Commercial Space Stations

NASA Request for Information NNHXXZCJ001L
Evolving ISS into a LEO Commercial Market

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The purpose of this RFI is to collect information from industry on how NASA can enable greater private access, use, and applications of LEO utilizing ISS, including crew and cargo transportation, to help industry identify commercially viable activities that would be self-sustaining.

NASA also plans collaborate with CASIS to use the inputs gathered from responses to this RFI as part of an overall strategy geared towards the eventual transition of NASA LEO capabilities to the private sector and to enable exploration capabilities.

This RFI provides an opportunity for NASA to learn about the interests of a range of external parties - commercial, international, and other USG sectors in the development of commercial activities and capabilities in LEO.

NASA is also interested in reducing or removing the barriers to the development of a commercially driven LEO market.

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Civilization in its present form faces several immediate and near term threats to its continued existence.

- Antibiotic Resistance (*added 6/6/14)
- Epidemic Diseases
- Political Corruption
- Human Overpopulation
- Irrational Religious Beliefs
- Tribalism, Gangsterism, Fascism
- Global Financial Instabilities – Debt*
- Conventional and Nuclear Weapons – War
- Industrial Contamination of the Holocene Biosphere – Air, Land and Water
- Carbon Dioxide and Emissions Induced Global Warming and Climate Change
- Agricultural Droughts and Blight, Insect, Weather and Flood Related Agricultural Losses
- Glaciers, Arctic Sea Ice, Greenland* and Antarctic Ice Sheet Losses and Sea Level Rise
- Ocean, Sea, River* and Lake Pollution and Ocean Chemistry Changes
- Deforestation, Soil Loss and Adverse Land Use Changes
- Groundwater Contamination and Aquifer Loss
- Biodiversity and Species Loss – Extinction
- Terrestrial Hazards – Floods, Tornadoes, Hurricanes, Volcanoes, Earthquakes and Tsunamis
- Extraterrestrial Hazards – Orbital Debris, Asteroid Impacts, Solar Flares and Cosmic Radiation

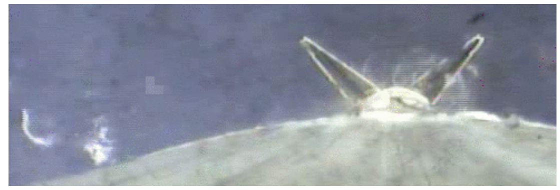
Civilization is by definition a collective human enterprise, not pure communism and not a democracy, and not even a purely corporate or commercial venture, but rather an industrial enterprise by willing participants. Clearly that industrial enterprise involves providing all of the physical and biological necessities of human life for everyone involved, and ensuring that those needs are maintained. That fundamentally involves activities such as maintaining a constant solar flux for leaf and soil production, large scale food agriculture, water and waste management and atmospheric and temperature control – since civilization is comprised of individuals, and we are indeed biological creatures known as humans.

The industrial activity that civilization must embark upon now is the complete removal of all industrial activities from the planetary biosphere, since they appear to be incompatible at the most fundamental level. Industrial activities such as agriculture, mining, minerals and metals extraction, processing and refining, inorganic and organic chemistry and construction are deadly to a natural ecological system. And even if the planet were able to support and sustain 10 billion humans, which it is not, any one of the previously mentioned hazards would eventually topple civilization – a super volcano in Wyoming, a massive earthquake in California, or a large asteroid strike anywhere, and it will all be over in a flash. Financial instability already has put it on the brink of disaster, and anything can put us over the edge.

This is the legacy you will be leaving your children unless an honest, rational attempt is made to pursue some beneficial industrial activities capable of providing solutions to these problems on a global scale. The development of space is by far the most effective problem solving global industrial initiative on the horizon; far more efficient and effective than the current paradigm of building skyscrapers and landfills or building nuclear submarines and aircraft carriers and then using them in the coming theaters of war. At the very least our global inventory of nuclear weapons and ballistic missiles can be put to valuable use as the preferred asteroid deflection strategy of last resort. So given the recent advances in reusable launch vehicles and advanced rocket engine propulsion, we are actually in pretty good shape to begin.

