VACUUM OPERATED GAS LIFT (VOGL) - brought to you by INFINITE HANGTIME

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This white paper explains how our novel technology can make future air operations simpler, safer, drastically cheaper, and more environmentally responsible. At the time of writing the design is patent pending. We welcome inquiries about how you can partner with us in this endeavor.

EXECUTIVE SUMMARY

Our experimental design is a ruggedized, rigid, vacuum balloon that can function as a very low-flying satellite, tethered aerostat, or extremely efficient cargo transport vehicle. The balloon can hover at altitudes lower than 20,000ft / 6,096m above ground level with no power (gas, electricity, etc.) requirements to retain lift/elevation for extended periods of time. The balloon's novel geometric shape and composite construction allow it to withstand external pressure, maintain internal pressure seal, and requires little to no maintenance. Energy required to transport VOGL at altitude is exponentially less than conventional air cargo and VOGL units may be scaled to accommodate payload delivery under adverse conditions.

BACKGROUND

Many studies have been performed on the topic of flight endurance. Very few studies have been performed on the topic of **'infinite lift.'** Infinite lift refers to the capacity to remain at altitude, with or without a payload, for extended periods of time with no power requirements and little to no maintenance requirements.

Conventionally designed aerostats and balloons are able to float for a finite period of time depending on gas retention capacity and environmental factors. Their design and construction materials make them expendable assets that are susceptible to adverse conditions. They are also known to ‘runaway’ in the gas column when imprecisely inflated. This normally destroys the vessel.

Traditional airborne platforms, such as airplanes and helicopters, have a short duration due to crew endurance, fuel capacity, and maintenance requirements. The majority of fuel expenditure occurs during takeoff.

Emerging platforms, such as drones and unmanned aerial vehicles (UAVs), are constrained by battery capacity, payload efficiency, signal range/fiber optic cable length, and susceptibility to jamming or environmental interference.

These constraints do not apply to our novel **Vacuum Operated Gas Lift (VOGL)** technology. Our products “float” in the atmosphere similar to how buoys and ships take advantage of their displacement-derived buoyancy. Our products only require additional energy when being moved from one location to another.

The energy requirements needed to move a VOGL unit are its primary advantage, being exponentially lower than those required for conventional airborne assets, even with a payload. A good analogy might be how a small trolling motor can move a bass boat or how a small tugboat can tow extremely large barges into harbor. Furthermore, the fluid drag on airborne vehicles is less than the drag on waterborne vehicles. Because of these advantages, we intend for VOGL technology to augment and eventually replace aspects of containerized waterborne and overland shipping. Concerns about VOGL cargo transport under adverse conditions could be alleviated by adding more VOGL units than required to maintain desired altitude.

VOGL is still experimental. The following proposed experiment is a balloon style lift system designed with a clean sheet approach to gas envelope structure. The core concept of this design, the vacuum balloon, was an inevitable discovery. The basic design principle at work is, “removing gas from within a sealed envelope removes mass from within the envelope.”

Therefore, if a gas envelope is immune to shape change caused by internal vacuum, and the entire system’s gross weight is less than the weight of its own internal gas volume, then we hypothesize that lift may be induced by removing sufficient gas from within the gas envelope, sustained by maintaining lower internal pressure, and diminished by equalizing internal pressure with the ambient atmosphere until zero lift remains. We further hypothesize that a lighter than air craft may be produced from advanced composites to employ this concept. The following design experiment harnesses this principle to change the system's position in the gas column (float) by modulating internal pressure to displace mass.

To our knowledge no one has ever successfully produced a vacuum balloon lift system like this. The main obstacle is avoiding structural collapse due to crushing external pressure while remaining lightweight enough to lift with air displacement. This experiment proposes to mitigate the crushing effect by employing a specific shape, material, and layup during the manufacturing process.

DESIGN DETAILS

Gas Envelope Assembly - The gas envelope assembly consists of a rigid unit-body structure made primarily from carbon fiber laminate. The individual gas envelope components include the wall spar (Figure 1), the central spar hollow tube (Figure 2-1), the top cap (Figure 2-2), and the bottom cap with filtered valve (Figure 2-3). The gas envelope should operate sustainably between zero and one atmosphere of negative internal pressure by harnessing positive external gas pressure to reinforce and strengthen the envelope structure. It does so by employing a novel wall spar shape that permits carbon fiber construction material while effectively containing vacuum. This rigid gas envelope design is intentionally configurable and scalable in order to promote maximum versatility. Multiple VOGL units can be added, or larger and stronger VOGL units can be created to achieve the lift required for custom payloads.

