1.0 INTRODUCTION

Until now, aeronautical flight vehicles have relied, almost exclusively, on a fixed-wing concept to elevate the aircraft and propel it through the atmosphere. One might comment that helicopters are the exception to this rule, but, as is well known, a helicopter utilizes a rotating fixed wing to generate the lift required to propel the aircraft. A cursory examination of NASA's websites and those of the USAF Research Laboratory reveals that while many concepts for new aircraft are under development, almost all of these rely on the fixed wing concept to generate lift. This information is readily available to the public, so one must assume that there may be other novel concepts under development that are clandestine in nature and, as such, not readily revealed to the public. However, it is safe to assume, given the general nature of aircraft design and development over the past sixty years that even these clandestine designs are also based on the fixed wing concept.

Our SDR Engineering Team has broken with this tradition and is currently developing a radically new concept for transportation, particularly drone and human-cargo aircraft that relies on the use of a sphere to generate the required lift and propel the spherical aircraft through the atmosphere (or water). This technology has been proven in battle since World War II, on every golf course on Earth and in numerous scientific studies; but no one has improved on it as dramatically as our design. The advantages of such a concept over that of the fixed wing concept are manifest. For example, by the very nature of the approach, the entire surface of the sphere is a lifting body, whereas in the fixed wing aircraft, the wings provide the predominant lift. As a result, the spherical aircraft could easily outperform any fixed wing aircraft, in terms of aerodynamics and efficiency. Radar signatures can be "tricked" using a sphere design. These features would be directly scalable to any sized sphere. With the rise of interest in autonomous unmanned aircraft, the innate scalability of the spherical aircraft and its attendant capabilities makes this design concept highly desirable. An aircraft carrier could hold and launch many, many more of these types of craft than they now do with a fixed wing craft. A submarine could launch such a runway-free craft. Many other advantages exist. Although Our SDR Engineering Team has developed the spherical aircraft concept to the point of feasibility, the firm now requires additional funding to build and test initial prototypes. Since the scientific and engineering basis for the concept has been clearly established, the firm believes that workable prototypes could be fabricated and tested within a year of initiation of a construction project.

2.0 APPROACH

This White Paper is intended as an introduction to a radical new flight technology that is under development by Our SDR Engineering Team. The basic concept underlying the technology together with some specific examples of how the technology could be used to fabricate working prototypes is discussed. Further details can be provided under executed NDA.

The theoretical basis for the proposed concept is derived from the fact that a translating sphere is unable to produce aerodynamic lift, because of its geometric symmetry, but a rotating sphere is capable of producing lift as a result of its a viscous interaction with air, water (or supplied molecules in space); the so called Magnus effect. Enhancements, optimizations and support technologies applied to the surface structure and system of the sphere provide the thrust needed to complete the design of the new proposed aeronautical vehicle.

The details of how a spinning ball creates lift are fairly complex. Next to any surface, the molecules of the air stick to the surface. This thin layer of molecules entrains or pulls the surrounding flow of air. For a spinning ball the external flow is pulled in the direction of the spin. If the ball is not translating, there is the spinning, vortex-like flow set up around the spinning ball, neglecting three-dimensional and viscous effects in the outer flow. If the ball is translating through the air at some velocity, then on one side of the ball the entrained flow opposes the free stream flow, while on the other side of the ball, the entrained and free stream flows are in the same direction. Adding the components of velocity for the entrained flow to the free stream flow, on one side of the ball the net velocity is less than free stream; while on the other, the net velocity is greater than free stream. The flow is then turned by the spinning ball, and a force is generated. Because of the change to the velocity field, the pressure field is also altered around the ball. The magnitude of the force can be computed by integrating the surface pressure times the area around the ball. The direction of the force is perpendicular (at a right angle) to the flow direction and perpendicular to the axis of rotation of the ball.

The Kutta-Joukowski lift theorem as referenced in Figure 1 for a single cylinder states the lift per unit length L is equal to the density rho of the air times the strength of the rotation Gamma times the velocity V of the air.