In this essay I recapitulate my previous work in this area and describe how this process might proceed.

The next step in space is space station independence and extreme cost reduction methods for human spaceflight, along with the necessary commercial markets and revenue required to support these new technological developments. I recommend commercial space stations in LEO and GEO.



The SpaceX paradigm for booster reusability consists of clustered engines in an octagonal circular grid with four fold symmetry, allowing greater space for a center landing engine, throttleable down to 40%. This has been demonstrated by a ballistic reentry to terminal velocity with a precision landing on water. Multiple engine restarts give the booster the ability to perform boost back burns after stage separation, momentum killing burns to reduce thermal and aerodynamic loads on the reentering booster, and then final terminal free fall descent and landing burns, giving very precise control over the landing location. Thus after nearly twenty years of preliminary efforts, the reusable booster conundrum has been solved. It is expected that competition will be introduced into this new industry with similar hydrogen fueled reusable launch vehicle alternatives from Blue Origin, and second generation methane fueled vehicles.

In order to sustain this new industry, vast new markets utilizing the increased flight rates and expanded payload capacities of this new generation of reusable launch vehicles and engines must be forthcoming. Low earth orbit provides a nearby radiation protected, zero-g, vacuum environment with 50% sunlight, making it a universal testing ground for space development and commercialization. Geosynchronous orbit provides infinite orbital lifetimes, unlimited sunlight, abundant local resources, and new economic opportunities such as large antenna and laser farms for deep space networks and laser communications.

To this end I have proposed and designed dual hatch plate inflatable tori, for the on-orbit usage of the pressurized upper stage cryogenic fuel tanks as space station modules and breathing oxygen storage. I then extrapolated hemispherical clamshell versions of these inflatable tori to asteroid processing, to use as radiation and impact shielding for the inflatable habitats residing in these pressurized fuel tanks. I have created a basic framework for space colonization, orbital debris mitigation, radiation and impact protection and solar thermal flux control using hydroponic plant growth for soil and food production. This scheme is critically dependent upon condensed matter physics breakthroughs in thermoelectricity in order to maintain the radiative thermal equilibrium of the light irradiated environment in a vacuum, without the cost and complexities of the active, mechanically driven, fluid vapor condensation system. Long term orbital storage of cryogenic fuel and oxygen will require new solid state cryocoolers as well, although for cryogens, efficient insulation and boiloff collection and reuse is equally effective, certainly for breathing oxygen, but also for liquid hydrogen using fuel cells, to produce water, heat and energy.

The more immediate problem of space station independence from Russia would be more simply solved by docking a large fully fueled spacecraft to the ISS, and then using it for reboost and attitude control. Clearly a second generation Dragon 2 or Dragonflyer spacecraft from SpaceX could handle this task, and since they are being designed for reusability and high flight rates, a servicing spacecraft of this type could be attached to the ISS at all times, obviating the need for any new core fuel servicing modules. This new paradigm of space station command and control by external spacecraft allows for the rapid deployment and testing of reusable spacecraft systems, and rapid passenger (space tourist) turnaround, and is eminently suitable for hazardous debris environments accompanying low Earth orbit operations. It also permits a more rapid development, deployment, testing and disposal of advanced habitats in an orbit synchronous with the International Space Station, such that an alternative refuge is always nearby and a fully functional reusable rescue and reentry spacecraft will be continuously available, if needed. The ability for multiplexed command and control across multiple docked spacecraft will be required – an ability also useful to any new large, clustered booster arrangements for heavy lift launch vehicles.

Identify capabilities that could be provided to NASA that would benefit the creation of private LEO systems and/or be suitable for sustainment of ISS through at least 2024 and, if applicable, for crewed missions beyond LEO. Systems, technologies and approaches should be identified.

The primary capability that I personally can provide you besides cheerleading, is leadership and advice. NASA and United States human spaceflight policies, through the actions of previous administrations and administrators, congresses and high level managers, have created some nearly intractable problems in terms of the necessary reductions in spaceflight costs, which must be solved before any progress can be achieved. Private industry, commercial concerns and crowd sourcing, funding and participation have taken up some of the slack, but some definite changes must occur before NASA can again be a leader in the development of low cost, commercially viable, market driven, human space flight operations.

