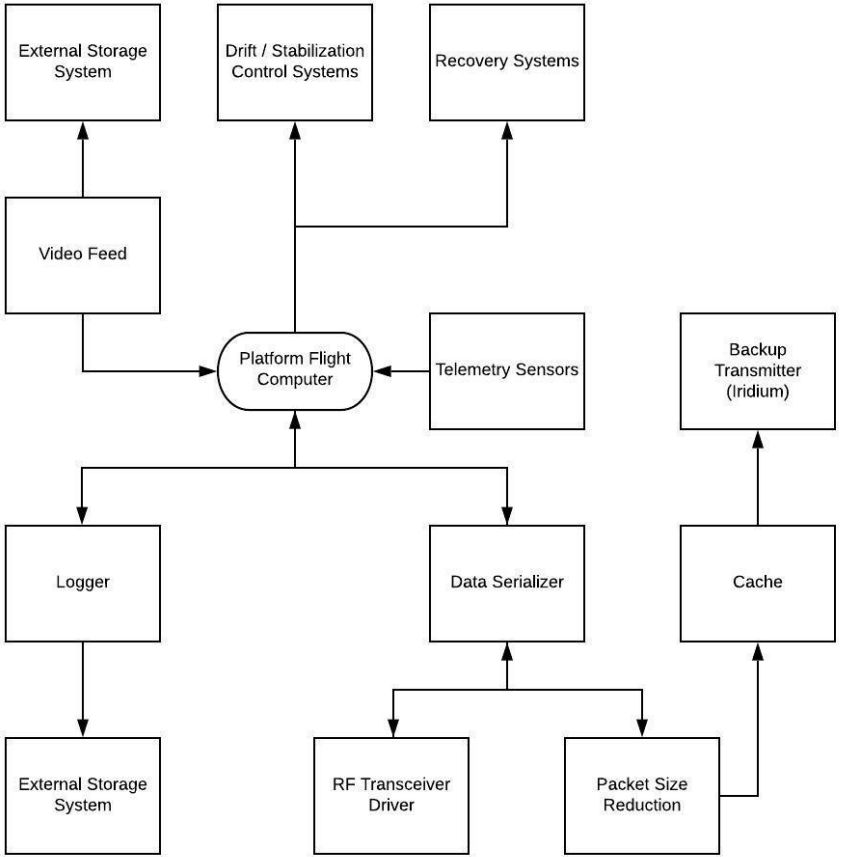
All primary and secondary balloon phase are filled until desired lift is achieved

Descent Phase



Secondary phase balloons are burst with nichrome release, descent until desired altitude

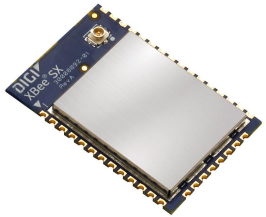
Systems Integration



Communications (Platform)

Primary System: 900MHz LoRa

- ~47 miles with a 10 element yagi and 1W transmitter
- Digi XBee SX 900
  - AES encrypted data packets
  - 10 kbps to 125 kbps
  - 100mW - 1W adjustable power



Secondary System: Iridium Network

- No practical range limitation
- Costs ~$0.10 per 50 bytes with a $15 monthly subscription
- RockBLOCK Mk2 Module
  - Consumes 100mA continuous, 470mA startup
  - Expensive

