NULL SHIP; LIGHTER THAN AIR TRAVEL BY VACUUM

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OBJECTIVES

The goal of this project is to explore novel designs and research areas relating to Vacuum Air Ships. Here we provide an overview of:

1. A brief history of the concept
2. Theoretical and material challenges
3. Previous and current design concepts
4. Other projects concerned with vacuum air travel
5. Future research plans

INTRODUCTION

The Vacuum Airship, or Null Ship, is a concept which has existed since as early as the 17th century. The basic idea is to contain an evacuated volume within the aircraft, rather than filling that volume with a lighter-than-air gas such as hydrogen or helium, as is done in nearly all conventional airships.
Few, if any, attempts have been made to build a prototype, and many consider the design to be purely hypothetical due to the immense pressure difference involved.

RESULTS

After mathematical analysis, the following equations were used to analyze the Concentric Shell Null Ship:

$$M_s = \frac{4}{3}\pi\left(\frac{P_{atm}}{1-\frac{{r_1}^2}{{r_2}^2}}\beta\right)({r_2}^3 - {r_1}^3)$$

(Mass of air between shells)

$$\Sigma\frac{F}{\Delta A} = \frac{P_s \Delta A}{\Delta A} - \frac{F_n N}{4\pi(r_2)^2} - \frac{P_{atm}\Delta A}{\Delta A}$$

(Air Pressure required between shells)

These mathematical relationships were derived from elementary physics concepts such as the Ideal Gas Law and Newton's Second Law. Though the analysis becomes somewhat too complicated to fully explain in a poster, the research was started simply by identifying how much force would be exerted on a spherical craft of a given radius by 'normal' atmosphere. Naturally, this amount of force would need to be "balanced" by a force of equal magnitude exerted outward by the pressurized air inside the craft.

This basic observation leads to the first major obstacle we encountered.

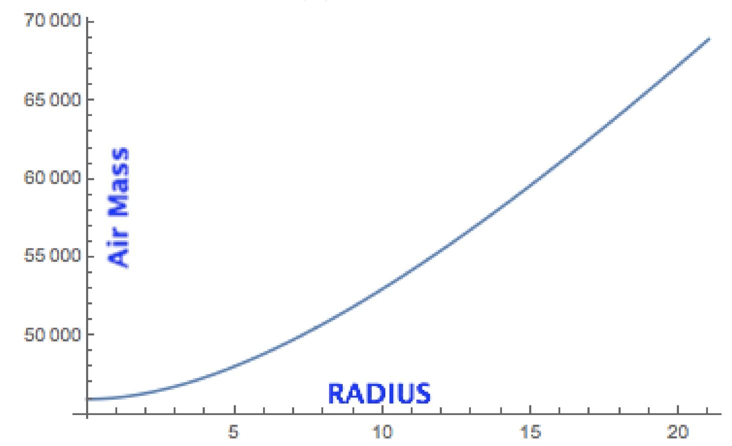

Figure 3: Air Mass vs. Radius

Preliminary analysis showed a critical flaw in the Concentric Shell design; the Ideal Gas Law showed that at the pressure needed to resist the compressive force of the atmosphere, air becomes too dense to achieve buoyancy. The graph above (fig.3) shows the mass of the air with respect to the radius of the internal shell. The graph demonstrates that mass only increases, with no minimum value falling below that of an ordinary balloon.