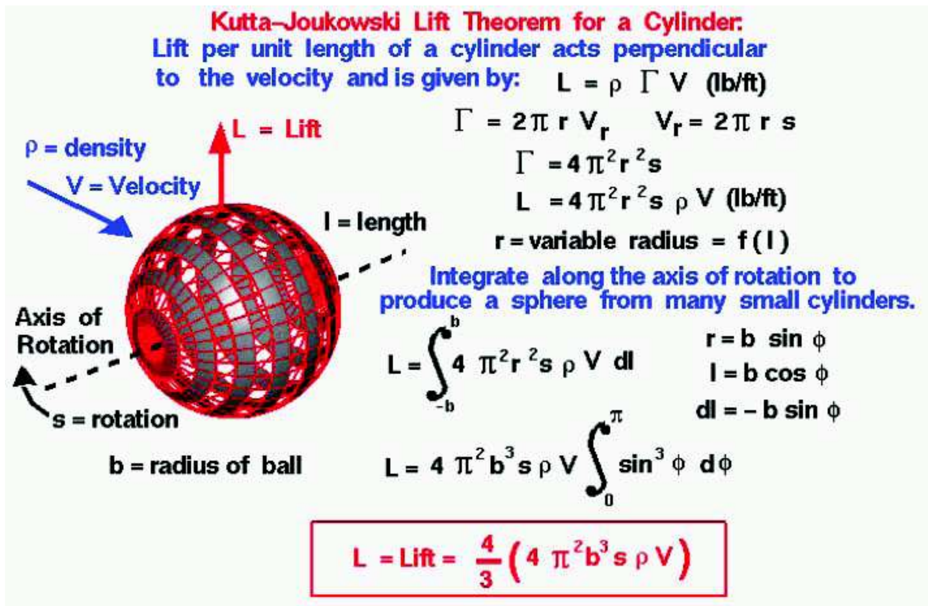


Figure 1 Kutta-Joukowski

The analysis represented in Figure 1 contains many simplified assumptions. The flow field is an ideal fluid field flow which can be generated by superimposing the field flow from an ideal vortex centered on the sphere with a uniform free stream flow. In this ideal model, the fluid (air) has no viscosity so there is no boundary layer despite the fact that viscosity is the real origin of the circulating flow.

The equation above describes the lift force generated on a smooth rotating sphere. In reality, the viscosity of the fluid generates a boundary layer on the sphere and any imperfections on the sphere's surface will disturb this boundary layer and disrupt the free stream flow. An example of this is the stitches on a baseball. On a baseball, the stitches cause the boundary layer to transition to turbulent flow which affects the amount of aerodynamic drag experienced by the ball. The stitches are not symmetrically distributed around the ball, so the real flow around the ball is separated, unsteady, and not uniform. To account for these real-world effects that have been neglected in our ideal flow model, one must define a lift coefficient. The lift coefficient is an experimentally determined factor that is multiplied times the ideal lift value to produce a real lift value. The ideal simplified model gives the first order effects and explains the relative importance of the factors that affect the lift force on the ball while all of the complex factors are modeled by the lift coefficient. The interaction between the surface of the sphere and the fluid in which it is immersed gives rise to all of the forces experienced by the sphere. The fluid itself is a loose mixture of molecules that are in random motion which generates kinetic energy. This energy is transferred to the sphere as it moves and thereby interacts with the fluid.

A full description of the details of airflow around a translating sphere can be very complicated and will depend critically on the size and velocity of the air flow. Nevertheless, the net effect on the sphere is rather simple; it results in drag but no lift. In other words, because of the symmetry of the sphere, all the complicated forces and effects of momentum, viscosity, and compressibility simply create a net force tending to drag the sphere in the direction of the free stream velocity, no lift results.

Like any body translating a fluid, in order to create lift it is necessary that there be an imbalance of pressure between the top of the body and the bottom of that body. This can most easily be seen when the body is an airfoil section. On an airfoil the distance an air molecule must follow when flowing over the top of the airfoil is significantly greater than the distance a molecule would flow when passing under the bottom of the airfoil. This difference in path length results in a difference in density and; therefore, a difference in pressure, between the top and bottom. On a sphere, all paths around the surface are great circles and they are the same length. Therefore, the airflow cannot generate a difference in pressure between one side and another. This leads to the simple realization that a purely translating sphere cannot generate lift.

Nevertheless, it is possible for a sphere to generate lift if the sphere is rotating. As discussed above, viscosity is a force that tends to make air molecules stick to the surface with which they are in contact. If a sphere is rotating at the same time it is translating the viscous forces will tend to move air from one side of the sphere to the other thereby creating a density and pressure differential. Any effect that results in creating a pressure differential from one side of the sphere to the other and is perpendicular to the flight velocity will create lift. This effect is referred to as the Magnus effect and is employed whenever topspin or backspin is placed on a tennis ball, for example. Although this effect is real, it is usually small and a relatively inefficient means of generating lift on a sphere.

Since drag tends to counteract lift, this explanation leads us to an important conclusion: the drag on a sphere is dominated by the flow separation over its rear face. If this separation could be minimized, the drag experienced by the sphere would be significantly reduced thereby multiplying the Magnus effect. The drag effect is apparent from experimental data, as shown in Figure 2

