# 1NC Materials

## 1NC—Orbital Colonies CP (USFG version)

### Text: The United States federal government should develop and deploy orbital space colonies.

### Lunar and Mars colonization make resupply, landing, and travel near impossible – the compendium of issues means orbital colonies solve best

Globus 3 (Al – Senior Research Associate at SJSU/NASA Ames Research Center, BA in Information Science, Editor-in-Chief of NSS Space Settlement Journal, Recipient of the NASA Software of the Year Award, multiple NASA Group Achievement Awards, NASA Public Service Medal, and the NSS Space Pioneer Award, Orbital Space Colonies, Windstorm Creative Full Spectrum Reference Books, “Where Should We Build Space Colonies?,” <http://space.alglobus.net/Basics/where.html>, mrs)

Supply There is a saying "Amateur soldiers think about tactics, professionals think about supply," perhaps because the well-fed army with plenty of ammunition tends to win. Fast and effective transportation to and from Earth is critical to the establishment and development of any space settlement. People will need to go back and forth frequently and in large numbers. Although bulk materials (steel, concrete, and water or their equivalents) are best mined and processed in space, colonies will need computer chips, specialty components, and other products from Earth. Early colonies will not be able to make everything they need and inevitably will require frequent resupplying. Building the first colony will necessitate moving people, materials, parts, food, and water to and from the work site. Critical tools and parts will be forgotten or break, and need to be supplied by Earth as quickly as possible. This will be far easier for a colony in Earth orbit than for either the Moon or Mars. To land on the Moon, plant a flag, hit a few golf balls, and dig up some rocks required no resupply. Raising a family and building a life off-world will. In this department, orbital colonies are the clear first choice as the early ones can be built much closer to Earth. Subsequent colonies can go further and further afield in small, manageable steps. Furthermore, rendezvous with an orbital colony will require less fuel and can be aborted at any time. Landing on the Moon or Mars is more challenging than docking with an orbital colony, requires more fuel, and carries much higher risk to the travelers. The Apollo missions took approximately three days to get to the Moon; travel times to Mars are currently over six months. Even with advanced propulsion, travel times to Mars will be measured in weeks. Travel from Earth to planetary orbit is measured in minutes, although time to get to a higher, space-colony orbit and rendezvous will probably be at least a few hours. With current transportation to Mars, launch opportunities come only once every two years. If you need something from Earth it may take years to get it. For a colony in Earth orbit, it may be possible to obtain key items in a day or so. This is equivalent to the difference between an ox-drawn cart and Federal Express. How many businesses ship their materials by Clipper ship rather than Airborne Express? There's a reason for their choice, and that same logic says we should colonize orbit before the Moon or Mars. Resupply isn't a make-or-break issue for Martian colonization, but the greater difficulty of resupply and travel will generate an endless series of problems, each of which will require time, energy, money, and attention to solve. The great Prussian military thinker, Carl von Clauswitz, noted that armies aren't usually stopped by the equivalent of a brick wall, but rather by an endless accumulation of small problems - equipment stuck in the mud, sick soldiers, food problems, and desertion. He called this phenomenon friction. Although we note some near-killer problems for early Martian and Lunar colonization, most of the issues amount to much less friction for orbital colonization. Each problem by itself seems manageable, but put them together in their thousands and the case for orbital colonies first, the Moon and Mars later, becomes undeniable.

## 1NC—Orbital Colonies CP (prize version)

### Text: The United States federal government should offer a phased prize of up to 8 billion dollars for the first privately owned company which achieves orbital colonization.

### The $8 billion prize brings prices for space tourism to $10,000

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In "Contest-Driven Development of Orbital Tourist Vehicles," 14 this author proposed using prizes to develop orbital vehicles for the tourism industry. The idea is to provide a series of prizes for successive launch of people into orbit. The dollars-per-passenger ratio decreases as more and more passengers are own; starting at something near current costs ($30 million) and ending at the desired price point of $10,000. A simple computer program was developed to explore the implications of this model. Using development cost and operations data from commercial firms circa 2006 it appears that one to eight billion dollars in prize money might be sufficient to get the orbital tourism market going. For reference, space shuttle flights cost over one billion each! The usual experts may say such a prize could not work, but they were wrong about the Ansari-X prize. Of course, prizes may fail to stimulate the desired development, but in that case no prize money need be spent.