Wall Spar Geometry and Layup - Complimentary constant curve geometry applied throughout the length and breadth of each individual wall spar should distribute the differential pressure load evenly along the entire spar surface (Figure 1-1 & Figure 3-1). The concave torus shape of each individual wall spar should permit use of lightweight composite construction material such as carbon fiber (Figure 3-2, Figure 4-1, and Figure 7-1). The complimentary constant curve geometry tapers evenly from the wall spar centerline to a flat tangent face oriented and sized for implementation as a bonding surface (Figure 1-2). Composites used for the wall spar are laid up unidirectionally and orthogonally in order to bear and distribute the differential pressure load in operation. When bonded the long flat spar faces unite and become structural support ribs reinforced by positive external gas pressure (Figure 7-2).

Central Spar Geometry and Layup - The central spar consists of a hollow tube arrayed vertically in the gas envelope (Figure 5-1 and Figure 6-1). Central spar composites are laid up orthogonally. The central spar gives structural support that is consistent with design load bearing requirements, and grants housing for future systems and payload development.

Top Cap - The top cap consists of a disc shaped structural member, non-sealing, installed near the topmost portion within the central spar (Figure 5-2). As a light duty part it can be manufactured using different materials and shapes to promote utility, and provides an ideal mounting platform for future systems and payload development.

Bottom Cap and Valve - The bottom cap consists of a disc shaped structural member, non-sealing, installed near the bottom most portion within the central spar (Figure 5-3). Its primary roles include mounting the inlet/outlet valve and providing an attachment point for ballast.

Sealing and Bonding Method - The wall spars are bonded to one another along the flat bonding faces (Figure 1-2), and on end to the central spar outer face (Figure 5-4), in an evenly revolving pattern around the central spar using chemical and mechanical bonds. The top and bottom caps are attached within the central spar using similar bonding methods.

Gas Control System - Gas evacuation from the storage envelope to increase buoyancy is achieved using any commonly available gas evacuation system, such as a vacuum pump, scaled to requirement. The evacuation system may or may not remain attached to the lift system during operation. Gas induction to the storage envelope, used to diminish buoyancy, is achieved by siphoning higher pressure ambient gas through an inlet/outlet valve into the storage envelope (Figure 5-5).

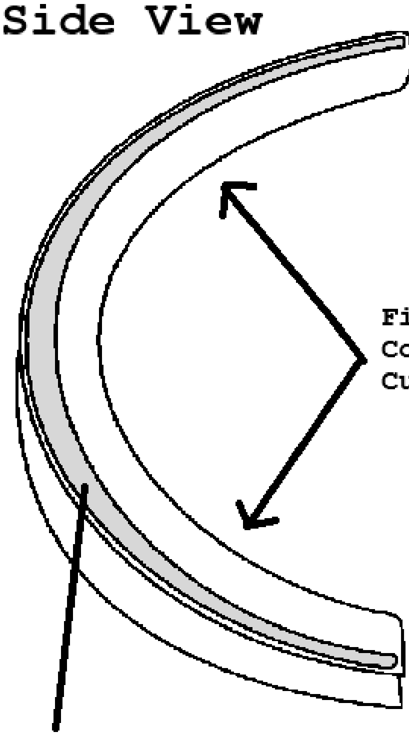
Fill-Gas - The optimum fill-gas is ambient temperature locally available atmospheric gas siphoned directly from the immediate atmosphere by means of a filtered equalizing valve. No special fill-gas type, preparation or infrastructure should be required. The gas evacuation system and gas envelope structure must be compatible with the fill-gas composition and temperature. Anywhere on Earth ambient air is the likeliest fill-gas candidate for this system, but other fill-gasses may be used. For instance, helium or hydrogen may dramatically increase some performance parameters at the cost of safety or sustainability.

The subject of this experiment will be approximately two point five meters wide and tall, and being made from single wall carbon fiber, should weigh less than six pounds laden with air. It will consist of forty wall spars. These specifications were chosen based on estimated material thickness versus load bearing in order to achieve a lighter than air net weight. While any levitation observed will represent massive success, even materially lowering the weight of the vessel without crushing it would partially prove the concept.