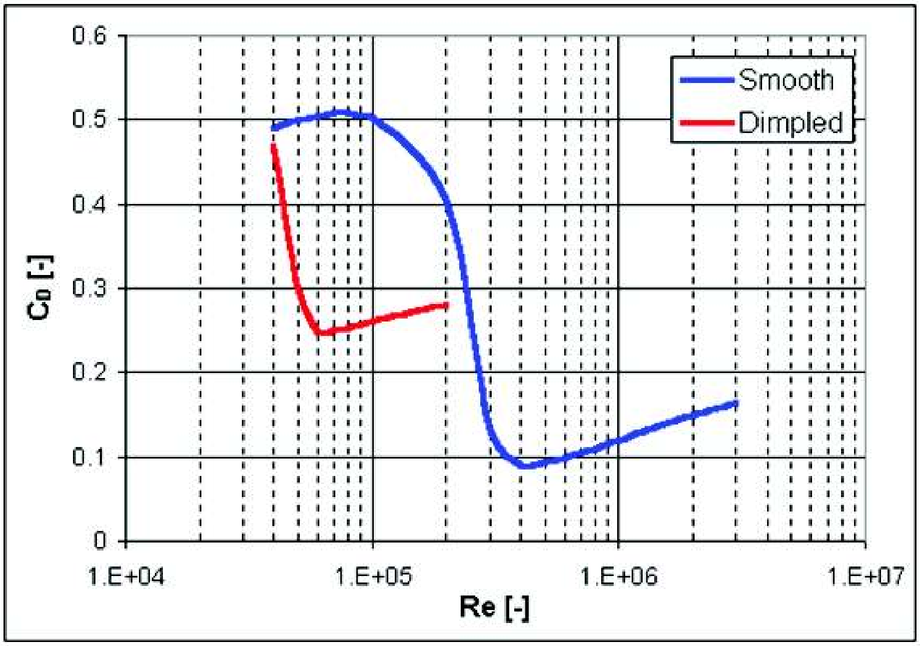


Figure 2

These data demonstrate that any two spheres that experience the same Reynolds number should exhibit the same aerodynamic characteristics even if the spheres are of different sizes or flying at different speeds. Figure 2 indicates that there is a significant change in the drag on a smooth sphere at a Reynolds number of about $3x10^5$. Below this R_e, the drag coefficient is roughly constant at 0.5. Above this R_e, the drag coefficient again becomes nearly constant at about 0.1. Why should this this particular Reynolds number cause such a large reduction in drag? As it turns out this is the critical point at which the air flowing around the sphere makes an important change. This is where the fluid flow separates appropriately referred to as flow separation. One of the key factors affecting flow separation is the behavior of the boundary layer. The boundary layer is a thin layer of air that lies very close to the surface of a body in motion. It is within this layer that the adverse pressure gradient develops that causes the airflow to separate from the surface.

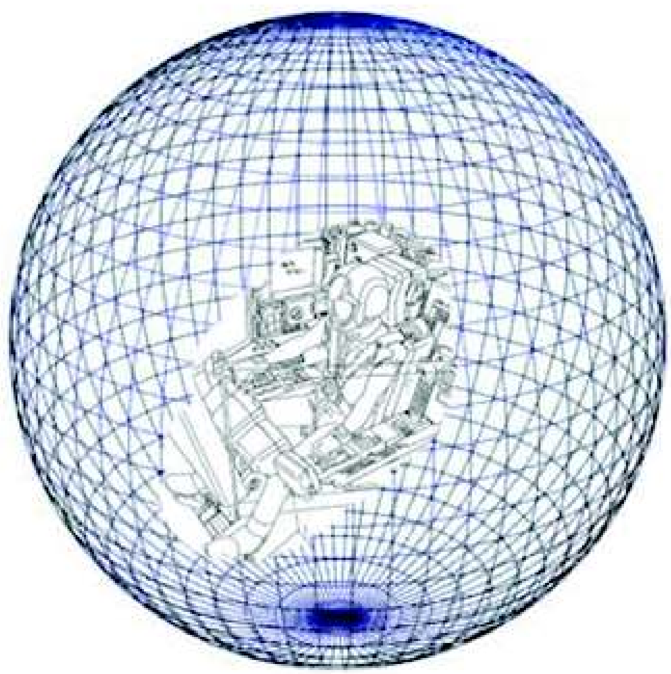
At low Reynolds numbers, the boundary layer remains very smooth and is called laminar. Laminar boundary layers are normally very desirable, because they reduce drag on most shapes. Unfortunately, laminar boundary layers are also very fragile and separate from the surface of a body very easily when they encounter an adverse pressure gradient. At that Reynolds number, however, the boundary layer switches from being laminar to turbulent. The location at which this change in the boundary layer occurs is called the transition point. A turbulent boundary layer causes mixing of the air near the surface that normally results in higher drag. However, the advantage of turbulence is that it speeds up the airflow and gives it more forward momentum. As a result, the boundary layer resists the adverse pressure gradient much longer before it separates from the surface. For example, in the case of a golf ball, increasing the speed is not an option since a golfer can only swing the club so fast, and this velocity is insufficient to exceed the transition Reynolds number. That leaves tripping the boundary layer as the only realistic alternative to reducing the drag on a golf ball. The purpose of the dimples is to do just that-to create a rough surface that promotes an early transition to a turbulent boundary layer. This turbulence helps the flow remain attached to the surface of the ball and reduces the size of the separated wake so as to reduce the drag it generates in flight. When the drag is reduced, the ball flies farther. Some golf ball manufacturers have even started including dimples with sharp corners rather than circular dimples since research indicates that these polygonal shapes reduce drag even more.

3.0 PRACTICAL DEVELOPMENT

Practical implementation of the theories behind the concept of flying spheres will involve the design and development of devices based on basic concepts described above. Our SDR Engineering Team has a variety of designs under consideration such as the one described below.