Unable to affect such changes myself, I have offered a new route to cost reductions through innovation, and remarkably enough, competition. The market I intend to compete for is pressurized space for new commercial space stations, and the most likely competition will be NASA derived Bigelow technology. There is a dire need for extreme cost reductions across the entire enterprise of human space flight, and the new paradigm of reusable capsule and upper stage based command, control and life support opens up an entirely new domain of inexpensive, mass produced, pressurized, shielded and protected habitats. I intend to exploit this remarkable opportunity to the greatest extent possible as future launch costs fall, and the size and scale of future deeply cryogenic wide diameter upper and core stages continue to grow.

Primary requirements for low cost habitat operations are optical light, electrical energy, pure oxygen, clean water and food, temperature control through heat transport and dissipation, humidity control through water condensation, cabin air carbon dioxide removal and human waste storage and disposal. These basic needs are best met by much simpler and lower cost alternatives to the current space station. Space stations of this nature will consist of sun pointing, solar panel shaded inflatable habitats, utilizing large scale hydroponic plant growth for carbon dioxide and air management, and a new generation of resonantly tuned thermoelectric and thermomagnetic devices – approaching Carnot cycle efficiency. At this level of efficiency thermal and humidity management become almost trivial engineering exercises.

In order to expedite their development I have proposed installing these inflatables into the upper stage fuel tanks of reusable launch vehicles, to facilitate their maintenance and to provide an extra layer of pressurization, producing a conductive and convective environment surrounding the habitat, and thus a direct method of removing excess heat from the metal containment vessel and dissipating it into space. This also has the added extra benefit of creating unlimited storage space for consumables and wastes through a hatch, and provides a large buffer space for radiation shielding and debris impact protection.

Another technology area in need of dramatic improvement is insulation, particularly cryogenic fluids, but certainly significant numbers of terrestrial homes, houses and buildings require massive retrofits. Non-friable vacuum and air insulating technologies offer up to an order of magnitude improvement in efficiency while retaining their structural integrity and strength, making deep space operations possible. Anticipated use of hydrogen and methane as deep space fuels will demand the complete elimination of spray on polyurethane insulation, and its replacement with new materials and/or innovative approaches. Cryogenic boiloff recirculation and redirection will be required to use, convert and store gases or water as they are produced, and to regulate the pressure and temperature of the storage tanks in zero gravity. Methane has one advantage – that it can be burned inside an environment to produce carbon dioxide for large scale hydroponic applications. Alternatively powerful hydrogen upper stage engines are available. For instance, Falcon Heavy crossfed boosters launching an efficient SSME driven core stage, yields an orbital solution for the core thus transforming it into a second stage requiring the space rated insulation.

Recommend private research or other activities and/or applications that could be performed on ISS that may enable future commercial value or demand.

The reusable space launch design problem is now well on its way to being solved. The primary revenue producing activity in low earth orbit will be commercial orbital space tourism within inflatable habitats, the only market capable of generating volume enough to sustain a reusable launch vehicle industry, and enough revenue such that investments in reusable methane engine development can proceed swiftly. If some industrial, materials processing or biomedical processes can hitch a ride on these human tended operations in low earth orbit, that merely improves the already good commercial space tourist outlook.

Space tourism requires accommodations, and the space station is not particularly suited for this use. Command, control and propulsion equipped spacecraft with life support capabilities docked to the ISS are well suited for space tourism, and NASA needs to present the space station as a viable option for spacecraft visits from any nation, corporation, organization or individual who wishes to participate. The space station possesses a large power generating capability, making it essentially a solar power satellite. This power can be sold to tourist spacecraft docked at the spaceport, or traded for reboost and control.