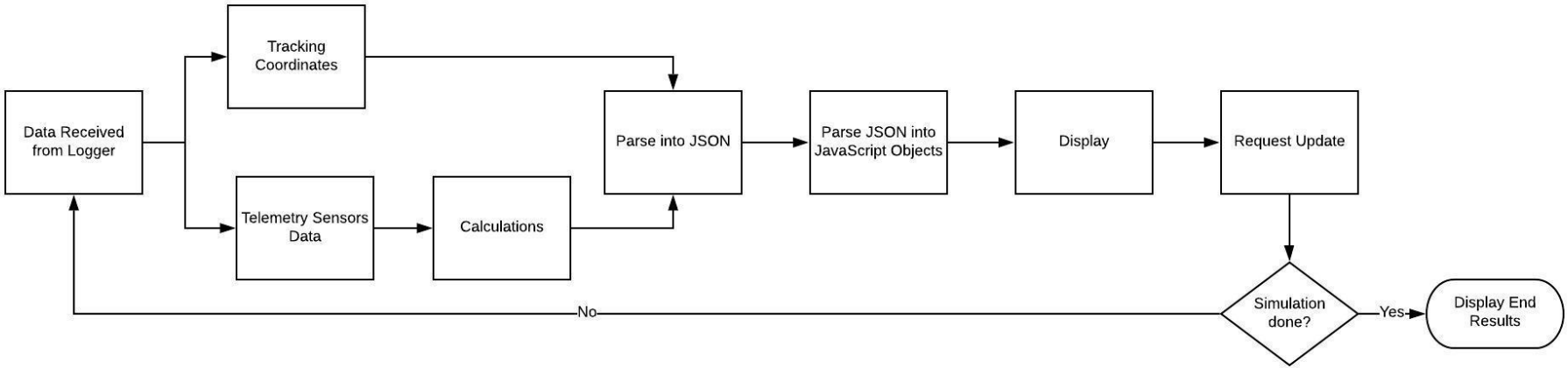
Communications (Rocket)

- Will only be using Iridium Network
  - Reduces space needed in rocket
  - More simplified design
  - Almost guaranteed signal
- Rocket will be sending a low amount of data but more frequently
  - GPS Coordinates
  - Altitude
- Can use the same receiver as the platform

Software

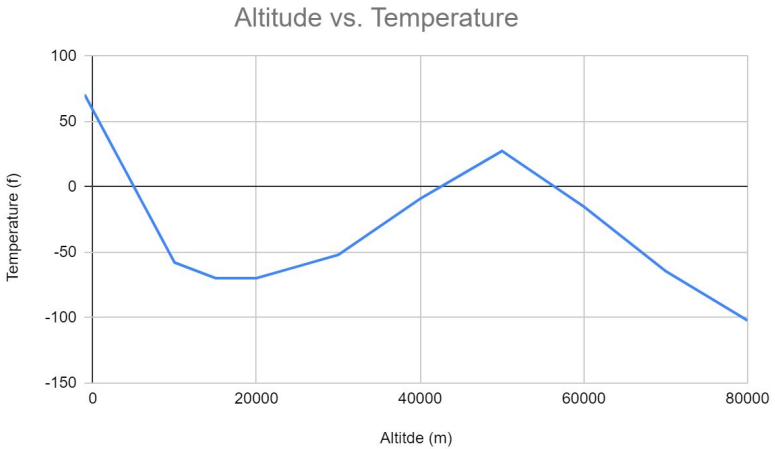
- Real-time tracker for the platform
- Get estimated landing time and coordinates
- Display flight information
    - Temperature
    - Last known coordinates
    - Altitude
    - Acceleration
    - Battery level
    - Raw sensor data for logging

Software Flowchart



Temperature Impact Management

Temperature: -70



Battery Performance:

- MLI Insulation for Battery Bay

Avionics Protection:

- Conformal Coating
- High R value Insulation

Motor Performance

- Environmental Cooling

Drift

While there is going to be a large amount of drift, we can, with good accuracy calculate where the platform will land

Motion $(x-y\ plane)$

$$\frac{dx}{dt} = -w(z)\cos\left[\varnothing(z)\right]$$

$$\frac{dy}{dt} = -w(z)\sin\left[\varnothing(z)\right]$$

where w *is speed*, $\varnothing$ *is direction*, z *is altitude*

Ascent Rate

$$\left(m_{balloon} + m_{payload} + m_{gas}\right)\frac{d^2z}{dt^2} = B - \left(m_{balloon} + m_{payload}\right)g - D$$

where

$$B = v(z)\left[\rho_{air}(z) - \rho_{gas}(z)\right] \qquad Buoyancy$$

$$D = \frac{1}{2}\rho_{air}(z)\left(\frac{dz}{dt}\right)^2 C(Re)\,A(z) \qquad Drag$$

Re generally ranges f rom 3×10^5 *to* 4×10^4