In this rendition, the “dimpled” sphere is built of a rigid frame composed of an inorganic composite. This material will afford the frame a very high modulus, but light in weight. The frame will support two turbine engines and will spin on a central axis. Control and fuel lines will feed along the outside of the frame to the engines, emerging from within the sphere at the axis of the frame. An equatorial sequentially triggered MagLev-like track, a bit like a continuous loop rail gun track belt, provides high speed electric spin, and suspension, of the outer shell. The turbines will provide one of a number of options we developed for forward thrust and steering capability for the sphere. The spin of the sphere will provide lift. Another system, not disclosed in this document, can provide pitch/roll/yaw variation.

The sphere's pilot, or drone sensor array, will be situated inside of the sphere supported in a second frame within the device. This frame will ride on the inside surface of the sphere in a full set of powered bearings and a gyrocompass will keep the frame stable in early versions and later supported by MagLev mounts in refined embodiments



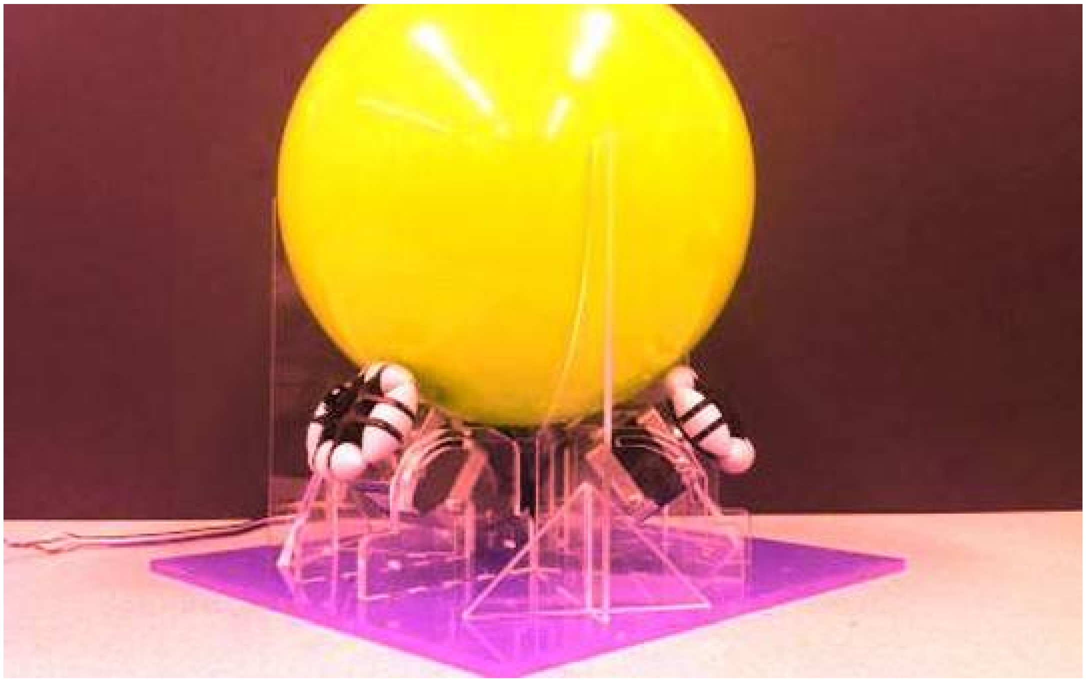
Future Embodiments Could Allow Human Transport

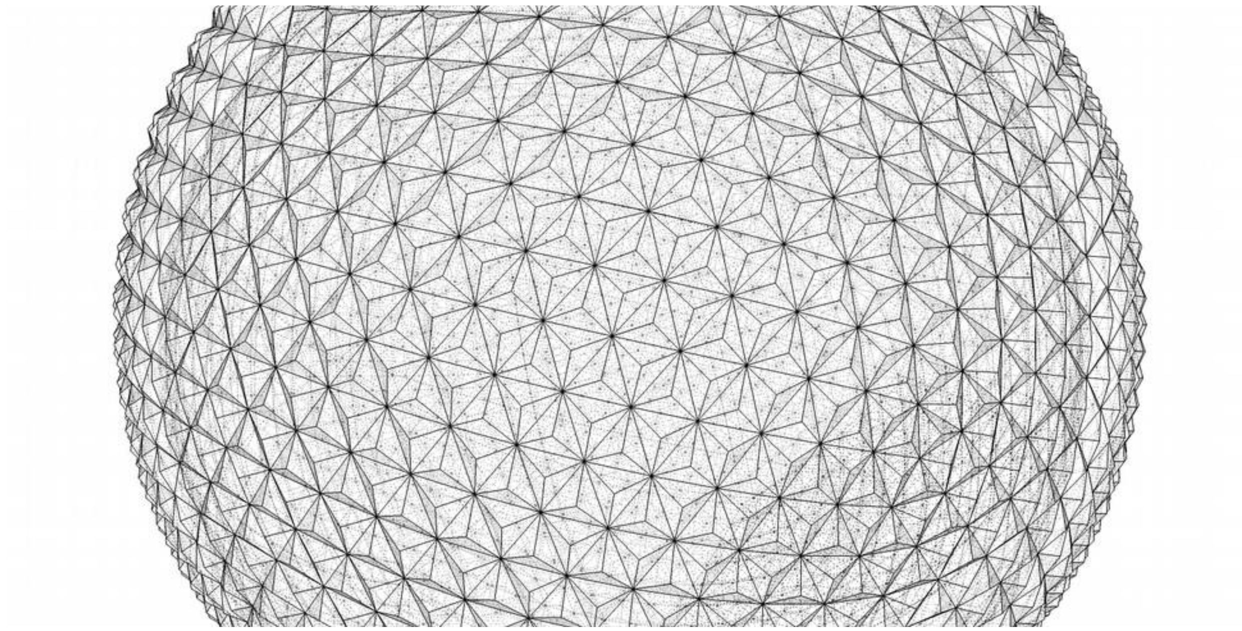
The plan for development of prototypes will begin with CAD development of preliminary designs which will then lead to the fabrication of small models. The small models will be used intended to master the fabrication and materials issues. These models will be subjected to wind tunnel testing to evaluate their aerodynamic qualities.