### **The $10,000 price point solves space settlement – ends in orbital colonies**

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At the right price, space tourism would require thousands of flights per year. In 1994, Patrick Colins, et al. 8 found that the Japanese market could provide about one million customers per year for spaceflight at about $10,000 per passenger. In 1996, Sven Abitzsch 9 found that approximately 20% of the U.S., Canadian and German populations and nearly 40% of the Japanese population would be willing to pay six months salary for a trip into space. This represents nearly a hundred million people. In 1999, Oily Barrett 10 found that 12% of United Kingdom residents, representing 3.5 million people, said they were willing to pay over $10,000 for a trip to space. In 2001, Crouch 11 surveyed the literature and found that the global space tourism market is a strong function of price. Table 1 shows Crouch's demand vs. price per ticket. If these projections are optimistic by no more than a factor of ten, and the price per ticket can be brought down to about $10,000, there is good reason to believe space tourism can support tens of thousands of launches per year, a rate comparable to the early decades of aviation. Considering space tourism from the easiest to the hardest, the following progression seems to make sense: 1. Sub-orbital flights. These flights go more-or-less straight up then straight down again. The whole flight may be less than an hour and tourists are in space for a few, extremely exciting, minutes.2. Orbital flights. The vehicle enters orbit and circles Earth for some time before returning. Such flights might last many hours. 3. Orbital hotels. The vehicle docks with a hotel in orbit then returns for more passengers. Visits might be anywhere from a few days to a few months. Interestingly, we already have a space hotel. The International Space Station (ISS), built at fantastic government expense, has hosted a number of tourists. 4. Zero/Low-G retirement homes. Weightlessness could be of great benefit to those confined to wheelchairs on Earth. Adding a first-rate medical facility to an orbital hotel makes a very desirable home for the disabled you don't need walkers or wheelchairs. 5. "Special group" habitats. "Special group" is a euphemism for religious fanatics who don't want to live with unbelievers. Some of these groups are quite wealthy and may want to build themselves a place in space where they don't have to. 6. Space settlements. Solving the basic problems and lowing the price through the previous steps may, at long last, bring space settlement within the economic grasp of the upper middle class.

### Lunar and Mars colonization make resupply, landing, and travel near impossible – the compendium of issues means orbital colonies solve best

Globus 3 (Al – Senior Research Associate at SJSU/NASA Ames Research Center, BA in Information Science, Editor-in-Chief of NSS Space Settlement Journal, Recipient of the NASA Software of the Year Award, multiple NASA Group Achievement Awards, NASA Public Service Medal, and the NSS Space Pioneer Award, Orbital Space Colonies, Windstorm Creative Full Spectrum Reference Books, “Where Should We Build Space Colonies?,” <http://space.alglobus.net/Basics/where.html>, mrs)

Supply There is a saying "Amateur soldiers think about tactics, professionals think about supply," perhaps because the well-fed army with plenty of ammunition tends to win. Fast and effective transportation to and from Earth is critical to the establishment and development of any space settlement. People will need to go back and forth frequently and in large numbers. Although bulk materials (steel, concrete, and water or their equivalents) are best mined and processed in space, colonies will need computer chips, specialty components, and other products from Earth. Early colonies will not be able to make everything they need and inevitably will require frequent resupplying. Building the first colony will necessitate moving people, materials, parts, food, and water to and from the work site. Critical tools and parts will be forgotten or break, and need to be supplied by Earth as quickly as possible. This will be far easier for a colony in Earth orbit than for either the Moon or Mars. To land on the Moon, plant a flag, hit a few golf balls, and dig up some rocks required no resupply. Raising a family and building a life off-world will. In this department, orbital colonies are the clear first choice as the early ones can be built much closer to Earth. Subsequent colonies can go further and further afield in small, manageable steps. Furthermore, rendezvous with an orbital colony will require less fuel and can be aborted at any time. Landing on the Moon or Mars is more challenging than docking with an orbital colony, requires more fuel, and carries much higher risk to the travelers. The Apollo missions took approximately three days to get to the Moon; travel times to Mars are currently over six months. Even with advanced propulsion, travel times to Mars will be measured in weeks. Travel from Earth to planetary orbit is measured in minutes, although time to get to a higher, space-colony orbit and rendezvous will probably be at least a few hours. With current transportation to Mars, launch opportunities come only once every two years. If you need something from Earth it may take years to get it. For a colony in Earth orbit, it may be possible to obtain key items in a day or so. This is equivalent to the difference between an ox-drawn cart and Federal Express. How many businesses ship their materials by Clipper ship rather than Airborne Express? There's a reason for their choice, and that same logic says we should colonize orbit before the Moon or Mars. Resupply isn't a make-or-break issue for Martian colonization, but the greater difficulty of resupply and travel will generate an endless series of problems, each of which will require time, energy, money, and attention to solve. The great Prussian military thinker, Carl von Clauswitz, noted that armies aren't usually stopped by the equivalent of a brick wall, but rather by an endless accumulation of small problems - equipment stuck in the mud, sick soldiers, food problems, and desertion. He called this phenomenon friction. Although we note some near-killer problems for early Martian and Lunar colonization, most of the issues amount to much less friction for orbital colonization. Each problem by itself seems manageable, but put them together in their thousands and the case for orbital colonies first, the Moon and Mars later, becomes undeniable.

