Rigid-Framed Solar Thermal Airship

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Introduction

Aerodesic is working on a solar airship to revolutionize air travel for a wide variety of markets. The design consists of a mix of geodesic structural engineering, aerospace framing materials, and solar air ballooning materials and methods. Their primary goal currently is to demonstrate feasibility of lifting a large, rigid object into the sky using only solar radiation, without requiring lighter-than-air gases.

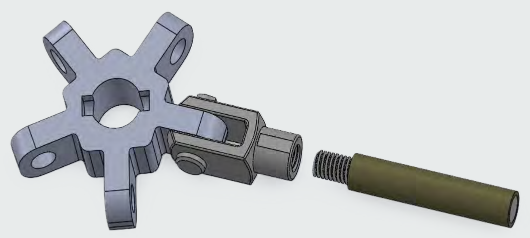
Design Objectives

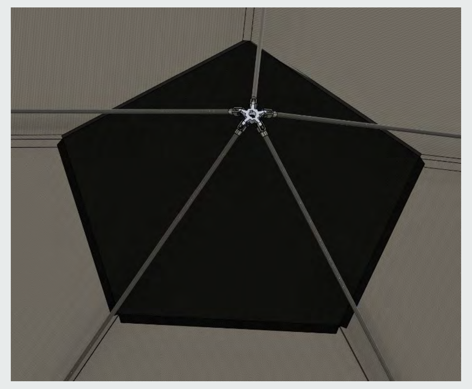
- Rigid structure for fixed internal volume
- Limited number of unique pieces
- Potential to carry cargo
- Heat and air-tight structure to retain lift capabilities

Structure

The airship's structure can be divided into two primary components: the thermal envelope and the frame. The envelope is constructed from multiple panels of polymer sheeting and designed to contain air and thermal energy.

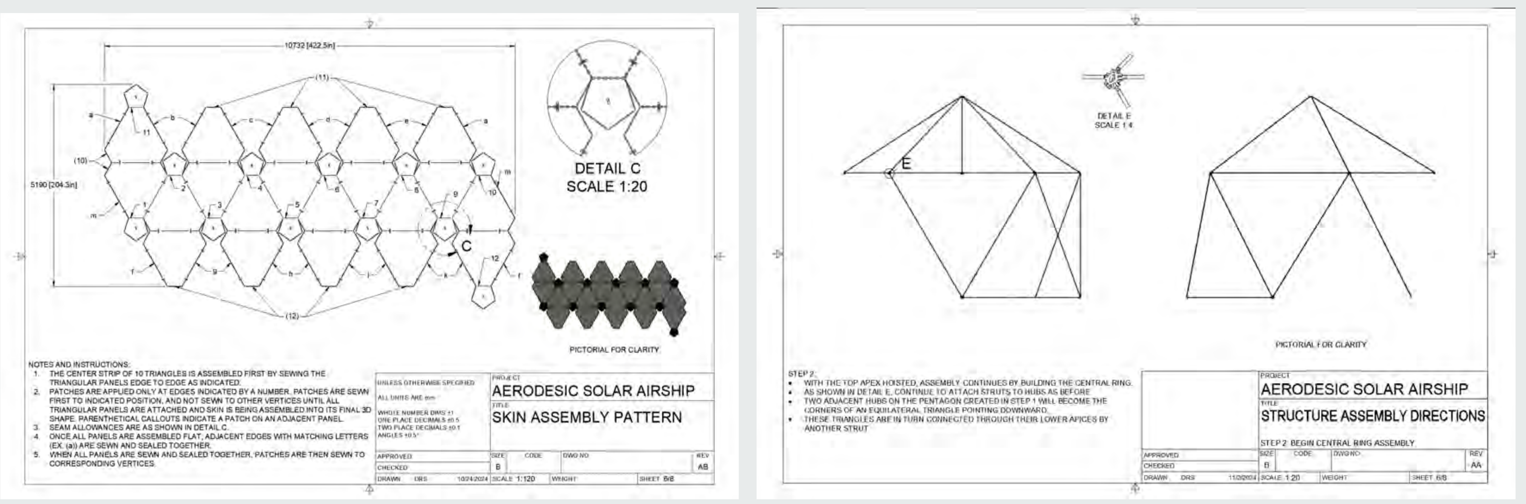
The airtight thermal envelope is used to retain heat to provide lift forces due to thermal differences. The envelope is made of PET aluminum coated mylar to aid in the reflection of infrared radiation internally, keeping the envelope warmer for longer.





The frame's primary function is to maintain the volume of the envelope. It is composed of 3D-printed hubs located at vertices, connected by carbon fiber rods to form the geodesic tensegrity.