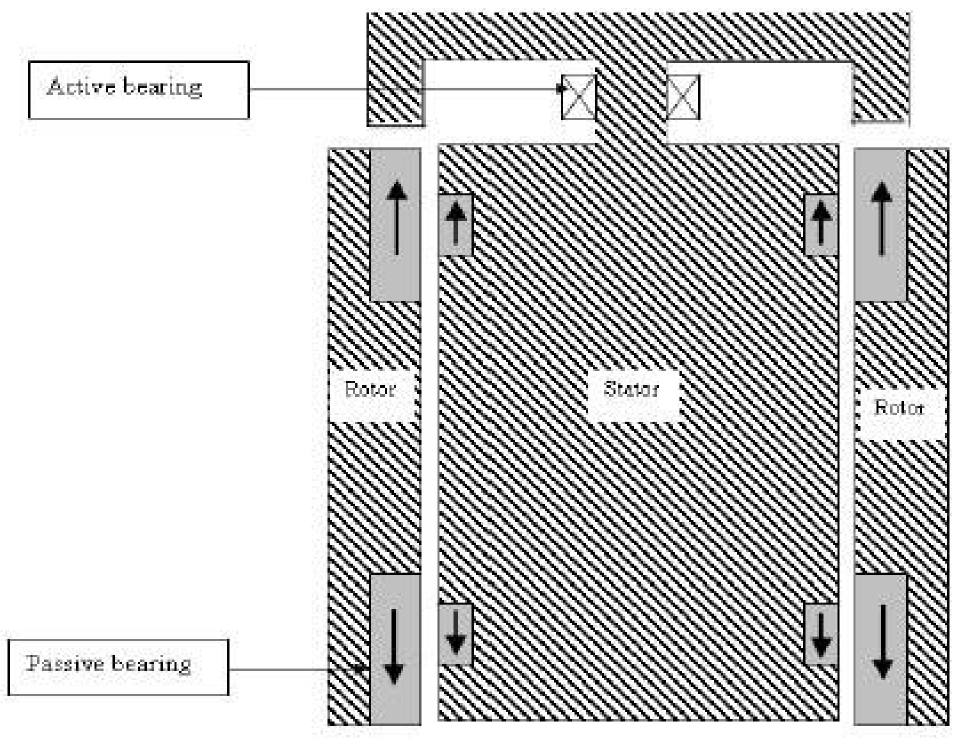
Our SDR Engineering Team is currently seeking funding to move this project ahead in its development.

Research Document Material Samples:

How to spin a sphere via one group's test:







Design principle scheme of magnetic bearings

The Kutta-Joukowski lift theorem for a single cylinder states the lift per unit length L is equal to the density rho of the air times the strength of the rotation Gamma times the velocity V of the air:

$$L = rho * Gamma * V$$

The strength of rotation is directly related to the rotational speed of the cylinder. For a cylinder of radius r rotating at angular speed s, the surface of the cylinder moves at speed Vr given by:

$$Vr = 2 * pi * r * s$$

Then the strength of rotation is equal to:

$$Gamma = 2 * pi * r * Vr$$

Combining these equations:

$$Gamma = 4 * pi^2 * r^2 * s$$

And substituting this value into the Kutta-Joukowski lift equation give:

$$L = 4 * pi^2 * r^2 * s * rho * V$$

This is the lift per unit length for a single small cylinder and is measured in force per length (lbs/ft). The ball is composed of an infinite number of cylinders with the radius of the cylinders changing along the axis of rotation.

$$r = f(l)$$

where l is a length measured along the axis of rotation. For a ball of radius b we have to integrate the lift per unit length along the axis of rotation from -b to +b. If we let S be the symbol for integration and dl be an increment of l:

$$L = S (4 * pi^2 * r^2 * s * rho * V) dl$$

If we let phi be an angle from the center of the ball along the axis of rotation:

$$r = b \sin(phi)$$

$$l = b \cos(phi)$$

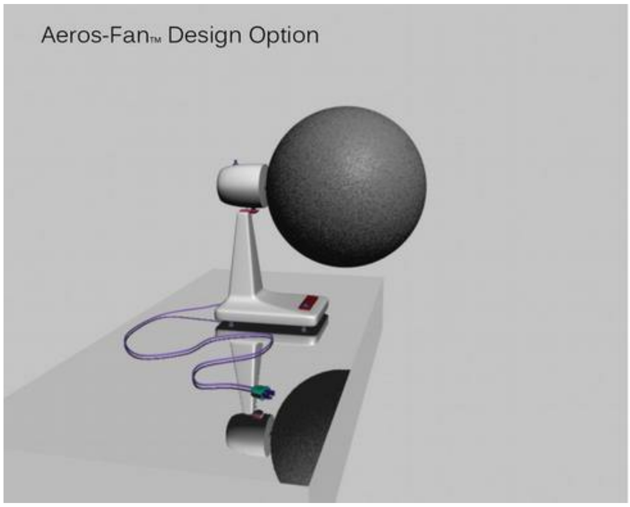
$$dl = - b \sin(phi) d(phi)$$

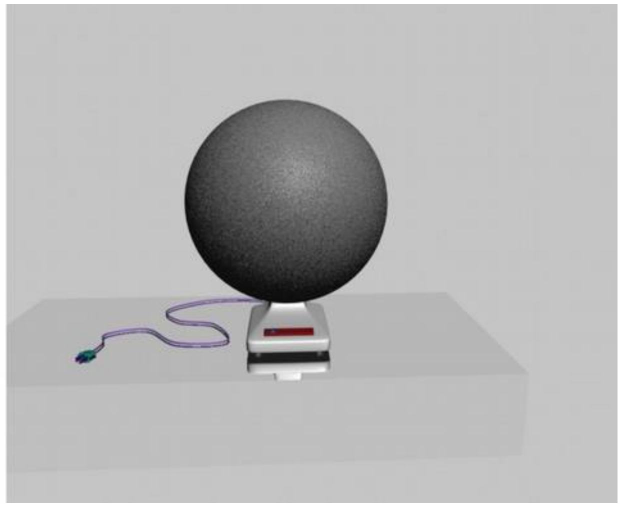
Then:

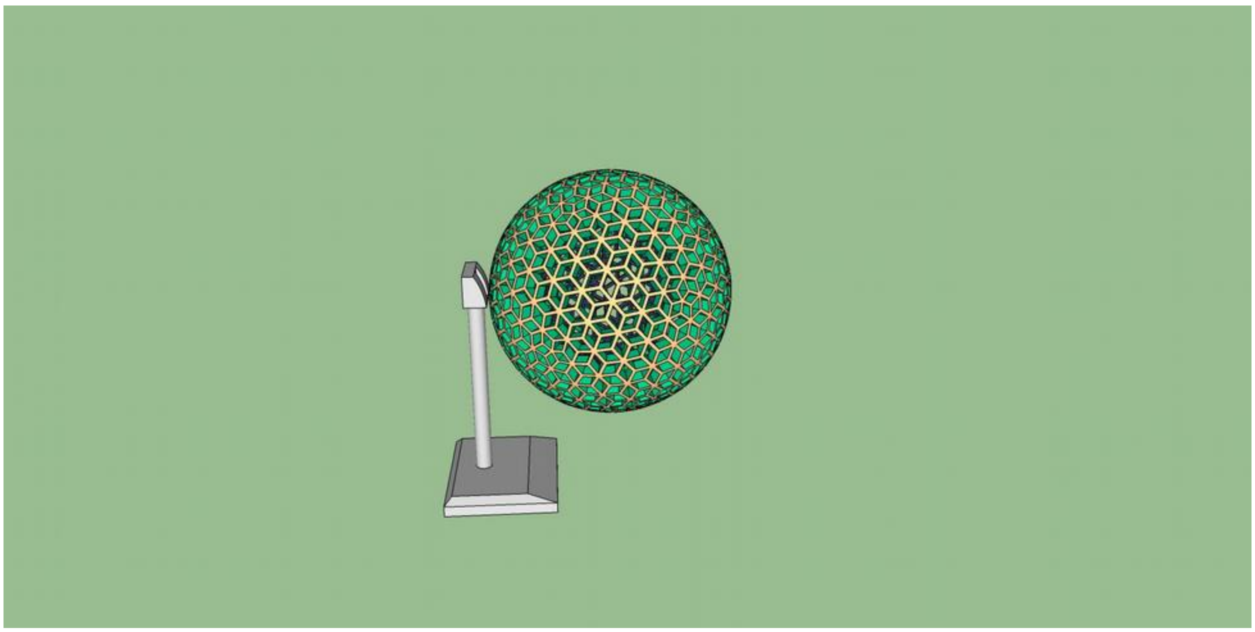
$$L = 4 * pi^2 * b^3 * s * rho * V * S (\sin(phi))^3 d(phi)$$