# Solvency Materials

## CP Solves Colonization – General

### Planetary colonization is only possible on Mars and the Moon – orbital colonies are superior in every way and solve resource access

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Because we are planetary creatures, when most people think about space colonization they usually envision homes on Mars or perhaps Earth's moon. Colonization of those bodies is in fact much less desirable than orbital colonization, even though Mars and the Moon are the only practical solid bodies suitable for colonization in the solar system, at least for the next few centuries. Venus is far too hot. Mercury is too hot during the day and too cold at night, as the days and nights are so long. Jupiter, Saturn, Neptune, and Uranus have no solid surface. Pluto is very far away. Comets and asteroids have too little gravity for a surface colony, although some have suggested that an asteroid could be hollowed out. This is actually a variant of an orbital colony. That leaves Mars and the Moon. However, both bodies are greatly inferior to orbital space colonies in every way except for access to materials. This advantage is important but not critical; lunar and asteroid mines can provide orbital colonies with everything they need. Mars has all the materials needed for colonization: oxygen, water, metals, carbon, silicon, and nitrogen. You can even generate rocket propellant from the atmosphere. The Moon has almost everything needed, the exceptions being carbon and nitrogen; water is only available at the poles, if at all. Orbit, by contrast, has literally nothing - a few atoms per cubic centimeter at best. How can you build enormous orbital colonies if there is nothing there? Fortunately, Near Earth Objects (NEOs, which include asteroids and comets with orbits near Earth's) have water, metals, carbon, and silicon -- everything we need except possibly nitrogen. NEOs are very accessible from Earth, some are easier to get to than our moon. NEOs can be mined and the materials transported to early orbital colonies near Earth. The Moon can also supply metals, silicon, and oxygen in large quantities. While developing the transportation will be a challenge, colonies on Mars and the Moon will also face significant transportation problems.

### Mars and moon colonization fail now – orbital colonies are possible now and solve the reasons they fail

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As Robert Zubrin suggests in The Case for Mars (Zubrin and Wagner, 1996), small groups of Martian explorers can carry select supplies (hydrogen, uranium, food, etc.) and make rocket fuel, water, oxygen, and other necessities from the Martian atmosphere. However, to truly colonize Mars will require extensive ground transportation systems to get the right materials to the right place at the right time. These systems will be difficult and expensive to build, particularly considering the long resupply times from Earth. While Mars has an edge in material availability, orbital colonies have many important advantages over the Moon and Mars. These include: Rapid resuppply from Earth Continuous, ample, reliable solar energy Better communication with Earth Great views of Earth (and eventually other planets) Control of (pseudo-)gravity levels Weightless and low-g recreation near the axis of rotation Relatively easy 0g construction of large living structures Greater independence Much greater growth potential Near-Earth orbital colonies can service our planet's tourist, energy, and materials markets more easily than the Moon, and Mars is too far away to easily trade with Earth. None of this means that colonizing the Moon or Mars is impossible, of course. It is simply that this option is less desirable, and is more likely to come along after orbital colonization has been firmly established. This essential point has escaped many space advocates, perhaps because we are accustomed to living on a planetary surface. It's difficult to imagine living inside a giant spacecraft and even harder to take the concept seriously: but we should. It has profound implications for the future course of our National and International space programs.

## CP Solves Colonization – Communication

### Lunar and Martian colonies make communication difficult – orbital colonies solve

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Communication Anything in Earth orbit can have excellent communication with Earth. In fact, much of our communications are carried by orbiting satellites already. Telephone, Internet, radio, and television signals are passed through satellites in everyday operations around the world. Any orbiting colony within a few thousand kilometers of Earth will be able to hook directly into Earth's communication system. All modes of communication, including the telephone, will work pretty much as if you were in Chicago or London.