Validation during the manufacturing process can be accomplished using commercially available laser measuring devices, such as LIDAR, alongside analog measurements confirmed by custom measuring jigs. Three separate witness coupons should be preserved from each wall spar and the central hollow spar ahead of unforeseen future validation requirements.

FIGURE 1

Wall Spar
Side View



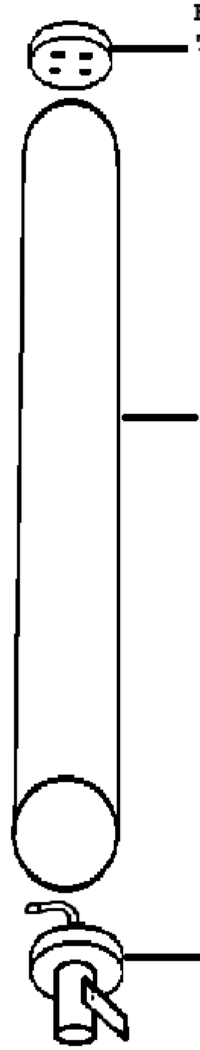


FIGURE 2

Central Spar
Components
Side View

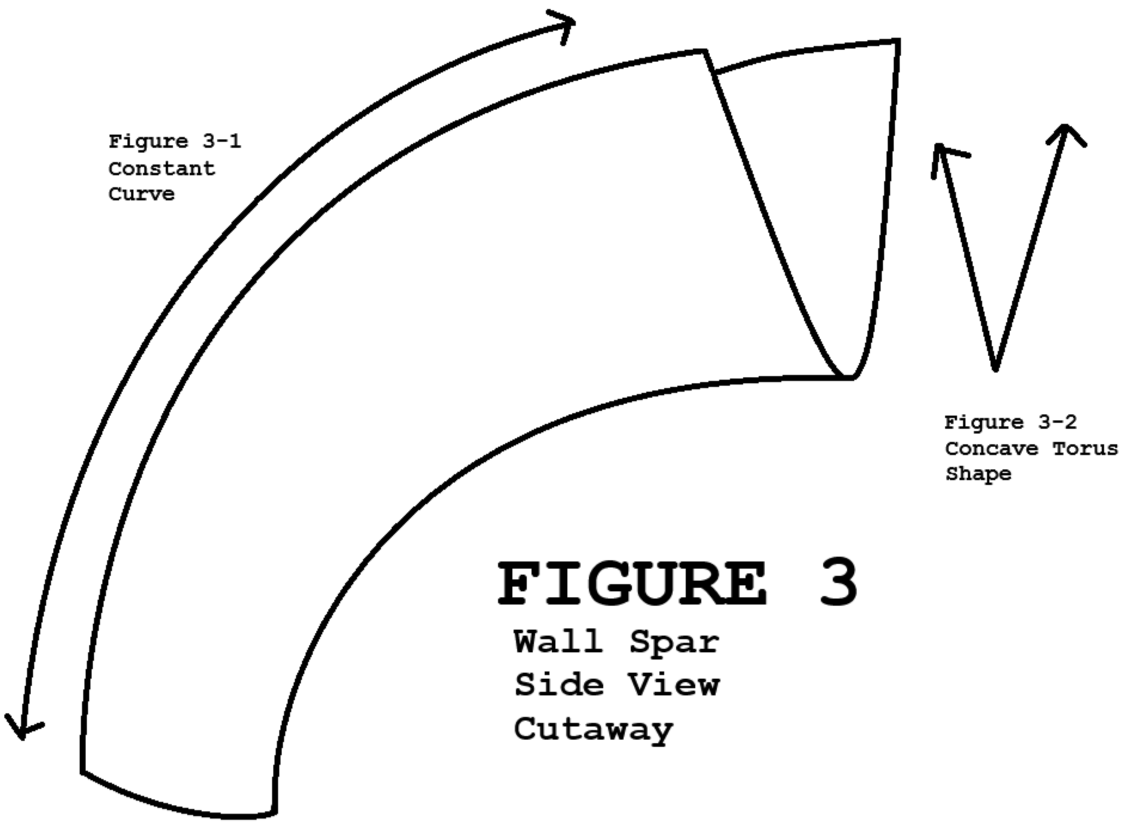


FIGURE 3

**Wall Spar
Side View
Cutaway**

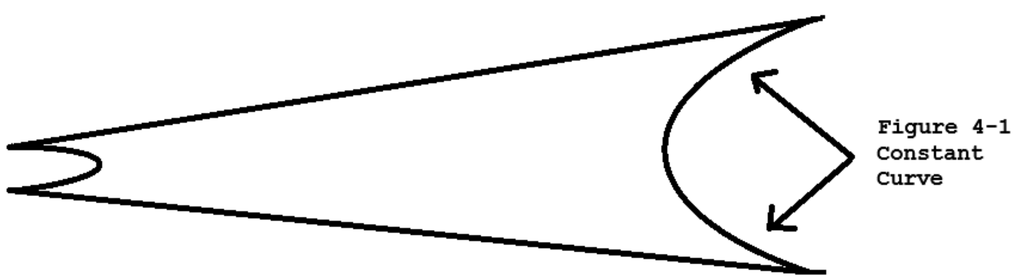
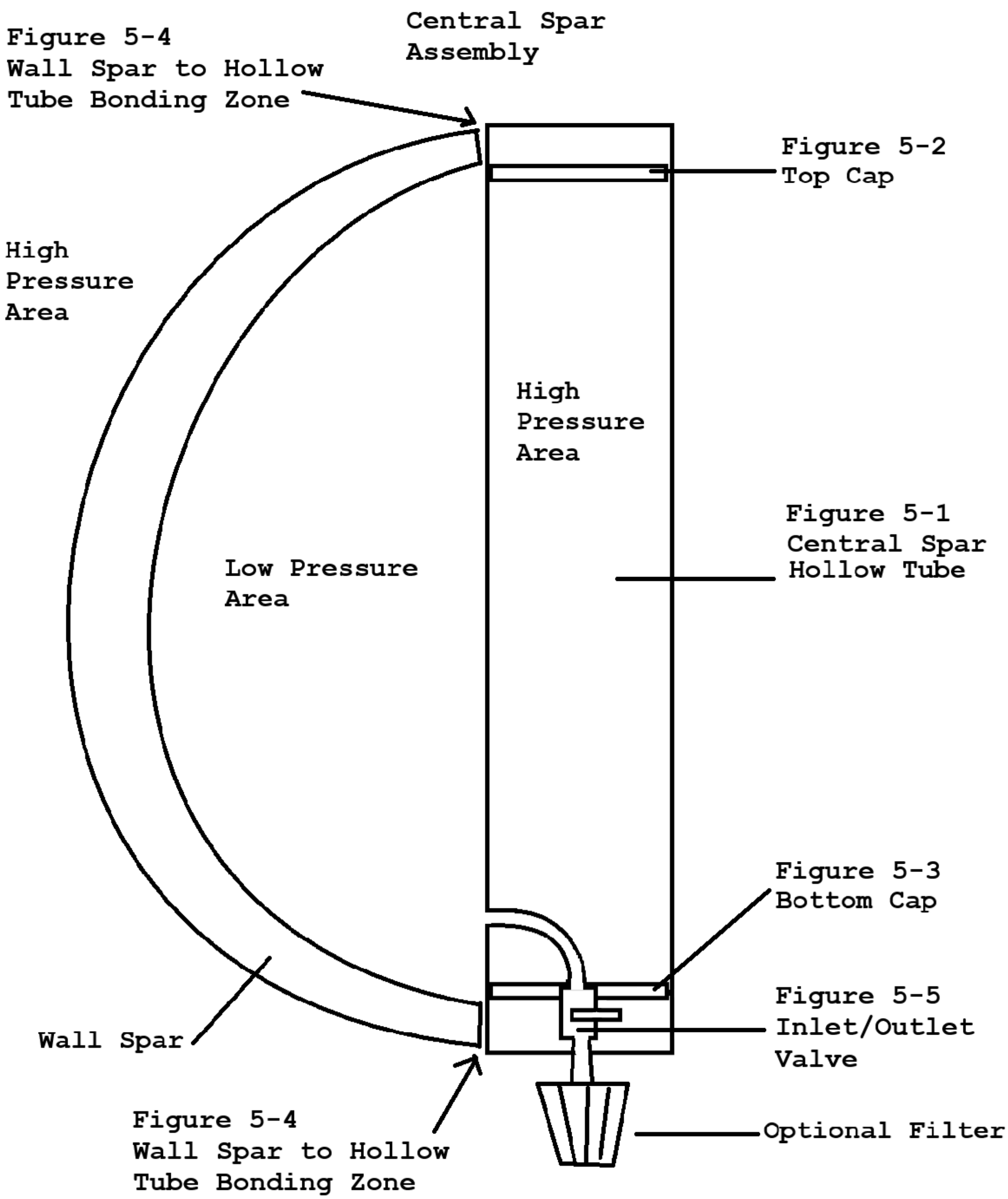