The space station itself exists right now, and represents an excellent testing site for sub-scale models or new technologies, particularly zero gravity hydroponic plant growth inside of small inflatable habitats, the inflatable habitats themselves, and all manner of life support systems and devices. This has already begun on the ISS with the Bigelow BEAM module and the Orbitec Veggie hydroponic plant chamber, and with some of the life support apparatus such as water electrolysis and Sabatier reactor converters. Some of the advanced testing on upper stage fuel scavenging and transfer, fuel boiloff recovery, upper stage tank repressurization, and cryogenic fuel storage can be accomplished in some very low Earth orbits after regular delivery flights of both crew and cargo to the space station, where the debris from any possible catastrophic failures will reenter the Earth's atmosphere very quickly, and thus no debris collision dangers will be presented to the higher space station and tourism occupied orbital altitudes.

Identify ISS crew transportation uses that would enable the development of commercial activities onboard the ISS or other LEO platforms (e.g. labs, human-tended facilities, etc) beyond NASA requirements.

The space station simply needs to remain a port and a refuge for independent (SpaceX, Blue Origin, Bigelow, etc.) or external (Russia, China, India, etc.) programs when they begin their own operations. The most damaging and persistent problem facing the commercial development of low earth orbit and deep space from a government perspective, is the cost and nonreusability of the Space Launch System (SLS) and the Orion capsule. The irony of this situation is that with current cryogenic engine and core stage efficiencies, the entire core stage of the SLS is easily capable of reaching orbit. SLS and Orion represent billions of dollars of investment capital and decades of development, not to mention four irreplaceable, valuable, powerful and efficient ground started SSMEs; all immediately discarded after every flight. This is a completely crippling behavior for any sustainable space program. One can only surmise that this is an instance of mass hypnosis and delusion that has overcome a large fraction of the United States aerospace sector workforce, NASA managerial staff and the congressional and executive branches of government, in thinking that this kind of program incompetence can persist indefinitely. This point has been driven home by recent events such as the loss of Russian import engines, the calls to split the space station between the principles, and the complete lack of new engine development in the government sector. This problem has been around since the Space Launch Initiative was canceled in 2002, and has only been exacerbated by the Constellation program, and the SLS and Orion programs. Reversing this trend means years of development efforts, which are best directed at intrinsic reusability.

Identify, any access, programmatic, and business related barriers (e.g. policy, legal and/or other barriers) to realizing these objectives.

The primary barriers to a commercial market driven space program in any orbit, is the Space Launch System and the Orion MPCV space capsule, since by very definition, they are not reusable spacecraft. Subject to extreme costs, unlimited schedules and numerous, almost fatal, technical design flaws, one need only to read the associated NASA Authorization Act language to point out these problems. This system was conceived and designed without an open, comprehensive negotiated consensus at all, with little thought to the damage being inflicted on the US propulsion development base from its neglect.

Identify any NASA capabilities or expertise that would help enable the transition of LEO to a more commercially driven presence.

Besides the International Space Station, the only other capabilities NASA has are the SLS and Orion programs. Absent cancellation, the focus of these programs needs to be radically shifted towards single SSME powered next generation 5 meter core stages, with roll control and orbital maneuvering engines; launching a stripped down integrated Orion capsule and life support systems without any of the reentry capabilities, using Falcon 9/Heavy type liquid reusable boosters and flying directly to high orbit station. The SLS design itself becomes reusable, until smaller and more efficient second generation cryogenic hydrogen and methane closed cycle engines become available, but it also requires a radical rethinking of the on-orbit uses of upper and core stage propulsion assets in space programs – space architecture. These uses will require the aforementioned advances in metal cryogenic liquid tankage, the inflatable habitats stored therein during launch, and the numerous hatch plate assemblies required for it to work, This is in addition to solar power assets required in the form of solar cells and parabolic light reflectors and the necessary thermoelectric condensed matter physics developments, which are needed elsewhere. NASA is eminently capable of tackling numerous technical difficulties at the project level, and there is no shortage of these when discussing space tourism and space colonization as the basis of the program; where intrinsic reusability, repurposing, or recovery of any space based development assets is the norm.

Identify capabilities and/or resources that NASA could purchase on a commercial basis that would enable post ISS NASA research activities.