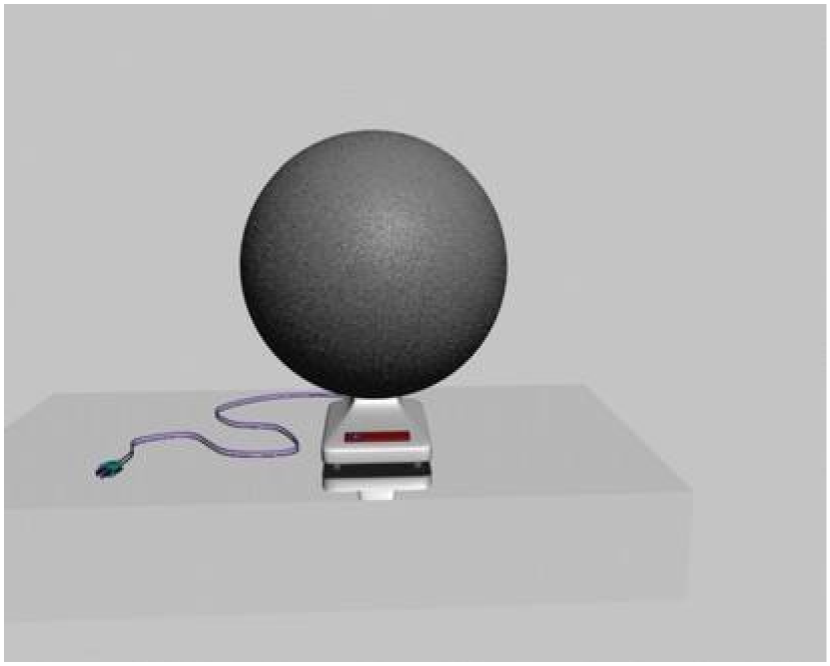
with the limits of integration going from zero to pi. Performing the integration:

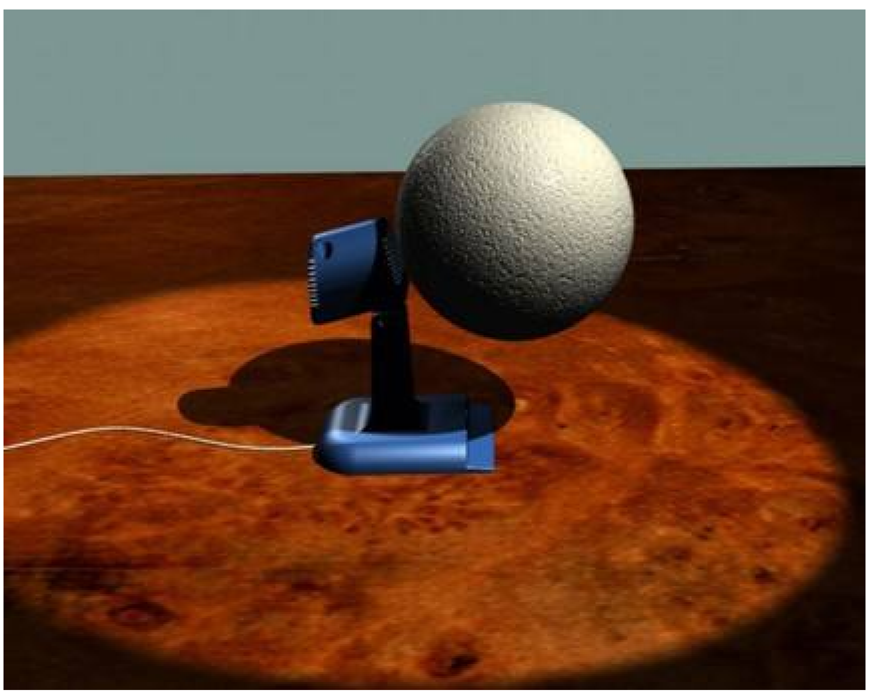
$$L = (4 * pi^2 * b^3 * s * rho * V) * 4 / 3$$