FIGURE 4

**Wall Spar
Top View**

FIGURE 5


Central Spar
Assembly
Figure 5-4
Wall Spar to Hollow
Tube Bonding Zone
Figure 5-2
Top Cap
High
Pressure
Area
High
Pressure
Area
Figure 5-1
Central Spar
Hollow Tube
Low Pressure
Area
Figure 5-3
Bottom Cap
Figure 5-5
Inlet/Outlet
Valve
Wall Spar
Optional Filter
Figure 5-4
Wall Spar to Hollow
Tube Bonding Zone

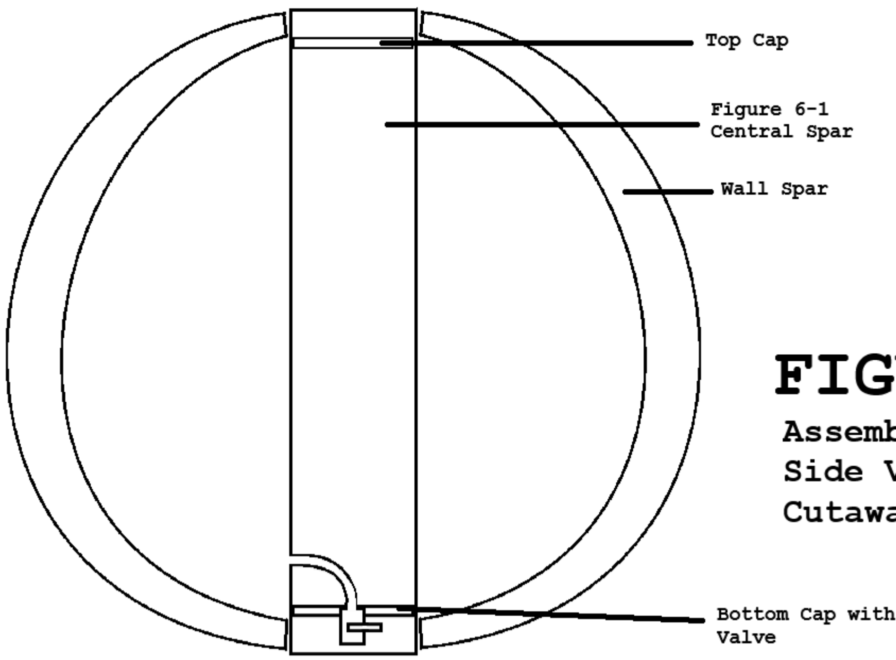


FIGURE 6
Assembled
Side View
Cutaway

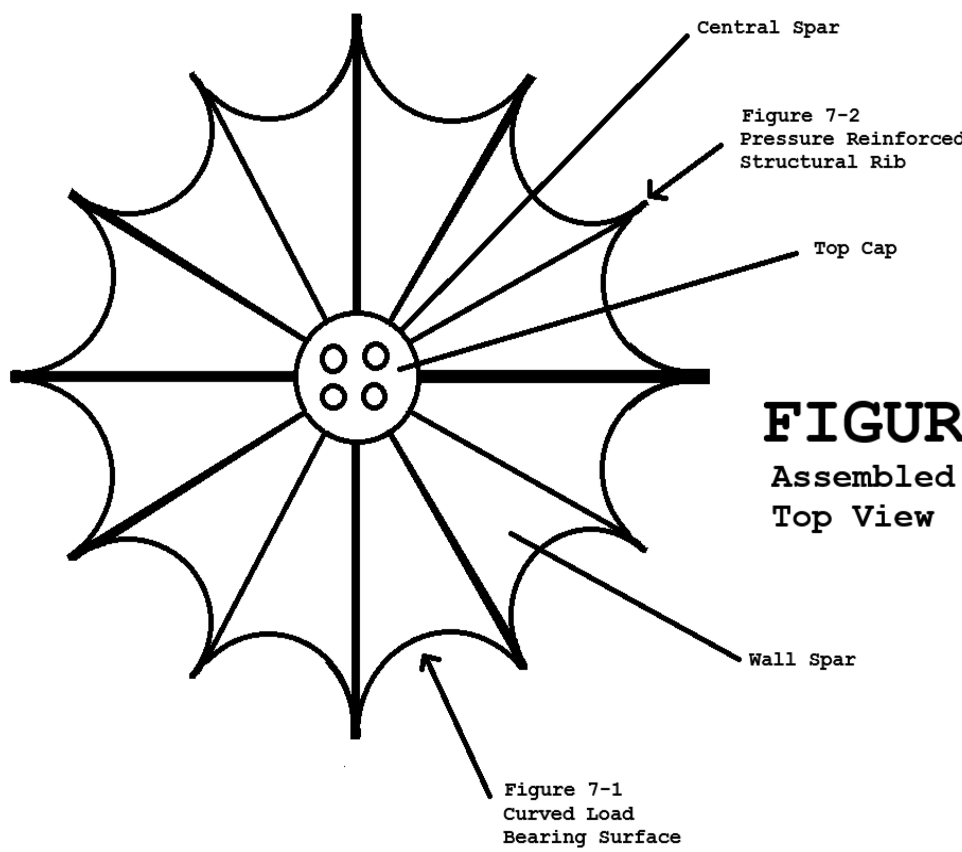


FIGURE 7
Assembled
Top View

DESIGN FACTORS

Sea level ambient air pressure is reliably fourteen point seven pounds per square inch. At twenty thousand feet above ground level we find about forty percent of that pressure, or around six pounds per square inch. These figures represent atmospheric pressure differences that should reduce the system's lift as it climbs owing to less ambient mass acting towards displacement. This should create a very stable neutral buoyancy effect at the specific altitude where mass equalization occurs. In theory the operational ceiling of this lift system is roughly the height of the local gas column minus payload. In practice the actual ceiling should be closely related to the gas storage envelope volume, system differential pressure tolerance, and vacuum system gas evacuation capacity. **There are several factors at work in the present lift system;**

Gas pressure ranges within and without the gas storage envelope were used when estimating design lift capacity, and should be monitored during use. These measurements may be understood as absolute pressure, and expressed as a barometric pressure ratio (BAR), inches or millimeters of mercury (inHg/mmHg), pounds per square inch (PSI), or Pascal (Pa).

Differential pressure equal to an amount between zero and one relative atmosphere internally is a desirable outcome of this system's lift-gas employment, and will always be present when ambient atmospheric gas is siphoned for lift-gas. As such, it is necessary for the lift-gas envelope to be manufactured to operate safely as a vacuum chamber.