Because the Moon is approximately a quarter of a million miles from Earth and wireless communication travels at 300 kilometers (186,000 miles) per second, colonies on the Moon will suffer at least a three-second round trip communication delay with Earth. This makes telephone conversations awkward, though email, television, radio, and instant messaging should work pretty much as they do here from the consumer's perspective.

Mars is a different story. The red planet is so far away that the delay between sending a signal to Mars and receiving a reply is at least six to forty minutes, depending on the planet's relative positions at that time. Instant messengers will chafe at the delay and telephone conversation is impossible. The distance will require significantly larger antennas and energy than communications between Earth and an orbital colony. This problem isn't a concept killer, but it is another headache for Martian colonies, adding just a little more friction.

## CP Solves Colonization – Energy

### Lunar colonies can’t solve energy needs – nuclear accidents, barriers to He-3 fusion, and cost – orbital colonies solve

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Energy In orbit there is no night, clouds, or atmosphere. As a result, the amount of solar energy available per unit surface area in Earth orbit is approximately seven times that of the Earth's surface. Further, space solar energy is 100 percent reliable and predictable. Near-Earth orbits may occasionally pass behind the planet, reducing or eliminating solar power production for a few minutes, but these times can be precisely predicted months in advance. Solar power can supply all the energy we need for orbital colonies in the inner solar system. Almost all Earth-orbiting satellites use solar energy; only a few military satellites have used nuclear power. For space colonies we need far more power, requiring much larger solar collectors. Space solar power can be generated by solar cells on large panels as with current satellites, or by concentrators that focus sunlight on a fluid, perhaps water, which is vaporized and used to turn turbines. Turbines are used today by hydroelectric plants to generate electricity, and are well understood. Turbines are more efficient than today's solar cells, but they also have moving parts and high temperature liquids, both of which tend to cause breakdowns and accidents. Both panels and concentrator/turbine systems can probably work, and different orbital colonies may use different systems. Understand though that orbital colonies can have ample solar-generated electrical energy 24/7 so long as sufficiently sized solar panels or appropriate concentrator-turbine systems can be built. This is a matter of building what we already understand in much greater quantities - which gives us the much sought after economies of scale. Economies of scale simply means that if you do the same thing over and over, you get good at it. By contrast, the moon has two-week nights when no solar power is available (except at the poles). Storing two weeks worth of power is a major headache. The only ways around this are nuclear or orbital solar-powered satellites that transmit power to the Moon's surface. There doesn't seem to be much, if any, uranium on the Moon, so fuel for fission reactors would have to be imported from Earth. This adds a risk of launch accidents that could spread nuclear fuel into our biosphere. Spacecraft bound for the outer solar system (e.g. Jupiter or Saturn) carry nuclear power plants now. Good containment is possible, and there's not much risk from the occasional probe, but launching the large amounts of fuel necessary for a lunar colony would almost certainly involve an accident at some point. The risk of inattention or mistakes is much greater for hundreds of launches per year than with one every decade. Colonizing the Moon with nuclear fuel shipped from Earth will also be expensive, and we can probably rule it out as a practical approach to generating large amounts of power. That leaves local sources. Helium-3, a special form of helium that suitable for advanced fusion reactors, is available on the Moon. However, in spite of many decades of effort and billions of dollars, no one has ever built a commercially viable fusion reactor, or even come close.The other approach to lunar power is solar power satellites. In this case, we build large satellites to generate electricity and place them in orbit around the Moon. The energy is then transmitted to the lunar surface during the two-week night. This is no different from the large solar power systems needed for orbital colonies, except that you also need to transmit the power to the Moon and build a system to collect it. Thus, lunar colonization has energy disadvantages in comparison to orbital colonization. There is a bit more friction.

### Martian colonies can’t solve energy needs – nuclear accidents, less solar energy, transit time, and cost – orbital colonies solve