Construction

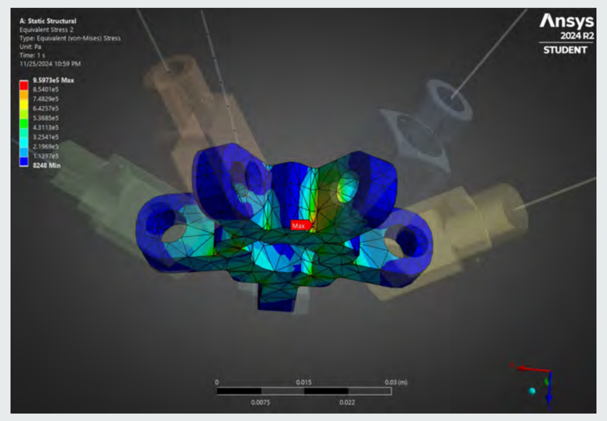


Selected pages from technical drawings created to illustrate the thermal envelope and structure assembly process

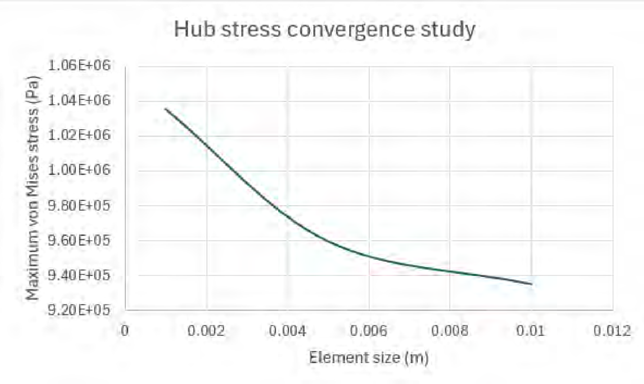
Finite Element Analysis

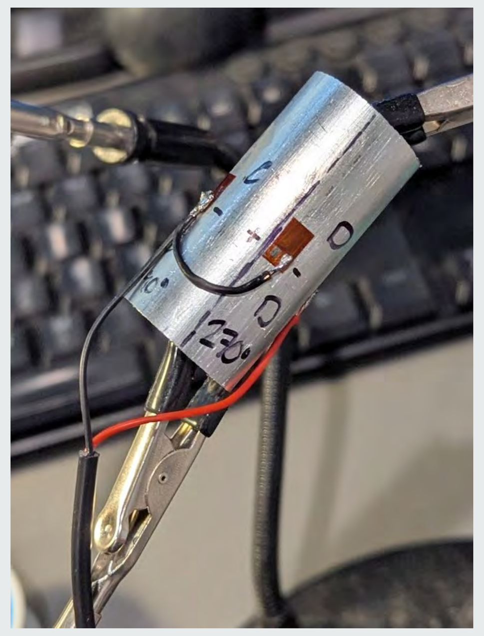
Analysis of the stresses experienced by the structure was performed via finite element analysis (FEA). To focus on strength of the hub design, a hub was chosen that would be tethered to the ground to hold the airship in place. Maximum stress found in a convergence study was localized on points where strut attachment arms connect to the hub's main body, indicating a need to reinforce this piece to withstand forces from the struts.

Verification of FEA results was performed by comparing to results from a strain gauge bridge attached to a representative strut while the thermal envelope was pressurized. This placed axial and bending loads on the struts.



FEA result model in Ansys





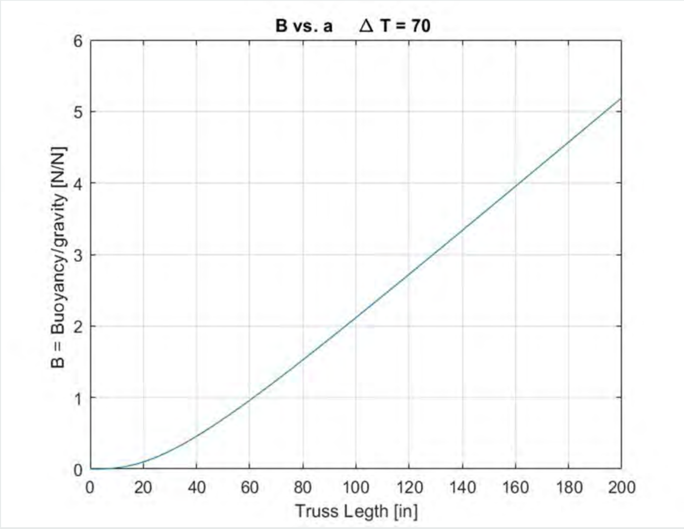
Strain gauge assembly

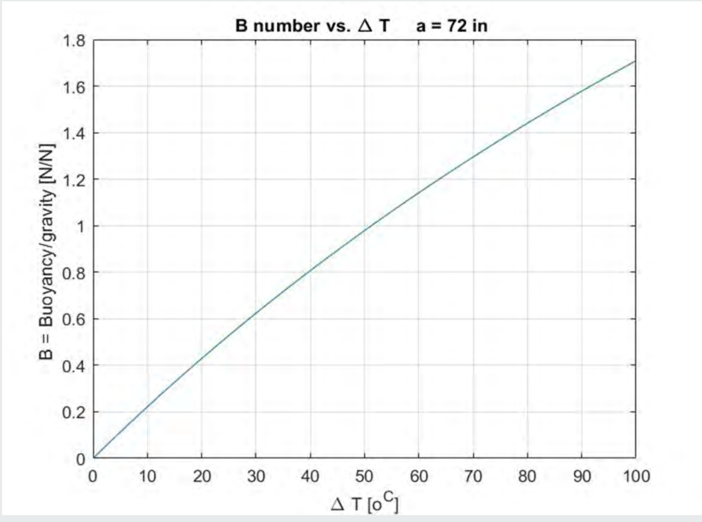
Technical Analysis

A buoyancy factor (B) can be used to effectively represent the vehicle's lift capability, defined as