NASA does not seem to understand what it is researching. NASA is an aerospace research organization and the commercial spaceflight industry will be soon offering environmental research space and space transportation for any other industrial concerns who may wish to rent, lease or purchase those services. With the exception of SLS and Orion and the extreme cost of the International Space Station, NASA has already done exactly what it needs to do to open up low earth orbit to more commercial investment. SLS and Orion are the problems that need to be confronted head on, and solving those problems will be the big money game changers, that have the potential to do more for the commercial space launch and habitation industry than other other aspect of NASA's charter. Launching large spacecraft into space, and enabling the researching of human habitation in space, is the research that NASA is supposed to be doing, and so congress must give someone the authority to reorganize and redirect these programs into high orbits, deep space reusability and habitation research if anything is going to be salvaged from this. Once in space in the most expedient, inexpensive and safe manner, transportation services may simply be purchased from the private sector and iteration of this public – private partnership can then proceed.

Any launcher and habitation design that is fixed in stone will not be successful on the open market. Thus congress and/or the executive branch must either cancel the offending programs, or relinquish control over the design of them, or put somebody in charge of them who can get the job done correctly.

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Direction To continue modern theoretical and experimental investigations into strongly correlated electron systems, lightweight, affordable earth to low earth orbit launch vehicle architectures, closed ecological life support systems, and super insulated, low carbon emission, earth sheltered homes and habitats for earth and space.

Director of Research **Launch LLC, The Tsiolkovsky Group, Marshall, Wisconsin, USA** **2006 - 2014**

Company Founder and Chief Executive Officer
Performed Multidisciplinary Research in the Natural Sciences
Engaged in Systems Engineering, Research and Development Projects
Published Seminal Reports for Emerging Commercial Space Flight Industry

Astronaut Training **Lansing Cay and Rudder Cut Cay, The Exuma Cays, The Bahamas** **2001 - 2005**

Machine Shop, Dock and Boatyard Construction, Hurricane Preparedness
Space Port, Resort, Astronaut Training and Launch Facilities Development

Elifritz vs. Elifritz **Civil Court Litigation, The State of Florida, Lansing Cay, Exuma Cays** **1998 - 2000**

Prosecuted a successful legal effort for defendant's discovery documents,
resulting in the half Bahamian island ownership of Lansing Cay, Exuma.

Elifritz vs. Elifritz **Supreme Court Order, The Commonwealth of the Bahamas, 1997 #20** **1996 - 1997**

Argued a successful legal defense of Bahamian island ownership,
resulting in a time sharing agreement with development restrictions.

Technical Director **Caribbean Marine Research Center, Lee Stocking Island, Bahamas** **1989 - 1995**

Personal Assistant to the Director of the Research Center
Scientific, Laboratory and Telecommunications Technical Director
Island and Field Coordinator for Resident, Guest and Scientist Safety
Performed, Published, and Presented Multidisciplinary Research Results

Software Engineer **AmTel Communications, Inc., McFarland, Wisconsin, USA** **1987 - 1988**

Developed and Maintained Self Recompiling polyFORTH II Nucleus
Maintained “EVE” - The World's Largest polyFORTH II Application
Implemented Training Programs for Programmers and Engineers
Assured Cross Target Compiler Capability Across Multiple CPUs

Director of Research **Syntech Living Systems, Windsor, Wisconsin, USA** **1981 - 1986**

Performed Basic Life Science Experiments
Designed Products for Scientific and Technical Markets
Implemented Machine Shop and Manufacturing Capabilities
Developed and Maintained Life Sciences Laboratories and Facilities

Education **The University of Wisconsin, Madison, Wisconsin, USA** **1978 - 1980**

Sixty four (64) degree credits in the Applied Mathematics, Engineering and Physics program, equivalent to an associate's degree in rocket science and engineering, including humanities and foreign language requirements, applied mathematics through advanced calculus and linear algebra, engineering mechanics through statics and dynamics, mechanics of materials and orbital mechanics, modern physics and chemistry, and extensive self study and life experiences, including field work.

Thomas Lee Elifritz - Scientific Publications and Presentations **1994 - 1995**

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Earth Colonization
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