Differential Pressure Calculation: $\Delta P = P1-P2$ where 'ΔP' is the difference between ambient atmospheric pressure 'P1' and gas pressure within the lift-gas envelope 'P2'.

Gravity is the force that powers buoyancy. Gravity on Earth is generally assumed to be at or around one gravity, but may vary on other planets.

Payload mass represents the gross flying weight of the lift-gas envelope with all systems, sub-systems, assemblies, attachments, cargo, passengers or other items being lifted during operation.

Gas density can be measured and expressed in kilograms per cubic meter, or using other units of measure.

Ambient atmospheric gas density correlates with immediately available displacement mass, and acts as an external lift performance variable. Accordingly, flight performance characteristics of this lift system will be affected by local meteorological factors such as atmospheric pressure, temperature, and composition.

Maximum displaceable volume represents the maximum amount of lift-gas that may be displaced internally by a given application of this system. It is essentially the practical lift limit imposed by lift-gas envelope capacity and gas evacuation system capability. For example, in the case of a balloon shaped application of this system calculating for a sphere is appropriate. Other shapes, such as a toroid, may be used.

Maximum Displaceable Volume Calculation: MDV = GV-(SDxGV) where 'MDV' is the gas envelope practical working maximum displaceable volume, 'GV' is the gas envelope gross volume, and SD is a system differential representing the gas evacuation system capability.

Buoyancy AKA lift by mass displacement, is the essential principle by which this gas system generates lift. System buoyancy should diminish or increase during operation corollary with external atmospheric density and displaced internal volume.