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Energy In orbit there is no night, clouds, or atmosphere. As a result, the amount of solar energy available per unit surface area in Earth orbit is approximately seven times that of the Earth's surface. Further, space solar energy is 100 percent reliable and predictable. Near-Earth orbits may occasionally pass behind the planet, reducing or eliminating solar power production for a few minutes, but these times can be precisely predicted months in advance. Solar power can supply all the energy we need for orbital colonies in the inner solar system. Almost all Earth-orbiting satellites use solar energy; only a few military satellites have used nuclear power. For space colonies we need far more power, requiring much larger solar collectors. Space solar power can be generated by solar cells on large panels as with current satellites, or by concentrators that focus sunlight on a fluid, perhaps water, which is vaporized and used to turn turbines. Turbines are used today by hydroelectric plants to generate electricity, and are well understood. Turbines are more efficient than today's solar cells, but they also have moving parts and high temperature liquids, both of which tend to cause breakdowns and accidents. Both panels and concentrator/turbine systems can probably work, and different orbital colonies may use different systems. Understand though that orbital colonies can have ample solar-generated electrical energy 24/7 so long as sufficiently sized solar panels or appropriate concentrator-turbine systems can be built. This is a matter of building what we already understand in much greater quantities - which gives us the much sought after economies of scale. Economies of scale simply means that if you do the same thing over and over, you get good at it. By contrast, the moon has two-week nights when no solar power is available (except at the poles). Storing two weeks worth of power is a major headache. The only ways around this are nuclear or orbital solar-powered satellites that transmit power to the Moon's surface. There doesn't seem to be much, if any, uranium on the Moon, so fuel for fission reactors would have to be imported from Earth. This adds a risk of launch accidents that could spread nuclear fuel into our biosphere. Spacecraft bound for the outer solar system (e.g. Jupiter or Saturn) carry nuclear power plants now. Good containment is possible, and there's not much risk from the occasional probe, but launching the large amounts of fuel necessary for a lunar colony would almost certainly involve an accident at some point. The risk of inattention or mistakes is much greater for hundreds of launches per year than with one every decade. Colonizing the Moon with nuclear fuel shipped from Earth will also be expensive, and we can probably rule it out as a practical approach to generating large amounts of power. That leaves local sources. Helium-3, a special form of helium that suitable for advanced fusion reactors, is available on the Moon. However, in spite of many decades of effort and billions of dollars, no one has ever built a commercially viable fusion reactor, or even come close.The other approach to lunar power is solar power satellites. In this case, we build large satellites to generate electricity and place them in orbit around the Moon. The energy is then transmitted to the lunar surface during the two-week night. This is no different from the large solar power systems needed for orbital colonies, except that you also need to transmit the power to the Moon and build a system to collect it. Thus, lunar colonization has energy disadvantages in comparison to orbital colonization. There is a bit more friction. The energy situation for Mars is far worse. Mars is much further from the Sun than Earth so the available solar energy is less (approximately 43 percent). Mars is 1.524 times further from the Sun than Earth. Since the amount of solar power available is inversely proportional to the square of the distance from the Sun, solar power satellites near Mars must be 2.29 times larger than those near Earth for the same power output. As a result, solar panels on or near Mars would have to be quite large. Further, Mars has a night and significant dust storms. Even between dust storms, dirt will accumulate on solar panels and need to be cleaned off, although robots to perform this chore can undoubtedly be built; just a little more friction. In practice, Martian colonies will require nuclear power and/or solar power satellites. If there is any nuclear fuel on Mars, we don't know where it is or how much is available. If nuclear fuel must be sent from Earth, it suffers from all the same issues as the Moon, plus will take significantly longer to deliver. If a source of easily processed nuclear fuel can be found on Mars there might be some hope, but processing and use of nuclear fuel is not an easy proposition. Large-scale nuclear energy production on Mars is likely to be very difficult for the foreseeable future. Even with the red planet's distance from the Sun, solar power satellites might be easier. Energy problems make Mars far less attractive for early settlement, though once solar power satellite technology is well established by orbital colonization, it could be used for Martian colonization.

## CP Solves Environmental Degradation

### Counterplan solves environmental degradation – solves the root cause

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Space settlement is life’s next step. Life has always expanded through time and space, creating the conditions for its own existence. Our oxygen-rich atmosphere was created and is sustained by life itself. All vigorous ecosystems are constantly expanding, pushing outward to make more room for themselves. That’s why plants and animals dragged themselves out of the sea and onto land millions of years ago. Life is poised to expand once again, but this time it will expand from our beautiful but tiny sphere into the infinitely larger canvas of space. Mars and the Moon typically take center stage in discussions of space settlement, but their combined surface area is only about one-third that of Earth. In contrast, the materials in the single largest asteroid (Ceres) could be converted into space settlements with a combined living area between 100 and 1,000 times the surface area of Earth. Each of those millions of settlements would be a giant spacecraft housing tens of thousands of people in a separate, closed ecosystem. Their relatively small size would make environmental accountability quick: if the occupants of a settlement failed to follow sound environmental practices, their home would rapidly degrade and become unlivable, but this would not affect other settlements, giving life redundancy and resiliency. Space settlement will give life what it lacks today: room to grow without degradation of the home planet. Space development can thus go far beyond preserving and restoring life on Earth. It can extend life throughout the cosmos. Think about that next time you look up at the stars.