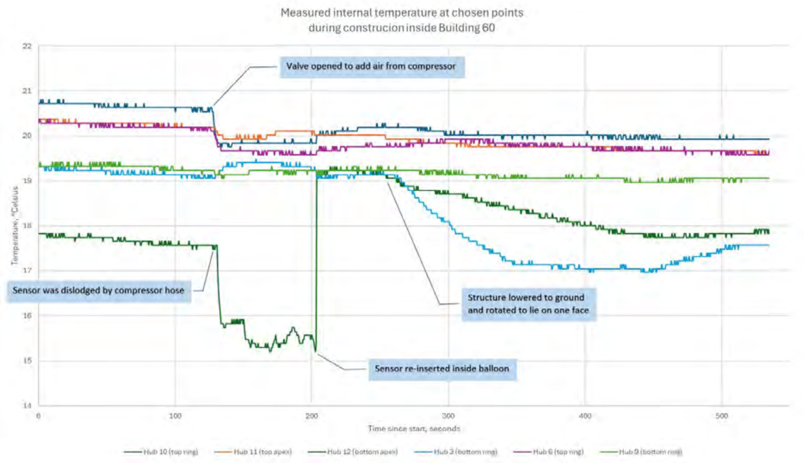
$$B = \frac{F_{buoyancy}}{m_{vehicle} \cdot g}$$

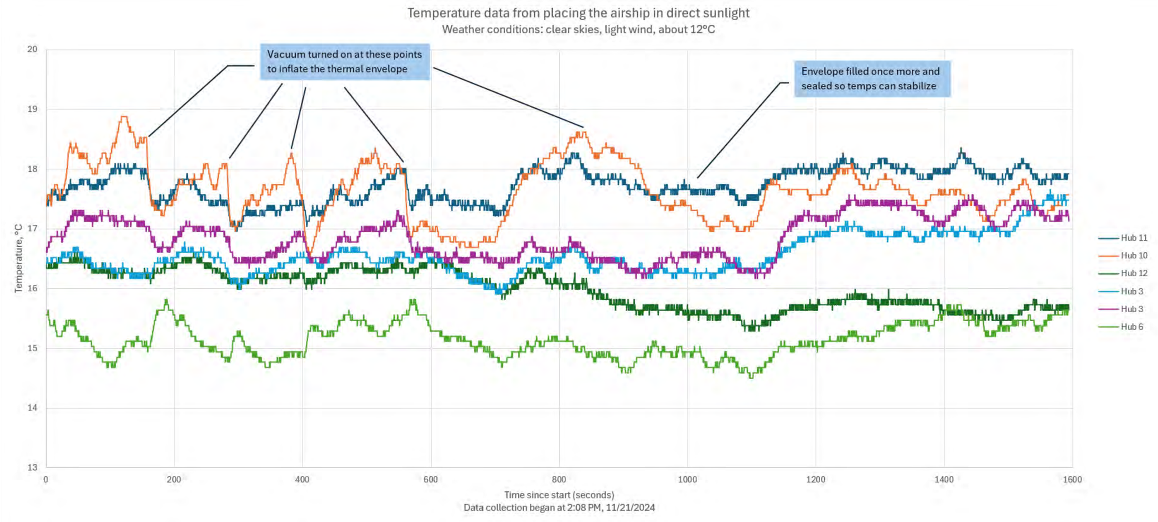
where $m_{vehicle}$ is the mass of the frame and envelope combined, and g is the gravitational acceleration constant. This can be extrapolated to strut length and temperature relations for lift to be achieved by the airship.





Temperature was measured at points inside the balloon during construction and in direct sunlight





Conclusions

This investigation focused on evaluating the feasibility of a rigid-framed solar thermal airship while prioritizing practical manufacturing and assembly methods. Key outcomes include:

- Simplified and Cost-Effective Manufacturing: The design incorporates only four repetitive parts, eliminating unique components that are difficult and expensive to produce. This approach ensures cost efficiency without compromising structural integrity.
- Ease of Assembly The airship's construction process was optimized for efficiency. The assembly begins with building the center ring of the geodesic frame while attaching hubs to their corresponding skin patches. Simultaneously, the thermal envelope is inflated, allowing struts to be secured in position.

These findings will now inform the development of a full-scale, 30-meter model by **Bentham LLC**, demonstrating the airship's operational feasibility and paving the way for sustainable advancements in aviation.