PRIMARY DESIGNS

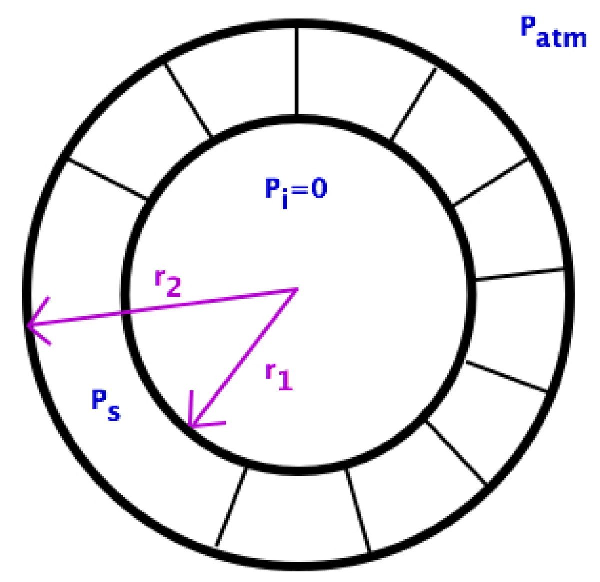

Figure 1: Concentric Shell Null Ship

Pictured to the left (fig.1) is the first general design concept we explored. The 'Concentric Shell' Null Ship featured two flexible spheres of non-porous material, connected by a series of support wires. The space between the two shells is pressurized and forced to expand, causing the empty volume inside to expand and remain open.
This particular design was abandoned after a mathematical analysis showed that air density between the shells would increase with air pressure and ultimately contribute too much mass, causing the craft to lose buoyancy. This problem is explored in more detail below.

The image to the right (fig. 2) depicts the current design iteration which was devised to counter the pressure vs. density problem described above and in the 'Results' section to the left. Here we have an empty volume (a vacuum) inside a flexible, non-porous shell. The structure of the craft is a series of circular tubes which are pressurized to resist the compressive force from the atmosphere. With this reduction in air volume, we hope to reduce the amount of air mass and thereby avoid the loss of buoyancy which caused the failure of the Concentric Shell Null Ship.

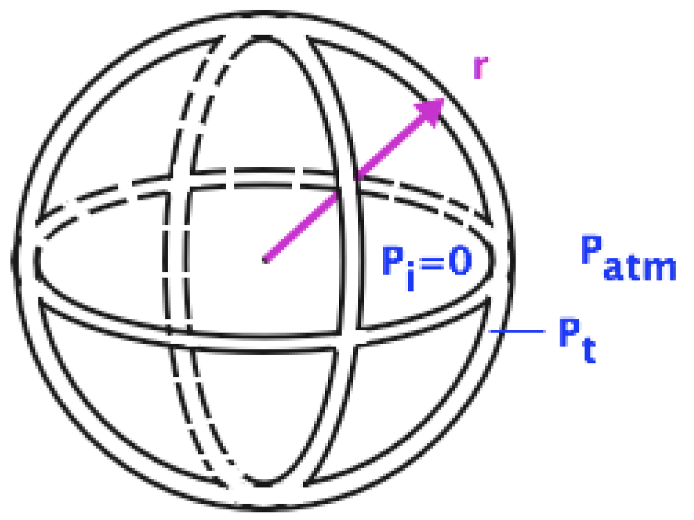

Figure 2: Rigid Air Beam Null Ship

CONCLUSION

The Concentric Shell Null Ship has been declared infeasible due to the mass vs. density problem described above (fig. 3).
The Rigid Air Beam Null Ship appears to be our most promising area of research. Reducing the volume of air would mean less mass. The reduced air volume would also make the process of heating the air inside the tubes more plausible; heating the air would allow greater air pressure at a lower density and, therefore, lower air mass.
One interesting result from the beginning of the Rigid Air Beam analysis is that the mass of the air inside the tubes is not significantly affected by the number of support tubes. This is a result of the fact that the required pressure in the tubes decreases if more tubes are used, and the mass increases by the same factor.

REFERENCES

- Akhmeteli et al, *Layered Shell Vacuum Balloon Patent Application Publication* 2006
- MacDonnell, J., *Francesco Lana-Terzi, S.J., http://www.faculty.fairfield.edu/jmac/sj/scientists/lana.htm* Accessed April, 2017.
- Clark, J.P., *Evacuated Airship for Mars Missions, https://www.nasa.gov*, Accessed May, 2017.

FUTURE RESEARCH

Present research efforts are focused on constructing models, both physical and mathematical, in order to fully describe the geometry and forces acting on each portion of the Rigid Air Beam design.
Entirely different design concepts for a Vacuum Airship have been suggested in recent times. Most notably, a U.S. patent filed in 2006 describes a "Layered Shell Vacuum Balloon" supported by a honeycomb structure of aluminum walls.
NASA is currently considering a similar design to explore the surface of Mars. According to their publication, the comparatively lower pressure of the Martian atmosphere favors the use of vacuum aircraft.