## CP Solves Ethnic Tensions

### Colonies solve ethnic tensions and are independent

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Somewhat Greater Independence A mature space colony, whether in orbit or on the Moon or Mars, can be extremely independent, at least in the long term. With first-class recycling plus a bit of asteroid dirt from time to time to make up losses, it should be possible to build space colonies that can live completely independently for very large periods of time; decades if not centuries or more. On Earth we all share the same air and water. Plants, animals, bacteria, and viruses move freely around the planet, and nobody is much farther than 20,000 kilometers (12,000 miles - a day on a typical commercial jet) away from anyone else. By contrast, each space colony will have its own separate air and water and quite a bit of control over what species exist in the colony. If someone screws up the environment of one colony, it will have little or no direct impact on other settlements. Further, Mars and the Moon are smaller than Earth. Those colonists will be living fairly close together despite personal desire. Orbital colonies can be tens of millions of miles apart. Given the apparently bottomless animosity of some groups, this may occasionally be a positive thing. When my kids fight, I tell them to go to their rooms. If orbital space colonies fight, we can tell them to go to opposite sides of the Sun.

## CP Solves Overview Effect

### Orbital colonies solve the overview effect – Lunar and Martian colonization also get rejected by private industry

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Views Space colonization is, at its core, a real estate business. The value of real estate is determined by many things, including "the view." In my hometown, a rundown house on a tiny lot with an ocean view sells for well over a million dollars. The same house a few blocks further inland is worth less than half that. Any space settlement will have a magnificant view of the stars at night, with the exception of Mars during a dust storm. Any settlement on the Moon or Mars will have a view of an unchanging, starkly beautiful, dead-as-a-doornail, rock strewn surface. However, settlements in Earth orbit will have one of the most stunning views in our solar system - the living, ever-changing Earth1. Anyone who has climbed a tall mountain knows what it feels like to be on top of the world, drinking in the vast panorama spread below. The view and feeling from orbit dwarfs that. Significantly. After all, the highest mountain on Earth is approximately eight kilometers (five miles). The lowest reasonably stable Earth orbit is approximately 160 kilometers (100 miles).

## CP Solves Space Solar

### Space colonies are the only way to solve space solar – it turns a profit

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Continuous solar energy coupled with experience in building large structures will allow colonies to build and maintain enormous solar power satellites. These can be used to transmit energy to Earth. As already discussed, there is ample, reliable solar energy in orbit, and collecting it in large quantities primarily involves scaling up the space solar energy systems we have today. This energy can be delivered to Earth by microwave beams tuned to pass through the atmosphere with little energy loss. Although the receiving antennas on the ground will be quite large, they should be able to let enough sunlight through for agriculture on the same land. Space solar power operations will consume nothing on Earth and generate no waste materials, although development and launch will involve some pollution. In particular, no greenhouse gasses or nuclear waste will be produced. The only operational terrestrial environmental impact will be the heat generated by transmission losses and using the electricity. Solar power satellites are financially impractical if launched from Earth, but if built in space using extraterrestrial resources by an orbital space colony, they may eventually be profitable. By contrast, Mars has no opportunity to supply Earth with energy. The Moon has some helium-3 that may be useful for advanced forms of fusion power, but we have spent billions of dollars on fusion research, and have yet to produce more power than consumed much less produced power economically.

### Orbital colonies develop exotic materials – these are lucrative

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New, exotic materials can fetch very high prices. A variety of techniques are used to develop new materials, including controlling pressure, temperature, gas composition, and so forth. Gravity affects material properties since heavy particles sink and light ones rise in fluids during material processing. In an orbital colony it is possible to control pseudo-gravity during processing. In principle this should allow the development of novel materials, some of which may be quite valuable. To date, the space program has failed to find a 'killer-app' material, a material so useful it justifies the entire space program. But the total number of orbital materials experiments has been small and very few materials experts have been to orbit conducting these investigations. It's reasonable to expect that, given a much more substantial effort, valuable materials will be discovered that can only be produced in orbit, or that can be produced more economically once a substantial orbital infrastructure is in place. By comparison, both the Moon and Mars have fixed gravity at the surface and are much less likely to be suitable for exotic materials production. In addition, Mars, as always, is too far away to service Earth materials markets economically, especially in competition with orbital colonies exploiting NEO materials.