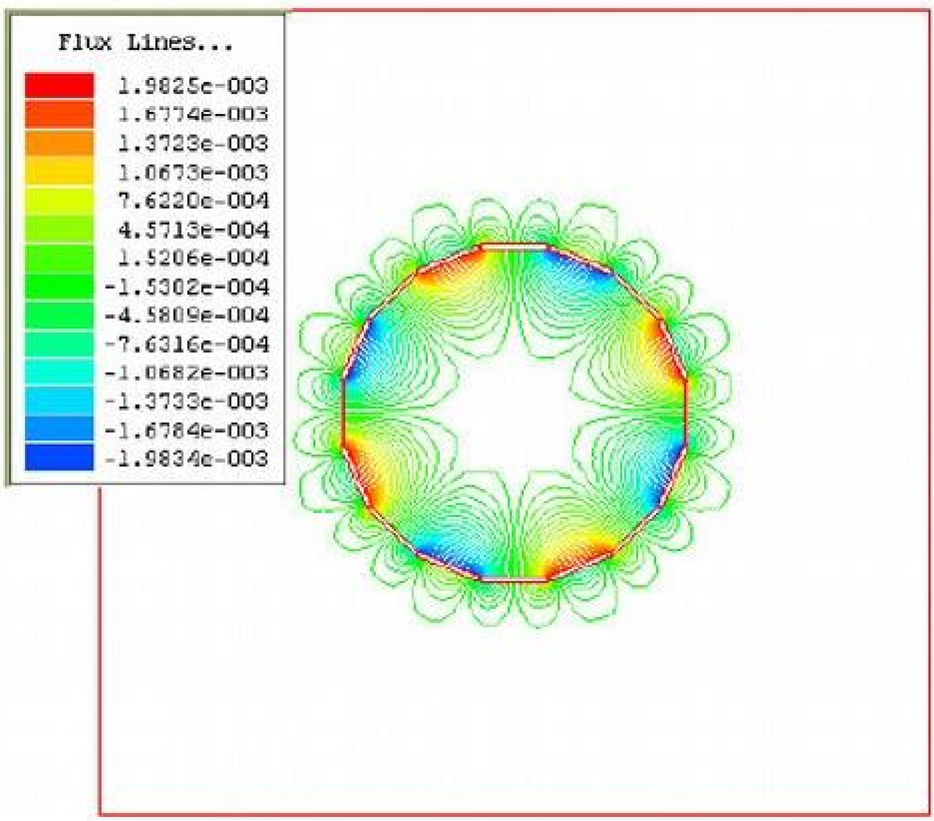

Aeros-Fan™ Design Option



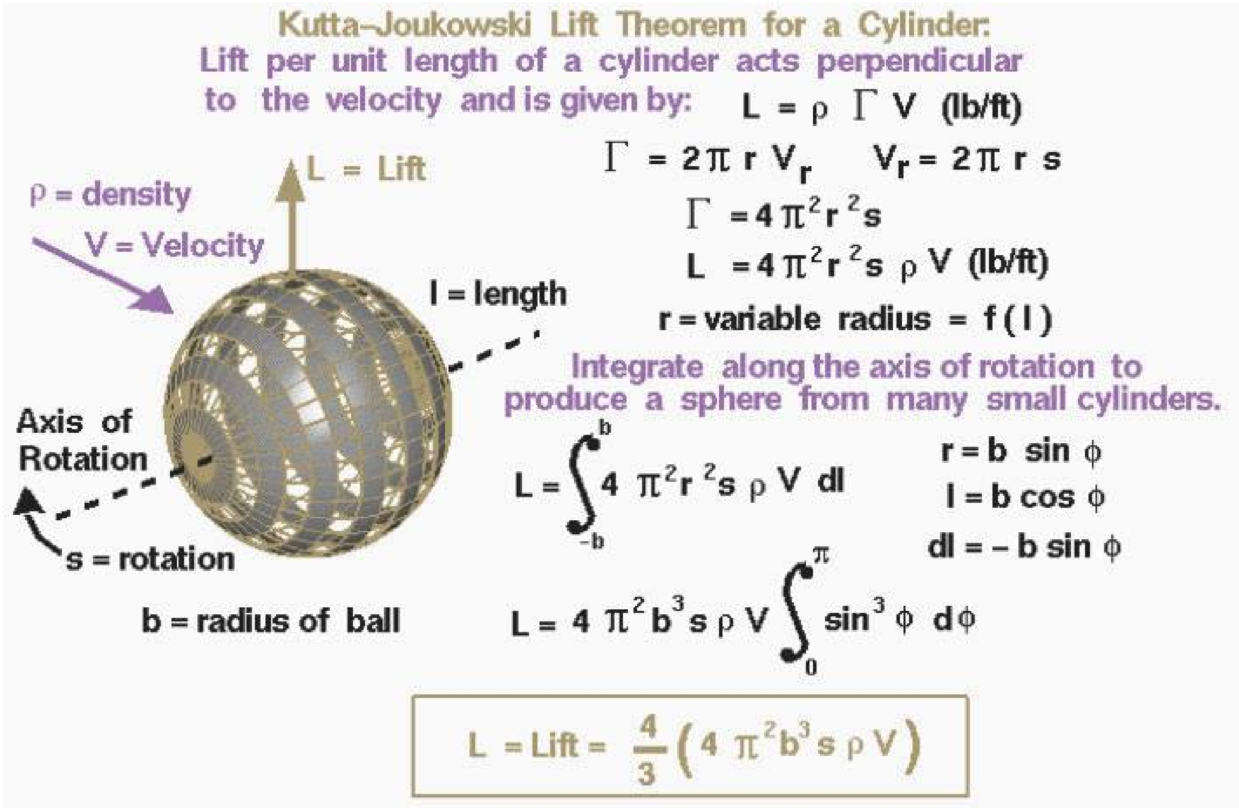








. M/G field lines with ideal Hal Bach magnets
(4 segments per pole)


Kutta–Joukowski Lift Theorem for a Cylinder:
Lift per unit length of a cylinder acts perpendicular
to the velocity and is given by: L = ρ Γ V (lb/ft)
L = Lift
ρ = density
V = Velocity
l = length
Axis of Rotation
s = rotation
b = radius of ball
Γ = 2π r Vr   Vr = 2π r s
Γ = 4π²r²s
L = 4π²r²s ρ V (lb/ft)
r = variable radius = f (l)
Integrate along the axis of rotation to
produce a sphere from many small cylinders.
L = ∫ from −b to b of 4 π²r²s ρ V dl
r = b sin φ
l = b cos φ
dl = − b sin φ
L = 4 π²b³s ρ V ∫ from 0 to π of sin³ φ dφ
L = Lift = 4/3 (4 π²b³s ρ V)