

# Space Colonization

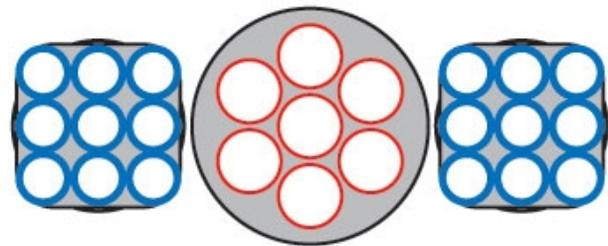
Thomas Lee Elifritz

The Tsiolkovsky Group, Marshall Space Flight Center, Marshall, Wisconsin USA

Humanity, for all its wonders and achievements, has initiated a global mass extinction event through industrial emissions and land over development, which is already causing irreversible changes to the atmosphere and the obvious deterioration of regional environments. The only credible way to avoid this carbon fueled global mass extinction is through the complete evacuation of the human species, and the industries that support us, off the Earth, and into space. An affordable and sustainable privately funded commercial space colonization effort is required to initiate this inevitable process of self preservation. In this paper I shall discuss the technological breakthroughs that will make space colonization a reality.

## Reusable Cryogenic Engines (Helium Free)

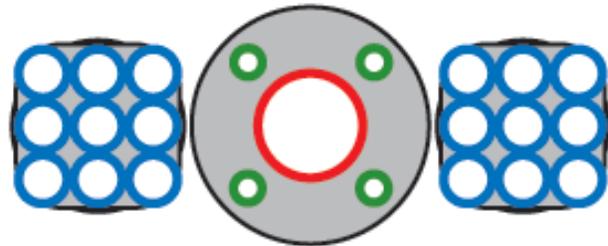
- Cryogenic Hydrogen and Methane
- Variable Tank Pressurization
- Deep Throttling
- Idle Thrust Mode
- Self Starts and Restarts
- Electric Thrust Vector Control



**BOOSTER ASSISTED**

## Reusable Cryogenic Launch Vehicles

- Mechanical Stage Clustering
- Cryogenic Fuel Cross Feeding
- Carbon Cryogenic Tank Insulation

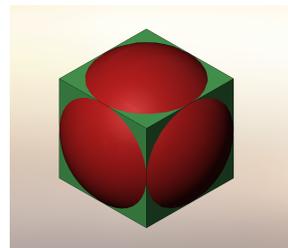


## Integrated Docking Nodes and Habitats

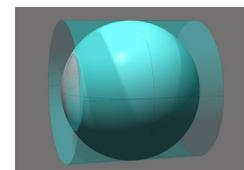
- Archimedes Cube (Docking Port Node)
- Archimedes Sphere (Internal Inflatable Habitat)
- Archimedes Cylinder (Upper Stage with Oxygen Tank and Reusable Cryogenic Engine)

Orbital space tourism will be the first application of this space development and colonization effort.

- Residual Fuel Pressurization and Storage
- Long Duration Space Rated Upper Stages
- Orbital Maneuvering and Fuel Restart Settling
- Boil Off Conversion, Storage and Transfer
- Deployable Thin Film Solar Reflectors



**Archimedes Cube**



**Archimedes Sphere**

## Sabatier Reaction Technology

Solar Panels, Batteries and Fuel Cells

LED Lighting and Hydroponic Plant Growth

Thermal Radiation and Radiators – Radiative Equilibrium

Solar Irradiance Manipulation – Absorption, Reflection, Concentration, Attenuation and Modulation

Space colonization depends upon revenue producing orbital space tourism to prefabricated space ports. Without any actual space economy all private commercial space development efforts are bound to fail. The traditional space based economies of commercial geosynchronous communications satellites and government funded intelligence and science missions have already produced commercial expendable launch vehicles such as the Atlas and the Delta, and government sponsored human spaceflight missions have recently produced two more launchers, the Antares and Falcon. The rapid turnaround daily flight operations necessary for the large scale development and colonization of space will require a fleet of reusable launch vehicles so large that only zero gravity orbital space tourism can sustain their demand. Fortunately, low earth orbit provides an ideal nearby environment in which to develop this business, in the form of a self cleaning, radiation protected, temporary workspace located a mere 250 miles away. Once the rapid construction and deconstruction of large orbital space tourist hotels is developed in the relative safety of low earth orbit, those techniques can easily be extended to geosynchronous orbits where continuous sunlight, infinite orbital lifetimes and economic opportunities are readily available.

What has been lacking thus far in the orbital space tourism business is corporate investment, primarily due to the absence of any clear architectural direction such a business might take, necessary to assess its overall cost effectiveness and viability (profitability) through the virtue of a definitive business plan. The strategy of extreme cost reduction through the reusability of the launch vehicles, combined with the preengineering and integration of free flying upper stages as modular components of space ports, gives the architecture the technical stability it requires for any routine space tourist operations to be assessed. Since this design only involves the ground retrofitting of Falcon upper stages and trunks, independent commercial space stations capable of accepting temporary tourists can begin operations just as soon as SpaceX begins flying cryogenic methane engines capable of differential pressurization of their fuel tanks, and purging, chilling and starting without the use of bulky internal helium tanks. Wide body reusable methane vehicles by SpaceX are expected to be flying as early as the year 2017.

Reversing the stacking order of the large volume hydrogen and methane tanks with the oxygen tanks will be required to allow for the internal inflation of large flexible pressure bladders into the upper top mounted fuel tanks, while still retaining the oxygen tanks for on-orbit storage of oxygen for breathing. This technique will require the strict aerodynamic and structural control authority obtained by the use of multiple small diameter cross fed boosters clustered around larger orbital capable central core stages. Cross feeding to adjacent boosters and to the core stages will allow for sequential staging events, which gives the core stages the capability to fly direct trajectories to whatever deep space destinations desired. Small diameter boosters will also be flown independently at a much higher rate in both single stick, two stage to orbit, passenger capsule flights, and as triple core, cross fed, heavy versions for cargo delivery. Hydrogen powered versions enable direct flights of wide diameter infrastructure tankage to high orbits.

Orbital space tourism leading directly to space colonization in high orbits, and lunar, mars and asteroid resource utilization are no longer the crackpot pipe dreams of space cadets, in fact quite the opposite, rocket ships of the 50's are now a reality and the entire industry is in the private and commercial sector. The only part NASA continues to play in this unfolding scenario is owning and operating the national laboratory known as the International Space Station and their funding of the commercial crew program. Given that space development and colonization is not within their charter and purview, and that a large sum of federal money is being wasted on solid rocket booster assisted expendable heavy lift launchers and capsules, one must come to the inevitable conclusion that NASA, our federal space agency, will not be assisting us in this effort. It is therefore incumbent upon both private and corporate investment capital to produce the large infusion of funds necessary, to develop, test and bring to market the wide array of technical advances that will be required before routine orbital spaceflight tourism operations may proceed, and this adventure begins. There appears to be no technical barriers to space colonization.