## CP Is Prerequisite to Solvency

### Lunar and Martian colonization can’t sustain life – gravity issues – orbital colonies solve and are a prerequisite

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Gravity and Pseudo-Gravity All of life has evolved under the force of Earth's gravity. The strength of that force, which we call 1g, plays a major role in the way our bodies work. We understand some of these effects, but it is quite likely that there are important unknown gravitational functions in living creatures. For example, we understand that gravity is crucial to development and maintenance of human bone and muscle, but we have only a vague idea of the exact mechanisms behind the effects we observe in adults. We have absolutely no data on the effect of low-g on children and, consequently, only the vaguest notion of the consequences of alternate gravity levels on a child's development. This is a real problem for colonization of the Moon and Mars, as neither has anything resembling 1g. Mars' gravity measures approximately one-third that of Earth, and the Moon's is even less, around one-seventh. Nonetheless, it may turn out that children can grow up on Mars with perfectly functional bodies, for Mars. It is certain that anyone raised on Mars will have great difficulty visiting Earth. For example, I weigh about 160 pounds. My muscles and bones are adapted to carrying that load. If I went to a more massive planet with 3g at the surface, the equivalent of moving from Mars to Earth, I would weigh 480 pounds and would probably spend all my time flat on my back, assuming my heart and lungs didn't immediately fail under the load. A child born and raised on the Moon or Mars will never live on Earth, and even a short visit would be an excruciating ordeal. Attending college on Earth will be out of the question. For me this is a concept killer. Some parents may accept raising children who can never live on Earth. I'm not one of them. A large orbital space colony can, by contrast, have nearly any pseudo-gravity desired. While orbital colonies will have far too little mass to have appreciable real gravity, something that feels like gravity and should have almost the same biological effect can be created. Real gravity is the attraction of all matter - stuff you can touch - for all other matter. The amount of attraction increases as the amount of matter increases (the amount of matter is called the mass). Earth is very large, has a lot of mass, and exerts significant gravitational force on us. We can create something that feels a lot like this force by spinning our colonies. This force, called pseudo-gravity, is the same force you feel when the car you are riding in takes a sharp turn at high speed. Your body tries to go straight but runs into the door, which is turning and pushes on your arm. Similarly, as an orbital space colony turns, the inside of the colony pushes on the feet of the inhabitants forcing them to go around. This force feels a great deal like gravity, although it isn't. What's important to note in this discussion is that the amount of this force can be controlled and that, for reasonable colony sizes and rotation rates, the force can be about 1g. For example, a 450-meter diameter colony that rotates at two rpm (rotations per minute) provides 1g at the rim. This is crucial. It means that children raised in an orbital space colony can be strong enough to visit Earth and still walk, run, climb, jump, and attend college. Moving to an orbital space colony from a strength perspective will not be a one-way ticket for adults or children. Even someone born and raised in a 1g orbital space colony (meaning a colony rotating fast enough to produce 1g of pseudo-gravity on the inside of the rim) would be physically strong enough to move to Earth without hardship. By contrast, being raised on Mars or the Moon almost certainly precludes visiting Earth, at least if you want to walk. Even for adults, living on Mars or the Moon for a few decades would make return to Earth a painful ordeal. Long-term Lunar and Martian residents would, at best, be wheelchair bound on Earth. Since orbital colonies can be sized and spun to create different pseudo-gravity levels, it will be possible to gradually experiment with lower pseudo-gravity levels. For example, a colony at 0.9g or 0.8g is feasible and possibly desirable for those who have lived many generations in orbit. Eventually, one might even see colonies with pseudo-gravity levels comparable to Mars and the Moon. If this does not create significant problems, then Lunar and Martian colonization can proceed.

### Orbital colonies solve better than colonization and are a prerequisite – now is key

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The Bottom Line on Where The best place to live on Mars is not nearly as nice as the most miserable part of Siberia. Mars is far colder; you can't go outside, and it's a months-long rocket ride if you want a Hawaiian vacation. The Moon is even colder. By contrast, orbital colonies have unique and desirable properties, particularly 0g recreation and great views. Building and maintaining orbital colonies should be quite a bit easier than similar sized homesteads on the Moon or Mars. They are better positioned to provide goods and services to Earth to contribute to the tremendous cost of space colonization. For these reasons, orbital colonies will almost certainly come first, with lunar and Martian colonization later. Perhaps much later. The sooner we recognize this and orient our space programs accordingly, the better.