Buoyant Force Calculation: FB = pVg where 'FB' is the Buoyant Force, 'p' is the ambient atmospheric gas density, 'V' is the displaced gas volume, and 'g' is gravitational acceleration in the local well.

Displacement Mass Equalization Altitude Calculation: V = P/AD where 'V' is the displaced gas Volume, 'P' is the gross payload, and 'AD' is the air density at desired equalization altitude.

EXPERIMENT WORKFLOW

Produce a foam wall spar pattern using either hotwire, CNC or vacuum molding techniques. Prepare and finish pattern surface. Validate pattern using LIDAR and measuring jigs. Preserve LIDAR point clouds. Photographically document sacrificial paint/chalk transfer marks from measuring jigs for congruency on wall spar ribs and valleys.

Produce a composite wall spar mold from pattern and finish mold surface. This mold should be manufactured from the same material as the wall spars to prevent expansion issues under thermal stress. Validate mold using LIDAR and measuring jigs. Preserve LIDAR point clouds. Photographically document sacrificial paint/chalk transfer marks from measuring jigs for congruency on wall spar ribs and valleys.

Produce required wall spars from mold and finish surfaces and bonding areas. Individually label each wall spar for tracking purposes. Validate spars using LIDAR and measuring jigs. Preserve LIDAR point clouds. Photographically document sacrificial paint/chalk transfer marks from measuring jigs for congruency on wall spar ribs and valleys.

Procure or produce a central hollow spar and prepare the bonding regions. Validate using LIDAR and measuring jigs. Preserve LIDAR point clouds. Photographically document sacrificial paint/chalk transfer marks from measuring jigs for congruency along central spar outer surface.

Produce a top cap using a 3d printer and validate using standard measuring tools. Record results.

Produce Bottom Cap using a 3d printer and validate using standard measuring tools. Record results. Install filtered valve and suction hose on bottom cap.

Assemble caps and central hollow spar using chemical bonding methods. Attach vacuum hose to vacuum port located within the central hollow spar lower interior portion.

Build assembly jig and validate using standard measuring tools.

Test fit all wall spars and the central hollow spar by assembling them, without bonding, using the assembly jig. Once dry fitment has been validated, bond all wall spars to the central spar using chemical bonding methods and the assembly jig. Validate assembly using LIDAR, and weigh assembly with inlet/outlet valve in the open position and fully laden with air. Preserve LIDAR point clouds. Record absolute internal air pressure and assembly weight in this condition. Securely fasten assembly to an anchoring point and attach vacuum source to valve.

Validate concept. Unload air from the gas envelope using a vacuum source and close the inlet/outlet valve. Detach vacuum source. Re-measure absolute internal air pressure and assembly weight in unladen condition with vacuum pump detached. Evaluate sealing and pressure tolerance throughout the process. Photographically document surface for abnormalities or deformation, and re-measure individual wall spars with jigs to detect deformation. Photographically document witness/transfer marks. The assembly may have achieved buoyancy at this stage. By comparing the empty and laden weights of a functioning assembly we should be able to discover whether this design concept is valid and functional.

APPLICATION

Any atmospheric lift activity within the domain of human endeavor requiring scalable lift and operating the lift-gas envelope between zero and one atmospheres relative to the local atmosphere. **This development may affect operations across multiple sectors, including;**

Transportation - The lift capabilities of this platform may scale favorably for transportation purposes, and may operate with heavy payloads in a safe, predictable manner. Additionally, lift-gas sustainment should be simplified to a valve operation, with zero lift-gas sustainment infrastructure or pollution.

Evacuation - This lift system's robust, sustainable design could make it useful in civil emergencies or remote areas for those affected by natural disasters or other crises.

Meteorology, Defense and Energy Production - This lift system's flight charactaristics may make it ideal for a wide variety of atmospheric data collection and other activity by potentially providing more flight time per capita than existing platforms.

And **Exoplanetary Atmospheric Exploration** - This lift system’s unique versatility and endurance could make it a favorable candidate for exoplanetary atmospheric exploration.

CONCLUSION

By removing the need for power and maintenance, VOGL may revolutionize the expense and safety concerns associated with conventional tethered aerostats, cargo transport vehicles and/or low-flying satellites. The pragmatic design will allow future users to produce VOGL with commercially available equipment and materials.

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