# Privatization Materials

## CP Enables Profit

### Space colonies can turn a profit – tourism

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Economics The final advantage for orbital colonies over Mars and the Moon is major. It's the economy, stupid. There is nothing that Mars can supply Earth with economically, for the same reasons that there are no economical mines or factories in Antarctica. Both are too far away and operations in those conditions are difficult. The Moon might support tourism and perhaps provide helium-3 for future fusion reactors, but both markets will be difficult to service. By contrast, orbital colonies can service Earth's tourism, energy, and exotic-materials markets as well as repair satellites. There is already a small orbital tourist market. Two wealthy individuals have paid the Russians approximately $20 million apiece to visit the International Space Station (ISS). Space Adventures Ltd. (www.spaceadventures.com) arranged these trips, and claims to have a contract to send two more. There are also a number of companies developing suborbital rockets to take tourists on short (about fifteen-minute) rides into space for approximately $100,000 per trip. As we will learn, orbital tourism is a promising approach to the first profit-generating steps toward orbital space colonization.

### Space colonies are the only way to solve space solar – it turns a profit

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Continuous solar energy coupled with experience in building large structures will allow colonies to build and maintain enormous solar power satellites. These can be used to transmit energy to Earth. As already discussed, there is ample, reliable solar energy in orbit, and collecting it in large quantities primarily involves scaling up the space solar energy systems we have today. This energy can be delivered to Earth by microwave beams tuned to pass through the atmosphere with little energy loss. Although the receiving antennas on the ground will be quite large, they should be able to let enough sunlight through for agriculture on the same land. Space solar power operations will consume nothing on Earth and generate no waste materials, although development and launch will involve some pollution. In particular, no greenhouse gasses or nuclear waste will be produced. The only operational terrestrial environmental impact will be the heat generated by transmission losses and using the electricity. Solar power satellites are financially impractical if launched from Earth, but if built in space using extraterrestrial resources by an orbital space colony, they may eventually be profitable. By contrast, Mars has no opportunity to supply Earth with energy. The Moon has some helium-3 that may be useful for advanced forms of fusion power, but we have spent billions of dollars on fusion research, and have yet to produce more power than consumed much less produced power economically.

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# Affirmative Responses

## No Solvency

### Space colonies fail and are years away – CO2, agriculture, and recycling

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There is another big difference. The air and water we need to live is recycled on a huge scale here on Earth, and we don't need to work too hard for that to happen. On a space colony, millions of times smaller than Earth, we will need to constantly monitor the air and water and take quick action if anything begins to go wrong. Here on Earth CO2 levels are rising and some are concerned that decades from now global warming will become a serious problem. On a space colony, rising CO2 levels will cause an immediate alarm and require fixing within hours to avoid the entire population suffocating. Every space colonist will be a rabid environmentalist by absolute necessity. On a space settlement, recycling will be a way of life. Here on Earth many people feel we can use things and throw them away. There are plenty of materials all around us. On a space colony, every atom is precious. Nothing, except perhaps the most toxic of toxic wastes, will be thrown away. Everything will be endlessly recycled, especially water. Waste water won't go out to the sea. It will run to the outside where sunlight will sterilize the waste, and then everything will be recycled through the agricultural section. Agriculture will be different too. On Earth, huge farms take advantage of natural conditions to grow the food we need to live. On a space colony, there are no natural conditions. Food will be grown in small, carefully controlled rooms where conditions are kept perfect for the crops being grown. This will lead to very high yields so the area needed for agriculture will be far smaller than on Earth. Furthermore, plants in the agricultural modules will be integrated into the atmosphere maintenance systems since plants produce oxygen and consume CO2. The further big difference will be low and zero-g recreation. On Earth, we always feel the pull of gravity and it's always the same amount (1g, the 'g' stands for gravity). On a rotating space colony, people just on the inside of the hull will feel a pull a lot like gravity and the amount will be 1g. However, as you go closer to the center of the colony the pull will gradually decrease until it's 0g right at the axis of rotation. This will be a lot of fun. Jumping 20 meters will be easy, even for the most out-of-shape colonists. Gymnasts and dancers will experience freedom of movement they could never have on Earth. New sports will be created to take advantage of freedom from gravity, and old sports will change to adapt to the new conditions. Baseball, American football, and basketball won't work very well in 0g, but they will still be played just inside the hull where 1g rules. However, soccer (called football outside the U.S.) can be easily adapted to 0g and we can expect some very exciting, and wild, 0g games. No one has ever built a space colony, and it is sufficiently difficult that it will be many years before that happens. Mankind has, however, been building space stations for decades. Space stations aren't homes, they are work camps, like the ones used to build the Alaska pipeline. Nonetheless, space stations are real today, so it's worth taking a look at what we've done.